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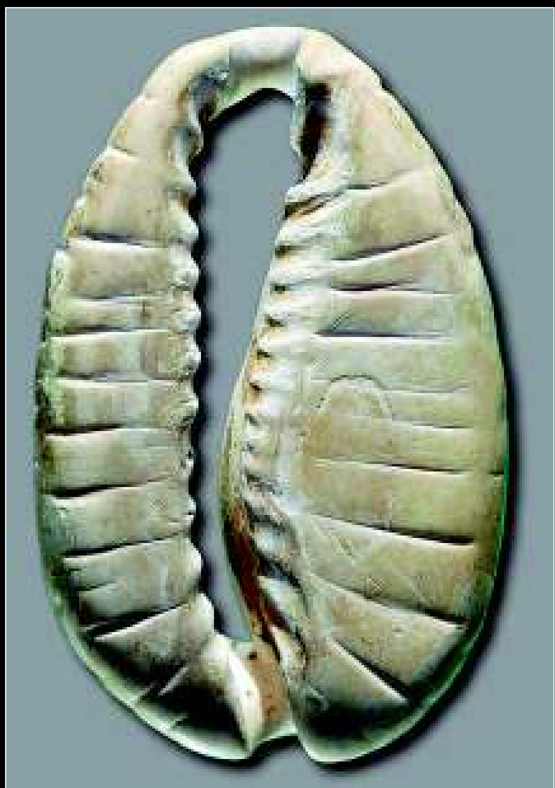
SUPLEMENTO - GEHIGARRIA 31

Not only Food

Marine, Terrestrial and Freshwater Molluscs in Archaeological Sites



Esteban Álvarez-Fernández
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ARANZADI
zientzia elkartea . sociedad de ciencias
society of sciences . societé de sciences

Esteban Álvarez-Fernández

(Santa Marina del Rey, León) realizó sus estudios universitarios en la Universidad de Salamanca y en la Universidad de Colonia (Alemania). Es doctor en Prehistoria por la Universidad de Salamanca. Ha ampliado sus estudios en el Forschungsbereich Altsteinzeit des Römisch-Germanischen Zentralmuseums (Neuwied, Alemania) y, dentro del Programa "Juan de la Cierva" (Ministerio de Educación y Ciencia), en el IIIPC - Universidad de Cantabria y en la UMR 6566-CREeAHH - Universidad de Rennes 1 (Francia).
En la actualidad es investigador del Departamento de Prehistoria, Historia Antigua y Arqueología de la Universidad de Salamanca (Programa "Ramón y Caja"del Ministerio de Ciencia e Innovación).
Esteban ha formado parte de más de una decena de proyectos de investigación, tanto nacionales, como internacionales. Su actividad científica se centra en el estudio de los restos arqueofaunísticos de origen marino procedentes de diferentes yacimientos prehistóricos del SW de Europa y del Norte de África.

(Santa Marina del Rey, León, Spain) studied at the University of Salamanca (Spain) and the University of Cologne (Germany). He was awarded a Ph.D. at the University of Salamanca. He has carried out further research at Forschungsbereich Altsteinzeit des Römisch-Germanischen Zentralmuseums (Neuwied, Germany) and within the "Juan de la Cierva" Programme (Ministry of Education and Science, Spain), at the IIIPC-University de Cantabria (Spain) and the UMR 6566-CREeAHH, University of Rennes 1 (France).
He is currently a researcher in the Department of Prehistory, Ancient History and Archaeology at the University of Salamanca, within the "Ramón y Cajal" Programme of the Ministry of Science and Innovation.
He has taken part in a wide number of research projects, both in Spain and abroad. His main scientific interest is the study of marine archaeofaunal remains found at prehistoric sites in SW Europe and North Africa.

(Santa Marina del Rey, Leon) Salamancako Unibertsitatean eta Koloniako Unibertsitatean (Alemania) egin zituen unibertsitate-ikasketak. Historiaurreko doktore da Salamancako Unibertsitatean. Forschungsbereich Altsteinzeit des Römisch-Germanischen Zentralmuseums (Neuwied, Alemania) delakoan sakondu zituen ikasketak eta "Juan de la Cierva" programan parte hartu du (Hezkuntza eta Zientzia Ministerioa), Kantabriako Unibertsitateko IIIPC arloan eta Renneseko Unibertsitateko (Frantzia) UMR 6566-CREeAHH delakoan.
Egun Salamancako Unibertsitateko Historiaurre, Antzinako Historia eta Arkeologiako Departamentuan lan egiten du ikertzaile modura (Zientzia eta Berrikuntzako Ministerioaren "Ramón y Cajal" programan).
Estebanek hamar ikerketa-proiektu baino gehiagotan parte hartu du, hala nazio barruan nola nazioartean. Bere zientzia-ikerketaren ardatza Europa hego-mendebaldeko eta Afrika iparraldeko historiaurreko aztarnategietatik etorritako itsas jatorriko fauna-arkeologikoen arrastoetan mamitzen da.

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Not only Food

Marine, Terrestrial and Freshwater Molluscs in Archaeological Sites

Proceedings of the 2nd Meeting of the ICAZ Archaeomalacology Working Group
(Santander, February 19th-22nd 2008)

Edited by
Esteban Álvarez-Fernández & Diana Carvajal-Contreras

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PRESENTACIÓN

Entre las líneas prioritarias de actuación de esta Consejería vinculadas con el Patrimonio Cultural ocupa un lugar central la gestión del Patrimonio Arqueológico.

Desde la propia formación de una unidad administrativa expresamente destinada a esa tarea hasta la consecución de la distinción de Patrimonio Mundial para nuestras cuevas con arte rupestre paleolítico, media un gran esfuerzo organizativo y presupuestario orientado a la adecuada gestión de una parte tan relevante de nuestro patrimonio.

Protección legal, conservación, investigación y difusión constituyen los cuatro pilares que sustentan esta acción patrimonial, y es en relación con este último que la Consejería ha decidido resueltamente apoyar la publicación que ahora se presenta.

La serie "Actuaciones Arqueológicas en Cantabria" y la de "Monografías Arqueológicas de Cantabria" plasman esa preocupación por un aspecto esencial en la administración del patrimonio: ofrecer al público especializado y a la ciudadanía en general los resultados de la investigación y la gestión arqueológicas, como mejor medio de fomentar la conservación de un patrimonio a través de su conocimiento y valorización.

La publicación "Marine, Terrestrial and Freshwater Molluscs in Archaeological Sites" recoge las actas de la 2ª Reunión del Grupo de Trabajo sobre Arqueomalacología del ICAZ, que se celebró en Santander en febrero de 2008 con ayuda de esta Consejería. La colaboración en la edición supone pues el colofón a una interesante iniciativa que supone un gran avance en el conocimiento científico de esta parte del registro arqueológico, refrendada por la excelencia de la entidad que la acoge: El hecho de que las actas se publiquen como suplemento de la revista Munibe de la Sociedad de Ciencias Aranzadi supone una garantía contrastada de calidad que acrecienta el valor de la publicación.

La Consejería de Cultura, Turismo y Deporte del Gobierno de Cantabria se felicita de poder colaborar con la Sociedad de Ciencias Aranzadi, con el ICAZ, con los organizadores del Coloquio y con todos los investigadores que, aportando sus conocimientos, han hecho posible este magnífico suplemento de la revista Munibe, al que desea el mayor de los éxitos.

D. FRANCISCO JAVIER LÓPEZ MARCANO
Consejero de Cultura, Turismo y Deporte del Gobierno de Cantabria

PREFACE

This volume is one of several books publishing the proceedings of the International Council of Archaeozoology (ICAZ), an organization created to exchange research related to the study of animal remains from archaeological sites.

The archaeomalacological working group within ICAZ agreed to meet in Santander, Spain, following a previous meeting in Gainesville (USA) (Szabó and Quitmayer 2008).

This second meeting was held at the University of Cantabria from the nineteenth to the twenty-second of February 2008. In this workshop, over 100 specialists prepared 31 oral communications and 30 posters.

The present volume, *Not only food: Marine, Terrestrial and Freshwater molluscs in Archaeological sites*, includes results of research conducted all over the world and contributions dealing with a wide range of topics related to archaeological mollusc shells. Its objective, from a holistic perspective, is to show that shells in archaeological contexts are not only used as food but also as tools and ornaments. Not only archaeomalacologists could be attracted to this volume, as researchers in related fields such as zooarchaeology, archaeology, zoology and anthropology could find relevant topics related to dating problems, conservation, ecology, palaeoeconomy, technology and methodological issues.

The book starts by grouping papers that study shell remains from Middle to Upper Palaeolithic contexts in Europe. The papers cover a variety of topics such as dating techniques on marine shell carbonates (Douka *et al.*). In addition, personal shell adornments are analyzed using taxonomy, technology, use wear analyses, Geographical Information System (GIS) data and experimental work to discuss mobility and exchange networks of hunter-gathers who lived at the Gargas Cave (San Juan-Foucher and Foucher), Maltravieso Cave site (Rodriguez-Hidalgo *et al.*), La Peña de Estebanvela site (Avezuela), El Horno Cave (Fano and Álvarez-Fernández), and Parco´s Cave (Estrada *et al.*).

From the Late Upper Pleistocene to the Neolithic periods at several locations in Europe and Asia, molluscs were part of the human diet and were also used as personal ornaments and raw material for tool manufacture. Taxonomic, technological, taphonomic, and spatial studies reveal that several techniques were used for manipulating shell remains, different habitats were exploited and several long-distance social networks were established by early

PRÓLOGO

Este volumen es uno de varios libros publicados de actas de congresos del International Council of Archaeozoology (ICAZ), una organización creada para fomentar el intercambio de investigaciones científicas relacionadas con los restos de animales documentados en los sitios arqueológicos.

El grupo de trabajo de arqueomalacología incluido en el ICAZ acordó reunirse en Santander, España, una vez que celebró su primera reunión científica en Gainesville (USA) (Szabó y Quitmayer 2008).

Este segundo encuentro tuvo lugar en la Universidad de Cantabria del 19 al 22 de Febrero del 2008. En esta reunión, cerca de 100 especialistas presentaron 61 trabajos: 31 comunicaciones y 30 en formato póster.

El presente volumen, que se traduce del inglés como: *"No solo comida: moluscos marinos, terrestres y de agua dulce en los contextos arqueológicos"*, incluye los resultados de las investigaciones llevadas en diferentes regiones del mundo y versan sobre un amplio rango de temas relacionados con los restos de moluscos arqueológicos. Su objetivo, desde una perspectiva holística, es mostrar que las conchas documentadas en diferentes contextos arqueológicos no sólo eran recogidas como alimento, sino también como materia prima para la elaboración de adornos e instrumentos.

Este libro comienza con un grupo de artículos que estudian restos de moluscos en contextos del Paleolítico Medio y del Paleolítico Superior en Europa y que cubren una variedad de tópicos, como las técnicas de datación en carbonatos de concha marina (Douka *et al.*). Adicionalmente adornos personales son analizados aplicando criterios taxononómicos, tecnológicos, de análisis de huellas de uso, utilizando los sistemas de información geográfica (SIG) y estudios de tipo experimental, para discutir aspectos como la movilidad y las redes de intercambio de los grupos de cazadores-recolectores que habitaron diferentes yacimientos; la Cueva Gargas (San Juan-Foucher y Foucher), la Cueva de Maltravieso (Rodriguez-Hidalgo *et al.*), el sitio La Peña de Estebanvela (Avezuela), la cueva de El Horno (Fano y Álvarez-Fernández), y la Cueva de Parco (Estrada *et al.*).

Del Pleistoceno superior-final al Neolítico, los moluscos fueron parte de la dieta humana y sus conchas fueron utilizadas también como adornos personales y materia prima para la confección de herramientas en varias localidades de Europa y Asia. Estudios taxonómicos, tecnológicos, tafonómicos y espaciales revelan que fueron utilizadas técnicas inhabitants at the Vestibule of Nerja Cave (Jorda *et al.*), Tell Aswad (Alarashi), Balma Guilanyà (Martinez-Moreno *et al.*), the cave of Mazaculos II (Gutiérrez and González), Oronsay, Colonsay, and other locations in Scotland (Hardy), Can Roqueta (Oliva), Cingle Vermell and Roc del Migdia (Oliva and YII). Shell remains were also used to reconstruct the dynamics of palaeoenvironmental conditions at Adak Island-Aleutian Islands (Antipushina)

From the Late Neolithic and Chalcolithic to the Bronze Age, further studies confirm continuity in the exploitation of shells as ornaments and tools production, in specialized craft contexts at Pyrgos-Mavroraki (Carannante) and Vera Basin (Maicas and Vidal). Later in time, allometry and actuallistic studies suggests that during Roman times there was evidence of oyster management at the site of Winchester (Campbell).

The study of archeomalacological remains from the Middle ages in Europe, based on taxonomic, biometric and taphonomic analyses, shows that the exploitation of shell remains at Beauvoir-sur-Mer (Dupont), Seville (Bernáldez and García) and Pontevedra (Álvarez-Fernández and Castro) was a specialized activity not only in the selection of specific niches for exploitation but also in the methods of collection and massive extraction of shell flesh.

Furthermore, moving to the Americas, specifically in Mesoamerica from Formative to Postclassic contexts, marine and freshwater shell remains have been the subject of taxonomic, typological and technological analysis in conjunction with experimental archaeology and use wear with Scanning Electron Microscopy to demonstrate that different tools and techniques were employed in shell production and exchange networks from the Pacific to the Caribbean Sea at Oxtankah (de Vega and Melgar), Xochicalco (Melgar), Teopantecuanitlan (Solis and Martinez) and Pezuapan (Solis and Monterrosa).

In the southern portion of the American Continent, at archaeological sites dated from the Late Holocene to the nineteenth century, malacological remains were subjected to taxonomic, technological, taphonomic, and spatial studies, in combination with lithic micro-wear analyses, written records and experimental archaeology. These studies show that people used shells as building material at Tunel VII-Argentina (Verdún), and as tools, containers and personal adornments at Patagonian sites (Zubimendi) and Low Paraná's wetland (Buc *et al.*).

Shell habitat availability, human foraging practices and the use of shells as tools and ornaments

variadas para manipular los restos de concha, que se explotaron diferentes ambientes y que se establecieron diferentes redes sociales de intercambio en el vestíbulo de la Cueva de Nerja (Jorda *et al.*), en Tell Aswad (Alarashi), en Balma Guilanyà (Martinez-Moreno *et al.*), en Mazaculos II (Gutiérrez y González), en Oronsay, Colonsay y otros sitios escoceses, así como en Can Roqueta (Oliva), Cingle Vermell y Roc del Migdia (Oliva e YII). Los restos de conchas fueron utilizados para reconstruir el paleoambiente en yacimientos de las Islas Aleutianas (Antipushina).

Del Neolítico tardío y Calcolítico a la Edad de Bronce, estudios adicionales confirmaron la continuidad en la explotación de conchas como adornos y en la producción de herramientas, en contextos de especialización artesanal, como en Pyrgos-Mavroraki (Carannante) y en los sitios de la Cuenca del Vera (Maicas y Vidal). Estudios alométricos y actualísticos sugieren que en tiempos de la ocupación Romana hubo evidencia de control de la ostra en el yacimiento de Winchester (Campbell).

Los estudios de restos arqueomalacológicos de la Edad Media en Europa se basan en análisis taxonómicos, biométricos y tafonómicos, mostrando que en Beauvoir-sur-Mer (Dupont), en sitios de Sevilla (Bernáldez y García) y en Pontevedra (Álvarez-Fernández y Castro) la explotación de moluscos fue una actividad especializada, no solo por la selección de diferentes nichos ecológicos, sino también por el empleo de técnicas de recolección y de extracción de su carne.

Además, trasladándonos al continente americano, específicamente a la región mesoaméricana en contextos del periodo Formativo al periodo Postclásico, las conchas marinas y de agua dulce han sido objeto de análisis taxonómicos, tipológicos y tecnológicos, experimentales y de huellas de uso, utilizando el microscopio electrónico de barrido. Gracias a las investigaciones llevadas a cabo en Oxtankah (de Vega y Melgar), Xochicalco (Melgar), Teopantecuanitlan (Solis y Martínez) y Pezuapan (Solis y Monterrosa) se ha demostrado que fueron empleadas diferentes herramientas y técnicas en la producción de objetos de concha y que se constatan redes de intercambio entre el Océano Pacifico y el Mar Caribe. En Suramérica, los sitios arqueológicos se ubican desde el Holoceno tardío al S. XIX. Los restos malacológicos fueron objeto de análisis similares. Éstos demostraron que los grupos humanos usaron las conchas como material constructivo en el Tunel VII-Argentina (Verdún), y como instrumentos, contenedores y adornos personales en sitios Patagónicos (Zubimendi) y de los humedales del Bajo Paraná (Buc et al.). En las Islas, fueron investigadas la disponibilidad de ambientes on islands were investigated at Puerto Rico (Rivera) and the Canary Islands (Mesa *et al.*) using several types of data derived from archaeomalacological, geoarchaeological and ethnoarchaeological studies.

Finally, Claassen presents interesting historical data on the shell button industry and the Japanese cultured pearl industry from the rivers of the United States using shell taxonomic information, the size of the beds, the yields, their sustainability, and the industrialized process of making buttons.

We would like to thank the following persons and institutions for their help and financial support in the publication of this volume: Sociedad de Ciencias Aranzadi (San Sebastián) and the Government of Cantabria (Consejería de Cultura, Turismo y Deporte).

The editors of the proceedings are grateful for the advice and assistance of Juantxo Agirre, Pablo Arias, Álvaro Arrizabalaga, Adriana Chauvín, Miriam Cubas, Marián Cueto, Mikel Fano, María José Iriarte, Roberto Ontañón, Peter Smith, Jesús Tapia and Luis C. Teira.

We would also like to thank our reviewers and authors, who have taken time from their busy schedules to work for this publication.

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para la explotación de conchas, sus prácticas de recolección y su uso como herramientas y adornos. En Puerto Rico (Rivera) y en las Canarias (Mesa et al.) se realizan investigaciones arqueomalacológicas, geoarqueológicas y etnoarqueológicas.

Finalmente, Claassen presenta datos históricos interesantes sobre la industria de botones de concha y la industria japonesa de perlas cultivadas de los ríos de Estados Unidos usando la información taxonómica, el tamaño de los lechos de conchas, su rendimiento, su sostenibilidad y el proceso industrial de la producción de botones.

Queremos agradecer a las siguientes personas e instituciones por su ayuda y apoyo financiero en la publicación de este volumen: la Sociedad de Ciencias Aranzadi (San Sebastián) y el Gobierno de Cantabria (Consejería de Cultura, Turismo y Deporte).

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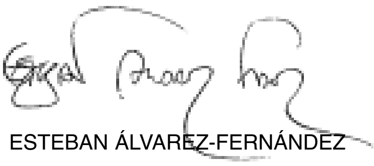

ESTEBAN ÁLVAREZ-FERNÁNDEZ

DIANA CARVAJAL-CONTRERAS

HITZAURREA

International Council of Archaeozoology (ICAZ) erakundeak egindako kongresuen aktak zenbait liburutan argitaratu dira. Liburu horietako bat da honako hau. Erakundea arkeologia-lekuetan dokumentatutako animalia-hondarrekin zerikusia duten ikerketa zientifikoen trukea sustatzeko sortu zen.

ICAZeko arkeomalakologiako lantaldeak Santanderren (Espainia) biltzea erabaki zuen, lehen bilera zientifikoa Gainesville-n (AEB) egin ondoren (Szabó eta Quitmayer, 2008).

Aipatu bigarren jardunaldia Kantabriako Unibertsitatean egin zen, 2008ko otsailaren 19tik 22ra bitartean. Bilera horietan, 100 aditu inguruk 61 lan aurkeztu zituzten: 31 lan txostenak izan ziren eta beste 30ak poster-formatuan aurkeztu ziren.

Liburu hau ingelesetik itzuli da izenburu honekin: *"Ez bakarrik janaria: itsasoko, lehorreko eta ur gezako moluskuak arkeologia-testuinguruetan"*. Liburuan, munduko hainbat eskualdetan egindako ikerketen emaitzak jasotzen dira, eta askotarikoak dira molusku arkeologikoen hondarrekin zerikusia duten gaiak.

Ikuspuntu holistikotik, helburua da erakustea hainbat arkeologia-testuingurutan dokumentatutako maskorrak ez zirela biltzen janari gisa bakarrik, bai eta apaingarriak eta tresnak egiteko lehengai gisa ere.

Liburua, arkeomalakologoentzat ez ezik, beste zenbait esparrutako ikertzaileentzat ere izan daiteke interesgarria (adibidez, arkeozoologiako, arkeologiako, zoologiako eta antropologiako ikertzaileentzat), kronologia-, kontserbazio-, ekologia-, antzinako ekonomia-, teknologia- eta metodologia-alderdiekin zerikusia duten ikerketa garrantzitsuak aurki ditzaketelako.

Liburuaren hasieran, artikulu batzuk daude, molusku-hondarrak Europako Erdi Paleolitoko eta Goi Paleolitoko testuinguruetan aztertzen dituztenak, eta artikuluotan, gainera, beste hainbat gai lantzen dira; adibidez, itsas maskorreko karbonatoetan datatzeko teknikak (Douka *et al.*). Bestalde, pertsonen apaingarriak aztertu egiten dira zenbait irizpide erabiliz: taxonomikoak, teknologikoak, erabilera-aztarnen ikerketa…; era berean, informazio geografikoko sistemak (GIS) eta azterketa esperimentalak baliatzen dira, besteak beste, aztarnategietan bizi izan ziren ehiztari-biltzaileen mugikortasunaz eta truke-sareez eztabaidatzeko (Gargasko haitzuloa –San Juan-Foucher eta Foucher–; Maltraviesoko haitzuloa –Rodriguez-Hidalgo *et al.*–; Peña de Estebanvelako lekua –Avezuela–; El Hornoko haitzuloa –Fano y Álvarez-Fernández–; eta Parcoko haitzuloa –Estrada *et al.*–).

Goi Pleistozenoaren amaieratik Neolitoaren bitartean, moluskuak gizakien dietaren barruan egon ziren, eta haien maskorrak pertsonen apaingarri eta tresnak egiteko lehengai gisa erabili zituzten Europako eta Asiako zenbait lekutan. Ikerketa taxonomikoek, teknologikoek, tafonomikoek eta espazialek jakitera eman dute zenbait teknika erabili zirela maskor-hondarrak manipulatzeko, hainbat ingurune ustiatu zirela, eta trukeak egiteko gizarte-sareak egon zirela leku batzuetan; hauek dira leku horietako batzuk: Nerjako haitzuloaren sarrera (Jorda *et al.*); Tell Aswad (Alarashi), Balma Guilanyà (Martinez-Moreno *et al.*); Mazaculos II (Gutiérrez eta González); Oronsay, Colonsay eta Eskoziako beste toki batzuk; bai eta Can Roqueta (Oliva), Cingle Vermell eta Roc del Migdia (Oliva eta Yll) ere. Maskor-hondarrak Aleutiarretako uharteetako aztarnategietan paleoingurunea birsortzeko erabili ziren (Antipushina).

Neolito berantiarretik eta Kalkolitotik Brontze Arora bitartean, beste ikerketa batzuek egiaztatutakoaren arabera, maskorrak apaingarri gisa erabiltzen eta tresnak egiten jarraitu zuten artisautzazko espezializazio-testuinguruetan (besteak beste, Pyrgos-Mavroraki –Carannante– eta Veraren arroko lekuak –Maicas eta Vidal–). Ikerketa alometrikoek eta aktualistikoek aditzera ematen dute erromatarren garaian ostra kontrolatzen zelako ebidentzia izan zutela Winchester-ko aztarnategian (Campbell).

Europako Erdi Aroko aztarna arkeomalakologikoen ikerketak azterketa taxonomikoetan, biometrikoetan eta tafonomikoetan oinarritzen dira, eta erakusten dute Beauvoir-sur-Mer (Dupont), Sevillako zenbait leku (Bernáldez eta García) eta Pontevedran (Álvarez-Fernández eta Castro) moluskuen ustiapena jarduera espezializatua izan zela, ez bakarrik txoko ekologiko desberdinak hautatzen zituztelako, bai eta haien mamia atera eta biltzeko hainbat teknika erabiltzen zituztelako ere.

Gainera, eta orain Amerikara jotzen dugu (zehazki, erdialdeko Amerikara, formazio-alditik aldi klasikoaren ondokora bitarteko testuinguruetan), itsasoko eta ur gezako maskorrez azterketa taxonomikoak, tipologikoak, teknologikoak eta esperimentalak egin dira, bai eta erabilera-aztarnen ingurukoak ere, ekortze-mikroskopio elektronikoa erabiliz. Oxtankah-en (Vega eta Melgar), Xochicalco-n (Melgar), Teopantecuanitlan-en (Solis eta Martínez) eta Pezuapan-en (Solis eta Monterrosa) egindako ikerketei esker, frogatuta gelditu da hainbat tresna eta teknika erabili zirela maskorrezko objektuak egiteko, eta Ozeano Barearen eta Karibe itsasoaren artean truke-sareak zeudela egiaztatu da. Hego Amerikan, arkeologia-lekuak Holozeno berantiarretik XIX. mendera artekoak dira. Antzeko azterketak egin ziren aztarna malakologikoei buruz. Azterketek argi utzi zuten gizataldeek maskorrak eraikuntzako material gisa erabili zituztela Argentinako Tunel VII maskortegian (Verdún), hala nola, tresna, edukiontzi eta pertsonentzako apaingarri gisa Patagoniako hainbat tokitan (Zubimendi) eta Behe Paranako hezeguneetan (Buc *et al.*). Uharteetan, maskorrak ustiatzeko, haiek biltzeko eta tresna nahiz apaingarri gisa erabiltzeko inguruneen egokitasuna aztertu zen. Puerto Ricon (Rivera) eta Kanarietan (Mesa *et al.*) ikerketa arkeomalakologikoak, geoarkeologikoak eta etnoarkeologikoak egiten dira.

Azkenik, Claassen-ek datu historiko interesgarriak ematen ditu maskorrezko botoien industriari buruz, bai eta Ameriketako Estatu Batuetako ibaietan hazitako perlen japoniar industriari buruz ere, eta, horretarako, informazio taxonomikoaz, maskor-geruzen neurriaz, haien errendimenduaz, iraunkortasunaz eta botoiak egiteko prozesu industrialaz baliatzen da.

Eskerrak eman nahi dizkiegu pertsona eta erakunde hauei liburu hau argitaratzeko emandako laguntza eta finantza-babesagatik: Aranzadi Zientzia Elkartea (Donostia) eta Kantabriako Gobernua (Kultura, Turismo eta Kirol Saila).

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Eskerrak eman nahi dizkiegu, halaber, gure orraztaileei eta egileei, beren agenda beteetatik denbora hartu baitzuten argitalpen honetan lan egiteko.

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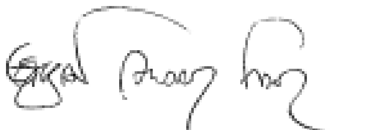

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S U M M A R Y / S U M A R I O

Radiocarbon dating of shell carbonates: old problems and new solutions

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Radiocarbon dating of shell carbonates: old problems and new solutions

Datación radiocarbónica en carbonatos de conchas: viejos problemas y nuevas soluciones

KEY WORDS: Radiocarbon, marine shells, pretreatment, Upper Palaeolithic, ornaments.
PALABRAS CLAVE: Radiocarbono, moluscos marinos, tratamiento previo, Paleolítico superior, ornamentos.
GAKO-HITZAK: Erradiokarbonoa, itsas moluskuak, aurretiko tratamendua, Goi Paleolitoa, apaingarriak.

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ABSTRACT

Marine shell carbonates are often considered problematic for radiocarbon dating. Problems most often identified include the reservoir effect and uncertainties over its quantification and temporal variability, the calibration of the radiocarbon age, the question of the hard-water effect and the possibility of samples of shells derived from fossil sources. However, it is the assessment of the preservation state, in chemical and physical terms, that is the key parameter affecting radiocarbon dating of shell carbonates. We review the current status of radiocarbon dating marine shell carbonates. In addition we report recent developments at the Oxford Radiocarbon Accelerator Unit (ORAU), University of Oxford. New protocols include more effective pretreatment and rigorous screening that, respectively, reduce the effect of secondary carbonate contamination and help us determine, with confidence, whether or not the marine shells have been diagenetically altered and therefore are suitable for dating. Finally we briefly discuss the application of this new approach to the current dating of the Middle to Upper Palaeolithic transition. Our future aim is to shed light on two broadly coinciding processes: the Neanderthal extinction and the initial dispersal of Anatomically Modern Humans (AMHs) along the Mediterranean rim.

RESUMEN

Los carbonatos de los moluscos marinos a menudo se consideran problemáticos para obtener fechas de radiocarbono. Los problemas identificados que incluyen más a menudo son el efecto de inercia y las incertidumbres sobre su cuantificación y variabilidad temporal, la calibración de la fecha de radiocarbono, la cuestión del efecto de agua pesada y la posibilidad de que las muestras de moluscos deriven de fuentes fósiles. Sin embargo, el problema del estado de preservación, en términos químicos y físicos, es el parámetro dominante que afecta la obtención de fechas de radiocarbono de los carbonatos de la concha. Revisamos el estado actual de la obtención de fechas de radiocarbono de los carbonatos de los moluscos marinos. Además divulgamos los progresos recientes en la unidad del acelerador de radiocarbono de Oxford (ORAU), Universidad de Oxford. Los nuevos protocolos incluyen un tratamiento previo más eficaz y la investigación rigurosa que, respectivamente, reducen el efecto de la contaminación secundaria del carbonato y nos ayudan a determinar, con confianza, si las conchas marinas se han alterado por diagénesis y por lo tanto son convenientes para fechar, o no. Finalmente discutimos brevemente el uso de este nuevo acercamiento para fechar la transición del Paleolítico medio al superior. Nuestro objetivo futuro es dar luz a dos procesos que coinciden ampliamente: la extinción del Neanderthal y la dispersión inicial de los seres humanos anatómicamente modernos (AMHs) a lo largo del borde mediterráneo.

LABURPENA

Itsas moluskuen karbonatoak problematikotzat jotzen dira askotan, erradiokarbono-datak kalkulatzeko. Gehien ageri diren arazoak hauek dira: inertzia-efektua, kuantifikazioari eta denbora-aldakortasunari buruzko ziurgabetasunak, erradiokarbono-dataren kalibraketa, ur astunaren eraginaren auzia, eta moluskuen laginak fosiletatik eratorriak izateko aukera. Dena den, babes-egoeraren arazoa, kimikako eta fisikako terminoetan, maskorraren karbonatoen erradiokarbono-datak lortzeari eragiten dion parametro nagusia da. Itsas moluskuen karbonatoen erradiokarbono-datak lortzearen egungo egoera berraztertu dugu. Gainera, Oxfordeko unibertsitateko erradiokarbono-azeleragailuaren (ORAU) unitateko azken aurrerapenen berri eman dugu. Protokolo berrietan, tratamendua eraginkorragoa izango da, karbonatoaren bigarren mailako kutsaduraren eragina murrizteko, eta ikerketa zorrotzagoa, itsas maskorrak diagenesi bidez aldatu diren, eta, beraz, datatzeko egokiak diren jakiteko. Azkenik, Erdi Paleolitotik Goi Paleolitorako trantsizioa datatzeko hurbilketa berri horri buruzko eztabaida labur bat egin genuen. Etorkizuneko helburua neurri handi batean uztartuta dauden bi prozesu azaltzea da: Neanderthalen desagertzea eta gizaki anatomikoki modernoak (AMHak) Mediterraneo itsasoaren itsasertzean zabaltzen hastea.

1. INTRODUCTION

Marine molluscs are deposited in archaeological sites either as a result of human or animal activity or by natural means (aeolian processes or marine transgressions). When safely attributed to human agency, molluscs excavated from archaeological sites serve as significant environmental, cultural and chronometric indicators.

Parameters regarding modern mollusca geographic distribution, water temperature tolerance, prefe-

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rred substrates and food selection are generally well-studied, hence, retrieval of this type of material from an archaeological site offers important local habitat and environmental information as well as insights into several behavioural features of the linked human community (e.g. exploitation of shellfish for food, for use in the production of tools or weapons, or utilization for symbolic reasons).

As dating material, molluscs offer both relative and absolute chronometric information.

Seasonality studies fall into the former category. Relative growth-ring and oxygen isotope measurements provide information regarding the age-at-death of shellfish within archaeological sites, and enable a seasonal signal to be diagnosed (e.g. Koike 1973, 1979, Deith 1983, Deith 1985, 1986, Milner 2001, Dupont 2006). This is critical information for the construction of seasonal subsistence patterns and the movement of people within specific regions in the past.

Absolute methods such as Radiocarbon (^{14}C) dating, Amino Acid Racemisation (AAR), Uranium-series and Electron Spin Resonance (ESR), can be all used for the direct dating of molluscan remains, allowing secure inter and intra-site correlations when humans are responsible for their accumulation (e.g. Kaufman 1971, Wehmiller 1984, Skinner 1988; Bezzera et al 2000, Penkman *et al.* 2008).

This paper specifically deals with ^{14}C dating and reviews the basis of the method in so far as it is used to date marine and estuarine shell carbonates. It will discuss the fundamental assumptions, related uncertainties and problems, along with new developments and their application to a significant problem of the European prehistory, the Middle to Upper Palaeolithic transition.

2. FUNDAMENTALS ON MARINE SHELLS

Molluscan skeletons are polycrystalline biominerals mainly composed of calcium carbonate ($CaCO_3$) precipitated as distinct layers within an organic proteinaceous matrix. In marine shells $CaCO_3$ comprises high-Mg calcite and aragonite, in several formations.

The two polymorphs, aragonite and calcite, share identical chemical compositions but quite different crystal structures and thermodynamic equilibria, with calcite being the stable form and aragonite the metastable form at present earth-surface temperatures and pressures.

Carbon (C) is one of the main elements molluscs make use of to form their exoskeletons. The origin of this carbon derives from various sources and the mixing of different carbon pools leads to their isotopic deviation from the ambient environment. Shells incorporate carbon deriving from two pools: oceanic dissolved inorganic carbon (DIC) and carbon from respiratory CO_2 mainly stemming from food metabolism (Tanaka *et al.* 1986, McConnaughey *et al.* 1997, Gillikin *et al.* 2007). For a full summary on the current status of research regarding the C isotopes of biological carbonates the reader is referred to recent publication by McConnaughey and Gillikin (2008) and references therein.

3. RADIOCARBON DATING OF SHELLS

Radiocarbon dating is the most commonly used chronometric technique in archaeology. Carbon (C) is found in the atmosphere in the form of three isotopes[1] ^{12}C, ^{13}C and ^{14}C, which account for the element's natural abundance. The first two, ^{12}C and ^{13}C, are stable isotopes and can be found in atmospheric concentrations of approximately 98.89% and 1.11% respectively, whereas ^{14}C is weakly radioactive and has an extremely low atmospheric activity, of about one per trillion ^{12}C atoms.

Radiocarbon is produced in the stratosphere and shortly after is oxidized to $^{14}CO_2$. It rapidly enters circulation and exchanges with the oceans and biosphere (Fairbanks *et al.* 2005, Bronk Ramsey 2008). Each living organism will incorporate ^{14}C atoms through photosynthetic, respiratory, metabolic, and other biological pathways and will reach isotopic equilibrium with the ambient environment. This ceases to exist when the organism dies. ^{14}C is no longer incorporated into its tissues, and the radioactive ^{14}C isotope undergoes nuclear decay. The decay progresses exponentially at a regular rate expressed as the constant known as the *radiocarbon half-life*, often quoted to be 5730[2] years.

[1] Isotopes are varieties of the same element, which contain the same number of electrons and protons (same atomic number) but different number of neutrons (hence different mass number) in their nuclei. Most elements are found in mixtures of two or more, stable and unstable (radioactive) isotopes. Variations in isotope abundance of an element are caused either by radioactive decay of the unstable isotopes or by isotope fractionation (Hoefs 2003: 1–5).

[2] Two values are often quoted for the rate of ^{14}C decay. The first to be published was the Libby half-life 5568 ± 30 years (Anderson and Libby 1951) and the second is the Cambridge half-life of 5730 ± 40 years (Godwin 1962), often thought to be more accurate. However, very recently (Fairbanks *et al.* 2005) supported the idea that the half-life may be significantly different, as much as 6000 years, although this idea is not widely accepted (see for example, Roberts and Southon 2007).

Using the radiocarbon decay equation, the remaining amount of ^{14}C measured within any archaeological specimen is translated into the amount of time elapsed since the organism's death.

Since its first application in the late 1940s a variety of materials found in the archaeological record have been used to decipher the age of a layer, an archaeological context or that of a single artifact.

Unfortunately, shells are often considered potentially problematic for radiocarbon dating, due to the inert instability of shell CaCO3 which can be chemically more active than other materials used in radiocarbon dating (i.e. wood, charcoal or bone).

4. SOURCES OF ERROR IN RADIOCARBON DATING OF MARINE SHELLS

Several factors may influence shell ^{14}C content causing errors towards younger or older ages, for example the hard-water effect will lead to older dates whereas contamination by young carbon, added in the form of recrystallization, may lead to ages which are too young (Bezzera *et al.* 2000).

Several uncertainties one has to account for when dating marine shell. These include:

1. *Isotope fractionation*. It refers to the alteration of the C isotope ratios ($^{13}C/^{12}C$ and $^{14}C/^{12}C$), through chemical or physical processes occurring at different interfaces along the biological pathways, as a result of differences in the reaction rates and bond strength of various molecular species (Pigati 2002). In the case of marine shells, preferential isotope fractionation of the C atoms may occur during the transfer of ^{14}C from atmospheric CO_2 to oceanic HCO_3- and during its incorporation to marine plants and subsequently to marine organisms. The effect of fractionation on ^{14}C is almost twice the effect on ^{13}C (Wigley and Muller 1981) and since ^{13}C is stable ^{14}C enrichment will result in higher activity and therefore younger radiocarbon age. Thus, even at the time of supposed equilibrium with the ambient environment, the isotopic ratios of marine shells may be strongly affected and distorted, requiring correction using the measured stable isotope ($\delta^{13}C$) and normalization based on international standards (for full summaries see: McCrea 1950, McConnaughey *et al*. 1997, Pigati 2002).

Analogous processes apply to other tissues when measured by ^{14}C, where an identical correction process is followed.

2. *Global and local marine reservoir effects*. When a carbonaceous material stays disconnected from the continuously renewed atmospheric C pool it becomes ^{14}C-depleted. Due to complex circulation patterns and rates of mixing, oceanic water may reside for centuries in the deep ocean where it becomes ^{14}C-depleted. The "old" deep water mixes with surface modern water as a result of oceanic currents and upwelling events (Hutchinson *et al.* 2004), hence the oceanic carbon signal is characterized by heterogeneity, both geographically and bathymetrically (Ascough *et al.* 2005). The observed offset between the true ^{14}C (atmospheric) age and the apparent ^{14}C (marine) age is called the *marine radiocarbon reservoir effect* and it may well vary in spatial and temporal terms (e.g. Kennett *et al.* 1997, Deo *et al.* 2004). Thus a correction is required in order to interpret reliably these radiocarbon ages. A global offset between the atmosphere and the surface oceans (termed R(t)), of about 400 radiocarbon years was calculated by Stuiver *et al.* (1986) using a simple box-model, with the atmospheric data based on the tree-ring derived calibration datasets.

However, this correction does not account for local conditions thus a further correction is required. Local deviations from global R (t) are expressed as ΔR values (local reservoir) and are based on ^{14}C dates of known-age (but pre-nuclear era) shell carbonates. The ΔR value is applied to correcting dated marine shells over long periods of time. Very often, paired samples of terrestrial and marine short-lived, contemporaneous organisms are also dated and the differences are thought to express the local ΔR conditions. More light could be shed on the validity of ΔR values for older periods of the radiocarbon timescale by dating marine organisms obtained from ocean cores that can be correlated safely with tephra levels of known terrestrial age.

The marine reservoir (R(t)) ages for the Mediterranean region (of particular interest in this study: see below) were estimated at 390 ± 85 ^{14}C BP (Siani *et al.* 2000), a value comparable to that for the North Atlantic Ocean (<65°N), and in accordance with the modern oceanic circulation patterns. The mean ΔR value was calculated at 35 ± 70 ^{14}C BP (Siani *et al.* 2000) and 58 ± 84 ^{14}C (Reimer *et al.* 2002) by subtracting the Mediterranean Sea apparent age from the model age of the mixed oceanic layer.

3. *The hard-water effect.* A number of studies demonstrate so-called hard-water influences on the age of shellfish. Species absorb dissolved carbon dioxide (CO_2) or bicarbonates (HCO_3–) leached out from limestone areas (dead-carbon sources), which make them exhibit reduced activity and hence display an older radiocarbon age. This

effect may add hundreds of years to the apparent age of a sample (Pilcher 1991, Bezzera *et al.* 2000) although more severe effects have been reported (e.g. Gischler *et al*. 2008). Similarly a hard-water effect may be generated by magmatic CO_2 brought into lakes and rivers from volcanic sources.

In open waters, the hard-water effect on shells is usually unnoticeable because of the overwhelming preponderance of marine dissolved inorganic carbon (DIC), mainly in the form of HCO_3^-, which obscures the products of the carbonate substrate solubility reaction[3].

The effect is larger in molluscan shells growing in localities (a) with restricted water circulation (b) where there is considerable mixing of fresh and oceanic water, (c) where the geological substrate is highly carbonaceous and (d) in areas with high abundance of terrestrial organic matter (Forman and Polyak 1997). In a paper published by Hogg *et al.* (1998), the dating of modern estuarine and subtidal shellfish showed that those living in rock pools give different radiocarbon ages from molluscs living in the open sea.

The ways in which species obtain their C and especially the way they feed (filter/ suspension-feeders, deposit/ detritus-feeders) is probably the most defining parameter on the manifestation of a hard-water effect although not many studies have addressed the issue in its full extent. It is generally assumed the deposit-feeders should be avoided, but since most gastropods fall in this category such a generalization seems rather limiting and certainly arbitrary, as several reliable dates have been produced by such species. Nonetheless, when possible, identification of species, their feeding patterns and growth localities are very important factors in the reliable dating of shells from enclosed seas.

In cases where the local reservoirs and the hard-water effect is thought to seriously affect the dates, a test can be made by the dating of few paired samples, i.e. pairs of contemporaneous marine and terrestrial material such as shell and charcoal, from the exact same depositional context (Kennett *et al.* 2002), or when this is not possible, pre-bomb modern shells of the same species as the archaeological ones and from localities where the latter were most likely collected, can be used.

4. *Time-averaging or the "old shell" problem.* It is often assumed that shellfish used as food was harvested alive and was brought to the archaeological site shortly after death, therefore the radiocarbon activity of the exoskeleton should reflect the time passed since the animal's death, and would therefore date the human activity.

However, in the case of dating ornamental shells or shells used for the production of tools, cutlery or other, a considerable amount of time may have elapsed between the animal's death and the time of use. This shell material may well have been picked up from fossil outcrops or long-dead beach assemblages and thanatocenoses. Dates based on such samples will always overestimate the age of the deposit thus can be only used as termini post quem.

Several studies have shown that molluscan shells have the potential of a long *post mortem* life and the fossil record is clearly biased in favour of organisms with such hard parts. The notion of "time-averaging", as the process by which biogenic remains from different time intervals come to be preserved together, has been long used in paleoecology, taxonomy, biostratigraphy and evolutionary studies; recently in AMS ^{14}C shell dating as well (for full summaries see: Flessa & Kowalewski 1994, Kidwell and Bosence 1991, Kidwell 1998).

Based on observations over the geological context of fossil shell assemblages, paleontologists have reported that the phenomenon of time-averaging operates over a broad range of time-scales. In actively forming death-assemblages on beaches, tidal flats, and nearshore sub-tidal habitats (<10 m) shell ages may span a period from present up to an extreme maximum of 45 kyr BP with a median age of 1000 years (Flessa and Kowalewski 1994). Shelly deposits from the subtidal shelf (>10m depth) to the continental slope (approximately 600 m) appear to have the same minimum and maximum ages, however the median age there appears to be approximately 10000 years.

As a result, according to this estimate, the modal age for a typical shell collected from a nearshore locality will be less than 1000 years old, which is often not manifestly larger than the typical standard deviations for a Palaeolithic radiocarbon date, although still a significant value.

At this point a note needs to be made. The studies mentioned above concern palaeontological material, which lack *human agency* in their deposi-

[3] $CaCO_3 \Leftrightarrow Ca^{2+} + CO_3^{2-} \Longrightarrow Ksp = [Ca^{2+}][CO_3^{2-}]$.

tion. Shells used for ornaments were most often chosen due to their shape, size and mainly vivid colouration. During deposition, shells will undergo several taphonomic processes, transporation, repeated burial/ exhumation cycles, wave or other predator actions (Kidwell 1998). These influences will have an effect on the appearance of the shells and will leave a diagenetic signature on them, in the form of fragmentation, surface pitting, polishing, encrustation, discolouration and bioerosion, all of which are very likely to render these specimens less appealing in the eyes of the prehistoric man.

Hence, it is sensible to suggest that the effect of time-averaging on prehistoric shell ornaments is small and almost minimal compared with the depositional uncertainties and the errors caused by. Though the "old shell" problem can perhaps have the most significant impact, it can usually be identified, minimized or even eliminated by careful sample selection and use of only well-preserved specimens for dating. Specimens with traces of weathering, abrasion, inclusions, or other marks that may indicate "old", "beach-worn" shells should be avoided (Rick *et al.* 2005). In addition, dating multiple samples throughout the stratigraphic sequence of the archaeological site is an ideal and the most efficient way to identify anomalously old dates and outliers, and refine site chronologies.

5. *Recrystallization.* In a burial environment shells often behave as open systems, incorporating exogenous carbon atoms, in the form of secondary $CaCO_3$. This process is commonly known as recrystallization or neomorphism, and alters the original C isotopic ratios and thus the inferred radiocarbon age.

It is broadly assumed, on thermodynamic grounds, that diagenesis of aragonite and high-Mg calcite of shells will result in dissolution and/or precipitation of low-Mg calcite cement (e.g., Folk and Assereto 1976, Allan & Matthews 1982, Morse & Mackenzie 1990, Magnani *et al.* 2007). Very rare and notable exceptions to this assumption that involve recrystallization from aragonite to aragonite (Enmar *et al.* 2000, Webb *et al.* 2007) have been reported in the literature, but these were attributed to very specific environmental conditions and aqueous geochemistry.

When diagenetic alteration occurs, the carbonate phase being dated will not be autochthonous, but will include secondary material incorporated in the system *post mortem*. This material may have different carbon isotopic composition from the shell matrix thus will lead to a erroneous age measurements. The scale or trend of this effect is unpredictable so that the age drifts may be of older or younger direction. Rigorous screening and effective pretreatment is required to identify evidence of contamination and reduce the risk of erroneous AMS ^{14}C ages (Chappell & Polach 1972).

5. RECENT ADVANCES IN SHELL DATING

The methods routinely used when dating carbonates include mechanical cleaning of the surface, occasional acid leaching when this is considered necessary and selection of aragonite parts, by using staining methods to differentiate calcite from aragonite (usually Fiegl's solution (Friedman 1959, Dickson 1966). The rest of the chemical pretreatment (phosphoric acid decomposition of the $CaCO_3$ and evolution of CO_2) has been basically unchanged since the 1950's (McCrea 1950) and is comparable for most radiocarbon laboratories around the world.

Recent attempts to date Palaeolithic-aged shells at the ORAU (Camps & Higham, *submitted*) have stimulated the development of stricter criteria to identify and minimize post-depositional alterations. The identification of diagenesis can be achieved by determining the mineralogical phases that are present in the sample, either with X-Ray diffraction (XRD), Fourier-Transform Infrared Spectroscopy (FTIR) and/or Scanning Electron Microscopy (SEM).

FTIR has been used to distinguish between aragonite and calcite (Subba Rao and Vasudeva Murthy 1972, Compere 1973), however broad band overlap hinders most qualitative and quantitative determinations for the carbonate polymorphs. For this reason, we do not use it as a method for high-precision characterization of calcite and aragonite mixtures.

XRD, on the other hand, can be used to identify, quantify and characterize phases in complex mineral assemblages. It is generally believed that this method is semi-quantitative, however workers in recent discussions suggest that with careful specimen preparation, calibration of the equipment and selection of the optimal conditions (highest peak/background ratio in optimum time) XRD scans may offer very accurate quantitative information (Hakanen and Koskikallio 1982, Chiu *et al.* 2005, Sepulcre *et al.* 2009). The detection limits we have obtained lie routinely in the range of 0.1-0.2% of calcite (i.e. secondary polymorph) in binary mixtures with aragonite (Fig. 1) and are comparable to the ones achieved by Chiu *et al.* (2005) and Sepulcre *et al.* (2009).

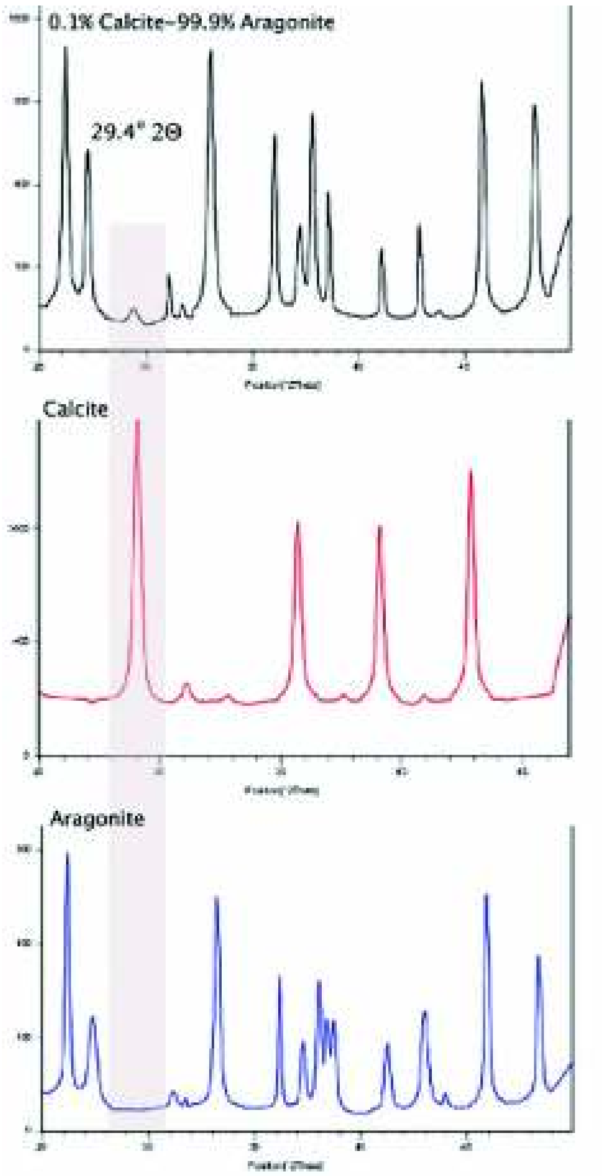

Figure 1. XRD spectra of (a) mixture of 0.1% calcite in 99.9% aragonite; (b) pure geological calcite; and (c) pure biogenic aragonite. Despite the broad peak overlap, the (114) peak at 29.4° 2Θ angle (range indicated by shadowing) is characteristic of calcite and is evident in binary mixtures of as low as 0.1% calcite.

SEM can be used to obtain high-resolution images of the shell surface and to directly document the preservation state of the aragonite phase (Fig. 2). The disadvantages of the method are that (i) minor contamination cannot be completely ruled out since an SEM micrograph is restricted to a small portion of the structure and cannot be used to check all crystalline phases; (ii) some experience is required with different shell microstructures (crossed- lamellar, nacreous, prismatic, homogenous) and (iii) $CaCO_3$ being non-conductive material, requires coating with carbon or gold which then renders the sample unsuitable for dating. With the help of Low-Vacuum SEM (LV-SEM) or Environmental SEM (ESEM) that do not require surface coating, we are able to use the same fragments for imaging and AMS ^{14}C dating.

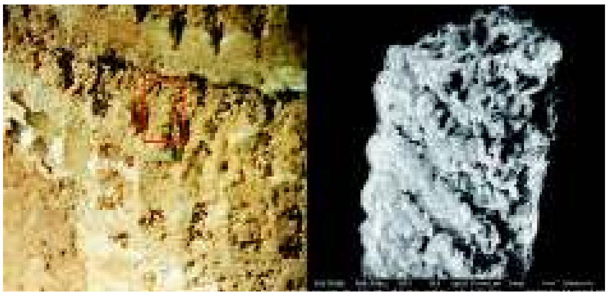

Figure 2. Close-up photograph and ESEM micrograph of a diagenetic Glycymeris sp. specimen from a Palaeolithic context. The mineralogical changes are observed macroscopically (left, red rectangle) and are confirmed microscopically (right), in the form of distinct calcite crystals that cover the entire surface of the sample and replace the original aragonite microstructure.

It is, therefore, advisable that every calcareous sample designed to undergo ^{14}C dating should have an XRD scan and/or an SEM micrograph associated with it so that an evaluation of the obtained result –in terms of sample quality- is possible. This should be provided either by the submitter or the dating facility, given that such a service is available.

In the ORAU, we have recently developed and proposed an additional, novel pretreatment step in case that secondary recrystallization is identified: that of the physical separation of the new protocol is termed CarDS (Carbonate Density Separation) and makes use of lithium polytungstate, a harmless, new-generation heavy liquid, to separate aragonite from secondary calcite (Douka *et al.* 2010, in press). Since both phases are found in the form of $CaCO_3$ with very similar composition, the application of chemical methods to eliminate one of the two may result in non-discriminatory, uncontrolled effects. Certain physical properties of the polymorphs, on the other hand, such as crystal structure and especially specific gravity are quite distinct; therefore they can be used as a basis to distinguish between calcite and aragonite. Aragonite is slightly heavier than calcite thus the former will sink and the latter will float when both are present in a solution of an intermediate density. After decanting the lighter mineral, we are able to isolate and date only the original, autochthonous phase.

The initial results of this new separation method are very promising and technical details are described in a forthcoming publication (Douka *et al.* 2010, in press).

6. RADIOCARBON DATING OF EUROPEAN PALAEOLITHIC SHELLS

The Middle to Upper Palaeolithic transition still remains one of the most vividly debated issues in European prehistory. It broadly revolves around the nature and timing of the replacement of Neanderthals by Anatomically Modern Humans (AMHs) around 35-45,000 years ago.

As early as 1960, Harvard prehistorian Hallam Movius states *"Time alone is the lens that can throw it [the Palaeolithic] into focus"*. (Movius 1960: 355). Dating the relevant evidence, however, has proven to be more challenging than originally thought, mainly due to the need for well-preserved, contaminant-free samples at the limit of the radiocarbon method.

Sample pretreatment chemistry is a continuously revised field with new protocols being developed by laboratories around the world. When the preservation state of a sample is particularly poor, however, pretreatment chemistry cannot provide effective solutions. Bad sample preservation often occurs in hot and humid environments, and in particular around the Mediterranean zone, where the organic biomolecules used to date bone or wood (collagen, cellulose respectively) quickly oxidize, disintegrate and/or bind with contaminants.

Shell carbonates, on the other hand, are abundant in most archaeological sites around the Mediterranean. Since the biomineral ($CaCO_3$) and not the organic matter is used for ^{14}C dating, marine shells are valuable chronological indicators with great potential.

At the onset of the European Upper Palaeolithic, marine shells become visible in the archaeological record. Their first appearance in Europe -in the form of shell artifacts- coincides with the spread of the Aurignacian, often associated with the physical expansion of modern human populations into Europe (Mellars 2005).

A new project aimed at the dating of shell artifacts from the early Upper Palaeolithic began at the ORAU in 2006. The main objective of the project is to establish a chronology for sites along the "southern dispersal route" of AMHs, all across the Mediterranean Rim, which contain evidence for the earliest, or else, "Proto" Aurignacian culture of the region (Mellars, 2004). This involves dating sites with a great geographic distribution, from the Levant to the Iberian Peninsula, and includes material from key sites in Lebanon, Turkey, Greece, Italy, France and Spain. The vast majority of these sites have never been reliably dated before due to problems in the preservation of bone collagen and the difficulties in effectively dating small residue remains of charcoal.

We have selected over 200 specimens of shell ornaments, analyzed their production methods, determined whether or not they were obtained from fossil sources and assayed their mineralogical phases using powder X-Ray Diffraction and SEM analysis. The shells that yielded diagenetic calcite in their XRD scans (approximately 5% of the total number of individual specimens) underwent an extra pretreatment step (CarDS protocol, in *Douka et al.*) to ensure the removal of the contaminating carbonate and ensure reliability in derived AMS determinations. The first radiocarbon results show great consistency and the majority of them will be reported soon after the completion of the project at the end of 2009.

7. CONCLUSIONS

If precautions are taken and a strict set of criteria and scientific protocols are used, shell carbonates can be excellent environmental, cultural and chronometric indicators for both historic and prehistoric sites. Archaeologists, archaeometrists and marine biologists all need to be aware of the potentials and pitfalls during the physical and chemical analyses of this material thus close collaboration of all workers is vital in the extraction of precise and accurate information from archaeological molluscan remains.

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Marine shell beads from the Gravettian at Gargas cave (Hautes- Pyrénées, France): cultural and territorial markers

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Marine shell beads from the Gravettian at Gargas cave (Hautes- Pyrénées, France): cultural and territorial markers

Objetos de adorno en concha del Gravetiense de la Cueva de Gargas (Altos Pirineos, Francia): marcadores culturales y territoriales

KEY WORDS: Gravettian – Pyrenees – Lithic Industry – Worked Bone – Shell ornaments – Technological traditions – Natural resources Long distance mobility.
PALABRAS CLAVE: Gravetiense, Pirineos, movilidad, Industria lítica, Industria ósea, objetos en concha, tradiciones tecnológicas, recursos naturales, contactos a larga distancia.
GAKO-HITZAK: Gravettiarra, Pirinioak, higikortasuna, industria litikoa, hezur-industria, maskorrez egindako objektuak, tradizio teknologikoak, natura-baliabideak, urruneko kontaktuak.

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ABSTRACT

The new perspectives opened up by a research project dealing with the Gravettian and the Solutrean in the Pyrenees allow us to situate the Gravettian occupations of Gargas Cave within networks of raw material procurement and of technological tradition exchanges, in a geographical context including the Western and Central Pyrenees.

A set of perforated shells from marine and fossil sources were discovered in Level 2 during the 2004-2007 excavations at Gargas. Therefore, these personal ornaments point up some direct links between Gargas, the Atlantic shore and the Miocene fossil outcrops of Aquitaine. This confirms a hypothesis about regular human movements between this region and the Central Pyrenean area.

RESUMEN

Gracias a un proyecto de investigación sobre el Gravetiense y el Solutrense en los Pirineos hemos podido documentar cinco ocupaciones gravetienses en la cueva de Gargas. Este hecho ha abierto nuevas perspectivas sobre el conocimiento de las redes de adquisición de materias primas y sobre los cambios de tradiciones tecnológicas en un contexto geográfico que incluye el Oeste y el Centro de la región pirenaica.

En el nivel 2 de Gargas (excavaciones del 2004 al 2007) se descubrieron un conjunto de conchas marinas, actuales y fósiles. Estos ejemplares apuntan a la existencia de contactos con la costa atlántica y con los sitios con fósiles miocenos aquitanos, lo que ratifica la hipótesis de la existencia de movimientos de grupos humanos, que con regularidad unían estas regiones con el área central de los Pirineos.

LABURPENA

Pirinioetan egindako Gravettiarrari eta Solutrearrari buruzko ikerketa-proiektu bati esker, Gargaseko haitzuloa bost aldiz okupatu zela dokumentatu dugu. Horrela, aukera berriak zabaldu dira lehengaiak eskuratzeko sareen ezagutzari eta tradizio teknologikoen aldaketei dagokienez, Pirinioetako mendebaldea eta ekialdea hartzen dituen testuinguru geografikoan.

Gargaseko 2. mailan (2004tik 2007ra arteko indusketak), itsas maskorrak aurkitu ziren, egungoak eta fosilak. Ale horiek aurkitu izanak adierazten du Atlantikoko itsasertzarekin kontaktua zegoela, bai eta Akitaniako fosil miozenoak zituzten lekuekin ere; eta horrek gizakien mugimenduen hipotesia berresten du, eskualde horiek eta Pirinioetako erdialdeko gunea lotzen zituztenei buruzkoa.

1. INTRODUCTION

The Gargas cave (Hautes-Pyrénées, France), located in the middle of the Pyrenean piedmont at the same distance from the Mediterranean and the Atlantic coastlines, is a key Gravettian site of south-western Europe because of its exceptional parietal art (Fig. 1) and rich archaeological strata.

The excavations carried out in the late 19th Century and early 20th Century showed that the deposit covered a wide chronological range: Mousterian, Chatelperronian, Aurignacian and Gravettian. A new series of excavations was commenced in 2004 with the aim of establishing a detailed stratigraphic sequence, more precise than the schematic profile proposed by E. Cartailhac and H. Breuil in their studies of 1911-1913 (Breuil and Cheynier 1958), that would enable us to better understand the relations between rock art and settlement levels. At the same time, a further objective has been to carry out the first palaeo-environmental study of the deposit.

The area excavated now (Fig. 2) corresponds to a debris cone, which closed the cave naturally. There are two *locus* within this area, separated by 20

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Figure 1. Gargas cave – Main painted panel (picture J.F. Peiré, DRAC Midi-Pyrénées).

metres. The first one (GES) is at the base of the cone, near the former Cartailhac-Breuil excavations. The second one (GPO), at the top of the cone, is near the prehistoric entrance and it has not been excavated.

In GES, we recognized the upper part of the stratigraphical sequence described for the Cartailhac-Breuil excavations and corresponding to the Gravettian occupations. In GPO, the filling shows some sedimentological differences, but the Gravettian ensemble is also represented there.

This fieldwork is a part of a research project in regard to the Gravettian- Solutrean complex in the Pyrenees that includes multidisciplinary studies on the archeological material from old collections in order to obtain a better characterization of the regional lithic and bone industries (Foucher 2004, 2006, Foucher *et al.* 2007, 2008, Foucher and San Juan 2008, San Juan-Foucher 2006, San Juan-Foucher and Vercoutère 2005).

The Gravettian levels discovered in the recent excavations (dated by C14-AMS to between 27,000 and 23,000 BP, see Tab. 1) have yielded lithic and bone assemblages that are characteristic of the middle Gravettian with *Noailles* burins, which has confirmed the initial attribution of the level. The bone industry is composed essentially by “mattocks” made on engraved herbivore ribs, smoothers, awls and retouchers. The antler waste products show that grooving was used for the equipment manufacturing, specially the “*sagaies d'Isturitz*”, type of point cha-

Locus	Level	Cultural attribution	BP date	Bone samples taxons	Laboratory ref.	References
Gargas-GPO	2.1	Grav MBN*	**23,590 ± 100**	Ibex / Izard	Ly-3400-Gr1	Foucher *et al.* i.p.
Gargas-GES	2.1	Grav MBN	**25,030 ± 110**	Reindeer	Ly-3404-GrA	Foucher *et al.* i.p.
Gargas-Cartailhac/Breuil	6	Grav MBN	25,050 ± 170	Reindeer antler	Ly-1625-GrA	Foucher 2004
Gargas-GES	2.1	Grav MBN	**25,230 ± 110**	Large sized herbivore	Ly-3406-GrA	Foucher *et al.* i.p
Gargas-GPO	2.1	Grav MBN	**25,520 ± 110**	Medium size herbivore	Ly-3401-GrA	Foucher *et al.* i.p
Gargas-GES	2.1	Grav MBN	**25,700 ± 120**	Red deer	Ly-3405-GrA	Foucher *et al.* i.p.
Gargas-GPO	2.3	Grav MBN	**25,920 ± 130**	Large sized herbivore	Ly-3403-GrA	Foucher *et al.* i.p
Gargas-GPO	2.2	Grav MBN	**26,260 ± 130**	Medium size herbivore	Ly-3402-GrA	Foucher *et al.* i.p.
Gargas-GES	2.3	Grav MBN	**26,380 ± 120**	Large sized herbivore	Ly-3410-GrA	Foucher *et al.* i.p
Gargas-GES	2.3	Grav MBN	**26,480 ± 420**	Large sized herbivore	Ly-3409-GrA	Foucher *et al.* i.p
Gargas-Panneau peint		Gravettien	26,860 ± 460	unidentified bone	GifA-92369	Clottes *et al.*1992
Gargas-GES	2.2	Grav MBN	**26,910 ± 130**	Large sized herbivore	Ly-3408-GrA	Foucher *et al.* i.p

Table 1. Gargas Cave - Radiocarbon (AMS) dates from the Middle Gravettian level with Noailles burins.

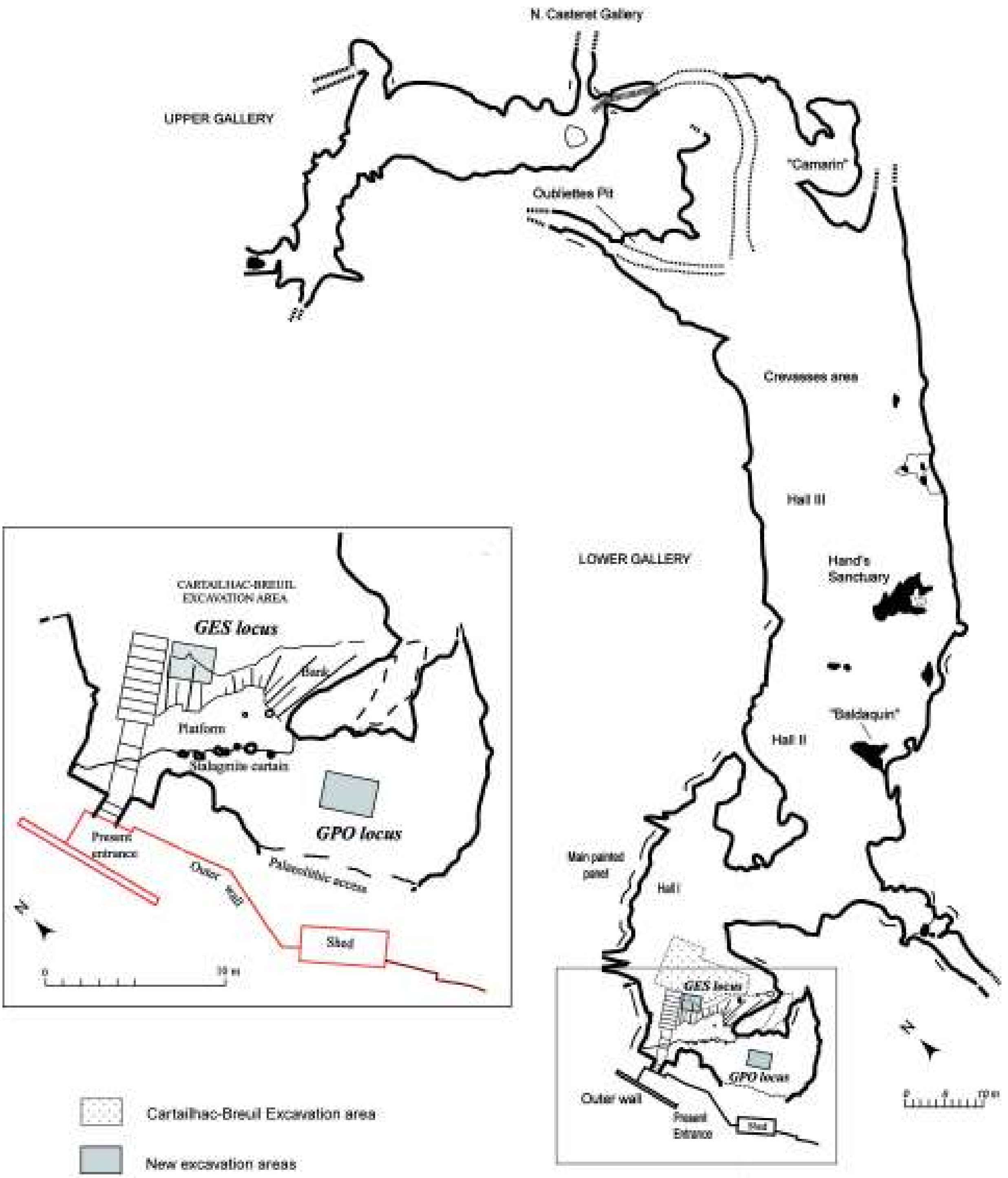

Figure 2. Gargas Cave. Location of old (1911-1913) and new (2004-2007) excavation areas (topographic map adapted from Barrière 1984, modified by Texier, Foucher 2004).

racteristic for the Gravettian, documented within the old collections. Perforated teeth of *Cervidae, Bovinae* and carnivores were used as body ornaments. The meat diet of the Gravettian was composed mainly by Reindeer, *Bovinae* and Izard (Pyrenean Chamois). The archaeozoological analysis allows us to establish also that men were at Gargas during all the periods of the year. The cave was then a butchery and consumption site.

The new archaeological material comprises a series of 17 personal ornaments made from marine shell beads (Fig. 3, 4, 5), including a dozen exam-

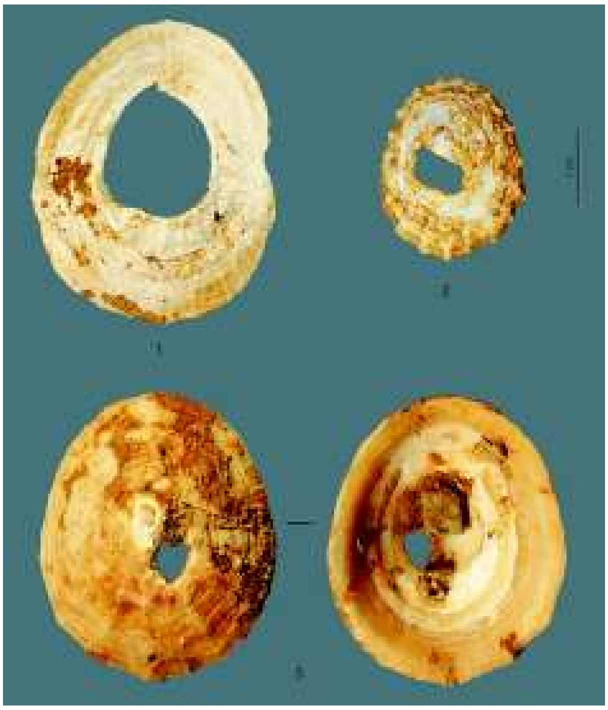

Figure 3. Atlantic gastropods – 1, 2, 3: *Patella vulgata*

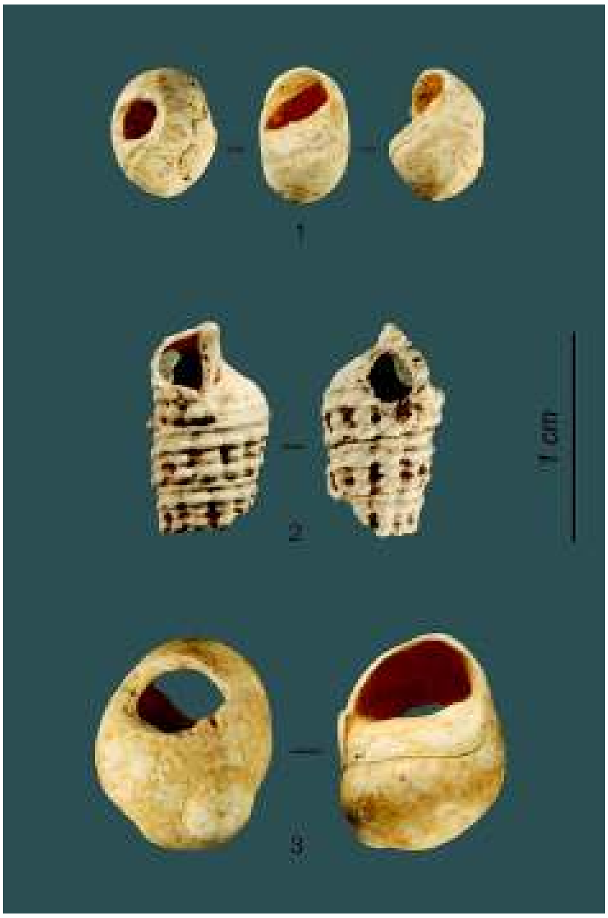

Figure 4. Fluvial and fossil species – 1: *Neritina fluviatilis*. 2: *Pirenella plicata*. 3: *Neritina picta*.

ples with a single perforation intact. The majority of these perforated shells are Atlantic gastropods well-documented in Gravettian deposits in south-west France (*Littorina obtusata, Littorina littorea, Patella vulgata, Nucella lapillus*), three pieces represent marine species found in both Mediterranean and Atlantic waters (*Trivia europea*), and one example comes from fluvial environment (*Neritina fluviatilis*). Two beads are made from fossil species (*Neritina picta and Pirenella plicata*) found in lower Miocene outcrops (*faluns*) in Aquitaine. None of these shells correspond to species restricted to the Mediterranean coast. Most of the potential sources are located at distances between 150 and 250 km from the cave, on the Basque coast and in the middle and lower valleys of the Adour and Gave de Pau. These areas coincide with the sources used for the supply of the most common allochthonous flint at Gargas (Foucher & San Juan 2005).

2. DISCUSSION

The results of preliminary research about the sources of siliceous raw materials and the techno-typological analyses of lithic industries, as well as observations about the patterns of manufacturing of bone and antler artefacts, clearly show that the Western Pyrenees was frequently visited by the Gravettian groups of Gargas. Some close relationships between Gargas and another Pyrenean caves (Isturitz, La Tuto de Camalhot / Saint Jean de Verges), are recently perceived through the morphological characteristics of engraved bone industries; this technological area is partially superimposed on the long distance movements for flint and shell procurement (Fig 6). The new ornamental objects of Gargas, radiocarbon dated from 27,000 to 25,000 BP, contribute to clarify the perception of the economic networks and the cultural interactions of Gravettian populations in the Central Pyrenees.

3. ACKNOWLEDGEMENTS

This study was done within the context of the projects “The Gravettian / Solutrean Complex on the Pyrenees: chrono-cultural context and procurement patterns on natural resources”, directed by C. San Juan-Foucher, and “Archaeology excavation in Gargas Cave (2004-2007)”, directed by P. Foucher, both financed by the French Ministry of Culture and the Hautes-Pyrénées General Council.

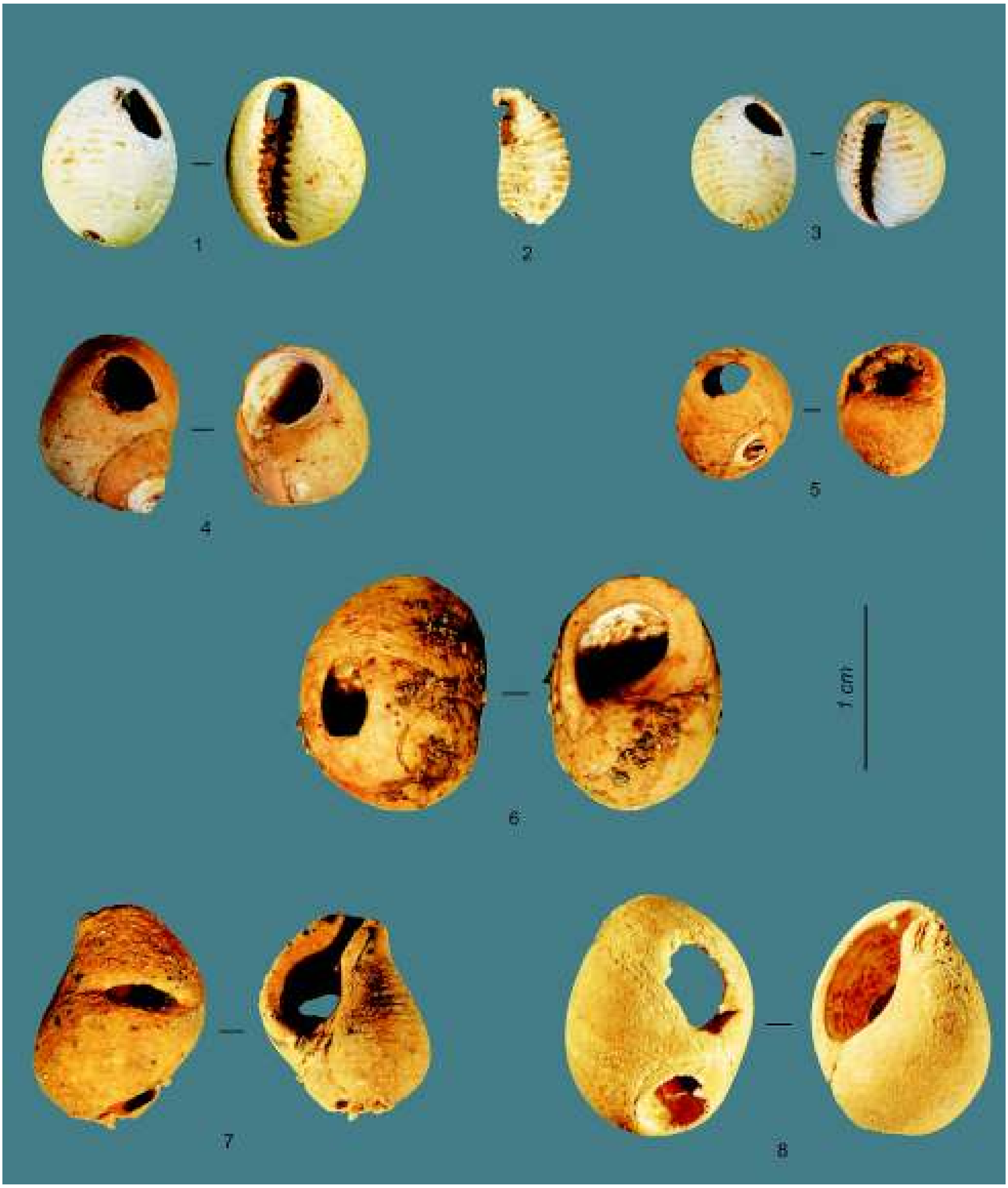

Figure 5. Atlantic gastropods – 1, 2, 3: T*rivia europea*. 4: *Littorina littorea*. 5, 6: *Littorina obtusata*. 7, 8: *Nucella lapillus*.

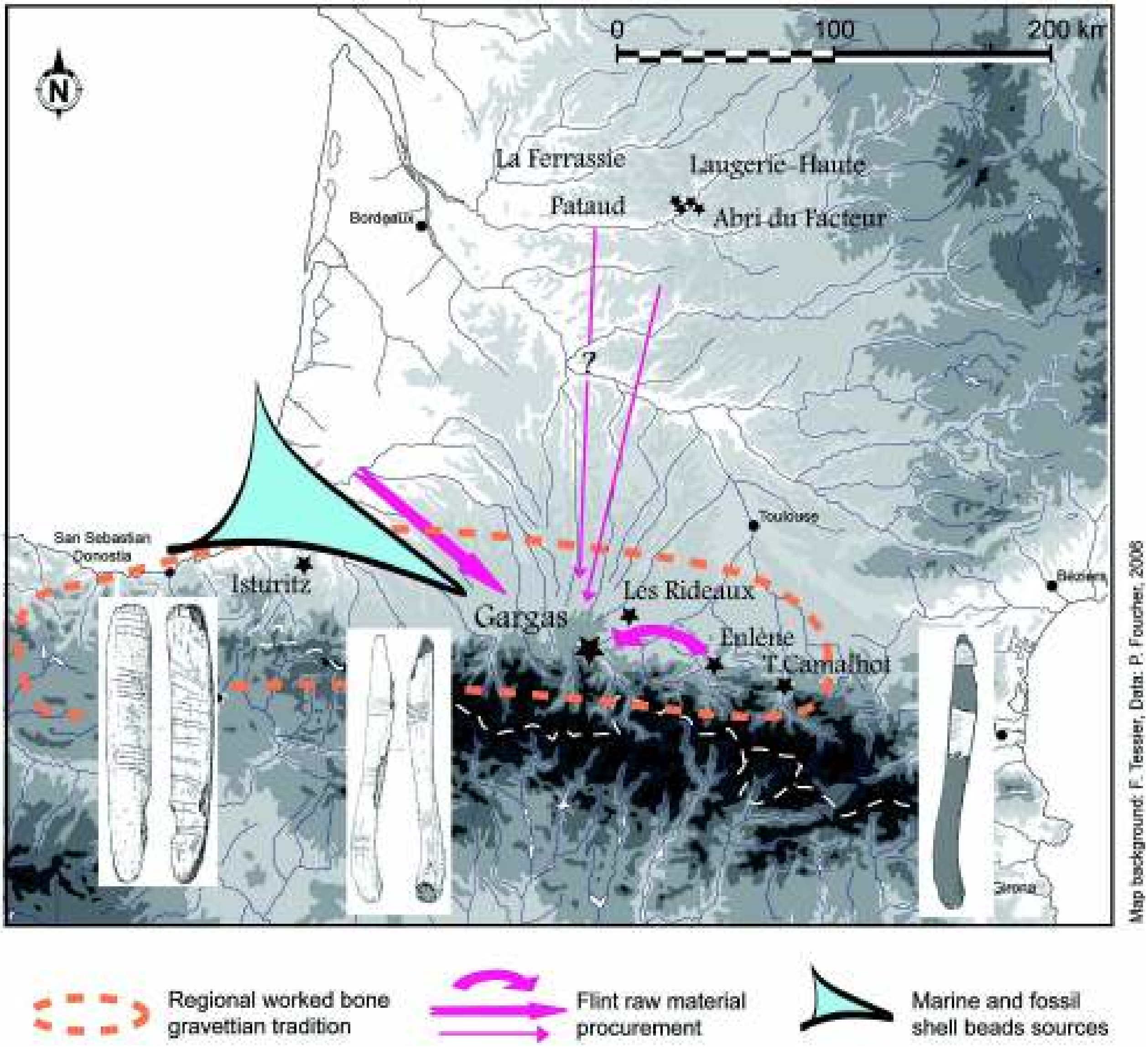

Figure 6. Networks of technological exchanges and raw material procurement for the Gargas Gravettian.

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Upper Paleolithic ornament seashells from Sala de las Chimeneas, Maltravieso cave (Cáceres, Spain)

Antonio J. RODRÍGUEZ-HIDALGO, Antoni CANALS, Palmira SALADIÉ, Ana B. GARCÍA & Marcos GARCÍA

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Upper Paleolithic ornament seashells from Sala de las Chimeneas, Maltravieso cave (Cáceres, Spain)

Colgantes en conchas marinas del Paleolítico superior de la Sala de las Chimeneas, Cueva de Maltravieso (Cáceres, Spain)

KEY WORDS: Upper Paleolithic, Personal ornaments, *Littorina obtusata, Patella vulgata*, mobility pattern, Tagus River.
PALABRAS CLAVE: Paleolítico superior, Elementos ornamentales, *Littorina obtusata, Patella vulgata*, patrones de movilidad, río Tajo.
GAKO-HITZAK: Goi Paleolitoa, Elementu apaingarriak, *Littorina obtusata, Patella vulgata*, higikortasun-patroiak, Tajo ibaia.

Antonio J. RODRÍGUEZ-HIDALGO[1,2], Antoni CANALS[1,3], Palmira SALADIÉ[2], Ana B. GARCÍA[2] & Marcos GARCÍA[4]

ABSTRACT

This work presents the findings from a taxonomic, technological and use-wear study conducted on two anthropogenic, perforated seashells that were recovered from the Sala de las Chimeneas, inside the Maltravieso cave site, Cáceres (Spain).Through morphometrical and use-wear analysis, the authors have characterized perforation techniques and the use of shells as decorative pendants. The selection of the represented species (*Littorina obtusata* and *Patella vulgata*) for the manufacture of ornamental elements is frequent in Palaeolithic contexts. These species are less frequent in Epipalaeolithic contexts and testimonial in producing economies, above all in the case of L. obtusata. Contextualisation of these archaeological remains within the framework of the western European Upper Paleolithic ornamental sets has allowed the identification of parallels between the specimens of Sala de las Chimeneas and some of late Pleistocene deposits located in the Portuguese stretch of the Tagus River. The ornamental pieces presented in this study suggest that, at the end of the Pleistocene, the Tagus basin heavily influenced the landscape conception and mobility patterns of groups of hunter-gatherers, affecting their level of interaction with the Atlantic coast and with hunter-gather groups located in the western reaches of the Iberian Peninsula.

RESUMEN

Se presenta el estudio taxonómico, tecnológico y traceológico de dos ejemplares de conchas marinas perforadas antrópicamente procedentes de la Sala de las Chimeneas de la cueva de Maltravieso, Cáceres, España. A través del estudio morfométrico y traceológico se han caracterizado las técnicas de perforación y el uso de las conchas como elementos de adorno-colgantes. La selección de las especies representadas (*Littorina obtusata* y *Patella vulgata*) para la realización de elementos ornamentales es frecuente en contextos paleolíticos, escasa en contextos epipaleolíticos y testimonial en contextos de economías productoras, sobre todo en el caso de L. obtusata. La contextualización de estas evidencias arqueológicas en el marco de los conjuntos ornamentales del Paleolítico superior del Oeste europeo ha permitido advertir paralelos entre los ejemplares de la Sala de las Chimeneas y algunos yacimientos del Paleolítico superior situados en el tramo portugués del río Tajo. Los restos ornamentales que se presentan en este trabajo indican que la cuenca de dicho río debió condicionar de forma importante la concepción del territorio y los patrones de movilidad de los grupos cazadores-recolectores del final de Pleistoceno, así como sus relaciones con la costa atlántica y con otros grupos de cazadores-recolectores costeros del oeste de la Península Ibérica.

LABURPENA

Antropikoki zulatutako itsas maskorren bi aleren azterketa taxonomikoa, teknologikoa eta trazeologikoa aurkezten da, Maltravieso (Cáceres, Espainia) haitzuloko Sala de las Chimeneas izenekotik ateratakoak. Azterketa morfometrikoaren eta trazeologikoaren bidez, zulatze-teknikak nolakoak ziren eta maskorrak apaingarri-zintzilikari gisa erabiltzen zirela ondorioztatu da. Apaingarriak egiteko erabiltzen zituzten espezieen aukeraketa (*Littorina obtusata* eta *Patella vulgata*) sarritan agertzen da Paleolitoaren testuinguruan, gutxitan Epipaleolitoan eta oso-oso gutxitan ekoizpen-ekonomiatan; batik bat, L. obtusata. Ebidentzia arkeologikoak Europa mendebaldeko Goi Paleolitoko apaingarrien artean kokatuta, paralelismoak aurkitu dira Sala de las Chimeneas izenekoan aurkitutako aleen eta Tajo ibaiaren Portugalgo zatiko Goi Paleolitoko aztarnategien artean. Lan honetan aurkezten diren apaingarrien hondakinek adierazten dute ibaiaren arroak lurraldearen ikuskeran eta ehiztari-biltzaileen taldeen higikortasun-patroietan eragin garrantzitsua zuela, bai eta Atlantikoko itsasertzarekiko eta iberiar penintsulako mendebaldeko ehiztari-biltzaileen beste talde batzuekiko harremanetan ere.

1. INTRODUCTION

The use of shells as personal ornaments is generalized in the Upper Palaeolithic, for hence it is been recognized as one of the earliest manifestations of symbolism than can be related to modern human behaviour (Kuhn *et al.* 2001, d'Errico *et al.* 2003). Three principal causes have been established to justify the presence of the

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shells in archaeological contexts: natural intrusions, food or raw material. The microwear study of the perforation, identified in some shells, allowed the identification of two types of objects: man made manipulated and natural origin (d'Errico *et al.* 2003, Stiner 2003).

However the origin of the shells cannot only provide information about mobility patterns and exchanges between groups also it can lead to palaeocological, chronological and behavioural patterns (Sacchi 1986, Tabourin 1993, Álvarez-Fernández 2001, Vanhaeren *et al.* 2004, Vanhaeren and d´Errico 2006, Álvarez-Fernández 2008).

The scarcity of Upper Palaeolithic sites in the Iberian plateau led some researchers to pose the depopulation hypothesis during the Last Glacial Maximum (Ripoll and Municio 1999, Corchón 2002). However, this picture has recently changed due to exhaustive works of some researchers that support the revised hypothesis highlighting preservation problems, archaeological survey and absence of karstic systems as major shortcomings, ruling out, therefore the depopulation hypothesis (see: Delibes and Díez 2006).

The same prospective was shared by some researches for the Extremadura case (Barrientos *et al.* 1985, Cerrillo 1996, Enríquez 1995, Enríquez 1997, Enríquez & Mordillo 1982;), this all despite the knowledge since 1956 of a rich sample or Rock-Art in Maltravieso cave (Callejo 1958). Recently, the discovery of other sites of Palaeolithic Rock-Art (Collado 2004) indicates that Maltravieso is not an isolated case.

2. THE MALTRAVIESO CAVE

The Maltravieso cave site is located in the surroundings of the city of Cáceres (Extremadura, Spain) (Fig 1A), inside the karst of Palaeozoic limestone called "*Calerizo Cacereño*". Since 2001 Maltravieso cave has been studied by a multidisciplinary group, "Primeros Pobladores de Extremadura /IPHES-URV". The results which are emerging from current research are summarized in the vast sedimentary complexity of the cavity and its protracted use by part of the hominid groups from at least 183 ky BPUTh until the Bronze Age (Barrero *et al.* 2005).

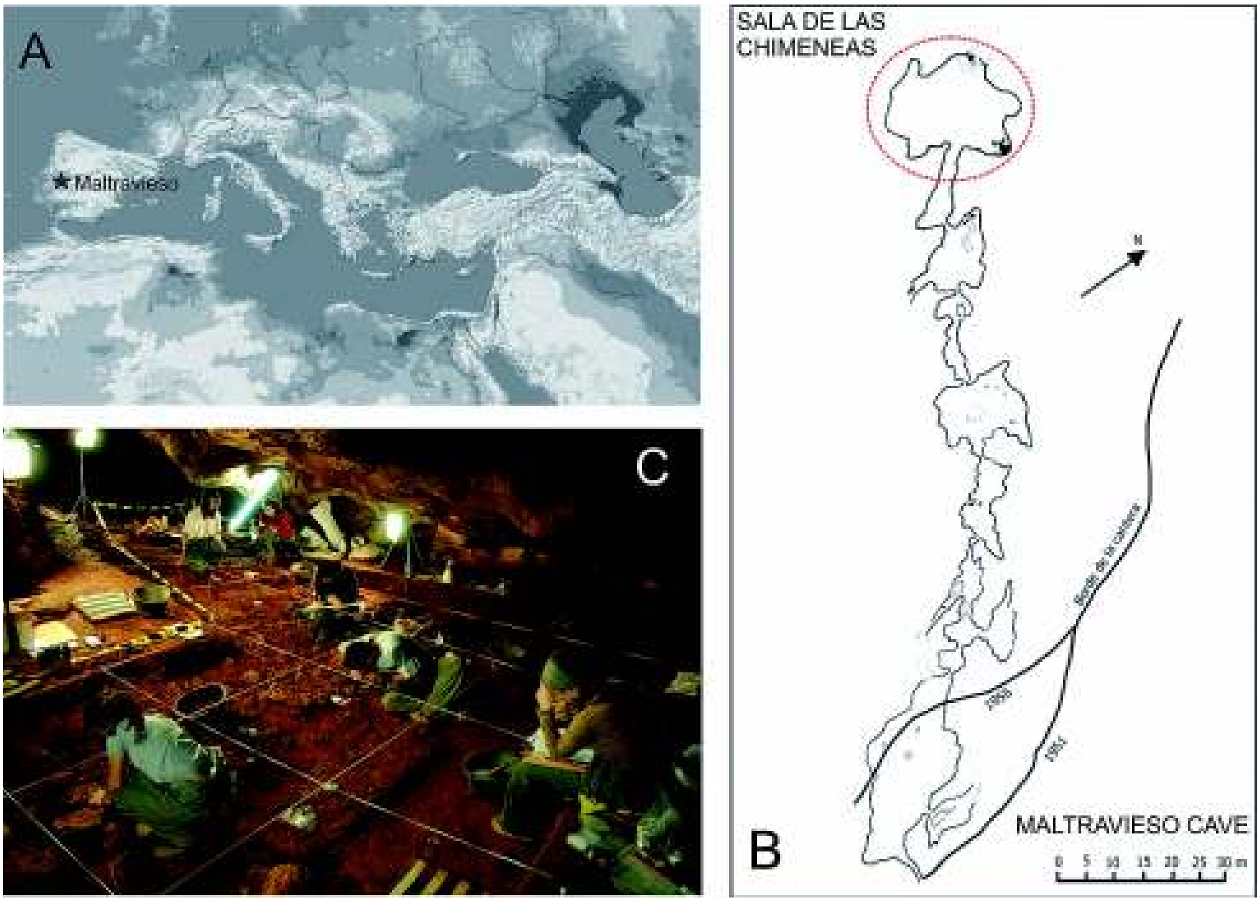

Figure 1. 1a) Map with the location of the Maltravieso Cave 1b) Circuit of the Maltravieso cave with the location of the Sala de las Chimeneas. 1c) Open-area excavation of the Sala de las Chimeneas.

The cavity consists of a series of intercommunicated rooms through corridors. At the moment, archaeological excavations are carried out in two of them: Sala de los Huesos (where an archaeo-paleontological record has been unearthed belonging to the second half of the middle Pleistocene) and the Sala de las Chimeneas. The latter is located at the bottom of the cavity (Fig 1B). Its name comes from the karst formations present in the ceiling of the cavity in the form of chimneys (ceiling tubes). The walls of the room contain a rich set of Palaeolithic Rock-Art in the form of hands in negative and engraving (Callejo 1958, Ripoll *et al.* 1999). During the archaeological seasons of 2005-2006 the research group began the open-area excavation of the room, with an area of 36 m^2 (Fig 1C) unearthing stone tools and faunal remains. The archaeological work at the Sala de las Chimeneas has revealed a stratigraphic sequence consisting of 4 levels (Fig. 2), the characterization of this sequence is based on the sections of the central alluvial cone (CN1) and the formations documented during the archaeological excavation, due to the impossibility of a stratigraphic pit test. The CN1 corresponds to the top of the cone, formed by fallen material from the ceiling tube at this point of the room; archaeological remains have not been documented in this level. The archaeological level (Level A) corresponds to the first phase of fine material input, a matrix of clay with slight organization. Underneath this layer there is the Level B. This is a gravitation rock fall, situated on top of Level C, laminated clay that does not seem to be related to the material from the ceiling tube whose thickness is unknown. Level A covers, in the form of a mantle, level B. Most of the archaeological remains were made available at the base level and between the blocks.

The archaeological record is composed by a stone tool set of 74 objects made primarily in quartz and to a lesser extent on quartzite and chert. It is important to highlight the lack of chert in the area, the nearest source is 100 Km away (Peña *et al.* in press.). The faunal remains are well represented as well as preserved, number of remains superior to four thousand NR. In this sample the most represented taxon is rabbit showing anthropic alterations in form of cutmarks (Rodríguez-Hidalgo 2008). During the excavation there have been located, among this archaeological record, the two shells that form the purpose of this study. The dating of the archaeological level through radio/geological and chronological techniques is ongoing.

3. TAXONOMICAL AND TRACEOLOGICAL ANALYSIS

Classical Linnaean classification using different atlas of malacology including (e.g. Poppe and Goto 1991) and the comparison with the specimens of the reference collection held at Palaeontology Department of the University of Barcelona have been applied for the taxonomical determination of the specimens.

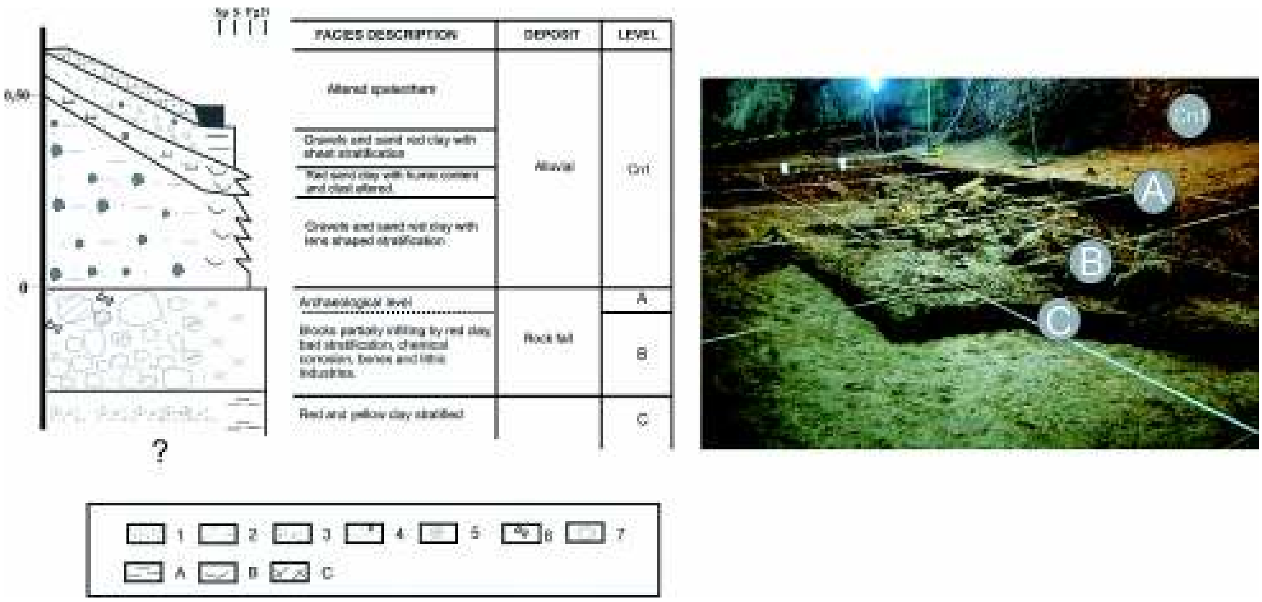

Figure 2. 2a) Sedimentology and stratigraphy of Sala de las Chimeneas Sedimentology of Sala de las Chimeneas (Mancha, personal comunication). Word abbreviated: Sp, Speleothem; S, Sand; Fg, Fine gravels, B; Blocks. Lithology: 1,Altered speleothem; 2.Humic content; 3,Sand and clay; 4,blocks of limestone and gravels (lithic clast); 5, quartz, 6, archaeological material, 7, chemical corrosion. Sedimentary structure and limits, A: Laminated; B: Lens shaped; C: Massive 2b) Main stratigraphic levels.

The represented taxa correspond to two marine molluscs of the species of *L. obtusata* and *P. vulgata* (Fig. 3) only present in the European Atlantic coast, being more abundant within this area in northern latitudes. The two specimens have perforations in their surface.

The identification of the perforation on the surface of the two specimens led the research team to carry out a microscopic analysis to classify the origin as either natural or anthropogenic. The study of the characterization of the perforations was based on the criteria developed by researchers as d'Errico (1993), Papi (1989) and Tabourin (1993); a binocular microscope (Optech LS) and ESEM (EIF quanta 600) were used for the observation of the material.

Littorina obtusata.

The perforation is characterized by an irregular contour with an oval shape (3.58mm length and 2.88mm width) located on the dorsal upper view (6.55mm from the outer lip. Fig. 4A), the hole section is irregular. A group of tenuous parallel striae on the edges of the perforation (Fig 4C) have been identified, at the same time the external surface (Fig 4B) of the shell presents a generalized polishing, however the abrasion has been only recorded on the outline of the perforation (Figs. 4D and 4E).

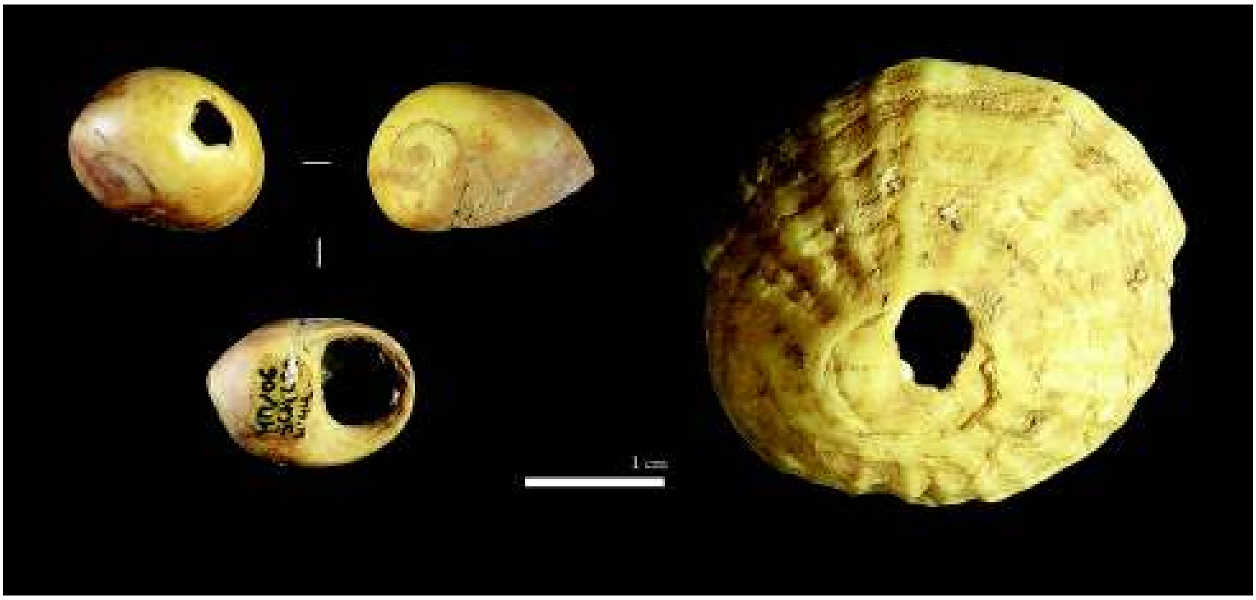

Figure 3. Shells, object of study. Left side: *Littorina obtusata*, right side: *Patella vulgata*.

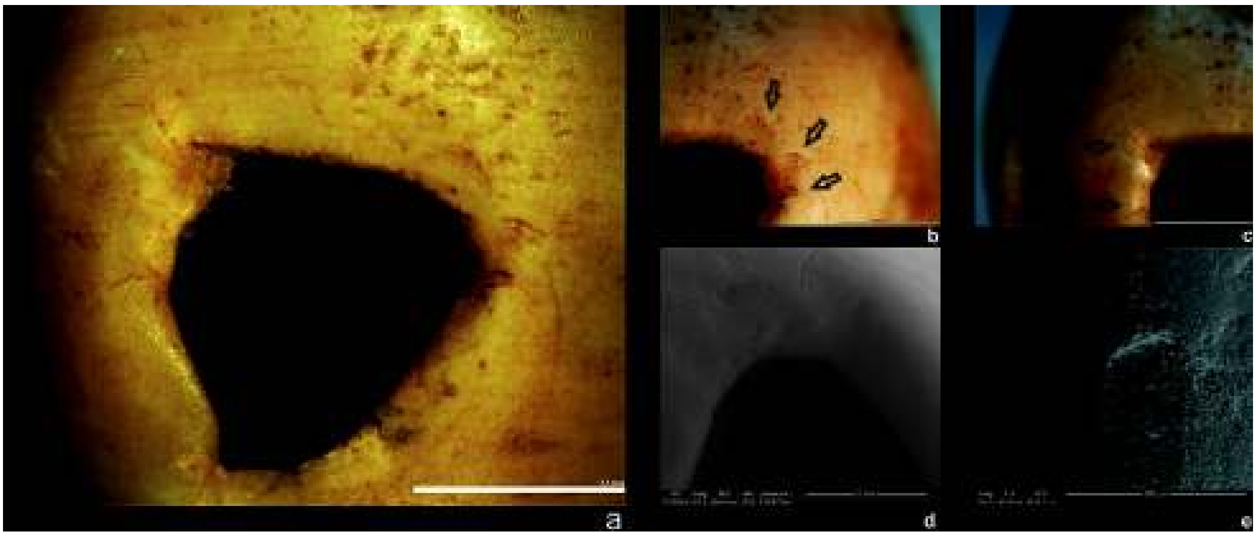

Figure 4. 4a) Perforation in *L. obtusata*. 4b) conchoidal scars. 4c) parallel striae. 4d) polishing in the outline of the perforation. 4e) detail of the abrasion in the outline of the hole.

Patella vulgata

A central perforation has been identified in this specimen with a circular outline slightly diverted from the top of the apex (6.68mm length x 5.97 mm width), presenting also a partial desquamation around the contour, the section is as well irregular.

The contour of the perforation presents a mild polished surface, being more intense on one side of it (Fig 5A and 5B). The outermost lip of the shell presents a partial fracture, showing both polishing and abrasion on the edge; therefore, the identified outline characteristics of the perforation are similar to those recorded for the *L. obtusata* (Fig 4c and 4d). The observed characteristics allow us to rule out a possible natural origin for the perforations, reinforcing the anthropogenic fracturing hypothesis. Once established the origin of the perforation the following step was to identify the perforation technique carried out and the utility of the shells as hanging elements.

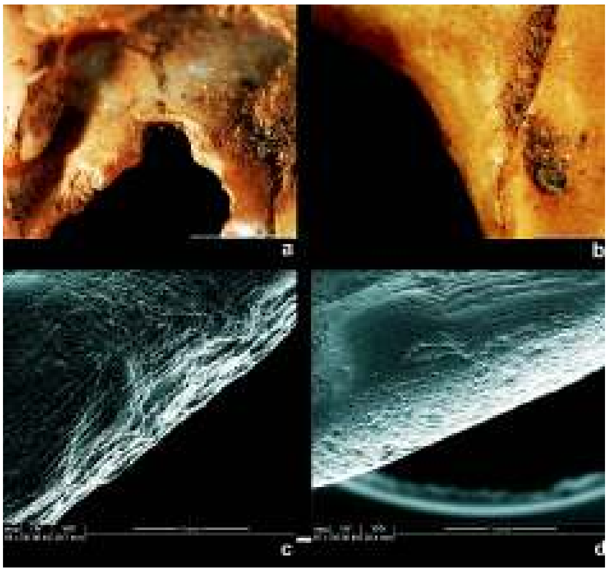

Figure 5. 5a and b) Detail of the perforated zone in *P. vulgata* with a more aggressive abrasion. 5c) Outside contour of the *P. vulgata*, non polished control-zone. 5e) Outside polished contour in *P. vulgata*.

According to d'Errico (1993) the perforation techniques can be identified through the observation of three traits: contour of the hole, morphology and microscopic damage; based on the results of the study eight types of perforation techniques were established by the researcher (Table 1). Recently a study was carried out by this research team on Littorinacea sample (Rodriguez-Hidalgo *et al.* forthcoming) stated those techniques presented by d'Errico (1993), and a new one was identified. This new technique named Inside-Out Bipolar Percussion has proved to be the most effective for the perforation of small spiral-shelled molluscs. The Inside Out Bipolar Percussion develops as follows:

a.) A bone or horn perforator, supported on a flat surface, is introduced through the aperture of the shell; b.) a small pebble is used to hit the surface of the shell at the opposite point of the active part of the punch; c.) This position leads to an inter-

		Action origin				Outline			Morphology								Microscopical criteria									
		Bivalvia		Gastropoda													Attack surface							Opposite surface		
		External side	Internal side	External side	Internal side	Circular	Elongated	Irregular	Cylindrical	Cylindrical concave	Conic convex	Conic straight	Conic concave	Biconic concave	Linear	Irregular	Impact point	Impact striae	Tool striae	Desquamation	Crack	Macroscopic abrasion	Natural abrasion	Conchoidal scars	Crack	Natural abrasion
Natural Action	Predator	X		X		X			X	X	X															
	Natural fracture	X		X		X		X						X		X				X	X		X	X	X	X
Anthropogenic Action	Punctual direct percussion	X		X		X		X								X	X			X	X			X	X	
	Diffused direct percussion	X		X		X		X								X	X	X		X	X			X	X	
	Indirect percussion	X	X		X	X		X								X	X			X	X			X	X	
	Pressure	X	X		X	X		X								X				X	X			X	X	
	Sawed	X		X			X					X			X				X					X	X	
	Rotate perforation	X	X	X		X					X		X						X	X				X		
	Abrasion	X		X		X		X							X							X		X		
	Scraped	X		X				X			X					X			X					X		
	Inside-Out Bipolar Percussion			X	X			X								X		X		X						

Table 1. Features for the determination of the origin and perforation technique on shells. The X show d´Errico observations (1993). In black, features present in archaeological *L. obtusata*; in grey, features presents in archaeological *P. vulgata*. The last row present the damage produced by Inside-Out Bipolar Percussion according to own experimental criteria. Table modified from d´Errico (1993).

nal and external pressure (bipolar) on a specific point of the shell. The result is a perforation with irregular contour, with presence of desquamation and conchoidal scars on the outside of the element. The diagnostic elements of this perforation technique are presented in Table 1. The coincidence of characteristics between the experimental results and the archaeological element lead to consider that the above mentioned technique was probably used to perforate the specimen *L. obtusata.*

The identified marks on the elements of *Patella vulgata* indicate an inside-out perforation, due to the presence of scars on the external surface of the shell; the resulting hole is characterized by a highly irregular circular section, due to the recognition of those traits, experimentation and application of d'Errico (1993) criteria the perforation technique has been identified as indirect percussion or pressure (Table 1). Damage has been noticed on the edge of the outer fracture; however the process that could cause such impact on the shell has been unidentified. A conclusive aspect can be posed in relation to the parallels observed for the polished surface that reinforce the anthropogenic origin of the alterations.

Two characteristics can be recognised from the previous assessment: macroscopic analysis of the two perforation outlines reveals the use of the shells as hanging elements, and the general polish on the outline and specific located abrasion present in the perforations could indicate a preferential friction zone.

4. DISCUSSION

The studies of perforated shells proceeding from western European sites indicate the importance in the selection of *L. obtusata* as raw material for the confection of ornamental objects. However, within the different Upper Palaeolithic periods their presence varies significantly. During the Gravetian and the Solutrean a fifth part of the documented shells belong to the *L. obtustata* species, being less represented during the Aurignacian and Magdalenian period (Vanhaeren & d`Errico 2002).

The compilation and revision of the malacology studies carried out in different archaeological sites in the Iberian Peninsula show special leading role of *L. obtusata* during the Upper Palaeolithic (Moreno 1995, Vanhaeren *et al.* 2004, Álvarez-Fernández 2006, Vanhaeren and d´Errico 2006).

Moreno`s studies (1995), focused on peninsular sites, show the lack of these gastropods in post-Palaeolithic chronologies. The presence of *P. vulgata* is chronologically more extensive, although it is rarely found perforated (Vanhaeren and d`Errico 2002). In the Cantabrian region and the Ebro valley, emphasizes the use of *L. obtusata* as beads during the Upper Palaeolithic. During the Epipalaeolithic and Mesolithic its presence is scarce, to the detriment of *Trivia* sp. Regarding *Patella vulgata*, its presence during the Magdalenian and the Azilian in Cantabrians sites is alimentary related due to the location of the sites near to the coast, examples are La Garma A and Asturian shell-middens (Álvarez-Fernández 2005).

Central Portugal sites must be taken into account for malacofauna studies not only because their geographical proximity to Extremadura also because the documented presence of the species *L. obtusata* within the shell collections for the realization of hanging elements. In these collections it can be observed that *L. obtusata* is the mollusc most used for the realization of the hanging elements. At the Grota do Caldeirão it has been documented in Early Upper Palaeolithic, Solutrean and Magdalenian layers (Zilhão 1997; Capellez 2003). In this sample *P. vulgata* is also present, although the specimens are not perforated (Chauviere 2002).

In the site of Lagar Velho, *L. obtusata* occurs in the terminal-Gravetian burial layer and in the occupation layers on terminal- Gravetian and medium-Solutrean (Vanhaeren and d`Errico 2002). The presence of shells on the aforementioned sites has been interpreted as grave goods included in burial contexts (Chauviere 2002; Vanhaeren & d`Errico 2002). Other Portuguese sites that present *L. obtusata* in their layers of medium-Solutrean are Lapa do Anecrial, with non-perforated specimens, Lapa do Suão, whose items have perforations and Vale Boi site at south western Portugal (Bicho *et al.* 2003).

Broadening the geographical scope, the association of *P. vulgata* and *L. obtusata* as hanging elements is also document in the Gravetian levels of Gargas (Foucher 2006) and Aurignacian level of Rothschild (France). In the Peninsula, as has been mentioned previously, *P. vulgata* is present in Solutrean levels of the Grota do Caldeirão site. Together with this case, the presence of both species has been documented in Upper Palaeolithic and Epipalaeolithic levels of Balmori, Cueto de la Mina, Abittaga, Santimamiñe, Riera, Rascaño, Piélagos, Peña del Perro, Pendo, Lumentxa and La Garma (Moreno 1995, Vanhaeren & d`Errico 2002, Álvarez-Fernández 2006).

The choice of certain species for the realization of personal ornaments could be conditioned by the availability of the material, therefore the biogeography is an important element to take into account (Stiner 2003). However, other authors suggest that ethnic and cultural preferences are those that determine this choice (Vanhaeren & d´Errico 2006).

The case of the Sala de las Chimeneas fits the Atlantic context of the Iberian Peninsula. The presence of ornaments made out of *L. obtusata* shells in this area can be determined by two aforementioned factors: biogeography and cultural preferences, however a conclusive hypothesis cannot be posed for the studied specimens recovered from Sala de las Chimeneas at the moment.

Despite the small number of recovered beads a possible cultural homogeneity can be suggested between the middle basin of Tagus River (for which Maltravieso represents the only site of the Upper Palaeolithic) and Portuguese Atlantic coast with a major density of sites. The presence of exotic raw material as seashells and chert at Sala de las Chimeneas suggest long distance interaction during this chronology. As has been documented by Bicho (Bicho 1997, Bicho *et al.* 2003) long distance human interaction existed during Upper Palaeolithic period either via Atlantic coast or inland-coastal routes, sometimes forming networks over 1000 kilometres. The presence of exotic raw material in the Sala de las Chimeneas could indicate the existence of these networks from the Atlantic coast and inland, possibly through the river valley routes (Fig 6).

5. CONCLUSIONS

Although the sedimentary and archaeological context of Sala de las Chimeneas where the shells were recovered is not yet determined, the presence of Upper Paleolithic materials, as chert for the production of blades, reinforce the posed hypothesis for the archaeological context. Chert presence indicate a catchment of raw materials at a long distance (Peña *et al.* in press.) as the source areas of this raw material are over a hundred kilometres away from the Maltravieso cave.

Figure 6. Orientation map of the Maltravieso cave and other site, of the Portuguese Upper Palaeolithic included in the basin of the river Tagus.

This characteristic indicates a high degree of mobility for these groups, as well as the possibility of exchanges between them. Along with these archaeological remains, the rich set of Rock-Art present in the Maltravieso cave is the main evidence of human transit inside the cavity during the Upper Palaeolithic.

The two specimens correspond to Atlantic seashells; one is the *L. obtusata* and the other *P. vulgata*. The anthropogenic contribution to the site of these two elements is indisputable. The technological study reports the man-made nature of the perforations. The microwear suggests their use as ornamental elements.

The Maltravieso cave, included in the Basin of Tagus River, is about 300 km. from the Atlantic coast, following the course of the river to its present outlet. The orohydrography in which the site is included was probably a determining factor for communication and mobility patterns during Upper Palaeolithic period. This fact is supported by the existence of a series of Portuguese Upper Palaeolithic sites, whose archaeological contexts show parallelisms with Sala de las Chimeneas. The intense settlement of the Atlantic and the Mediterranean coasts of the Iberian Peninsula during the Upper Palaeolithic contrasts with the lack of recorded sites located in the interior during the same chronological period.

The case of Maltravieso cave can be used as a reference site to establish the mobility patterns among human groups during the Upper Palaeolithic. In this regard, the available archaeological record suggests the probability of using the valleys of main rivers as transit routes from the coast to the peninsular inland. The high mobility of these groups as well as the extensive network could be identified as seasonal movements or as communication channel between the groups. The presence of the materials can also provide valuable information for designing the territory where these groups developed their activities, as well as, establish a possible relationship between sites or neighbours in the Upper Palaeolithic, in Portuguese Tagus and the interior of the Peninsula.

At present, the archaeological work at Maltravieso Cave site is at a technical stop. The continuation of this is essential, since we must take into account that Maltravieso is the only case available throughout Extremadura for the knowledge of Upper Palaeolithic hunter-gatherers groups.

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7. ADDENDA

During the publication of this document, we have obtained the radiometric dating of two charcoal fragments from the archaeological level with an age of 17,840 BP and 17,930 (AMS), resulting in the first dating for this period at regional level.

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The personal ornaments made from molluscs at the Middle-Late Magdalenian site of La Peña de Estebanvela (Segovia, Spain)

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The personal ornaments made from molluscs at the Middle-Late Magdalenian site of La Peña de Estebanvela (Segovia, Spain)

Los objetos de adorno-en concha del Magdaleniense medio-superior de La Peña de Estebanvela (Segovia, España)

KEY WORDS: Spanish Northern Plateau / Magdalenian / Molluscs / Personal ornaments / Experimental program.
PALABRAS CLAVE: Meseta Norte / Magdaleniense / Moluscos / Adornos-colgantes / Programa experimental.
GAKO-HITZAK: Ipar Goi-ordokia / Magdaleniarra / Moluskuak / Apaingarriak-zintzilikariak / Programa esperimentala.

Bárbara AVEZUELA[1]

ABSTRACT

The site of La Peña de Estebanvela is situated on the south edge of the Duero river basin in contact with the mountains of the Central System. This rock shelter offers a sequence attributed to the Middle-Late Magdalenian. Its ornamental collection is made up of six species of marine molluscs, one freshwater mollusc and three red deer atrophied canines, all of them perforated. We present a technological study of the perforations made on the molluscs and an experimental comparative collection. Furthermore, we try to go beyond the taxonomic and technological descriptive analyses in order to assess the potential relationship of the groups who lived in La Peña de Estebanvela with the coasts.

RESUMEN

El yacimiento de la Peña de Estebanvela se encuentra situado en el borde sur de la cuenca del Duero en contacto con el Sistema Central. El relleno de este abrigo rocoso nos ofrece una secuencia atribuida al Magdaleniense Medio-Final. Su conjunto ornamental está compuesto por seis especies de moluscos marinos, una especie de molusco dulceacuícola y tres caninos atrofiados de ciervo, todos ellos perforados. Realizando una coleccion experimental de referencia presentamos un estudio tecnológico de las perforaciones realizadas sobre los moluscos y damos un paso más allá intentando superar el terreno descriptivo, tanto taxonómico como tecnológico, para adentrarnos en una valoración sobre cuál fue la relación que tuvieron los grupos que habitaron la Peña de Estebanvela con las costas.

LABURPENA

Peña de Estebanvelako aztarnategia Duero ibaiaren arroaren hegoaldeko ertzean dago, Mendikate Zentralaren ondoan. Gune harritsu horretan, Magdaleniar kulturaren erdialde-amaierarekin lotutako sekuentzia bat ageri da. Apaingarrien multzoa itsas moluskuen sei espeziek, ur gezatako moluskuen espezie batek eta oreinen hiru letagin atrofiatuk osatzen dute, eta guztiak ere zulatuta daude. Erreferentziazko bilduma esperimental bat eginez, moluskuei egindako zulaketen azterketa teknologikoa aurkezten dugu eta beste urrats bat ematen dugu eremu deskribatzailea, taxonomikoa zein teknologikoa, gainditzen saiatzeko, Peña de Estebanvelan bizi izan zirenek itsasertzekin zer-nolako harremanak izan zituzten baloratzeko.

1. INTRODUCTION

The study of personal ornaments has important anthropological meaning since these elements have a polysemous character that, depending on the context, can constitute an aesthetic expression but can also serve as a personal reaffirmation of belonging to a group or social status. They can be used as ritual elements, offerings or amulets. All these characteristics transform them into valuable elements as exchange goods and, in any case, into elements that shape the system of communication within the society in which these objects are created and used (Taborin 2004).

Therefore, we decided to study the personal ornaments from the Middle-Late Magdalenian site of La Peña de Estebanvela as a cohesive group even though when we recovered the material, perforated shells were grouped with the malacofauna and perforated red deer canines were included in the osseous tools.

Our objectives were: to identify the origin of raw materials and its possible selection; to know the processes of transformation and where they were carried out; to discriminate between failures and perforations broken by use. We were sure that reconstructing the operational sequence was a necessary step. For our study we wanted to create our own experimental comparative collection of technological or manufacture traces and apply the results to our archaeological series to see what information this provided.

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2. LA PEÑA DE ESTEBANVELA

The site of la Peña de Estebanvela is situated on the south edge of the Duero river basin in contact with the mountains of the Central System, at 1065 metres above sea level. Estebanvela is located in the province of Segovia, in a zone of contact with the provinces of Soria and Guadalajara through a natural pass (Fig. 1).

Figure 1. La Peña de Estebanvela map situation.

La Peña de Estevanvela is a rock shelter situated in an abandoned meander of the river Aguisejo (Fig. 2).

Figure 2. The Midle-Late Magdalenian site of la Peña de Estebanvela.

The site was discovered in 1992 and work started in 1999 and continues today. The site was under the direction of Sergio Ripoll, Carmen Cacho and Francisco J. Muñoz in the first phase, and is currently under the direction of Carmen Cacho. All work done on the site through 2004 has been published in several articles and in a monograph (Cacho *et al.* 2006, Yravedra 2005, Cacho *et al.* 2003: 191-198., Muñoz *et al.* 2001: 155-160, Ripoll *et al.* 2001: 225-232, Cacho Quesada *et al.* 1998: 175-182); the latest novelties have also been presented (Cacho Quesada *et al.* 2008: 143-152). This rock shelter offers a sequence attributed to the Middle-Late Magdalenian. Thus far, all the personal ornaments belong to the Late Magdalenian Levels (I-II)[1] and Upper Magdalenian levels (III-IV). The Middle Magdalenian Levels have only been excavated in a very small surface (V-VI).

The ornamental collection is made up of six species of marine molluscs, one freshwater mollusc and three red deer atrophied canines, all perforated (Fig. 3)

	I	II	III	IV
Cyclope neritea	3	3	9	1
Trivia arctica	1	2	5	-
Trivia pulex	-	1	1	-
Littorina obtusata	1	-	1	-
Nassarius reticulatus	-	1	-	-
Marine gastropod doubtful species	-	-	1	-
Theodoxus fluviatilis	-	2	4	-
Cervus elaphus	1	1	1	-

Figure 3. La Peña de Estebanvela personal ornaments distributed by levels.

3. THE EXPERIMENTS

To create our own direct comparative collection to interpret the fossil record we selected different types of raw materials (we decided to experiment only with molluscs because the majority of the archaeological collection consisted of mollusc remains). First of all, we chose various types of gastropods and bivalves[2] based on the size and hardness of the shells, as well as their presence in the

[1] Levels IV-III: 14,810 cal BP-13,910 cal BP, calendric age. Levels II-I: 13,610 cal BP-12,860 cal BP (Cacho *et al.* 2006, Cacho *et al.* 2008: 143-152).

archaeological collection of La Peña de Estebanvela and other sites that we are studying. Second, we selected different types of lithic tools and abrasives. Finally, for the experiment, we used different techniques and played with different variables like gesture or the state of the molluscs and registered all the data as we went through the experiment.

The first technique used was **abrasion** (Fig. 4). We have tested abrasion on 7 units; this technique can only be executed from the outside of the shells. We used different types of abrasives in our experiments: fine grain and heavy grain sandstone. The materials produced different types of striae. Another variable that we used is the gesture selected to abrade, that is, playing with the passivity and mobility of the shells. In both cases we obtained a surface with organized parallel striae, but in second case the process took longer. The perforations obtained display a circular contour generated by the convex morphology of the surface of the molluscs; their cross-section is linear. The striae of the worked surface follow the direction of the executed gestures: crossed, circular or parallel.

Figure 4. Abrasion. Different gestures used and circular perforation with organized parallel striae.

The second technique used was **indirect percussion** (Fig. 5). This technique is less traumatic than direct percussion[3] and it allows better delimitation of the desired perforation size and exact location. Indirect percussion can be done from either the inside or outside of gastropods and bivalves, although in the case of the former, the dimensions of the natural aperture may constrain perforation. We made

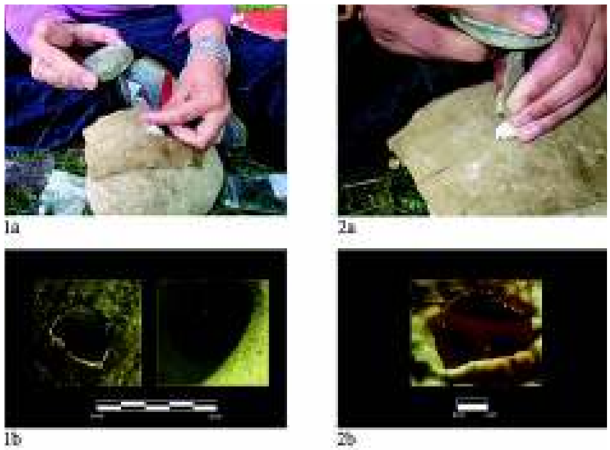

Figure 5. Indirect percussion. 1a-1b, from the inside of gastropod. 2a-2b, from the outside of gastropod.

indirect percussion perforations from the inside of 6 units and the outside of 7. In two cases we were not able to make the perforation and the *Littorina obtusata* that we were perforating broke, once from the inside of the aperture and once from the outside.

In all the cases we used perforators and the contours obtained are mostly irregular although in two cases the contours were determined by the morphology of the drill and the resulting form was triangular.

The hammer used in all the cases was a hard one, a quartzite of about 100 grams.

The obtained perforations vary in size from 1.2 to 1.4 mm on *Conus* and *Cerastoderma*, species whose shell is much harder than those of other species like the *Littorina litorea* in which we obtained a perforation of 6 mm. The cross-sections are irregular in all the cases.

Macroscopically we can observe in the attack surface all types of fissures and rises although the general tendency is for isolated rises and micro rises. Nevertheless in the opposing surface we found the contrary, a tendency to continuous rises, accompanied by fissures.

The next technique used was **direct pressure** (Fig. 6) from the inside and outside of gastropods and bivalves. We made 16 perforations by pressure, 12 from the inside and 4 from the outside. In 4 cases, from the inside of a *Littorina litorea*, a *Littorina obtusata*, a *Patella* and a *Gibbula* we could not obtain our objective.

[2] The chosen species were: 12 *Littorina litorea,* 8 *Columbella rustica,* 8 *Nassarius reticulatus,* 5 *Littorina obtusata,* 7 *Cerastoderma edule,* 2 *Conus mediterraneus,* 2 *Gibbula cineraria,* 3 *Patella caerulea,* 1 *Cerithium vulgatum.*

[3] We tried to use direct percussion but the technique was too severe and the results were always broken shells.

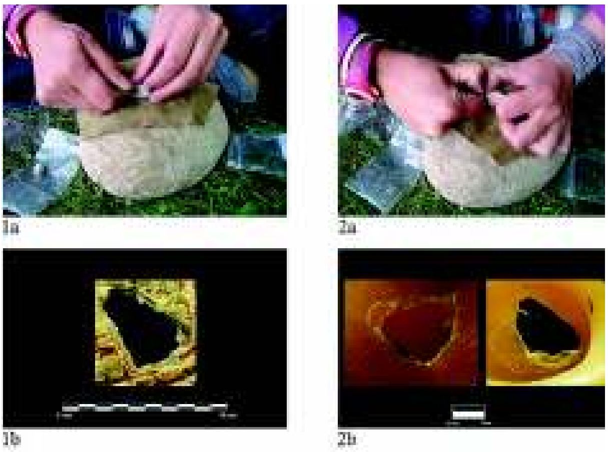

Figure 6. Direct pressure. 1a-1b, from the inside of gastropod. 2a-2b, from the outside of gastropod.

The lithic tools used were perforators of different sizes and a burin. In the 13 units in which we obtained the perforation successfully, twice the contour tended to a rounded form, nevertheless in the rest of units the form was polygonal, almost triangular, always conditioned by the cross-section of the end of the lithic tool that we used. Sometimes the perforation follows the structural lines of the shell. We found fissures and rises in the attack surface as well as in the opposite one and the cross-section is always irregular.

The fourth technique, semicircular rotation (Fig. 7), was employed on 7 gastropods and two bivalves. We were able to make a perforation with this technique from the inside of the aperture of a *Littorina litorea* but the technique is not easy to execute from this position due to a lack of manoeuvrability inside the aperture.

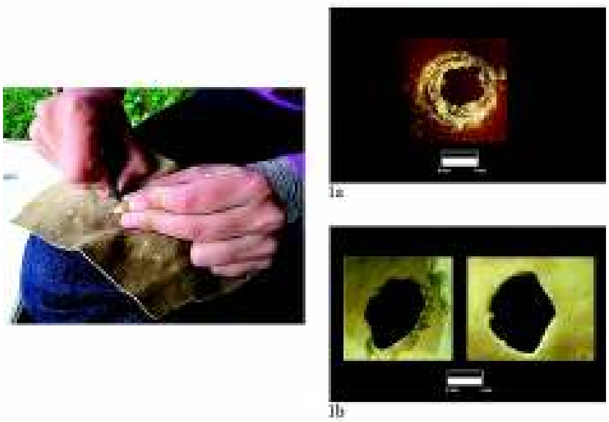

Figure 7. Semicircular rotation. 1a, from the outside of gastropod, circular with striae left by lithic tool. 1b, from de inside of gastropod, rotation with pressure, we can see the cross- section of the tool used in the morphology of the perforation.

The rest of the perforations were made externally by semicircular rotation using perforators of different sizes. The obtained holes were circular and the cross-section conical. Only in one case was the cross-section not conical: that made from the inside of the *Littorina*, *Horea* perhaps because from that position it is not possible to control the movement. We observed striae left by lithics in the walls of the perforation and rises in the active and opposing surfaces.

And finally, the last technique used was sawing (Fig. 8), used on the back of two gastropods with the edges of two flakes. The result is two extended furrows, conical-rectums, with striae from lithics in the walls of the perforation and rises in the opposite face.

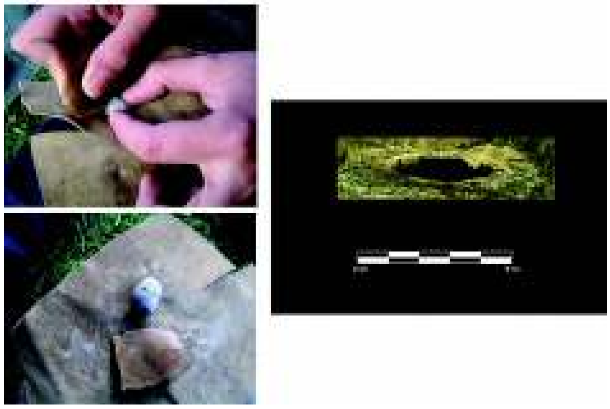

Figure 8. Sawing. Furrow conical-rectum with striae from lithics in the walls of the perforation.

4. STUDY OF THE ARCHAEOLOGICAL COLLECTION

This small collection of personal ornaments is made up of six species of marine molluscs, one freshwater mollusc and three red deer atrophied canines (Fig. 3). For the technological study we apply the results of our experiments and those from other authors (D'errico *et al.* 1993, Alvarez-Fernández 2006, Taborin 1993).

The first specie represented is the *Cyclope neritea* (Fig.9); we have 16 perforated specimens. The perforations vary in size depending on the wear that they have suffered, including specimens with perforations broken from use.

From the contours of the perforations we recognize several wear stages

1. Rectangular perforations are those that have limited wear.

2. Next are perforations that are rounded towards the ring of the peristome… (Fig. 9. 1)

3. …until making contact and fusing with the peristome. Then, the perforation begins to fracture in the opposite direction (Fig. 9. 3).

4. In the final stage the body whorl fractures completely, before fusing with the perforation. The result is always the exposure of the columella (Fig. 9. 4).

Because of the poor condition of the shells' surfaces and the wearing down of the perforations, in many cases we have not been able to determine the perforation techniques. However, in some cases we identified some points of impact inside the ring of the peristome near the siphonal canal, possibly to prepare the size of the perforations.

The suspension of all the *Cyclopes* created the same wear pattern: abrasion towards the ring of the peristome with rounding that follows its natural arc, erasure of the internal lip denticles of the external lip of the aperture (Fig.9. 4), levelling of the convexity, and perforation edges with traumatic fractures in the direction of the shell base. Thus, we suggest that *Cyclopes* was suspended, not sewn.

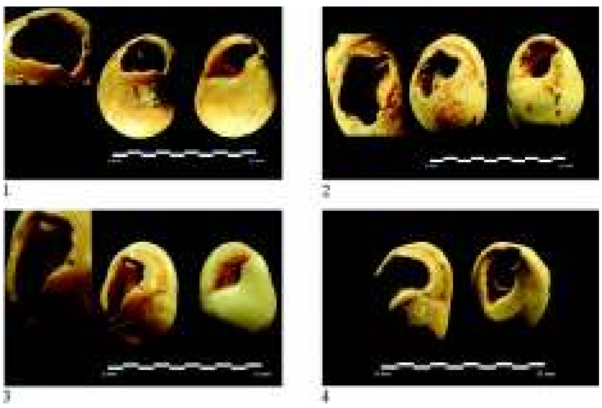

Figure 9. *Cyclope neritea* wiht different wear stages. 1, from level II, perforation rounded towards the ring of the peristome. 2, from level I, rectangular perforation with limited wear. 3, from level III, perforation begins to fracture in the opposite direction to the ring of the peristome. 4, from level III, body whorl fractures completely, exposure of the columella, erasure of the internal lip denticles of the aperture, levelling of the convexity.

The second specie is ***Trivia arctica*** (Fig. 10.1,3,4); we have 8 specimens. Only 4 are complete and conserve the perforations. The rest conserve part of the broken perforations (Fig. 10.3) or are fragments.

The third specie is ***Trivia pulex***, represented by two specimens, one biperforated (Fig. 10.2) and other with only one perforation opposite to the siphonal canal.

All the *Trivia* are biperforated (except the *Trivia pulex* mentioned) and the location of the perforations is the same for all of them. We identified the technique of rotation together with pressure in one case (Fig.10.2) and we can observe the profile of the cross-section of the perforating tool.

The different degrees of wear are also interesting. In the complete specimens the ribs begin to lose their edges in the most convex surfaces (Fig. 10.1) and can form a facet in the convexity (Bonnardin 2003: 99-114). In the fragments that did not conserve the perforations, we found this kind of wear almost perforating the shell (Fig. 10.4).

The fourth specie represented is a freshwater one (Fechter & Falkner 1993) – in fact, the only freshwater type. Of 6 specimens of ***Theodoxus fluviatilis***, 2 are perforated by rotation, 1 has a manufacture fracture of the perforation, and finally three complete specimens without perforations we interpreted as a stock of raw material.

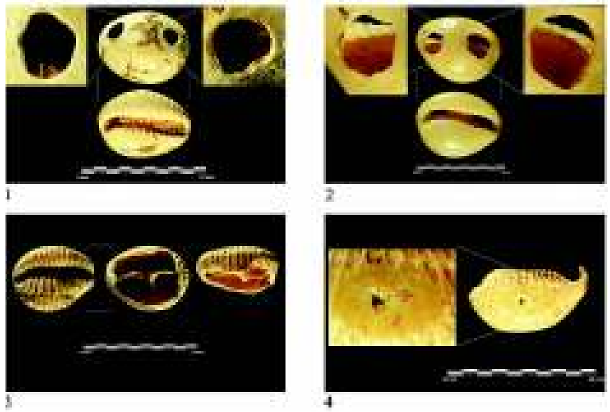

Figure 10. *Trivia* with different degrees of wear. 1, *Trivia arctica*, from level III, the ribs begin to lose their edges in the convex surfaces. 2, *Trivia pulex*, from level II, technique of rotation together with pressure. 3, *Trivia arctica*, from level II. 4, *Trivia arctica*, from level III, the wear can form a facet in the convexity and almost perforate the shell.

The next specie is ***Littorina obtusata***. We have two specimens with the perforation broken by use (Fig 11.1, 2). The perforations of the *Littorina obtusata* are of a considerable size. The technique used is internal pressure or indirect percussion.

We also have one specimen of ***Nassarius reticulatus*** perforated by internal pressure and with signs of suspension (Fig. 11.3).

Finally, there is a doubtful marine gastropod (maybe ***Columbella rustica*** or *Nucella lapillus*) perforated by multidirectional abrasion (Fig. 11.4). This specimen has its outer lip abraded, so that, part of the body whorl has disappeared and the aperture and the siphonal canal did not conserve its original morphology.

The three atrophied red deer canines have been perforated by the same technique, bipolar rotation. The perforations are made in the medial part of the root; with biconical morphology and circular striae left by the tool used to make them. The

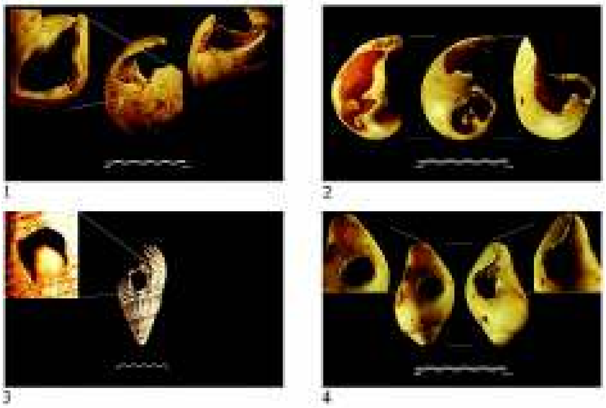

Figure 11. 1, *Littorina obtusata*, from level III, perforation broken by use. 2, *Littorina obtusata*, from level I, perforation broken by use. 3, *Nassarirus reticulatus*, from level III, perforated by internal pressure and signs of suspension. 4, doubtful marine gastropod, from level III, perforated by multidirectional abrasion and with the outer lip abraded. Part of the body whorl has disappeared and the aperture and the siphonal canal did not conserve its original morphology.

specimen from Level III has an incomplete perforation but the part that remains has the same characteristics as the rest of the canines. The wear on the specimen from Level I, despite the superficial fissures and rises, reflects a possible lateral attachment.

5. ORIGIN OF RAW MATERIALS AND IMPLICATIONS FOR HUMAN MOBILITY AND ACTIVITIES PRACTICED ON THE SITE

Considering the origin of manufactured species of mollusc ornaments to establish a relation with the coasts, we can say that *Cyclope neritea* is a typically Mediterranean species, since by their habitat requirements they could not colonize Atlantic coasts in cold periods (Álvarez-Fernández 2006, Taborin 1993), although nowadays the former proliferates on Cantabrian beaches (Palacios and Vega 1997). *Trivia pulex* currently only appears in the Mediterranean sea (Brunet and Capdevila 2005). *Trivia arctica* and *Nassarius reticulatus* could be Atlantic or Mediterranean (Lindner 2000).

The only species with some controversy about its origin is *Littorina obtusata* that currently only proliferates in the Atlantic coasts (Lindner 2000, Palacios & Vega 1997). Its presence in Mediterranean sites like Cueva Ambrosio (Ripoll 1998) and Cueva de Nerja (Jordá *et al.* 2008) could be explained by colonizations in cold periods of typical Atlantic species in the Mediterranean Sea (Álvarez-Fernández 2006; Taborin 1993) but the explanation of long distance contacts could be admissible too, so we might consider both origins - Atlantic or Mediterranean - possible for *Littorina obtusata*.

But the question is how did these marine molluscs arrive at the site?

The first hypothesis could be that the inhabitants of La Peña de Estebanvela had direct access to the coasts. If this was true, we must ask why we do not have any complete marine specimens without perforations stocked as a raw material like the *Theodoxus fluviatilis*.

We might say that these personal ornaments made on marine molluscs were not manufactured in the site; again, we only found failures during manufacture in the *Theodoxus fluviatilis*.

The other most reasonable hypothesis is that the inhabitants of La Peña de Estebanvela obtained these personal ornaments by some exchange with other groups. We know that the Magdalenian hunt-er-gatherer groups that lived in La Peña de Estebanvela were there during the summer, the autumn and beginnings of the winter (Cacho *et al.* 2006, Yravedra 2005) and it is possible that during the rest of the year they moved towards the north looking for better climatic conditions and then they obtained these personal ornaments. Unfortunately the lack of archaeological registries in the Plateau cannot corroborate this hypothesis for the moment.

The only perforated teeth we found at the site are the three red deer atrophied canines. The preference for this support does not have a direct relation with the consumed fauna present at the site, which are always more diverse (Yravedra 2005). That there is a material choice is clear, but for the moment we are not able to establish if the canines correspond to the same red deer individuals present in the faunal assemblage or if they arrived at the site by another means.

6. CONCLUSIONS

The presence of marine molluscs at the site (the nearest coast is more than 200 km away in a straight line) clearly indicates a mobility of the hunter-gatherer groups in the Upper-Late Magdalenian. In the same way it is important to underline that most of the personal ornaments have a high degree of wear; some of them had been used till they were unsuitable, indicating the symbolic value of these objects. The choice of atrophied red deer canines to perforate informs us also about the inclusion of these personal ornaments inside a symbolic world.

The identification of the techniques used for the manufacture of the perforations has not been as productive as we thought at first, although as we have seen it has served us to identify some of them. However we cannot identify an evolution or preference for any particular technique through the sequence.

We also identified wear traces and fracture models repeatedly. That could indicate a specific way to wear these objects on the body.

In the cases in which we have not been able to identify the techniques of the perforations we cannot exclude the possibility that these specimens were gathered because they were already perforated naturally, as some authors point out (Vanhaeren & D'Errico 2001: 201-240). Clearly, this option would have been the easiest one. If this were the case we could incorporate another question about the selection of raw material but the data are currently insufficient to affirm or to reject this possibility.

We know that the archaeological collection is too limited to make many general conclusions. Now we know that these personal ornaments had important symbolic value for the inhabitants of la Peña de Estebanvela. We are sure that in coming years the site will give us the possibility to amplify our study and will provide some more answers to our questions.

7. ACKNOWLEDGEMENTS

This paper is the result synthesis of the research carried out to apply for the Diploma de Estudios Avanzados on September 2006. I want to thank the Vicerrectorado de Investigación de la UNED who granted me a FPI scholarship to carry out this project. Sergio Ripoll and Carmen Cacho, who entrusted me with the study of the personal ornaments of La Peña de Estebanvela. Aline Averbouh who supervise the experiments. And finally I want to thank Elisabeth Stone for her friendly revision of the English version of this work.

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Magdalenian marine shells from El Horno Cave (Ramales, Cantabria, Spain) in the regional context

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Magdalenian marine shells from El Horno Cave (Ramales, Cantabria, Spain) in the regional context

La fauna malacológica marina del yacimiento magdaleniense de El Horno en su contexto cantábrico

KEY WORDS: Magdalenian, Cantabrian Spain, malacological record, shell beads.
PALABRAS CLAVE: Magdaleniense, Región Cantábrica, registro malacológico, objetos de adorno-colgantes sobre concha.
GAKO-HITZAK: Magdaleniarra, Kantaurialdea, malakologia-erregistroa, maskorrez egindako apaingarriak-zintzilikariak.

Miguel Ángel FANO[1], Esteban ÁLVAREZ-FERNÁNDEZ[2]

ABSTRACT

The aim of this paper is to present the available information about the intensity and way in which the Magdalenian groups at El Horno Cave exploited the malacological resources provided by the Bay of Biscay. The location of the site, in the upper Asón Valley and a long way from the coast, gives a specific weight to the malacological record within the analysis of the population dynamics of the societies being studied. In the case of El Horno, hardly any evidence has been found that the malacological resources were used as food, but in contrast, they were used to make personal ornaments. Other late-final Magdalenian sites in the interior of Cantabrian Spain, like the deposits in the Asón Valley, have yielded small numbers of molluscs with and without bromatological value. However, most of the malacological material was equally transformed into objects of adornment.

RESUMEN

El artículo tiene por objeto presentar la información disponible acerca de la intensidad y el modo en el que los grupos magdalenienses de El Horno explotaron los recursos malacológicos proporcionados por el Mar Cantábrico. La localización del asentamiento, en la parte alta del valle del río Asón y alejado del litoral, proporciona un peso específico al registro malacológico a la hora de analizar la dinámica del poblamiento de las sociedades estudiadas. En el caso de El Horno, apenas existen evidencias de un aprovechamiento alimenticio de los recursos malacológicos, pero sí en cambio de su transformación en objetos de adorno personal. Al igual que ocurre en la cuenca del Asón, otros yacimientos interiores de la región cantábrica con ocupaciones del final del Magdaleniense han proporcionado escasos moluscos con y sin interés bromatológico. Ese material malacológico también fue transformado, en su mayor parte, en objetos de adorno-colgantes.

LABURPENA

El Hornoko magdaleniar taldeek Bizkaiko golkoak emandako malakologia-errekurtsoak ustiatzeko intentsitateari eta moduari buruzko informazioa ematea da komunikazioaren helburua. Kokalekua Ason ibaiaren goiko aldean zegoen, itsasertzetik urrun, eta horrek ikertutako gizarteen populatzearen dinamika aztertzean pisu espezifiko handia ematen dio malakologia-erregistroari. El Hornoren kasuan, ez dago ia malakologia-baliabideak jateko erabiltzen zituztenaren ebidentziarik, baina bai apaingarriak egiteko erabili izanaren ebidentziak. Ason ibaiaren arroan gertatzen den moduan, Magdaleniarraren amaierako kantaurialdeko barrualdeko beste aztarnategi batzuetan ere, interes bromatologiko handiagoko edo txikiagoko molusku gutxi agertu dira. Malakologia-material hori ere transformatua izan zen; batik bat, apaingarriak eta zintzilikariak egiteko.

1. INTRODUCTION

In general, a Palaeolithic settlement begins to make sense and can be interpreted correctly in its regional context. Without doubt, the mobility of hunter-gather groups makes it difficult to understand a site in isolation, and consequently studies at a regional scale become especially pertinent (*cf.* Price and Peterkin 2000, Boyle 2000).

In the particular case of Cantabrian Spain, various studies have reflected the question of territories and mobility of societies in the late Palaeolithic (see recent reviews by González Sainz and González Urquijo 2007, Terradas *et al.* 2007), but the references for their reflections have been the traditional analytical units (middle and late Magdalenian…) and, apart from the occasional exception (Menéndez *et al.* 2005), the Cantabrian corridor as a whole. At the same time, contributions have been made about different kinds of contacts with societies in more or less distant areas, such as the Pyrenees or southwest France (see, among others, Fritz *et al.* 2007, Corchón *et al.* 2009).

As a result, high-quality information is beginning to come available about the circulation of materials

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such as flint, or ideas such as those connected with technical processes or graphic activity. This data enables trends to be defined at a macro-spatial level, like the reduced mobility seen in Cantabrian Spain after 12,500/12,000 BP (González Sainz 1989; González- Sainz & González Urquijo 2007). However, information about the circulation of materials, ideas and possibly people over middle or long distances, to be understood more fully, needs to be supported by knowledge about population dynamics at a local scale. It would be difficult to understand long distance interaction if we did not know the relationship of sites with their immediate surroundings (Fano and Rivero, in press).

The problem arises when this scale is to be defined, given the difficulty in determining the territory occupied by hunter-gatherer societies. In the current case, the Asón valley has been chosen as the unit of study, so as to define, within the framework of a medium-term project, population dynamics in the area during the period 13,000-11,500 BP, normally denominated the late-final Magdalenian (LFM).

The establishment of this model requires a comparative study between the different settlements that were occupied during this time. In the first place, this analysis must examine the typology, technology and functionality of the lithic and bone implements that were used; their manufacture (phases of the *chaîne opératoire* that have been identified) and the types of activities that were carried out. Equally important is the identification of the areas of provenance of the lithic raw materials. Secondly, the food resources that were exploited at each settlement should be compared, with special attention given to the way in which they were managed. Thirdly, a comparative study should be made of materials that were especially significant from the cultural point of view, such as portable art objects and other artefacts used as personal ornamentation, which can also be analysed from the viewpoint of the *chaînes opératoires*. The reconstruction of these makes it possible to compare different settlements and explore whether the same model of graphic representation existed in artistic production within the area of study (Fritz 1999).

The analysis described above will contribute to define the role played by each settlement within its regional context, but this definition will need a specific study of the characteristics of each site (Fano 2001). In this sense, we begin with the premise that intentionality existed behind the choice of each site, and therefore it is also very likely that a reciprocal relationship existed between the characteristics of the settlement and the activity that was carried out in and/or from that place. Consequently, a link could be found between the characteristics of the site and the remains left behind by the activity carried out by the human group – the archaeological record *sensu stricto*. It is therefore important to analyse those factors that determine the habitability conditions of the settlement. If we assess objectively the characteristics of the occupied areas, our hypothesis about the role played by each site in its regional context will become more solid.

In summary, the aim is to introduce a more integrated perspective to the social facts provided by archaeological research. If we attempt to achieve a representation of the organizational strategies of hunter-gatherer societies in the late Palaeolithic, each of the types of analysis mentioned above should be conceived within an overall framework of research (*cf.* Terradas 2001).

It cannot be denied that the approach described above must face a large number of difficulties, and these should be taken into account when the solidity of the resulting model is assessed. Among these difficulties are, in the first place, the problem of determining how representative the archaeological record is; in fact, only in recent years have we known of the existence of late Magdalenian habitation areas in the upper Asón, apart from the well-known problem of the conservation and/or location of open-air settlements. In second place, closely connected with the former point, certain modifications to the environment oblige us not only to accept the loss of information, but also to take into account the morphology of the geographical area around the sites during the Palaeolithic. The variations to the landscape have been highly significant in places. This is the case of some Magdalenian sites located near the present-day mouth of the River Asón, i.e. within a completely different environment from the one the Magdalenian groups knew (Figure 1), because of the Flandrian transgressive episode.

Finally, in third place, we must mention a problem that is inherent in any spatial archaeological study, noted some years ago by I. Hodder and C. Orton (1990), and this is the relationship of contemporaneity that can be established between different sites. Thus, when we establish comparisons between archaeological levels for which no absolute dates are available, attributed to the same period because of the material that has been recovered from them, it is difficult to know whether we are relating occupations that actually are close in time. Even if the levels have been dated, many factors have to be considered when we assess how representative the determinations are, such as the factors connected with the dynamic processes that intervene in the formation of Palaeolithic sites (Texier 2001).

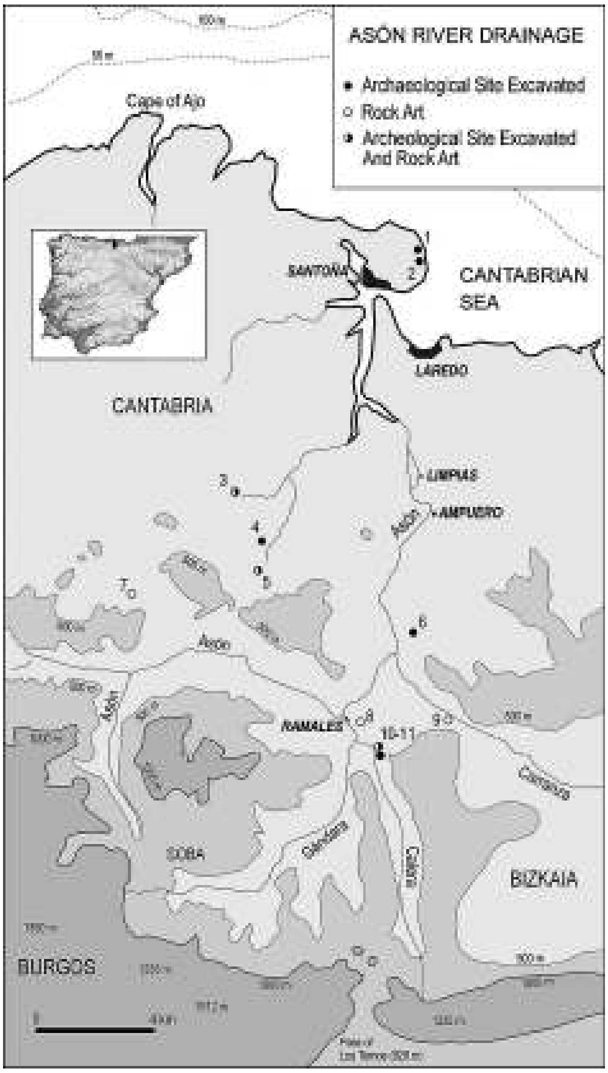

Figure 1. Location of El Horno Cave and other late Magdalenian sites in the Asón Valley. A number of Magdalenian cave art sites are included as they could correspond to the period being studied. 1. La Fragua; 2. El Perro; 3. El Otero; 4. La Chora; 5. Cobrantes; 6. El Valle; 7. Los Emboscados; 8. La Cullalvera; 9. Sotarriza; 10-11. El Mirón and El Horno.

In this paper we point out the role that malacological fauna could play in the development of the above-mentioned model. To achieve this, we use the information that has already been published about objects of adornment made from shells found at El Horno Cave, during the first excavation seasons (1999-01) (Vanhaeren *et al.* 2005, Álvarez-Fernández 2006). In addition, we incorporate into the discussion data on ornamentation found in the latest seasons (2004-07) (Figure 2), and the few unmodified archaeomalacological remains found during all the fieldwork. Because of its provenance, this archaeological material is especially interesting for understanding population dynamics in the Asón Valley, above all in the case of shell beads. The mere discovery of adornments made from shells at a montane site is in itself a significant fact. At the same time, personal ornamentation is one of the most significant elements from the cultural point of view, a circumstance which makes it particularly useful to characterize Palaeolithic societies. It constitutes a vehicle of expression, with very varied functions, capable of acting as a form of cohesion for a human group and also as a differentiating element of a group in its social context (Álvarez-Fernández 2006, Taborin 1993, Vanhaeren 2002, White 1999). Certain factors, such as their dispersion in time and space, their relative abundance, their essentially symbolic function, and the possibilities of updating studies, favour this proposal (Vanhaeren *et al.* 2005).

As will be shown in the course of this study, we do not always possess high-quality data. For example, old excavation reports do not provide information about the horizontal distribution of the objects and the non-use of screens to fine-sieve the sediment (this practice was only introduced in Cantabrian Spain in the 1960s) caused the loss of most small-sized objects. The material found by old excavations is susceptible to taphonomic, archaeozoological, morphometric and technological analysis; but the true worth of the data is only achieved through the comparison with other objects recovered by modern excavations. Finally, another significant bias is produced by the lack, until very recently, of an analysis of the full *chaîne opératoire* of the objects of adornment. In our case, the *chaîne opératoire* analysis has been combined with experimental studies and a visual examination of the archaeological material using a binocular magnifying-glass (Álvarez-Fernández 2006).

2. EL HORNO CAVE

El Horno Cave is situated at the base of an impressive vertical cliff, known as "Pared del Eco" (Wall of the Echo), on the south-west side of the hill Monte Pando, at 200m above sea level and 20km in a straight line from the present-day coastline. It was excavated by one of the authors (M. Á. Fano) during six seasons between 1999 and 2007, over a surface of 3.5 square metres.

Four main archaeological layers and a reworked superficial level were identified. The former consists of an archaeologically almost sterile Unit 3, above the bedrock; a Unit 2, attributed to the Upper-Late Magdalenian with a very typical bone assemblage; a Unit 1, that has also yielded Magdalenian remains; and a Unit 0 interpreted as a palimpsest of different prehistoric occupations. Radiocarbon dates for Unit 1 and 2 (12,530 ±

Figure 2. Magdalenian shell beads from El Horno Cave. 1-4: Turritella sp. (M32.522, N32.831, M33.30.15, N32.817); 5: *Nassarius reticulatus* (N32.1005); 6: *Nassarius incrasatus* (M32.718.1); 7: *Littorina obtusata* (N32.964.1); 8: *Trivia* sp. (N32.1065.1).

190BP [12862 ± 430 cal BC][1] ; 12,250 ± 190 BP [12481 ± 424 cal BC]) are consistent with the cultural attribution given to these layers on the basis of their archaeological content (Fano *et al.* 2005, Fano 2005).

The series of *in situ* levels could only be clearly identified in one part of the excavated area. In other parts (squares M33 and N33), Level 1 could not be identified with clarity and, although materials have been found at equivalent depths to the *in situ* levels, they lacked a clear sedimentary context. The study of the lithic and bone assemblages has shown that this part of the deposit generally includes materials of the same chronology as the intact levels. In fact, this context yielded proportions of retouched lithic artefacts that are intermediate between those of Level 1 and Level 2, although in general more similar to those of Level 2, as well as certain diagnostic osseous artefacts. It is therefore thought most likely that the suspended ornaments found in this context belong to the same period as the objects found in the *in situ* levels, and their stratigraphic provenance is given in this study with the denomination Level 1-2. However, only the objects from Levels 1, 2 and 3 have been included in the quantification of the remains (NR and MNI).

3. PRESENTATION OF THE MALACOLOGICAL ASSEMBLAGE

The NR of the malacological remains documented from the LFM levels at El Horno Cave comes to a total of 64, which correspond to a MNI of 37. Nearly 90% of the MNI are gastropods, and the remaining percentage consists of bivalves (Table 1 and Figure 3).

The molluscs with no dietary value predominate (91.2%). In fact all the identified gastropod species have no dietary interest. They are small marine gastropods, quite well-preserved and were almost certainly gathered on beaches. In some cases the signs of water and sand erosion can be recognized. Specimens with holes caused by perforating animals have also been documented.

The opposite occurs in the case of the bivalves. The three species possess dietary value and their shells have reached us in a fragmented and decalcified state. Consequently it is difficult to know whe-

[1] The calibrations were made with the CalPal 2007_HULU curve. The calculations were made with the CalPal programme (Weninger *et al.* 2007).

EL HORNO CAVE (Levels 1, 2, 3)				
Taxa	**NR**	**% NR**	**MNI**	**% MNI**
Gastropods				
Trivia sp.	8		8	
Littorina obtusata	3		3	
Littorina obtusata/fabalis	1		1	
Littorina sp.	4		1	
Nassarius reticulatus	2		2	
Nassarius mutabilis	1		1	
Nassarius incrassatus	1		1	
Nucella lapillus	1		1	
Turritella sp.	22		14	
Unidentified gastropods	3		1	
Total Gastropods	**46**	**71.87%**	**33**	**89.18%**
Bivalves				
Mytilidae family	12		1	
Cerastoderma sp.	2		1	
Ostrea sp.	1		1	
Unidentified bivalves	3		1	
Total Bivalves	**18**	**28.13%**	**4**	**10.82%**
TOTAL MARINE MOLLUSCS	**64**	**100%**	**37**	**100%**

Tabla 1. Abundance of taxa in Levels 1, 2 and 3 at El Horno.

Figure 4. Right: fragmented *Nassarius mutabilis* specimen from Level 1 at El Horno (N32.497.1). Left: whole specimen from Tito Bustillo Cave (Level 1a).

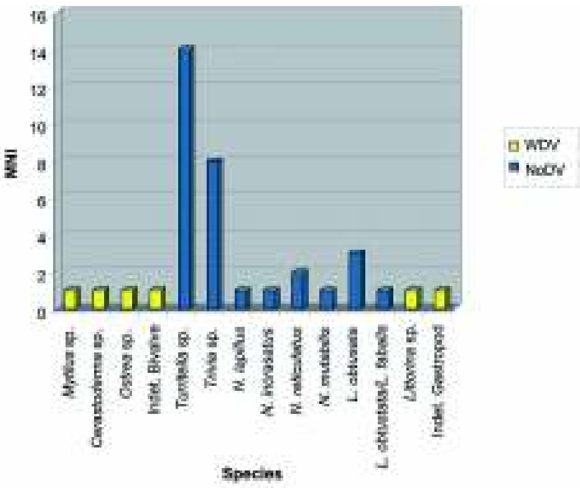

Figure 3. Marine molluscs (NR and MNI) from El Horno (Levels 1, 2 and 3) with dietary value (WDV) and without dietary value (NoDV).

ther they were gathered as food, or belonged to dead animals and were collected on beaches.

All the classified species, except one, are common on the Atlantic shores of North Spain (Bay of Biscay). Only the *Nassarius mutabilis* specimen has a Mediterranean provenance (Figure 4) (Taborin 1993). The find of an object from Mediterranean source, the result of long-distance interaction among Magdalenian societies, is not an isolated event at Late Glacial sites in Cantabrian Spain – compare, for example, the cases of El Mirón or La Garma A (Álvarez-Fernández 2006).

Some 20 shells have been modified. These are all gastropods and make up nearly 54% of the total number of molluscs from the site and nearly 60% of the gastropods. If we add the shell beads recovered from Level 1-2, the number of modified shells reaches 24. All the specimens are perforated near the aperture of the shell. In addition, some of them display wear-marks produced by their use and remains of ochre on their surface (Table 2). These circumstances all suggest that the shells were used as shell beads.

The full malacological assemblage includes objects with use-wear marks around the perforations (at least two *Turritella* sp., two *Trivia* sp. and a *Nucella lapillus*); perforated specimens with no wear-marks (*Turritella* sp.); shells that broke during the manufacturing process (at least one of the *Turritella* sp. specimens); and unmodified shells (*Trivia* sp. specimens, *Littorina obtusata* and *Turritella* sp.) that we interpret as the raw material for the manufacture of ornaments.

Almost all the specimens have a single perforation, located at the edge of the labrum, except for two *Turritella* sp. specimens, where the perforation is in the spirals, possibly because they were using shells which did not preserve the mouth. The only species with two holes is *Trivia* sp.; all the specimens possess one near the siphonal canal and another at the base of the shell.

The most common technique used to perforate the shells is pressure, with the hole being rounded off afterwards. Only in two cases (*Littorina obtusata, Nassarius reticulatus*) has abrasion been used as the perforating technique, and in one rotation was used (*Nucella lapillus*). Some 54.2% of the total number of adornments conserve the remains of ochre on their surface (Table 2).

Cat. number	Unit	Taxon	Number of Perforations	Location of Perforation	Perforation Technique	Use wear	Ochre
N32.7.2	1	*Turritella* sp.	1	2b	Pressure	No	No
N32.371	1	*Turritella* sp.	1	2b	Pressure	?	Yes
N32.7.1	1	*Turritella* sp.	1	2b	Pressure	?	No
N32.365	1	*Turritella* sp.	1	2b	Pressure	Yes	Yes
M32.522	1 or 2?	*Turritella* sp.	1	2b	Pressure	No	No
N32.831	1	*Turritella* sp.	1	6 broken	Pressure	Yes	No
N32.817	1	*Turritella* sp.	1	2b	Pressure	?	No
N32.5.1	1	*Trivia* sp.	2	Trivia type	Pressure	?	Yes
N32.357.1	1	*Trivia* sp.	2	Trivia type	Pressure	?	Yes
N32.1065.1	1	*Trivia* sp.	2	Trivia type	Pressure	Yes	No
N32.361	1	*N. lapillus*	1	2c	Scraping and rotation	Yes	Yes
N32.964.1	1	*L. obtusata*	1	2c	Abrasion	?	Yes
M32.718.1	1	*N. incrassatus*	1	2c	Pressure	?	No
N32.1005	1	*N. reticulatus*	1	2b	Abrasion	?	Yes
M33.30.14	1-2	*Trivia* sp.	2	Trivia type	Pressure	Yes	Yes
M33.29.7	1-2	*Trivia* sp.	2	Trivia type	Pressure	?	Yes
N33.49.10	1-2	*N. incrassatus*	1	2c	Pressure	?	Yes
N33.49.9	1-2	*L. obtusata*	1	2c	Pressure	?	No
M33.30.15	2	*Turritella* sp.	1	6 broken	Pressure	No	No
N32.379.2	2	*Trivia* sp.	2	Trivia type	Pressure	?	Yes
N33.54.1	2	*Trivia* sp.	2	Trivia type	Pressure	?	Yes
N33.53.1	2	*N. reticulatus*	1	2c	?	?	No
N33.51.3	3	*Turritella* sp.	1	2c	Pressure	No	No
N33.51.4	3	*Turritella* sp.	1	2c	Pressure	?	Yes

Table 2. Summary of some results of the shell beads analysis. The table includes information already published (Vanhaeren *et al.* 2005) together with data from the last excavation seasons. The four specimens from Level 1-2, probably ascribable to the LFM are also included. (Object N33.54.1 was cited as N32.54.1 in the previous publication.)

The *Nassarius mutabilis* specimen should probably be included within the personal ornamentation assemblage at El Horno, as when this species is found at archaeological sites it has usually been made into a shell bead, such as at Le Figuier (Gard, France), in a context with the same chronology as El Horno (Taborin 1993, Álvarez-Fernández 2006). However, the specimen from El Horno is fragmented and decalcified and it is difficult to reach a definite conclusion in this respect.

4. LOCAL AND REGIONAL CONTEXT

4.1. In the case of the Asón Valley, archaeomalacological analyses of greater or lesser detail have been made for four sites: El Perro, La Chora[2], El Otero and El Horno. Other sites are currently being studied (La Fragua and El Mirón). We cannot take the data from the excavations at El Valle into account, because of the dubious chronological attribution of the material[3].

Except at El Horno, in the cited deposits with available information, the malacological fauna is dominated by species with dietary interest. Although *Mytilus* sp., *Ostrea* sp. and *Cerastoderma* sp. are present at El Horno, in the lower part of the valley, taxa with no ornamental value predominate. Thus, in Levels 2 and 3 at El Otero, almost all the species have dietary value, and *Ostrea edulis* and *Patella* sp. are the most abundant molluscs (Madariaga 1966).

At El Perro, nearly 95% of the MNI are of dietary interest, with a predominance of *Patella* sp., followed by *Littorina littorea* and *Mytilus galloprovincialis* (Moreno 1994). At La Fragua, a similar

[2] At this site, all the cited species, except *Turritella* sp. have dietary value, and *Patella vulgata*, *Ostrea edulis* and *Crassostrea gigas* are abundant. At least one of the *Turritella* sp. specimens had been made into a suspended object of adornment (Madariaga 1963). However, the chronological attribution of the archaeological remains is unsure, as a later revision of the material revealed that the deposit at La Chora also includes an Azilian occupation (González-Sainz 1989).

[3] A *Turritella* sp. specimen was found, amongst other objects of adornment, during the original excavations carried out by H. Breuil and H. Obermaier between 1909 and 1912 (Álvarez-Fernández 2006). These objects were ascribed to a generic Magdalenian, probably late Magdalenian. Similarly, the scarce objects (1 specimen of *Turritella* sp. (NR:1) and 1 valve of Veneridae family (NR:1)) found by more recent excavations, which we have examined in the MRPAC, come from the G1C2/1 sondage, Level 1, strata 1.7, a context difficult to attribute chronologically (García-Gelabert and Talavera 2004, 163).

percentage of molluscs possess dietary value, with a predominance of *Patella vulgata* (Gutiérrez, in prep.).

As regards the species with no dietary value, the taxa used by the Magdalenian groups at El Horno to make their adornments are also found, to a lesser or greater extent, at the other sites in the Asón Valley. The data that has been published about El Mirón show the use of *Trivia* sp. and *Littorina obtusata* shells to make shell beads. The technological study of these objects indicates that the perforations in the three specimens were made by abrasion. The holes are located, in the case of the two *Littorina obtusata* specimens, in the area at the base of the shell; in the case of the *Trivia* sp. adornment, one near the siphonal canal and the other at the base of the shell. By observing the holes with a binocular magnifying-glass, no use-wear marks could be identified, nor any remains of ochre (Álvarez-Fernández 2006).

A few specimens that could have been gathered to make ornaments have been cited for El Otero. Based on the list of species given by B. Madariaga (1966), we suppose that these can possibly be identified as the marine gastropod *Charonia rubicunda*. Shell beads were found at La Fragua, made from taxa with no dietary interest (*Nassarius reticulatus,* Trivia sp. and *Turritella* sp.) (Gutiérrez, pers. comm.). In the case of El Perro, shells of the same species[4] found at El Horno have been cited, but the author of the study (Moreno 1994: 268) only indicates they are "possible materials for the manufacture of ornaments" without giving any further details about their possible modification. The above-mentioned finds at La Fragua confirm the need for a re-assessment of the malacological assemblage from El Perro.

The data we possess for shell beads in the Asón Valley, based on the direct study of material from El Horno and El Mirón, show differences in the location of the perforation in the case of the *Littorina obtusata* specimens. The two examples from the former site are perforated on the edge of the labrum, while the two objects found at El Mirón possess perforations at the base of the shell. In addition, at El Horno, the full *chaîne opératoire* can be reconstructed (presence of raw material, shells fractured during the process of manufacturing the perforation, and perforated shells with and without use-wear marks). In this way, it is likely that some of the beads were being made at the site, while others were abandoned in the cave after being used. In contrast, at El Mirón, based on the available information (Álvarez Fernández 2006), only part of the *chaîne opératoire* is represented (complete shell beads).

4.2. As occurs in the Asón Valley, the archaeological deposits in the interior of Cantabrian Spain with LFM occupations have yielded a small number of molluscs with and without dietary interest (Álvarez- Fernández 2008,). In general, most of the malacological remains have been made into suspended objects of adornment. In contrast, at sites located nearer the present-day coast line (<10km), the percentage of molluscs with dietary interest comes to over 95%, and the species with no dietary value are less common, and include a number of beads. Therefore, the quantitative data that has been obtained in recent years has confirmed, in general terms, the hypothesis suggested two decades ago using more precarious archaeomalacological information (González-Sainz 1989: 178).

The sites that are clearly more distant from the modern shore (>10km) for which quantitative data is available are: Las Caldas, Los Canes, Rascaño, Piélago I, Piélago II, El Horno and Erralla. At these sites the MNI is low, and the presence of suspended objects of adornment is common. At two locations (Los Canes and El Horno), the objects made into beads outnumber the unmodified shells.

At sites near or next to the present-day shore (<10km): La Riera, Morín, La Garma A, El Perro and Laminak II, the percentage of molluscs with dietary interest reaches between 95 and 100%. Other sites currently being studied appear to behave in the same way: La Pila, La Fragua (Gutiérrez, pers. comm.) and Santa Catalina (Berganza *et al.,* in press). One exception is Santimamiñe, a site which has recently been re-excavated and which contains very few malacological remains, including two perforated specimens of *Littorina obtusata* (Gutiérrez, pers. comm.)[5]. The malacological analyses carried out for La Riera and La Garma A also include technological studies that have verified the manufacture of adornments from gastropods with no dietary interest.

[4] They are 1 specimen of *Turritella* sp. (NR:1), 2 specimens of L. *obtusata/fabalis* (NR:2), 2 of *Trivia* sp. (NR:2), 8 of *Nucella lapillus* (NR:16) and 3 of *Nassarius reticulatus* (NR:4) (Moreno 1994: Table IV.3).

[5] This data confirms the influence of other factors, as well as the location of sites in relation with the coastline, in the greater or lesser presence of malacological remains (González-Sainz 1989: 177).

	Levels	MNI	Taxa	SB Nº?
Nalón drainage				
Caldas	0-II	6	*Chlamys varia, Pecten* sp., *Antalis* sp.	2
Sella drainage				
La Riera	24, 21-23	712	*Littorina littorea, Osilinus lineatus, Patella vulgata, Patella intermedia, Trivia* sp., *Littorina saxatilis*	1
Deva-Cares drainage				
Los Canes	2C	15	*Patella vulgata, Patella* sp., *Acanthocardia* sp., *Littorina obtusata* y *Trivia* sp.	11
Miera drainage				
Rascaño	2b	3	*Chlamys* sp., *Littorina obtusata, Terenidae* Fam.	1
Piélago I	5	1?	*Turritella* sp.	1
Piélago II	5, 7	8?	*Patella vulgata, Littorina obtusata*	1
Morín	2	8	*Patella* sp., *Patella vulgata, Mytilus galloprovincialis, Ruditapes decussatus, Scrobicularia plana*	0
Garma A	N, O	3007	*Patella* sp., *Patella vulgata, Patella intermedia, Patella ulyssiponensis, Osilinus lineatus, Littorina littorea, Mytilus* sp., *Mytilus galloprovincialis, Callista chione, Ostrea* sp., *Cerastoderma* sp., *Nucella lapillus, Nassarius incrassatus, Natica* sp., *Nassarius reticulatus, Trivia* sp., *Littorina obtusata*	4
Asón drainage				
El Horno	1,2,3	37	*Mytilus* sp., *Cerastoderma* sp., *Ostrea* sp., *Trivia* sp., *Nucella lapillus, Turritella* sp., *Nassarius reticulatus, Nassarius incrasatus, Nassarius mutabilis, Littorina obtusata*	20
El Perro	2C	977	*Patella* sp., *Osilinus lineatus, Littorina littorea, Mytilus galloprovincialis, Tapes/Venerupis, Ostrea* sp., *Cerastoderma* sp., *Gibbula* sp., *Nucella lapillus, Nassarius reticulatus, Trivia* sp., *Littorina obtusata/fabalis, Turritella* sp., *Littorina saxatilis,*	?
Oiz-Lea drainage				
Laminak II	II	387	*Patella vulgata, Patella ulyssiponensis, Patella intermedia, Patella* sp., *Osilinus lineatus, Littorina littorea, Mytlus galloprovincialis, Mytilaster minimus*	?
Urola drainage				
Erralla	II	2	*Osilinus lineatus, Patella* sp.	0

Table 3. Taxa documented at archaeological sites in Cantabrian Spain (drainage basins from west to east) with levels attributed to the LFM. The species without dietary interest are underlined. The number of shell beads (SB) recovered at each site is also given. Only sites with no ambiguities in the definite attribution of the materials to the LFM, and with detailed malacological analysis of the full stratigraphic sequence, are included.

Finally, the systematic review of malacological material carried out by one of the authors (E. Álvarez-Fernández) in recent years appears to confirm, with small differences, the observations made in a previous publication about the distribution of the various gastropod species made into adornments along the Cantabrian corridor (Vanhaeren *et al.* 2005). In general, the species seen at El Horno are the ones most commonly found at Magdalenian sites in Cantabrian Spain (Álvarez-Fernández 2006: 293). If we refer to definite contexts, i.e. those with no apparent mixing of materials belonging to different periods, we can observe that except for *Nassarius reticulatus*, a very rare species in the region with only 10 specimens known, the species found at El Horno are present in the Magdalenian contexts in the western part of the region (Entrefoces, La Paloma, Las Caldas, Cueto de la Mina…). However, if we reduce the chronology and refer exclusively to the final part of the Magdalenian period, we can see that, except for *Trivia* sp., the other species documented at El Horno are not common in that area. If we only consider sites with no ambiguities in their chronology, the single exception is the find of *Littorina obtusata* at Los Canes. In the Miera valley (Rascaño, Piélago II…) the presence of the gastropods found at El Horno become more common, with a more or less clear continuity in the record towards the east as far as the interior of France (*cf.* Vanhaeren *et al.* 2005). It is not easy to find an explanation for this fact. Perhaps it is related to sampling problems, as specimens of the gastropod species being studied here are present at late glacial sites in western Cantabrian Spain whose chronology is uncertain. In any case, specimens of some of the species found at El Horno have been documented at definite Azilian sites in the west of the region, such as Oscura de Ania or Los Azules (Álvarez-Fernández 2006).

5. CONCLUSIONS

El Horno has provided significant information for understanding the relationship of final Magdalenian societies with the Bay of Biscay. This relationship is not well known, as several factors seriously affect an ideal understanding of it. This is the case of the environmental transformations mentioned above. Above all, we know that the Flandrian transgressive episode certainly affected the late glacial coast. The main conclusion of this is that an important part of the archaeological record corresponding to the final Palaeolithic is missing. Consequently, data from late Magdalenian coastal sites is not available and it is not easy to assess the relatively small volume of malacological remains, in comparison with later periods. We may wonder if we lack the rich malacological assemblages of the truly coastal settlements, now submerged under the sea or covered by sediments. In any case, other especially significant data from the cultural point of view, such as that provided by the study of cave art, appears to prove that human societies at the end of the Palaeolithic were fully familiar with the marine environment (Fano *et al*. 2008).

The finds of marine malacological remains at a montane site such as El Horno also provides significant data for the analysis of the organizational strategies of the hunter-gatherer groups being studied. The marine malacofauna that has been analysed appears to confirm that the Magdalenian groups who occupied El Horno did not exploit the marine environment from the settlement, as species with dietary interest are rare at the site. This is the usual situation at inland sites in the late Magdalenian, and logically contrasts with the malacological record at coastal sites, where taxa with dietary interest predominate. Instead, the marine malacofauna that has been found at El Horno was used as the raw material to make shell beads, which demonstrates that the Magdalenian groups using the cave maintained a relationship with the coastal environment. The available record shows how the raw material was taken to the site, where all parts of the *chaîne opératoire* have been documented: unmodified gastropods, shells broken during the manufacturing process, and beads with and without use-wear marks. The coastal resources were probably exploited from other sites nearer the shore. In fact, preliminary information about the seasonality of hunting at different settlements in the Asón valley during the LFM, such as at El Horno (late winter and early spring), El Mirón (late spring and summer) and La Fragua (late summer and autumn) (*cf.* Costamagno and Fano 2005, Marín 2008, Marín and González Morales 2007) is coherent with a model of territorial management based on mobility. This logistical and/or residential mobility is responsible for the presence of the malacological material at El Horno. Coastal sites like El Perro, La Fragua (Figure 1) and other sites which have been lost because of the changes to the environment, may have been used by the same hunter-gatherer groups who occupied El Horno.

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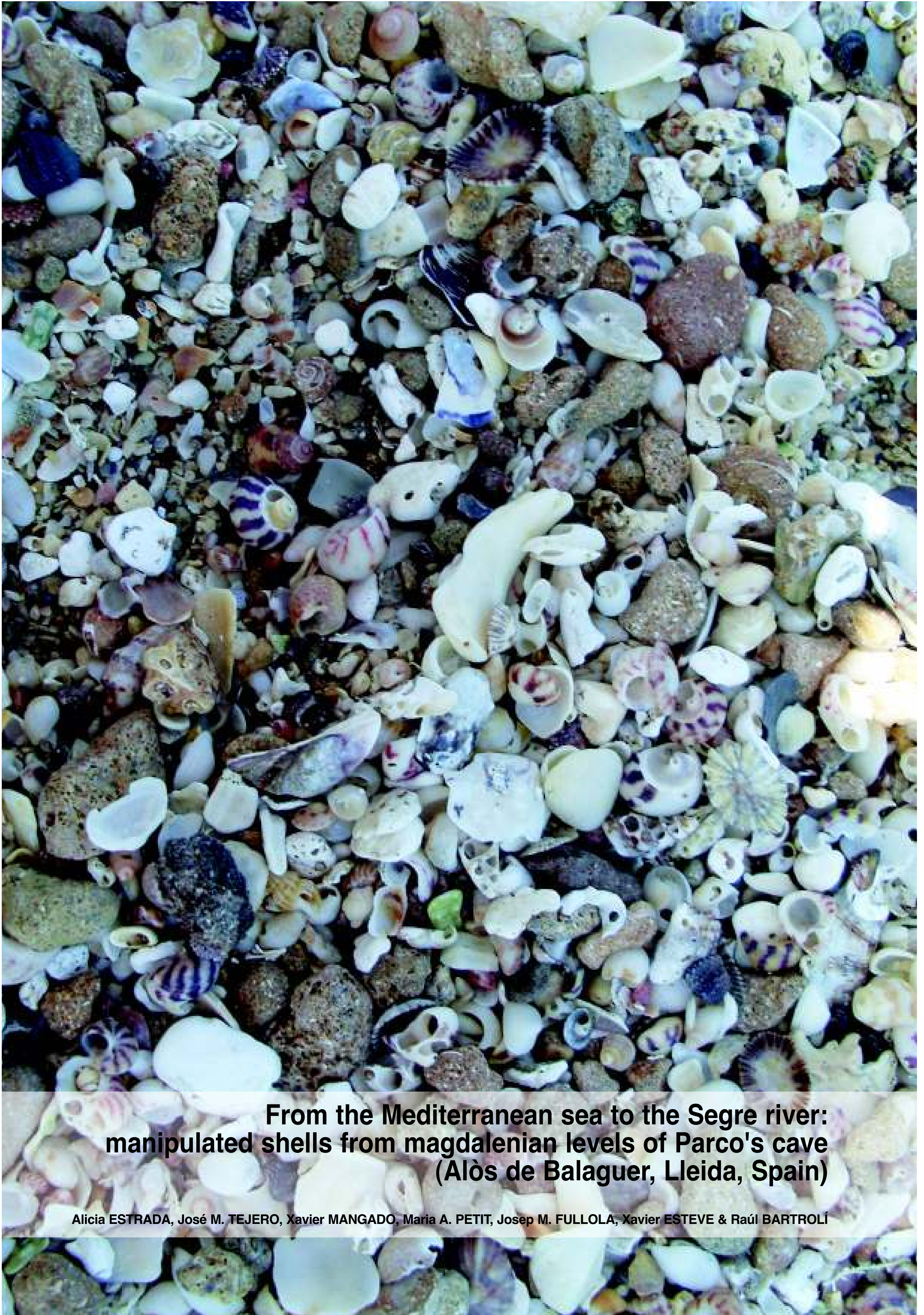

From the Mediterranean sea to the Segre river: manipulated shells from magdalenian levels of Parco's cave (Alòs de Balaguer, Lleida, Spain)

Alicia ESTRADA, José M. TEJERO, Xavier MANGADO, Maria A. PETIT, Josep M. FULLOLA, Xavier ESTEVE & Raúl BARTROLÍ

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Del Mar Mediterraneo al río Segre: Conchas manipuladas de los niveles magdalenienses de la Cueva de El Parco (Alòs de Balaguer, Lleida, España)

KEY WORDS: Manipulated shells. Magdalenian. Upper Paleolithic. Catalonia. Spain.
PALABRAS CLAVE: Conchas manipuladas antrópicamente. Magdaleniense. Paleolítico superior. Cataluña. España.
GAKO-HITZAK: Antropikoki manipulatutako maskorrak. Magdaleniarra. Goi Paleolitoa. Katalunia. Espainia.

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ABSTRACT

Discovered in 1974, Parco's Cave has been the object of intensive and systematic excavations by the Seminari d'Estudis i Recerques Prehistòriques (SERP) of the University of Barcelona since 1987. The malacofauna remains obtained from the upper Magdalenian level (N. II) will be presented and discussed. To date, more than 40 evidences have been identified; among these taxa we distinguish the presence of exclusively fluvial species, such as *Teodoxus fluviatilis*, as well as exclusively marine species, such as *Homalopoma sanguineum* and *Cyclope neritea* – both being strictly of Mediterranean origins. While the origin of the former raises no question whatsoever since their catchment was done from the nearby river Segre, the procurement of marine gastropods, however, which has been identified so far exclusively in Cantabrian sites could suggest the possibility of a new doorway through the Ebro Basin, thereby strongly pointing to the possibility of a new way between the Mediterranean Basin and the Cantabrian area other than the commonly known North Pyrenean corridor. Here, we shall also report on the taxonomical, technological as well as the Geographical Information System (GIS) data of perforated shells found at Parco's Cave.

RESUMEN

Descubierta para la Prehistoria en 1974, la Cueva de del Parco ha sido objeto de excavaciones sistemáticas por el SERP de la Universitat de Barcelona desde 1987. De estos trabajos, todavía en curso, procede un conjunto de malacofacuna recuperada en el nivel Magdaleniense superior (N. II) que presentamos en este trabajo. Los efectivos hallados hasta el momento contabilizan más de cuarenta ejemplares. Entre los taxones presentes en el yacimiento se cuentan tanto especies fluviales - *Teodoxus fluviatilis* –, como marinas – *Homalopoma sanguineum, Cyclope neritea, Dentalium* sp., *Chlamys* sp. *y Glycymeris* sp. –. La procedencia de los primeros no plantea ningún problema (recolección en el río Segre a unas decenas de metros del yacimiento). En cambio, el aprovisionamiento de *H. sanguineum* y de *C. neritea* abren la posibilidad de una vía de contacto a través del Valle del Ebro que excluye, como única zona de paso entre el Mediterráneo peninsular y la zona cántabra, al corredor nordpirenaico. En este artículo presentamos los datos taxonómicos, tecnológicos y de distribución espacial de las conchas perforadas de Parco y señalamos las implicaciones territoriales referidas que su repartición geográfica parecen señalar – El Valle del Ebro como vía de comunicación entre el ámbito mediterráneo y cantábrico peninsulares –.

LABURPENA

Historiaurreko Cueva del Parco 1974. urtean aurkitu zuten, eta bertan Universitat de Barcelonako SERPek indusketa sistematikoak egin ditu, 1987. urteaz geroztik. Oraindik amaitu gabe dauden lan horietan, Goi Magdaleniarreko mailan (II. m.) jasotako malakofauna-multzo bat aurkezten dugu lan honetan. Orain arte berrogei aletik gora aurkitu dira. Aztarnategiko taxonen artean ibaiko espezieak –Teodoxus fluviatilis– nahiz itsasokoak –*Homalopoma sanguineum, Cyclope neritea, Dentalium* sp., eta *Glycymeris* sp. – ageri dira. Lehenengoen jatorriak ez du arazorik sortzen (Segre ibaian bilduak, aztarnategitik dozenaka metrotara). Aldiz, Homalopoma eta Cyclopeen hornikuntzak adierazten du Ebro Bailaran zehar bide bat egon zitekeela, eta Mediterraneo penintsularretik kantaurialderako pasabide bakarra ez zela Pirinioen iparraldeko korridorea. Artikulu honetan, Parcoko maskor zulatuen datu taxonomikoak, teknologikoak eta haien banaketari buruzkoak aurkezten ditugu, eta haien banaketa geografikoak itxuraz adierazten dituen lurralde-inplikazioak erakusten ditugu –Ebro Bailara, penintsulako mediterraneoko eta kantaurialdeko eremuen arteko komunikabidea–.

1. INTRODUCTION

Parco's Cave is located in the North-Eastern part of the Iberian Peninsula. The site is situated in the Montsec pre-Pyrenean calcareous range at an elevation of 420 m. above sea level, and faces south overlooking the Segre river, which is 120 m. below (Fig. 1).

The site was discovered in 1974, first works were made by Professor Maluquer de Motes, who dug a deep sounding affecting Magdalenian levels. From 1987 we are studying the site from a spatial point of view (Mangado *et al.* 2007).

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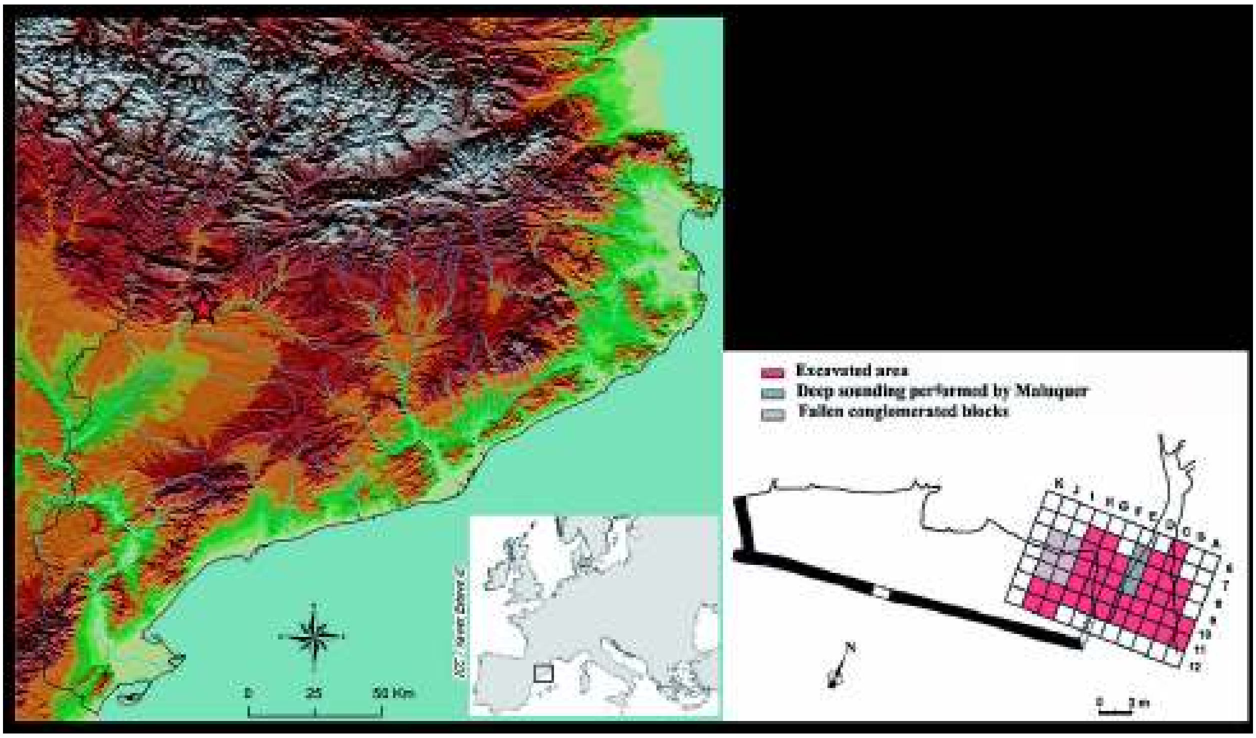

Figure 1. Location and plane of Parco's Cave.

Morphologically, Parco's Cave consists of a cave that opens to the west into a rockshelter. The cave gallery is 10.5 m. long. The rockshelter is rectangular in shape, approximately 5.5 m. wide (Fig. 1).

Level II covers an area of approximately 16 m^2 into the cave and 30 m^2 in the rockshelter (Fullola *et al.* 2006).

The site presents a long stratigraphical sequence corresponding from the Bronze Age to Upper Magdalenian levels and probably Middle Magdalenian. In this paper we will present only the malacofauna data corresponding to the Magdalenian levels excavated until now. They are dated between the 13th and 14th millennia BP (Table 1).

GEOLOGICAL LEVELS		ARCHAEOLOGICAL LEVELS		
Level	Dates	Level	Dates	Fire pits
		II	12,605+60 BP	Epigonal Level
			12,560+130 BP	EC17
			12,460+60 BP	EC18
			13,175+ 60 BP	EC19
			13,025+ 50 BP	EC25
			13,090+50 BP	EC39
III	13,070+140 BP			
IV	12,900+130 BP			
v	13,890+130 BP			
VIb	13,950+150 BP			
VII	13,720+140 BP			
XI	14,300+150 BP			

Table 1. ^{14}C datations

Lithic and bone industry are related to final upper Magdalenian and upper Magdalenian periods. A high number of different kinds of fire pits and debris deposits have been documented.

Lithic assemblage is mainly based on blade technology to obtain blades and bladelets as supports for a wide number of different tools as end-scrapers, burins, retouched and pointed bladelets. Some microburins and scalene bladelets have been also documented (Fig. 2).

Raw material analyses allow us to define a double catchment strategy. On one hand, local chert is the main raw material used for the manufacture of chipped stone tools. On the other hand, a regional chert source is privileged for tool manufacture of retouched bladelets and some end-scrapers and burins (Mangado 2005).

The best types represented in the bone industry are projectiles, needles and ornaments which we present in this paper (Fig. 2).

A strict correspondence between raw material and type is observed. The projectile points are made of red deer antler (*Cervus elaphus*), whereas for the needles people used bones more likely obtained from food remains.

Two types of spear points have been recognized, both characteristic of this upper Palaeolithic phase: spear points with simple or double bevel.

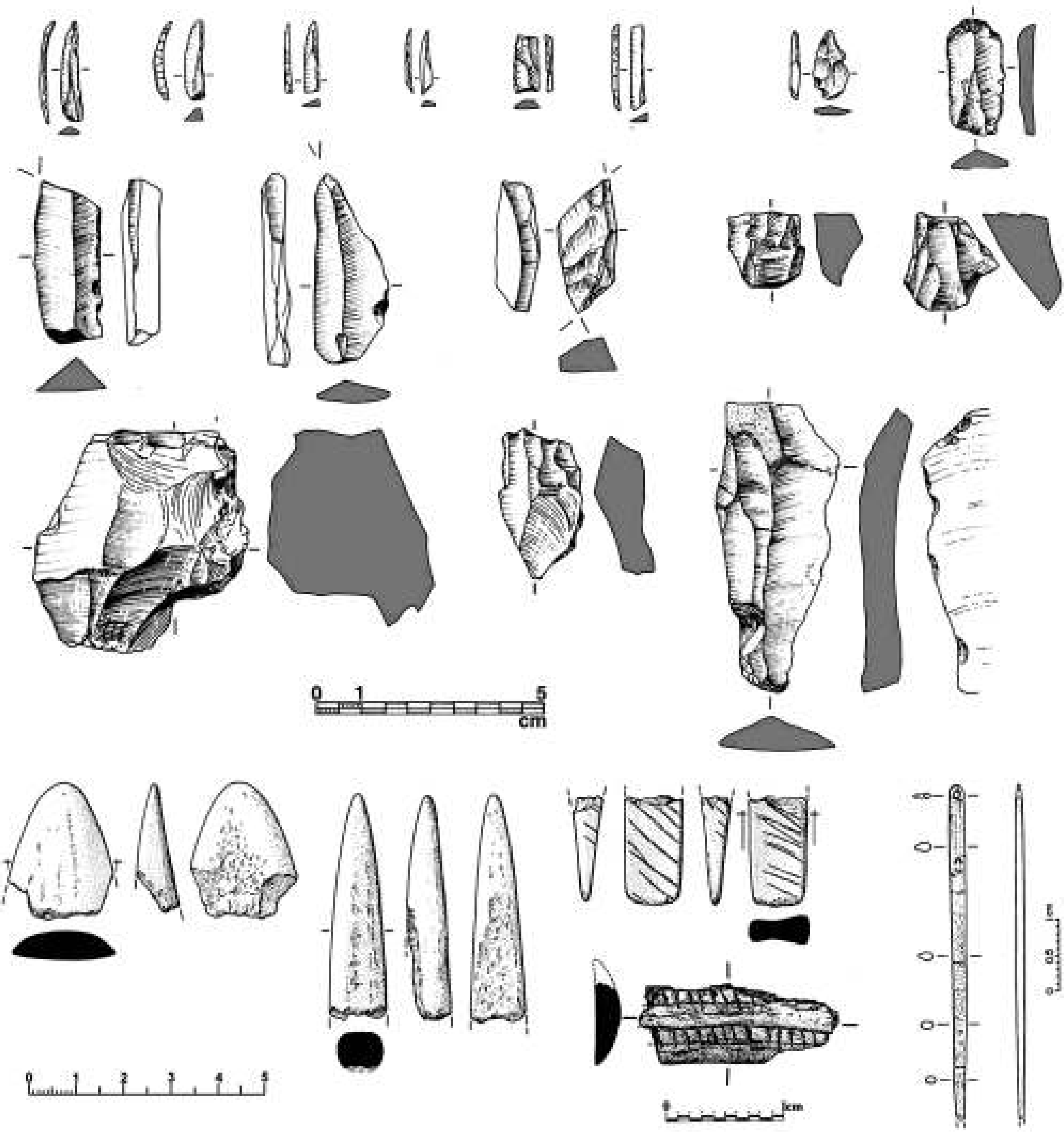

Figure 1. Lithics and bone industry remains from Magdalenian levels (Desings R. Álvarez).

The different stages of tool production of this bone industry start from the preparation of blanks ("baguettes") by double-grooved. The final morphology of the object is obtained using the scraping technique and - rarely - a finishing abrasive (Tejero 2005, Tejero and Fullola 2008).

Faunal analyses show that rabbit (*Oryctolagus cuniculus*) and wild goat (*Capra pyrenaica*) are the most frequent taxa, the last one being characteristic of the steep surroundings in which the cavity is located (Nadal 1998).

Faunal remains included species such as red deer (*Cervus elaphus*), european roe deer (*Capreolus capreolus*), wolf (*Canis lupus*) and trout (*Salmo trutta*).

The faunal remains, raw material procurement, lithic technology, micro use-wear analysis, and complexity of occupations, allow us to define this site as a seasonal, recurrent and relatively long term temporary settlement.

2. TAXONOMICAL AND TECHNOLOGICAL DESCRIPTION OF SHELLS

- Taphonomic aspects

The condition of the malacological evidences at the site is generally good. In some elements (*Dentalium, Cyclope*) there are signs of erosion after deposition due to rolling in the sand. Fractures can be observed at the perforation level probably related to the use to which pieces have been put and which will be determined in future studies of the whole remains. Also, as mentioned in the materials description, some of the shells show ochre remnants (bivalves) and one, a *Homalopoma* (7D-2025), shows thermo alteration.

We have documented six different types of malacological evidence among the archaeological remains provided by the excavation of level II since 1991 to 2008 (Table 2. Fig. 3):

Taxon	Manipulates	Non manipulates	TOTAL	Origine	Class
Chlamys sp.		1	1	Marine shell	bivalves
Theodoxus fluviatilis	6		6	Fluvial shell	gastropodes
Homalopoma sanguineum	8	17	25	Marine shell	gastropodes
Cyclope neritea	1	4	5	Marine shell	gastropodes
Cyclope sp.		1	1		
Dentalium sp.	2		2	Marine shell	scaphopodes
Glycymeris sp.		1	1	Marine shell	bivalves
TOTAL	18	23	41		

Table 2. Taxonomical distribution of manipulated shells from Magdalenian levels.

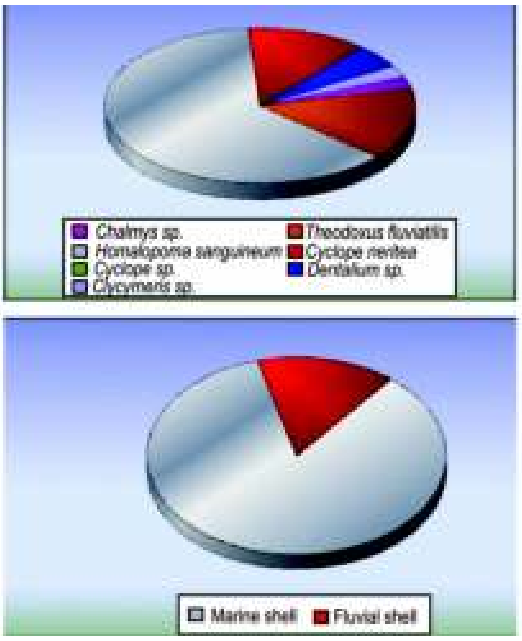

Figure 3. Taxonomical distribution of manipulated shells from Magdalenian levels.

A/ Manipulated evidences (NR=18):

The microscopic study of the collection has been carried out with a stereoscopic microscope (stereomicroscope) Kyowa SDZ-P at between 7 to 40 magnifications.

Three different types of manipulation have been observed:

- Perforated malacofauna

Cyclope neritea shell is perforated by indirect percussion, without any previous cut. In any case abrasion traces have not been documented. As a result, the perforation is not more than 2 - 2,5 mm (Fig. 4).

Five *Theodoxus fluviatilis*. Their system of perforation was made by indirect percussion; only in one case a previous cut was documented. One of these shells presents a double perforation, whose sizes are between 1 and 2 mm.

Eight *Homalopoma sanguineum* perforated shells. Basically, they present irregular shapes and elongated morphologies. In one case, double perforated. Perforations are about 1 to 2.5 mm (Tejero 2005). In those cases where the technique for making the perforation can be determined they have been made by indirect percussion. The manufacturing process has been determined based on bibliographic references of other authors (Taborin 1993, D'Errico *et al.* 1993).

- Malacological remains with ochre smudges.

The bivalve (*Chlamys*). This fact could be related with the use of this kind of shell as a little container for colorant.

- Shaping remains

Two *Dentalium* with sawing stries related to lithic edge skidding.

B/ Not manipulated evidence but with other evidence perforated in the site (NR= 23)

They are fragments of *Cyclope neritea*, *Theodoxus fluviatilis* and *Homalopoma sanguineum.* Some pieces shows a similar type of fracture; next to this fracture, it could be suggested the limit of a perforation. We think that, even they are fractured, they were ornaments, probably broken *in situ*, as shown by the same species well preserved described above.

C/ Not manipulated shells (intact or fragments) in the site (NR=1)

Glycymeris shell does not shows any manipulation, for its emplacement in the site (next to the others perforated shells) and taking into

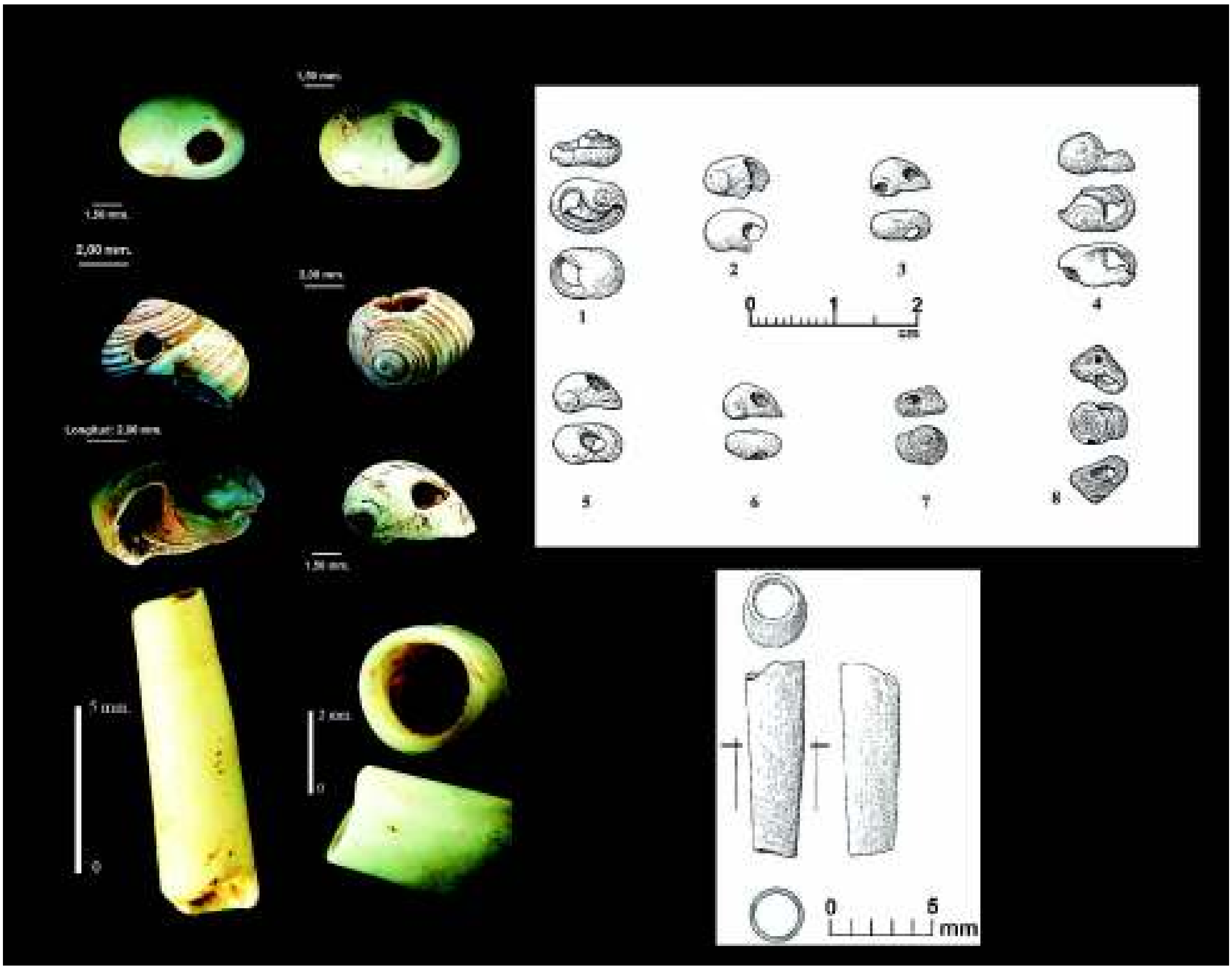

Figure 4. *Theodoxus fluviatilis, Homalopoma sanguineum, Cyclope neritea* and *Dentalium* sp. (Drawings R.Álvarez).

account its common use during Prehistory, as ornaments or as little containers (Taborin 1993), it must be considered among the remains presented in this paper.

3. SPATIAL DISTRIBUTION

Perforated malacofauna is mainly located inside the cave area of the site that basically is the zone where more different activities have been documented for the Magdalenian period, such as flint knapping, hide work and cooking activities related to a high number of different types of fire pits (Fig. 5). Even though, we cannot observe any significant distribution of these items.

4. CONCLUSIONS

To date, 41 evidences have been identified; all of them related to the symbolic sphere of magdalenian populations occupying Parco's cave. The shells appeared as ornaments (as part of pendants, necklaces, or sewn in the clothes) or as little containers (*Glycymeris* sp. and *Chlamys* sp.) and obviously not related to food chain.

Among these taxa found on the site we distinguish the presence of exclusively fluvial species, such as *Teodoxus fluviatilis*, as well as exclusively marine species, such *Homalopoma sanguineum*, *Cyclope neritea*, - both being strictly of Mediterranean origins - and *Dentalium* sp. While the origin of the former raises no question whatsoever since their catchment was done from the nearby river Segre, the procurement of marine gastropods, however, which has been identified so far exclusively in Cantabrian sites (Álvarez 2002) could suggest the possibility of a new doorway through the Ebro Basin, thereby strongly pointing to the possibility of a new way between the Mediterranean Basin and the Cantabrian area other than the commonly known North Pyrenean corridor (Fig. 6).

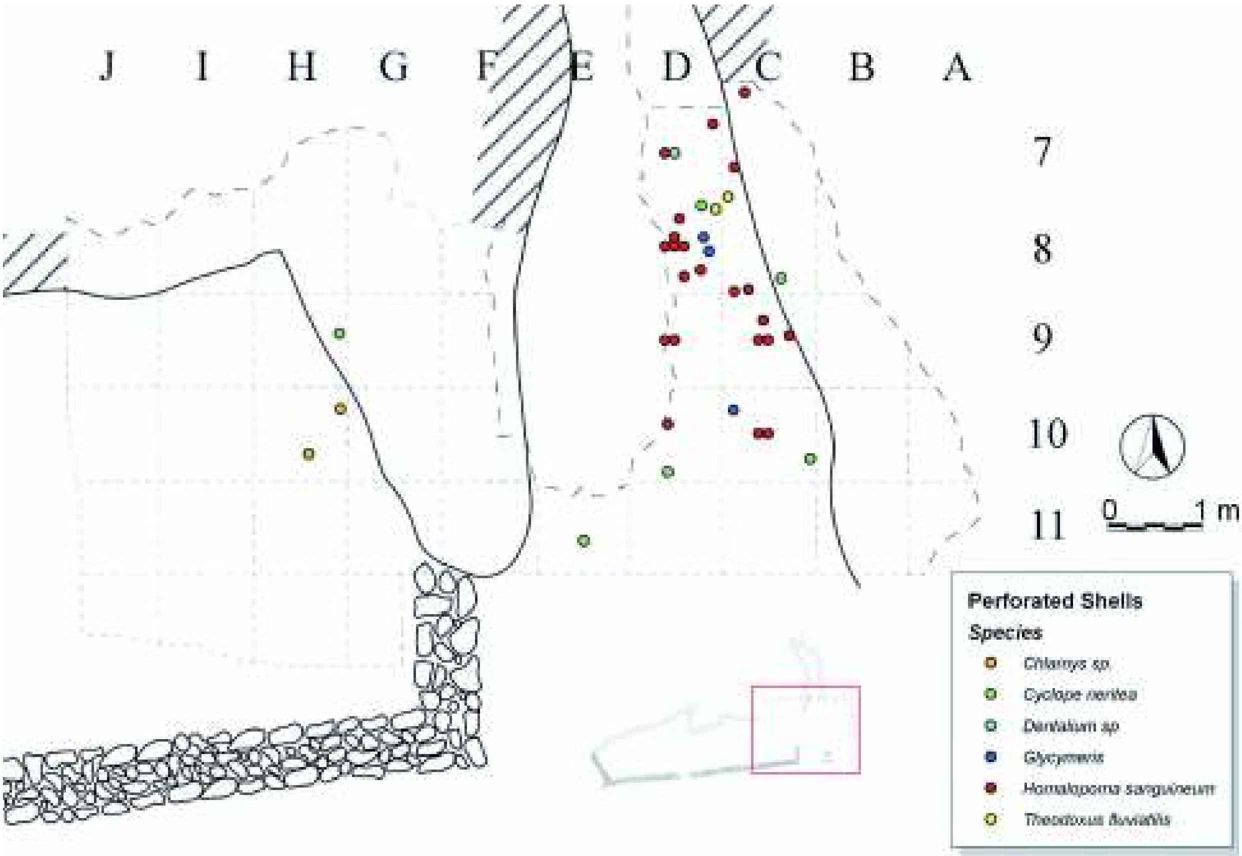

Figure 5. Spatial distribution of malacofauna remains in the site.

Figure 6. Two possible ways from Mediterranean Sea to Cantabrian Region (After Álvarez 2002 modified).

5. ACKNOWLEDGEMENTS

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Archaeomalacological remains from the Upper Pleistocene – Early Holocene record of the *Vestíbulo* of Nerja Cave (Malaga, Spain)

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Archaeomalacological remains from the Upper Pleistocene – Early Holocene record of the *Vestíbulo* of Nerja Cave (Malaga, Spain)

Restos arqueomalacológicos del Pleistoceno superior – Holoceno inferior del *Vestíbulo* de la cueva de Nerja (Málaga, España)

KEY WORDS: Molluscs, cave deposits, shell-midden, food, personal ornaments.
PALABRAS CLAVE: Moluscos, depósito karstico, conchero, alimentos, adornos personales.
GAKO-HITZAK: Moluskuak, metaketa karstikoa, maskortegia, elikagaiak, apaingarri pertsonalak.

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ABSTRACT

During the Late Upper Pleistocene and the Early Holocene, an important stratigraphic series was deposited in the access (*Vestíbulo* chamber) to Nerja Cave (Malaga province, South of Spain). This series is characterized by the presence of a significant record of human activities from 30 ky to 6 ky cal BP, constituting one of the broadest archaelogical records in the Western Mediterranean zone in this age. These deposits contain artifacts typical of various cultural assemblages (Gravettian, Solutrean, Magdalenian, Epipalaeolithic and Neolithic) and appear together with plentiful plant remains (thirty taxa of conifers and angiosperms), almost a hundred species of invertebrates (Mollusca, Crustacea, Echinoidea), and vertebrates (more than hundred species of fish, reptiles, birds and mammals, including seals and dolphins) related to human activities in the Cave. Especially notable among the invertebrate remains is the abundant presence of marine and continental molluscs: 87 taxa and more than 135,000 specimens (80 kg of shells) of Gastropoda, Scaphopoda, Bivalvia and Cephalopoda. Many of these specimens were part of the human diet, but others were used as ornaments, and some species were introduced through non cultural processes.

RESUMEN

Durante el Pleistoceno superior final y el Holoceno inferior se depositó una potente serie estratigráfica en una de las salas (Vestíbulo) de la antigua entrada de la Cueva de Nerja (Málaga, España), caracterizada por contener importantes restos de actividad humana comprendida entre 30.000 y 6.000 años cal BP. Estas evidencias son el resultado de la ocupación antrópica de la cueva durante los periodos Gravetiense, Solutrense, Magdaleniense, Epipaleolítico y Neolítico, constituyendo una de las más importantes secuencias arqueológicas y paleobiológicas del Mediterráneo Occidental para esta cronología. Los restos tecnológicos están acompañados por un elevado número de restos de vegetales y de animales relacionados con las actividades antrópicas desarrolladas en la cueva. Entre los invertebrados destaca la abundante presencia de moluscos continentales y marinos: 87 taxones y más de 135.000 restos (80 kg de conchas) de Gastropoda, Scaphopoda, Bivalvia y Cephalopoda. En esta colección destaca la abundante presencia de moluscos utilizados para la alimentación, aunque también los hay utilizados como adornos-colgantes; algunas especies fueron introducidas en la cueva de forma accidental por el hombre y, finalmente, otras corresponden a moluscos troglófilos.

LABURPENA

Goi Pleistozenoaren amaieran eta Behe Holozenoan, Nerjako (Malaga, Espainia) haitzuloko antzinako sarrerako geletako batean (Vestibulo izenekoan) serie estratigrafiko mardul bat metatu zen, 30.000 eta 6.000 urte cal BP arteko giza jardueraren hondar garrantzitsuak dituena. Ebidentzia horiek adierazten dute Gravettiar, Solutrear, Magdaleniar, Epipaleolito eta Neolito periodoetan okupazio antropikoa izan zela haitzuloan, eta hori dela Mendebaldeko Mediterraneoko sekuentzia arkeologiko eta paleobiologiko garrantzitsuenetako bat, kronologia honi dagokionez. Hondakin teknologikoekin batera haitzuloan garatutako jarduera antropikoekin lotutako landareen eta animalien hondakin ugari agertu dira. Ornogabeen artean, kontinenteko eta itsasoko molusku ugariren presentzia nabarmentzen da: 87 taxon eta Gastropoda, Scaphopoda, Bibalbio eta Zefalopodoen 135.000 hondakin (80 kg maskor) baino gehiago. Bilduma horretan, atentzioa ematen du elikadurarako erabiltzen ziren moluskuak asko zirela, baina apaingarri-zintzilikaritarako ere asko erabiltzen zituzten; espezie batzuk ustekabean sartu zituen gizakiak haitzuloan, eta, beste batzuk, berriz, molusku troglofiloak ziren.

1. INTRODUCTION

Nerja Cave is located in Malaga province (Spain), in the southern end of the Iberian Peninsula, on the Mediterranean coast of Andalusia known as *Costa del Sol Oriental*, and on the North side of Alboran Sea (Fig. 1.1). The cave is situated in the zone of contact between the Almijara mountains and the coastal plain, up to 158 metres above sea level and to one thousand metres away from the present coastline. Geologically, the cave developed in the Triasic dolomitic marbles of Almijara mountains, in contact

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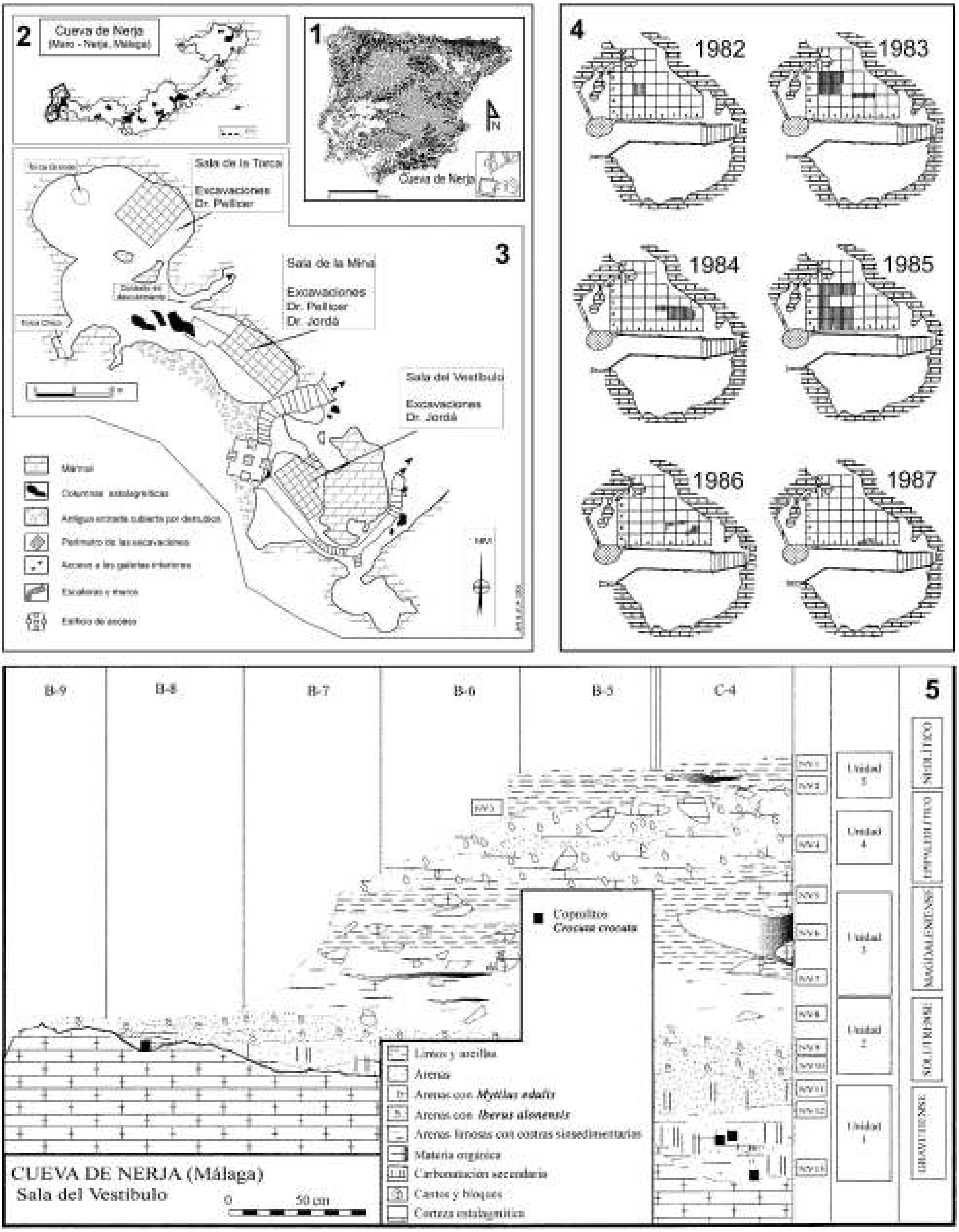

Figure 1. Nerja Cave (Málaga province, South of Spain): 1: Geographical location. 2: Cave map. 3: Access chambers with archaeological excavations. 4: *Vestíbulo* chamber and its archaeological excavations by professor Francisco Jordá Cerdá. 5: Stratigraphy of *Vestíbulo* chamber.

with the quaternary conglomerates produced by alluvial fans that form the coastal plain.

The cave, discovered in 1959, has a large subterranean extension (Fig. 1.2), but the archaeological deposits are located in its external chambers. During their occupation by humans, these chambers (Fig. 1.3) formed a great rock shelter; while at the present these chambers are partially filled by sediments. At the moment, there are three outer chambers: *Torca, Mina* and *Vestíbulo*. This study focuses on the *Vestíbulo* chamber.

During the Late Upper Pleistocene and the Lower and Middle Holocene an important stratigraphical series was deposited in the entry of Nerja Cave (Jordá *et al.* 1990). This large vertical record constitutes one of the most important archaeological and palaeobiological sequences of the western Mediterranean, containing evidence in the Gravettian, Solutrean, Magdalenian, Mesolithic, Neolithic and Copper Age. A recent paper summarizes the extensive bibliography on the archaeological record of Nerja Cave (Villalba *et al.* 2007, with references).

The first excavations in the Vestíbulo chamber were undertaken by Ana M. de la Quadra Salcedo between 1962 and 1963. Later, Professor Francisco Jordá Cerdá carried out archaeological excavations between 1982 and 1987 (Fig. 1.4). The stratigraphic sequence of the *Vestíbulo* rests on a basal speleothem and is articulated in five lithostratigraphic units (Jordá *et al*. 1990) that correspond to different cultural periods: Gravettian, Solutrean, Mediterranean Upper Magdalenian, Mediterranean Microblade Epipalaeolithic and Neolithic (Fig. 1.5), and are separated by four hiatuses.

Between 1979 and 1986 we studied the molluscs of the archaeological record of Nerja Cave recovered during the excavations of Professor Francisco Jordá Cerdá at *La Mina* chamber (campaigns of 1979, 1980 and 1981) and the *Vestíbulo* chamber (campaigns of 1982, 1983 and 1984). This research has been extensively published. (Jordá 1981, 1982, 1983, 1984-85, 1986, González-Tablas *et al.* 1984; Jordá *et al.* 1987; Aura *et al.* 1993; Jordá *et al.* 2003). However, in this research, we studied only the mollusc record recovered in a square metres test unit in the *Vestíbulo* chamber (C-4). Later, other scholars studied the molluscs from the excavations of professors Manuel Pellicer Catalán (*La Mina* and *La Torca* chambers; see Serrano *et al.*, 1995, 1997, 1998) and Ana M. de la Quadra Salcedo (*Vestíbulo* chamber; see Lozano-Francisco *et al.* 2003, 2004, Vera *et al.* 2003), with results similar to ours.

In this paper we present the preliminary results obtained from the study of the molluscs recovered during the archaeological excavations in *Vestíbulo* chamber of Nerja Cave made by Professor Francisco Jordá between 1983 and 1987 (Fig. 1.4), excluding the materials already published of the C-4 test unit, which were studied using a different methodology. These excavations recovered the archaeological record of the *Vestíbulo* sequence between the Gravettian and the Neolithic.

2. MATERIALS AND METHODS

The malacological collection of *Vestíbulo* occupied 77 standard trays (38 x 29 x 4 cm) that were housed in the Department of Prehistory, Archaeology and Ancient History at the University of Salamanca; when we completed our study, the collections were placed in the Provincial Museum of Malaga. The studied material was recovered directly during the excavation and from screened sediments; all the sediments were washed and selected by sizes across a triple sieve, and later sorted. The invertebrate remains were further sorted later in the laboratory, where the molluscs were separated from the rest of the invertebrates. The mollusc assemblage was packed in cardboard trays; every tray was identified with contextual information and/or the excavation unit. During the excavations from 1983 to 1987 (Fig. 1.4) in the Vestibulo, a series of tests left from the excavations of Ana M. de la Quadra in 1962 and 1963 were excavated. For this reason, some units correspond to portions of several grids; this is reflected in the labeling of the boxes. This differential excavation suggests that the volume of excavated sediment changes very much from one level to another, between 3,94 m^3 of the Solutrean levels and 1,22 m^3 of the Magdalenian ones. In relation to the archaeological levels, we have studied all the detected ones in the *Vestíbulo* during the excavations of Professor Francisco Jordá Cerdá: from the NV13 up to the NV 1, excluding the NV11, detected in C-4, but that does not appear in the rest of the excavation.

To identify the molluscs to species, as well as for information on habitat and distribution, we consulted a variety of references on both marine molluscs (Malatesta, 1963, 1974, Cox and cols., 1969-1972, Nordsieck, 1968, 1969; Parenzan, 1976, Ghisotti and Melone, 1975, Lindner, 2000; D'Angelo and Gargiullo, 1978, Luque, 1984, Riedl, 1986, Poppe and Goto, 1991, 1993, Mexía, 2000) and continental ones (Macan, 1969, Gasull, 1971, Madurga, 1973, Kerney *et al.* 1983). We followed the systems of Bruschi *et al.* (1985), Lindner (2000), and online sources such as NatureServe (2008), Hardy's Internet Guide to Marine Gastropods (2005) and Fauna Ibérica (2008).

All the data were recorded in a database containing the following fields: location data, list of taxa recognized in every excavation unit, recognized elements of every taxon and ecological characteristics of every taxon. The **location data** contains the information of the recuperational context: site (Nerja Cave), chamber (*Vestíbulo*), year of excavation (1983, 1984, 1985, 1986, 1987), unit or sets of portions of several units (a prismatic test and a conic test), stratigraphic unit (NV1 a NV13, except NV11) and spit operar tire leves (from a to z). The **list of taxa** (Table 1) is composed of 12 taxa of continental snails, 34 of marine snails, 36 of marine bivalves, 3 of scaphopods and 1 of cephalopods. The **recognized elements** of every taxon can be seen in Table 2. From this information we calculated the **total number of remains** (NR) and the **minimum number of individuals** (MNI), for both the snails and for the bivalves, expressed in number and in weight. The MNI of the snails was obtained by the addition of the entire specimens with the major numeric value of the different identified fragments (apical extremes, aperture fragments of opening, columela and siphon channel). The MNI of the bivalves was obtained by the addition of the entire valves and articular extremes of valves divided by two. The MNI of the scaphopods was obtained by the addition of the entire specimens and the different fragments. The MNI of cephalopods is difficult to calculate as their fragments are not identifiable as unique parts of the shell; in addition, typically there was only one fragment in the excavation unit, and so for every set of remains in a unit of excavation we might say that the MNI is 1. Due to the difference of excavated volume in every level, to compare the content in molluscs of the different levels we calculated this content for unit of volume (m^3), and so obtained comparable values. The **ecological characteristics** used in the database can be seen in Table 3.

3. RESULTS

The mollusc remains of the *Vestíbulo* of Nerja Cave record constitute an extraordinary collection, composed of more than 136,000 specimens that suggest more than 78 kg weight. More than 120,000 of these specimens (65 kg) originate from an Epipalaeolithic shell midden. From a descriptive standpoint (Table 1), the collection consists of 35 taxa of marine gastropods, 12 taxa of continental (freshwater and terrestrial) gastropodos, 36 taxa of marine bivalves, 3 taxa of scaphopods, 1 taxon of cephalopods and other one indeterminated mollusc (in total, eighty-six taxa of molluscs). In addition, we have detected numerous echinoid remains (presented in a recent paper; see Villalba *et al.*, 2007) as well as crustaceans (E. Álvarez-Fernández, pers comm).

TABLE 1. NERJA CAVE. VESTÍBULO. MOLLUSCS TAXA

CONTINENTAL GASTROPODA (12 taxa)	MARINE GASTROPODA (35 taxa)		MARINE BIVALVIA (36 taxa)	
Melanopsis laevigata	*Fissurelidae indet.*	*L. obtusata*	*Glycymeris glycymeris*	*Ostreidae indet.*
Melanopsis sp.	*Patella vulgata*	*L. saxatalis*	*Glycymeris* sp.	*Bornia sebetia*
Theodoxus fluviatilis	*P. caerulea*	*Trivia arctica*	*Mitylus edulis*	*Acanthocardia tuberculata*
Hydrobia assimineiformensis	*P. ferruginea*	*Trivia* sp.	*Mitylus* sp.	*Acanthocardia* sp.
Hydrobia sp.	*P. intermedia*	*Cerithium vulgatum*	*Lithophaga lithophaga*	*Cerastoderma edule*
Rumina decollata	*P. nigra*	*Cerithium* sp.	*Modiolus adriaticus*	*C. glaucum*
Sphinterochilla cariosula hispanica	*P. rustica*	*Cerithiidae inder.*	*M. barbatus*	*Cerastoderma* sp.
Iberus alonensis	*P. ulyssiponensis*	*Phalium saburom*	*Modiolus* sp.	*Laevicardium norvegicum*
I. marmoratus	*Patella* sp.	*Charonia rubicunda*	*Mitylidae indet.*	*Cardidae indet.*
Iberus sp.	*Addisonia lateralis*	*Charonia* sp.	*Chlamys varia*	*Mactra stultorum*
Helicella unifasciata	*Monodonta articulata*	*Nucella lapillus*	*Chlamys* sp.	*Solen marginatus*
Gastropoda indet.	*M. turbinata*	*Stramonita haemastoma*	*Pecten maximus*	*Solen* sp.
	Monodonta sp.	*Buccinidae indet.*	*P. jacobeus*	*Solenidae indet.*
SCAPHOPODA (3 taxa)	*Gibbula richardi*	*Columbella rustica*	*Pecten* sp.	*Venus verrucosa*
Dentalium dentale	*Gibbula* sp.	*Cyclope neritea*	*Pectinidae indet*	*Tapes decussatus*
D. vulgare	*Trochidae indet.*	*C. pellucida*	*Spondylus* sp.	*Tapes* sp.
Dentalium sp.	*Littorina punctata*	*Conus mediterraneus*	*Ostrea edulis*	Veneridae indet.
		Gastropoda indet.	Ostrea sp.	Bivalvia indet.
CEPHALOPODA (1 taxon)				
Sepia sp.				

Table 1. Nerja Cave. Vestíbulo. Molluscs taxa.

TABLE 2. NERJA CAVE. RECOGNIZED ELEMENTS					
GASTROPODS			**BIVALVES**		
complete specimens	infantile	not burned	complete valve (left or right)	infantile	not burned
		burned			burned
	juvenile	not burned		juvenile	not burned
		burned			burned
	adult	not burned		adult	not burned
		burned			burned
complete specimens with perforation	apical	not burned	articular extreme		not burned
		burned			burned
	dorsal	not burned	fragments		not burned
		burned			burned
	labial	not burned	sea rolled fragment		
		burned	bivalve specimen		
identified fragments	apical extreme	not burned	crusted valves		
		burned			
	aperture fragment	not burned	SCAPHOPODS		
		burned	complete specimens		
	columela	not burned	fragments (proximal, mesial, distal)		
		burned			
	siphon chanel	not burned	SCAPHOPODS		
		burned	inner shell fragments		
fragments		not burned			
		burned			
crusted specimens					

Table 2. Nerja Cave. Recognized elements.

The number of specimens has overcome our initial forecasts that were based on our previous work (Jordá, 1981, 1982, 1983, 1984-85, 1986, González-Tablas *et al*. 1984, Jordá *et al*. 1987; Aura *et al*. 1993, Jordá *et al*. 2003); our results so far contrast enormously with the data presented by other authors for other chambers of Nerja Cave (Serrano *et al*. 1995, Lozano-Francisco *et al*. 2004), in spite of the similarity in age with the assemblage analysed here.

In relation with the **vertical distribution** of the molluscs in the *Vestibulo* archaeological record, during the Gravettian the terrestrial snails, used as food, dominate; in the Solutrean levels terrestrial snails continue to dominate, but marine snails begin to be consumed; during the Magdalenian the marine molluscs (bivalves) dominate. The marine molluscs reach their maximum during the Epipalaeolithic, giving rise to a shell midden, formed primarily by *M. edulis* and diverse species of *Patella*. The variation of the number of specimens by cubic metre in percentage expresses the change that happens in the transition between Solutrean – Magdalenian (Fig. 2.A).

Of the more than 136,000 remains of molluscs coming from the Vestíbulo of Nerja Cave, a small, but nonetheless important, part is made up of those specimens that were used as **personal ornaments.** Almost all of the personal ornaments from the *Vestíbulo* (136 of 137) are made from molluscs. The distribution of the molluscs used as personal ornaments along the *Vestíbulo* archaeological sequence is as follows (the Epipalaeolithic personal ornaments are currently being studied):

- **Gravettian** (Fig. 2.B): The chosen species are two gastropods, *L. obtusata* and *T. fluviatilis*, and one scaphopod, *Dentalium* sp. *L. obtusata* is represented by three complete specimens, *T. fluviatilis* by two complete specimens and a fragment, and finally we count three specimens of *Dentalium* sp. We must add for this period two fragments of marine gastropods that we cannot identify, which bear traces of manufacture. In addition there is one singular hanging object whose nature we have not been able to identify.

- **Solutrean** (Fig. 2.C): Among the 85 personal ornaments from this chronological period we once again find L. *obtusata*, this time, represented by 21 specimens that conserve the complete perforation and 8 broken/fragmented specimens; T. *fluviatilis* is represented by 24 perforated specimens and

TABLE 3. NERJA CAVE. ECOLOGICAL CHARACTERISTICS	
DOMAIN	continental, marine
HABITAT	terrestrial, freshwater, bentonic (epifauna and infauna), nectonic
ENVIRONMENT	fluvial, lacustrine, fluvio-lacustrine, palustrine, karstic, fluvio-karstic, litoral, continental platform
SUB-ENVIRONMENT	dtuary, delta, lagoon, beach, dune, clif
VERTICAL DISTRIBUTION	supralitoral, mesolitoral, sublitoral, supratidal, intertidal, subtidal
DEPTH	in intervals or above or below a concrete value in meters
SUBSTRATUM	rocky, gravelly, sandy, siltly, organic, algal, coralline, shells
WATER ENERGY	quiet, trouble, swell,
WATER CLARITY	turbid, clear
SALINITY	fresh water, salty, marine, hipersaline
SALINITY TOLERANCE	eurihaline, stenohaline
WATER TEMPERATURE	in ºC, warm, cold, temperate
TEMPERATURE TOLERANCE	euritermic, stenotermic
HABITS	troglophilus, drill-hole, fixed, mobile
FOOD	carnivorous, herbivorous, carrion
GEOGRAPHIC DISTRIBUTION	cosmopolitan, Alboran Sea, Mediterranean Sea, Black Sea, Atlanthic Ocean, etc

Table 3. Nerja Cave. Ecological characteristics.

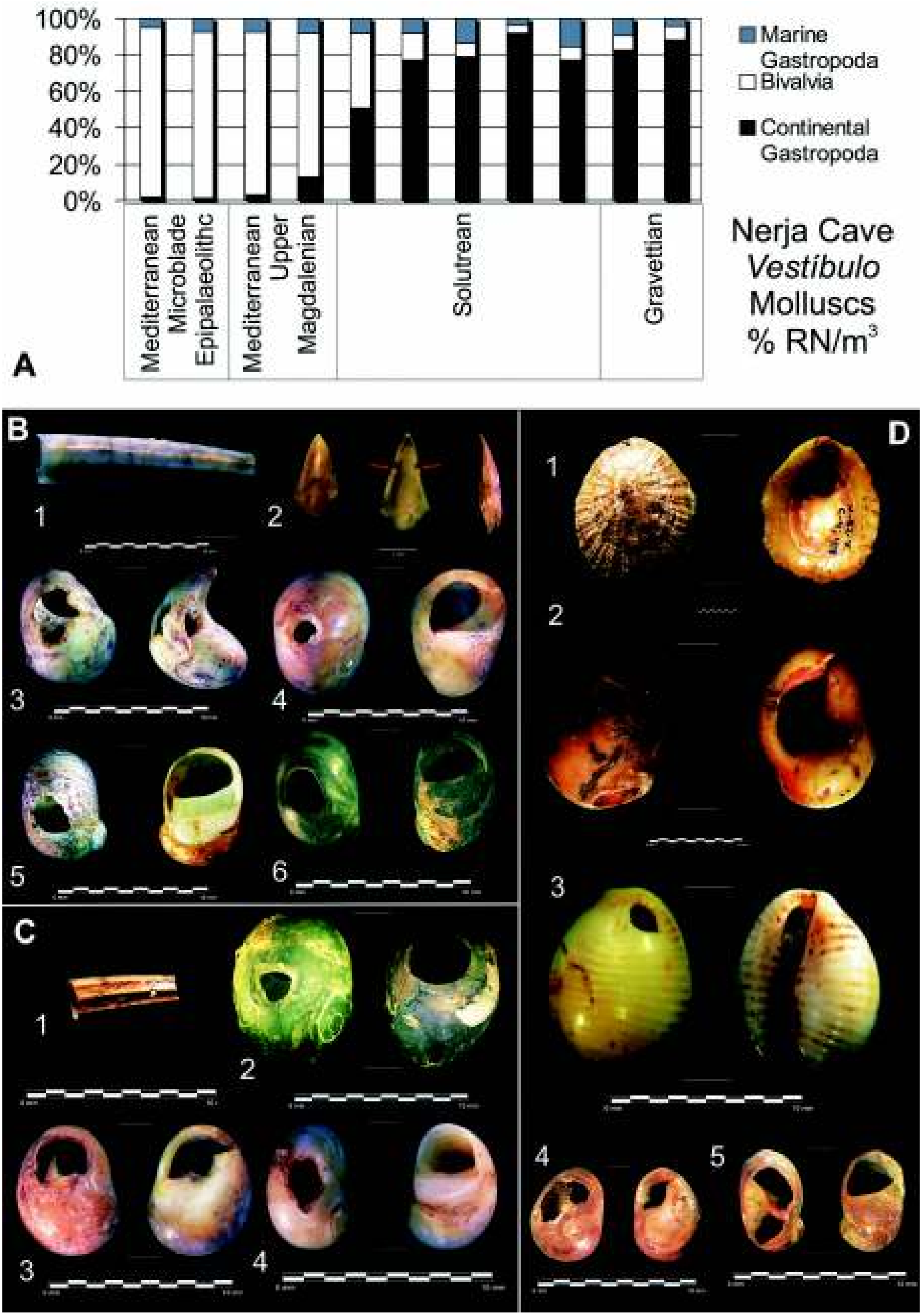

Figure 2. A: Distribution of the molluscs from the archaeological levels of *Vestíbulo* chamber of Nerja Cave in % Number of Remains (NR) / m3 of sediment. B: Gravettian personal ornaments: 1, *Dentalium* sp.; 2, singular hanging object whose nature we have been unable to identify, with two lateral marks; 3 and 4, *Littorina obtusata*; 5 and 6, *Theodoxus fluviatilis.* C: Solutrean personal ornaments: 1, *Dentalium* sp.; 2, *L. obtusata*; 3, *Cyclope neritea*; 4, T. *fluviatilis.* D: Magdalenian personal ornaments: 1, *Patella* sp.; 2, *Nucella lapillus*; 3, *Trivia arctica*; 4, *C. neritea; 5, T. fluviatilis.*

there are 10 examples of *Dentalium* sp. Some new species of gastropods were used as personal ornaments such as 16 *Cyclope* (2 *neritea*, 10 *pellucida*, 4 sp.), 1 *C. rustica*, 1 *L. saxatalis*, 1 indeterminate complete specimen and 1 undetermined fragment.

- Magdalenian (Fig. 2.D): The most frequently represented species in the previous levels are also present in the Magdalenian. Among these, the most common species is *Cyclope*: in its *neritea* variant, 15 specimens; in *pellucida*, 11 speciments. We found also 2 fragments of *L. obtusata,* 10 T. *fluviatilis*, 2 *Patella sp*., 1 *N. lapillus* and 1 *T. arctica*.

Except *Dentalium*, which because of its morphology does not need a perforation to be suspended, all the examples have only one perforation, which is not always complete. In many cases we identified the techniques used to make the perforations but in other cases because of the eroded condition of the shells' surface and the wearing down of the perforations, we have not been able to establish these techniques. We do not show the results of the technological analysis of the perforations here because of the lack of space but we will do it soon in a more detailed publication.

The origin of the species used, except the *T. fluviatilis* which is a freshwater gastropod, is marine and could be Mediterranean, so they could have been gathered on the coast closest to the site. The only species to which this might not apply is *L. obtusata* and *N. lapillus*. In the present, this species are only present along the Atlantic coast. This factor makes the presence of this species and the possible Mediterranean origin of the collection more problematic. The first hypothesis to explain its presence is that in cold periods, species that today are found only in the Atlantic may have colonized the Mediterranean Sea (Álvarez-Fernández 2006, Taborin 1993). Another hypothesis would involve long distance trade or other contact. We do not have any data to reject either of the hypotheses, so for the moment both explanations stand.

4. CONCLUSIONS

- Nerja Cave archaeological record is distinguished by the abundant presence of human transported marine and continental molluscs: 86 taxa and more than 136,000 specimens (more than 78 kg) of Gastropoda, Scaphopoda, Bivalvia and Cephalopoda.

- Terrestrial snails were consumed as food during Gravettian and Solutrean. Marine molluscs were consumed from Late Solutrean and Mediterranean Upper Magdalenian through the Mediterranean Microblade Epipalaeolithic, with development during this period of an important shell midden.

- Others molluscs, like snails and scaphopods, were used as personal ornaments, from the Gravettian to Magdalenian and the Epipalaeolithic. The species most represented throughout the sequence (*L. obtusata, T. fluviatilis* and *Dentalium* sp.) appear in all levels, except *C. neritea* and *pellucida* which are absent during the Gravettian. All these species appear recurrently in Palaeolithic levels of several European sites.

- Finally, some species were introduced in the cave accidentally.

5. ACKNOWLEDGEMENTS

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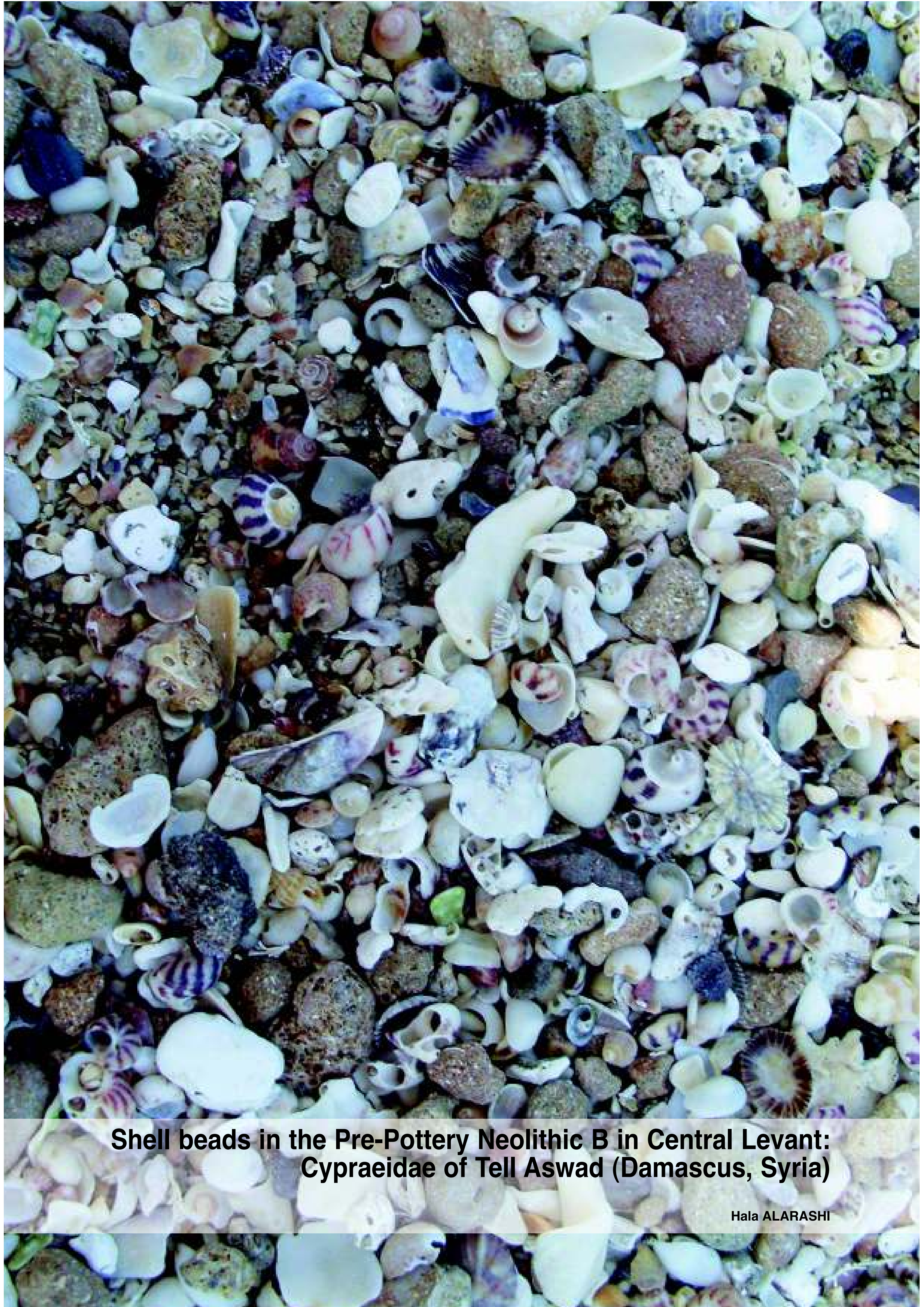

Shell beads in the Pre-Pottery Neolithic B in Central Levant: Cypraeidae of Tell Aswad (Damascus, Syria)

Hala ALARASHI

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Shell beads in the Pre-Pottery Neolithic B in Central Levant: Cypraeidae of Tell Aswad (Damascus, Syria)

Conchas perforadas en el PPNB en Levante Central: las Cypraeidae de Tell Aswad (Damasco, Siria)

KEY WORDS: Levant, PPNB, Cowries, Beads, Technology.
PALABRAS CLAVE: Levante, PPNB, Cauris, adornos, tecnología.
GAKO-HITZAK: Ekialdea, PPNB, Cauris, apaingarriak, teknologia.

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ABSTRACT

At Tell Aswad, a Pre-Pottery Neolithic B site in Central Levant, a number of marine shell beads were found. Within this assemblage, the Cypraeidae specimens are the most numerous (14 objects). The present study reveals that several techniques were used for manipulating cowrie beads: grinding or hammering, engraving, drilling, etc. Local use wear observed on some areas as well as the location of the perforations are related to various attachment systems. Finally, the decorated incisions made on the ventral and lateral faces of some shell cowries, are one of the most original aspects for shell bead-making in the PPNB period in the Levant.

RESUMEN

En Tell Aswad, yacimiento del Neolítico Precerámico B del Levante Central, se ha encontrado un cierto número de adornos realizados en conchas marinas. De este conjunto destacan las de Cypraeidae por ser las más numerosas (14 objetos). Este estudio revela el uso de varias técnicas de fabricación de los adornos en cauris: abrasión o percusión, grabado, perforación, etc. Las trazas de uso observadas en algunas áreas, así como la localización de las perforaciones son los testimonios de varios modos de sistemas de atado. Por fin, las incisiones decorativas realizadas sobre las partes laterales y ventrales de algunos cauris, son uno de los aspectos más originales de la fabricación de ornamentos en concha del periodo PPNB en Levante.

LABURPENA

Tell Aswad aztarnategian, Ekialdeko erdialdeko Neolitoko Prezeramiko B garaikoan, itsas maskorrez egindako zenbait apaingarri aurkitu dira. Multzo horretan, Cypraeidae familiakoak nabarmentzen dira, ugarienak direlako (14 objektu). Ikerketa honi esker jakin dugu kauriz egindako apiangarriak fabrikatzeko zenbait teknika erabiltzen zituztela: urratzea edo kolpekatzea, zizelatzea, zulatzea, etab. Zenbait arlotan hautemandako erabilerek eta zulaketen kokapenek erakusten dute lotzeko zenbait sistema erabiltzen zituztela. Azkenik, kauri batzuen alboetako eta sabelaldeko faseetan egindako ebaki apaingarriak Ekialdeko PPNB periodoko maskorren fabrikazioko alderdirik originalenetako bat dira.

1. INTRODUCTION

The Neolithic settlement of Tell Aswad is located 30 km south-east of Damascus in Syria (Fig. 1). The first soundings by H. de Contenson in 1971-72 were followed by the excavations conducted by D. Stordeur and B. Jammous between 2001 and 2007 (Stordeur *et al.* in press). According to the radiocarbon dates and the preliminary study of the archaeological material, the earliest occupation of the site corresponds to the Early Pre-Pottery Neolithic B (EPPNB, *ca.* 9,500-9,200 cal. BP). The subsequent levels, dated to the Middle PPNB (*ca.* 9,200-8,500 cal. BP) and Late PPNB periods (*ca.* 9,200-8,500 cal. BP), are well documented. The settlement was also sporadically occupied during the early Pottery Neolithic.

The excavation seasons 2001-2007 yielded a large collection of beads (more than 238 objects) made from various raw materials (bone, shell, clay and stone). This collection is stored at the National Museum of Damascus where the access to the archaeological material is restricted. The shell category comprised 46 objects, *i.e.* 19.3 % of the assemblage. The taxonomic identification of the mollusc species is still in progress and 8 families have been recognized: Conidae, Cypraeidae, Dentaliidae, Glycymerididae, Littorinidae (?), Muricidae, Nassariidae, and Neritidae.

The cowries of Tell Aswad are particularly interesting because of the diversity they show from a technological and typological point of view. A total of fourteen cowries were collected at the site (Table 1; Fig. 2). Most of them were found in the Middle PPNB levels

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Figure 1. Tell Aswad and some contemporaneous sites in the Levant.

N°	Conserved parts	Preservation	Removed dorsum	Removing technique	Holes	Perforation technique	Local surface wear					Incisions		Cracks		Period	Study
							Ventral face	Lateral face	Dorsum opening	Natural aperture extremities	holes	Ventral face	Lateral face	Ventral face	Lateral face		
9	complete	damaged	yes	?	1	drilling?	?	?	?	?	?	?	?	?	?	MPPNB	impossible
11	LP	burnt	yes	grinding	?		no	no	yes	?		no	no	yes	no	LPPNB	yes
33	complete	good state	yes	grinding	no		yes	yes	yes	yes		yes	yes	no	no	LPPNB	yes
35	LP	fragile and cracked	yes	grinding	?		yes	no	yes	?		no	no	yes	yes	MPPNB	yes
42	complete	fragile and broken	yes	?	1	drilling	yes	?	?	?	yes	no	no	yes	yes	MPPNB	partial
43	complete	fragile and broken	no	no	5	drilling on ventral f. percussion on dorsum	?	?			hole on ventral f.	no	no	?	?	MPPNB	partial
104	complete	fragile and cracked	yes	grinding	no		?	?	?	probable		no	no	yes	no	MPPNB	yes
132	complete	good state	yes	grinding	no		yes	no	yes	yes		no	no	yes	yes	MPPNB	yes
143	CP	good state	yes	hammering	?		yes	no	yes	?		yes	yes	no	no	LPPNB	yes
144	LP	burnt	yes	grinding	?		no	no	?	?		no	no	yes	yes	MPPNB	yes
176	CP	fragile and cracked	yes	grinding	1	drilling	no	no	yes	?	yes	no	no	yes	yes	MPPNB	yes
180	complete	fragile and broken	yes	grinding	no		?	?	?	?		no	no	yes	?	LPPNB	yes
CM-30a	complete	?	yes	hammering	no		?	?	?	?		?	?	?	?	MPPNB	no
CM-57	LP	?	yes	grinding	1	drilling	?	?	?	?	yes	?	?	?	?	MPPNB	no

Table 1. Main typological and technological aspects of the cowrie beads found at Tell Aswad. CS: columellar part; LS: labral part.

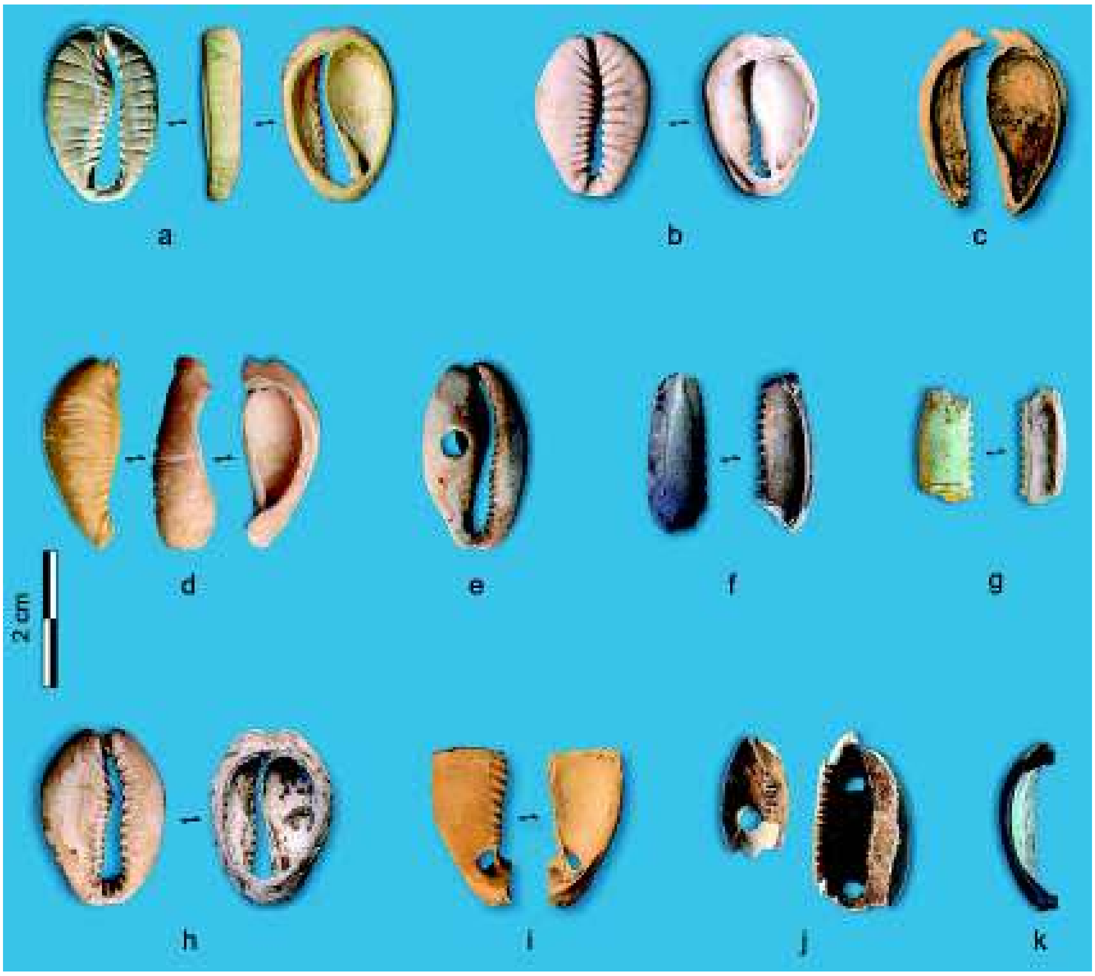

Figure 2. Cowrie beads from Tell Aswad (excavations 2001-2007). a: Complete specimen n°33 (from left to right: ventral, lateral and dorsal views); b: Complete specimen n°132 (ventral and dorsal views); c: Bad-preserved and broken specimen n°180 (dorsal view); d: Columellar part n°143 (ventral, lateral and dorsal views); e: Complete specimen n°42 (ventral view); f: Labral part n°144 (lateral and dorsal views); g: Labral part n°35 (lateral and dorsal views) h: Complete specimen n°104 (ventral and dorsal views); i: Broken columellar part n°176 (ventral and dorsal views); j: Broken specimen n°43 (ventral view of the columellar part and lateral view of the inner labral part); k: Labral part n° 11 (dorsal view).

and only few in the Late PPNB levels. Two of these cowries (n°CM-30a and CM-57) were previously analyzed by C. Maréchal (Maréchal 1995). Descriptions given for these elements in the present study come exclusively from the Maréchal's paper.

2. METHODOLOGY

For the terminology of the anatomical parts of the cowrie shell, I refer to the work of F. Lorenz and A. Hubert (2000). Figure 3 shows the main terms used in this study.

The taxonomical identification of the Cypraeidae discovered between 2001 and 2007 has been made by Dr. David S. Reese (pers. comm.). *Erosaria spurca* was identified for all the items except for the object n° 42 (Fig. 2e). This latter could belong to *Luria lurida*. Both species live in the Mediterranean Sea. C. Maréchal already identified one *Monetaria moneta* (Maréchal 1995: 135), species coming from the Red Sea.

The state of preservation of the shells is generally poor. Most of them look fragile and have lost their natural colors. Moreover, due to the bad preservation of the shell structure, some elements have cracked and been damaged after excavation. Indeed, three cowries found together in the same stratigraphic context were particularly fragile. Two of them have immediately broken just after they were taken out of the earth (n°9 and 43), and a third one, (n°42) just after being photographed. It was not then possible to analyze microscopically these three cowries.

Post-depositional processes could have been responsible for the low preservation of the cowries at Tell Aswad, as observed for the animal and human bone remains (L. Gourichon, pers. comm.). It is therefore difficult to determine the original state of the shell surface at the time when the cowries were imported into the site. They could have been

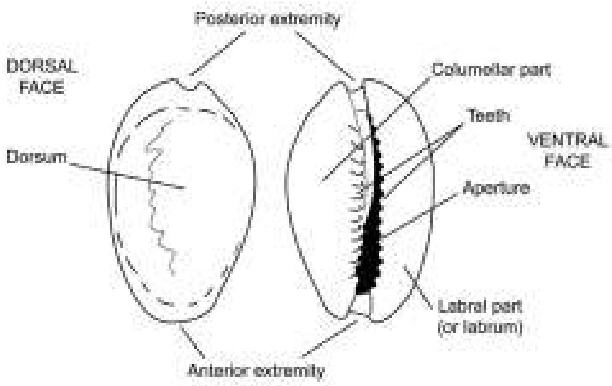

Figure 3. Main anatomical parts of the cowrie shell.

collected already dead from the seashore rather than gathered alive. However, the provenance of the shells cannot be deduced from a microscopic examination because fresh collected shells eventually present in the collection would have been modified superficially by post-depositional process.

This study focuses on the human-made modifications of the cowries of Tell Aswad. Most of the elements were examined using a stereomicroscope (Motic SMZ-168) with a maximum magnification of 40x.

3. RESULTS

3.1. Removal of the dorsum

At Tell Aswad, the dorsum of the cowries is absent for thirteen cases. For eight items the surface of the edge of the missing dorsum is flat and quite regular (n°11, 33, 35, 132, 144, 176, 180, see Fig. 2; n°CM-57, *cf*. Maréchal 1995: fig. 115h). Two cowries (n°104 and 180; respectively Fig. 2h and 2c) have overall a straight plane of opening although the edge is heavily damaged. An incomplete cowrie (columellar part n°143, Fig. 2d) shows very smooth but not flat edge. Finally, there are no precise descriptions for three cowries: specimen n°CM-30a, studied by C. Maréchal (Maréchal 1995: fig. 115c), and specimens n°9 and 42 (Fig. 2e).

Natural processes can abrade and even perforate dead gastropod shells exposed on the seashore. In the case of the hard-textured cowrie shell, it is hardly expected that such natural modification produces regular and flat plane of a removed dorsum, but exceptional cases could occur.

Technologically, the removal of the dorsum consists in taking away the rounded part of the dorsal surface. This results in a large opening situated in the opposite face of the natural aperture of the shell (ventral side). Among the methods commonly used for making perforations on shells, at least three main techniques could have been employed to remove the dorsum of the cowrie shells: grinding, sawing and hammering. The grinding technique leaves a flattened ridge around the hole (Francis 1989, Maréchal 1991, 1995, Bar-Yosef 1997; Maréchal et Alarashi 2008). Spindle-shaped striations are normally observed on the surrounding surface; their arrangement can indicate the orientation of the abrasion (d'Errico *et al*. 1993).

Sawing technique is also commonly used for making holes in gastropod or bivalve shells but technological patterns have been only described for little perforations (Francis 1989, d'Errico *et al.* 1993, Bar-Yosef 1997). In the case of cowrie dorsum removal by sawing, archaeological and experimental data are not available. The personal experimentations I made using sharp flint blades as tools indicate that sawing could be easily distinguished from grinding technique. Indeed, this technique leaves series of striations on the shell section as well as around the edge (Fig. 4a). The striations show clearly the direction of the sawing movement during the operation. When the blade slips, fine and isolated striations sometimes mark the lateral surfaces of the cowrie (Fig. 4b). Once removed the dorsum, a regular but not entirely flat opening edge results due to the frequent disruptions occurring during the motion. On the experimental specimens, deep sawing grooves are systematically noticed (Fig. 4c).

Hammering is another technique attested for making holes on shells (*Ibidem*). With this technique, removing the cowrie dorsum implies the shaping of the original shell by direct or indirect percussion. The large hole obtained shows irregular, rough, chipped and sharp edges.

For the two latter techniques (sawing and hammering), the operation can be finalized by rubbing the dorsal face in order to flatten the irregularities of the surface (Francis 1989). Thus, grinding can be used in a final step and then erase the diagnostic traces made by the preceding methods.

Because of the smooth aspect of the circumference, no tool marks or striations directly related to the dorsum removal were observed microscopically on the cowries of Tell Aswad. At least, two techniques can be deduced from the morphological features of the edge surface: grinding and hammering. Eight items could witness the first technique (n°11, 33, 35, 132, 144, 176, 180 and CM-57) because of the flatness and regularity of the dorsal surface (*e.g.* Fig. 2a, 2b, 2c, 2f, 2g, 2i, 2k). For two other cowries, the hammering technique is suggested: the small specimen of *Monetaria moneta* (n°CM-30a) found during the previous excavations (Maréchal 1995: fig. 115c) and an incised columellar part (n°143). For the first item, the hypothesis was made by C. Maréchal without precise description (Maréchal 1995: 135). According to my observations, the second element shows a tortuous transversal section with irregular but relatively smooth ridge (Fig. 2d). This pattern could have resulted from the hammering method. Sawing technique was not evidenced but combination including hammering plus grinding or sawing plus grinding cannot be totally excluded.

3.2. Perforations

Small holes are present on five complete or fragmentary cowries at Tell Aswad. In the absence of striations, only the shape and size of the orifice have been taken in account to identify the nature of the perforations as well as the techniques used to make them.

To obtain small perforations on shells, various techniques can be employed: gouging, hammering, sawing, drilling, scratching or grinding (*e.g.* Francis 1989).

Some families of marine gastropod predators such as Naticidae and Muricidae make holes in the test of gastropod and bivalve shells which can

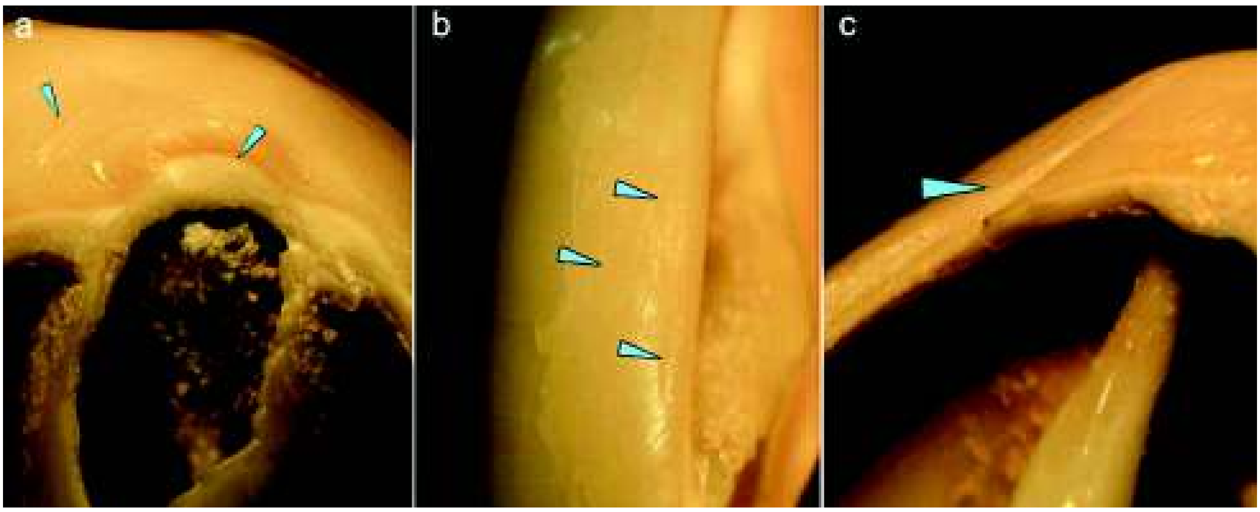

Figure 4. Experiment of sawing technique made on a modern cowrie to remove the dorsum part (magnification x10). a: striations on the shell section; b: isolated striations caused by the slipping of the blade on the lateral side; c: regular but not entirely flat opening edge due to the frequent disruptions occurring during the motion.

reach 4-5 mm in diameter (Carriker and Yochelson 1968, cited by d'Errico *et al.* 1993). The morphology of the hole for the first family is conic and for the second is cylindrical. These natural characteristics could be confused with human-made perforations. At Tell Aswad, one item could have been naturally perforated: the labral fragment n°57 studied by C. Maréchal (1995: fig. 115h). Indeed, she has suggested that the hole was initially made by a marine predator and subsequently enlarged by drilling from the inner side of the shell (Maréchal 1995: 136).

For four objects, the location and shape of the holes attest a human modification. The cowrie n°43, with 5 holes (Fig. 2j), is the most complex case found in this collection. The specimen was almost complete when it was discovered but it was broken after talking it out from the earth. The two pairs of holes are situated symmetrically in an opposite way on the lateral sides of the dorsum. Their perimeters are irregular and slightly chipped. They were probably made by either direct or indirect percussion. The fifth hole is located in the centre of the columellar ventral side. In the absence of striations, only the subcircular and regular circumference suggests the use of drilling technique by a rotating movement.

Another example is offered by the cowrie n°42 (Fig. 2e and 5) which shows a hole situated also on the ventral side and quite similar to the fifth hole of the precedent object. I would like to precise that these previous cowries (n°42 and 43) were found together with a very bad-preserved third cowrie displaying at least one hole situated also on the larger area of the columellar part (cowrie n°9, no picture available).

The broken columellar fragment n°176 has a large and circular hole (nearly 5mm) located on the ventral side near the anterior extremity (Fig. 2i). The regular circumference of the hole could indicate the use of drilling technique.

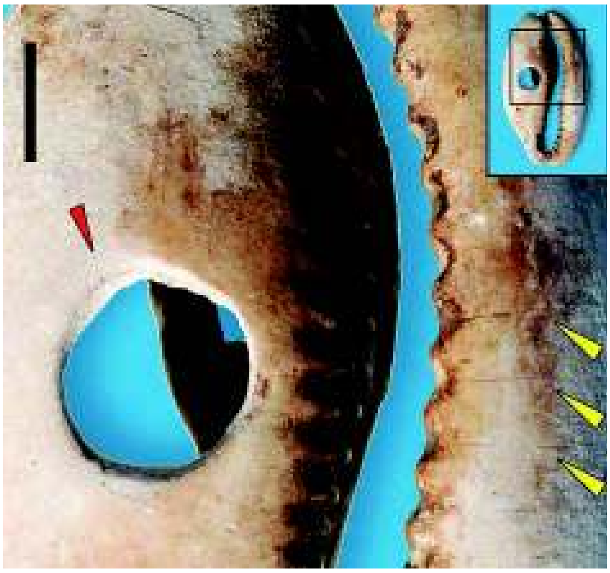

Figure 5. Detail of the ventral face of the cowrie n°42. Note the notch-like use wear on the perimeter of the perforation on the columellar part (red arrow), and a series of thin crack lines around the natural aperture (yellow arrows) (scale bar: ¼ cm).

3.3. Incisions

Two types of linear traces were observed on the surface of ten complete or fragmentary cowries found at Tell Aswad (Table 1). The first type corresponds to V-shaped grooves in cross-section made by a back-and-forth movement using sharp stone tools. Two cowrie shells show this pattern.

The first case is the item n°33, where the features were partially erased by the surface wear, especially on the columellar part and on the lateral sides. On the ventral face, the incisions are arranged in a radial manner around the aperture of the shell, each one starting from a point between two columellar or labral teeth (Fig. 2a and 6). On both lateral sides, the incisions are parallel and more numerous than the ventral ones (about 15-20 compared to 10) although some of them clearly match together. This pattern clearly suggests a decorative purpose of the cowrie surface by engraving.

On the second element, the columellar fragment n°143, several more or less parallel incisions are distributed on the lateral and ventral faces. Their organization is not regular and some of them

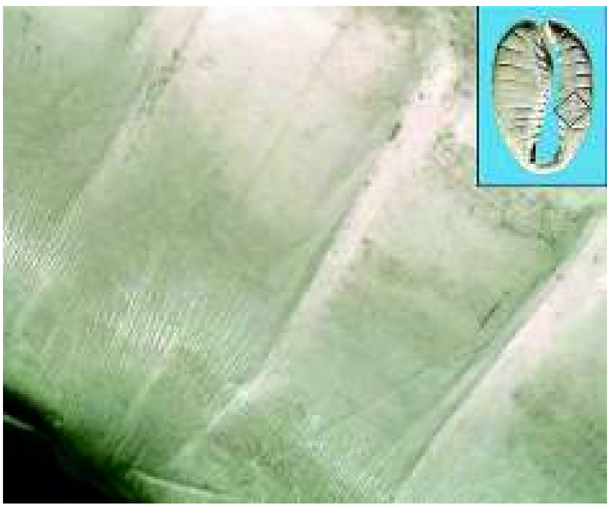

Figure 6. Detail of the V-shaped incisions made on the ventral labial part on the cowrie n°33 (magnification x20).

are superimposed or crossed each other. On the lateral side, two incisions were more deeply engraved than the others (Fig. 2d).

The second type of traces looks like very thin lines darkened by mineral deposits. Some of them can be only detected by microscopic observation. There are obviously fine cracks naturally occurred on the outer test layers such as those I observed on modern cowries. Eight cowries (n°11, 35, 42, 104, 132, 144, 176 and 180) present such pattern on the ventral and lateral faces. In some cases, the cracks are distributed in a similar manner to the artificial incisions previously described for the cowrie n°33 and 143. Thus, in the case of heavy shell surface wear, they could be misinterpreted as corresponding to the bottom of V-shaped grooves and then be confused with the first type. However, the cracks have a systematic equal and thin width and look very often like broken lines (Fig. 5 and 7); these two features cannot be observed for the tool-made incisions.

3.4. Local surface wear

As previously mentioned, natural polishing of the overall shell surface cannot be excluded at Tell Aswad (dead shells gathered from the seashore).

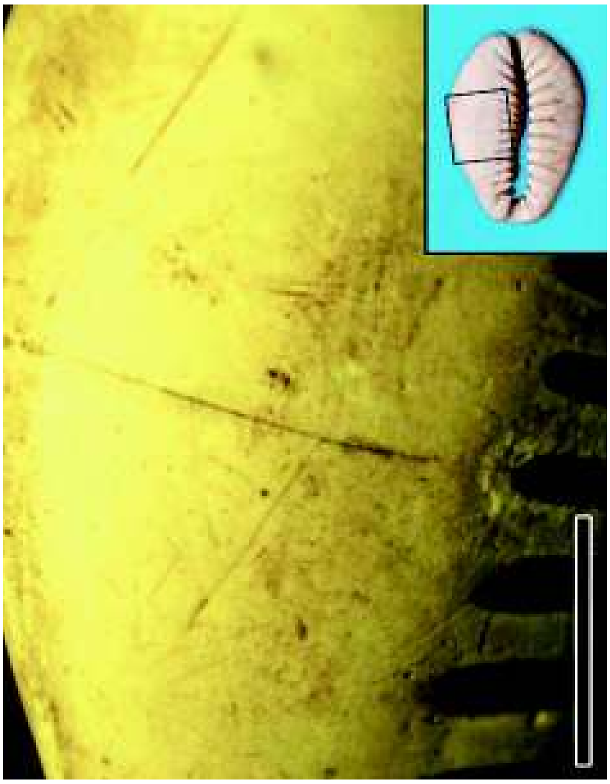

Figure 7 Detail of the ventral labral face of the cowrie n°132 showing a thin crack line (scale bar: ¼ cm).

Only local surface wear affecting particular areas is described here. Five areas can be distinguished: the dorsum opening, the ventral face and lateral faces, the perimeter of the perforations and the extremities of the natural aperture (Table 1).

For several elements, the absence of tool marks related to the dorsum removal can be due to the smoothing of the opening edges. The surrounding surface has even sometimes a “lustré” aspect (e. g. n°143).

For the cowries n°33 and 132, the ventral face is heavily worn in such a way that the original convex part is flattened and the prominences of the columellar and labial teeth are erased (Fig. 6 and 7). For n°33, the ventral face looks as if it was abraded on a plane surface. Friction caused by a long-term use or repetitive contact may have produced this pattern. Nevertheless, this specimen also shows perfect flattened lateral sides where some incisions are almost completely erased (Fig. 2a). This erosion is observed in a well defined area corresponding to the middle of the lateral surfaces which suggest a specific local friction.

Local wear was observed also on the perimeter of some holes. It is the case for the specimens n°42 and 43 where their similar central perforations both have a shallow notch on their perimeter. In both cases, the notch is oriented in the same direction (Fig. 2j and 5). This observation is likely to give us some clues about the attachment method.

On the decorated cowrie n°33, worn areas have been recognized at both extremities of the natural aperture. The areas are well delimited and look clearly polished. On the ventral face, the wear has particularly affected the posterior and anterior extremities of the natural aperture canals. On the anterior extremity, this wear pattern results in a V-shaped use mark diverging outward (Fig. 8). On the dorsal face and again on both extremities, the edge of the removed dorsum is notched (Fig. 9). Local use wear was also noticed on the extremities of the cowrie n°132, and maybe on those of the n°104.

4. DISCUSSION

Many Natufian and PPNA sites in the Levant have yielded cowries without dorsum (Maréchal 1991; Bar-Yosef 1991; Reese 1991) but information about the methods used for removing the dorsum is generally absent or indicates the hammering technique for these periods. The use of grinding technique for making shell beads is already evidenced in the Final Natufian levels of Mureybet

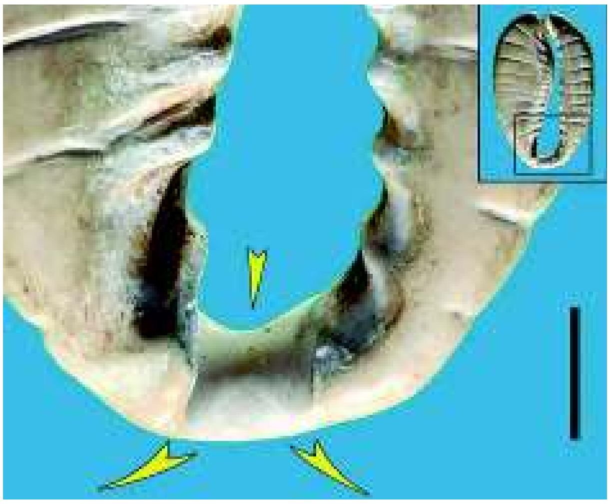

Figure 8 Detail of the ventral labral face of the cowrie n°132 showing a thin crack line (scale bar: ¼ cm).

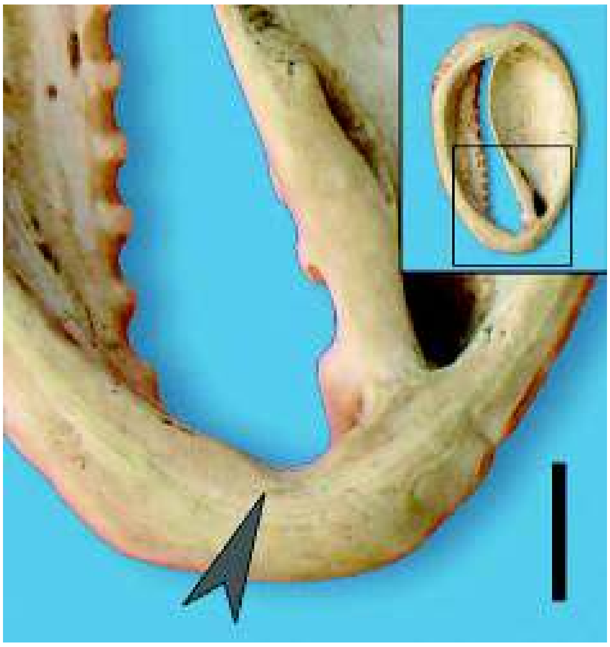

Figure 9 Detail of the dorsal face of the anterior extremity of the cowrie n°33 showing a notch produced by a use wear on the edge of the removed dorsum (scale bar: ¼ cm).

(ca. 12,500 cal. BP), in the Middle Euphrates, but only for making holes in Neritidae shells (Maréchal 1991: 608, Maréchal and Alarashi 2008: 578). The sawing technique was applied during the PPNB period in Cyprus to make small holes in the dorsum part of cowries (Serrand *et al.* 2005). When data are available for the same period in the Near East, grinding technique is mentioned in many cases for the dorsum removal (Bar-Yosef 2000, 2005, Goring-Morris *et al.* 1994-95, Reese 1991).

At Tell Aswad, the methods employed to remove the dorsum part was deduced from the morphological features of the opening ridge and the surrounding areas. Only the grinding and the hammering techniques were clearly evidenced, although the sawing method or a combination of different techniques cannot be definitely excluded. Further analysis could improve these preliminary observations. According to the experiments I made on modern specimens, the grinding technique seems to be more profitable in terms of time and energy costs than the sawing method. Hammering could be quite rapid as a technique but it is more risky.

Apart from the dorsum removal, at least five cowries were perforated at Tell Aswad. Two methods were employed to make holes: drilling on the ventral face and direct or indirect percussion on the dorsal convex part. Given the low number of specimens, it cannot be asserted that this observation reflects a general trend. However, it is interesting to highlight the originality of the location of the drilled perforations. As far as I know, holes made on the ventral face of the cowries were never documented for the Neolithic times in the region. Moreover, when perforated cowries are mentioned in the archaeological literature – exclusively on the dorsal face – the techniques employed are either sawing (*e.g.* Serrand *et al.* 2005: fig. 5n) or percussion (*e.g.* Bienert and Gebel 2004: fig. 13-10). At Tell Aswad, the ventral perforation concerns not only cowries without dorsum but also the unique specimen with dorsum found at the site.

The presence of a series of incisions on two cowrie beads at Tell Aswad is unexpected. Such a feature was never described until now for other Levantine Neolithic sites. In the case of the cowrie n°33, the distribution of the incisions seems to have a decorative purpose, that of emphasizing the natural teeth of the shells. On the other hand, the incisions made on the columellar part n°143 are relatively rough and not so well organized. Thus, the ornamental character of the incisions is not really evident for this object.

Cowrie shells have commonly been used as symbols related to specific anatomic parts of the human body such as the eye or the vulva (Gregory 1996, Goren *et al.* 2001, Kroeber 2001). It is delicate to address the symbolic, esthetical or cultural reasons for these incisions, and many possible answers could be proposed. For instance, might the cowrie n°33 have artificially represented a complex natural patterning of the original shell (like in *Erosaria nebrites*)? Or simply represented other radial-structured symbols like sun, mouth or eye? All that we can say is that, contrary to Jericho

(Goren *et al.* 2001), no cowrie shells were used to model eyes of the plastered skulls found at Tell Aswad (Stordeur and Khawam 2007).

According to the various means of attachment (removed dorsum and perforations) as well as the local use wear, it is obvious that the cowries found at the site were used as beads. However, no specific or direct information is available about the ways in which these ornaments were used (pendants, necklaces, belts, diadems, buttons, etc.). Nevertheless, some suggestions can be made. For one cowrie, the presence of incisions on the ventral and lateral faces clearly indicates the exposition of these anatomical parts. The location of the perforations, the use wear of the aperture extremities and the dorsum removal imply also that the cowries were tied to another material (leather, clothes, etc.) and/or were connected to other beads.

The exceptional cowrie n°33 offers some interesting indications about a possible attachment system. The V-shaped use wear pattern observed on the anterior extremity of the aperture indicates that a string was tied at this place and was pulled out in two opposite directions.

Finally, the data collected for the exceptional discovery of the three cowrie beads found in association (n°9, 42 and 43) are not sufficient to deduce a possible system of attachment. However, it has been already noted that the cowries n°42 and 43 share the same pattern on their ventral perforations: a shallow notch, oriented in the same direction in both cases and probably produced by the action of a string, was observed on their perimeter.

5. CONCLUSIONS

The original shape of the cowries of Tell Aswad was modified in various manners and degrees. Three principal sets of operations can be defined: dorsum removal, perforations and incisions. For the first category, grinding and hammering techniques have been identified. Perforations by drilling were made on the ventral face. For one cowrie, holes were made by percussion on its non-removed dorsum. Relatively deep and long incisions were engraved on the ventral and lateral faces of two specimens. Local surface wear observed on some cowries could be indicative of the attachment system employed to hang the beads.

The presence of cowrie shells at Tell Aswad can be considered a common cultural point between the Southern and Northern Levant PPNB sites. All the shells were identified as *Erosaria spurca* except one as *Luria lurida*. These two species originated in the Mediterranean Sea, about 110 km east from the site. One shell, identified as *Monetaria moneta*, comes from the Red Sea. Tell Aswad is about 500 km from the Red Sea (Aqaba). Some of the cowrie shells found at the site of Tell Halula, in the Northern Levant, belong to both Red and Mediterranean seas (M. Molist, personal communication). This attests that cowry shells were part of a long distance system of exchange and circulation of various items and raw materials. The cowrie shells from the village of Tell Aswad were transformed and fitted to be suspended and tied. One of these beads was beautifully engraved. This feature is one of the most original aspects for shell beads of the PPNB period. Up to now, decorated cowries have never been mentioned elsewhere in the Neolithic Near East.

In some Northern Levant sites, such as Tell Halula, cowries are mainly found in funerary context. In Southern Levant, some of them were employed as eyes in large human figurines or in plastered skulls which is not the case at Tell Aswad. At this site, only one cowrie bead was found associated with a human skeleton whereas the remaining collection was discovered in various domestic contexts: dwellings, refuse areas, pits, etc. Further comparative study within my PhD framework with the huge collection of cowries from Tell Halula (about 300 specimens) could enlighten the remaining issues.

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Lost in the mountains? Marine ornaments in the Mesolithic of the northeast of the Iberian Peninsula

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Lost in the mountains? Marine ornaments in the Mesolithic of the northeast of the Iberian Peninsula

¿Perdidos en las montañas? Ornamentos en concha en el Mesolítico del NE de la Península Ibérica

KEY WORDS: South-eastern Pyrenees, Mesolithic, "cultural landscape", *Columbella rustica*, Boreal.
PALABRAS CLAVE: SE de los Pirineos, Mesolítico, "Paisaje cultural", *Columbella rustica*, Boreal
GAKO-HITZAK: Pirinioetako HE, Mesolitoa, "Paisaia kulturala", *Columbella rustica*, Boreala.

Jorge MARTÍNEZ-MORENO[1], Rafael MORA[1] & Joel CASANOVA[1]

ABSTRACT

In recent years, modified Mediterranean marine shells (especially *Columbella rustica*) have been documented in Mesolithic sites in the Southern Pyrenees and Ebro Basin. Some scholars suggest that the presence of this gastropod allows us to identify a long-distance social network that created a common "cultural landscape". We introduce new data obtained in the South-eastern Pyrenean site of Balma Guilanyà. The chronometric and technical contextualization of this assemblage reveals the transformations that affected the technical, social and cultural spheres of the Postglacial hunter-gatherers from the South Pyrenees and Ebro Valley.

RESUMEN

En los últimos años se han documentado conchas marinas, principalmente de la especie *Columbella rustica*, en yacimientos mesolíticos situados al Sur de los Pirineos y en la Cuenca del río Ebro. Algunos investigadores sugieren que la presencia de *C. rustica* permite la identificación de redes sociales a larga distancia creando un paisaje cultural. En este artículo damos a conocer nuevos datos del yacimiento de Balma Guilanyà, en el SE de los Pirineos. Su contextualización temporal y técnica indica la existencia de transformaciones que afectaron desde el punto de vista técnico, social y cultural a los grupos de cazadores-recolectores del Posglaciar al sur de los Pirineos y en el Valle del Ebro.

LABURPENA

Azken urteotan, itsas maskorrak dokumentatu dira, *Columbella rustica* espeziekoak nagusiki, Pirinioen hegoaldeko eta Ebro ibaiaren arroko Mesolitoko aztarnategietan. Ikertzaile batzuen arabera, C. rustica ageri izanak adierazten du urruneko gizarte-sareak identifikatzen direla, eta, horren ondorioz, paisaia kultural bat sortzen dela. Artikulu honetan, Balma Guilanyà aztarnategiari (Pirinioetako HE) buruzko datu berriak jakinarazten ditugu. Aztarnategiaren denbora-testuinguruak eta testuinguru teknikoak adierazten dute transformazioak izan zirela, eta transformazio horiek Glaziar ondoko garaiko Pirinioen hegoaldeko eta Ebro Bailarako ehiztari-biltzaileei eragin ziela ikuspuntu tekniko, sozial eta kulturalari dagokionez.

1. INTERPRETING THE SIGNIFICANCE OF MARINE ORNAMENTS

There is a consensus that ornaments are identifiers that can be used to analyse the implications of "modern" behaviour. In fact, they are currently a proxy for tracking the dispersion of anatomically modern *Homo sapiens* during the upper Pleistocene throughout the Old World (White 2007). However, an attempt to integrate these artefacts into the study of the behaviour and social organisation of hunter-gatherers has a relatively short history. Since the beginning of Palaeoanthropology, ornaments have with a few exceptions, (see Taborin 1993), traditionally been treated as little more than curiosities, and sometimes their explanatory potential has even been questioned (Binford 1989).

This lack of interest has continued until relatively recent times. Perhaps the turning point came with the acceptance of a new theoretical agenda which coincided with a calling for an analysis of past cultural entities. From this perspective, personal ornaments are the key for reconstructing social dynamics of groups that lived in the past (Turner 1980).

In the Iberian Peninsula, although there is a long tradition of studying these artefacts, the recent synthesis by Esteban Álvarez-Fernández (2006) is essential for investigating aspects related with cataloguing, description and geographical distribution of ornaments from minerals, bones and shells. It is no exaggeration to say that this work opens new perspectives with which to analyse the social function of these indicators during the Upper Palaeolithic and Mesolithic.

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2. A "CULTURAL LANDSCAPE" IN THE NORTH IBERIAN MESOLITHIC?

In this article we discuss the hypothesis that a "cultural landscape" was consolidated in the northeast of the Iberian Peninsula during the Mesolithic in which artefacts, ideas and possibly people circulated (Barandiarán y Cava 1992). This notion has been explored by various authors, who have considered that the choice of *Columbella rustica* is a key attribute (Alday 2002, Cava 2004, Arias 2007).

In a similar vein, Álvarez-Fernández examines the importance of selecting this gastropod. His detailed catalogue shows that this ornament is frequent in Mesolithic settlements of the Ebro Valley, in contrast to the Cantabrian area where *Trivia sp*. is more common (Álvarez-Fernández 2006, 2007). Three clusters of settlements appear in the biogeographic region around the Ebro Valley; one located in the Upper Ebro Valley or Ribera Alavesa (Fuente Hoz, Mendandia, Atxoste, Kampanoste, Kampanoste Goikoa), other located on the southern slopes of the Western Pyrenees (Zatoya, Aizpea, Padre Areso, Peña 14, Legunova, Forcas II) and the last one located in Lower Ebro (Baños de Ariño, Ángel 1, Ángel 2, Botiqueria de los Moros, Costalena, Pontet and Margineda) (see postscript and appendix I). In 18 settlements included in this study, there are only two in which this gastropod has not been found, while this species has been documented in only one site belonging to the Cantabrian "cultural" area (Berroberria) (fig. 1).

A total of 116 marine shells have been recorded from the sites in the Ebro Valley, of which *Columbella* accounts for more than 60%. The assemblages are generally not very numerous (fewer than 5 items) and more than 10 are only recovered in a few cases. In practically all the sites, it is either the only species represented or is the most abundant, associated with other gastropods, bivalves and scaphopods, although these are always very scarce (Álvarez-Fernández 2006). The only sites in which *Columbella* has not appeared are Kampanoste and Mendandia, in the Upper

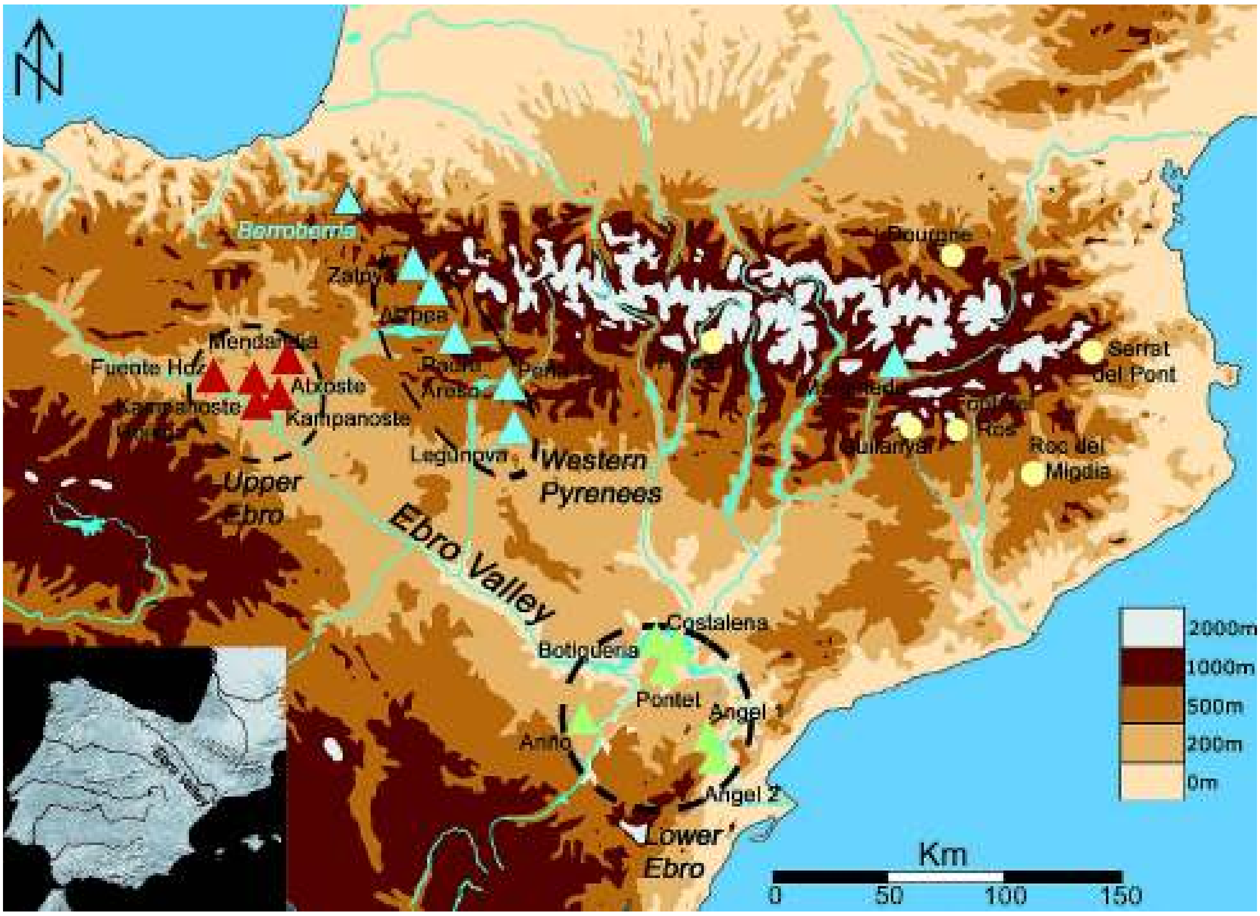

Figure 1. Location of the Mesolithic settlements clusters in the Ebro Basin analysed by Álvarez-Fernández (2006) (▲), those discussed in this article (O), and Berroberia (△) (the only "Atlantic" site with Columbella).

Ebro (fig. 1), where *N. reticulatus*, considered an Atlantic indicator, has mainly been recovered (Alday 2002).

A clear pattern emerges from this description: the circulation of *Columbella rustica* links the Mesolithic settlements of the Ebro Basin (Álvarez-Fernández 2008). This vector implies that this Mediterranean gastropod was transported, and its presence has been recorded in enclaves separated from the Western Pyrenees and the Ribera Alavesa by distances of more than 300 km from the present coastline (fig. 1). This pattern is not exclusive to this geographical area or this period. During the Upper Palaeolithic and Mesolithic of Western Europe, marine shells were transported over great distances, defining axes associated with the major European river basins (Taborin 1993, Álvarez-Fernández 2006).

Within this general panorama two anomalies emerge. The first is Berroberria, a settlement included within the Cantabrian area in which *Columbella* has been documented. However, this site is not far from the Western Pyrenees and Upper Ebro Mesolithic sites with which it offers important parallels (Cava 2004), so the presence of this Mediterranean ornament in an "Atlantic" context does not represent a problem.

The second case is Margineda (fig. 1). Its geographical position appears to define an isolated point that is difficult to relate with the Ebro Basin. This assemblage was not studied directly by Álvarez-Fernández, but was included on the basis of the information published (Guilaine and Martzluff 1995). This settlement has provided one of the most important assemblages of Mesolithic marine ornaments found in the Ebro Basin, which suggests regular contact with the Mediterranean (see appendix I).

3. CONSIDERING THE NOTION OF GEOGRAPHIC ISOLATION

The image of apparent "isolation" referred to in Margineda derives both from its geographical position and the cultural context ascribed to it, since this settlement is considered a clear example of the "facies of fortune" phenomenon. This concept describes a process of technical degeneration characteristic of the Postglacial lithic assemblages that have been documented in various settlements on the northern side of the Pyrenees which are ascribed to the Boreal chronozone (Dourgne c9, Adoutx, Cauna d'Arques, Roc d'en Bertran and Margineda c4) (Barbaza *et al*. 1984). The adaption to mountain ecosystems would have isolated these populations from the networks through which technical innovations circulated. This lack of contact was not restricted to techno-economic processes, but also affected life style and social organisation, resulting in them being cut off from the groups that settled in the Pyrenees.

In recent years we have been analysing the process of human settlement in the South-eastern Pyrenees, and a central focus of this project is the study of the variations observed in the Postglacial hunter-gatherers (Pallarés and Mora 1999). In this area, we have been able to recognise similar attributes to those of the north Pyrenean sites in which Margineda (in the south Pyrenees) indicates this process of isolation (Barbaza *et al*. 1984, Guilaine 1993, Guilaine and Martzluff 1995). On the basis of this observation, a question that arises is how to determine whether this process is geographically dispersed in a way that could be considered a possible territorial indicator. From this point of view, the assemblage of marine ornaments recovered in one of the settlements we are investigating in the South Pyrenees, Balma Guilanyà, will enable us to test the hypothesis of geographical isolation proposed for the Mesolithic hunter-gatherers in the Pyrenees (Martínez-Moreno *et al*. 2006, 2007).

4. BALMA GUILANYÀ: A SMALL ROCK SHELTER "LOST" IN THE PYRENEES

Balma Guilanyà is a small rock-shelter located at a height of 1150 m in a marginal valley of the southern Pre-Pyrenees. This geographical position supports the idea of Mesolithic settlements as "lost" places; however, several indicators contradict this picture. In this stratigraphic sequence two sedimentary units are differentiated, separated by a massive fall of rocks from the shelter's overhang. Several occupations have been documented in the upper level that have been dated to the Boreal and Pre-Boreal and; there two occupations in the lower level, dated to GI-1a and GI-1e (table 1) (Casanova *et al.* 2007).

The fall of the rock-shelter's overhang has sealed and separated the Late Glacial units from those of the Postglacial. This has prevented vertical migrations and/or their components being mixed up by post-depositional process and allows us to infer that these levels have a certain degree of contextual integrity. However, the vertical dispersion of these units, 15-20 cm thick, defines palimpsests that have been created by an indeterminate number of visits.

Level	Marine shells	# Lab	BP	Sample	cal BP (2σ)	Climatic zone
C	11 *Columbella* rustica	Beta-210730	8,640 ± 50	*Corylus*	9,740 - 9,500	B
	1 *Cyclope* sp.	Beta-185064	8,680 ± 50	charcoal	9,790 - 9,510	B
	1 *Acanthocardia* sp.	UBAR-368	8,970 ± 430	charcoal	1,250 - 9,050	PB/B
	7 *Antalis* sp.	Beta-186168	9,410 ± 60	charcoal	10,810 -10,490	PB
	9 nd.					
C1	2 *Columbella* rustica	Beta-210728	9,840 ± 50	Corylus	11,360 -11,160	PB
	5 *Antalis* sp.					
E	1 *Columbella* rustica					
	1 *Nassarius* reticulatus	Beta-210729	10,940 ± 50	Corylus	12,960 -12,840	GI-1a
	5 *Antalis* sp.	UBAR-367	11,460 ± 230	charcoal	13,800 -12,920	GI-1
EJ		Beta-185066	12,180 ± 50	charcoal	14,160 -13,920	GI-1e

Table 1. Archaeo-stratigraphic sequence of Guilanyà showing the malacological record, the BP radiometric series with its respective calibrated ranges Cal BP (IntCal04), and their assignation to the chronoclimatic events of the Late Glacial/Holocene.

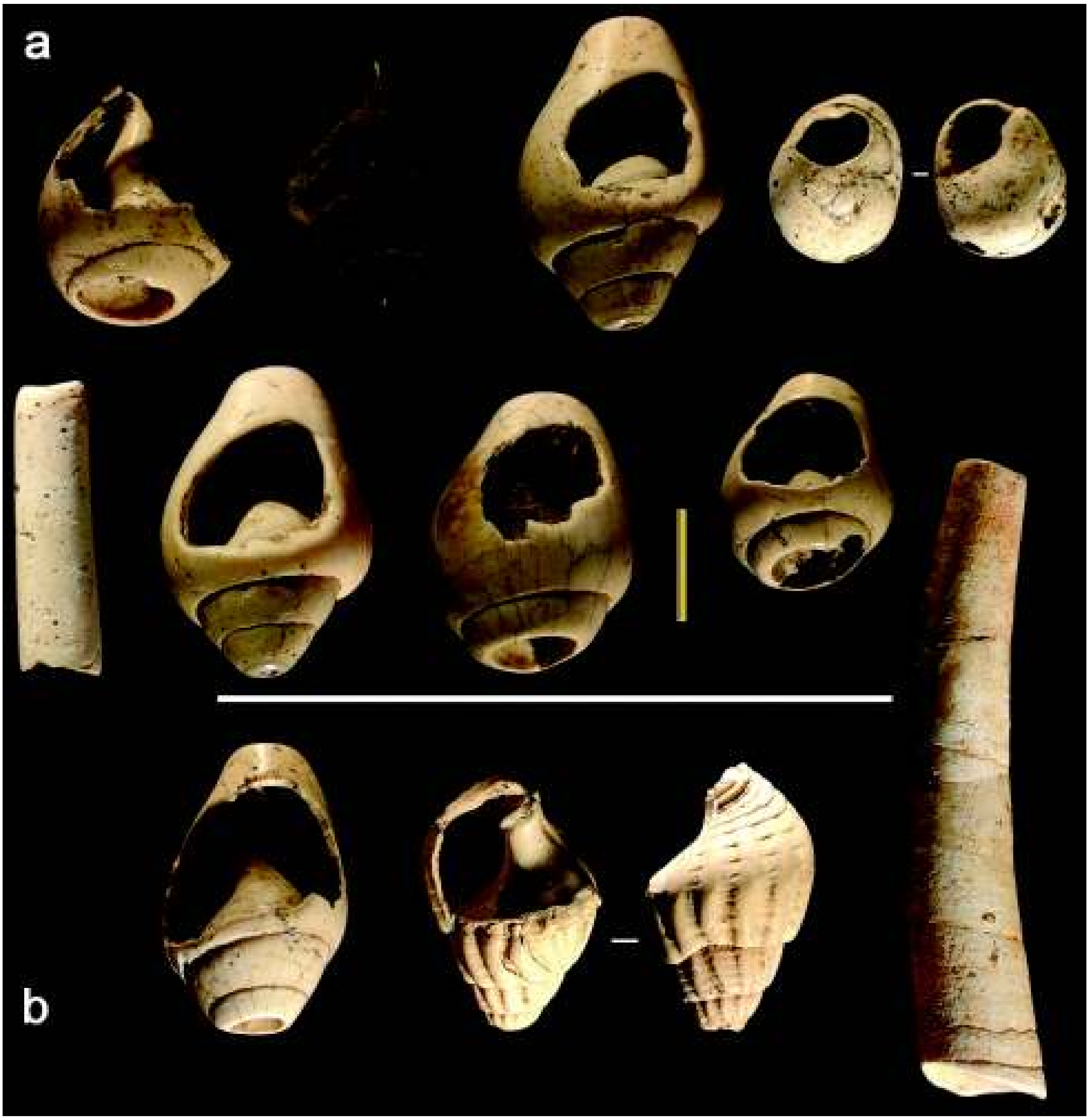

Figure 2. Columbella rustica, Cyclope sp. and *Antalis* sp. from Mesolithic levels of Guilanyà. In the lower part Columbella, Nassarius reticulatus and Antalis sp. from level E. (b) Note the intensely polished surfaces and the remodelling of (a) the perforations, which suggests a long use (graphic scale 5 mm).

The occupation of level C was particularly intense. Several ^{14}C AMS datings on charcoal and hazelnut shells allow us to determine that it is the result of an accumulation of visits between 10,800 and 9,500 cal BP (table 1). The anthracological record can be included in the Boreal chronozone.

Twenty-nine marine shells have been recovered from this level, and *Columbella rustica* is the most abundant species with 11 specimens. These are associated with several scaphopods (7), 1 broken fragment of *Acanthocardia sp*. with a hole on the apical edge, 1 perforated *Cyclope sp*. and several fragments of indeterminate bivalves. These remains were found scattered randomly over the area excavated. No precise relationships between them could be determined, so we think they were brought here at different times. Although we shall not analyse their attributes in detail here, we note that their surfaces are intensely polished, the perforations have been considerably remodelled and the apical area of some of them has been cut back (fig. 2). This suggests that they were attached for a long time to clothing or were part of ornaments before they were deposited in the settlement by chance.

Similarly, in level E, which correspond with GI-1a (or Allerod amelioration), several scaphopods were recovered with *Columbella* and 1 unperforated -but natural drilled- *N. reticulatus*. This find would suggest this gastropod would not be considered exclusively an "Atlantic" vector, and could have colonised the Mediterranean during the Upper Pleistocene. This is an interesting hypothesis, since the association of *Columbella* with *N. reticulatus* in various Mesolithic sites in the Upper Ebro valley is interpreted as the result of their collection from different marine basins (Alday 2002, Cava 2004). This observation should be analysed in detail at the assemblages of the South-eastern Pyrenees.

5. TRACING THE DISPERSION OF COLUMBELLA RUSTICA THROUGH THE SOUTH-EASTERN PYRENEES

The presence of *Columbella* is not restricted to this site, and can be traced through several Mesolithic settlements. We do not intend to build an exhaustive catalogue on the distribution of a very common gastropod on the northern side of the Pyrenees, and refer the reader to other works (Taborin 1993). However, we present some examples that indicate its dispersion through this region, focusing our attention on Margineda, Dourgne, Font del Ros and Roc del Migdia.

As we have noted, Margineda was included by Álvarez-Fernández thanks to published material (Guilaine and Martlzuff 1995). This rock shelter is located in the interior of the south face of the Axial Pyrenean massif at a height of some 1000 m a.s.l. (fig. 1). Twelve *Columbella* shells have been recorded in the Mesolithic level, c4, together with 2 gastropods classified as "Nassa". From the evidence published we think this attribution is incorrect, and that it is *Cyclope* sp. *Columbella* also appears in the early Neolithic levels.

Dourgne is a small rock-shelter located on the northern side of the Pyrenees at a height of some 700 m. a.s.l. (fig. 1). This settlement contains a long chronocultural sequence with several early Neolithic and Mesolithic levels and *Columbella* ornaments have been found in all of them. In one of the Mesolithic levels – c9 – 14 gastropods were recovered in the same square and have been interpreted as part of a possible necklace (Guilaine 1993).

Font del Ros is in the foothills of the sierras of the Eastern Pyrenees at about 669 m a.s.l. More than 1500 m^2 of this open air settlement were excavated, with several occupations being documented around a spring. The radiometric differences in different parts of the settlement suggest that this accumulation is the result of several visits over a period of 800 years (Martínez-Moreno *et al.* 2006, 2007). Three *Columbella* shells, perforated bivalves and scaphopods have been recovered from this site (Pallarés and Mora 1999).

The last site is Roc del Migdia, a rock-shelter adjacent to the southern Pyrenean environment that shares various attributes with the settlements discussed in this article, including an abundance of *Columbella* and other marine ornaments (*Trivia sp.*) (Oliva and Yll 2008). Some of these can be attributed to the Mesolithic, but the taphonomic problems detected in this shelter (Yll *et al.* 1994) make necessary their precise contextualisation, and some relation with very recent chrono-cultural periods cannot be discounted.

This quick review reveals that the selection of this gastropod as an ornament is a recurrent feature of these eastern Pyrenean settlements and these assemblages have stylistic attributes similar to those described in the sites of the Ebro Valley by Álvarez-Fernández (2006). The examples referred to imply distances from the Mediterranean coast of between 90 and 150 km. These similarities enable us to suggest that the settlements of the South-eastern Pyrenees could have formed part of that Mesolithic "cultural landscape", while permitting an axis to be traced connecting both sides of the Pyrenees with the Ebro Valley.

6. *COLUMBELLA RUSTICA* AND *FACIES OF FORTUNE*: TWO CONCURRENT PHENOMENA

The choice of *Columbella* as an icon of a social network that linked the populations of the Ebro Valley during the Mesolithic is a hypothesis that deserves to be explored. Two elements will enable the evaluation this statement: the techno-stylistic attributes of Postglacial lithic artefacts, and the chronometric range in which this ornaments appears.

As we have said, traditionally the "facies of fortune" documented on the North-eastern Pyrenees entails geographical isolation and social encapsulation (Barbaza *et al*, 1984). Alternatively, we suggest that the lithic assemblages of the South-eastern Pyrenees Mesolithic shares similar attributes, resulting of the remodelling the artefacts' organisational principles, generating a response based on the simplification of the technical design. In other words, these technical solutions were not exclusively functional responses conditioned by ecological factors (constrictions imposed by adapting to mountain *milieu*), and it does not represent a regressive cultural process (Martínez-Moreno *et al*. 2006, 2007).

Assemblages with techno-stylistic attributes that are no different from those described in the South-eastern Pyrenees are described in the settlements of the Lower Ebro, Upper Ebro and Western Pyrenees, although with their own specific characteristics derived from the availability of raw materials or activities carried out in those settlements (see contributions in Alday 2006). This suggests that the pattern detected in the South-eastern Pyrenees is dispersed over a wide geographic area vertebrated around the Ebro Basin.

Another aspect to be examined is the temporal dimension of this process. We assume that if it is an organisational response, it will be recorded in a similar temporal frame. At the same time, if this process can be found throughout this geographical area it would support the contention that this was a general pattern, not the result of specific adaptive situations. However, several factors make it difficult to carry out a radiometric evaluation: the differences in the number of dated occupations, the imprecision of many radiocarbon dates due to high standard deviations and problems related with their archaeological context, limiting the possibility to obtain a precise timeline.

As an alternative we propose grouping the radiometric records in which *Columbella* appears on the basis of geographical clusters: Upper Ebro, Western Pyrenees, Lower Ebro and South-eastern Pyrenees. The aim is to compare the ages of the ornaments and evaluate whether they represent a recurrent chronometric frame. In order to carry out this analysis the available radiocarbon dates were converted into calibrated ranges (cal BP) with 2σ following the IntCal04 curve contained in CalPal software (Weninger *et al*. 2006) (fig. 3).

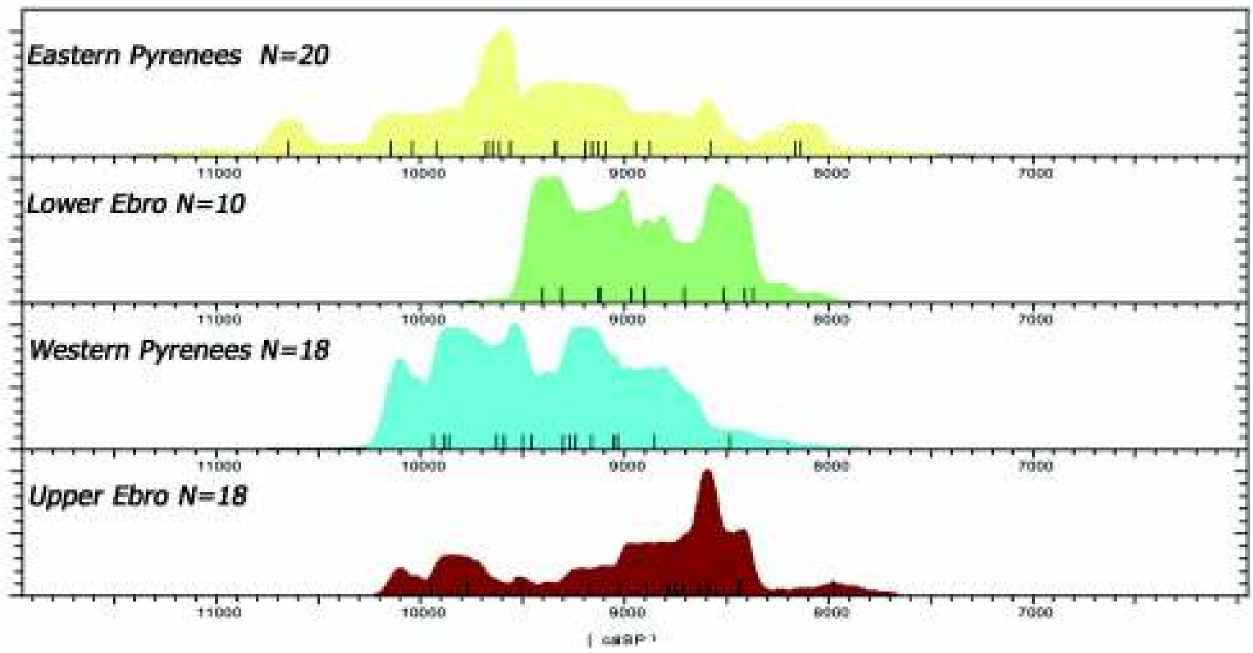

Figure 3. Chronometric distribution of the different geographical clusters where Columbella rustica has been detected, expressed in cal BP Ka.

This software enables these Gaussian distributions of irregular geometry expressed by the accumulation of probabilities of different dates to be displayed visually. This procedure enables these chronometric ranges to be compared by treating them as solar years. Broadly speaking, the graph produced from 66 14C radiocarbon datings shows that this ornament is *particularly* frequent between 10,000-8,500 cal BP. Chronoclimatically, these assemblages are positioned within the Boreal period, observation that coincides with the results obtained from the palaeoecological analysis carried out in these sites (see Alday 2006). We do not think it advisable to draw further conclusions, due the irregular quality of the radiometric record currently available.

The two hypotheses implied in our analysis suggest that *Columbella rustica* can be correlated with the technical situations originally described in the North-eastern Pyrenees (Barbaza *et al*. 1984). Their geographical dispersion and their persistence over time suggest that far from being adaptations to specific situations, they formed part of a technical and social tradition belonging to a particular spatio-temporal pattern. Moreover, these techno-complexes are recorded in other settlements within these geographical clusters, which we have not included in this article, within a similar temporal range (Alday 2006). At the same time, *Columbella* continues after 8.5 ka cal BP, and it is frequent during the final Mesolithic and early Neolithic (Álvarez-Fernández 2008).

From this point of view, the possibility that this ornament identifies a process that is not only recorded around the Ebro Basin becomes more compelling. Equally important is the trans-Pyrenean vector detected on the basis of the sites discussed in this article. The integration of this area is appealing since it expands the possible “cultural landscape” –or social network, as we prefer– that connects the Ebro Valley with the Rousillon-Languedoc and the Garonne Basin. This observation deserves to be analysed in future contributions.

7. DISCUSSION

Far from being isolated populations, Mesolithic people in the Ebro Valley and the South Pyrenees shared technical and symbolic elements that reveal a social network in which artefacts, ideas and possibly people moved. In this respect, *Columbella rustica* is an icon that traces the dispersion of the “cultural landscape” (Barandiarán y Cava 1992, Alday 2006, Álvarez-Fernández 2006, Arias 2007) that can be recognised in the north of the Iberian Peninsula.

Guilanyà and similar settlements describe the expansion of hunter-gatherers to be traced through the South Pyrenees, a process that is little known. The use of the mountain ecosystems has prompted various reflections since the supply of resources suitable for exploitation in these environments was severely restricted. The concurrence of various natural events meant that in these places the availability of abundant resources could be predicted, but were restricted to certain periods of the annual cycle. Seen in this way, recurrent occupation of these apparently isolated settlements depicts patterns of mobility that involved increased planning of subsistence activities (Gamble 1993).

We assume that these strategies continued for a long time in the eastern Pyrenees and could go back to the GI-1 interstadial, when Mediterranean ornaments and *Nassarius reticulatus* have been recorded in Guilanyà (fig. 2). These indicators open new perspectives when considering the history of the construction of that “cultural landscape” (or social network), which probably began in the Late Glacial period, a hypothesis we are currently working on (Martínez-Moreno *et al.* 2007). We suspect that precious information for understanding the behaviour of hunter-gatherers in the Late Glacial and Postglacial periods in Southwest Europe lies hidden in these small settlements “lost” in the mountains.

8. POSTSCRIPT

During the revision of this paper, new information has been published about the presence of *C. rustica* in two Mesolithic sites of the South-eastern Pyrenees and therefore they have been included in this paper: Forcas II (Álvarez-Fernández 2008) and Bauma del Serrat del Pont (Alcalde and Saña 2008) (see fig 1 and appendix I). Both sites share a techno-typological pattern and a chronological frame similar to the South-eastern Pyrenean sites mentioned in this paper. The implications of these new assemblages deserve to be discussed in future contributions.

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11. APPENDIX I

Appendix I: Gastropod ornaments from Mesolithic sites discussed in the text. Key of geographic cluster is: Atlantic (A), Upper Ebro Basin (UE), South-western Pyrenees (WP), Lower Ebro Basin (LE), North-eastern Pyrenees (NEP), South-eastern Pyrenees (SEP) (see fig. 1). Data from; 1-Álvarez-Fernández 2007; 2-Álvarez-Fernández 2008; 3-Guilaine (ed.) 1993; 4-Guilaine and Martzluff (ed.) 1995 (modified); 5- Alcalde and Saña (eds.) 2008, 6- Oliva and Yll (2008). *Columbella rustica* in Forcas II is mentioned in Alvárez-Fernández (2008) *Trivia* sp., *Nassarius* sp. *Cyclope* sp. and *Columbella* are cited for Roc del Migdia (Álvarez-Fernández 2008, Oliva and Yll 2008); but in an unclear stratigraphic context.

Sites	Cluster	*L. obtusata*	*Trivia*	*N. reticulatus*	*Cyclope*	*C. rustica*	*Cerithium*	*Naticidae*	Reference
Berreberria	A		1			1			1
Fuente Hoz	UE	1	1			5			1
Mendandia	UE		1	5				1	1
Atxoste	UE			3		1		1	1
Kampanoste Goikoa	UE					2			1
Kampanoste	UE			18					1
Zatoya	WP					1			1
Aizpea	WP			1		5			1
Padre Areso	WP					1			1
Peña 14	WP					2			1
Legunova	WP					1			1
Forcas II	WP					*			2
Baños de Ariño	LE					3			1
Angel 1	LE					14	1		1
Angel 2	LE					3	1		1
Botiqueria Moros	LE					8			1
Costalena	LE					9	1		1
Pontet	LE		3			3			1
Dourgne	NEP					14			3
Margineda	SEP				2	12			4
Guilanyà	SEP				1	11			
Font del Ros	SEP					3			
Serrat del Pont	SEP					14			5
Roc del Migdia	SEP		* ?	* ?	* ?	8 ?			2,6

Appendix 1.

New data on Asturian shell midden sites: the cave of Mazaculos II (Asturias, Northern Spain)

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New data on Asturian shell midden sites: the cave of Mazaculos II (Asturias, Northern Spain)

Nuevos datos sobre los Concherso asturienses: la cueva de Mazaculos II (Asturias, España)

KEY WORDS: Archaeomalacology, Asturian, Mesolithic, shell midden, molluscs.
PALABRAS CLAVE: Arqueomalacología, Asturiense, Mesolítico, conchero, moluscos
GAKO-HITZAK: Arkeomalakologia, Asturiensea, Mesolitoa, maskortegia, moluskuak.

F. Igor GUTIÉRREZ[(1)] & MANUEL GONZÁLEZ[(1)]

ABSTRACT

Throughout the 20th century, research on Mesolithic shell midden sites in northern Spain was focused predominately on the Asturian chronocultural period (≈ 9,000 - 6,000 BP). However, the last twenty years have seen a decline in the archaeological investigation of the Asturian period, while research on Mesolithic shell midden sites has increased in other areas of northern Spain, such as eastern Cantabria and the Basque Country. In spite of the large amount of investigations conducted on the Asturian shell middens during the past century, only a few detailed archaeomalacological analyses have been carried out. In this paper we present the preliminary results of the archaeomalacological analysis from the Asturian shell midden site of Mazaculos II (La Franca, Asturias). These new data are used to address both species representation patterns and collection areas as well as to compare these results to established data from previous molluscan research on the Asturian. Exploitation was concentrated on species of *Patella* genera and *Osilinus lineatus*, as usual in Asturian shell middens. Collection was performed in the rocky intertidal zone, especially in low, exposed areas The study does not detect important changes in time, and consequently the exploitation pattern remains stable during the Asturian and early Neolithic.

RESUMEN

A lo largo del siglo XX la investigación del fenómeno de los concheros mesolíticos en el norte de la Península Ibérica ha sido casi exclusivamente dedicada al Asturiense (≈ 9000 - 6000 BP). Sin embargo, en los últimos veinte años las investigaciones sobre este período han sido bastante escasas, mientras han crecido los trabajos sobre concheros en otras áreas, como el oriente de Cantabria o el País Vasco. A pesar de la gran cantidad de trabajos realizados sobre los concheros asturienses durante el siglo pasado, hasta el momento solo se han llevado a cabo unos pocos análisis arqueomalacológicos con cierto detalle. En esta comunicación se presentan nuevos datos relativos a la explotación de moluscos procedentes del conchero de la Cueva de Mazaculos II (La Franca, Asturias). Estos datos se utilizan para discutir cuestiones relacionadas con los patrones de representación de especies y las áreas de recolección, y para comparar con la información previa disponible para el Asturiense. Así, la explotación se ha centrado fundamentalmente en las especies del género *Patella* y *Osilinus* lineatus, como es habitual en los concheros asturienses. La recolección se ha llevado a cabo en el intermareal rocoso, especialmente en zonas bajas y expuestas. No se han detectado grandes cambios a lo largo del tiempo, y por tanto, el mismo patrón de explotación se mantiene estable durante el Asturiense y los inicios del Neolítico.

LABURPENA

XX. mendean zehar, Iberiar Penintsularen iparraldeko Mesolitoko maskortegien fenomenoaren ikerketa ia-ia Asturienseari (≈ 9000 - 6000 BP) buruzkoa soilik izan da. Hala ere, azken hogei urteotan, periodo horri buruzko ikerketak nahiko urriak izan dira, eta, beste gune batzuetako maskortegiei buruzko lanen kopurua hazi egin da; esate baterako, Kantabriako ekialdekoa eta Euskal Herrikoa. Aurreko mendean Asturienseko maskortegiei buruzko lan asko egin ziren arren, gaur arte analisi arkeomalakologiko batzuk baino ez dira egin, nolabaiteko xehetasunez. Komunikazio honetan, Cueva de Mazaculos II (La Franca, Asturias) izeneko haitzuloko maskortegitik ateratako moluskuen ustiapenari buruzko datu berri batzuk aurkezten dira. Espezieak adierazteko patroiekin eta bilketarako guneekin lotutako auziak eztabaidatzeko erabiltzen dira datu horiek, eta Asturienseari buruzko aurretiko informazioa alderatzeko. Ustiapenaren oinarria Patella eta Osilinus lineatus generoetako espezieek osatu dute batik bat, Asturienseko maskortegietan ohikoa den moduan. Marearteko gune harritsuan egin da bilketa; eta bereziki, gune baxu eta arriskutsuetan. Ez da aldaketa handirik hauteman denboran zehar, eta, beraz, ustiapen-patroia egonkorra da Asturiensean eta Neolitoaren hasieran zehar.

1. INTRODUCTION

Studies regarding the Asturian began at the start of the 20th century with the works of several authors. Thus, despite the fact that Hugo Obermaier (1916) first coined the term that gave its name to this period, the Conde de la Vega del Sella (1914, 1916, 1923) contributed, to a greater extent, to the widespread knowledge of the Asturian. After the excavations carried out in the Cueva de El Penicial (Vega del

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Sella 1914), and later in other caves in the area, such as Cueto de la Mina or Balmori (Vega del Sella 1916), he established the stratigraphic position and the main characteristics of this period. Thus, the Asturian is characterized as being a culture situated between the Palaeolithic and the Neolithic, and having noticeable quantities of marine molluscs in its deposits, as well as the characteristic Asturian picks (Fig. 1). From a geographic point of view, Vega del Sella himself defined the Asturian territory as that extended along the coastal strip between Oviedo and Santander, with a nuclear area around Llanes, in Eastern Asturias.

The hypothesis supported by Vega del Sella was contradicted in the mid-20th century by Jordá (1959), who adapted Crusafont's "karstic rejuvenation theory" to attribute the Asturian shell middens in cave mouths to the Lower Palaeolithic. This theory was based on the interpretation of concreted remains of middens in the walls and ceilings of cave mouths as evidence of cycles of deposit and erosion. Asturian deposits had been eroded in an early date during a humid period of karstic reactivation, leaving only concreted patches in caves where Middle and Upper Palaeolithic layers were subsequently deposited. This interpretation implied an Early Palaeolithic date for the Asturian.

From the 1960s, the introduction of new radiocarbon dating techniques by American researchers contributed to the solution of this chronological problem. Thus, Clark (1976) corroborated, through radiocarbon dating and a re-evaluation of the stratigraphic evidence, the hypothesis proposed by Vega del Sella, who situated the Asturian in the Mesolithic (≈ 9000 - 6000 BP). Once the chronological problem was solved, following research has focused on explaining the Asturian ways of life, within the framework of processual theories that were being introduced by Anglo-Saxon researchers (Bailey 1973, Clark 1976, Straus 1979). These theories had a clear influence on the new generations of Spanish researchers who adopted the new perspectives for the study of the Asturian during the 1980s (González Morales 1982). Since 1986, the study of the Asturian decreased in terms of scientific production, as only some academic works (Craighead 1995, Fano 1998, Gutiérrez 2008) and synthesis articles (Bailey and Craighead 2003, González 1989, 1996, Fano and González 2004) were produced, and only a few field archaeological research projects were carried out (Arias *et al.* 2007 a, b).

The introduction of processual archaeology in the region implied not only the adoption of new methods and research techniques, but also a stronger concern with the analysis of settlement patterns, initiating a wide debate around the relationship between the Asturian and the Azilian. Straus (1979) proposed the contemporaneity of both of them on the basis of the partial overlapping of the available radiocarbon dates; differences were explained in terms of complementary functionality: Azilian occupations represented the terrestrial hunting heritage of Late Palaeolithic in multipurpose sites, while Asturian middens evidenced a coastal adaptation with occupations specialized in marine resources, culminating the trend to diversification also visible in Final Pleistocene times. Later, González (1989), with a larger database of radiocarbon dates and the evaluation of stratigraphic information, concluded that

Figure 1. Different views of an Asturian pick from Mazaculos II.

Asturian and Azilian were independent and non-contemporaneous chronostratigraphic periods.

In this framework, the study of molluscs is a research domain which has not received much detailed attention. The first works by Vega del Sella only contained lists of species, and they did not include quantifications or other analyses. Clark (1976), on his side, starts presenting quantitative data in some of his works, but without an in-depth methodological development. The first detailed archaeomalacological analyses started with Ortea´s works at Mazaculos and La Riera. However, only the complete study of La Riera was published (Ortea 1986), meaning that this is the only detailed analysis of an Asturian shell-midden that exists at present. On the other hand, it is worth noting that the Asturian levels at this site are the worst characterized of the entire sequence, given that the sample sizes are very poor. Also, his works at Mazaculos (González *et al*. 1980; Llera & Ortea unpublished report) do not present the degree of detail that would be desired for a good understanding of the site. Lastly, Craighead (1995) carried out a study of the molluscs at La Riera, completing the work done by Ortea, and emphasizing economic and environmental aspects through the application of innovative analytical techniques. In the same way, Gutiérrez (2008) carried out a detailed analysis of the material from La Llana shell midden site.

Thus, with the aim of alleviating the shortage of detailed information regarding mollusc exploitation during the Asturian, this paper will present new archaeomalacological data from the site of Mazaculos. These data, obtained through modern and detailed methodologies (Gutiérrez 2008; Moreno 1994), are placed in relation to the available information for Mazaculos (González *et al*. 1980, Llera and Ortea, unpublished report), and other Asturian sites (Clark 1976, González 1982), as La Riera (Ortea 1986, Craighead 1995, Bailey and Craighead 2003), La Llana (Gutiérrez 2008) and Poza l'Egua (Arias *et al*. 2007a). Also, we have included the early Neolithic level at Mazaculos in order to establish differences or similarities with Asturian exploitation patterns.

2. GEOGRAPHIC FRAMEWORK

The Cave of Mazaculos is located in the Principality of Asturias (northern Spain), in the eastern region and very close to the current coastline (Fig. 2). It is situated in a limestone massif near the Cabra River, which flows into La Franca beach. The cave is located at 35 metres above current sea level, and its entrance is a great shelter with a NNW orientation. Its distance to the sea at present is approximately 400 metres.

The eastern region of Asturias presents a characteristic orography, with a coastal platform limited towards the south by mountainous alignments that can be crossed relatively comfortably across the rivers' paths, which flow in a south-north direction. This probably caused the mobility of human groups to have been limited and mainly restricted to the coastal platform, with very scarce occupation of the interior.

3. BACKGROUND

The cave has been of interest from the start of the 20th century (Alcalde del Río *et al*. 1911, Vega del Sella 1916 and 1923), although the first interventions as part of a research project did not take place until the end of the 1970s (González *et al*.

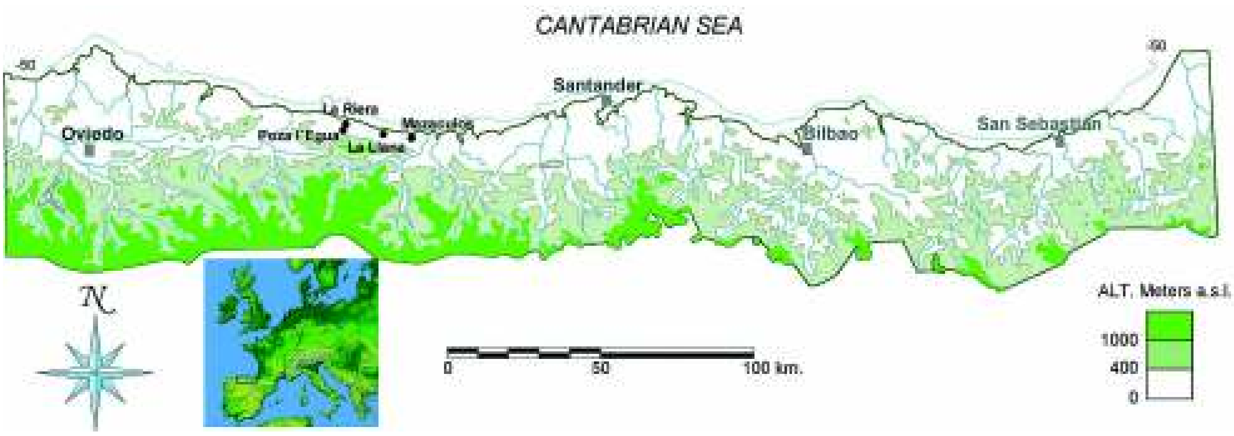

Figure 1. Location of the Asturian sites cited in the text.

1980). The excavation took place between 1976 and 1983, and focused on two areas named Sector 1 (shell-midden in the exterior shelter) and Sector 3 (shell deposit in the first interior hall). The archaeological works exposed four main levels in Sector 1 and two in Sector 3, chronologically comprising the entire Mesolithic, but with no clear evidence of previous occupational periods. However, the works in Sector 3 allowed the identification of levels dated to the Neolithic, which completed the sequence (González 1995: 68).

Several preliminary publications on the site have presented information regarding the Asturian shell-midden and its composition (González *et al*. 1980:56). The scarce information available, obtained from Sector 1, shows that the primary species being exploited were *Patella vulgata, Patella intermedia* and *Osilinus lineatus*. Other species were present in the shell-midden, but we did not have quantitative data that indicate their importance in the collection strategies, because only presence-absence data are presented in the existing reports (Llera and Ortea, unpublished report). However, according to the authors of this report, such species were especially scarce.

4. ARCHAEOMALACOLOGICAL ANALYSIS OF MAZACULOS II

The identification of the material has been carried out using comparative collections (Museo Nacional de Ciencias Naturales de Madrid and Museum National de Histoire Naturelle de París), specialized guides (Poppe and Gotto 1993a, 1993b, Hayward *et al*. 1998, Kerney and Cameron, 1999) and observations in the present coast. Nomenclature used for molluscs is based on the CLEMAM systematic (http://www.somali.asso.fr/clemam/index.clemam.html). About quantification methodology, material was separated in different categories of fragmentation for MNI calculation (Gutiérrez 2008, Moreno 1994), the index used as the base for the determination of relative frequencies.

Next we will present the data corresponding to the malacological fauna recovered during the excavation in Sector 3. Two main units were identified in this Sector, named A3 (Mesolithic) and A2 (Neolithic). Level A2 was divided into three sub-levels (from top to the bottom: A2 + A2base, A2 base and A2bottom) (see: Table 1). Due to formation processes in this portion of the site, including the steep ramp over the excavated area, stratigraphic contact among sub-levels were irregular in cases, this affecting mainly the precise cultural attribution of A2bottom, still depending on the evaluation of its complete record.

Level A3 (NISP: 2558) is made up of 20 taxa, four of which are bivalves, nine are marine gastropods, four are land gastropods, two are crustaceans and one is an echinoderm, with an MNI of 1116 and a weight of 1384 grams. Thus, in this Mesolithic level the genus *Patella* represents 80% of the shell-midden, followed by *Osilinus lineatus*, representing 11%. The rest of the assemblage is composed of marginal species that appear in small quantities. It is worth noting the relative abundance of the barnacle *Pollicipes pollicipes* (3.1%) and the scarcity of bivalves (1.5%). Amongst the gastropods, apart from those already mentioned, *Gibbula* sp., *Littorina littorea*, and *Littorina obtusata* are also present.

Level A2 (NISP: 21722) is composed of three sublevels, which encompass 32 taxa, six of which are bivalves, sixteen are marine gastropods, six are land gastropods, four are crustaceans, and one is an equinoderm. The main characteristic of level A2 is the similarity in composition of the three sub-levels, which combined present an MNI of 7035 individuals and weigh 8509 grams. In all of them there is a predominance of the genus *Patella*, which represents up to 75-80% of the MNI, whilst *Osilinus lineatus* represents 13%. It is relatively surprising that, as is the case during the Mesolithic, the next most represented taxon is the barnacle *Pollicipes pollicipes* (5-7%). In terms of the marginal species, the collection of bivalves (*Mytilus galloprovincialis, Ostrea edulis, Ruditapes decussatus, Scrobicularia plana*) is similar in the entire sequence except in the upper level A2+A2base, where species diversity is notably less (probable due to the small sample size). Meanwhile, amongst the marine gastropods we find *Gibbula* sp., *Littorina littorea, Littorea obtusata, Littorina saxatilis, Melarhaphe neritoides, Nassarius reticulatus, Nassarius incrassatus, Hydrobia ulvae, Charonia lampas* or *Nucella lapillus*. The same happens with the crabs Brachyura sp. and the echinoid *Paracentrotus lividus* identified at the site, which appear marginally. Finally, in the malacological groups studied, taxa of subsistence, ornamental, intrusive-nature types and of a potentially modifiable nature have been identified. (Gutiérrez 2008).

Level and Period	A3 Asturian		A2bottom Neolithic?		A2base Neolithic		A2+A2base Neolithic	
Bivalvia	MNI	%MNI	MNI	%MNI	MNI	%MNI	MNI	%MNI
Mytilus galloprovincialis Lamarck, 1819	12	1,08	41	1,24	37	1,13	6	1,28
Ostrea edulis Linné, 1758	3	0,27	2	0,06	1	0,03		
Ruditapes decussatus (Linné, 1758)	1	0,09	1	0,03				
Scrobicularia plana (Da Costa, 1778)	1	0,09	1	0,03	1	0,03		
Striarca lactea (Linné, 1758)			2	0,06				
Veneridae sp.			1	0,03	1	0,03		
Total Bivalvia	17	1,52	48	1,45	40	1,22	6	1,28
Gastropods: Prosobranchia	MNI	%MNI	MNI	%MNI	MNI	%MNI	MNI	%MNI
Charonia lampas (Linné, 1758)			1	0,03				
Gibbula sp.	1	0,09	1	0,03	2	0,06		
Gibbula umbilicalis (Da Costa, 1778)	1	0,09	1	0,03				
Hydrobia ulvae (Pennant, 1777)			1	0,03				
Littorina littorea (Linné, 1758)	1	0,09	3	0,09	2	0,06		
Littorina obtusata (Linné, 1758)	1	0,09	1	0,03	1	0,03		
Littorina saxatilis (Olivi, 1792)					1	0,03	1	0,21
Melarhaphe neritoides (Linné, 1758)					2	0,06		
Nassarius incrassatus (Ström, 1768)			1	0,03	1	0,03	1	0,21
Nassarius reticulatus (Linné, 1758)			1	0,03				
Nucella lapillus (Linné, 1758)							1	0,21
Osilinus lineatus (Da Costa, 1778)	128	11,47	453	13,70	443	13,58	64	13,70
Patella vulgata Linné, 1758	196	17,56	555	16,78	466	14,29	54	11,56
Patella intermedia Murray in Knapp, 1857	227	20,34	524	15,85	472	14,47	63	13,49
Patella ulyssiponensis Gmelin, 1791	75	6,72	215	6,50	162	4,97	20	4,28
Patella sp.	427	38,26	1319	39,89	1446	44,34	215	46,04
Total Gastropods: Prosobranchia	1057	94,71	3076	93,01	2998	91,93	419	89,72
Gastropods: Pulmonata	MNI	%MNI	MNI	%MNI	MNI	%MNI	MNI	%MNI
Cepaea nemoralis (Linné, 1758)	1	0,09	1	0,03	3	0,09	2	0,43
Claussilidae sp.	1	0,09			1	0,03	2	0,43
Cochlostoma sp.	2	0,18	3	0,09			1	0,21
Cryptomphalus aspersus (O.F. Müller, 1774)					1	0,03	1	0,21
Helicidae sp.	1	0,09	1	0,03				
Pomatias elegans (O.F. Müller, 1774)			1	0,03	1	0,03		
Total Gastropods: Pulmonata	5	0,45	6	0,18	6	0,18	6	1,28
Crustacea	MNI	%MNI	MNI	%MNI	MNI	%MNI	MNI	%MNI
Brachyura sp.	1	0,09	1	0,03	1	0,03		
Balanus sp.					1	0,03		
Pollicipes pollicipes Leach, 1817	35	3,14	174	5,26	213	6,53	35	7,49
Annelida	MNI	%MNI	MNI	%MNI	MNI	%MNI	MNI	%MNI
Serpulidae sp.			1	0,03	1	0,03		
Echinodermata	MNI	%MNI	MNI	%MNI	MNI	%MNI	MNI	%MNI
Paracentrotus lividus (Lamarck, 1816)	1	0,09	1	0,03	1	0,03	1	0,21
TOTAL	1116	100	3307	100	3261	100	467	100

Table 1. Absolute (MNI) and relative (%MNI) frequencies of molluscs in Sector 3 at Mazaculos.

5. SPECIES REPRESENTATION DURING THE ASTURIAN AND THE EARLY NEOLITHIC

Both periods present a similar exploitation pattern, with a predominance of *Patella*. The second most represented species is *Osilinus lineatus*, but its contribution does not exceed 14% of the MNI, either in A3 (Asturian) or in A2 (Neolithic). Something similar happens in the Asturian levels of Sector 1 (González *et al*. 1980:56), as the quantities of *Osilinus lineatus* range between 37% and 28% depending on the level. However, these counts do not take the marginal species into account, so the importance of *Osilinus lineatus* will, in fact, be slightly inferior. Therefore, the *Patella* genus is the most exploited although, whereas in Sector 1, Ortea identified all the material to species level, in the case of Sector 3 the effects of taphonomic processes led to a large part of the material to be identified to genus level, as can be seen in Fig. 3.

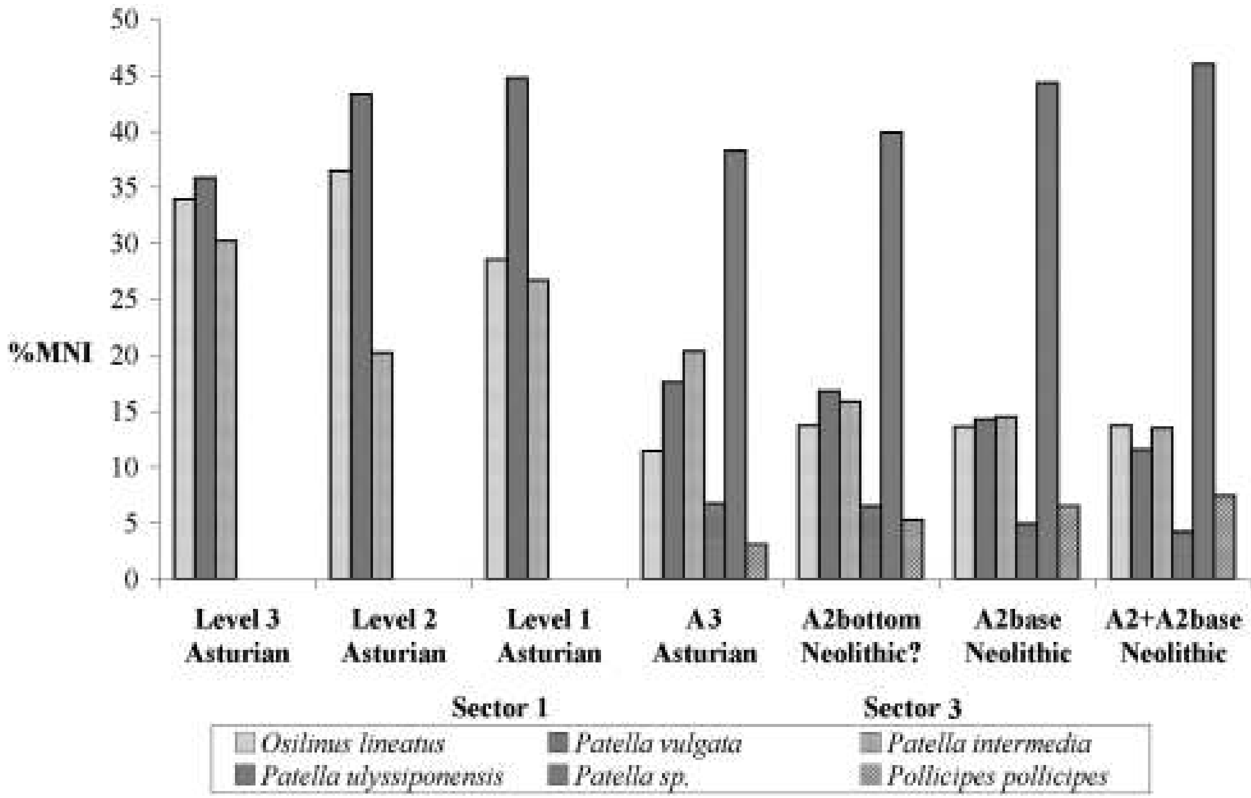

Figure 3. Distribution of the most abundant molluscs at Mazaculos by stratigraphic units. The data for Levels 3, 2 and 1 come from Ortea's analysis of Sector 1 published in González *et al.* (1980).

The rest of the species are scarcely represented and hardly show any importance in terms of contribution to subsistence. In Sector 3 at Mazaculos it is interesting to remark that after *Patella* and *Osilinus lineatus*, the most represented species is the barnacle *Pollicipes pollicipes*, somewhat unusual in shell-middens in the Cantabrian region. Thus, it can be observed how its quantities increase slightly throughout the sequence, from 3% in the Mesolithic level (A3) to 7% in the upper Neolithic level (A2+A2base). This increase reflects the exploitation of low and exposed shores, possibly more than in previous periods.

If we look at the data from other Asturian sites (Arias *et al*. 2007 for Poza l´Egua; Clark 1976: 43-118 and 225-233 for El Penicial, Coberizas, Arnero, Balmori, and Fonfría, amongst others; Gutiérrez 2008 for La Llana; Ortea 1986 for La Riera) we find that the pattern for the collected species is very similar, with a predominance of the *Patella* genus followed by *Osilinus lineatus* and then a series of marginal species, which generally include bivalves, marine gastropods, land gastropods, crustaceans and echinoderms.

6. COLLECTION AREAS

First, from the substratum perspective, collection has taken place exclusively in rocky areas. There are no species from sandy bottoms and those from muddy beds appear only sparsely in both levels at Mazaculos. This pattern can be also noted in La Llana, La Riera, Poza l'Egua and other Asturian sites (Clark 1976) and has traditionally been associated with the lack of big estuaries in the area.

If we look at the vertical zonation of the collected species, we observe that they all live in the intertidal range even though some can also be found in the supratidal (*Melarhaphe neritoides, Littorina saxatilis*) or in the subtidal (*Charonia lampas, Gibbula sp., Haliotis tuberculata, Nassarius reticulatus, Paracentrotus lividus, Pollicipes pollicipes*). If we calculate the ratios of length to height (L/H) of *Patella vulgata* (for an explanation of the method see: Craighead 1995) to establish the zonation, it seems that the lower areas have been the most exploited. This implies that there are no differences among sites because the exploitation took place in the lower areas not only at Mazaculos but also at La Riera and La Llana.

Last, collection could have taken place in exposed or sheltered areas. Craighead's study (1995; see also: Bailey and Craighead 2003) of *Patella vulgata* at La Riera established a discriminating function in order to calculate coastal exposure of the areas where the limpets came from. This was done using biometric measurements (length, width, height). If this function is applied, we can observe that more than 90% of the *Patella vulgata* specimens found at Mazaculos come from exposed coasts (Table 2). In addition, there is a large presence of species that only inhabit exposed coasts, such as the *Charonia lampas, Gibbula umbilicalis, Haliotis tuberculata, Melarhaphe neritoides, Patella intermedia, and Patella ulyssiponensis* molluscs, the echinoderm *Paracentrotus lividus*, and the *Pollicipes pollicipes* crustacean in particular. The scarce presence of species typical of sheltered coasts, such as *Hydrobia ulvae*, *Ruditapes decussatus* or *Scrobicularia plana*, supports the hypothesis that collection was focused on exposed areas.

However, differences can be noted if we compare La Riera, which shows exploitation in sheltered areas (we should approach this datum with caution given the small size of the sample available for analysis), to Mazaculos and La Llana, which show a clear exploitation of exposed areas.

7. CONCLUSIONS

Therefore, in terms of species representation, it is possible to talk about an Asturian species representation pattern. Thus, the collection of molluscs by human populations was fundamentally focused on the *Patella* genus, and to a lesser extent on *Osilinus lineatus*. Moreover, the appearance of other marginal species is also common, including marine bivalves, marine gastropods, land gastropods, crustaceans and echinoderms. As can be noted from the Mazaculos analysis, during the Neolithic the group of species being exploited presents the same characteristics as during the Asturian.

Regarding the collection areas, mollusc exploitation took place in rocky intertidal areas, with a predominance of collection in lower and exposed shores. This pattern is probably conditioned by the morphology of the coast, where these types of areas, rocky and exposed, are predominant, and it would have been maintained during the Asturian and the Neolithic, an indication of the lack of marked changes in climatic conditions across these periods. On the other hand, the lack of large estuaries in the zone, especially in the core of higher concentration of Asturian sites, impeded an increase in the diversity of exploited species (a fact that is also observed in other areas of the Cantabrian coast during the Mesolithic and the Neolithic), explaining the stability of exploitation patterns and areas in these periods.

The similarities documented in the exploitation of molluscs during the Asturian and early Neolithic seem to indicate that in the coastal areas of the Cantabrian region the introduction of agriculture and stockbreeding kept a slow pace. Thus, populations living along the coastal area continued the exploitation of molluscs at least to ca. 5,000 BP, although during the Neolithic the quantities of shells accumulated in sites were much less than in Mesolithic times. This allows us to suppose that local hunter-gatherer groups adopted the new economic forms of the Neolithic in a gradual way, probably under the influence of Neolithic groups of external origin settled in the inland areas of the region, that coexisted alongside them, but maybe not maintaining close social interaction. However, some authors have proposed that local groups were developing the new Neolithic lifeways in an autochthonous way.

Patella vulgata	Zonation		Exposure	
	High Shore	Low Shore	Exposed	Sheltered
MZ A3 (Asturian)	30,2%	69,8%	92,5%	7,5%
MZ A2bottom (Neolithic)	35,7%	64,3%	96,2%	3,8%
MZ A2base (Neolithic)	35,8%	64,2%	95,3%	4,7%
MZ A2+A2base (Neolithic)	39,1%	60,9%	91,3%	8,7%

Table 2. Zonation and exposure of Patella vulgata at Mazaculos II.

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Analysis of malacofauna remains from archaeological sites on Adak Island (Aleutian Islands, USA)

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Analysis of malacofauna remains from archaeological sites on Adak Island (Aleutian Islands, USA)

Análisis de los restos malacológicos de los yacimientos de la Isla de Adak (Islas Aleutianas, USA)

KEY WORDS: Shell midden, Aleutian Islands, Holocene, palaeoenvironmental reconstructions
PALABRAS CLAVE: Concheros, Islas Aleutianas, Holoceno, reconstrucciones paleoambientales
GAKO-HITZAK: Maskortegiak, Aleutiar uharteak, Holozenoa, Berregite paleoanbientalak.

Zhanna ANTIPUSHINA[1]

ABSTRACT

Two shell middens on Adak Island, Aleutian Islands (Alaska, U.S.A) have been investigated to reconstruct the dynamics of palaeoenvironmental conditions. Radiocarbon data showed that a first shell midden near Clam lagoon was formed about 6500 years ago. Shell analysis shows that the taxonomic composition changed significantly during the existence of this settlement. The second shell midden, situated near Sweeper Cove, was dated from the 8th century to the 19th century AD. Analysis of these remains allows us to distinguish different climatic periods in the development of the ancient settlement. However, the intertidal environment has not change since the 8th century AD.

RESUMEN

Se han investigado dos concheros en la isla de Adak, en las islas Aleutianas (Alaska, Estados Unidos) para reconstruir la dinámica de las condiciones palaeoambientales. Los datos de radiocarbono demostraron que un primer conchero cerca a Clam lagoon se formó hace aproximadamente 6500 años. El análisis de sus moluscos demuestra que la composición taxonómica cambió perceptiblemente durante la existencia de este asentamiento. El segundo conchero, situado cerca de Sweeper Cove, se fechó entre los siglos VIII y XIX d.C. Los análisis de estos restos permitieron distinguir diversos períodos climáticos en el desarrollo del antiguo asentamiento. Sin embargo, el ambiente intermareal no presenta cambios desde el siglo VIII d.C.

LABURPENA

Adak uhartean, Aleutiar uharteetan (Alaska, AEB), bi maskortegi ikertu dira, baldintza paleoanbientalen dinamika berregiteko. Erradiokarbonoaren datuek frogatu zuten Clam lagoonetik hurbil dagoen lehen maskortegia duela 6.500 urte inguru eratu zela. Moluskuen analisiak frogatzen du konposizio taxonomikoa modu adierazgarrian aldatzen dela kokaleku hori dagoen artean. Bigarren maskortegia, Sweeper Covetik hurbil dagoena, K.o. VIII. eta XIX. mendeen artean datatu zen. Hondakin horien analisiari esker, zenbait klima-periodo bereizi ziren antzinako kokalekuaren garapenean. Dena den, marearteko giroan ez da aldaketarik nabarmentzen K.o. VIII. mendeaz geroztik.

1. INTRODUCTION

Shell midden formations are characteristic of ancient coastal communities. These deposits are widely-distributed over costal zones around the world. Our study focuses on the North Pacific, an area with relatively cold climatic conditions.

The history of Aleutian Islands started about 8700 ^{14}C years BP (Laughlin 1975). The inhabitants of this region based their subsistence on the consumption of marine resources (Veniaminov 1984, McCartney, 1975, Veltre and Veltre 1983). They kept their traditional hunting and gathering strategies until the 18th – 19th centuries AD. As a result, mollusc remains were accumulated during the entire period of existence of these settlements for several millennia.

William Dall conducted the first archaeological excavation of the Aleutian shell middens in 1870-1874 (Dall 1877). He identified invertebrate remains from shell middens in several islands. Since that time, the interest in these deposits has not decreased.

In spite of the great number of archaeological sites and more than 100-years of research (Collins 1937, Spaulding 1962, Desautels *et al.* 1970, Veltre 1974, 1975, Clark 1996, Luttrell and Corbett 2000), some of these shell mounds have not yet been analyzed.

Mollusc remains can give us important data for palaeoenvironmental reconstructions, as an excellent material to recreate past ecological dynamics.

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We reconstruct palaeoenvironmental conditions, based on analysis of shell remains from archaeological sites at Adak Island, Aleutian Islands. They were excavated by members of the Western Aleutian Archaeological and Palaeobiological Project (WAAPP), lead by D.L. West (University of Kansas).

We investigated two shell middens. One shell midden ADK-171 is situated on the eastern coast of the Clam lagoon (51°55'32" N, 176°33'37" E), the second shell midden ADK-009 – on the south coast of the Sweeper Cove (51°51'10" N, 176°38'18" E) (Fig. 1).

2. MATERIALS AND METHODS

The excavation areas in both sites were 1m^2 and were excavated according to recognizable stratigraphic layers no thicker than 10 cm (Dinesman *et al.* 1999, Causey *et al.* 2005). Material was screened or sorted by hand. We used radiocarbon dating of fish bone collagen calibrated with OxCal 3.10. The dates obtained from the marine animal remains turned out to be a hundred years earlier because of the reservoir effect, so we used the calibration curve Marine04 (Reimer and Reimer 2001, Hughen *et al.* 2004) and the regional correction ΔR for the southern part of the Bering sea (Stuiver and Braziunas 1993).

We used the number of identified specimens (NISP) for quantification of chitons. For bivalves the number of umbo was counted (MNI). For gastropods, MNI was determined by the presence of >50% of the shell (Grayson 1984, Mason *et al.* 1998, Claassen 2000, Glassow 2000, Mason *et al.* 2000, Bird *et al.* 2002, Dinesman and Savinetsky 2003, Antipushina 2008).

The samples were identified to the lowest taxonomical level possible using the reference collections housed at the Zoological Museum MSU, Institute of Ecology and Evolution RAS and Zoological Institute RAS.

3. RESULTS AND DISCUSSIONS

The ADK-171 profile included a cultural layer and several natural layers. The total depth of this profile was 2.7 m, and the cultural layer in this profile was 100 to 140 cm deep. Three radiocarbon dates show that the cultural layers were formed at the end of the 6th millennium cal BC (6141±123 yr BP, IEMAE-1281; 6172±192 yr BP,

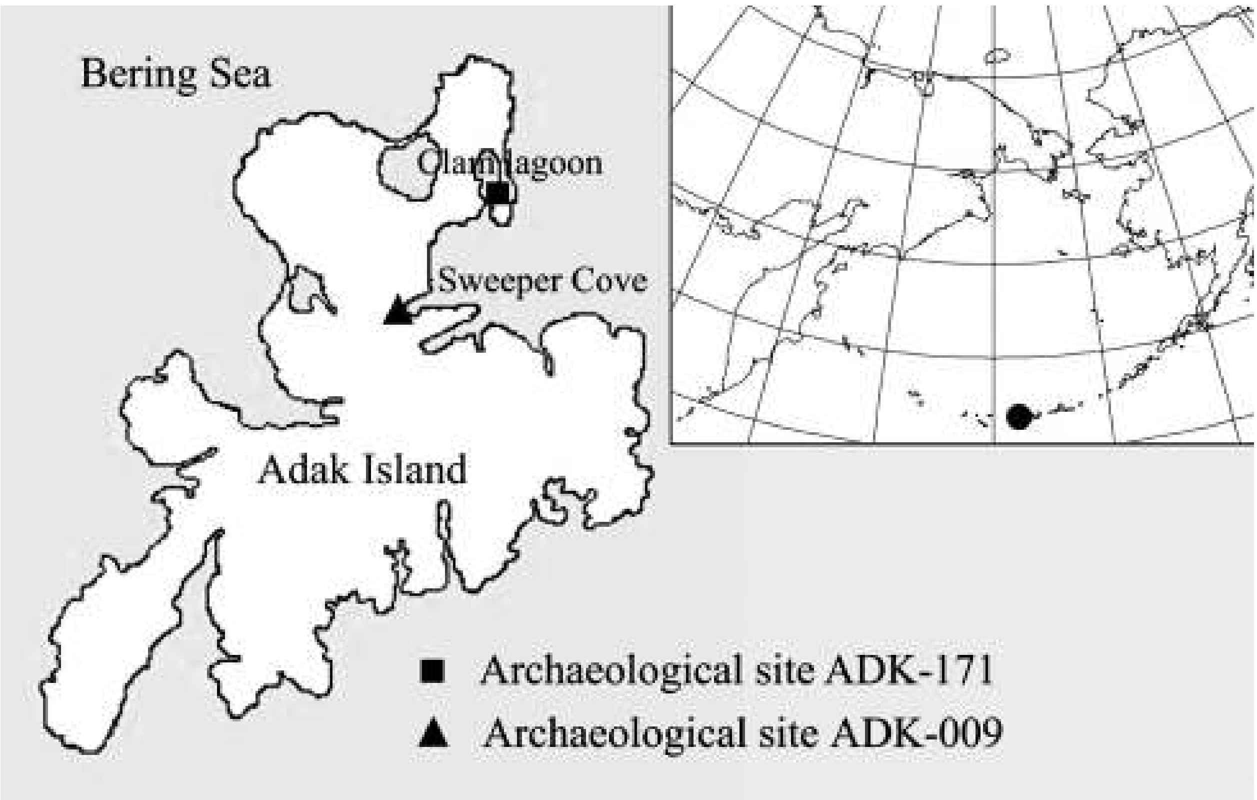

Figure 1. Map of investigation area.

Profile ADK-171	
0 - 5 cm	Present-day sod
	Peaty sod, grayish chestnut, friable, unstructured, pierced by roots; transition to the underlying horizon is distinct and even.
6 - 10 cm	40-year-old ash
	Between tussocks – light brown to grayish olive-brown, loamy, ductile, adhesive, unstructured; pierced by roots; transition to the underlying horizon is gradual, the boundary uneven.
10 – 50 cm	Peaty soil
10 – 18 cm	Under tussocks – dark grey to chestnut getting lighter, loamy, ductile, adhesive, unstructured; pierced by roots; transition to the underlying horizon is gradual.
18 - 50 cm	Peaty, dark chestnut, homogeneous, compacted, ductile, adhesive; densely pierced by roots; plant remains are well decomposed; transition to the underlying horizon is abrupt and even.
50 - 61 cm	Sandwich Volcanic ash
	Heterogeneous tephra layers. Coarse-grained clastic ash (50-54 cm) is replaced by inequigranular sandy volcanic ash with coarse clastic concretions (54-57 cm) still lower (57-60 cm) is presented by fine- grained volcanic ash olive color; the boundary is abrupt and even.
61 - 100 cm	Stratified mineral stratum
	Heterogeneous stratified tephra thickness. Interchanging volcanic ash layers, from brown chestnut to light olive tinted with grayish black; ash layers is fine- grained, ductile, adhesive; many fine roots; low boundary is abrupt and even.
100 - 140 cm	Cultural layer
100 - 125 cm	Layer of densely large clam shells packed, almost without fine-grained mineral material, bones. During the excavation we divided this layer into two – layer 2 and layer 3.
125 - 129 cm	Layer of re-deposited volcanic ash, grayish-pink, fine-grained to loamy, adhesive.
129 - 141 cm	Layer of small mussel shells. Shells is mixed with tiny fragments of the charcoal. In the left part of side and along slopes the layer flattens and consists only of broken shells. Crumbs of shells prevail at the contact with lower horizon, material gets sooty. We called this horizon – layer 4.
140 -150 cm	Volcanic ash? Sandy loam, brown-pink to grayish brown, compacted, ductile, adhesive, friable upon drying, possible volcanic ash; impregnated with well decomposed organic matter; the boundary is abrupt and even.
150 - 166 cm	Intermediate Volcanic ash
	Heterogeneous stratified tephra stratum; the streaks alternate with the lenses of mineral material from volcanic ash; inequigranular to well sorted, saturated with coarse clastic ash; variegated- light olive to light brown; ductile, adhesive; the boundary is abrupt and even.
166 cm and lower	Dune sand
	Homogenous sand, unstructured, middle- grained, whitish grey; indistinct ferruginous streaks and spots on depth 166 - 170 cm and 222 - 230 cm; streaks of black-colored minerals; the boundary is abrupt and even.

IEMAE-1248; 6,525±94 yr BP, IEMAE-1296). These data confirm that ADK-171 is the oldest archaeological site found on the Adak Island (Luttrell and Corbett 2000).

The total depth of the ADK-009 profile was 170 cm, and the cultural layer in this profile was 22 to 166 cm deep. Four radiocarbon dates from fish bone collagen, show that the cultural layer was formed from the beginning of 8th to the beginning of 19th centuries cal AD (Table 1).

Depth of horizon (cm)	Laboratory number IEMAE-	Material dated	Radiocarbon age, years BP	Calibrated dates, years AD (2σ
23 – 38	1264	fish bone collagen	755±72	1627 – 1890
45 – 79	1242	fish bone collagen	1126±103	1260 – 1660
115 – 127	1288	fish bone collagen	1360±74	1060 – 1410
150 – 160	1265	fish bone collagen	1888±50	590 – 900

Table 1. Radiocarbon dating of ADK-009

Profile ADK-009	
1 – 13 cm	Re-deposited culture layer
	Dark-gray to black sward culture layer pierced by roots, saturated with crashed shells and bones.
13 – 18 cm	Buried sod
	Dark-brown to brown buried motley sod with inclusions of light-brown presumably ash spots.
18 – 20 cm	40-year-old ash
	Light-brown fine-sorted compressed ash layer of uneven thickness
20 – 22 cm	Humus streak
	Light-brown to brown smeared humus streak
22 – 166 cm	Culture layer
22 – 56 cm	Layer I
22 – 35 cm	Dark-gray to black fine-grained mineral material saturated with crashed shells, pierced by roots, with inclusions of sparse bones. Lens of sea urchin plates in the bottom left corner.
35 – 37 cm	Streak of fine-grained material: dark-brown to brown with black tint, compressed, unstructured, adhesive, almost without bones and shells.
37 – 56 cm	Heterogeneous horizon of crashed shells and bones interchanging with lenses of fine-grained material.

Profile ADK-009	
56 – 107 cm	Layer II
56 – 64 cm	Fine-grained material: compressed, ductile, adhesive, saturated with crashed shells. The thickness of this layer is decreasing toward to right corner, the stratigraphy is getting disrupted.
64 – 107 cm	Heterogeneous layer: sea urchin plates prevail in the upper part of it, charcoal streaks are found at the depth of 71 – 73 cm and 93 – 97 cm, gastropod shells appears below 99 cm.
107 – 123 cm	Layer III
107 – 112 cm	Fine-grained material: brown, wet, ductile, adhesive, saturated with bones.
112 – 123 cm	Layer of crashed shells and sea urchin plates, almost without fine-grained material.
123 – 140 cm	Layer IV
123 – 128 cm	Brown fine-grained material saturated with crashed shells and bones.
128 – 140 cm	Heterogeneous layer of midden: crashed shells and fine-grained material constitute the upper part of it, the lens of see urchin plates is found in the right corner.
140 – 166 cm	Layer V
140 – 150 cm	Brown fine-grained material saturated with crashed shells and bones.
150 – 166 cm	Light-brown fine-grained material, unstructured, adhesive, with sparse grains of clastic ash. The upper 5 cm of it are darker, saturated with bones only.
166 – 173 cm	Underlying bedrock

The molluscs from these shell middens include: 6 species of chitons (Polyplacophora), 22 species of gastropods (Gastropoda) and 12 species of bivalves (Bivalvia) (Table 1). Among these species the following were the most frequent species in the sample: a foolish mussel *Mytilus trossulus*, a Nuttall's cockle *Clinocardium nuttallii*, a limpet *Lottia pelta*, a periwinkle Littorina sitkana, and a chiton *Katharina tunicata* (Table 2).

According to ethnographical data, these shellfish species were important as food resources for Aleutians (Zubkova 1948, McCartney 1975, Veniaminov 1984).

Analysis of malacofauna remains from the shell midden ADK-171

There were identified 2500 mollusc remains at ADK-171. Bivalves dominate the sample followed by gastropods and chiton remains.

The analysis shows that mollusc taxonomic composition changed significantly during the existence of the ancient settlement (Fig. 2). The foolish

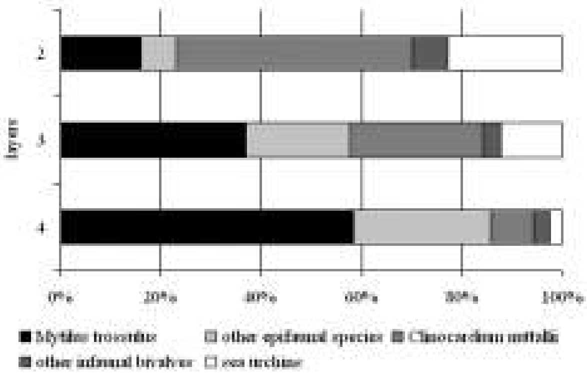

Figure 2. Dynamic of portions of invertebrates' remains.

Chitons (Polyplacophora)	*Lepidozona* sp.
	Boreochiton beringensis beringensis (Jakovleva, 1952)
	Tonicella submarmorea (Middendorff, 1847)
	Mopalia wosnessenskii Middendorff, 1847
	Katharina tunicata (Wood, 1815)
	Cryptochiton stelleri (Middendorff, 1847)
Gastropods (Gastropoda)	*Problacmaea sybaritica* (Dall, 1871)
	Lottia digitalis (Rathke, 1833)
	Lottia pelta (Rathke in Eschscholtz, 1833)
	Testudinalia scutum (Rathke, 1833)
	Puncturella longifissa Dall, 1914
	Crepidula sp.
	Ariadnaria insignis (Middendorff, 1848)
	Trichotropis bicarinata bicarinata (Sowerby, 1825)
	Littorina aleutica Dall, 1872
	Littorina sitkana Philippi, 1846
	Cryptonatica sp.
	Onoba aurivillii (Dall, 1887)
	Onoba sp.
	Fusitriton oregonensis (Redfield, 1846)
	Boreotrophon cepula (Sowerby, 1880)
	Nucella heyseana (Dunker, 1882)
	Nucella lima (Gmelin, 1791)
	Buccinum percrassum Dall, 1883
	Aulacofusus periscelidus (Dall, 1891)
	Colus sp.
	Neptunea sp.
	Volutopsius castaneus (Mörch, 1857)
	Astyris sp.
Bivalves (Bivalvia)	*Modiolus modiolus* (Linnaeus, 1758)
	Mytilus trossulus Gould, 1850
	Monia macrohisma (Deshayes, 1839)
	Hiatella arctica (Linnaeus, 1767)
	Kellia laperousi Deshayes, 1839
	Cyclocardia ventricosa (Gould, 1850)
	Clinocardium nuttallii (Conrad, 1837)
	Serripes groenlandicus (Mohr, 1786)
	Saxidomus giganteus (Deshayes, 1839)
	Macoma sp.
	Mactromeris polynima (Stimpson, 1860)
	Mya truncata Linnaeus, 1758

Table 2. Taxonomic list of molluscs from the Aleutian shell middens.

mussel decreases from layer 4 to layer 2 as well as other epifaunal species – chitons, gastropods and barnacles. On the contrary, Nuttall's cockle remains increase from layer 4 to layer 2 as well as other bivalves inhabiting sandy substrates and sea urchins.

This situation illustrates the change of substrates at Clam lagoon's intertidal zone. Probably, the intertidal zone was rocky around the end of the 6th millennium cal BC. During the existence of the ancient settlement, the rocky portion decreased and the sandy substrate began to dominate. As a consequence the invertebrates' taxonomic structure changed.

It could be possible that this change was the result of sea level transformations. At the same time, the decrease of predator pressure (i.e. sea otter) over sea urchin and clam populations led to increasing their populations.

Analysis of malacofauna remains from the shell midden ADK-009

There were identified 7000 mollusc remains at ADK-009. The bivalve remains dominate the sample.

Epifaunal molluscs dominate all layers of this shell midden. They represent more than 90% of the sample. This proportion did not change significantly from layer to layer. They are evidence of a rocky substrate at Sweeper Cove's intertidal zone from the 8th century cal AD to nowadays (Antipushina 2006b).

Three zoogeographical groups of species - arctic-boreal, high-boreal and low-boreal, were identified. However, the proportions of these different zoogeographical groups were not constant in all the layers (Fig. 3). For example, in layers IV and I, there is a decrease of arctic-boreal and high-boreal species. Moreover, remains of low-boreal gastropods such as *Nucella heyseana*, uncommon for this region, were found in the same layers. On the contrary, arctic-boreal and high-boreal species increased in layers III and II. Probably, this increment was a consequence of a change in temperature.

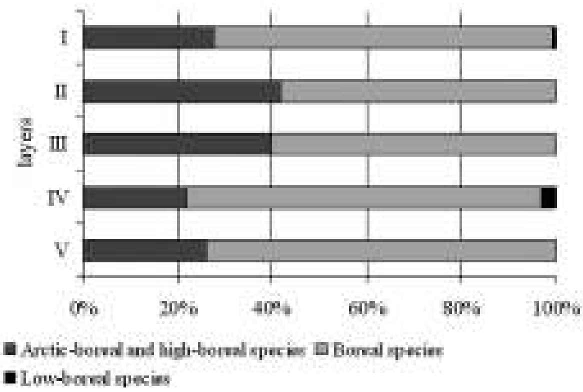

Figure 3. Zoogeographical spectra of molluscs from shell midden ADK-009.

Analysis of mollusc taxonomic composition suggests the following temperature periods in the development of this shell midden. The period from the 8th to the middle of the 11th centuries was cold. A warmer period from the middle of the 11th to the middle of the 12th centuries was identified by the presence of low-boreal gastropod *Nucella heyseana* into higher latitudes and a decrease of psychrophilic species. The increase in arctic-boreal and high-boreal species from the middle of the 12th to the middle of the 16th centuries was the evidence of colder temperatures. This period corresponds with the so-called "Little Ice Age" (Cook *et al.* 2004, Savinetsky *et al.* 2004).

4. CONCLUSIONS

The ancient Aleutians gathered molluscs, especially a foolish mussel (*Mytilus trossulus*), a Nuttall's cockle (*Clinocardium nuttallii*), a limpet (*Lottia pelta*), a periwinkle (*Littorina sitkana*), and a chiton (*Katharina tunicata*). Analyses of mollusc taxonomic compositions were used for palaeoenvironmental reconstruction of ADK-009 and ADK-171.

A decrease in epifaunal species and an increase in infaunal species illustrate a change of substrate at Clam lagoon's intertidal zone. The intertidal zone was rockier 6500 years ago. During the existence of the ancient settlement, the rocky environment decreased, and the invertebrate species changed. At the same time, the decrease of predator pressure (i.e. sea otter) over sea urchin and clam populations led to an increase in their populations.

The substrate type at Sweeper Cove's intertidal zone has not changed significantly from the 8th century cal AD to our time. We made such conclusion because of epifaunal molluscs' remains dominated in all layers of ADK-009.

Analysis of the mollusc taxonomic composition allows us to distinguish different temperature periods at ADK-009. The period from the 8th to the middle of the 11th centuries was colder. Two warmer periods were identified, one from the middle of the 11th to the middle of the 12th centuries and the other from the middle of the 16th to the 19th centuries. The colder period from the middle of the 12th to the middle of the 16th centuries corresponds to the "Little Ice Age".

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Shell as a raw material for tools and jewellery in Mesolithic Scotland.

Karen HARDY

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Shell as a raw material for tools and jewellery in Mesolithic Scotland

Concha como materia prima para la elaboración de útiles y objetos de adorno en el Mesolítico de Escocia

KEY WORDS: Scotland, Mesolithic, shell, ornaments, tools.
PALABRAS CLAVE: Escocia, Mesolítico, concha, adornos, herramientas.
GAKO-HITZAK: Eskozia, Mesolitoa, maskorra, apaingarriak, tresnak.

Karen HARDY[(1)]

ABSTRACT

Scotland has thousands of miles of coastline and numerous prehistoric sites. Many of Scotland's Mesolithic sites lie near or adjacent to the coast and shell middens are relatively common. Most of the shells in these middens appear to be related to food however in certain sites evidence for shells as jewellery and as raw material for tool manufacture is beginning to emerge. Little is currently known about the use of shell as a raw material in Scotland and this article discusses the current evidence.

RESUMEN

Escocia tiene miles de millas de línea costera y numerosos sitios prehistóricos. Los sitios mesolíticos se ubican cerca de la costa, o adyacentes a ella. Aquí los concheros son relativamente comunes. En ellos, la mayor parte de las conchas parecen estar relacionadas con alimento; sin embargo, ciertas evidencias en los sitios indican la utilización de las conchas como adorno o materia prima para la manufactura de herramientas. Poco se sabe actualmente sobre el uso de la concha como materia prima en Escocia y este artículo discute la evidencia actual.

LABURPENA

Eskoziako kostaldeak milaka miliako luzera du, bai eta historiaurreko leku ugari ere. Mesolitoko lekuak itsasertzetik hurbil daude, edo itsasertzaren ondoan. Maskortegiak aurkitzea nahiko arrunta da. Maskortegietan, maskor gehienek elikadurarekin dute zerikusia; hala ere, ebidentzia batzuek adierazten dute maskorrak apaingarri gisa eta tresnak egiteko lehengai gisa ere erabiltzen zirela. Gutxi dakigu, gaur egun, zer erabilera zuen Eskozian maskorrak lehengai gisa, eta artikulu honek gaur egungo ebidentzia jorratzen du.

1. INTRODUCTION

Scotland has a vast coastline to the north, east and west. As well as its mainland coastline, Scotland also has hundreds of islands lying to the north and west. A wide variety of molluscs can be found on most coastlines, including both gastropods and bivalves. Examples of common bivalves include cockles (Family Cardiidae), mussels (Family Mytilidae) and scallops (Family Pectinidae), gastropods include limpets (Family Patellidae) and winkles (Family Littorinidae).

Shellfish were important in Scottish prehistoric and historic times, as the large numbers of shell middens dating from the Mesolithic up to relatively recent times demonstrates (Hardy and Caldwell 2009, Hardy and Wickham-Jones 2009).

Shell provides a versatile raw material for tool manufacture; it is waterproof and can have a very sharp cutting edge. Large shells can be used as containers and shell can be fashioned into jewellery. Ethnographic accounts from across the world record a wide range of social uses for shells including currency, gift exchange, in medicine, to convey messages or ideas in code, as charms, as net sinkers, as fertility objects particularly as marriage gifts, as amulets against sterility, for divination and to stuff mouths of dead people (Carey 1998; Gaibole 2004, Claassen 1999, Jackson 1917, Mair 1969, Sciama and Eicher 1998, Sillitoe 1988). Large tiger cowries were used extensively in Oceania as lamps, vegetable peelers and scrapers, octopus lures, net sinkers, ornaments and pottery smoothers (Spennemann 1993). Shell artefacts are also widespread on archaeological sites (e.g. Bar-Yosef Mayer 2005, Chilardi *et al.* 2005, Serrand and Bonnissent 2005, Szabo and O'Connor 2004, Wilkens 2005)

But little is known about the use of shells as artefacts or for decoration in Scotland though perforated cowrie shells have been identified on several Mesolithic and Neolithic sites (Lacaille 1954, Bonsall *et al.* 1992, Clarke and Shepherd forthcoming, Connock *et al.* 1992, Hardy 2009, Mellars 1987). Limpet rings occur on the Neolithic site of Isbister in Orkney (Henshall 1983) but it is not clear

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whether these were collected as rings or were manufactured, however their presence on the site may be significant. Shell implements are also little known in Scotland though at Sand in Applecross scallop (fam. *Pectinidae*) shell tools and a shell with a section cut out of it were found (Hardy 2009). Evidence for the use of shells as tools is also present from shell middens on the small island of Oronsay (Lacaille 1954) and at Ulva Cave (Russell *et al.* 1995).

The Mesolithic occupation of west coast Scotland covers the period from around 8000BC to around 4000BC (Ashmore 2004). The earliest shell midden date of 7580-7180BC is from Druimvargie rockshelter near Oban (Bonsall *et al.* 1995). Soon after this there is a spate of dates between 7000 - 6500BC from shell middens along the west coast including An Corran, Isle of Skye (Hardy, *et al.* forthcoming), Sand, Applecross peninsula and Loch a Sguirr, Raasay (Hardy and Wickham-Jones 2009) and Ulva Cave, Mull (Bonsall *et al.* 1994). Shell middens with Mesolithic tool assemblages continue to around 4000BC. Indeed, west coast Scotland is well known for its Mesolithic shell middens which are widespread (e.g. Bonsall *et al.* 1994, Hardy and Wickham-Jones 2002, Lacaille 1954, Mellars 2004, Pollard *et al.* 1996) though lithic scatters are also common (Ballin 2008, Hardy and Wickham-Jones 2009, McCullagh 1989, Wickham-Jones and Hardy 2004, Wickham-Jones 1990). Much of the west coast of Scotland is covered in acidic soils and uncharred organic remains rarely survive outside the protective environment of the shell middens. This has afforded middens an importance in the Scottish Mesolithic as they can contain organic material (Illus 4), including both artefacts and ecofacts. These include bone and antler tools such as bevel ended and pointed artefacts and harpoons as well as extensive evidence for consumption of marine and land resources (Bonsall *et al.* 1992, Hardy and Wickham-Jones 2009, Hardy *et al.* forthcoming). A series of large open-air shell middens can be found on Oronsay which is a small island attached at low tide to the larger island of Colonsay in the southern Hebrides and middens occur northwards from here along the west coast. Shell middens can be found in rockshelters, for example at Sand in Applecross (Hardy and Wickham-Jones 2009), or in caves such as on the island of Ulva off Mull (Bonsall *et al.* 1992) as well as in the open air, such as on the islands of Risga (Pollard *et al.* 1996) and Oronsay. It is likely that the distribution of shell middens was far greater in prehistory than it is today and that many no longer survive. Some evidence exists, particularly from the southern Hebridean island of Islay to suggest that the shells from middens may have been subsequently used to fertilize nearby fields (Hardy and Caldwell 2009).

The five large open-air shell middens on Oronsay are perhaps the best examples known in Scotland. They first received attention in the late 19th century and several excavations have taken place. Caisteal nan Gillean was partially excavated between 1874 and 1882 and Cnoc Sligeach was partially excavated in1884 and again in 1913 (Lacaille 1954). During the 1970's, a team from Cambridge University excavated the Oronsay midden, Cnoc Coig. As well as an extensive assemblage of cultural items including shell jewellery and artefacts made from shell, Cnoc Coig was found to contain the only Mesolithic human remains that have been found so far in Scotland (Mellars 1987).

2. MOLLUSCS IN SCOTLAND

There are almost 200 mollusc species living on Scotland's shorelines (Hayward *et al.* 1996). However only very few of these occur regularly in shell middens. These include species from the following families Patellidae, Muricidae, Littorinidae, Triviidae, Buccinidae, Mytilidae, Pectinidae, Ostreidae, Cardiidae and Solenidae. Of these, species of Littorinidae continue to be collected commercially, species of Mytilidae, Pectinidae, Ostreidae are farmed today and species of Cardiidae and .Solenidae are still collected but on a smaller scale. Scallops (Pectinidae) and oysters (Ostreidae) are considered a delicacy today while species of mussel (Mytilidae) can be found in most supermarkets. Though limpets (Patellidae) are rarely eaten today, records demonstrate that they were eaten regularly in historical times (Martin 1999, Wickham-Jones 2003). Martin (1999) describes their use as a tonic to promote breast milk and one case in which the water from boiled limpets was fed to an infant whose mother had no milk. Though cowries (Triviidae) are unlikely to have been an economically important resource, they are small and relatively rare in Britain, they seem to have been significant in prehistory as their presence on some Mesolithic and Neolithic sites demonstrates.

3. SHELLS AS JEWELLERY

Shells have been modified and used as jewellery across the world in the past and continue to be used as jewellery today. In Scotland, the extent of the use of shells as jewellery in the Mesolithic and Neolithic is still little known. The limpet shell rings at the Neolithic site of Isbister in Orkney (Henshall 1983) have not been examined microscopically but the consistency of their shape suggests they may have been artificially formed.

3.1. Cowrie shells

Cowrie shells occur naturally around the coasts of Britain and Ireland (MacDougal 2003, 2004) and they are found today on beaches in many places around the coastline, such as the Isle of Skye, Orkney, Holy Island (Lindisfarne) and Howick, Northumberland. The small size and relative rarity of cowries continues to excite interest among local children who collect them. Two types of cowrie occur on British beaches, the Spotted cowrie (*Trivia monacha*) that only occurs in western Britain and the Arctic cowrie (*Trivia arctica*) that occurs all around Britain (Hayward *et al*. 1996). The Arctic cowrie grows to a maximum of 10mm while the spotted cowrie grows to 12mm. Though these two species are difficult to distinguish when young it is sometimes possible to distinguish between them on the basis of size as all cowrie shells over 10mm in length are spotted cowries. Modern spotted cowrie shells can have two clearly defined spots on their surface and are fawn in colour while the arctic cowrie is normally creamy white. Archaeological samples do not retain their colour however species identification can be carried out by size. A sample of cowries from Cnoc Sligeach on Oronsay, was measured and this demonstrates that both types of cowrie are probably present. (Table 1).

Cowrie shells with opposing perforations have been found on several Mesolithic sites in west coast Scotland. These include Cnoc Sligeach on Oronsay (Lacaille 1954), Cnoc Coig (Mellars 1987), Carding Mill Bay (Connock *et al* 1992), Ulva Cave on the island of Ulva off Mull (Russell *et al* 1995) and Sand, near Applecross (Hardy 2009) (Fig. 1). Although the holes in cowrie shells were assumed to have been artificially made (Simpson 1996, 2003), this may not be the case.

There are six gastropod families that feed by drilling through the shells of their prey. The most common of these, are the naticids and muricids (Hayward *et al.* 1996); one example if these is the dogwhelk (*Nucella lapillus*). Species of both naticids and muricids occur around Britain and both create characteristic holes in the shells of their prey. The method of attack involves drilling a hole with a characteristically symmetrical shape and sloping sides in order to access the meat inside. Cowries with holes can be found on beaches today and an example of a cowrie shell with two opposing holes, identical to those found on archaeological sites, was collected recently on a beach in Northumberland (Fig 1). Taborin (1993) also confirms the presence of naturally perforated cowrie shells on beaches today.

Cowrie shells are small and have a relatively compact, thick shell. Several attempts were made to perforate a range of large and small recently collected cowrie shells. The direct percussion method was attempted using a range of tools including the pointed tip of a sharp metal kitchen knife, a small crosshead screwdriver, a sewing needle, the tip of a screw and a small drill. Because of the small size of the shells, there was a high risk of injury to fingers. Further attempts with indirect percussion method included hammering a small crosshead screwdriver against the shell and an attempt to make a small incision into the shell was also attempted. Finally the cowrie was held by one person in pliers while another attempted to make a hole using a hand drill and a small crosshead screwdriver.

All of these attempts failed to make any impact on the shell surface. The compact nature of the shell matrix together with their very small size makes them difficult to work with. Taborin (1993) did succeed in creating experimental holes in cowries by making a small cut or incision into the shell which was then expanded. An attempt to replicate this failed to create a hole. The only raw material used in the Scottish Mesolithic that could be hard enough to perforate a cowrie shell is stone. It is perhaps conceivable that a type of drill was constructed using a pointed microlith on a haft, however due to their small size, even this

Figure 1. Left, modern cowrie shell collected at Howick, Northumberland; right, cowrie shell from Sand (Scotland's First Settlers project).

would have been very difficult unless a grip of some sort was used to hold the cowrie shell. The small number of use wear studies that have been undertaken on north British Mesolithic material did not explore the use of shell as a raw material, however borers with evidence of rotational movements consistent with making holes were sometimes identified (Dumont 1985, Finalyson 2000, Hardy 2004, 2007, in press).

A selection of cowrie shells from a modern reference collection at the Royal Museum of Scotland was examined. Around 20% of the shells have holes which occured naturally. A study of tiger cowries (*Cypraea Tigris*) in Oceania has demonstrated that many of the breakage patterns found on these shells are in fact the result of biogenic rather than anthropogenic factors (Spennemann 1993). This may also be the case with the Scottish examples.

The perforated cowrie shells from Sand, and some modern shells with natural perforations, were examined using an optical light microscope (Meiji ML 2305).to 100 magnifications (Fig 2a). These include seven cowrie shells from Sand including two with opposing perforations. Microscopic examination revealed that all these perforations have sharp irregular borders and there was no observable difference between the holes in shells found on archaeological sites and the natural perforations in cowries collected from the beach (Fig. 2b).

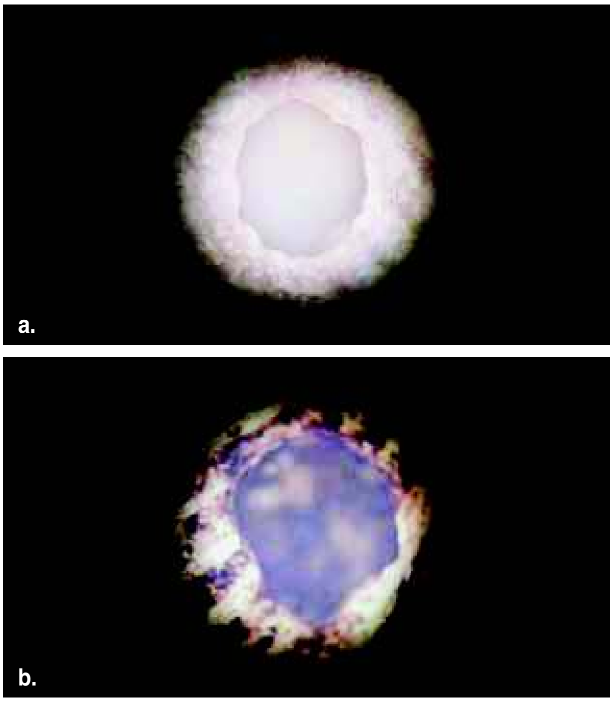

Figure 2. Modern cowrie shell hole at 40 magnifications. Figure 2b, Sand cowrie shell hole at 40 magnifications (Scotland's First Settlers project).

An additional sixty-eight cowrie shells from three Mesolithic shell middens in Oronsay (Cnoc Coig, Caisteal nan Gillean II and Cnoc Sligeach) were also examined by eye of which sixty-three had large double perforations. None of these shells showed any clear evidence either of artificial manufacture or wear suggesting use. A sample of 10 perforated cowries was selected and the distance between the near sides and far sides of the holes were measured (Table 1). There is a degree of consistency in the size of the holes and the distance between the holes which may indicate that they are the result of predation by an animal with pincers.

Full width of shell (mm)	Nearest distance between holes (mm)	Distance between outer limits of holes (mm)	Distance between nearest and outer limits of holes (mm) (size of holes)
17	4.1	9.2	5.1
11	3	9	6
12	4	9.1	5.1
12.7	5.2	9.9	4.7
13	5.2	10	4.8
12	3.9	9.7	5.8
8.5	3.2	7.5	4.3
7.8	2.7	6.7	4
7.8	3.2	7.1	3.9
8.9	3	7.7	4.7
10.9	3.5	9.5	6
9	2	7	5
1.9	3.9	8.9	5
85	3.1	7.2	4.1
78	3.1	8	4.9
15	4.7	9.4	4.7
Mean	3.6	8.4	4.9

Table 1. Size of perforations, cowrie shells Cnoc Sligeach.

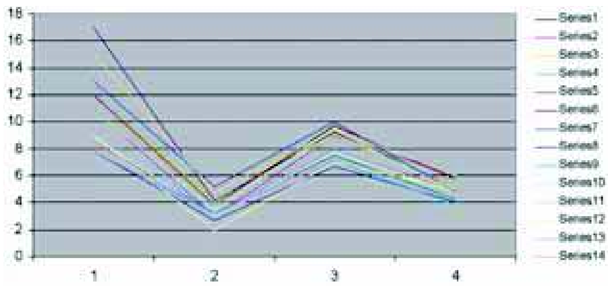

Figure 3. Comparison of sizes of cowrie shell holes.
Key: 1: Length of shell; 2: Nearest distance between holes; 3. Distance between outer limits of holes; 4 Distance between nearest and outer limits of holes.

Use wear traces on experimentally perforated cowrie shell holes (Taborin 1993) demonstrate characteristic traces none of which was present on any of the holes in the artefacts from Sand; indeed no clear use-wear was observed.

It is possible therefore that the cowrie shells recovered from these middens could be items that had not yet been used.

A combination of the occurrence of naturally perforated cowrie shells which occur on beaches today, and the difficulty in creating holes similar to those found on the Mesolithic examples from Scotland, even using modern metal tools, suggests that the perforations on cowrie shells found at Scottish Mesolithic sites are likely to be natural. This does not preclude human use and if indeed these shells are naturally perforated, their rarity value may have made them into precious objects.

At the Neolithic village site of Skara Brae (Clarke and Shepherd forthcoming) the perforations on cowrie shells are clearly artificial, the holes have been created by rubbing. Experimental rubbing of a modern cowrie shell on a beach rock demonstrated that in a matter of seconds a hole appears. This method of manufacture produces clearly characteristic traces and a flat profile around the hole which corresponds closely with the traces found on the shells from Skara Brae (Fig 4). No artefacts with obviously manufactured holes such as these have been found on Scottish Mesolithic sites. It is possible that if the technology of rubbing was not known about in the Mesolithic, and the evidence suggests this was the case, perforated cowrie shells may have represented items of great value during this time. The contrast between the difficulty of making a hole through percussion, like the ones found on cowries in Mesolithic middens and the ease of making a hole by rubbing, as found in some Neolithic sites is notable

Figure 4. Rubbed holes in shells from Skara Brae.

Cowries are special, of that there is little doubt. Even in Scotland, where the surviving evidence for non lithic material culture in the Mesolithic is so limited and where virtually no evidence for personal adornment or artistic expression has been identified, cowrie shells stand out as being an important surviving item with no obvious manufacturing or food procuring role.

3.2. Oyster and scallop shells

The Oronsay shell middens have produced an assemblage of large oyster and scallop shells. Sizes range from 145 – 100 mm in length and 145 – 98 in width. Many of these shells are perforated (Fig 5a,b). Some of the perforations have areas of smoothing and rounding that are consistent with wear and suggest they may have been hung, certainly the technology for cord or string manufacture is very likely to have been well understood (Hardy 2008).

A number of oyster shells were not perforated and had no evidence of use. They may represent raw materials. The shells are thick and very compact and boring or hammering through the many layers of such a hard and brittle material must have required skill and patience in order not to break the shell. The shells are large and are likely to have been spectacular if worn as jewellery.

Figure 5. Perforated oyster shell, 5b perforated scallop shell, Oronsay.

4. SHELL AS TOOLS

Many shells have the potential to be used as tools as they are found, or modified into functional objects and shells or pieces of shells worked into tools is well known from many places across the world. There has not yet been any detailed study in Scotland of the use-wear on limpet and other small shells from middens. While many shells have the potential to be used as tools, in Scotland evidence is currently largely restricted to scallops (fam. Pectinidae), and cockles (fam.Cardiidae). There is documentary evidence for the use of limpet shells (fam Patellidae) as small receptacles (Martin 1994) and there is an account of an ancient highland custom of using a clam or scallop shell (fam. Pectinidae) for drinking whisky (Johnson and Boswell 2007)

Fragments of scallop shells have been recorded at the Mesolithic midden site of Ulva Cave (Bonsall *et al*. 1994) but it is not known whether these shells show evidence of being cut or shaped, or whether they have any use wear. Three pieces of worked scallop shell were found at Sand. These include one whole scallop with a segment cut out of it (Fig 6) and two scallop fragments, one of which displayed clear evidence of rounding (Fig 7a,b).

Figure 7. 7a Scallop fragment, probably unused; 7b scallop fragment showing rounding on pointed edge, Sand (Scotland's First Settlers project).

Figure 6. Cut scallop Sand (Scotland's First Settlers project).

This piece of scallop had been shaped into a rounded point and was markedly worn smooth along its edges and around the point while the other piece did not appear to have been used. Additionally, one whole scallop was found in fragments and refitted. The breakage on the scallop core from Sand is very unlikely to be natural, scallop shells keep their shape well, and when they do break, it is usually along the lines of natural weakness, down the ray lines of the shell, or in the area near the hinge where the shell is thin. The segment cut out of the scallop shell is a large area very carefully cut out with a corner linking the vertical and horizontal cut in a way that is very unlikely to be natural.

Additionally, 8 cockleshells from Cnoc Sligeach all had heavily worn edges (Lacaille 1954) and perforations on the hinge, though several of the perforations appear natural (Fig 8).

Figure 8. Cockle shells from Cnoc Sligeach.

This small assemblage of worked scallop shell is probably no more than the tip of the iceberg. It is very likely that the use of shell in Scotland was much more widespread than this small sample suggests and it is possible that the presence of worked or culturally modified shells has largely gone undetected. Scallop shells are large and tough and consequently are not only excellent for working into tools, but could also be used in a range of different ways as whole shells. In Tierra del Fuego for example, large mussel shells were used as recipients for collecting oils and animal fat as meat was being cooked, as containers in which to prepare paints, as tweezers to remove facial hair, as jewellery and as knives and scrapers (Bridges 1949, Orquera and Piana 1999, Mansur and Clemente, in press). The Scottish scallop shells are large enough to have been used and while it is not possible to reconstruct specific uses, the small number of worked and clearly used pieces is sufficient to suggest that during the Mesolithic they are likely to have been an important raw material for tool manufacture or used as receptacles for various substances.

One final group of modified shell remains enigmatic. The shell midden at Sand consists predominantly of limpet shell. Of the limpet shells in the midden, a small proportion (around 3%) had holes in them. The holes are always found in the same place to one side of the apex. They are easily distinguishable from the natural erosion that occurs at the apex.

Limpet predators include dogwhelk (*Nucella lapillus*), species of starfish and different species of crab, however only the dogwhelk drills holes through the shells to reach the meat inside. Dogwhelk perforations are normally sited to one side of the apex of the limpet, and they are small and symmetrical and unlike the holes found on the limpets shells from Sand. A sample of perforated limpets collected from the beach at Sand today demonstrates that though the holes in archaeological limpets are sited in around the same area, they are generally both larger and less symmetrical than the holes made by predators. A sample of perforated limpet shells was also examined from midden sites on Oronsay and these were remarkably similar. A number of limpet shells from Ulva Cave have perforations that appear the have been made from the inside (Russell *et al*. 1995). There are several ways in which the holes could have been created; one explanation for this may lie in the friable nature of the shell as the perforations have become enlarged over time through natural erosion. It is also possible that the perforations were made as part of the extraction process, either in knocking the shell off the rock or in extracting the limpet from the shell. Alternatively, the holes may have been created as a result of subsequent settling and trampling or when prepared for use as bait. Ethnographic evidence from Guernsey demonstrates that fishermen used to knock holes in limpets and string them up to suspend in willow pots in order to catch crayfish (*Palinurus elephas*). The evidence from Sand, where a large assemblage of fishbone has been studied (Parks and Barratt 2009), suggests that a catch-all method of stationary traps is likely to have been used. These traps would have caught fish as they swam with the tide and may not therefore have been baited.

Limpets can be roasted or boiled and eaten immediately, they can also be hung and dried or salted for storage however, eating large numbers of limpets can cause serious health problems unless the the limpet's radula or 'toothed tongue' is removed before consumption (Solem 1965).

Though limpets with holes in occur on the beach and are clearly the result of natural processes, it is very unlikely that these were collected as limpets with holes will not contain meat. Small assemblages of perforated limpets also occur on several other sites (Hardy and Wickham-Jones 2009) from many different periods (7th millennium BC to recent times).

5. CONCLUSION

Examples of modified shell are rare in the Scottish Mesolithic and Neolithic. This may be partly due to the absence of burials with decorative shells that are found in other places. But shell as a raw material has not been widely recognised in Scotland so the current evidence is unlikely to represent its true extent. Equally some shell is likely to have degraded, Scottish mussel (fam. *Mytilidae*) shell for example can be very sharp when fresh, but these thin shells do not survive well in Scottish archaeological contexts.

However shell is a wonderful natural resource which was abundantly available and it seems hard to believe that it was not widely used. The distinction between the perforations on cowrie shells from the Mesolithic which are likely to be natural, and those on the Neolithic examples which were demonstrably artificial, perhaps reflects their popularity as demand for them may have exceeded supply.

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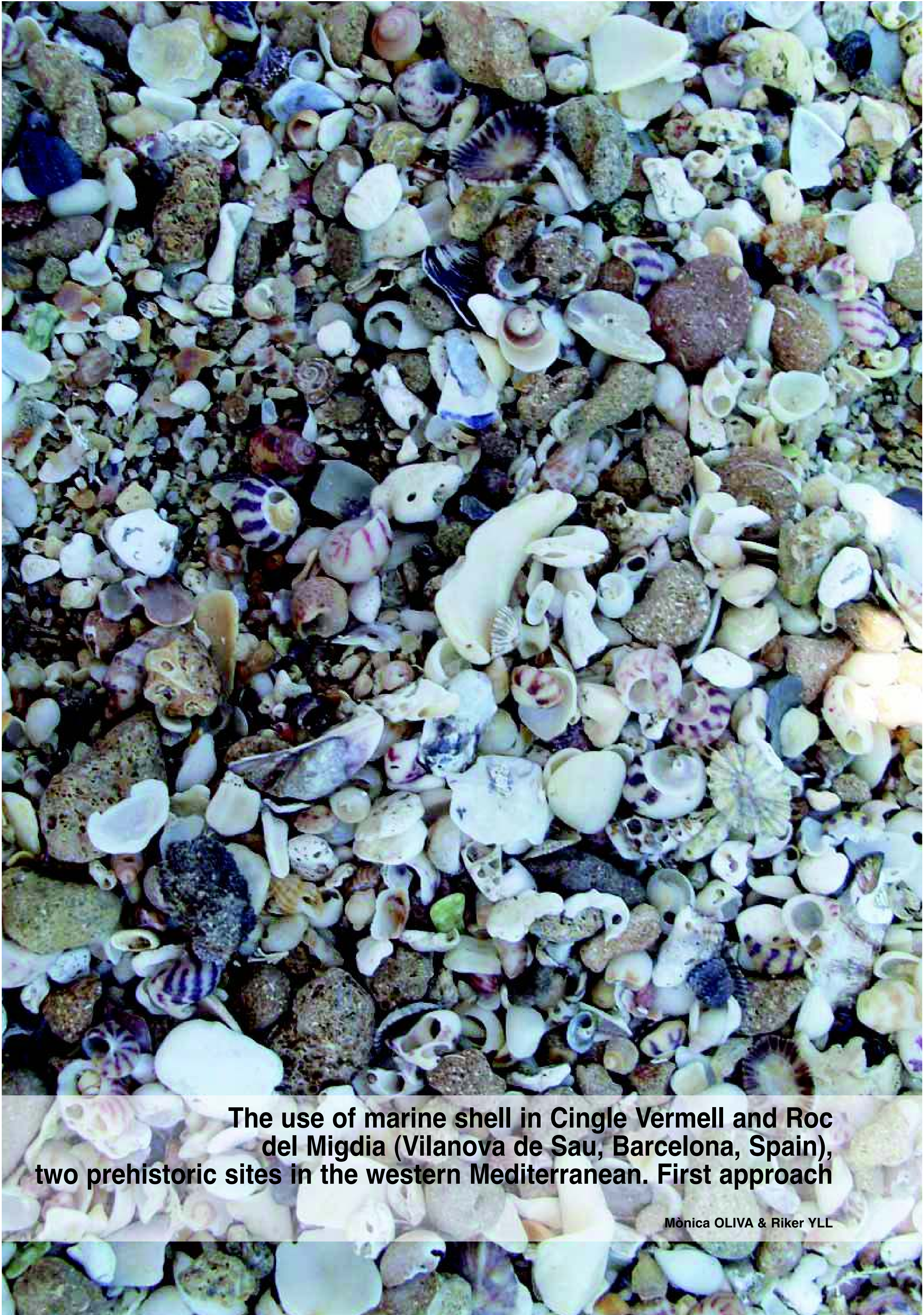

The use of marine shell in Cingle Vermell and Roc del Migdia (Vilanova de Sau, Barcelona, Spain), two prehistoric sites in the western Mediterranean. First approach

Mònica OLIVA & Riker YLL

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El uso de conchas marinas en Cingle Vermell y Roc del Migdia (Vilanova de Sau, Barcelona), dos yacimientos prehistóricos en el Mediterraneo occidental. Primeros datos

KEY WORDS: Holocene, Ornements, Shells, Cingle Vermell, Roc del Migdia.
PALABRAS CLAVE: Holoceno, Adornos, Conchas, Cingle Vermell, Roc del Migdia.
GAKO-HITZAK: Holozenoa, Apaingarriak, Maskorrak, Cingle Vermell, Roc del Migdia.

Mònica OLIVA[1] & Riker YLL[2]

ABSTRACT

This paper presents the results of a preliminary study of malacological materials in the archaeological sites of the Roc del Migdia and the Cingle Vermell. The rock shelters are located 15 km east of the city of Vic (Barcelona province) in the Sau Valley of north eastern Catalonia. The valley lies near the intersection of distinct climatic influences, which create a zone in which there is a wide range of different biological communities supporting a broad range of potential human food resources. One foreign material recovered at these sites is marine Mollusca, which are represented by a few ornaments and fragmented shells from the occupation levels. These ornaments were made using species like Hinia, Trivia and Cyclope. All of them are single perforated or bi-perforated using different techniques and all ornaments are of small size. Early excavations at the Roc del Migdia reported an occupation chronology from the upper Palaeolithic until the Bronze Age. There are few contemporary archaeological sites in the immediate area with the exception of the Cingle Vermell that show evidence for Epipalaeolithic occupation. The sites are involved in the multidisciplinary project Evolució de les Ocupacions Humanes des del Paleolitic al Neolitic a la Vall de Sau (Osona).

RESUMEN

Presentamos los resultados de un estudio preliminar sobre los materiales de malacología marina de los yacimientos arqueológicos de Roc del Migdia y Cingle Vermell. El gran abrigo rocoso en el que se hallan se ubica a 15 km al este de la ciudad de Vic (provincia de Barcelona) al noreste de Cataluña, en el Valle de Sau. El valle es un punto de intersección de distintas influencias climáticas que ha originado una zona con amplias posibilidades biológicas y con un potencial enorme de cara a los recursos humanos. Uno de los materiales foráneos hallados en estos yacimientos es la malacología marina, representada en adornos y fragmentos de conchas recuperados en los niveles de ocupación. Estos adornos están hechos sobre Hinia, Trivia y Cyclope. Todos, de pequeño tamaño, presentan una o dos perforaciones en las que se han utilizado diversas técnicas. Las excavaciones del Roc del Migdia han permitido documentar una larga ocupación desde el Paleolítico a la edad del Bronce. Hay pocos yacimientos contemporáneos cercanos a excepción de Cingle Vermell con una ocupación Mesolítica. Ambos yacimientos se inscriben en el proyecto multidisciplinario Evolució de les Ocupacions Humanes des del Paleolitic al Neolitic a la Vall de Sau (Osona).

LABURPENA

Roc del Migdia eta Cingle Vermell aztarnategi arkeologikoetako itsas malakologiako materialei buruzko atariko ikerketa aurkezten dugu. Gune harritsu handi batean daude, Vic hiritik (Bartzelona) ekialdera, 15 km-ra, Kataluniaren ipar-ekialdean, Sau bailaran. Bailara zenbait eragin klimatikoren elkargunea da, aukera biologiko ugarikoa, eta giza baliabideei dagokionez potentzial izugarria duen gunea. Aztarnategi horietan aurkitutako material arrotzetako bat itsas malakologia da, kokalekuen mailetan berreskuratutako apaingarrien eta maskor-zatien bidez adierazia. Apaingarriak egiteko zenbait espezie erabili ziren; esate baterako, Hinia, Trivia eta Cyclope izenekoak. Guztiak txikiak dira eta zulo bat edo bi dituzte, zenbait teknika erabiliz eginak. Roc del Migdiako indusketei esker, Paleolitotik Brontze Arora arteko okupazio luzea dokumentatu ahal izan da. Handik hurbil, aztarnategi garaikide gutxi daude, Cingle Vermell izan ezik, Mesolitoko kokaleku izandakoa. Bi aztarnategiak Evolució de les Ocupacions Humanes des del Paleolitic al Neolitic a la Vall de Sau (Osona) izeneko diziplina anitzeko proiektuan sartzen dira.

1. THE ARCHAEOLOGICAL SITES

During the Seventies, the low zone of cliffs next to the river Ter and the shelters of the valley of Sau (Vilanova de Sau, Barcelona) were prospected and three archaeological sites were located, revealing a chronology that stretched from the Upper Palaeolithic to the Bronze Age (Vila, 1985, Yll *et al.* 1994, Yll *et al.* 1996; Paz *et al.* 1992). The malacological remains discussed here correspond to materials recovered from two of these sites: Cingle Vermell and the Roc del Migdia. Cingle Vermell

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and Roc del Migdia are two rock shelter archaeological sites located some 15 km east of the city of Vic in north eastern Catalonia (see the map), which lies at the base of a 100 m cliff at an altitude of 650 m above sea level, dominating the confluence of the river Ter and its tributary, the Moran, in the Sau Valley. The cliffs above the rock shelter consist of a red conglomerate capped by limestone and marl, the degraded remnants of which form steep slopes below the site. Today these slopes support a dense Holm Oak (*Quercus ilex* L.) woodland. In addition, the valley lies near the juncture of distinct climatic influences. These factors combine with temperature inversion effects and extreme topographic variability to create a zone in which a wide range of different biological communities occur within a limited geographical area, supporting a broad range of potential human food resources. This would have been a considerable attraction to prehistoric populations with an economy based upon hunting and gathering. (Fig. 1):

Figure 1. Map showing the position of both sites in the northeast of the Iberian Peninsula.

2. METHODOLOGY

Analytic parameters used for molluscs and objects follow and adapt preceding papers and studies[1] which resume some variables: taxonomy identification if possible with some classic manuals[2], final morphology of the object, morphometry (width, length, diameter, perforations diameters for circular holes….all the sizes in mm), description of human modifications[3] or natural modifications with microscopy visualization[4] (technological modifications- polish, percussion points, fractured areas…[5]-, perforations morphology- one directional or bi-directional simple or complex-, situation of hole (central, eccentric…) to determinate fixation or suspension system (without, indirect -holes or another fixed objects- or direct- open/closed circular or ring finger, projected areas), functional traces if they are possible to discern and support with experimental procedures.

3. CINGLE VERMELL

The deposit shows a unique sedimentary level evidence, very homogenous, with abundant faunal remains and lithic artefacts (Vila, 1985). This site has produced evidence for Epipalaeolithic occupation and has a radiocarbon date of 9760 ±160 years BP (uncal). The archaeological remains include a collection of mollusca elements. There is evidence to suggest that the people who settled here brought with them artefacts from far afield. The shell remains, which are mostly of ornamental function, may indicate occasional consumption in littoral zones before a few specimens were selectively brought back to the site with other objects. Total species determinates at Cingle Vermell indicate a variety of origins and intentional use: *Nassarius incrassatus, Cyclope pellucida, Trivia monacha, Dentalium* sp. *(vulgare), Pecten* sp. *(Pecten jacobaeus), Acanthocardia tuberculata, Cardium* sp[6] and *Acanthocardia spinosa*[7]. *Pecten* sp., *Acanthocardia and Cardium* sp. are edibe species and they are represented with some fragmentary valves. The majority of fragments of *Pecten* sp. may be derived from the same valves, of 2 individuals.

[1] (Oliva 2002 and 2007).
[2] Dance (1992), Fetcher and Falkner (1993) and Lindner (1999).
[3] Based in Barge (1982), D'Errico *et al.* (1993), Taborin (1993), Oliva (2002) and Estrada (2004).
[4] Observed traces with binocular Optika Lab-2, WF 10x/20 mm and WF20x/13mm, continous zoom (1x-4x), arriving until 80x. Photo with Digital Microscopy Moticam1000 1.3 mp.
[5] Distinction traces of concentric rotation, irregular perforation, abrasive vertical lines, abrasive horizontal lines, in all-directional lines, polish parallel lines, oblique lines...
[6] *Cardium* used as a generic name. Sometimes the *Cerastoderma* or *Acanthocardia* valves identification is a dificult task when the object is high modified.
[7] Revised previous determination in Vila (1985).

Cardiidae only are represented by broken valves and some fragments.

The shell ornaments from Cingle Vermell include some perforated gastropod and scaphopod shells. Ornamental pieces are made from shells of *Trivia monacha, Cyclope, Nassarius* sp. and *Dentalium*. Of particular interest are the *Trivia* specimens, having 2 perforations each, and some of the *Cyclope pellucida* (4 individuals), perforated in a distinct zone of the shell, as well as one of the *Dentalium* and the perforated *Nassarius incrassatus*. The ornaments are characterised by perforations and it may be that they formed part of a suspension system or, in the case of *Trivia* sp., they may have been fixed to another object (leather for example, as ethnographic usages) because traces lines between and around holes indicates repeated polish movement over surface. (Fig. 2).

Figure 2. Ornaments from Cingle Vermell.

Using a binocular microscope it is possible to distinguish the different techniques used in production of the ornaments. The specimen of *Nassarius incrassatus* bears an irregular perforation (3mm x 3mm) with rectangular tendency, made by controlled percussion. A trace product of abrasion is visible around the edge of the perforation(?).The *Dentalium vulgare* specimen shows signs of suspension, with erosive edges and abrasive traces in the surface (Fig. 3). The Dentalium shells from Roc del Migdia also show evidence of such use.

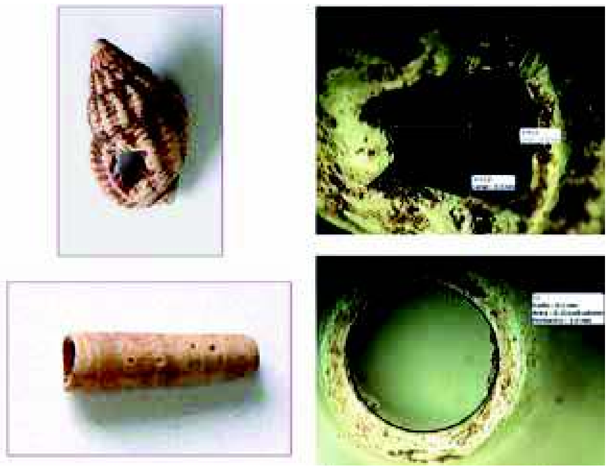

Figure 3. The specimens of *Nassarius incrassatus* and *Dentalium* sp. Detail photo at 40x and 60x.

The specimens of *Cyclope pellucida* present perforations in the body whorl, above the aperture. The holes are irregular but show rectangular intentionality and were using two techniques: abrasion against another hard material and controlled percussion. (Fig. 4). The situation of the holes may suggest suspension: small gastropods could be suspended by a string or thread like pendants. Some similar examples have been studied from Abric de la Cativera (El Catllar, Tarragona) (Estrada, 2004).

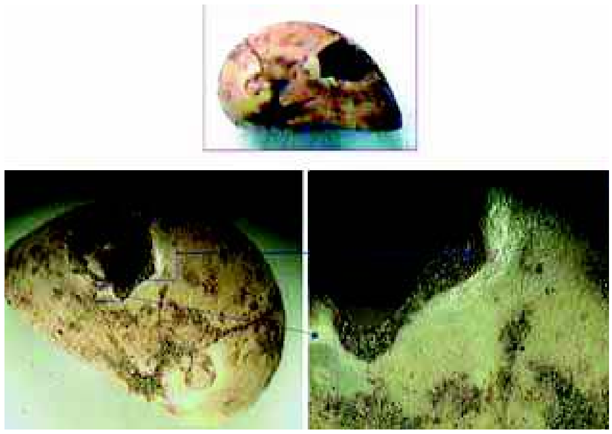

Figure 4. Perforated *Cyclope* sp. with abrasive traces at 80x.

The specimens of *Trivia monacha* show great similarity: they are more or less the same size and the holes are situated in the same zone, forming a parallel duo. Perforations are irregular but with a circular intentionality (2mm x 2mm), made by initial abrasive movement and controlled percussion. We can observe use traces around the siphonal canal and between the holes, suggesting that they were connected with a string. This indicates that the shell were suspended, alternatively they may have been fixed to clothing. (Fig. 5).

The shell ornaments from Cingle Vermell are clearly similar to ornamental types described in France and the north of the Iberian peninsula during the Epipalaeolithic,. Similar artefacts from the same period have been found at Abric de la Cativera (El Catllar, Tarragona), Balma de la Griera (Calafell, Tarragona) and Balma del Gai (Moià, Barcelona).

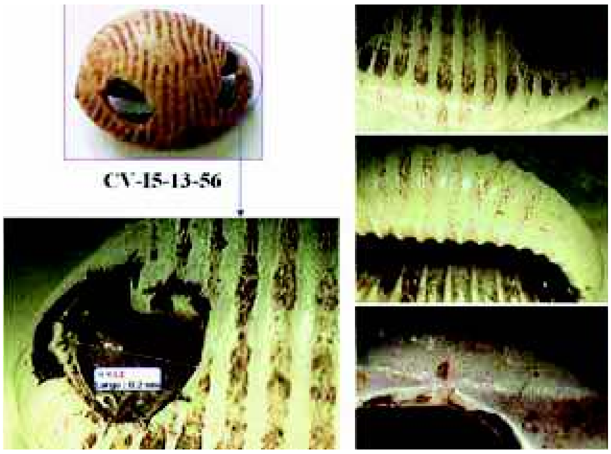

Figure 5. Exemplar of double perforated *Trivia* sp., detail photo at 40x and 60x.

Shells of *Glycymeris violascens, Pecten jacobaeus, Acanthocardia* sp., *Nassarius* sp. and *Cyclope pellucida* were also present at all of these sites. Additionally, evidence of leather work, ochre use and lithic industry were found at some of these site. (Estrada 2004).

4. ROC DEL MIGDIA

The Roc del Migdia displays a complex stratigraphy from the Upper Palaeolithic until the Bronze Age, and also the remains of a Roman grave (Yll *et al.* 1994, Yll *et al.* 1996, Paz *et al.* 1992). Recent excavations at the site have shown there to be a series of sealed Epipalaeolithic layers which have produced the following uncalibrated radiocarbon dates: 7,280 ±370 years BP (UBAR 197), 7,950 ±370 years BP (UBAR 198), 8,190 ±320 years BP (UBAR 196) and 8,800 ±240 years BP (UBAR 272). These levels contain líthic instruments of flint and quartz, as well as faunal remains (*Cervus elaphus, Capreolus capreolus, Sus scrofa* and especially rabbit: *Oryctolagus cuniculus*), terrestrial and marine Mollusca, and ochre remains associated with the lithics.

The different prehistoric levels at Roc del Migdia contained a significant number of shell artefacts, such as perforated valves, bivalve fragments and gastropods and scaphopods used as ornamental objects. Species represented are *Glycymeris glycymeris* sp., *Chamelea gallina* sp., *Pecten* sp., *Cardium* sp., *Patella vulgata* y *Patella* sp., *Mytilus* sp., *Columbella rustica* sp., *Conus mediterraneus* sp. *Buccinum* sp. and *Dentalium vulgare* sp. Currently, 72 malacological objects have been discovered in several years at Roc del Migdia. The presence of unaltered shell, such as the *Glycymeris* sp. valves, and some burned fragments and valves of *Mytilus* sp. and *Glycymeris* sp. suggests distinct uses. Some of the individuals were dispersed across the same archaeological level (for example fragments of the same *Glycymeris* sp. or *G. insubrica* in the J14 and J13 sectors). The relationship between the burned fragments of different malacological species and the different combustion structures is not evident. But, there is a relationship between these burned fragments and the ash-coloured levels in which they appear. These sedimentary units seem to correspond on many occasions to the result of cleaning of the combustion structures.

Most of the *Glycymeris* sp. valves have an apical perforation, in the umbo zone, made by human action. One of the valves, *Glycymeris* RM82- I10-V-247 has a double perforation, one of them over the surface, in the ventral proximal margin made by natural action like a predation(for example, by naticids or muricids). The perforations by humans show two techniques: in *Glycymeris* RM07-G- 120-62e, there are traces suggestive of rotation with a lithic tool, but in *Glycymeris* RM07- G-100- H10-12b an initial abrasive process and secondly a direct concentrically rotation to make a bigger and regular hole can be seen. Abrasive traces were also observed in some shell debris and fragmentary valves: a few small *Chamelea gallina* fragments display a brilliant surface concentrated on the pallial zone, maybe the result of a erosive/abrasive use with this edge, and of burning; some of the burned *Glycymeris* shells present intense erosive effects over the surface or on the valve margin, but it cannot be determined whether this is as the result of human action; finally in the *Glycymeris* valve RM91-K9-8-nocoord some abrasive traces with irregular direction were observed that can be compared with examples from other prehistoric sites (Oliva in this volume) and it is possible that it would be used like a object or tool. This question is currently the subject of further study (Fig.6). Other examples of *Glycymeris* sp. (*Glycymeris glycymeris and Glycymeris violascens*) were found in a nearby site, Balma del Gai (Moià, Bages), mostly fragmented, eroded and burned shells (Estrada, 2004).

The greatest component of the marine shell assemblage in Roc del Migdia is the used ornamental objects. Despite the number of them, currently 48 ornamental pieces, there is no evidence of on-site production, such as primary material. The ornaments are made from shells of *Columbella rustica* and *Conus mediterraneus with* 3 perforated *Glycymeris glycymeris* valves, a small number of *Dentalium vulgare* and one *Cardium* sp. bead (Fig. 7).

Ornaments made with *Columbella rustica* often appear in western Mediterranean prehistory.

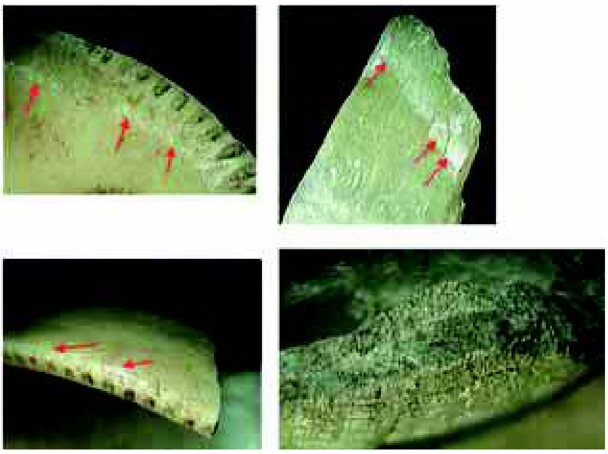

Figure 6. Fire action and abrasive traces, detailed at 60x and 80x.

At sites in the Ebro Valley this species represents nearly 65% of the total number of molluscs (Álvarez-Fernández, 2006) and their known presence in the Epipalaeolithic is increasing in the Mediterranean area. The *Columbella rustica* ornaments at Roc del Migdia present the same characteristics following a established pattern: 22 of them are an entire shell, with spire, and a high number are burned or have fire alterations; for the remaining 9 shells, the spire is absent, taken off with an intentional abrasive action to allow them to be threaded, preserving the spiral cord. (Fig. 8).

Figure 7. Ornaments examples from Roc del Migdia.

All of *Columbella rustica* ornaments have one perforation in the body whorl, at the shoulder. The irregular perforations also follow a size standard (4mm - 7 mm) but they show different techniques: controlled percussion or pressure, abrasive action, and concentric rotation with a tool. Wear from working appears around the perforations and also on the abrasive surface of the spire zone.

Abrasion suggestive of use frequently appears in the same parts of the shell and, for the *Columbella* shells with spires intact, are interpreted as a possible system of fixation by 2 points, the shell then being sewed to another object. For *Columbella* ornaments without spire a suspension system is also suspected but under light microscopy are not remarkable. The differences between natural erosive action around the lip area of experimental *Columbella* (Fig 9, photograph labelled 'B') and the wear on the archaeological Columbella (Fig 9, photograph labelled 'A') clearly suggest that the archaeological object has been subject to wear resulting from human-induced factors, for example being in contact with leather. A small number of the *Columbella* ornaments show variations such as regular perforations with straight corners, fractures, and a second peforation in the spire (Fig 10).

The relation between malacological remains and their ornamental use in clothes is sustained by other types of evidence. Indeed, almost 20% of the lithic remains analyzed appear to have been used for working skin or hide. There is also a remarkable quantity of pebbles suitable for use in tanning, and some of them present traces of pigments of different colours. *Columbella* was used frequently during the Palaeolithic and Epipalaeolithic periods and finds of Columbella contemporary with those at Roc del

	Absolute chronology BP uncal			Total (*)	Traces of work (**)	
Species	**8190**	**8190/8800**	**8800**		**with**	**without**
Columbella rustica	19	2		21	21	
Dentalium vulgare	4	1		5	3	2
Glycymeris sp.	13	2	1	16	3	13
Mytilus sp.	1	1		2		2
Pectem sp.		1		1		1
Conus mediterraneus	1			1	1	
Total	38	7	1	46	28	18

Figure 8. Table with absolute chronology and working presence of the different species of malacofaunal remains in the Mesolithic levels of the Roc del Migdia. (*) Only elements with chronological assignation. (**) Fire action not included.

Migdia were documented in Font del Ros (Berga, Barcelona) and Balma Margineda (Andorra).

At Roc del Migdia 11 specimens of *Dentalium vulgare* were recorded, some of them still threaded together to form necklaces or bracelets. Observed wear shows technological but also use wear: broken and eroded edges and traces of surface abrasion following a single direction, resulting from suspension and contact with another object or the skin. (Fig. 11).

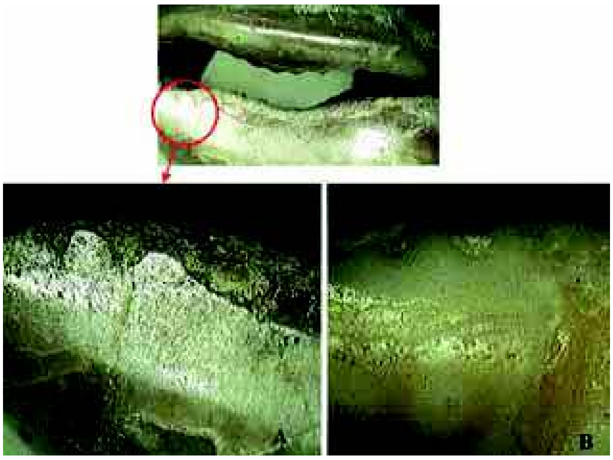

Figure 9. Comparing columbella friction traces: A- archaeological object; B: experimental object. Detail photo at 80x.

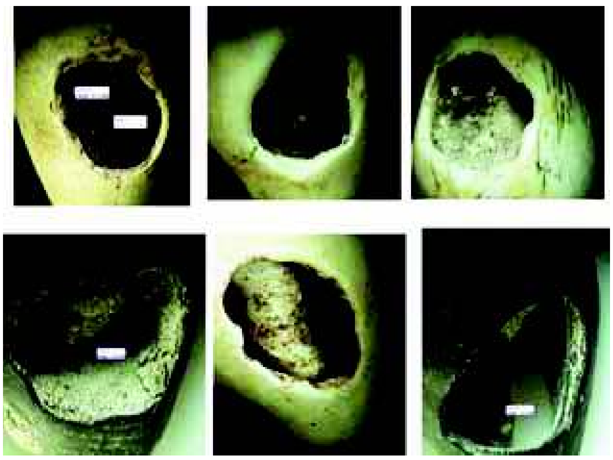

Figure 10. Examples of columbella holes. All photographs at 40x.

Some of the *Dentalium* objects at Roc del Migdia were recovered from an area of 6m², in a clearly delimited space, with another ornamental objects (perforated *Columbella rustica*) from a level corresponding to the in the Epipalaeolithic to Neolithic transition (7280 BP). This type of ornament is common in Epipalaeolithic settlements in nearby areas like Balma del Gai (Moià, Barcelona), Font del Ros (Berga, Barcelona), Sota Palou (Campdevànol, Girona), Balma Margineda (Andorra) and also in El

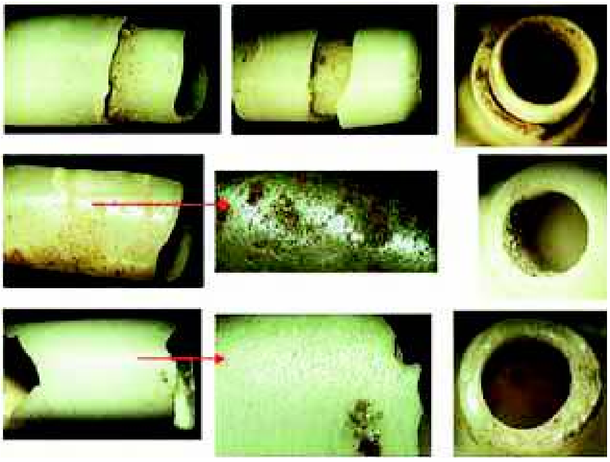

Figure 11. Use evidences in *Dentalium* sp. pieces. Detail at 60x and 80x.

Filador (Priorat, Tarragona) where 13 ornaments of *Dentalium vulgare* have been analysed (Estrada 2004). There is also a continuity of this type of ornament, which is still present at prehistoric sites during the Neolithic and Bronze Age (Oliva 2006).

Finally a circular bead made with a *Cardium* sp. valve is of note because these bead types are more common as ornaments in the Early Neolithic in the north-east Iberian Peninsula. The use is generalized in 3rd-2nd millennium BP when they are found in collective burials (Oliva 2006). The bead presents a central one-directional perforation with a lithic drill using a concentric technique.

Currently, it appears that the spatial distribution of ornamental pieces in Roc del Migdia indicates two areas with special concentration, the most important under the rock shelter, against the wall (Fig. 12). Future fieldwork in the Epipalaeolithic level may increase the number of artefacts and also the areas from which they are recovered, or reveal pieces associated with specific structures.

5. CONCLUSIONS

The presence of marine malacological objects at the Epipalaeolithic sites of Cingle Vermell and Roc del Migdia contributes to the understanding of the mobility of Epipalaeolithic population around northeast Iberian Peninsula that is accepted in historiography. The possibility of foreign origin (Atlantic littoral) of the *Trivia monacha* from Cingle Vermell contributes to the discussion of the movement of shells of Mediterranean species or Atlantic species from one area to the other. At this time, some authors noted that the natural distribution of some species is not clear, but this controversial idea does not exclude that there could be contact between groups of humans, nor

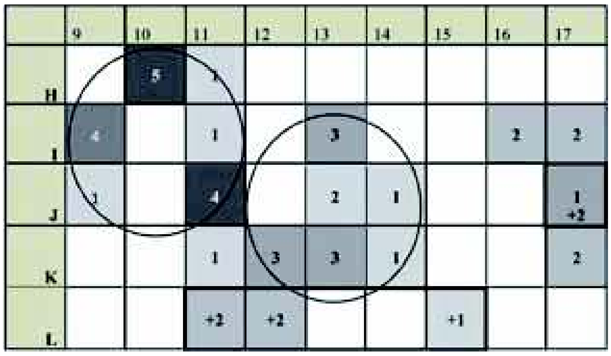

Figure 12. Spatial distribution of ornamental pieces in level (8190 BP). The values with + present remains with chronologies older than 8100 years BP.

that there could have been a particular idea or symbolic attribute associated with this shell that travelled from east to west (Taborin 2004, Álvarez-Fernández, 2006). Currently, although *Trivia* is the most represented species for ornamental pieces in sites on the Atlantic front, in the northeast it only appears in Cingle Vermell. (Alvarez-Fernández 2006).

Both sites have a huge quantity of ornaments, especially Roc del Migdia, with evidence indicating how they were used but there is little evidence of ornament production at the sites. The presence of lithic tools lends weight to the idea that the perforations were made at the settlement, but there is still an absence of shell debris.

It is likely that the continuing work at Roc del Migdia may help identify more evidence of shell ornament manufacture at the site.

6. ACKNOWLEDGEMENTS

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Technology, production and use of malacological ornaments and tools at the prehistoric site of Can Roqueta (Sabadell, Barcelona, Spain)

Mònica OLIVA

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Technology, production and use of malacological ornaments and tools at the prehistoric site of Can Roqueta (Sabadell, Barcelona, Spain)

Tecnología, producción y uso de adornos y útiles de concha en el sitio prehistórico de Can Roqueta (Sabadell, Barcelona, España)

KEY WORDS: Can Roqueta, Malacology, Shell, Ornaments, Production.
PALABRAS CLAVE: Can Roqueta, Malacologia, Conchas, Adornos, Producción.
GAKO-HITZAK: Can Roqueta, Malakologia, Maskorrak, Apaingarriak, Ekoizpena.

Mònica OLIVA[1]

ABSTRACT

This paper presents the interim results of the typological, technological and spatial analyses of shell ornaments from the site of Can Roqueta near Barcelona, Spain. Can Roqueta is dated between the 5th and 4th millennium BC (Ancient Neolithic) to Modern Age. Most mollusc remains are ornaments that were found in funerary contexts, storage pits and habitation areas. This paper determines the variety of shell species chosen by the ancient people who settled in the area during the different periods and tries to discern their use. We analyzed different mollusc remains by using experimental archaeology and use-wear analysis, and established their functions since some shells might have been used as tools.

RESUMEN

En este artículo presentamos los resultados preliminares del estudio tipológico, tecnológico y espacial de los adornos y artefactos de malacología marina del yacimiento de Can Roqueta en Sabadell (Barcelona). Can Roqueta muestra una diacronía en sus ocupaciones que va del V-IV milenio BC (Neolítico antiguo) hasta época medieval y moderna. Muchos artefactos malacológicos se transformaron en adornos que han sido recuperados en contextos funerarios, estructuras de almacenaje y áreas habitacionales. Esto también determina la variedad de especies elegidas por los antiguos pobladores durante las diferentes épocas, cosa que variará su uso. Se documentan diferentes tipos de adorno y útiles que con la ayuda de la experimentación y rastreo de huellas tecnológicas estamos tratando de establecer su nivel funcional ya que algunos artefactos malacológicos pudieron ser usados como herramientas.

LABURPENA

Artikulu honetan, Sabadelleko (Bartzelona) Can Roqueta aztarnategiko itsas malakologiako apaingarrien eta tramankuluen ikerketa tipologiko, teknologiko eta espazialaren atariko emaitzak aurkezten ditugu. Can Roquetako okupazioetan diakronia ageri da V.-IV. BC milurtekotik (antzinako Neolitoa) Erdi Arora eta Aro modernora arte. Tramankulu malakologiko asko apaingarri bihurtu ziren, eta hilobietan, biltegi-egituretan eta bizitokietan berreskuratu dira. Gainera, horri esker, garai bateko eta besteko antzinako populatzaileek aukeratutako espezieak ere zehazten dira, bai eta erabilera nola aldatu zen ere. Mota askotako apaingarriak eta lanabesak dokumentatu dira, eta esperimentazioaren eta arrasto teknologikoen aztarna jarraitzearen laguntzaz, zertarako erabiltzen ziren ezarri nahian gabiltza, tramankulu malakologiko batzuk tresna gisa erabili ahal izan zituztelako.

1. INTRODUCTION

Can Roqueta is an archaeological complex in Sabadell, near Barcelona, located in an industrial area with high property development. The chronological sequence begins in the Neolithic and finishes with Modern structures. To date, 2500 archaeological structures have been documented in an area of 58 hectares in the course of several excavations, and further archaeological sites are to be expected as work in the area has not yet been completed. *Can Roqueta* is one of the biggest prehistoric and historic sites in the Iberian Peninsula and it is situated in the north-east, in Catalonia, 20 km from the Mediterranean coast. The site is on the side of the River Ripoll, in a large ecological valley with water resources (Carlús *et al.* 2007) (Fig. 1):

2. METHODOLOGY

In this section, the analytic parameters used for molluscs and ornamental objects is given, as well as some conclusions related to preceding papers and studies (Oliva 2002, 2007) which summarised certain variables: taxonomic identification

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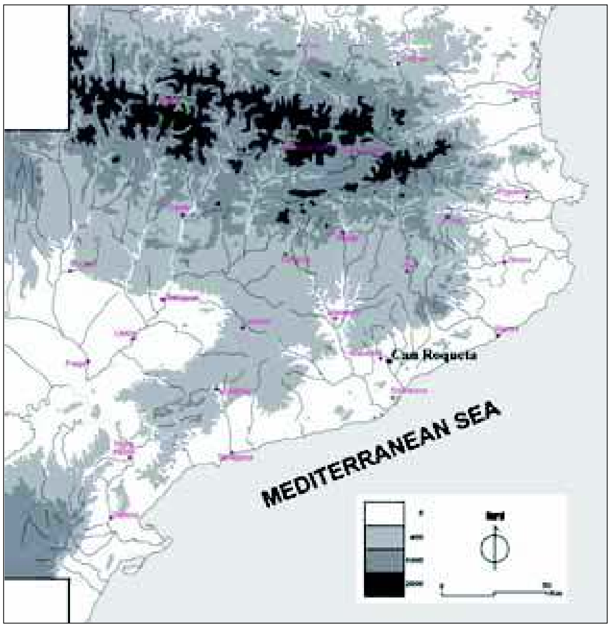

Figure 1. Map showing the location of Can Roqueta near Barcelona.

whenever possible with classic manuals (Dance 1992, Fetcher and Falkner 1993, Lindner 1999), final morphology of the object, morphometry (width, length, diameter, perforation diameters for circular holes….all the sizes in mm), description of human modifications (Barge 1982, d'Errico *et al.* 1993, Taborin 1993, Oliva 2002, Estrada 2004) or natural modifications with microscopic visualization[1] (technological modifications- polish, percussion points, fractured areas[2]… -perforations morphology- uni-directional or bi-directional, simple or complex-, hole situation (central, eccentric…) to determinate the fixation or suspension system (without, indirect -holes or other fixed objects- or direct- open/closed circular or ring finger, projected areas), use-wear marks whenever they can be discerned, and supported by experimental procedures.

3. ANCIENT NEOLITHIC (6600/5900 BP: 5500-5200 cal. BC) AND POST-CARDIAL NEOLITHIC (5920 / 5280 BP: 4300-3800 cal. BC).

The Neolithic in the north-east of the Iberian Peninsula was the trae explosion of personal ornamentation diversity, with the circulation around Europe of some minerals and raw materials, like marine mollusca pieces, to produce manufactured items. The importance of these objects in Neolithic societies is revealed in some burials, as they became the way to express the differences and similarities between communities. Also, the intention of ornamental objects in graves or houses was to assert the different economical and social status of the population. Ornaments at this time were represented by bone pendants, perforated teeth and tusks, bracelets, perforated shells, stone beads, and bone rings (Martin 1998).

The ancient evidence in Can Roqueta consists of storage pits and graves from the 6th to 4th millennium BC and shells transformed into ornaments made with valves of *Glycymeris* sp. One exceptional ornament made with a *Glycymeris* valve is the object CRII-775, found in a Cardial Neolithic storage pit. It is a broken disc with a central hole, which is ornamented with several grooves, probably made with a flint cutter tool, finely polished over the valve surface and all around the central hole. It has no clear use-wear traces. Similar ornaments appeared in Palaeolithic Aurignacian contexts at French sites, like the pendant of Castelmerle (Taborin 2004), although it resembles even more the Cueva de Chaves object (Huesca, Aragón), which displays lines of grooves on its right hand side. Some examples of mollusca uses in the Post-cardial Neolithic are the ornaments and fragmented shells in the tombs. The first case is the 15 valves of *Glycymeris* sp. that were found in CRII-651, a double tomb with a young woman and her unborn child found under large stones. The valves were all around the floor and above the woman's back, all perforated by the same technique: abrasive process in the umbo. According to the radiocarbon date, the tomb is clearly dated in the last phase of the Ancient Neolithic period (Oliva *et al.* 2008). Another example is a perforated valve under the right hand of a skeleton, out of three buried in CRCRV255, a complex structure with a ditch (Terrats and Oliva 2006). The *Glycymeris* valve was also perforated with abrasive technique in the umbo (Fig.2.). This kind of ornament often appears in the Ancient Neolithic and we can find further examples in the northeast of the Iberian Peninsula at Neolithic archaeological sites like: La Draga (Banyoles, Girona) (Bosch *et al.* 2000), Can Tintorer (Gavà, Barcelona) (Estrada and Nadal, 1994).

[1] Observed traces with binocular Optika Lab-2, WF 10x/20 mm and WF20x/13mm, continous zoom (1x-4x), arriving until 80x. Photo with Digital Microscopy Moticam1000 1.3 mp.

[2] Distinguishing traces of concentric rotation, irregular perforation, abrasive vertical lines, abrasive horizontal lines, in all-directional lines, polish parallel lines, oblique lines...

Figure 2. Perforated *Glycymeris* sp.made by abrasive technique associated with individual 2 in CRCRV255.

4. EARLY BRONZE AGE (from 2300 to 1300 cal. BC)

During the Early Bronze Age (late 3rd millennium and 2nd millennium) there was an increase in more or less permanent habitation areas, and long duration settlements. It was the beginning of metallic production. Changes in the funerary context, like collective burials in *hypogeum* graves, are evidence of profound social transformation, with distinguished groups with social differences within the communities, which implied a high pressure on the environment, resources, etc.

The continuous settlements in *Can Roqueta* during the Early Bronze Age (2,000-1,400 BC) are so concentrated that they involve a diversity of structures like storage pits, dwelling "huts" and overall complex graves and burials.

This period was also characterized by an increase in the morphological variety and the procedures to transform shells, basically in ornaments. Bivalves (*Cerastoderma glaucum* and *Glycymeris* sp.), gastropods (*Stramonita haemastoma, Charonia lampas*) and scaphopods (*Dentalium vulgare*) were the chosen species for that finality. The study of prehistoric ornamentation at *Can Roqueta* evidences the non standardized attributes in individual graves and we could also discern that the same ornamental type was not repeated from one grave to another, so one serial ornament is exclusive to one collective burial (Oliva 2004, 2006). The variability in ornamental issues shows technologically old procedures and is represented by bone V-perforated buttons, perforated shells and gastropods, *cardium*[3] beads, *dentalium* beads, *Glycymeris* pendants, bronze rings or bracelets. The manufactured metallic objects in *Can Roqueta* are smaller and rare. Bones and marine malacology were still the basic raw material to produce ornamental items.

The ornamental example of shell used in *Can Roqueta* are over 400 *cardium* beads forming necklaces and bracelets on arms and ankles in an excavated grave containing 10 skeletons. The tomb architecture of CRTR151, with epi-bell beaker ceramics, evidences that these beads may be an ancient reminiscence of the Chalcolithic period, and the radiocarbon date of 3,530±40 BP (1963-1745 cal. BC)[4] confirms this (Carlús *et al*. in press). The beads are very small (4-8 mm max. diameter) and show great similarity amongst each other. Most of them are 5 mm in diameter and are 1-2mm wide (Fig. 3).

Beads, pendants and perforated gastropods were also associated with buried individuals in CRII459 (above), where nearly 20 polished circular *cardium* beads and two pendants were found over the chest of 2 individuals, buried in a collective tomb with another 24 skeletons. All these beads are of different sizes, with irregular outlines and erosion surfaces. The beads have a central perforation, made from one face, probably with a flint drilling tool. Their size is larger than the beads recovered in CRTR151 and the edges are very irregular. The production of these beads was regular and follows a pattern noted in our experimental process: a controlled fracture of valves to get an initial pre-form, polishing the outline surfaces, and perforating a central hole with a stone point or flint drill (or perhaps a bronze point in historic chronologies) in a concentric circular way. Our experimental process also noted that the circular pre-form needs to stay fixed over a surface to ensure a successful hole, and finally the circular form is finished by polishing all its surfaces (Oliva 2002, 2004a).

Cardium circular beads are an ornamental object from the Ancient Neolithic, an example of which is the site of Barranc d'en Fabra (Amposta, Tarragona) with 1500 cardium beads. Small beads continue to be found until the 3rd millennium, when groups of cardium beads have been found in funerary caves like Cova de les Aigües *de Brics*

[3] *Cardium* used as a generic name because *Cerastoderma or Acanthocardia* identification is a difficult task when the object is highly manufacturated.
[4] Laboratory: UBAR-863 Calibration data set: intcal04.14c (Mestres, 2006).

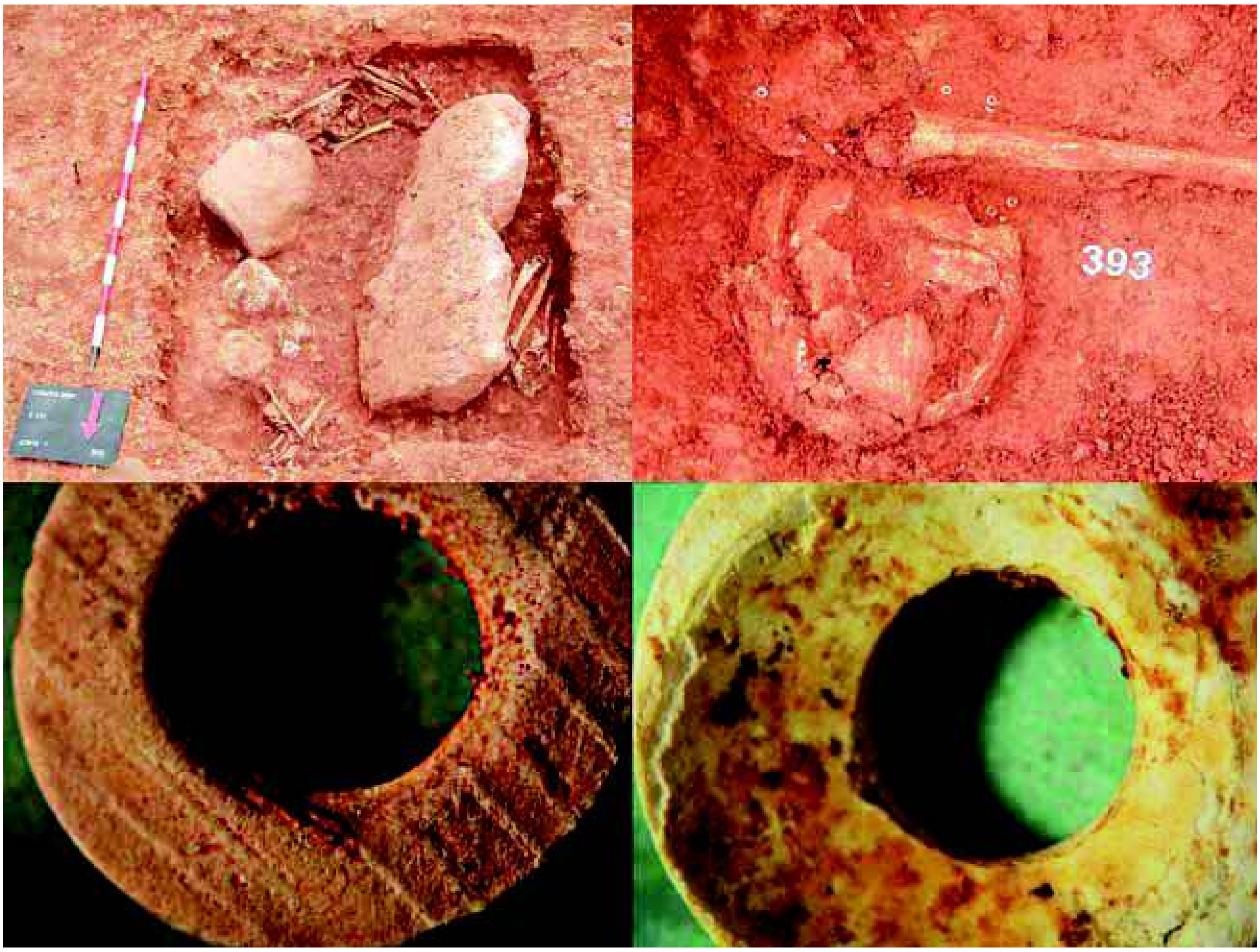

Figure 3. Collective grave CRTR151with small cardium beads associated with 10 individuals. Beads photograph at 40x.

(Lleida) with more than 100 cardium beads or in megalithic graves in the northeast like Túmul I de Serra Clarena (Castellfollit del Boix, Barcelona) with 357 small cardium beads. Exceptionally, two beads were found in an incineration tomb from the Early Iron Age in *Can Piteu-Can Roqueta* cemetery (Carlús *et al*. 2007).

The pendants in CRII459 were made using the same technique on polished valves of *Glycymeris* sp. They have long form and an umbo perforation made on one side. In contrast, in the central pit, a *S. haemastoma* was found in a damaged state between a baby's hands, who had been placed in the arms of an adult woman.

The last example of shells in collective burials is the structure CRII498 where the skeletons of children and young people appeared with only their own ornamental necklaces and bracelets made with some *D. vulgare* beads. These beads were cut, their edges were polished, and some were still inserted in each other.

At this time some perforated *G. glycymeris* valves were thrown and mixed with sediments and waste materials in storage pits or grave-pits. Some *Glycymeris* sp. have natural perforations but others have perforations in the umbo made by abrasive friction or direct perforation by spinning a stone tool. In an experimental process we verified the resulting traces with a flint drill in the hole using a double technique: first the umbo was polished against a rough surface, and secondly a direct perforation was made. Those techniques continued during the Late Bronze Age and Early Iron Age, mostly without an ornamental attribution (Oliva 2004, 2007) due to its large size and the archaeological context, generalized in later chronologies. Also, we can identify fragmented *Glycymeris glycymeris* and *Chamelea gallina* involved with storage and waste structures that were thought to be subsistence refuse. These shell middens have also been detected in coastal settlements near Can Roqueta like Camí del Mig (Cabrils, Barcelona), Cova del Duc (Sitges, Barcelona) or C/Riereta-Sant

Pau (Barcelona), probably involved with a secondary food resource and a malacological functional diversity (Oliva 2007a).

5. LATER BRONZE AGE AND EARLY IRON AGE (from 1350 to 500 cal. BC)

At the end of the Bronze Age, metallic goods became important objects across the whole Mediterranean Sea. Copper, bronze, gold and silver products were used in Mediterranean trade, also with other exotic materials like glass and amber. Those changes were involved with great social complexity and unequal relations between communities, characterized by social segmentation and differences in access to resources and products. Some residual objects made with bones, marine malacology with perforated valves, were found in storage pits. One of the ornaments is represented by a *Conus* doubly-perforated: at the spire zone (made by abrasive technique) and lateral surface zone (made by controlled percussion). The traces observed in the apical zone suggested a use by suspension, hung up, in a necklace. This ornament was found in a hut (CRTR210), in the middle of a sediment level with exceptional objects: a large number of ceramic vessels and a fragment of human skull.

The diversity of mollusca at the end of the Bronze Age in Can Roqueta is large: there are gastropods like *Charonia lampas, Stramonita haemastoma, Cassis sulcosa- Phalium (Tylocasis) granulatum undulatum, Conus* sp. or *Conus mediterraneus*. Also we can find bivalves like *Glycymeris* sp., *Glycymeris violascenscens- insubrica, Glycymeris bimaculata, Glycymeris glycymeris, Cerastoderma glaucum, Chamelea gallina, Ruditapes decussatus, Mytilus edulis, Pecten jacobaeus, Arca noae, Acanthocardia tuberculata, Callista chione* and finally one scaphopod *Dentalium vulgare*. The amount of each one and the total number cannot permit us to talk about a subsistence resource.

The *Glycymeris* valves show again transformation evidences: the small ones may be ornamental but the mid and big sizes present non ornamental traces. Perforations were made by abrasive friction, direct percussion and natural processes (perforated by naticids). The intentional behaviour to perforate the large valves was probably to make containers (spoons, pickers, small vessels…) or for other uses like smoothing tools, weight pieces… (Oliva 2007b). The intentional perforation of shells is also evident in some cases: CRII-123-2-77, a *Glycymeris* valve perforated through the umbo with rectangle form, made by a mixed technique: percussion and sawn outline (Fig.4).

Figure 4. *Glycymeris insubrica* CRII-123-2-77 with regular hole.

Several shell objects display burnt surfaces through contact with fire (ovens, fireplaces…). Some were in contact with oven or fireplace ashes while others were probably placed over grills or containers in a fire because they were not cremated.

The groups of valves, without any transformed parts, found in storage areas or huts at Can Roqueta in this chronological moment might be raw material in storage places. Gathering was an easy task (the site is only 20km from the coast following the river), so the human groups could have access to beach valve deposits during the whole year. Species like *Stramonita haemastoma, Charonia lampas*, and *Phalium granulatum undulatum* located in storage pits without traces of human manipulation are a singular material because they are rare in that chronology, and their functional interpretation may involve status or prestige goods. Marine mollusca in household contexts is unusual but they have been documented in the late Bronze Age town of Genó (Aitona, Lleida) and nearest coastal sites like Mas Castellar (Pontós, Girona) and Illa d'en Reixach (Ullastret, Girona) (Maya *et al.* 1998, Buxó *et al.* 1998, Güell 1999).

In the Iron Age (700-550 BC) Can Roqueta had a large population, with nearly 1800 structures (big storage pits, dwelling huts, combustion structures and ovens, ditches, water cisterns and funerary areas). The incineration will be the new funerary ritual represented in Can Piteu-Can Roqueta graveyard or cemetery. Perforated valves and fragments form the larger collection in this phase. *Glycymeris* sp., *Cerastoderma glaucum* and *Acanthocardia* *tuberculata* are the most representative species (Fig.5). They used large *Glycymeris* sp. valves, almost all perforated, and with other uses rather than ornamental. All the valves were collected when the animal was dead and the surface of some was in process of being destroyed or attacked by naticids or other abrasive circumstances.

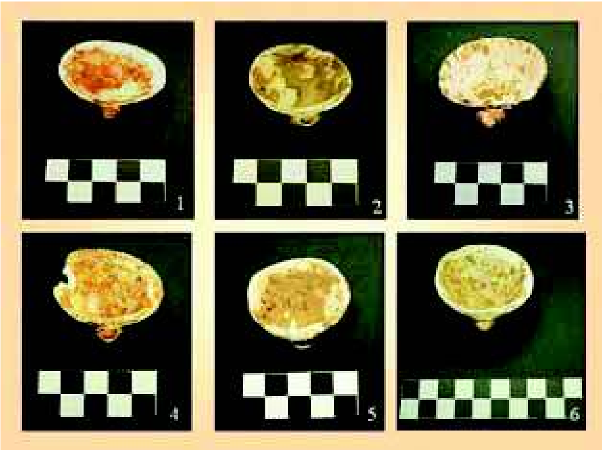

Figure 5. Perforated *Glycymeris* shells from the Early Iron Age at Can Roqueta.

Not all of them have had ornamental uses: some valves display a polished zone on the back side or posterior margin, probably as a result of several activities. Some of them found in storage pits, transformed by a polishing technique against stone, were used to create tools, cut leather and decorate ceramic surfaces. This is the most representative material at Can Roqueta in the Early Iron Age, specifically in the Can Roqueta/Can Revella area. (Fig. 6).

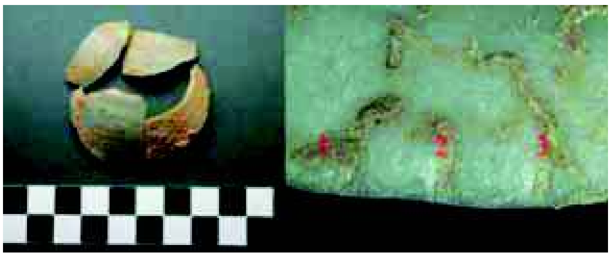

Figure 6. Burnt and fragmented *Glycymeris* with traces on the back side or posterior margin made against a hard surface (60x).

On the other hand, a few objects appeared in the incineration cemetery in Can Piteu-Can Roqueta with 1190 incineration tombs. Only an *Arca noae* valve, 2 circular beads made from *Cardium* sp., an indeterminate gastropod and a perforated *Glycymeris* sp. were found in 2 ceramic vessels with human ashes and bones (CPR1041 and CPR505). Some valves appeared in other ceramic containers in the Iron Age necropolis, storage pits and dwellings in the northeast. Edible species like *Cerastoderma* sp. and *Pecten* sp. appeared as grave goods at Can Bec de Baix (Agullana, Girona) (Toledo and Palol 2006), Coll s'Avenc (Tavertet. Barcelona) (Molist *et al.* 1985) and Cova de Montmany (Pallejà, Barcelona) (Maya 1986).

6. THE IBERIAN PERIOD, LATE ROMAN AGE AND MIDDLE AGES

The malacological pieces in the Iberian period (V-IV A.D) at Can Roqueta are very few. We could only document fragmented shells and some large perforated valves, most of them with burnt marks that indicates a functional use as tools.

Little historical evidence is found until the late Roman Age (6th century A.D) with a large village located in the Can Roqueta/Torre-Romeu area and some structures from the Middle Ages (13th – 15th centuries AD) in the *Can Roqueta* II area. Some structures and effectives, including 80 storage pits, huts and "lacus", were built and used between the 5th and 6th centuries AD. Valves of *Glycymeris* sp. with natural perforations or damaged surfaces are the only mollusca artefacts in this period. Instead, use-wear analysis shows suspension use or fixation to another element that has not been preserved. The only gastropod, *Bolinus brandaris* was found in a "lacus" (wine storage pit).

This situation contrasts with the nearest settlements during this period, like Els Mallols (Cerdanyola del Vallès), with some malacological objects in all production areas (Estrada and Nadal, 2007). Finally, medieval mollusca is represented by one perforated *Glycymeris glycymeris*.

7. CONCLUSIONS

The variability in the species may be associated with different uses throughout Prehistory and History at the site. The marine mollusca species at Can Roqueta were used to make ornamental objects, basically in the Neolithic and Early Bronze Age when the primary use is one of the most important in the community: social and symbolic functions as ornamental objects, probably in life and also in death. A greater use comes with population increase and the social differences in accessing resources in the Bronze Age. Diversity in morphological form also marks these economic and social changes: many mollusca ornaments, although not all group members, were allowed to have them. In the late Bronze Age and early Iron Age mollusca have several uses, some valves show evidence of being used as tools, while ornamental use is restricted and rare. The chosen species in this period could be a functional response to technological needs: shells used as a tool or pieces of support, with a very few effectives that may be food resources. In the historical period, the mollusca objects remain and their presence continues until the Modern Age, when they become subsistence effectives.

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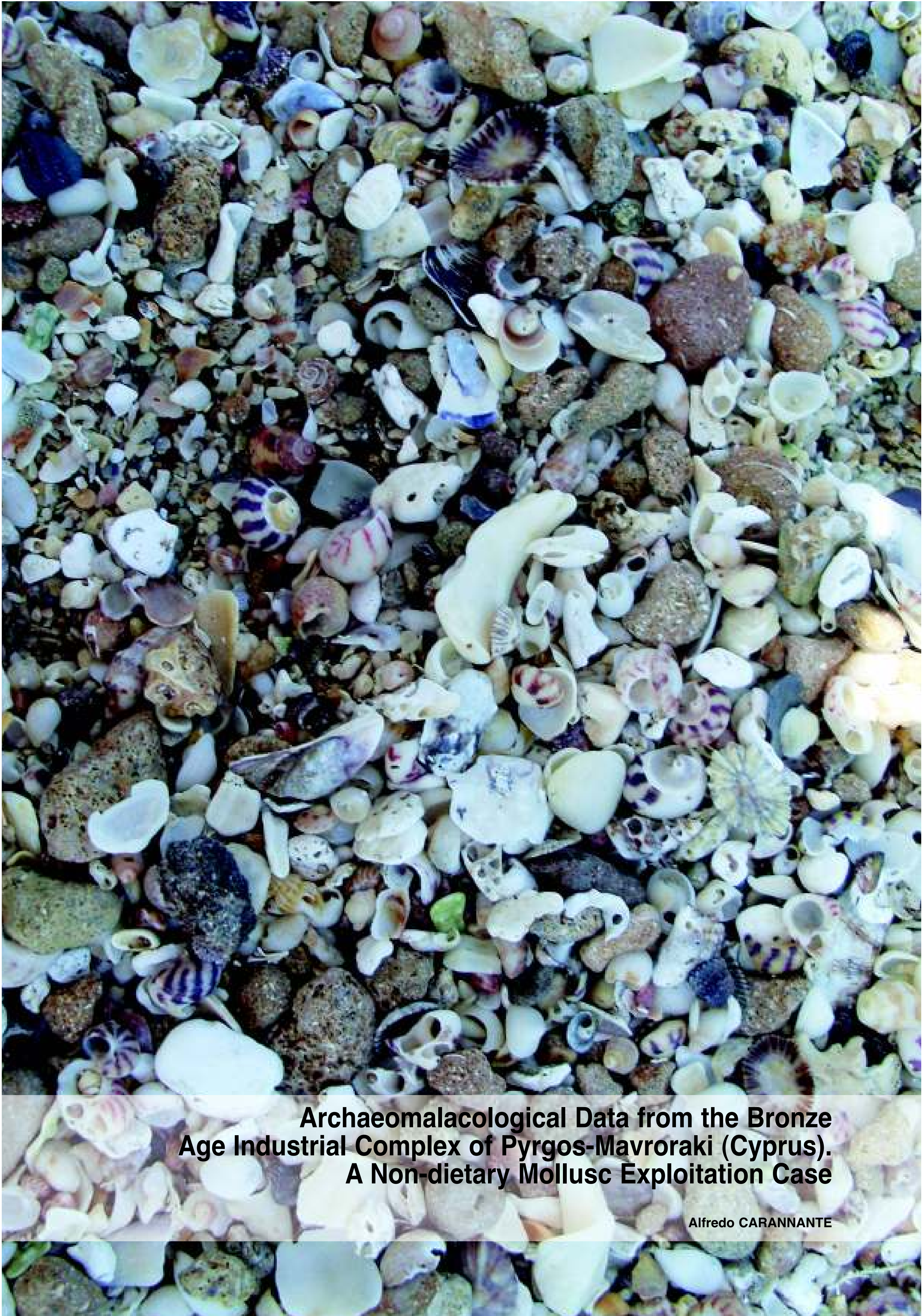

Archaeomalacological Data from the Bronze Age Industrial Complex of Pyrgos-Mavroraki (Cyprus). A Non-dietary Mollusc Exploitation Case

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Archaeomalacological Data from the Bronze Age Industrial Complex of Pyrgos-Mavroraki (Cyprus). A Non-dietary Mollusc Exploitation Case

Datos arqueomalacológicos del Complejo Industrial de la Edad de Bronce de Pyrgos-Mavroraki (Chipre): un caso de explotación de moluscos sin interés alimenticio

KEY WORDS: Cyprus, Bronze Age, Shells, Ornaments, Beads.
PALABRAS CLAVE: Chipre, Edad de Bronce, Conchas, ornamentos, objetos de adorno-colgantes
GAKO-HITZAK: Zipre, Brontze Aroa, Maskorrak, apaingarriak, apaingarri-zintzilikariak

Alfredo CARANNANTE[(1)]

ABSTRACT

Several shells come from the Early and Middle Bronze Age industrial complex of Pyrgos-Mavroraki (Cyprus). Here, metallurgical and textile industrial activities are well documented together with oil, perfume and wine production but no food processing or food consumption is attested. Archaeomalacological analysis confirms that the area excavated to date was only used for industry but not for housing. Most of the shells are ascribable to an ornamental use and/or to an apotropaic value. Archaeomalacological analyses in Pyrgos revealed that the cultural world of Pyrgos had deep roots in the prehistoric Cypriot tradition and was part of a strongly characterized culture, although some shell remains testify contacts with far countries.

RESUMEN

En el Complejo Industrial de la Edad de Bronce (fases antigua y media) de Pyrgos-Mavroraki (Chipre) se han clasificado varias conchas. En este sitio se han documentado bien actividades industriales junto con la producción de aceite, perfumes y vino, pero no el procesado y el consumo de alimentos. Hasta el momento, los estudios arqueomalacológicos confirman que el área excavada sólo fue usada para la industria y no como lugar de hábitat. La presencia de la mayor parte de las conchas es interpretada como de uso ornamental y/o apotropaico. Estos análisis también revelan que el mundo cultural de Pyrgos estaba muy enraizado en la Chipre prehistórica y que formaban parte de una cultura fuertemente caracterizada, a pesar de que algunas de las conchas nos indican la existencia de contactos con países lejanos.

LABURPENA

Brontze Aroko (Behe eta Erdi Brontze Aroa) Pyrgos-Mavroraki (Zipre) Konplexu Industrialean, zenbait maskor dokumentatu dira. Leku horretan, jarduera industrialez gain, olioaren, lurrinen eta ardoaren ekoizpena dokumentatu dira, baina ez elikagaien prozesaturik ez kontsumorik. Gaur arte, ikerketa arkeomalakologikoek berretsi dute indusketa egindako eremua industriarako soilik erabili zela, eta ez bizileku gisa. Maskor gehienen erabilera apaingarri gisa edo/eta apotropaiko gisa interpretatu da. Gainera, analisiek erakusten dute Pyrgoseko kulturak erro sakonak dituela historiaurreko Zipren eta izaera handiko kultura osatzen zuela, maskor batzuek urruneko herrialdeekiko harremanak adierazten dituzten arren.

1. INTRODUCTION

The archaeological research of the last decades is showing the complexity of the prehistoric Cypriot world. Bioarchaeological analyses on the remains from recently discovered sites are furnishing important information about the relationship between ancient human populations and their ecosystem. Several papers report archaeomalacological data from prehistoric Cypriot sites (for a synthetic review, see: Reese 1985, 1996, 2003). Many of them (*e.g.* Reese 1983, 1996, 2003) analyze for each species the probable use of the mollusc and/or of its shell. Those papers generally report also a list of the rooms where archaeomalacological remains were found. Nevertheless, none of the archaeomalacological reports contextualizes in detail the archaeomalacological datum so far. Such a detailed contextualization has been possible in the site of Pyrgos-Mavroraki thanks to the close cooperation between the excavators and the archaeozoologists. In this site it has been possible to relate the shell remains with the archaeological contexts where they were discovered. The association between the shell remains and the other archaeological findings provides useful data that otherwise could lie unexpressed.

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The aim of this work is to contribute to the knowledge of the marine organisms exploitation in Bronze Age Cyprus and to show how archaeomalacology can contribute to the reconstruction of the prehistoric cultures.

2. THE SITE OF PYRGOS-MAVRORAKI

Pyrgos-Mavroraki is one of the most interesting discoveries in recent Cypriot archaeology.

The site is situated 8 kilometres from the ancient city of Amathus (Amathous, Amathount or Amathunte) and about 4 kilometres from the southern coast of Cyprus (Fig. 1).

Figure 1. Map of Cyprus with the location of the Bronze Age sites mentioned in the text.

The excavation of the site started in 1998 and continues to bring to light a unique Bronze Age industrial complex.

The first occupation of the site is probably dated to the end of the Chalcolithic period. In the Early and Middle Bronze Age, Pyrgos covered more than 25 hectares (Belgiorno 2004).

The settlement was destroyed in the first half of the 19th century BC (Middle Bronze Age) by a sudden and violent earthquake that preserved *in situ* most of the domestic objects under the collapse of the mud brick structures (Belgiorno 2004: 22).

The importance of the site consists not only of the fact that it is a rare industrial complex, but also its archaeological integrity which has supplied precious documents to reconstruct the most ancient Mediterranean industrial system.

The area excavated to date consists of several rooms (Fig. 2).

A large olive press for oil production stood in the centre of one of these rooms dividing it into two different areas (Belgiorno 2004, 2005). The western area was utilized as an oil jar storeroom and

Figure 2. Plan of the Pyrgos-Mavroraki excavated area with the rooms devoted to metallurgy, oil production and storing, perfume production and weaving (from Belgiorno 2007, modified).

housed nine giant *pithos*-jars with a total capacity of several thousands litres; while the eastern one was utilized as a perfume factory. Many vases and stone tools connected to all the processes of perfume production (in which olive oil had a central role) were found in this last area and analyzed in order to identify attars and essences used in ancient perfumery (see: Belgiorno 2005, 2007).

Oil and olive waste were not only used in the perfume industry but also as fuel for intensive metallurgical activities as attested in the rooms (Fig. 2) that surround the “oil room” on three sides (Belgiorno 2004). All the phases of copper processing -from ore smelting to copper alloy melting and to the final refining of metal objects- are attested in those metallurgical areas of the complex (Belgiorno 2004, Giardino 2004).

A stove still filled with half-baked loom weights was found near the furnaces in the southernmost excavated point of the “metallurgical area”.

The westernmost room of the excavation seems to have been devoted to the weaving industry. The remains of a complete loom were found in this room together with many vases, loom weights and spindle whorls still containing textile fibres remains, the analysis of which revealed the yarns and the dyes used at Pyrgos in the Bronze Age (Belgiorno 2004, Lentini 2004). Oil was also used for spinning activities in the weaving industry room.

The importance of Pyrgos-Mavroraki comes partly from the abundance of remains and structures that were found there, but mainly from the attention they received. Archaeometrical analyses, bioarchaeological studies and experimental archaeology trials have always supported traditional archaeological research on the site. Kinds of remains generally neglected in other excavations, such as textile fragments found in earth samples inside fusaroles, chemical compounds absorbed by pottery surfaces, pollens and shell fragments, have been collected and studied on this site and their analysis has been the framework for the whole Pyrgos research.

The first archaeozoological analysis (see: Cerilli and Tagliacozzo 2004) carried out on the Pyrgos findings was focused on the vertebrate remains. Among vertebrates, mammal remains are very scarce and there are practically no fish and bird remains. The scarcity of such remains in comparison with other categories of archaeological materials has already been pointed out by Cerilli and Tagliacozzo (2004). It cannot be sufficiently explained by taphonomical conditions, such as the chemistry and the granulometry of the surrounding sediments.

A concentration of seven cattle mandibles, a swine mandible and a stag (deer) antler fragment in an area connected with intensive metallurgical activity was of particular interest to Cerilli and Tagliacozzo (2004). Taphonomical analysis suggested that such remains correlate with an ornamental use such as furnishing or with an unknown use in ritual activities (Cerilli and Tagliacozzo 2004).

All the data on vertebrate remains in the site affirm that food-related activities are not attested in the excavated area (Cerilli & Tagliacozzo 2004: 51).

The scarce and badly preserved bone fragments brought to light in recent years do not modify the archaeozoological picture: no food processing or consumption is attested in the excavated area to date.

3. GENERAL ARCHAEOMALACOLOGICAL DATA FROM PYRGOS-MAVRORAKI

Archaeomalacological remains (137 sea shell remains) are much more represented than vertebrate ones. A first observation of the archaeomalacological datum (Tab. 1) already reveals a wide diversity in the presence of species. 28 *taxa* of marine molluscs were identified in Pyrgos: 19 gastropod *taxa*, 8 bivalves and 1 scaphopod.

No remains pertain to fossil shells collected from outcropping oryctocoenosis.

In archaeomalacological analysis, more than in the analysis of vertebrate remains, it is fundamental to verify why the shells were collected. Living molluscs may have been collected as food or for industrial uses (such as purple-dye or byssus production) whereas empty shells may have been collected to be used as ornamental beads, as pendants, for apotropaic purposes or as raw material to produce different kinds of ornamental objects, instruments and utensils.

Only 16 *taxa* (*Arca, Barbatia, Glycymeris, Cardiidae, Ostrea, Pinna, Spondylus, Bolinus, Charonia, Hexaplex, Monodonta, Ocenebra, Patella, Phalium, Strombus, Thais*) are compatible with an alimentary use among the molluscs identified in Pyrgos. These *taxa* include 72 shell remains, 52.5% of the minimum number of individuals. However, this percentage falls to 36.5% if

CLASS	TAXON	NISP	MNI	CLASS	TAXON	NISP	MNI
Gastropoda	*Patella* spp.	22	18	Gastropoda	*Columbella rustica*	5	5
Gastropoda	*Monodonta turbinata*	3	2	Gastropoda	*Fasciolaria lignaria*	1	1
Gastropoda	*Cerithium vulgatum*	1	1	Gastropoda	*Gibberula miliaria*	37	37
Gastropoda (Indo-Pacific)	*Strombus tricornis*	1	1	Gastropoda	*Conus* sp.	2	2
Gastropoda	*Erosaria spurca*	3	3	Gastropoda	Indeterminable Gastropoda	2	2
Gastropoda	*Luria lurida*	4	3	Bivalvia	*Arca noae*	4	4
Gastropoda	Indeterminable Cypraeidae	3	3	Bivalvia	*Barbatia barbata*	1	1
Gastropoda (Indo-Pacific)	*Malea pomum*	1	1	Bivalvia	*Glycymeris* sp.	5	4
Gastropoda	*Phalium undulatum*	10	10	Bivalvia	*Pinna nobilis*	2	1
Gastropoda	*Charonia tritonis*	7	7	Bivalvia	*Ostrea edulis*	1	1
Gastropoda	*Bolinus brandaris*	1	1	Bivalvia	*Spondylus gaederopus*	1	1
Gastropoda	*Hexaplex trunculus*	8	8	Bivalvia	*Cerastoderma glaucum*	9	7
Gastropoda	*Ocenebra erinaceus*	3	3	Bivalvia	Indeterminable Cardiidae	2	2
Gastropoda	*Thais haemastoma*	1	1	Bivalvia	Indeterminable Bivalvia	1	1
Gastropoda	*Buccinulum corneum*	2	2	Scaphopoda	*Dentalium vulgare*	4	4

Table 1. Number of Identified Specimens values and Minimum Number of Individual values for the different mollusc taxa from Pyrgos-Mavroraki.

we exclude shells that appear water-worn, bio-eroded by sponges, holed by marine predators or encrusted inside by fouling organisms. It falls again to 27.0% of the assemblage -just 37 individuals- if the worked shells are also excluded. Moreover, these few shell remains compatible with an alimentary use were dispersed in the different rooms of the complex, then they do not look like food debris. Thus Pyrgos archeomalacological datum agrees with the data emerged from the study of vertebrate remains; both suggest that the preparation of meals and and consumption did not take place in the rooms of the building excavated to date. Consequently, the same rooms were used exclusively for industrial activities and were definitely separate from the living areas not yet excavated.

4. MUREX SHELLS

One of the rooms of the Pyrgos-Mavroraki complex was clearly devoted to weaving activities. A lot of vases and spindle-whorls still containing textile fibres, loom weights and a tank probably used for dying were found here. Clots of purple-red material were also discovered in this room (Belgiorno 2004: 27). Archaeometrical analyses of these clots showed a high concentration of bromine. Purple-dye molecules differ from vegetal indigo-dye molecules in the presence of two bromine atoms. This datum suggests the use of murex purple-dye on the site (Lentini 2004: 39). This is one of the earliest attestations of the industrial use of purple-dye.

The Mediterranean Muricidae genera *Hexaplex, Bolinus, Thais* and *Ocenebra* (associable under the trivial name of murex shells) were exploited from the Bronze Age onwards in the Aegean and the Near East to produce the most expensive dye of antiquity (see: Becker 2001, Spanier 1990, Stieglitz 1994, among others). Specimens of all these species were discovered in Pyrgos; 13 murex shells: 8 *Hexaplex trunculus* (Linné, 1758), 1 *Bolinus brandaris*, 3 *Ocenebra erinaceus* and 1 *Thais haemastoma*. Eight of them preserved the last whorl and seven of these were holed by percussion. That originally suggested to the archaeologists (see: Lentini 2004: 39) that these shells were collected and holed to catch the hypobranchial gland containing the purple-dye. However, among the holed murex shells from Pyrgos, one is intensely bio-eroded, two are encrusted inside by serpulid worms and other fouling organisms and another is water-worn: thus these shells were collected after the death of the mollusc. Another holed murex shell was found associated with a stone pendant. These findings affirm that murex shells from Pyrgos were connected with ornamental use rather than with industrial purple-dye production on the site.

The use of murex shells as pendants was widespread throughout the Bronze Age Mediterranean sites. The use of such a kind of ornament is attested in several Bronze Age Cypriot sites: two holed specimens collected dead that “could easily be strung as pendants” (Reese 1996) come from Alambra-Mouttes, six or seven come from Sotira-Teppes (Dance 1961), three from Sotira-Kaminoudhia (Reese 2003), three from Maa-Palaeokastro (Reese 1988) and two from Bronze Age levels of Kition (Reese 1985). Many murex shells were also found in several tombs at Hala Sultan Tekké (Reese 1985).

Murex shells holed on the last whorl for ornamental aim have been discovered also in many Middle and Late Helladic tombs of continental Greece (Reese 1998: 279), in several Minoan contexts on Crete (see: Reese 1995), in some inland Turkish sites (see: Reese 1986) and in one Calabrian (Southern Italy) site (Tagliacozzo 1994: 590).

Figure 3. Pen shell from Pyrgos-Mavroraki.

The pen shells cling to the substrate by byssus filaments that were used in antiquity to produce the sea silk (byssus), the most luxurious textile.

Many ancient textile fibres have been identified in Pyrgos (Lentini 2004: 42) but among them, unfortunately, no byssus fibre was found.

Pinna nobilis has the thickest nacreous stratum among the Mediterranean shells. The Pyrgos pen shell fragment is a worked umbonal part, smoothed on the edges and with a hole drilled in the centre. It was probably part of a big mother-of-pearl pendant intended for use as an ornament or as an utensil (e.g. large spoon, spatula) rather than as a jewel.

The Pyrgos worked pen shell is a rare find. Mother-of-pearl artefacts made from Indo-Pacific shells are widespread throughout the Chalcolithic and Bronze Age Near East and Egyptian sites (see: Bar-Yosef Mayer 2002, among others). In contrast, data on prehistoric Mediterranean nacre handicraft are very scarce because of the extreme fragility of pen shells. Many fragments of *Pinna nobilis* are reported at Late Bronze Age Hala Sultan Tekké (Demetropoulos 1979) but they were the only attestation in Cyprus until now. Pen shell remains are more attested in the Aegean sites. They have been found in several Minoan centres on Crete (see: Reese 1995, among others), in many sites of continental Greece from Macedonia (Becker 1996) to Laconia (Reese 1994) and in some Aegean islands (Reese 2006, among others). Some of these findings are smoothed on the edges and bored as the *Pinna* object from Pyrgos.

A worked pen shell has been found at Lefkandi on Euboea island (Greece). It was "worn down to spoon or palette-shape and may have been utilized as tool" (Reese 2006). A "quadrilateral plaque with a central hole" and fragments with smoothed sides from pen shells were also found in Poliochni on Lemnos island (Karali 1999: 36) and another *Pinna* bored fragment comes from Thermi on Lesbos island (Shackleton 1968: 127). *Pinna nobilis* fragments are also attested in many Bronze Age sites of Adriatic coast of Italy (see: Wilkens 1995: 497 among others).

5. ORNAMENTAL PENDANTS AND BEADS

Many of the shells from Pyrgos-Mavroraki are connected with ornamental use. 101 shells of the whole assemblage allow us to verify holing; 59 of them show one or more holes and 54 are artificially holed by percussion, abrasion or drilling.

The best example of the ornamental use of the shells on the site is a necklace made up of 35 holed and water-worn shells (Fig. 4). All the shells, from three mollusc species, were found together in the "perfume factory" area. 32 specimens of *Gibberula miliaria* artificially holed by abrasion of the apex were used to make this jewel; some of them have a second hole created by marine predators or by natural erosion on the last whorl. This is a unique attestation of the ornamental use of this species. Other five holed Gibberula shells have been found in other areas of the site: four come from the "weaving room" and one was found next to the loom weights stove. The presence of another small gastropod shell in the "perfume factory" necklace is even more unusual: a specimen of the Tonnidae *Malea pomum*, an Indo-Pacific species. Finally, two worked tusk shells of the scaphopod *Dentalium vulgare* probably closed the necklace.

The ornamental use of tusk shell is attested in many prehistoric Cypriot and Eastern Mediterranean sites (see: Reese 1985, 1996, 2003, among others). The Cypriot Bronze Age sites of Kafkallia necropolis, Maa-Palaeokastro, Alambra and Episkopi produced *Dentalium* remains (Reese 1985: 352).

Figure 4. Shell necklace from Pyrgos-Mavroraki.

Other common shells were also used as pendants and beads in Pyrgos. Holed shells of *Barbatia barbata* - a single valve holed by percussion-, *Glycymeris insubrica* - three drilled valves -, *Cerastoderma glaucum* - two valves holed by percussion - a single *Columbella rustica* and a single *Luria lurida* with two holes that suggest its use as a bead, were discovered in addition to the above mentioned murex shells.

The ornamental use of such species is attested also in other Cypriot Bronze Age sites as Kition (one *Cerastoderma*, three *Glycymeris*), Hala Sultan Tekké (two *Cerastoderma*, six *Columbella*), Kalopsidha (some *Cerastoderma* in Early Cypriot tombs), Kourion-Bamboula (one *Glycymeris* in a Bronze Age tomb), Palaepaphos-Teratsoudhia (two *Glycymeris*), Maa-Palaeokastro (some *Glycymeris*) (Reese 1985, 1988), Marki-Alonia (two *Cerastoderma*) (Frenkel and Webb 1994: 215) and Sotira-Kaminoudhia (two *Glycymeris*, one *Barbatia*) (Reese 2003). Two *Conus sp*. fragments were also found at Pyrgos-Mavroraki.

7. UNPERFORATED ORNAMENTAL SHELLS

The mere ornamental use is more difficult to uphold when not edible species unholed shells are found in archaeological contexts.

Three *Erosaria spurca* specimens, three *Luria lurida* and three fragments of other unidentifiable cowries were found in Pyrgos-Mavroraki. Five of them were certainly from unholed shells and just one of them has two holes as mentioned above.

Cowrie shells without natural or artificial holes have been found also in other contemporary Cypriot sites. Four of the seven cowries found in the Bronze Age levels of Kition were not holed (Reese 1985) and two unholed *Erosaria* were found at Maa-Palaeokastro (Reese 1988).

Unworked cowrie shells are attested also outside the island. They have been found in Minoan sites as Myrtos (Shackleton 1972: 324) and Kommos (18 unholed shells) (Reese 1995), at Ayios Mamas in the Chalcidice Peninsula (Greece) (Becker 1996) and in several Near Eastern sites (see: Bar-Yosef Mayer 2000, Reese 1991, among others).

Other unperforated shells of inedible species have been found in Pyrgos: two *Buccinulum corneum* specimens, two *Columbella rustica* and a single *Fasciolaria lignaria*. *Comparable data* are reported in one only Cypriot Bronze Age site, Maa-Palaeokastro where four unholed *Buccinulum* specimens and a single unholed *Columbella* were found (Reese 1988). In contrast, a special value seems to be connected with the unperforated shells of *Buccinulum*, *Columbella* and *Fasciolaria* in the Minoan world. Indeed, unperforated shells of these species are diffusely attested in Cretan Bronze Age sites and on Thera island (see: Reese 1995, among others). At some Minoan sites a peculiar interest in these unholed shells is evident. Only few of the 75 *Columbella* specimens and of the *Buccinulum* specimens found in the Minoan peak sanctuary of Mount Youktas were holed (Reese 1995). A similar situation is attested in the Minoan site of Kommos where only 8 of the 59 *Buccinulum* shells were holed, only 3 of the 30 *Columbella* shells were holed and none of the three *Fasciolaria* shells were holed (Reese 1995). Comparable data are reported from other Cretan sites as Pseira, Mochlos (Reese *et al.* 2004) and Monastiraki (Carannante 2006).

The unperforated shells of inedible species are generally interpreted as shells waiting to be manufactured, or as gaming pieces, or as votive depositions; more correctly Becker (1996: 14) renounces defining their function and counts this kind of remains as *"objets énigmatiques"*. Indeed, it is impossible to propose a functional classification for them. We can evoke symbolic, apotropaic or merely aesthetical functions, however such splitting reflects only the pedantic need for classification of the modern scholar; it does not help us to understand the complex overlapping of the symbolic, apotropaic and aesthetic values that are often inseparable in the human mind. However, the imperforated shells of Pyrgos-Mavroraki come from different areas of the complex, rather than being accumulated in the same place. Therefore they were not waiting to be manufactured.

8. CASSID LIPS

Ten *Phalium undulatum* remains have been found in Pyrgos. Six of them are external lips sawed off from the shell to obtain a crescent (Fig. 5). D.S. Reese dedicated a detailed paper (Reese 1989) to this kind of remains, which he called "Cassid lips" or "Phalium lips".

A Phalium shell whose external lip was sawed off was also found in Pyrgos. This datum demonstrates that the "Cassid lips" were produced directly on the site.

"Cassid lips" were probably suspended as pendants and are a common find particularly in Near Eastern sites. They have been often found in sanctuaries, in tombs or in votive contexts (Reese 1989: 38).

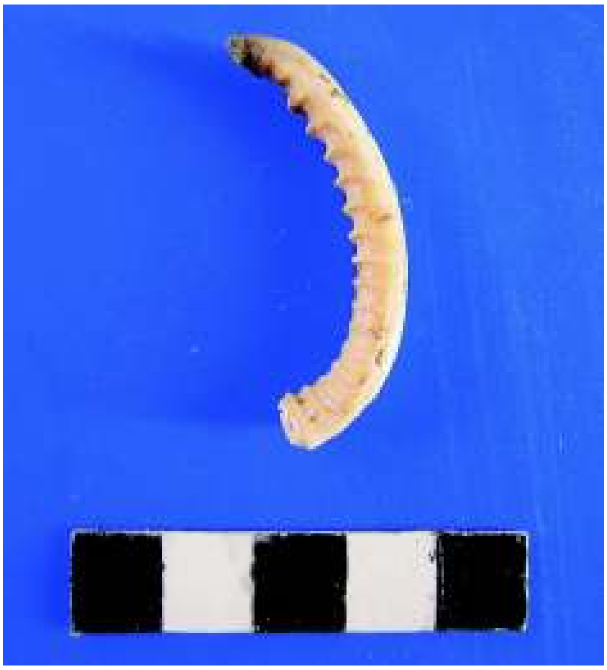

Figure 5. "Cassid lip" from Pyrgos-Mavroraki.

"Cassid lips" were a widespread object in Cyprus, southern Anatolia and Near East from the earliest Neolithic phases (Reese 1989). The "Cassid lip" pendant tradition continued in the Near East and in Cyprus also in the Bronze Age and also spread into inner Syria and northern Mesopotamia (Reese 1989: 36).

"Cassid lips" are attested in Cyprus from Aceramic Neolithic (c.a. 7000-6000 B.C.) (Reese 1989) but the continuity of this tradition is also attested in several Bronze Age and later sites. Two "Cassid lips" fragments were found at Late Chalcolithic/Early Bronze Age Sotira-Kaminoudhia, one was found at Middle-Late Bronze Age Episkopi-Phaneromeni and two at Late Bronze Age Hala Sultan Tekké (Reese 1989). The Cypro-Archaic IIA (1200-1190 B.C.) Tomb 232 at Amathus, nearby Pyrgos-Mavroraki, produced eight "Cassid lips".

Reese (1989: 38) points out that "Cassid lips" from Near Eastern sites are often holed to be used as pendants while those from Cyprus are always unholed. The Pyrgos-Mavroraki ones are all unholed and confirm the Reese remark.

9. "PHILIA PENDANTS"

A "Cassid lip" pendant is a kind of ornament common to a cultural *koiné* that embraced all the prehistoric eastern Mediterranean regions from Taurus to Jordan and from Cyprus to the Euphrates. In contrast, another kind of ornament is exclusive to Cyprus and somewhat limited to the first phase of the Early Bronze Age. This phase is denominated "Philia phase" and marks the transition from the Chalcolithic to the Bronze Age. The typical ornament of this phase is called the "Philia pendant" and is considered one of the "index fossils" of the period (Webb and Frankel 1999).

"Philia pendants" consist of a ring with generally one or two protrusions sometimes similar to a fish tail so they were initially called "fish amulets" (Dikaios and Steward 1962: 264). They were generally made of shell whereas they were also made of stone at most inland settlements.

A complete shell "Philia pendant" and a fragment of a second one carved in gastropod shell have been brought to light in Pyrgos-Mavroraki.

"Philia pendants" have been found at Kissonerga-Mosphilia (all made of shell), in some Philia-Laksa tou Kasinou tombs (most of which made of shell), in several Nicosia-Ayia Paraskevi tombs (45 examples in picrolite), in a Sotira-Kaminoudhia tomb (Webb and Frankel 1999, among others) and at Mylos on the Kyrenia Pass (Dikaios and Steward 1962: 264).

Such objects, according to Frankel and Webb (2004), had not merely an ornamental value but had also an important role in the assertion and maintenance of cultural identity in the transition from the Chalcolithic to the first phase of Cypriot Bronze Age.

10. TRITON SHELLS

Seven *Charonia tritonis*, the triton shell, remains have been found in Pyrgos: two apical parts of two specimens and five little fragments.

Triton shells are attested in Bronze Age Cyprus at Kition (three fragments from some deposits in a sacred area), Hala Sultan Tekké (at least three specimens) and Sotira-Kaminoudhia (six fragments) but their use to make trumpets, vases or spoons is attested on the island from the Neolithic (Reese 1985, 2003).

The large triton shells were used in the Aegean and Cypriot Bronze Age to make libation vases (*rhyton*) by removing the columella. These vases had an important role in Minoan ritual activities (for a concise review of this topic see: Åström & Reese 1990). In the two upper portions of triton shell found in Pyrgos, however, the columella had not been removed so it is possible to affirm they were not used as *rhyta*.

The use of triton shell as a trumpet is more well-known. This kind of instrument was made removing the apex in order to blow air into the spire. Such trumpets produced a loud, deep sound and had been made in Mediterranean countries from prehistory until a few years ago. One of the Hala Sultan Tekké *Charonia* shells has "broken tip… and may have been used as a trumpet" (Reese 1985: 354).

Both the apexes of the Pyrgos triton shells were not removed, thus they were not used as trumpets, but one of them was worked in an unusual way: two holes and the trace of a third one on the first whorls of the spire seem to be arranged in a specific way. Such holes may just have been used to hang the large shell as an ornament. The arrangement of the holes, however, recall some Amerindian ethnical wind instruments, which were made of shells perforated in several places in order to produce a modulated sound, such as in an ocarina. Ethnographical studies and tests of experimental archaeology are being carried out to confirm or to refute such a hypothesis.

11. EXOTIC SHELLS

Triton was not the only large shell used in Pyrgos-Mavroraki. A 17 centimetre tall *Strombus* shell is perhaps the most peculiar archaeomalacological find at the site (Fig. 6).

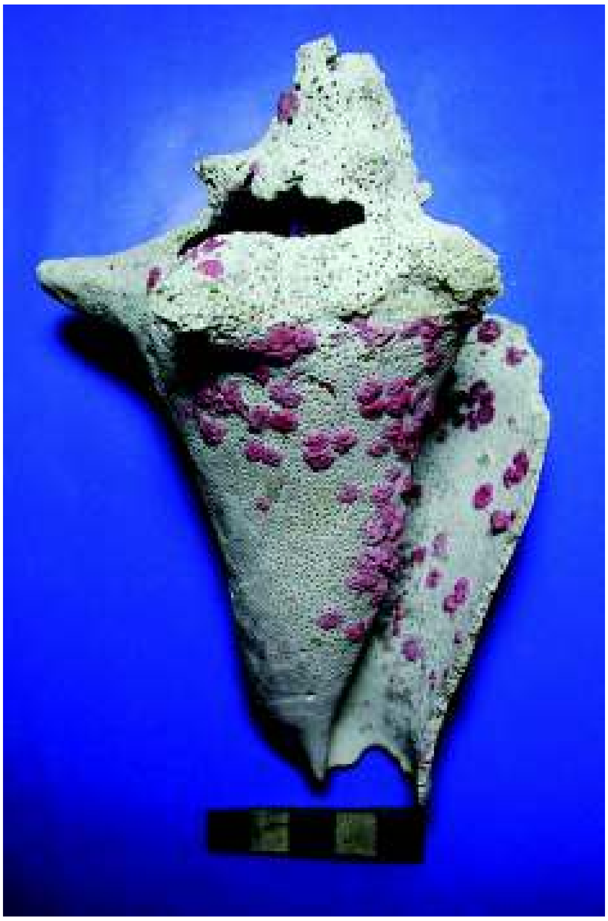

Figure 6. *Strombus tricornis* shell from Pyrgos-Mavroraki.

Nowadays this genus is extinct in the Mediterranean sea. The Pyrgos shell is a specimen of the Indo-Pacific species *Strombus tricornis* and not of the fossil Mediterranean *Strombus bubonius*.

The Pyrgos *Strombus* shell is intensely bio-eroded, riddled by sponges and covered by reddish encrustations of foraminifera *Miniacina miniacea*. Fouling foraminifera, bryozoans, worms and ostreids are present on the internal surfaces. Such data show that the shell was collected a long time after the death of the mollusc on an Indo-Pacific coast (probably on the Red Sea or Persian Gulf coasts).

The *Malea pomum* specimen used as a bead in the Pyrgos necklace is a second attestation of an exotic shell in the site.

We owe the first synthesis on exotic shells discovered in prehistoric Mediterranean sites to D.S. Reese (1991). The scholar demonstrated how the "trade" of exotic shells progressively developed beginning from regions nearest to the Red Sea and the Persian Gulf to expand as far as Turkey (Reese 1991). Indo-Pacific shells are widespread in Neolithic, Chalcolithic and Bronze Age sites from the eastern Mediterranean coasts to Mesopotamia and to southern Anatolia.

Strombus shells have been found in some Syrian and Turkish Bronze Age sites. They are attested in the Dagan temple at Mari (five specimens from votive deposits), at Tell Chuera (six *Strombus decorus*) and in the Early Bronze Age strata at Kurban Höyük (one worn *Strombus* shell) (Reese 1990, 1991). Many other exotic species are however attested in several Turkish sites far from the Indo-pacific coasts such as Alishar Höyük e Karkemish (Reese 1986, 1991).

The earliest attestation of Indo-Pacific shells in Turkey dates back to the Early Neolithic. In the Bronze Age, exotic shells were used in several sites on Greek islands and mainland, in Turkey and even in southern Russia (Reese 1991). In contrast, the earliest Indo-Pacific shells in Cyprus are reported in the Cypriot Archaic period (c.a. 850 B.C.) (Reese 1991: 167-168). Reese remarks that such a paradoxical absence of exotic shells in the Cypriot prehistory contrasts with the intensive contemporary exchanges attested between the island and the Near East. Ostrich egg-shell fragments, ivory and even Nilotic fish remains are, in fact, reported in Bronze Age Cypriot sites (Reese 1991: 188).

The Pyrgos-Mavroraki datum finally modifies this anomalous situation.

12. CONCLUSIONS

Archaeomalacological data from Pyrgos-Mavroraki confirm that the areas excavated to date had no housing function but only an industrial one as no food consumption of molluscs is attested.

Most of the shells seem to be ascribable to an ornamental use and/or to an apotropaic value.

Some of the ornaments were manufactured on the site as demonstrated by the "Cassid lip" data.

One of the data which emerged from archaeomalacological analyses is the cultural continuity with the most ancient Cypriot phases that characterize Bronze Age Pyrgos.

"Cassid lip pendants" manufacturing and use at Pyrgos testify to the continuation of a Neolithic and Chalcolithic eastern Mediterranean tradition that in other Cypriot contemporary sites is less attested.

The unperforated "Cassid lips pendants" of Pyrgos match well with the Cypriot tradition already remarked by Reese (1989) whereas the Near Eastern ones are generally bored.

"Philia pendants" of Pyrgos testify to a strong sense of belonging of the local community to the Cypriot cultural *koiné* of the first phase of the Early Bronze Age, according to Frankel and Webb's idea (see: Frankel and Webb 2004). However, whereas on the one hand these archaeomalacological data suggest that the cultural world of Pyrgos had deep roots in the ancient Cypriot tradition and was part of a strongly characterized Cypriot culture, on the other hand there is evidence of the opening to contacts and to influences of the cultural world external to Cyprus. Indo-Pacific shells found in Pyrgos-Mavroraki are a unique case in the Cypriot Bronze Age. They confirm exchanges with the Near East or Egypt which to date have only been attested by other kinds of remains, like ivory and ostrich egg-shell fragments. Moreover the imperforated inedible shells from Pyrgos, very rare in other Cypriot Bronze Age sites, but widespread in the Aegean ones, may suggest mere affinities or alternatively cultural connections with contemporary western cultures.

Another datum is supplied by the distributional analysis of archaeomalacological remains at Pyrgos.

Six of the nine cowries discovered in the industrial complex of Pyrgos were found in the weaving room (see Fig. 2) and two in the perfume factory. In addition, the *Gibberula* necklace was found in the perfume area as the *Conus* fragments. Four more holed *Gibberula* shells were found in the weaving room while another one was lying near the loom weight stove. Both the "Philia" pendants, four of the six "Cassid lip" pendants and nine of the thirteen murex shells were also found in the weaving room. These data suggest that whoever wore shell ornaments or brought unperforated shells as the cowries mainly frequented the rooms devoted to the textile and perfume industries rather than areas devoted to metallurgical activities.

An attempt to interpret these distributional data could be made considering the role of cowries in the ancient and modern Mediterranean cultures.

Cowries were used in the prehistory for different purposes: as ornament, amulet, in funerary rituals and also as money (see: Bar-Yosef Mayer 2000, Becker 1996, among others). Nevertheless their shells had been used in Mediterranean countries as simple ornaments or lucky charms from prehistory until a few decades ago, mainly by women (*e.g.* Gobert 1951, Reese 1991: 189).

Cowries have always stimulated human imagination; in fact the aperture of their shell surrounded by the lips recalls the human vulva. Because of such genital symbolism, many cultures associate these shells with apotropaic powers for the protection of female fertility or against the evil eye (e.g. a *Luria lurida* pendant was presented by the grandmother to her granddaughter when she had her menarche in some southern Italy regions until the beginning of the last century). This can explain why cowries are often found in young girls' graves as reported by Reese (1991: 189). Both archaeological and ethnographical data suggest that cowries have been generally associated with the female gender since prehistory in Mediterranean cultures. Thus the concentration of the cowries, of the shell necklace and of the other ornamental shells in the weaving room and in the perfume factory of Pyrgos-Mavroraki may reflect a division of production activities between women and men in an industrial complex where both sexes were actively involved.

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More than food: beads and shell tools from late prehistory in the Spanish Southeast

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More than food: beads and shell tools from late prehistory in the Spanish Southeast

Más que comida: cuentas y útiles en concha de la Prehistoria reciente en el SE de España

KEY WORDS: Neolithic, Chalcolithic, Southeast Iberia, Ornaments, Shell-tools.
PALABRAS CLAVE: Neolítico, Calcolítico, Sureste de la Península Ibérica, Adornos, Útiles.
GAKO-HITZAK: Neolitoa, Kalkolitoa, Iberiar penintsularen hego-ekialdea, Apaingarriak, Lanabesak.

Ruth MAICAS[1] & Aixa VIDAL[2]

ABSTRACT

Current reviews of the bromatologic role of malacological remains favour their attribution to ornamental uses in prehistoric societies. Beads and other ornaments are frequent in archaeological assemblages in Mediterranean Late Prehistory, although they are not the only form of shell manufacturing in these sites. This paper discusses objects from Luis Siret's collection in the Museo Arqueológico Nacional (Madrid, Spain). Among other topics, we emphasize his pioneer role in Spanish archaeology, particularly as regards malacological studies, and the first analyses and experimental works carried out in Spain at the end of the 19th century. Here we revise more than 2,600 objects manufactured from malacological materials collected from Neolithic and Chalcolitic sites in the Vera Basin (Almeria, Spain). Personal ornaments, such as beads and pendants, comprise the main group, together with a small assemblage of tools. The existence of shell materials in inland sites far from the sea is also worth mentioning. Shell objects are evident in 30 out of the 35 burials documented in the Upper Almanzora, being frequently the main component of grave-goods. We study the shell industry in order to explain the functionality of these assemblages in Neolithic and Chalcolithic societies, as well as some evidence of the social value of shell tools, such as small vessels.

RESUMEN

La revisión del valor bromatológico de los restos malacológicos incrementa el papel atribuido a los objetos ornamentales en sociedades prehistóricas. Cuentas y otros objetos de adorno son frecuentes en los conjuntos arqueológicos de la Prehistoria reciente del Mediterráneo, aunque no constituyen en nuestros yacimientos la única producción de objetos de concha. Hablaremos de los objetos procedentes de la Colección Siret del Museo Arqueológico Nacional (Madrid, España), recordando el papel desempeñado por Luis Siret como pionero en la Arqueología española, en este caso, sus estudios malacológicos, con los primeros análisis y trabajos experimentales realizados en España a fines del s. XIX. Expondremos una síntesis de los materiales relativos a los conjuntos del Neolítico y Calcolítico de la Cuenca de Vera (Almería, España), para la que se analizaron más de 2,600 objetos realizados sobre concha. Adornos personales -cuentas y colgantes- componen el grupo más numeroso, pero también aparece un pequeño conjunto de herramientas. Objetos de concha se han documentado en 30 de las 35 sepulturas del Alto Almanzora, en muchos casos como el principal componente de los ajuares. El estudio de la industria sobre concha intenta explicar la funcionalidad de estos conjuntos en sociedades neolíticas y calcolíticas. Asimismo, los útiles sobre concha, como los pequeños recipientes, nos acercan a su valor social

LABURPENA

Hondakin malakologikoen balio bromatologikoak historiaurreko gizarteetako apaingarrien eginkizuna handitzen du. Aleak eta apaintzeko beste objektu batzuk ugariak dira Mediterraneoko Historiaurrearen amaierako multzo arkeologikoetan, baina ez dira maskorrez egindako ekoizpen bakarrak gure aztarnategietan. Museo Arqueológico Nacionaleko (Madril, Espainia) Siret bildumako objektuei buruz hitz egingo dugu, eta Luis Siretek Espainiako Arkeologiaren aitzindari gisa izan zuen zeregina gogoratuko dugu; horretarako, bere ikerketa malakologikoak, Espainian XIX. mendearen amaieran egindako lehen analisi eta lan esperimentalak ekarriko ditugu gogora. Cuenca de Verako (Almeria, Espainia) Neolitoko eta Kalkolitoko multzoetan, maskorrez egindako 2.600 objektu baino gehiago aztertu ziren, eta material horien sintesi bat aurkeztuko dugu. Apaingarri pertsonalek –aleak eta zintzilikariak– osatzen dute multzorik ugariena, baina tresnen multzo txiki bat ere badago. Alto Almanzorako 35 hilobitatik 30etan dokumentatu dira maskorrez egindako objektuak, sarritan hornidurаren osagai nagusi gisa. Maskorren gaineko industriaren ikerketaren helburua Neolitoko eta Kalkolitoko gizarte horietan multzoek zuten funtzionaltasuna azaltzea da. Gainera, maskorrez egindako lanabesek haien gizarte-baliora hurbiltzen gaituzte; esate baterako, ontzi txikiek.

1. INTRODUCTION

The meaning of "ornament" is more than an aesthetic issue. Ornamental objects are symbols that reveal age, sex and "status" differences, either within a specific human group or between different groups. A hygienic, religious or even exchange value may also be embedded in them. Altogether, they are more complex than the word "ornament" could suggest. Among the assemblages preser-

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ved, shell materials represent one of the main resources for ornaments. Beads and pendants are extremely common in archaeological assemblages in Mediterranean Late Prehistory, but they are not the exclusive products of shell raw material found in our sites. Unfortunately, it is very difficult to identify shell tools, as they usually show only subtle intentional modifications. Moreover, the large number of items found in littoral sites explains a non-conservative behaviour as regards shells (for a detailed version of some of the aspects discussed here, see Daniella Bar Yosef's compilation [2005]).

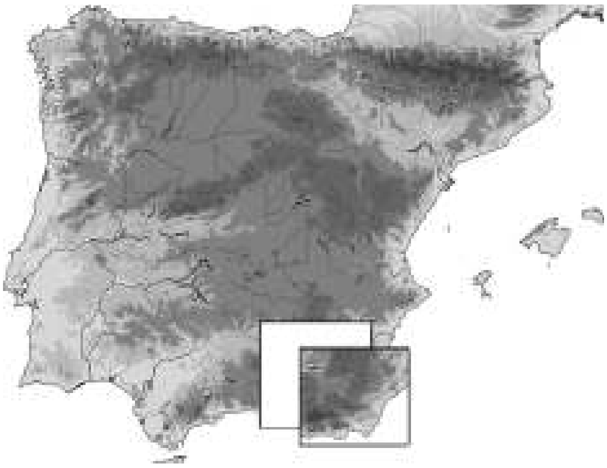

Figure 1. The Spanish Southeast

Our study considers the Siret collection from the Museo Arqueológico Nacional (Madrid, Spain). As discussed elsewhere (Maicas 2007), Louis Siret was a Belgian engineer who developed the first systematisations of Southeast Spanish prehistory at the end of the 19th - beginning of the 20th century. His deep understanding, artistic ability and scientific curiosity provided one of the best collections available in order to study the Neolithic, Chalcolithic, and Bronze Age in the Mediterranean area. He is also credited with both the pioneer field research in the Southeast and the first material analyses and experimentations aiming at –among others– identifying the nature and function of the recovered objects. We inherited, for instance, his analyses to differentiate the raw material of the tiny discoidal beads and some experiments on functionality, as well as his notes about the optimal lithic tools to open bivalves (Fig. 2).

The large number of archaeological materials collected by Siret includes not only pristine archaeological materials but also experimentation of techniques and uses on ancient tools, together with replications of artefact forms and manufacture using several raw materials (lithic, malacological, bone). Although Siret's role in experimental archaeology is not well known, he left many reproductions and some notes explaining his interest in understanding manufacture techniques and use. In some cases, he supplemented these studies with chemical analyses to characterize small artefacts (Maicas 2007: 20-24).

Siret's outstanding work produced a large body of information concerning shell objects; the volume of his collection, therefore, allows new research on this topic –and will probably continue to do so.

2. THE BIVALVES

The different taxa of Glycymeris fill the first place in our shell assemblages. Together with *Cerastoderma glaucum* and *Acanthocardia tuberculata*, they integrate the main group of bivalves in these post-Palaeolithic sites. These shells might have been used as pendants in a number of cases because of the simplicity of their manufacture and the high frequency of finding naturally perforated shells. However, not all valves were used as personal ornaments.

Different kinds of organic and inorganic remains (lipids and pigments) can be identified in the internal surface of many valves; moreover, some of them present morphological changes unsuitable for ornament-related uses. Considering the nature of these internal remains, the valve size and their contextual situation, we propose that these shells may have served as small vessels for mixing pigments, for instance. The presence of holes in or near the umbo does not contradict this function. Siret suggested that these holes were appropriate to introduce some kind of wooden stick to function as handles, as in the case of the shell spoons found in the Caribbean and Philippines (*e.g.* Perdikaris *et al.* 2008, Vitales 2008). The perforation may also have functioned like a small funnel or filter, making the shell a sort of lamp (*cf.* Siret and Siret's [1890] suggestion for Argaric clay spoons) or a primitive minute colander or strainer. In different contexts, we can identify shells used as vessels to store makeup, mainly at funerary sites, like the well-known case of the 4th millennium predynastic Egypt, where burial goods include makeup, pallets and small vessels (Baduel 2005).

In other examples, the remains preserved inside the valves were identified as bitumen (Siret and Siret 1890: 146). This substance may have functioned as a sort of glue or mastic to haft lithic

Figure 2. Shells and flint tools used by Louis Siret in his experimental work.

tools, or even to mend highly valuable clay vessels (Connan *et al.* 2006). Once again, the presence of the substance inside the valves may explain their use as middle- or short-time small containers.

A related use is the possibility of manufacturing shell spoons. The presence of spoons in different raw materials is widespread around the Mediterranean basin and almost anecdotic, but not absent, in Northern Europe. Their numbers are usually low, dominating in the Middle East, Greece and Spain (with about two hundred specimens each), followed by Italy and the French coast (Vidal and Mallía 2008). Interestingly enough, they are almost exclusive of Neolithic times -only followed by Chalcolithic specimens in number-, a period coinciding with a substantial change in dietary staples (Sherratt 1997) and, probably, social eating habits (Whittle 2003), though there are no definite conclusions as regards their specific use. Siret and Siret (1890), for instance, suggested these artefacts might have been used as oil lamps in Argaric times.

The scarcity of spoons elsewhere may be due to different reasons: natural, systemic or archaeological. The important variations in wood availability noted at this time (Maicas 2007: 199), with a considerable reduction of workable and strong woods, probably forced the Chalcolithic inhabitants of the area to resort to alternative materials, such as bone and shells. Spoons, however, may be rarely found for different anthropic reasons. Their almost exclusive occurrence in domestic contexts may have biased recovery, as well as the ambiguity in their description. In spite of the couple of dozen clay spoons found in Southern Greece and Andalusia, spoons everywhere could have been made mainly from organic materials, such as bone, wood and shell, especially in Neolithic times, when pottery manufacture was still a highly expensive technology, restricted, according to some authors, to non-culinary tasks (*e.g.* Gimbutas *et al*. 1989). Within this framework, shells could have provided an almost natural and versatile container.

In spite of Siret's early suggestions, the possibility of using shells for spoons (Fig. 3) has only recently been considered in Spanish collections (Pascual 1998, Maicas 1999, Ruiz 1999, Luján 2004). It provides, however, an interesting avenue for research, particularly considering the large number of molluscs found in littoral sites, as well as in some inland locations. On the one hand, the little difficulty in obtaining the raw material made them perfect candidates to fulfil this function. On the other, the expeditive technology needed to transform them into vessels or spoons, together with the possibility of taking direct advantage of fragments eroded by the sea, are clear manufacturing advantages comparing to more time-demanding technologies such as pottery or wood-work.

Besides vessels and pendants, *Glycymerys, Cerastoderma* and *Acanthocardia* valves served as potter's tools, exemplified by the decoration of the famous cardial pottery, but also by scrapers or burnishers in many cases. In the latter situation this function is suggested by the lack of perforation and abrasion traces (Fig. 4) and the shell overall size, which made them inadequate for ornaments such as bracelets or even rings.

Ornaments, however, are undoubtedly the most important category for manufactured shells. For instance, valve fragments of *Glycymeris* with rounded forms, plate sections and a frequently eccentric hole are frequent from Neolithic to Bronze Age contexts. In this way, non-perforated objects could represent raw material for the elaboration of ornaments, but their presence in burial contexts makes it rather improbable. Another popular version of shell modification is the imitation of deer canines. This alteration is interesting, especially because no real deer canines were recovered in Southeastern Spain for Neolithic-Chalcolithic times, but their imitations in shell appear in large

Figure 3. *Glycymeris* small vessel or spoon. Zájara, Cuevas de Almanzora, Almería (Chalcolithic).

Figure 4. Glycymeris *abraded* in dorsal view. Garcel, Antas, Almería (Late Neolithic).

numbers in some specific contexts (Maicas 2007). Nevertheless, the interpretation of both *Glycymeris* fragments and imitation of deer canines is unclear, as well as the presence of non-perforated shells in funerary contexts.

Still in the "ornament" category, there is another important group in the assemblage known as "Pectunculus bracelets", manufactured from *Glycymeris bimaculata* from sea deposits and sometimes showing their complete surfaces attacked by lithofagus. These bracelets are documented from the Early Neolithic to the Bronze Age, mainly in a littoral distribution, but with a very important inland presence. The importance attributed to these objects probably explains their reuse after breakage, adapted by drilling holes to join the different fragments and preparing a new articulated bracelet (Fig. 5), in a similar fashion to restoration holes in pottery.

Figure 5. Fragment of articulated bracelet showing holes. Buena Arena, Purchena, Almería (Late Neolithic).

3. GASTROPODS AND SCAPHOPODA

Some gastropods could be made into ornaments with a simple perforation, either natural or intentional. In our sites, the most frequent specimens are *Conus mediterraneus* followed by *Columbella rustica*. Conus, especially when naturally perforated in the apex, were frequently retrieved; in the second group, however, a similar hole would not be useful for any kind of suspension string. In the case of Columbella, it is necessary to enlarge the hole or perforate the *spira* with a second aperture (Maicas 2007: 174).

Other frequent raw materials are *Luria lurida* and *Trivia europaea mediterranea*. In the specimens of the genus *Marginella*, single and double holes are observed, but this is an extremely infrequent taxon in the sites prospected by Siret due to the difficult retrieval of the small size specimens of this shell with 19th century excavation techniques.

The extremely fragmented examples of *Thais haemastoma* and the larger ones of *Cassis undulata* are infrequent, but their inland presence is noteworthy.

Rather than an ornament, the shell of big gastropods like *Charonia nodifera* could have made other kinds of objects such as musical instruments, small vessels (Fig. 6), or a series of different tools. There are a few examples in Los Millares,

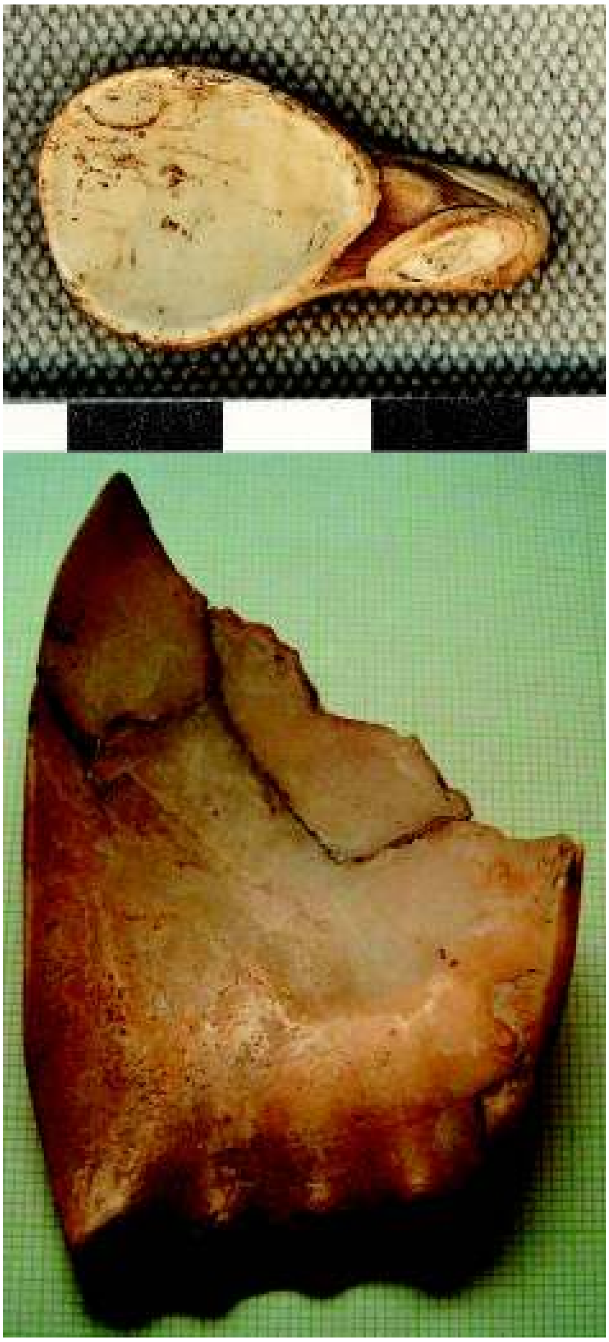

Figure 6. Shell spoons Almizaraque, Cuevas de Almanzora, Almería (Chalcolithic).

Almizaraque and Rambla de Huéchar, where Siret himself identified the abrasion of part of the spira to make some kind of horns or trumpets. Moreover, he also found some fragments cut out from the big gastropod showing an important abrasion in their external surface and tiny unidentified particles on both surfaces. These cuts take advantage of the natural curve of the mollusc shell, a technique that provides both a small concavity and a flat area that facilitates the addition of a handle to the object, making it a sort of vessel or spoon. At the same time, this handle area shows the undulated natural form of the gastropod, which could be also useful as an imprecise scraper. Moreover, some shell fragments that present a small surface worked in a rounded form perpendicular to the object axis may also have functioned as burnishers in pottery decoration.

Finally, due to their natural morphology, Scaphopoda specimens found in these prehistoric sites may only be postulated as mollusc beads.

4. BEADS AND PENDANT WITH GEOMETRIC PARAMETERS

The breaking and abrasion by sea phenomena can form natural "beads", such as the small cupules from *Conus*. Most frequently, though, the beads have experienced important transformations, making it very difficult to recognize their original forms. The modifications sometimes show simple geometric patterns; thus, they could be classified according to their appearances. In Southeast Iberia, the most frequent shape of shell materials is the discoidal bead, first analysed by Siret (Maicas 2007: 24).

5. SUMMARY

Abrasion is the most frequent manufacturing technique found in these assemblages. We observe percussion and grooving too, as well as combinations of different techniques in the same objects. For the preparation of holes, the use of both flint and metal drills can be identified, according to the period. Marks of flint drills are easily recognized by their conical shape and clear parallel striation. Metal drills, on the other hand, produce rather cylindrical profiles and plain walls (Barciela 2004: 562).

So far, the aesthetic value of these molluscs is impossible to assess in prehistoric societies, but colour was most probably important in this aspect (for a different discussion of the role of colour in the selection of raw materials, see Roberts 2008). It is likely that the presence of a crackled transparent substance over the surfaces -probably resin- observed both on *Glycymeris* sp. and *Conus mediterraneus* shells was related to the interest in intensifying the original colour of the shell.

The time spent in manufacturing either an ornament or any other non-utilitarian object is important from a modern perspective, but it may not be the same parameter for prehistoric societies, making it difficult to evaluate their significance in their original systemic contexts. Social identity as a symbol, quality of handicraft, size, colour and resource availability are some of the aspects that may determine whether an object is accessible or not. In this situation, molluscs directly recovered and used without any intentional modification may have been available for all the members of a community; taxonomic selection, on the other hand, may indicate a previously assigned value, which determines the sense of gathering them. The presence of sea molluscs frequent in inland sites some 60km from the sea (30 out of 35 graves from Alto Almanzora) suggests some kind of exchange relationship. The differences in shell material percentages between Neolithic and Chalcolithic assemblages further show at least a change in the social value of these items.

The concentration of *Conus* and *Columbella* shells in Almizaraque suggests the existence of a workshop, possibly with a production similar to those in Egypt or the Near East. Since Siret's first finding of these workshops in Los Toyos (Siret and Siret 1890) the reports of different manufacture *loci* have increased, suggesting basically domestic and scarcely specialized production (Pascual 2005: 284).

Among Southeastern Iberian organic artefacts, shell was the most abundant material during the Neolithic, although it continued to be significant during the next period, especially in Millares' graves. As the recovery of shell in coastal sites is quite frequent and non-specific, it may have been an easily accessible raw material for ornaments and small utilitarian objects. Then, why is the percentage of shell objects higher at Neolithic than at Chalcolithic sites? Is it just a mirror of the increasing social differentiation in Chalcolithic societies? The existence of new and exotic materials had probably devaluated the ornamental role of the humble local shell; however, it seems to have retained its importance for utilitarian uses.

Many authors have considered the social value of adornments; the collections we discussed, however, present the serious drawback of lacking a detailed context of finding. Furthermore, the broad chronological frame considered would lead to different interpretations for the many cases. Basically the social value of these objects is testified by their continual use during a long time period, the imitation of some types (such as the deer canines), and their medium- and long-distance trade. Its use, however, should not have been restricted to a ritual sphere as they were probably present in daily life as well as in special occasions and burials.

Some other shell artefacts, like spoons and vessels, are more easily identified with daily maintenance activities. Nevertheless, their activities probably exceeded the mere feeding and storage functions, further considering social or ritual representational functions, like the body use of colorants identified in human remains, probably represented here in the small vessels with the remains of these materials. These aspects of shell technology provide "food for thought" and postulate new questions that will demand further work in the future.

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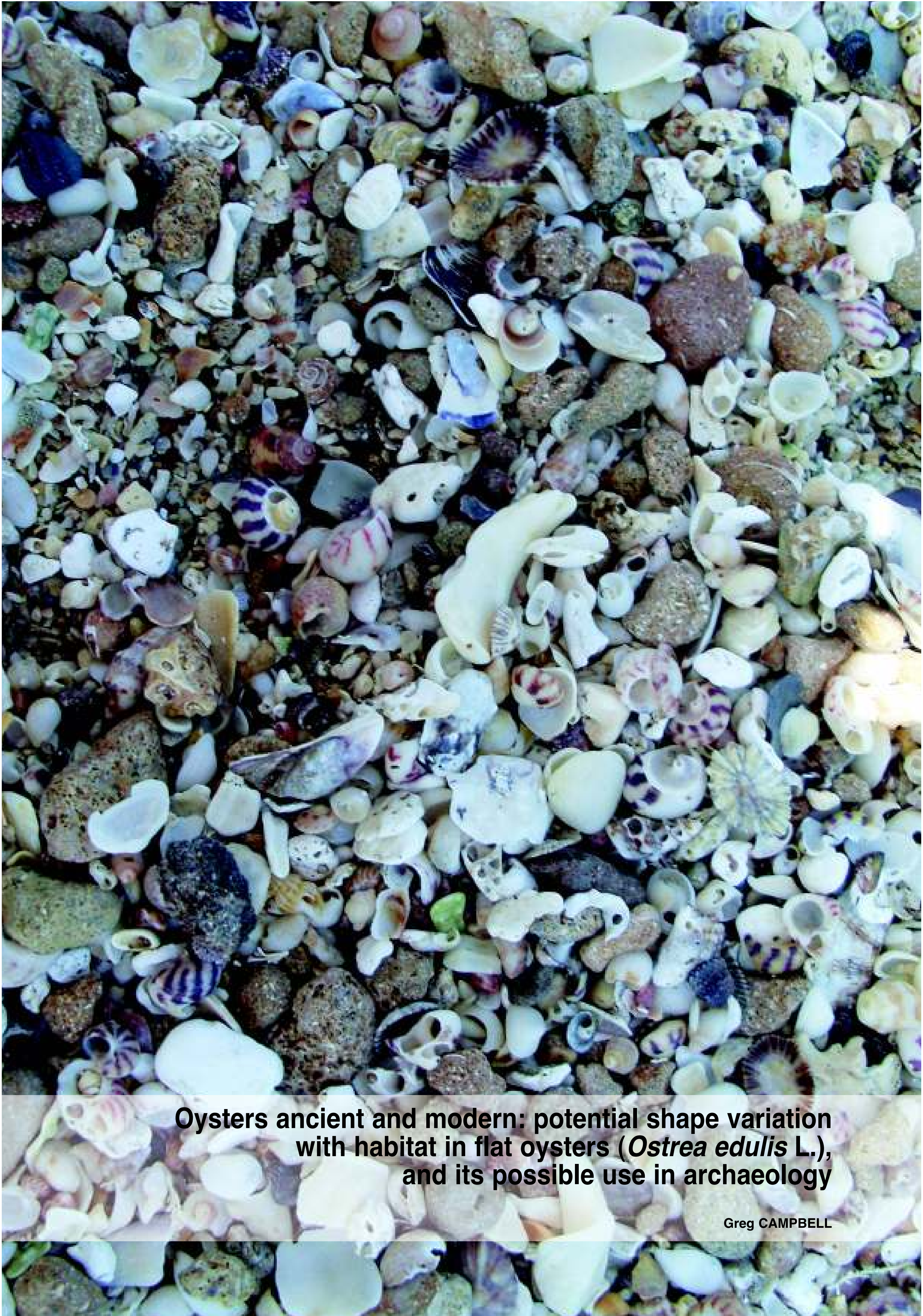

Oysters ancient and modern: potential shape variation with habitat in flat oysters (*Ostrea edulis* L.), and its possible use in archaeology

Greg CAMPBELL

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Oysters ancient and modern: potential shape variation with habitat in flat oysters (*Ostrea edulis* L.), and its possible use in archaeology

Ostras antiguas y modernas: variación potencial de la forma y el hábitat de la ostra plana (*Ostrea edulis* L.) y su posible uso en Arqueología

KEY WORDS: Archaeology, *Ostrea edulis*, morphology, methodology, management.
PALABRAS CLAVE: Arqueología, *Ostrea edulis*, morfología, metodología, manipulación
GAKO-HITZAK: Arkeologia, *Ostrea edulis*, morfologia, metodologia, manipulazioa.

Greg CAMPBELL[(1)]

ABSTRACT

Recognition of two distinct shapes in shells of flat oyster (*Ostrea edulis L.*) from late 3rd-4th Century A.D. Winchester, central southern England, prompted comparison with shapes of modern *O. edulis* samples across the Solent, and development of methods which define shell shape objectively for this species, despite its notorious variability. Relative proportions in the plane of commissure were a more consistent means of comparing shape than proportions based on maximum shell dimensions. Shell shape varied between harbours, near-shore and deeper water, probably in response to differing bed currents. Archaeological shells changed abruptly during growth from a range of shapes to a single shape, arguing for oyster management in late Roman England.

RESUMEN

A finales del siglo III y en el siglo IV d. C. se reconocen en Winchester, Centro-Sur de Inglaterra, dos formas distintas de la ostra plana *Ostrea edulis* L. gracias a la comparación con las formas de ejemplares modernos procedentes del Estrecho de Solent. De esta forma se han desarrollado métodos que definen la forma de la concha de esta especie de una manera objetiva, a pesar de su notoria variabilidad. Para ello, se optó por tener en cuenta las proporciones relativas de la zona de la charnela, más que las dimensiones máximas de las valvas. El tamaño de las valvas varía entre los puertos, en las áreas cercanas a la costa y en las zonas profundas, posiblemente como respuesta a las corrientes del fondo del mar. Las valvas de las ostras del sitio arqueológico cambiaron de forma abrupta durante su crecimiento, de formas variadas a simples, lo que puede interpretarse como un indicio de manipulación durante el periodo tardorromano en Inglaterra.

LABURPENA

K.o. III. mendearen amaieran eta IV.aren hasieran, Winchesterren, Ingalaterrako erdialde-hegoaldean, *Ostrea edulis* ostra lauaren bi forma desberdin bereizi ziren, Solent itsasartetik hartutako ale modernoekin alderatuz. Espezie horretako maskorraren forma objektiboki zehazteko medotoak garatu dira, espezie horren aldakortasuna nabaria den arren. Horretarako, txangaren guneko proportzio erlatiboak kontuan hartu ziren, kuskuen neurri maximoak kontuan hartu beharrean. Kuskuen tamaina aldatu egiten da portu batetik bestera, kostatik hurbil eta gune sakonetan; seguruenik, itsas hondoko korronteak direla eta. Leku arkeologikoko ostren kuskuak asko aldatu ziren hazten ari ziren artean, askotariko formetatik forma sinpleetara, eta hori Ingalaterrako erromatar berantiarreko manipulazio-zantzu bat bezala interpreta daiteke.

1. INTRODUCTION

Oysters, marine bivalves of the Order Ostreoida, are rough-shelled inequivalve monomyarian epi-faunal filter-feeders which live cemented by the larger left valve to reasonably stable surfaces where current speeds are not extreme. Oysters are large, delectable, accessible, and often densely packed, sometimes forming reefs, so they are consumed by humans around the world, and have been for thousands of years (See: Waselkov 1987). The main oyster of the European Atlantic, the Baltic, the Mediterranean and the Black Sea is the common, edible or flat oyster *Ostrea edulis* Linnaeus, 1758 (Tebble 1966: 53). The right valve is flat, and the left valve is cupped (Tebble 1966: 53). In oysters, the hinge is not typical of bivalves (Yonge 1960: 27), having a central chondrophore flanked by flattened surfaces called bourrelets (Stenzel 1971: 974). The visceral mass is held in a bowl-like cavity in the left valve ventral to the hinge, surrounded by the more gently sloping mantle cavity; the ventral extent of the visceral cavity is marked by the ventral edge of the single adductor muscle scar (Yonge 1960: Fig. 9). This oyster has been grown artificially since at least Classical times (Pliny the Elder: *Historia Naturalis* IX, 59). In later prehistoric and historic periods in England, oysters were transported regularly to sites inland (*e.g.* Winder 1988).

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The author assessed the marine shell from Staple Gardens (51º3.9'N, 1°19.0'W: Site Code AY93) in Winchester, central southern England. The history and archaeology of this city are summarised by James (1997). Founded by the Romans shortly after their invasion of Britain in A.D. 43, Winchester remained a major town until the decline of Roman Britain in the later Fourth Century. Winchester was the capital of an early English kingdom, the first capital of a united England (from A.D. 927 until the Norman Conquest of A. D. 1066), and has remained a major English town.

Oysters of the Roman period (A.D. 43 – *circa* A.D. 410) from this site appeared to come in two distinct shapes (Fig. 1). Occasionally the shell was the 'classic' shape, rounded with the hinge small and triangular (Fig. 1a). However, most were oval (shell height was manifestly greater than shell length) with large straight-sided hinges, resembling those in the oyster genus *Crassostrea* (Fig. 1b). Most of these oval shells had changed shape abruptly, usually in their third or fourth year. This growth step could be slight (Fig. 2a), but in some cases the shell changed from rounded to oval (Fig. 2b). Such a 'step' was also marked by a change in the colour and spacing of growth-bands in the hinge (Fig. 2c); in some cases the hinge changed from a curved and triangular shape typical of *O. edulis* to a broad and straight *Crassostrea*-like hinge (Fig. 2d). A possible explanation of these growth steps was a sudden change in habitat during the life of the oyster.

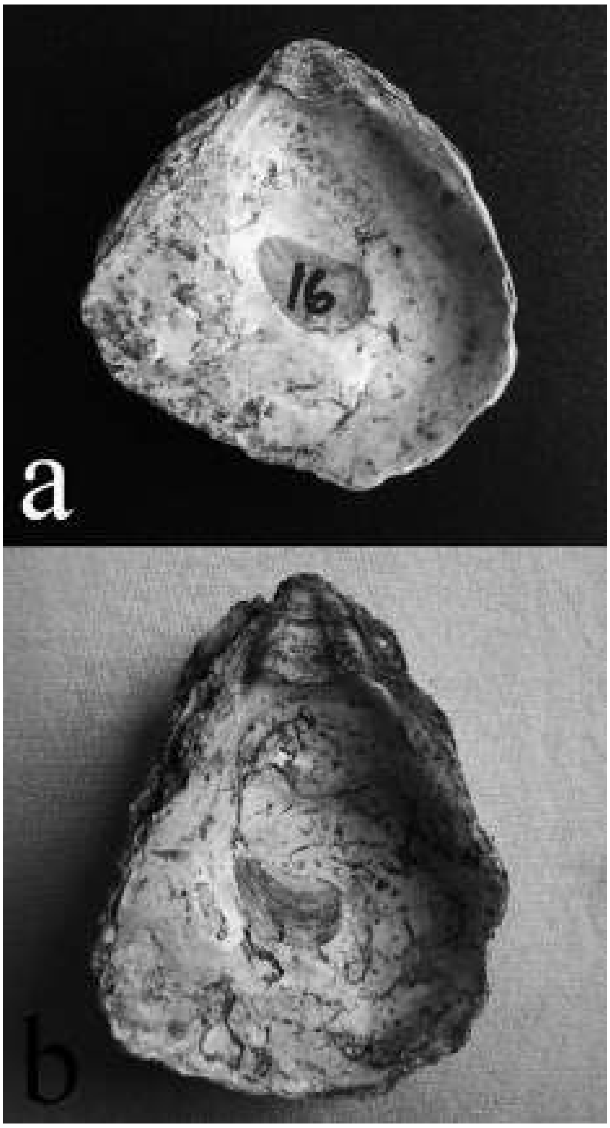

Figure 1. Left (lower) valves typical of late Roman oyster (*O. edulis*) shapes from Staple Gardens, Winchester. (a): round morphotype. Hmax 81 mm; (b): oval morphotype. Hmax 88 mm.

The chief aim of this study was to determine whether *O. edulis* shape is likely to vary significantly with habitat. If the relationship between habitat and typical shape is understood, the relationship can be used to reconstruct habitat from typical shape, a process familiar to palaeontologists (*e.g.* Seilacher *et al.* 1985). Each species of oyster exhibits a wide range of variation to suit local conditions: this ecophenotypic variation is so great that shell shapes and forms are not reliable for distinguishing species, a situation lamented by almost every oyster taxonomist (*e.g.*: Gunter 1950: 438; Yonge 1960: 78; Franc 1960: 2086; Galtsoff 1964: 18; Stenzel 1971: 1016; Harry 1985: 122). Therefore there have been few biological studies of shell shape variation with habitat in *O. edulis.* However, ecophenotypic variation in the eastern oyster *Crassostrea virginica* (Gmelin, 1791) has been well-studied (*e.g.* Gunter 1938; Gunter 1950; Galtsoff 1964), and is applied regularly to archaeological shells to reconstruct habitat (*e.g.* Kent 1992). In contrast, the only readily available studies of *O. edulis* variation seem to be those of the archaeo-malacologist Winder (*e.g.* Winder 1992: 197), who found off-shore oysters were taller than oysters from the adjacent large sheltered bay.

It was not certain that the perceived shape differences in the Roman Winchester oysters were genuine, since methods of determining shape variation in *O. edulis* are not widely developed in biology. Variety is so great that defining consistent dimensions to measure can be controversial (Stenzel 1971: 955-958). Another aim of this study was to determine whether it is likely that there is a simple way to measure *O. edulis* shells to make shell shape objectively comparable between samples, both biological and archaeological.

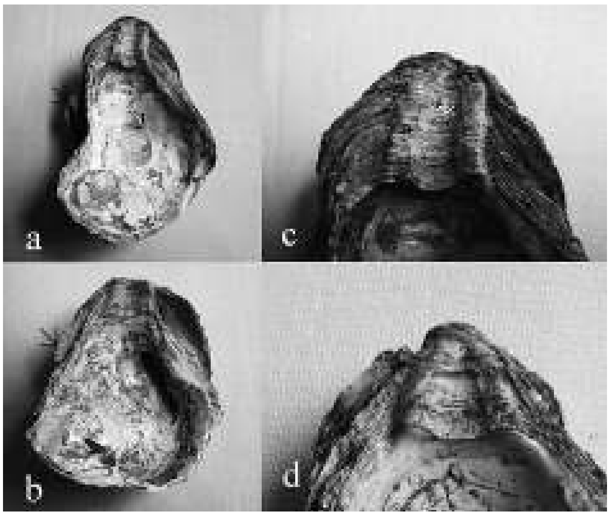

Figure 2. Growth steps in oval late Roman oysters from Staple Gardens, Winchester. (a): slight growth step (posterior of original shell arrowed) (Hmax: 110mm); (b): step change from round to oval morphotype (Hmax: 96mm); (c): typical oval morphotype hinge, showing growth step (white arrow) (Hinge width Wh: 23mm); (d): hinge showing growth-step from typical *O. edulis* hinge to typical oval morphotype (Wh: 24mm).

Also, breakage rates can be very high in archaeological shell, with loss of the margins rendering most oyster shells unfit to measure. Another aim was to determine whether it is likely that there are consistent relationships between shell features which survive well in archaeological oysters and overall shell size, so that archaeological oyster shell sizes can be estimated.

2. MATERIAL

One late Roman deposit, context 2239, a fill in a pit of the site's Phase 2.3 (Late Third – mid Fourth Century A.D.) provided oysters in statistically useful numbers: 56 upper valves (none complete enough to be measurable) and 74 bases, of which 40 were measurable. This was an individual layer within the pit, and it was likely that it was a single depositional event. Winchester lies about 20km upriver from Southampton Water, one of the four bays in the central southern English coast used as harbours (Fig. 3). The harbours empty and fill twice a day due to the tides, via channels locally called 'lakes'. The coast is separated from the Isle of Wight by the broad strait called the Solent. Tidal currents in the Solent and along the coast are strong, up to 2 m/sec (Velegrakis 2000, 33) forming sand and gravel dunes and maintaining a natural channel up to 28m deep down the Solent (Dyer 1971), while the beds of the harbours and lakes are fine mud and muddy sand (Dyer 1980: Fig. 2).

Most samples of oysters were taken at recorded positions from known commercial beds, by local governments as part of the monthly programme monitoring oyster food safety, and assessed by the Health Protection Agency's Wessex Environmental Microbiology Service (WEMS), Southampton. Samples were selected to compare harbours, and to approximate a transect across

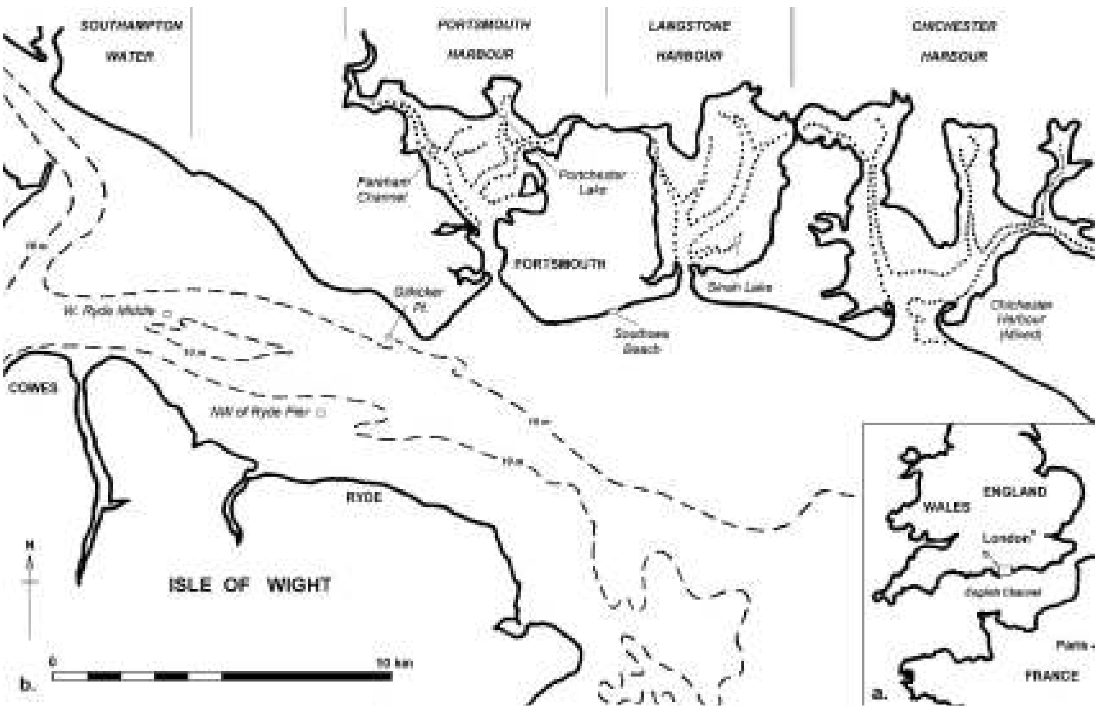

Figure 3. Locations of modern comparative samples of *O. edulis*.

the east Solent (Fig. 3). A larger sample with a wider size range was also obtained from Southsea Beach. All of these samples derive from sub-tidal populations regularly fished by dredging, which will have prevented the formation of oyster reefs. This region has one of the few remaining self-sustaining oyster fisheries in Europe, so the oysters tend to grow from spat settled naturally on the bed; there were no abrupt changes in shape (as observed in the archaeological material) in the modern shells, suggesting that transplantation between beds (if any) had occurred some years previously. The modern oyster sample locations and details are presented in Table 1.

3. METHODS

Measurements (Fig. 4), taken on the left (lower) valve to the nearest 1 mm, were: maximum shell height (Hmax) and shell length (Lmax); height across the body (Hb) from the centre of the chondrophore to the adductor muscle scar ventral edge; height at greatest posterior extent of mantle chamber (He); and hinge width (Wh), distance across the bourrelets at the hinge's ventral edge. Two dimensions were taken in the plane of commissure: *closure height* (Hc), maximum height across the plane of commissure from the centre of the chondrophore; and *closure length* (Lc), maximum length across the plane of commissure. The plane of commissure in the left valve is marked by a narrow commissural shelf (Stenzel 1971: 990 and Fig. J7, 987) set somewhat internally from the shell margin in the left valve, and slightly internally from the margin in the right valve. With a little practice (and by feeling with the fingertips), these features can be found accurately, and their dimensions can be measured to the nearest 1mm.

To compare the extent to which shells were 'tall', two ratios of height to length were calculated: *shell HLR* (Hmax/Lc), already used in archaeology (*e.g.* Winder 1992: 196-197; Kent 1992: 25-27); and *closure HLR* (Hc/Lc). *Closure eccentricity* (He/Hc) was calculated to compare the extent to which the shells were 'off-centre'. *Shell-to-body height ratio* (Hc/Hb) was calculated to evaluate the relationship between overall shell size and a well-preserved dimension of archaeological oysters. *Hinge-width ratio* (Wh/Lc) was used to compare relative hinge size.

Bivalve shell dimensions can vary exponentially with size within a habitat, and it is this allometry that varies between habitats (Seed 1980: 37-39). Therefore, if the allometry is significantly non-isometric, ratios of dimensions can vary between shells in the same habitat simply because they are different sizes. The modern samples had their allometry estimated by least-squares fitting of an exponential relationship, and a linear relationship. Shell sizes in the modern oyster samples forming a transect across the Solent, and the two archaeological morphotypes from deposit 2239, had their average sizes tested for significant differences (Sokal and Rolph 1995: 210-211). If the sizes were significantly different, comparison of

							closure		closure		closure		Hinge-width		shell-to-body	
		sample	Lat.	Long.	depth	n	height		hght-lgth ratio		excentricity		ratio		height ratio	
					(m)		Hc	s.d.	Hc/Lc	s.d.	He/Hc	s.d.	Wh/Lc	s.d.	Hc/Hb	s.d.
modern sample transect	Solent channel	W Ryde middle	50° 46.7'	1° 14.9'	13	9	66	6	0.923	0.073	0.662	0.057	0.287	0.036	1.545	0.074
	Solent channel	NW of Ryde Pier	50° 45.2'	1° 10.9'	5	10	63	8	0.927	0.053	0.700	0.061	0.272	0.033	1.604	0.047
	near-shore	Gilkicker	50° 46.4'	1° 9.2'	9	10	59	5	0.924	0.059	0.640	0.052	0.250	0.033	1.659	0.106
	harbour lake	Portchester Lake	50° 50.1'	1° 6.6'	2	11	59	8	0.869	0.058	0.638	0.054	0.248	0.035	1.601	0.054
	harbour lake	Fareham Channel	50° 50.0'	1° 8.6'	4	10	60	8	0.875	0.061	0.652	0.049	0.242	0.022	1.607	0.059
	harbour lake	Sinah Lake	50° 48.2'	1° 0.0'	3	9	57	5	0.891	0.036	0.644	0.040	0.234	0.027	1.596	0.039
	ANOVA	$F_{[5,53]}$					2.06		2.09		1.99		3.79		2.76	
		Probability					0.085		0.081		0.095		0.0053		0.027	
	Kruskal-Wallis	$H_{[5,59]}$					10.1		7.82		7.56		12.9		11.2	
		Probability					0.073		0.17		0.18		0.024		0.047	
	near-shore	Southsea	50° 47'	1° 4'		71	58	7	0.893	0.056	0.617	0.072	0.258	0.039	1.705	0.122
Roman pit fill 2239	t-test	round				13	83	6	0.893	0.048	0.656	0.092	0.282	0.040	1.628	0.085
		oval				27	71	8	1.033	0.078	0.698	0.049	0.324	0.028	1.623	0.096
		t[38]					4.77		5.93		1.90		3.88		0.178	
		Probability					0.00027		7.1×10^{-7}		0.065		0.0041		0.86	
	Mann-Whitney	U					181.5		350.5		257		280.5		180.5	
		t					0.174		5.05		2.35		3.04		0.145	
		Probability					0.86		4.3×10^{-7}		0.019		0.0024		0.89	

Table 1. Location, size and shape ratios for modern and archaeological samples of flat oyster (*Ostrea edulis* L.)

shapes would probably require analysis by ANCOVA on the log-transformed data (Campbell 2008: 115-116). Shell shapes in the modern samples forming a transect across the Solent were compared by ANOVAs on the shape ratios, and shell shapes in the two archaeological morphotypes from deposit 2239 were compared by t-tests on the shape ratios (Sokal and Rolph 1995: 223-225). Since sample sizes were small and the distributions of the ratios may not have been normal, distribution-free tests were also employed: shell shape ratios in the modern transect samples were subjected to Kruskal-Wallis tests (Sokal and Rolph 1995: 423-427), and the two archaeological morphotypes were compared by Mann-Whitney *U* tests (Sokal and Rolph 1995: 427-430). A difference was said to be significant if its probability was less than 0.05.

4. RESULTS

4.1. Relationship between dimensions

The lines of maximum shell height (Hmax) and length (Lmax) were not consistently related to features of the shell. The point on the umbo which defined the dorsal point of maximum height could be above the chondrophore or either bourrelet, depending on the extent of curvature in the growth of the hinge. The point on the ventral edge defining Hmax could be anterior, directly ventrally or posterior to the adductor scar. However, the maximum dimensions in the plane of commissure did have consistent relationships with other shell features in both modern and archaeological shells, regardless of size or shape (Fig. 4). The line of maximum closure height (Hc) passed through the centre of the adductor muscle scar, usually within ±1mm of the ventral edge of the scar; closure shell height and maximum body height are on the same alignment. Also, closure length Lc was parallel to the hinge axis, regardless of the relative orientation of Lc and Hc. These relationships held true even in one- or two-year-old shells, despite their xenomorphism (the strong trend for young shells to fit the shape of their substrates) (Stenzel 1971: 1021). The only shells which did not conform were those which bore clear evidence of trauma or physical growth restriction.

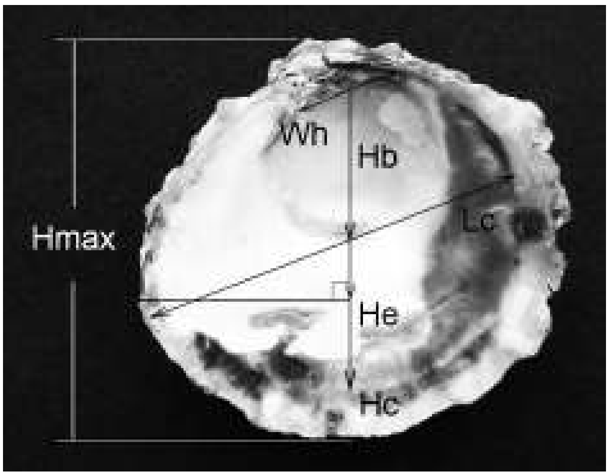

Figure 4. Inside of L. valve of *O. edulis*, showing measurements taken.

4.2. Modern Oysters

In the modern samples, the scatter in the relationship of height with other variables such as length (Fig. 5) was consistently broader with maximum shell height Hmax (Fig. 5a) than with closure height Hc (Fig. 5b). Regression coefficients (r^2) were consistently lower with Hmax than with Hc for all shape ratios in all modern samples. For example, the relationship between height and length in the sample with the largest size range (Southsea Beach) had a greater scatter and larger regression coefficient with Hmax (Fig. 5a) than with Hc (Fig. 5b). Distributions of shape ratios were also consistently broader in range and more poly-modal when generated using Hmax than when Hc was employed. For example, the distribution of shell HLR for Southsea Beach (Fig. 5c) was probably positively skewed and possibly poly-modal, while closure HLR (Fig. 5d) in the same sample was narrower in

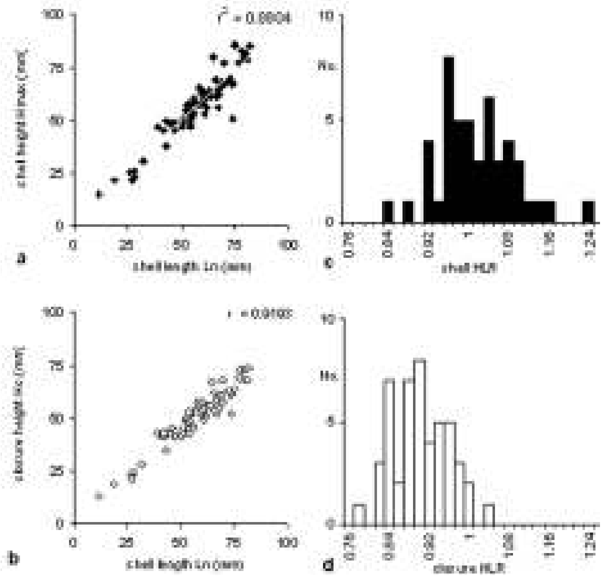

Figure 5. Modern oyster *O. edulis* sample from Southsea Beach: height as a function of shell length for (a): shell height Hmax; (b): closure height Hc; and distribution of height-length ratio HLR using (c): shell height Hmax; (d): closure height Hc. Regression coefficient ' r2 ' for least-squares fitting to straight line.

range and more obviously normally distributed. Closure height was therefore used in shape comparison throughout this paper.

Height-length allometry was very similar in all the modern samples, and was well-approximated by a linear relationship (isometry); positive or negative allometry could not be distinguished in these small samples with their restricted size ranges. Even in the modern sample with the fullest range of sizes and ages (Southsea Beach) the allometry was very well approximated by a linear relationship (Fig. 5b; $r^2 = 0.919$); fitting to an exponential relationship generated an allometry ($Hc = (1.246)Lc^{0.918}$) which did not significantly improve the regression ($r^2 = 0.947$). Shell sizes in the other modern oyster samples forming a transect across the Solent were not significantly different and had similar standard deviations (Table 1). Therefore shell shape was compared via the ratios.

There was a significant variation between samples in the shell-to-body height ratio (Hc/Hb) (Table 1). Closure HLR and closure eccentricity (He/Hc) did tend to vary with conditions, but the variations were not statistically significant. However, hinge-width ratio (Wh/Lc) varied across the transect, and this variation was very significant. There was also some correlation between closure HLR and hinge-width ratio, with harbour oysters having the smallest values of both ratios, near-shore oysters having larger ratios, and deeper water oysters having greater hinge width ratios.

Modern harbour oysters were distinctive (Fig. 6): as well as being thin-shelled and frilly-edged, about a third had extensions of the shell around the hinge. These were not auricles (anterior and posterior extensions of the hinge, as in some scallops), but lobe-like extensions of the margin. Usually these lobes were posterior to the hinge (Fig. 6a), but some shells had lobes both anterior and posterior to the hinge, sometimes weak (Fig. 6b), often clear (Fig. 6c) and sometimes spectacular (Fig. 6d). The average shell shapes in the samples showed a gradation with conditions (Fig. 7): rounded, frilly, occasionally lobed shells in harbours give way to smooth-edged more oval forms as sample position moved further into the Solent.

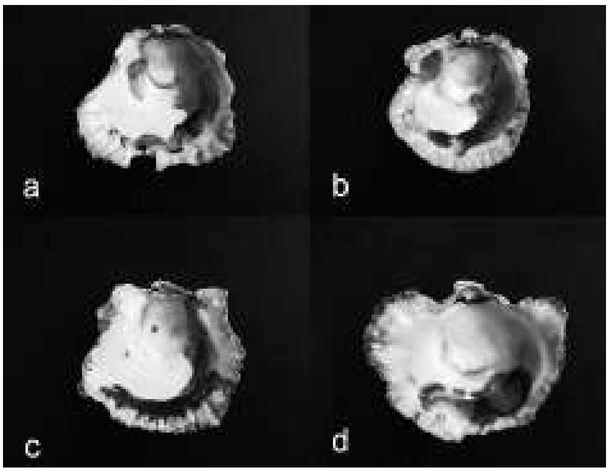

Figure 6. Inside of modern oyster (*O. edulis*) left (lower) valves from Chichester Harbour lakes which were (a) lobate (Hmax: 75mm); (b) weakly bi-lobate (Hmax: 77 mm); (c) bi-lobate (Hmax: 79mm); and (d) strongly bi-lobate (Hmax: 80mm).

4.3. Archaeological oysters

The round and oval archaeological morphotypes in deposit 2239 were significantly different in size according to the t-test, but were effectively the same according to the Mann-Whitney *U* test (Table 1). Height-length allometry was not similar for the two archaeological morphotypes (Fig. 8a), but positive or negative allometry could not be distinguished due to the restricted size ranges and broad spreads. In the round morphotype the allometry was as well approximated by a linear relationship ($r^2 = 0.618$) as an exponential one ($r^2 = 0.619$). In the oval morphotype the linear relationship ($r^2 = 0.625$) was marginally better than an exponential one ($r^2 = 0.614$). Therefore shell shape was compared via the ratios.

The shell-to-body height ratio was not significantly different between morphotypes (Table 1); closure HLR and hinge-width ratios were very significantly greater in the oval form, and closure eccentricity was significantly larger in the oval form according to the distribution-free test. The round morphotype had closure HLR values similar to modern near-shore oysters, and hinge-width ratios similar to deeper-water oysters. The oval morphotype had closure HLR, eccentricity and hinge-width ratios much larger than any of the modern samples. The closure HLR showed a weak positive correlation with hinge-width ratio ($r^2 = 0.22$), and this relationship produced a good separation of the two morphs (Fig. 8b); 'round' in this case seem to be defined principally as a shell with a closure HLR of less than 0.97, provided its hinge-width ratio was also less than 0.34.

5. DISCUSSION

The chief aim of this study was to determine whether *O. edulis* shape is likely to vary significantly with habitat. Visual examination of shape of modern samples was encouraging: shells in har-

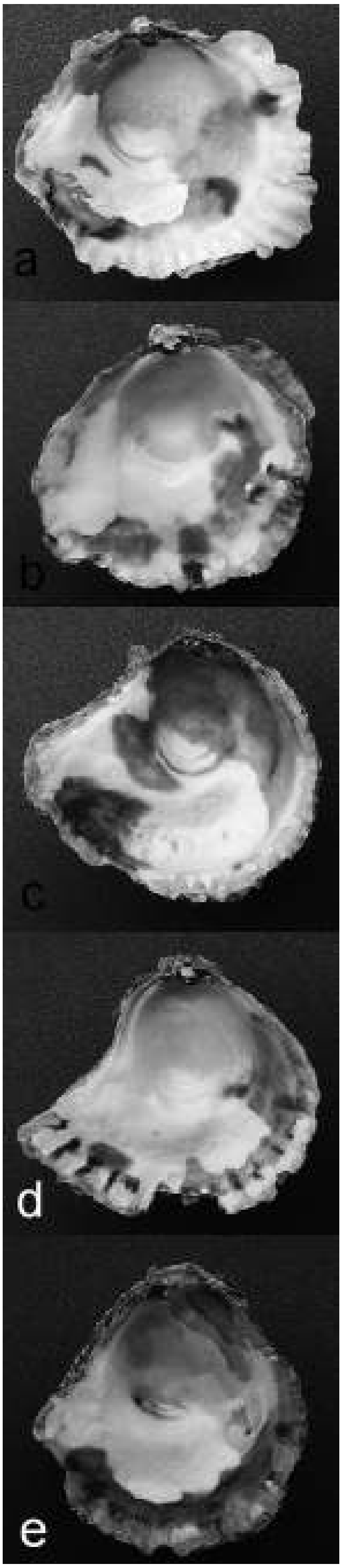

Figure 7. Inside views of an oyster (*O. edulis*) left (lower) valve of median shape from a series of modern Solent samples: adjusted to a common arbitrary height. (a) Portchester Lake, a small harbour channel (Hmax: 63mm); (b) Fareham Lake, a large harbour channel (Hmax: 63mm); (c) Gilkicker Point, near-shore (Hmax: 65mm); (d) NW of Ryde, Solent channel edge (Hmax: 69mm); and (e) West Ryde Middle Bed, in Solent channel (Hmax: 72mm).

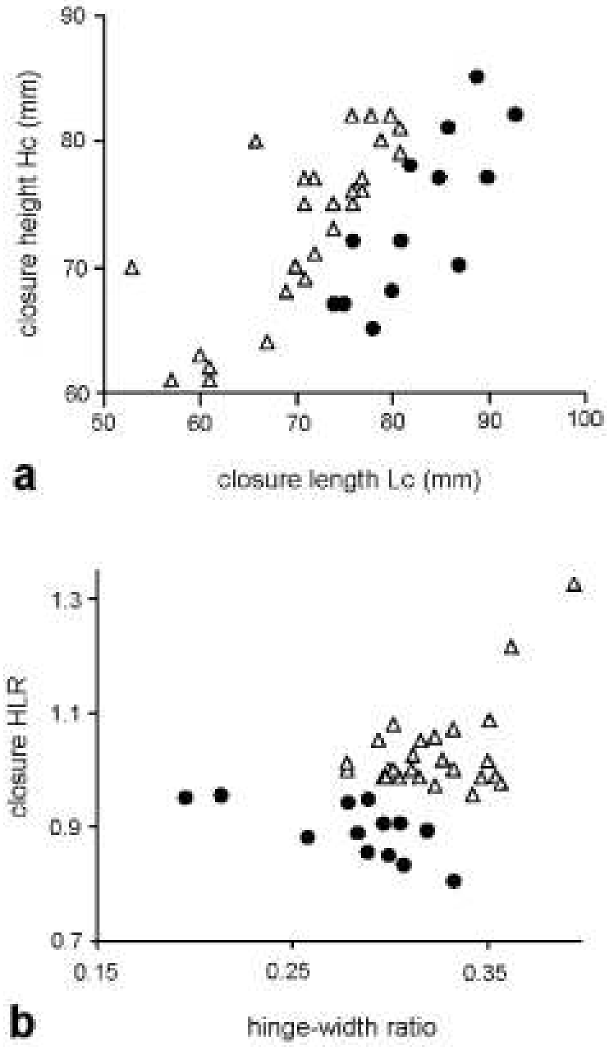

Figure 8. Archaeological *O. edulis* from Winchester AY93 late Roman pit fill 2239. (a): closure height as a function of closure length. (b): distribution of closure HLR (Hc/Lc) with hinge-with ratio (Wh/Lc). Open triangles: oval morph; solid dots: round morph.

bour lakes were thin, frilly-edged, occasionally lobed with small triangular hinges, and shells tended to become increasingly heavy, more streamlined and broader- and straighter-hinged with increasing distance from shore. Simple arithmetic ratios of shell dimensions followed the same trends in shape, with the relative width of the hinge showing the greatest rate of change, and a statistically significant difference between samples.The true nature of the variation of shape with habitat has not been determined by this study. The number of samples and the numbers in each sample were small, and the variability within a habitat was not tested by repeat sampling.

The differences in shape might be caused by hydrodynamic differences between oyster beds (Fig. 9). In harbours, slow steady tidal flows produce

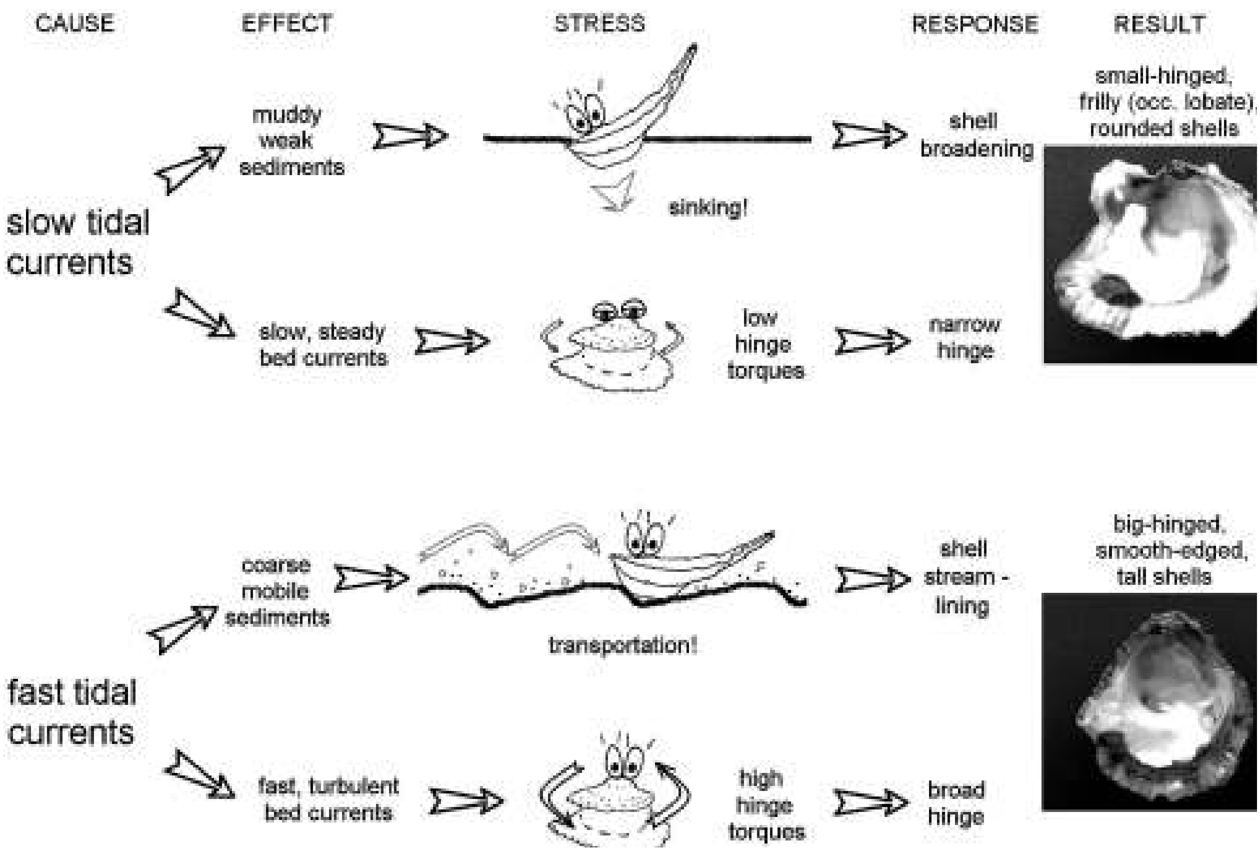

Figure 9. A possible explanation for oyster shell shape variation between beds.

soft muddy beds where the main risk to oysters is sinking, so the high surface area of broad, round, and occasionally lobate shells is advantageous. In stronger more turbulent tidal flows off-shore, the risk of sinking falls but the risk of transportation increases, so heavier and more streamlined shells are advantageous. Also, oysters in harbours are subjected to low and steady currents which generate little torsional force on the upper valves, so the hinges can be quite small. The faster turbulent currents off-shore generate greater twisting forces on the upper valve, so oysters tend to grow broader stronger hinges off-shore. The oyster hinge has the tensilium both anterior and posterior to the resilium (Trueman 1951: 138), on the bourrelets (Stenzel 1971: 974), so the oyster hinge is particularly effective against torsional forces (Hautmann 2004: 168).

Another aim of this study was to determine whether it is likely that there is a simple way to measure *O. edulis* shells to make shell shape objectively comparable between samples, both biological and archaeological. Some morphometric studies of marine shells employ over a dozen measurements (*e.g.* McDonald *et al.* 1991: 325) or examine the interrelationships of dozens of features (*e.g.* Carvajal-Rodriguez *et al* 2005: 314). Fortunately, significant differences in shape were discerned in this study by employing only four measurements, a feasible number to take when faced with potentially thousands of oysters that some excavations produce.

Oyster ecophenotypic variation is likely to be more successfully studied using dimensions in the plane of commissure rather than maximum overall size:

(1): The correlations with maximum dimensions in the plane of commissure (Hc, Lc) are more precise than those based on maximum shell dimensions (Hmax, Lmax). In the modern material studied here, r^2 was always greater for shape ratios based on Hc than the analogous ratios based on Hmax. If there is ecophenotypic shape variation, it will be more detectable in the plane of commissure than in the overall shell.

(2): Maximum dimensions in the plane of commissure are orientated precisely with features in the valve, making them simple and quick to locate on a valve, and consistent between valves. Maximum shell dimensions are not so consistently positioned with respect to the hinge or margins, and are therefore different between valves. This more consistent commissural orientation is probably why the commissural dimensions correlate more precisely.

(3): Dimensions in the plane of commissure are identical for both valves of the same oyster, but (because oysters are inequivalve) Hmax and Lmax can only be measured on the larger (left) valve. Therefore the sample sizes for shell shape in archaeology will be larger if the commissure is measured, since the more numerous type of either valve in any archaeological deposit can be measured.

(4): Dimensions are better preserved in the plane of commissure than in the whole shell. Hc and Lc are taken on features that are inset from the shell edge (slightly in the right valve, distinctly in the left). Hmax and Lmax are measured on the shell edge, so the margins and umbones must be intact. Erosion of the fragile shell margins and loss of the umbones is common in archaeological oysters, and can be severe. Umbones and margins of modern oysters can be worn away or broken during life or recovery. The sample sizes for shell shape in archaeology will be larger if the commissure is employed, since the shells retaining the commissural shelf and inner edge of the hinge will always be more numerous than those in which the margins and umbones are intact. Also, smaller shells tend to be thinner and more fragile than larger shells, and therefore more likely to have damaged umbones and margins, so employing Hmax and Lmax biases the analysis towards larger shells.

Another aim was to determine whether it is likely that there are consistent relationships between shell features which survive well in archaeological oysters and overall shell size, so that archaeological oyster shell sizes can be estimated. Well-preserved dimensions have been used previously to reconstruct shell size distributions of other archaeologically important bivalves that preserve poorly (*e.g.* Buchanan 1985). Unfortunately, shell-to-body height ratio in the archaeological and modern samples varied widely (Table 1). Size and shape of the visceral cavity has little predictive value for shell size and shape in archaeological material. The inter-relationship between other features measured in this study (height, length, hinge width) also varied significantly between samples. Therefore it is unlikely that original shell size can be estimated well from a badly preserved shell.

Applying the methodology developed here to the two morphotypes thought to exist in deposit 2239 confirmed the distinction. The relationship between height and length was distinct for the two morphs, and the average proportions were different: length typically was greater than height in the round morph, but not in the oval morph. The average proportions of the hinge to width were also different, the round morph tended to have smaller hinges. Of course the intention was not to show the shells in the round morph were 'round' internally or externally, but to see whether the morphs were significantly different according to a method useful for studying ecophenotypic variation. Since it does seem probable that oyster shape varies with conditions in the bed, it seems probable that the two morphs were growing in different beds. The round morph had shell shape like modern harbour-offshore oysters, while the oval morph had more oval and wider-hinged shells than any modern form.

The archaeological shells in the oval morph changed from a range of shapes to one typical shape, and from a range of hinge morphologies to a single morphology. Since it does seem probable that oyster shape varies with conditions in which the oyster grows, it seems probable that these oysters have moved from a range of growth conditions to a single one. This suggests intentional human intervention, such as the re-laying of dredged oysters to a single site for 'fattening'. If so, it may be the first direct evidence for oyster management in British archaeology.

The archaeological shells were larger on average than the modern samples (Table 1). It is therefore possible that the difference in shape between modern and ancient oysters is due to exponential allometry during growth. However, the oval archaeological morphotype had a height-length ratio and hinge-width ratio much greater than any of the modern samples (Table 1). Also, almost all the oval oysters had taken on a similar shape from a range of shapes following a growth step, suggesting the oysters grew relatively quickly into the oval shape. It is more likely that the oval morphotype grew in conditions that were different from those of any of the modern samples of this present study.

6. CONCLUSIONS

Since this small study identified trends, and detected one which appears to be statistically significant, it is probable that there is ecophenotypic variation in *O. edulis*. This variation may be due to hydrodynamic differences between beds. Further more detailed research to elucidate the relationship between shape and conditions of growth is likely to be worthwhile.

Using measurements in the plane of commissure in preference to maximum external dimensions is recommended for oysters because they are more precisely correlated, consistently related to features of the shell, better preserved in archaeological shells and the same for either left or right valve.

Since the 'oval' and 'round' archaeological shells also differed significantly in shell shape and hinge shape, they were genuinely different morphotypes. Since such differences seem to be ecophenotypic, it also seems probable that the archaeological morphotypes grew in different types of bed. The growth-steps in the oval oysters, showing they likely were moved from a range of growth conditions to a single habitat during life, probably indicated Roman oyster management.

7. ACKNOWLEDGEMENTS

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A large-scale exploitation of oysters during the Middle Ages at Beauvoir-sur-Mer (France)

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A large-scale exploitation of oysters during the Middle Ages at Beauvoir-sur-Mer (France)

Explotación de ostrasa gran escala en el yacimiento medieval de Beauvoir sur-Mar (France)

KEY WORDS: Flat oyster, Middle Ages, specialization, biometry, associated fauna.
PALABRAS CLAVE: Ostra plana, Edad Media, especialización, biometría, fauna asociada.
GAKO-HITZAK: Ostra laua, Erdi Aroa, espezializazioa, biometria, fauna.

Catherine DUPONT[1]

ABSTRACT

Large amounts of flat oysters, *Ostrea edulis*, dating from the Middle Ages are frequently recovered from middens along the French Atlantic facade. Some of the middens are genuine hills eight metres high. But most are less well known because of their position beneath the modern surface. The economic impact of activities linked to these middens has been largely underestimated. One of them, located at Beauvoir-sur-Mer, was recently excavated. Our first aim in analyzing these deposits was to determine if oyster was the only species represented. With that in mind we sampled and sieved the deposit. More than three thousand valves of oysters were studied. Biometric analysis linked to the observation of the opening scars gives information on the technique used to gather the bivalve. The associated fauna informs us about the territory exploited. This study shows that the exploitation of oysters in some of these sites was a specialized activity, with massive extraction and export of oyster meat. The economic importance of these localities on the French Atlantic littoral has been underestimated for the Middle Ages.

RESUMEN

En la fachada Atlántica francesa se documentan frecuentemente grandes acumulaciones de ostra plana *Ostrea edulis* de cronología medieval. Algunos de estos depósitos destacan en el paisaje como promontorios de ocho metros de altura, aunque la mayor parte son mal conocidos por su situación bajo el nivel de suelo actual. Esta es la razón por la que a menudo se ha infravalorado la actividad económica ligada a estas ostras. Una de estas acumulaciones, localizada en Beauvoir-sur-Mer, ha sido recientemente excavada. El depósito fue sistemáticamente muestreado y tamizado, con el objetivo principal de determinar si el conchero estaba formado exclusivamente por esta especie. Más de tres mil valvas de ostra han sido estudiadas. Los análisis biométricos ligados a la observación de las marcas de abertura de las conchas ofrecen información acerca de la técnica utilizada en el marisqueo del bivalvo. La fauna asociada completa el marco del territorio de captación. Este estudio muestra que la explotación de las ostras en algunos yacimientos arqueológicos constituye una actividad especializada, realizándose la extracción previa de la carne del bivalvo para su posterior exportación. Consideramos que se ha infravalorado la importancia de estas áreas en el litoral Atlántico francés durante la Edad Media.

LABURPENA

Frantziako fatxada atlantikoan, Ostrea edulis ostra lauaren metaketa handiak (Erdi Arokoak) dokumentatzen dira sarritan. Metaketa horietako batzuk paisaian nabarmentzen dira, zortzi metroko altuerako gailurrak osatzen baitituzte, baina gehienak ez dira behar bezala ezagutzen, gaur egun lur azpian daudelako. Horregatik ez da sarritan behar bezala balioetsi ostra horiekin lotutako jarduera ekonomikoa. Metaketa horietako batean, Beauvoir-sur-Mer kantonamendukoan, indusketak egin dira duela gutxi. Laginak atera eta sistematikoki bahetu zen; helburu nagusia zen maskortegia soilik espezi horrek osatzen zuen ala ez jakitea. Ostren hiru mila kusku baino gehiago aztertu dira. Maskorren irekiduren markak hautematearekin lotutako analisi biometrikoek bibalbioak biltzeko erabilitako teknikari buruzko informazioa ematen dute. Horrekin lotutako faunak osatzen du bilketa-eremuaren esparrua. Ikerketak erakusten du aztarnategi arkeologiko batzuetako ostren ustiapena jarduera espezializatua zela, eta bibalbioaren haragia ateratzen zutela, esportatzeko. Frantziako kostalde atlantikoko guneek Erdi Aroan zuten garrantzia gutxietsi dela uste dugu.

1. INTRODUCTION

Studies of shells in archaeological contexts are still rare in France, and this makes it difficult to incorporate the present studies of shells in general chronological context. Another obstacle is the absence of a good description of the shelly deposits during the excavations discussed here. This explains some absences in the malacological study presented in this paper: paucity of elements of datation and of the stratigraphic description of this accumulation of shells. The shell analysis presented has been realized in 2006, twenty-two years after the excavation of the Beauvoir-sur-Mer site.

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The deposit of Beauvoir-sur-Mer is 1600 metrers long and 20 to 25 metrers wide with a height that varies between 1 and 2 metrers (Ters and Viaud 1983). Currently it is 2 km from the seashore (Fig. 1). The shape of the deposit seems to correspond to an old waterway, perhaps an estuary, which is today filled in. In figure 1, we can see that this deposit is parallel to waterways that still work. The distance between the archaeological site and the seashore is linked to anthropic action. Some dykes have been built in this part of the seashore to protect this marsh from the inundations. So the shape and the location of the shell midden can correspond to the transport of these oysters by boat. A part of the present village of Beauvoir-sur-Mer is built on this shell deposit.

A radiocarbon date on oyster discovered inside the shell midden attributes a part of the deposit accumulation to between the 11th and the 14th century (900±60 BP, GIF 5702, Ters and Viaud 1983). The imprecision of the calibration is linked to the reservoir effect of datation on shells (deltaR of -260±65: Marchand *et al.* in press; Two sigma Ranges, Hughen *et al.* 2004, Stuiver and Reimer 1993). The second dating element is the construction of a castle which has been built on the deposit (Soret 1994). Its initial construction is dated to the 13th century. Even if the midden accumulation began before this date, it is not impossible that it continued into other areas after the construction of the castle, so we do not know the total chronological extension of this accumulation.

Although the middens of Beauvoir-sur-Mer have not been previously studied, references to these accumulations exist (Soret 1985, Rousseau 1963, Begouen 1937, Baudoin 1912, Mourain de Sourdeval 1864, Rivière 1834). All these authors know Beauvoir-sur-Mer by prospection and not by excavation. Their interest in this site is linked to the predominance of the flat oyster *Ostrea edulis* in the deposit.

But the site of Beauvoir-sur-Mer is not the only accumulation composed virtually exclusively of flat oysters with joined individuals and located at the limit of old marshes nowadays drained: Bourgneuf-en-Retz, Champagné-les-Marais, La rue de l'industrie (Le Langon) and Saint-Michel-en-L'Herm (Fig. 1, Dupont and Bougeant 2008, Verger 2005,

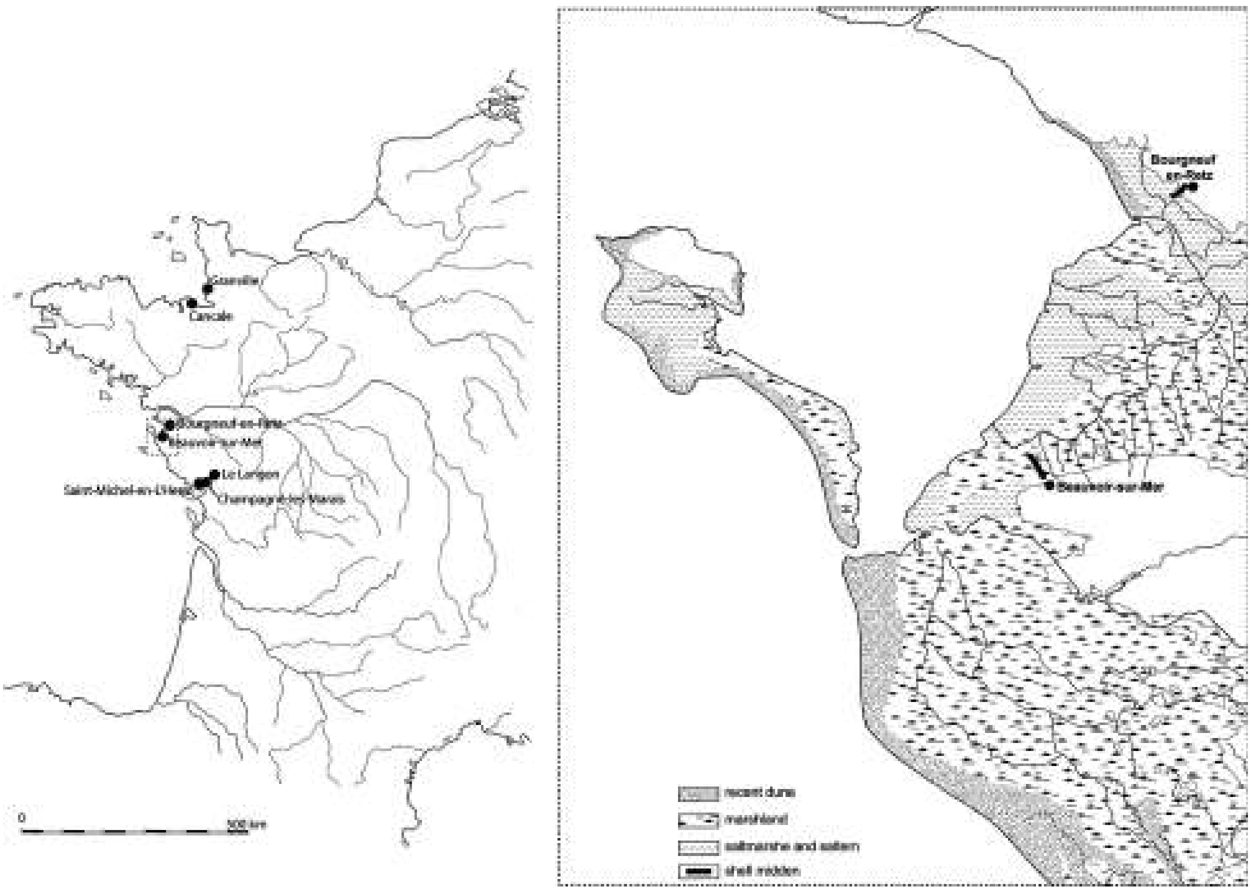

Figure 1. Location of oyster deposits referred to the text. (CAD LQuesnel).

Gruet and Prigent 1986, Soret 1985, Verger 1968, Rousseau 1963, Baudoin 1912). The one at Saint-Michel-en-L'Herm is the best known because it has been exploited from 1924 to 1964 to improve soils and construct roads (Verger 2005). Its volume has been estimated between 200 000 and 600 000m^3 (Verger 2005). This shell midden presents other common points with the one at Beauvoir-sur-Mer: it is located on muddy Flandrian sediment, its shape seems to follow the shape of an old waterway and it is known to have been formed between the 11th and the 13th centuries (Verger 2005). The stratigraphic position of the Bourgneuf-en-Retz is known thanks to the cleaning out of a drain. Its position above the muddy Flandrian sediment is the element that encourages authors to attribute this deposit to the same period as the ones at Beauvoir-sur-Mer and Saint-Michel-en-L'Herm (Verger 2005). The one at Champagné-les-Marais is only known by prospection and there is no information about the chronology of its formation.

The knowledge of the deposit at the village of Langon is recent and has been excavated (M.L. Hervé dir. / INRAP) and studied since the first version of this paper (Dupont and Bougeant 2008). It is the first archaeological site with such an accumulation of oysters attributed to the Roman period (1 to 125 AD). Its common points with the one at Beauvoir-sur-Mer are its localization at the margin of an old marsh, a shell midden composed exclusively of flat oysters and the presence of joined shells.

There are also references to more recent accumulations such as those at Granville or Cancale until the 18th century. For example the ones at Granville were approximately 300 metres long by 200 metres wide and 2 to 3 metres high in 1830 (Levesque 1982).

In the past, several of these deposits of oysters were attributed to natural accumulations because of the presence of many joined valves. However, this observation is not incompatible with the opening of oysters and an anthropic origin.

The excavation took place in 1984, managed by N. Rouzeau, during which 65 kg of oysters were extracted individually by hand from the sediment. Some shells were joined while others were not. All the shells found were examined before and after washing above a column of 2mm and 0.5mm sieves. As mentioned before, scientific interest in shells is new in France and so this archaeological site, mainly composed of shells, did not form the subject of a report in the 1980s. This lack of information contrasts with what we have obtained from the shells.

The position of the muscular impression allows for the determination of lateralization of the valves. All the fragments which could not be lateralized were counted when their dimension was greater than 0.5cm. Of the 5673 counted remains, 1919 were right valves and 1814 were left ones. The minimum number of individuals (MNI) of oysters represented in the studied sample is thus 1919.

Our primary goal was to understand how these oysters were exploited. We therefore observed and recorded the stigmata of both associated marine organisms and the tools used by men. For the associated marine organisms, stigmata consist of typical perforations (single or in network) or calcareous tubes. The stigmata linked to tools used by men are notches, breaks or scratching. Biometric data were recorded in order to know if the oysters have been selected during gathering as well as during extraction of the meat. Other parameters, such as the size of the oysters opened and the proportion of joined valves, allow us to define the level of specialisation of oyster exploitation.

2. THE GATHERING OF OYSTERS

2.1. Selection of oysters during gathering

The distribution of the height of right and left valves for all oysters sampled in the archaeological deposit is shown in figure 2a. This diagram shows that all sizes of oysters are represented in the deposit: both the small and the big ones have been carried to the site.

The presence of joined valves can be linked to the transport of live oysters at Beauvoir-sur-Mer. In figure 2b, only the joined oysters of the shell midden are shown. The mean height is 54 mm for the right valves and 60 mm for the left valves. These values are the same as those obtained for all oysters and further reinforce the interpretation that both small and large live oysters were gathered and carried onto the site.

2.2. The marine animal-life associated with oysters: a view of the environment exploited

To know how oysters have been gathered it is important to know the characteristics of the environment where they developed. The endofauna and epifauna associated with the oysters give an indirect idea. Some oysters were still aggregated together in the archaeological deposit (Table 1). When they do not show traits of death (stigmata of marine organisms attachments inside the valves, polished aspect of the valves), they have been

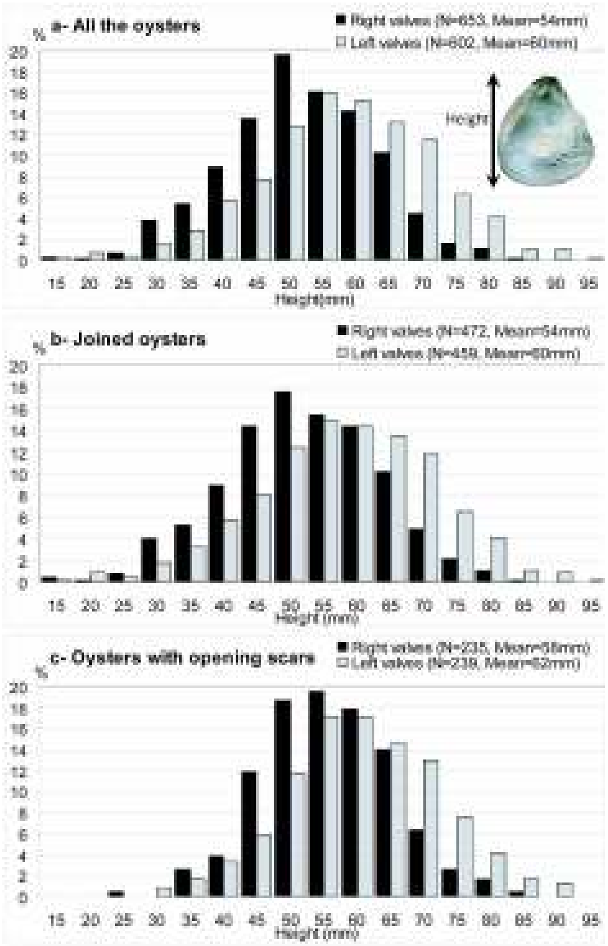

Figure 2. Histogram of distribution of heights of (a) all, (b) joined and (c) oysters with opening scars at Beauvoir-sur-Mer.

Epifauna and endofauna	Right valves (N=848)	Left valves (N=823)
unidentified	63.6%	24.7%
Serpulids	3.8%	9.7%
Marine sponge (*Cliona*)	0.4%	6.2%
Polydora sp.	8.8%	12.9%
Bryozoa	1.8%	4.6%
Ocenebra sp.	7.4%	5.6%
Barnacle	0.1%	0.0%
Spirorbis sp.	0.2%	0.5%
Spat oysters	1.2%	3.9%
live oysters	4.3%	26.9%
association with dead oysters	0.8%	12.4%
former fixing on an oyster	1.3%	15.4%

Table 1. Percentage of the epifauna and endofauna observed on oysters in the archaeological deposit of Beauvoir-sur-Mer.

considered as "live oysters" when gathered. Many of the oysters studied have indications of old oyster attachments: flat zones and presence of shelly remains on the external face.

They could have been separated during gathering but also after their disposal by action of various taphonomic agents. If all these indices of association are taken into account (Table 1), more than 51% of the oysters exploited were attached to another oyster shell during the gathering. Thus, this bivalve at Beauvoir-sur-Mer was undoubtedly exploited from a dense oyster-bed. Other stigmata linked to the marine fauna associated with the oysters have been observed (Table 1). The higher frequencies obtained for the left valves are regularly observed (C. Dupont, unpublished). The left valve fixed the oyster to the substrate. The right one is mobile and directly exposed to the marine currents. The space provided between the left valve and the substrate can provide a more secure environment for marine fauna. These observations have been made only on well preserved shells. They show that some oysters (6% of the left valves) were attacked by the marine sponge *Cliona* which lives in the subtidal zone. The rate shown is too low to demonstrate dredging of the entirety of the oysters in the subtidal zone. It shows that some of these oysters came from very low areas of the seashore and could be exploited at the time of the greatest range of tides. The frequency of *Polydora* (Table 1), a worm that lives mainly in muddy environments, is 13% for the left valves. This percentage is not sufficiently high (inferior to 80%) to testify to the exploitation of muddy bottoms but does show that the exploited coast was sheltered from strong swells and undercurrents. Such an environment may be found today in the bay opposite the site from the midlittoral (eulittoral) zone of the seashore

The assumption of the exploitation of a muddy zone is not corroborated by all the shells observed in the sediment associated with oysters. If some species can support muddy environments like *Cerastoderma edulis* (mainly in sandy bottoms) or *Mytilus edulis, Littorina littorea, Chlamys varia* (rocky bottoms) this is not the case for *Patella* sp., *Gibbula umbilicalis* and *Chiton* sp. which live in strict rocky environments. The presence of stigmata linked to the oyster drill *Ocenebra* sp. (Table 1) shows that the exploited zone was saline.

Lastly, one barnacle, perhaps *Balanus crenatus* (identification Y. Gruet), was found on the right valve of one oyster. Based on the sediment associated with the oysters sieved, the scarcity of barnacles cannot be associated with separation of this crustacean after the death of the oysters. In addition, when they are abundant in the environment they remain partly fixed on oysters as, for example, at Saint-Michel-en-L'Herm (Gruet and Prigent 1986, Baudoin 1916). This characteristic testifies to an environment which did not allow the development of barnacles, such as one in which there was a high density of oysters.

2.3. Tools used to gather oysters

Perforations on oysters drew our attention (Fig. 3). The excavation of oysters was carried out by hand,

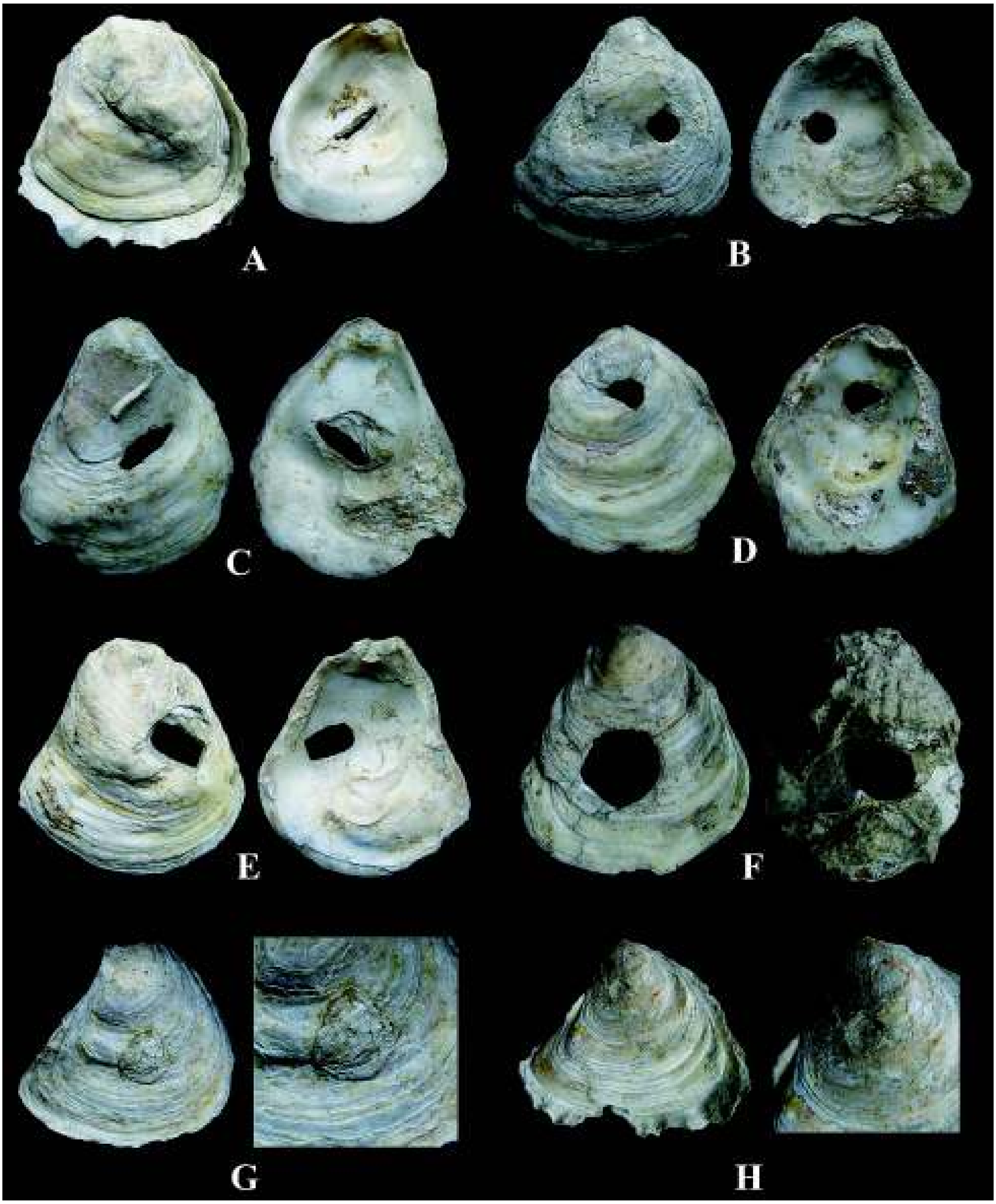

Figure 3. Different perforation shapes observed on the oysters of Beauvoir-sur-Mer: A: crack (L=77 mm), B: circular (L=85 mm), C: oval (L=98 mm), D: triangular (L=84 mm), E: quadrangular (L=91 mm), F: pentagonal (L=111 mm), Impacts of a tool on the surface of oysters: G: circular impact (L=120 mm), H: pentagonal impact (L=90 mm) (photos C. Dupont).

hence these perforations could not have been caused by trowels. Furthermore, these holes were covered with sediment, which makes it possible to reject their recent origin. In total, 20 perforated valves were observed. In spite of this limited number compared to the 3724 observed oyster valves, they could suggest that they were the result of tools used to gather the oysters.

Among these 20 valves, 19 are right and only one is left; the latter was joined with a right perforated valve (Fig. 3-F). This whole specimen seems to correspond to the action of a tool which could have pierced the entire thickness of the oyster. The predominance of perforations on right valves is confirming evidence for their creation during gathering. When the oyster spat develops on a support, it is the left valve which takes a more or less concave shape that conforms to the shape of the substrate on which it is adhered. The right valve, which closes the bivalve, thus seems more vulnerable to the action of a collection tool.

In order to have additional information on the tool or the tools used, these perforations have been analysed according to their shape and dimensions (Fig. 4). The dimension measured is the biggest opening of perforations. The confidence intervals make it possible, despite everything else, to take into account the variability of dimensions of perforations for each shape. This confidence interval is close to the extreme values of the size of the perforations because of the small number of perforations. It shows that the smallest perforations have rather round shapes while the largest more angular. These differences can correspond to different degrees of force applied when driving in the tool. The teeth of the tool could have a pointed tip with a more angular shape at the base.

However, the presence of both round and angular impacts (Fig. 3-G and H) does not make it possible to exclude the use of two tools: one with a rounded tip, the other with a broader angular shape tooth.

Several tools are used to exploit oysters: the dredger, the rake, double rakes and the mortise axe (Fig. 5, Clerc 1828). The mortise axe and the long handled rakes are intended for use in the intertidal zone.

The low frequency of stigmata observed could correspond to raking of the marine bottom using various kinds of less destructive rakes rather than the mortise axe which would perhaps cause more perforations.

3. ACTIVITIES LINKED TO THE EXPLOITATION OF OYSTER MEAT

3.1. The selection of opened oysters

Opening scars have been observed on 59% of the right valves and 67% of the left ones. The most frequent scar observed is a notch which is precisely 8 mm wide at the edge of the oyster opposite the hinge. The opening movement with a knife seems to be standardized.

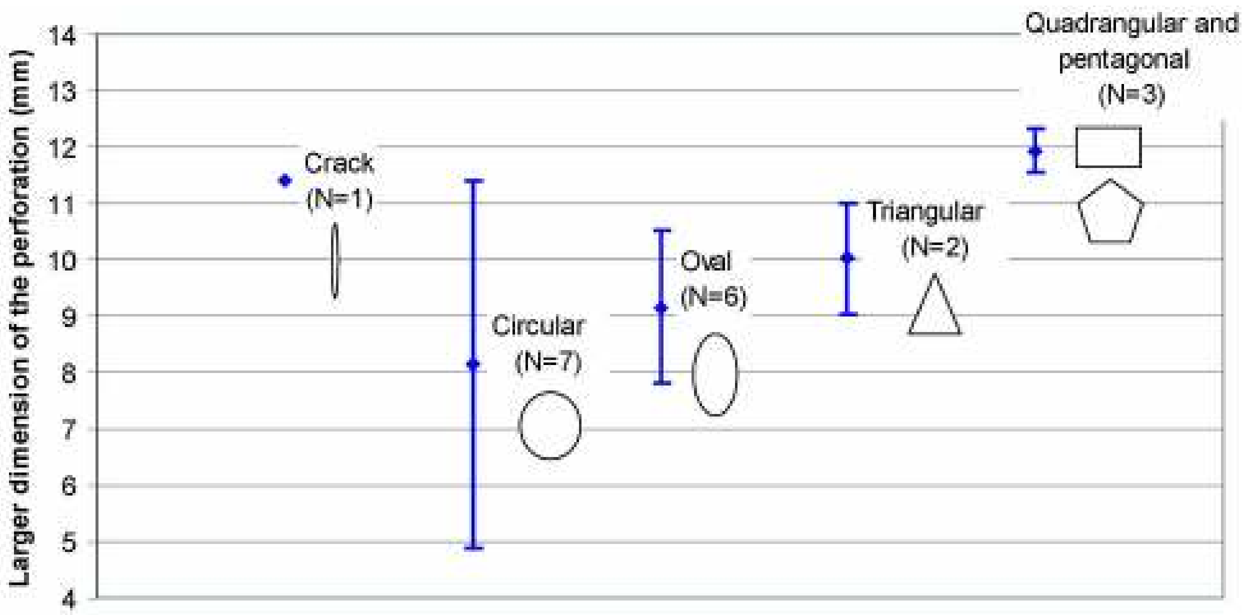

Figure 4. Measurement of the larger dimension of perforations observed on oysters according to the shape of the stigmata (C. Dupont)

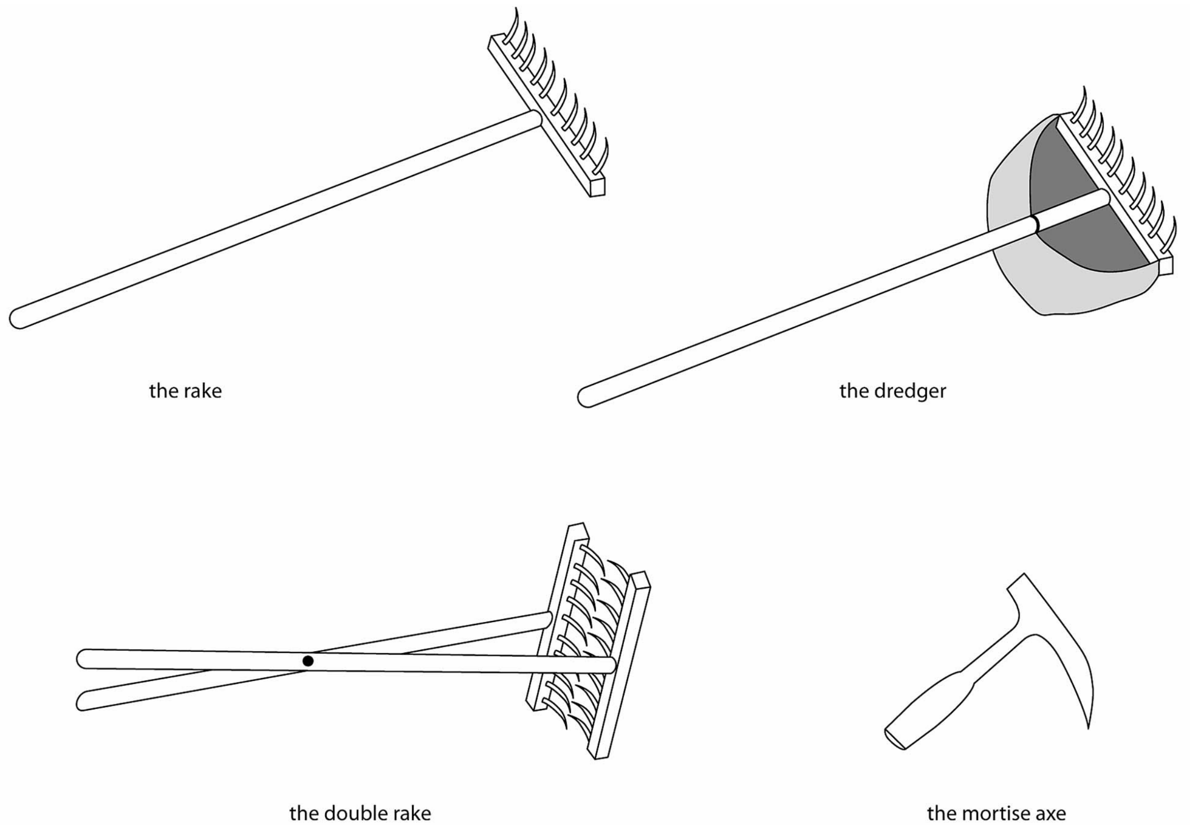

Figure 5. Example of implements potentially used to exploit the oysters (CAD L. Quesnel).

We have already demonstrated that all sizes of oysters were gathered. But have they all been opened? The presence of opening scars on shells provides an answer. Figure 2c shows the frequency of all the oysters with opening scars in the archaeological assemblage. Compared to the whole oysters (Fig. 2a), figure 2c shows that the exclusion of oysters without scars increases the dimensions of oysters exploited: 58 mm for the right valves and 62 mm for the left ones. This shows that smaller oysters were gathered and brought to the site but that some of them were not opened. These smaller individuals were transported fixed on larger oysters, and in the studied sample some are still attached.

3.2. The joined oysters

Twenty eight percent of the MNI of oysters were found as joined valves at Beauvoir-sur-Mer. This is undoubtedly an underestimation because of the conditions of conservation and transport of the shells after excavation. The presence of joined oysters is not incompatible with their consumption – some of these joined oysters had opening scars on their internal side (Fig. 6).

If, as the many scars observed show, large numbers of the oysters at Beauvoir-sur-Mer were opened, why were they found joined in the deposit?

Two elements help the two valves of oysters to remain joined. The first is the adductor muscle and the second is the ligament. Opening the oysters requires that the muscle be cut. The oyster can then be half opened and the meat extracted without separating the valves. The ligament present at the hinge maintained the oysters half-opened and this was also true at the time of disposal of the oysters. The ligament is difficult to observe in archaeological contexts because it became detached from the shells. So the way that the oysters of Beauvoir-sur-Mer were consumed (or processed for consumption) did not necessitate separation of the two valves.

3. DISCUSSION

To begin the discussion it can be interesting to summarize the similarities of the archaeological site of Beauvoir-sur-Mer with that of Saint-Michel-en-L'Herm which may be partly contemporaneous.

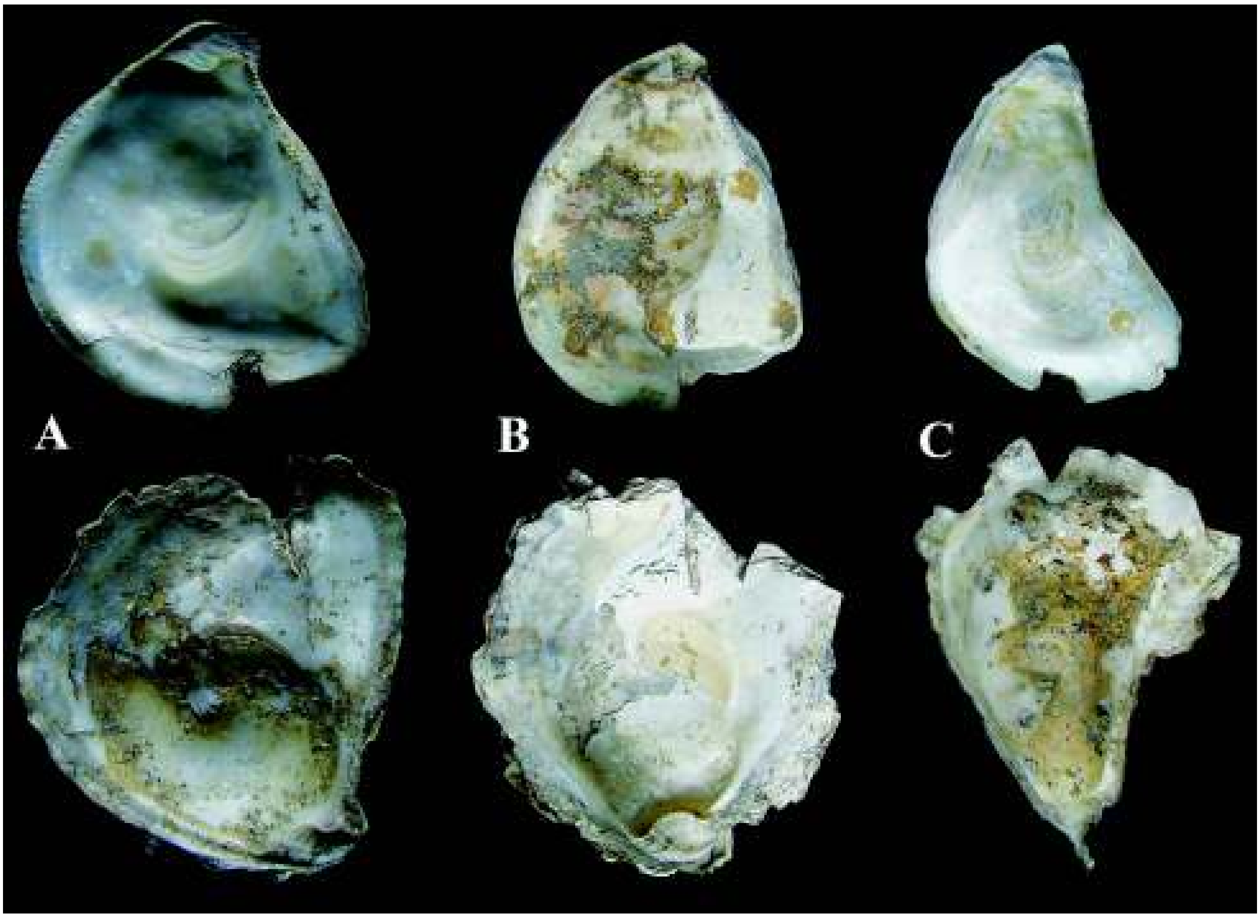

Figure 6. Opening scars on the internal side of associated valves of oysters: A (L=92 mm), B (L=120 mm), C (L=107 mm) (photos C. Dupont)

These shell middens are composed mainly of oysters. Thus, in contrast to shells found in accumulations of kitchen waste, these middens testify to a specialized activity, targeted on one species.

Both contain medieval accumulations of oysters on a muddy Flandrian sediment (Ters and Viaud 1983) next to the limit of old marshes, now drained. Baudoin (1916) comments on the serpentine shape of shell middens at Saint-Michel-en-L'Herm – a description that is in harmony with the shape of a marine waterway such as the one at Beauvoir-sur-Mer. These rivers were broader during the formation of the shell middens than they are now. Thus, the oysters could have been transported by boat from the seashore to shell middens.

Oyster gathering was done by raking natural oyster-beds on the seashore sometimes during low tides. At Beauvoir-sur-Mer and Saint-Michel-en-L'Herm, the gatherers did not take the time to separate smaller oysters from the larger ones during gathering (Gruet and Prigent 1986, Baudoin 1916), nor was a selection made prior to opening the oysters.

In both of these shell middens, some oysters remained joined. The proportion of joined oysters at Beauvoir-sur-Mer (28% of MNI) is similar to what was observed at Saint-Michel-en-L'Herm (22% and 40% for the two samples studied, Gruet and Prigent 1986). The ligament that keeps the two valves joined was observed at both Beauvoir-sur-Mer and Saint-Michel-en-L'Herm (Gruet and Prigent 1986; Quatrefages quoted in Baudoin 1916). More than 59% of the oysters of Beauvoir-sur-Mer (62% at Saint-Michel-en-L'Herm, Gruet and Prigent 1986) show opening scars on the edge opposite the hinge, attesting to fast extraction of the meat without systematically disassociating the two valves.

But what became of the meat? Levesque (1982) notes that in 1786 the meat of the largest oysters could be transported from November to mid-April without preparation on straw in baskets. The same process is described in 1873 by the British doctor Lister (quoted in Levasseur 2005). Outside of this period it could be salted. Lister reports that in salt, the meat can be preserved for more than one month. These oysters "à potage" were intended to be cooked and put in ragouts. Texts dating from the 18th century, like the report of Le Masson du Parc in 1730, attest to these modes of export in baskets either fresh during the winter, or pickled at other times, for the towns of Cancale and Granville. The curing of oysters in salt cannot be excluded at Beauvoir-sur-Mer, because this marine product of high value was exploited and exported from there.

The system of gathering which resulted in the accumulations of Beauvoir-sur-Mer and Saint-Michel-en-L'Herm seems particularly destructive for the oyster beds. Because of the massive gathering procedures, young oysters are taken before they could reach a satisfactory size, and some were discarded during the extraction of the meat. In addition, removing dead shells reduces the surfaces on which spat oysters can grow. Thus, this activity could have a considerable impact on natural oyster-beds and lead to reducing the long-term viability of the industry. Today, these beds of oysters have disappeared. A few of them still existed during the 19th century but were in danger of over-exploitation (Cavoleau 1844).

The potential of the information which could be gained from the shell midden at Beauvoir-sur-Mer has been undoubtedly underestimated. This archaeological site is perhaps not an epiphenomenon. It could be part of a complex supply network of marine products for the cities. Indeed, there are indications of archaeological sites with a similar activity known but which have not yet been explored. The recent development (less than 5 years) of malacological analyses along the French Atlantic façade for historical contexts shows that villages located on the limit of old marshes show an exclusive exploitation of oysters outside habitat zones. The composition of these deposits contrasts with food refuse of the local populations. These coastal populations (Roman and medieval) also gathered limpets *Patella* sp., periwinkles *Littorina littorea*, fan scallops *Chlamys varia*, common edible cockles *Cerastoderma edule*, thick topped shells *Osilinus lineatus*, mussels *Mytilus edulis*, peppery furrow shells *Scrobicularia plana* and clams *Ruditapes decussatus*.

It would be interesting to know if all these sites with an exclusive exploitation of oysters are contemporary. The recent study at Langon, mentioned earlier, provides the beginning of answer. Although most of these sites seem to be medieval, this activity may have begun by the 1st century AD. We can also observe that oyster shells are found in lower quantities at medieval sites far from the sea compared with Roman ones. While this can be linked to archaeological biases (excavation of food refuses is less systematic in medieval contexts) we can suggest other possibilities. If exploitation of oysters increased during the Middle Ages, to what do these industrial exploitations of oysters correspond? Do they reflect an increased request from urban populations for marine products? The extraction of the meat from the shell would reduce the weight of product to be transported. Are new processes of preservation, such as the use of salt, the initiator of this new activity? Did the evolution of tastes and recipes get a new request? Historical sources are missing on this subject or have not yet been found. The limits of preservation conditions do not enable one to follow the course of the oyster meat from place of production to point of consumption because of the lack of associated artefacts currently found in these shell middens (ceramics for example) and the scarcity of excavations of such archaeological sites. One can, however, wonder whether the consumption of oysters and its economic impact during the Middle Ages, have been underestimated.

4. ACKNOWLEDGEMENTS

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Shells in the Middle Ages: archaeomalacological remains from the city walls at Pontevedra (Galicia, Spain)

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Shells in the Middle Ages: archaeomalacological remains from the city walls at Pontevedra (Galicia, Spain)

Conchas en la Edad Media: restos arqueomalacológicos de las murallas de Pontevedra (Galicia, España)

KEY WORDS: Marine molluscs, food, biometry, Middle Ages, North Spain.
PALABRAS CLAVE: Moluscos marinos, alimentación, biometría, Edad Media, Norte de España.
GAKO-HITZAK: Itsas moluskuak, elikadura, biometria, Erdi Aroa, Espainiaren iparraldea.

Esteban ÁLVAREZ-FERNÁNDEZ[1] & Juan Carlos CASTRO[2]

ABSTRACT

This paper presents the results of the first study of medieval malacological remains in the north of the Iberian Peninsula. The remains were recovered by excavations of the city walls at Pontevedra (Galicia, Spain).

RESUMEN

Se presenta el primer estudio malacológico de época medieval en el Norte de la P. Ibérica, procedente de las excavaciones llevadas a cabo en las murallas de la ciudad de Pontevedra (Galicia, España).

LABURPENA

Iberiar penintsularen iparraldeko Erdi Aroko lehen ikerketa malakologikoa aurkezten da, Pontevedra (Galizia, Espainia) hiriko harresietako induskeketatik aterata.

1. INTRODUCTION. THE ARCHAEOLOGICAL DEPOSIT

Pontevedra is located at the end of Pontevedra Ría, at the mouth of Lérez River, in Galicia. It is built on a rocky ridge, flattened by erosion. This ridge is not very high but has forced Lérez River to go around it on its northern side, before entering the Ría. Pontevedra has a strategic position since, when sailing up river from the sea, it is the first place where the Ría can be crossed by bridge in a north-south direction. The city was founded by Romans. In the Middle Ages, Pontevedra reached its greatest splendour when it become one of the most important ports in Galicia. This importance lasted until the 16th century (de la Peña 1996) (Fig. 1 left).

The archaeological fieldwork was carried out in 2004 (with a complementary phase in 2005), and was triggered by the project of building a new centre for Pontevedra Provincial Museum.The excavation area was centred on a section of the medieval city wall, nearly 55m long, and it included sectors both inside and outside the wall.

The area where this section of wall was built has been interpreted, in view of the archaeological record, as the city rubbish-dump, located on the bank of the River Lérez (Pontevedra Ria). A large number of bones, pottery, charcoal, and marine malacological remains were found. Although no radiocarbon determinations are currently available, the age of the deposit can be dated between the 12th - 13th and 15th centuries. The construction of the wall meant that, at least in the excavated sector, the dump was covered over by a series of pavements and previous layers of stones, aimed at preparing the terrain. The wall was demolished during the second half of the 19th century (Fig. 1 right)

2. METHODOLOGY OF THE STUDY OF THE MALACOLOGICAL REMAINS

The archaeological shell remains found in the city walls were determined to species level, using shells

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Figure 1. Left: location of the archaeological site. Right: archaeological excavations at the medieval city walls in Pontevedra (Spain).

characteristics such as size and shape, ornamentation and hinge, and by comparison with our reference collection of modern specimens. The nomenclature used for both gastropods and bivalves has been taken from CLEMAM (*Check List of European Marine Mollusca*, Muséum National d´Histoire Naturelle, Paris: http://www.somali.asso.fr/clemam).

The methodology used in the present work was adapted from R. Moreno's methods (Moreno 1994, Álvarez-Fernández 2007). The total number of remains (NR) was defined as the total number of specimens from each archaeological level.

For gastropods, in order to avoid the over-representation of species with a tendency to fragment, the minimum number of individuals (MNI) was defined using R. Moreno's formula:

MNI =ICOM + IFRA + [FAPI or (FEST + FUMB), whichever is the greater], where

ICOM = number of whole specimens

FAPI = number of apex fragments (without neither buccal zone nor umbo)

FEST = number of stoma fragments

FUMB = number of umbo fragments

IFRA = number of fragmented specimens with intact columella end and a broken lip. This parameter differs from R. Moreno, who included specimens with the apex but without the buccal zone.

For bivalves, NMI = VCOM + VFRA + FCHC + (FCHA or FCHP, whichever is the greater), where:

VCOM = number of whole valves

VFRA = number of fragmented valves

FCHC = number of whole hinge fragments

FCHA = number of anterior hinge fragments

FCHP = number of posterior hinge fragments

This index was calculated, separately, for right and left valves. The greater value was taken as the final MNI.

Biometric data were determined in whole specimens in order to establish possible climate indicators or selective gathering. All the data obtained, both qualitative and quantitative, has been processed using selected statistical tests.

3. MALACOLOGICAL REMAINS FROM THE CITY WALLS AT PONTEVEDRA (SPAIN): CLASSIFICATION, QUANTIFICATION, TAPHONOMY

A total of 1545 malacological remains were recovered from the rubbish dump, and the MNI has been calculated as 810. The sample of molluscs was varied, and a total of 14 different species of gastropods and bivalves were identified. The latter were the most common (90.6% of the total MNI). Among the bivalves the most abundant species was the flat oyster *Ostrea edulis* (Linné 1758) which represented nearly 50% of these molluscs. It was followed by the clam *Ruditapes decussatus* (Linné 1758) and the cockle *Cerastoderma glaucum* (Poiret 1789), with quite similar percentages (24.25% and 22.60%, respectively). Only 21 specimens of mussel *Mytilus galloprovincialis* (Lamarck 1819) were found (2.9%). Regarding gastropods, the most common species was the periwinkle *Littorina littorea* (Linné 1758), with 68 specimens. With percentages below 2%, the other species were represented by specimens of the bivalves: *Glycymeris glycymeris* (Linné 1758), *Pecten maximus* (Linné 1758) and *Venus verrucosa* (Linné 1758), and the gastropods: *Patella vulgata* (Linné 1758), *Patella intermedia* (Murrai in Knapp, 1857), *Patella* sp., *Neptunea contraria* (Linné 1771), *Charonia lampas* (Linné 1758), *Gibbula* sp. and *Nassarius reticulatus* (Linné 1758) (Fig. 2, 3; Table 1).

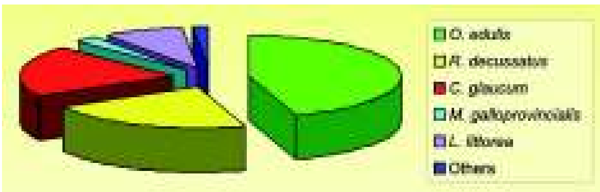

Figure 2. MNI percentages for the different mollusc species recovered by the city walls at Pontevedra (Spain).

3.1. The great majority of molluscs found were edible (99.5% of the MNI).

Ostrea edulis is usually found in estuaries, in all substrates, mainly sandy or muddy. *Littorina liitorea*, *Patella* sp. and *Mytilus galloprovincialis* live attached to the rocks in the intertidal fringe. *Ruditapes decussatus* and *Cerastoderma glaucum* live in sandy

	GASTROPODS	
	NR	MNI
Littorina littorea	68	68
Neptunea contraria	1	1
Charonia lampas	1	1
Patella vulgata	2	2
Patella intermedia	1	1
Patella sp.	1	1
Gibbula sp.	1	1
Nassarius reticulatus	1	1
	BIVALVES	
	NR	MNI
Ostrea edulis	755	364
Ruditapes decussatus	310	178
Cerastoderma glaucum	325	166
Mytilus galloprovincialis	62	21
Glycymeris glycymeris	1	1
Pecten maximus	15	3
Venus verrucosa	1	1
Total	1469	734
TOTALS	1545	810

Table 1. Abundance of taxa from Pontevedra city walls (Spain).

substrates, usually in estuaries or in sandy beaches. *Pecten maximus* and *Venus verrucosa* live in sandy substrates, usually in sandy beaches.

There is a preference for mollucs from estuarines or sandy beaches (*Ostrea edulis, Ruditapes decussatus* and *Cerastoderma glaucum*) (ca 88 %).

The good conservation of the specimens clearly indicates that molluscs were gathered alive, most probably for food, and were not collected dead in the shores. Specimens collected dead in the beaches are usually eroded and not intact.

For example, five *Cerastoderma glaucum* specimens preserve the ligaments joining the right and left valves. Fragmentation only affects the bivalves, mainly *Pecten maximus* and *Mytilus galloprovincialis*, and to a lesser degree, *Ostrea edulis*, *Ruditapes decussatus* and *Cerastoderma glaucum*.

Only one specimen, a *Glycymeris glycymeris* valve, displayed alterations to its surface, and had been gathered after prolonged exposure to coastal hydrodynamics. No other specimens were found with other organisms incrusted on their surfaces (barnacles, etc.).

A number of the flat oyster valves showed evidence of human alterations, as a result of extracting the animal by leverage (Fig. 3 left). These alterations are found on the opposite side of the shell to the hinge.

The absence of alterations by fire suggests that molluscs were probably eaten fresh or were boiled.

4. MALACOLOGICAL REMAINS FROM THE CITY WALLS AT PONTEVEDRA (SPAIN): BIOMETRY

Biometric analysis has been carried out for the shells of the most common species in the deposit: *Ostrea edulis, Cerastoderma glaucum* and *Ruditapes decussatus* (Table 2).

To determine if the bivalves of a certain size were gathered selectively, the right valves of the species were chosen as these totalled a higher MNI. The variable "length" was used for all the shells. In view of the data, a preference can be seen for medium and large-sized specimens of all the species.

The modern-day commercial size of oysters (left valves) in the Galician Rias Bajas is 60-70mm, a length they reach at an age of 18-24 months. Bearing in mind this information, the percentage of oysters with lengths ≥ 60mm is 65.1%. However, the range with the largest number of specimens is between 60-70 mm (33.1%). Few archaeological specimens are longer than 90mm (4 shells), whereas modern oysters can reach 150mm in length.

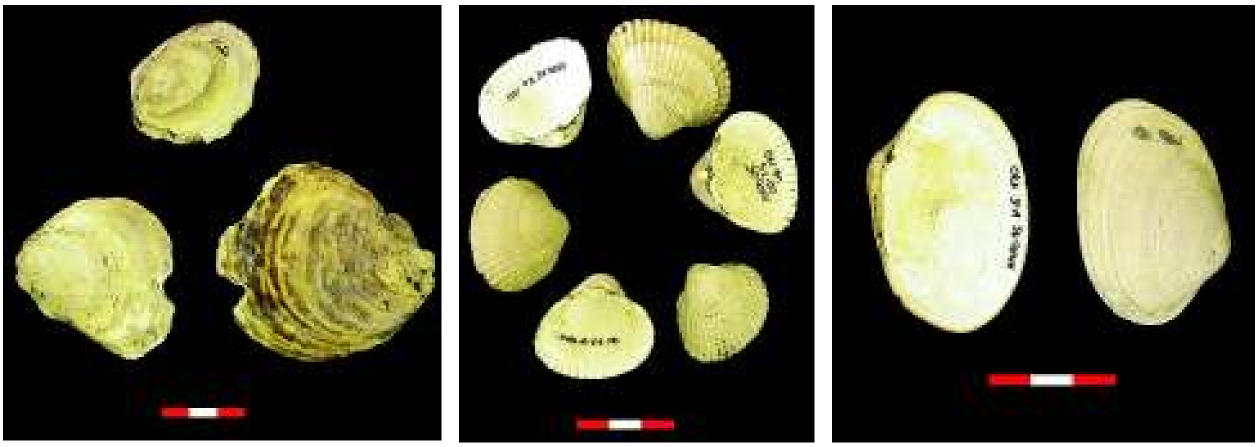

Figure 3. Specimens of *Ostrea edulis* (left), *Cerastoderma glaucum* (middle) and *Ruditapes decussatus* (right), from Pontevedra city walls (Spain).

	LMRO	LMLO	HMRO	HMLO	LMRC	LMLC	HMRC	HMLC	LMRR	LMLR	HMRR	HMLR
N	212	180	212	180	124	53	124	53	117	35	117	35
Mean (mm)	58.31	64.64	60.67	66.09	35.29	34.49	31.52	30.69	52.34	51.42	38.75	37.34
Median (mm)	58.35	65.45	59.65	65.6	36.2	35.5	32.35	31	52.9	53.4	38.6	37.1
Mode	57.4	66.1	57.4	69	36.2	39.8	32.4	34.2	57.6	54.8	43	35.6
Variance	76.76	144.72	85.87	179.74	23.56	26.12	17	20.4	37.61	34.91	25.95	21.07
s.d.	8.76	12.03	9.26	13.40	4.85	5.11	4.12	4.51	6.13	5.9	5.09	4.59
Minimum (mm)	29.3	32.6	40.1	33.1	13.2	19.02	11.8	15.9	30.2	37.2	56.8	28.3
Maximum (mm)	85.8	103.1	91.5	119.9	43.3	42.3	37.9	36.8	64.2	59.9	23.5	51.5

Table 2. *Descriptive statistics* of the measurements of length (LM) and height (HM), taken from right (R) and left (L) valves of the species *Ostrea edulis* (O), *Cerastoderma glaucum* (C) and *Ruditapes decussatus* (R) found by the medieval city walls at Pontevedra (Spain).

As regards the cockles, their commercial size is between 30 and 40mm. They reach this size in the first year of the three years they can live. The percentage of this bivalve with a size ≥ 30mm is 79.03%. The range with the largest number of specimens is between 30-<35mm (67.74%).

Finally, in the case of the clams, in the Atlantic façade of France their modern commercial size is between 40 and 50mm (Queró and Vayne 1998). The percentage of archaeological specimens ≥ 40mm is 36.75%. The range with largest number of specimens is 35-<40mm (43.58%). Only one specimen is over 50mm in length; modern *R. decussatus* specimens can reach a length of 70mm.

5. MALACOLOGICAL REMAINS OF MEDIEVAL AGE IN THE IBERIAN PENINSULA

Few references have been made to the presence of marine molluscs at medieval sites in the Iberian Peninsula, and studies of an exclusively archaeomalacological type (correct classification to species level, quantification, taphonomy, biometry, etc.) are rare.

In the first place, referring only to the north of the Iberian Peninsula, we can cite the *Patella* sp. remains recorded by archaeological excavations in the city of Oviedo (Asturias), with ages that range from the 12th and 13th centuries to the 18th century (Adán 1997). At the early medieval fortress of Bolera de los Moros (Piñeres, Peñarrubia, Cantabria) eleven *Ostrea edulis* shells were recorded (Sarabia 2002). Similarly, *Ostrea edulis* and *Venus verrucosa* shells were found at Camargo Castle, also in Cantabria, dated from the mid-8th century onwards (Bohigas 2000). The indeterminate malacological remains found in Level II at the parish church of St Maria de la Asunción in Laredo (Cantabria) are more modern (16th – 19th centuries) (Rasines and Laudes 2000).

Further south, discoveries and research on malacological remains are more frequent. Thus, for instance, at the medieval city of Mértola (Baixo Alentejo, Portugal) a small number of remains (thirty individuals) of different gastropod and bival-

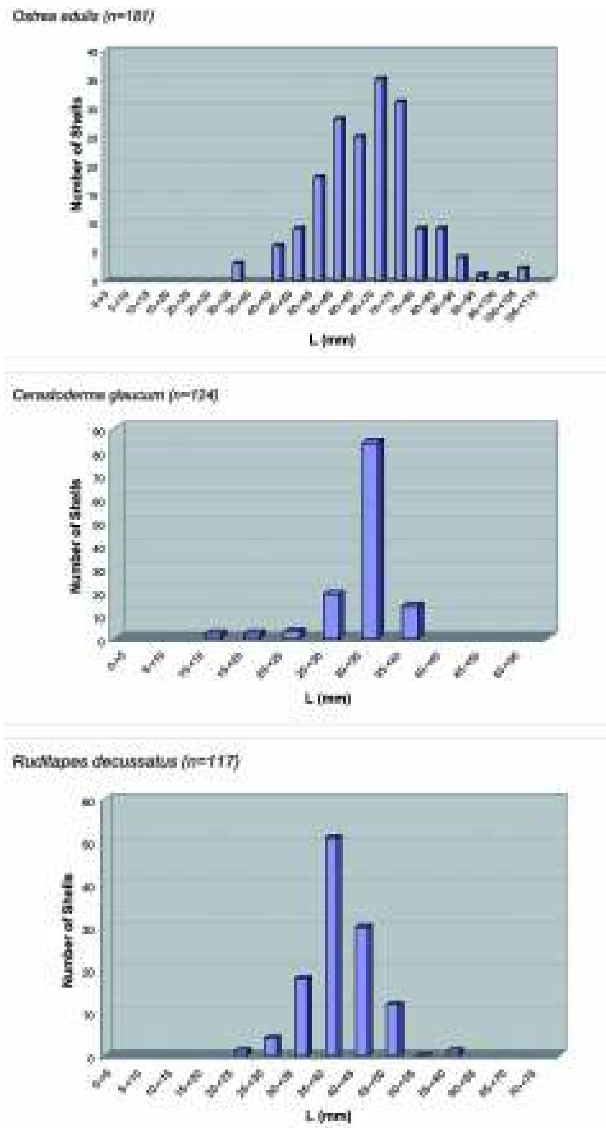

Figure 4. Frequencies of the size (mm) of left valves of *Ostrea edulis* (O) and of right valves of *Cerastoderma glaucum* (C) and *Ruditapes decussatus* (R) from the city walls at Pontevedra.

ve species have been documented. The most common species are *Ruditapes decussatus*, followed by *Cerastoderma edule* (Moreno 1993). Different archaeological excavations in the city of Seville, dated in the 11th – 19th centuries, have recorded large amounts of malacological remains, mainly belonging to oysters (Bernáldez and Bernáldez 2002). The Islamic rubbish-dump at the ancient Roman villa at La Almagra (Huelva) (12th and 13th centuries) includes several pits with large quantities of malacological remains. Nº. 8 yielded over 1300 *Ensis minor* individuals, associated with fewer remains of other species (mainly *Ruditapes decussatus* and *Ostrea edulis*), whereas some 250 individuals were found in pit nº. 100, mainly *Ruditapes decussatus* and *Solen margaritaceus* (Bernáldez and Bernáldez 2005).

6. FIRST REFLECTIONS

6.1. Molluscs were, most probably, collected alive, for food, and eaten fresh or boiled

The sample of marine molluscs, found in the course of the excavation by the medieval city walls at Pontevedra are evidence for the consumption of three main bivalve species with bromatological interest: *Ostrea edulis, Cerastoderma glaucum* and *Ruditapes decussatus*. These species were certainly collected in the Ría or in the sandy shores. Some species, like periwinkles, were gathered in the nearby rocky shores.

The shells that have been studied are in an optimal state of conservation. Thus, for example, human action can be recognized in the oysters, as some flat valves still preserve the marks made when extracting the animal. This suggests that these molluscs were either eaten raw, or the shells were opened before being cooked.

6.2. Specimens of a certain size were chosen

The biometric analysis that has been undertaken has shown that the bivalves (*Ostrea edulis, Cerastoderma glaucum* and *Ruditapes decussatus*) were selected for their consumption according to their size. In this way, by comparing the archaeological specimens with modern shellfish on sale in the Rias Bajas in Galicia, it can be noted that the medieval inhabitants of Pontevedra selected the medium and large-sized specimens of the above species.

The appreciable size of the shells suggests that there was probably no over-exploitation (in the Middle Ages, molluscs were certainly not the main source of food, even at sites with plenty of shellfish resources).

Although no information is currently available, it can be supposed that natural oyster banks existed in the area during the medieval period, as in different parts of the Atlantic façade of France in the Middle Ages and Renaissance. The earliest data comes from the Roman period, as has been documented at many locations in Europe, such as at the site of La Ferme aux Mouches 2 (Somme, France) (Dupont and Blondiau 2006). In the Iberian Peninsula they have been cited at Tarragona city (Luján 1988).

Archaeomalacological research at medieval sites on the Atlantic façade of France are, as in our region, quite scarce. A recent study of molluscs found at the monastery of Saint-Vivien (Charente-Maritime), dated in the late 14th century indicates a predominant consumption of oysters (>60%). Other species include mussels, clams, scallops and limpets. The biometric data for the oysters (mean: 57mm; left valves) (Dupont 2005) shows the individuals were slightly smaller than the ones recovered from Pontevedra city walls.

It was not until the 18th century that oysters began to be farmed in the salt-works reservoirs on the Atlantic coast of France. Later they were grown in specially prepared tanks (Héral 1991). In Galicia, the natural oyster banks disappeared in the 1950s, which led to the development of oyster farming, above all from the 1970s (Pérez 1987).

In the case of clams, the earliest evidence of their farming comes from Japan in the 8th century, and may go back to the 13th century in Galicia (Cifuentes *et al.* 1990). Bouxin introduced a standardized farming technique on different kinds of substrates in 1936 (de Valence and Pierre 1991). Finally, in this region, cockle farming goes back to the middle of the last century.

Future archaeomalacological studies at other sites in northern Spain will contribute towards a better understanding of marine components of the medieval diet in this part of the Iberian Peninsula based on the archaeological evidence.

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Indirect detection of changes in Seville population studying size changes in oysters?

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Indirect detection of changes in Seville population studying size changes in oysters?

Detección indirecta de cambios en la población de Sevilla a partir de cambios de tamaño en ostras?

KEY WORDS: *Ostrea edulis*, Paleobiology, Paleodemography, Middle Ages, Modern Age.
PALABRAS CLAVE: *Ostrea edulis*, paleobiología, paleodemografía, Edad Media, Edad Moderna.
GAKO-HITZAK: *Ostrea edulis,* paleobiologia, paleodemografia, Erdi Aroa, Aro Modernoa.

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ABSTRACT

Shell middens contain important information on subsistence activity in human economies. The use of paleodemographic documentation can explain the importance of certain products in our diet. One of these products is oyster (*Ostrea edulis*) (Ladero 1989), also found in pictorial documentation of the studied centuries (See: Fig. 1). We have measured two hundred and eighty-three (N=283) right valves of *Ostrea edulis* (Linnaeus 1752), sampled from four archaeological deposits found in Seville that date back to the 14th and 18th centuries A.D. In this paper we present the hypothesis on the possible relationship between oyster consumption and demographic changes undergone in Seville during these centuries.

RESUMEN

Si bien los paleobasureros son un exponente de la actividad trófica del hombre en el pasado, la documentación paleodemográfica que conocemos puede explicar la importancia que tuvieron ciertos productos en nuestra alimentación. Uno de esos alimentos, descritos en la bibliografía (Ladero 1989) y en las pinturas de la época, es la ostra –por ejemplo fig. 1 -. Se han medido 283 valvas de *Ostrea edulis* (Linnaeus 1752) procedentes del registro paleobiológico de cuatro yacimientos arqueológicos localizados en la ciudad de Sevilla y datados entre los siglos XIV y XVIII d. C. En este trabajo se presenta una hipótesis de la posible relación que mantuvo el consumo de ostras con los cambios demográficos que experimentó Sevilla en este periodo histórico.

LABURPENA

Paleozabortegiak antzinako gizakiaren jarduera trofikoaren erakusgarriak badira ere, ezagutzen dugun dokumentazio paleodemografikoak azal dezake zer-nolako garrantzia izan zuten zenbait produktuk elikaduran. Elikagai horietako bat, bibliografian (Ladero 1989) eta garai hartako margolanetan deskribatua, ostra da –esate baterako, 1. irudia–. Ostrea edulisen 283 kusku neurtu dira (Linnaeus 1752), Sevilla hiriko lau aztarnategi arkeologikotako erregistro paleobiologikotik ateratakoak, K.o. XIV. eta XVIII. mendeen artean datatuak. Lan honetan, Sevillan periodo historiko hartan izandako aldaketa demografikoan ostren kontsumoak izan zezakeen eraginari buruzko hipotesi bat aurkezten da.

1. INTRODUCTION

Shell middens are a record of the use of natural resources and environment by humankind. These structures have become a reliable record that can be used to interpret the evolution of subsistence in a specific ecosystem and culture. Taking into account not only the contents but also the features and distribution of the container, middens stand for an indicator of the environmental impact of humankind on the different species from the exploited ecosystem (Bernáldez 1996, 2002).

Figure 1. In this still life from Meléndez (17th and 18th centuries) called *"Ostras, huevos y un perol"* oysters are presented on a table without luxury. This shows that consumption of oysters is not only restricted to the wealthy.

Seville has a rich archaeological record dating back to the 8th century b.C. The frequent discove-

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ries of organic material in archaeological deposits, either as rubbish from other periods (Bernáldez and Bernáldez 1998), as an offering (Minniti and Peyronel 2005; Bernáldez and Bernáldez 2005a, Álvarez-Fernández, 2006) or because of its use in constructions (Bernáldez & Bernáldez, 2002, Bernáldez *et al.* 2009 in press, Niveau de Villedary 2006, Arruda and De Freitas 2008, Abad and Sala 2007, Arancibia and Escalante 2006) contributes to the reliability of the paleobiologic interpretation of these deposits and, in some cases, show the overexploitation of natural resources (Swadling, 1976, Jerardino 1997, Mannino and Thomas 2002, Milner *et al.* 2007, Erlandson *et al.* 2008). This is verified in present-day societies by actualistic pieces of research carried out in different places (Catterall *et al.* 1987, Hockey and Bosman 1986, Keough *et al.* 1993, Nagaoka 2002).

One of the most common species identified in archaeological deposits from the end of the 14th century till the 18th is *Ostrea edulis* (Linnaeus 1952). During this 400 year period, changes in the average size of valves have been observed. Some of these changes correspond, at least in this city, to human demographic changes. The importance of this type of food for the 17th century population is described by Morales (1989:146). In 1562, a pair of oysters cost four *maravedíes*, a reasonable price for salary earners in those times, taking into account that a stevedore earned 350 *maravedíes*. Also, 17th century still lifes from the Netherland and Spanish pictorial schools seem to show the relevance of this food, the difference between these two being that in the former this element appears on wealthy family tables while in Spanish still lifes, oysters can be seen in common people's kitchens (Fig.1).

As a conclusion, oyster value in the 16th and 17th centuries can be deduced through archaeological discoveries, bibliographical quotes and paintings.

2. POPULATION ECOLOGY OF *OSTREA EDULIS*

The genus *Ostrea* has been an important food source over the centuries (Zobele and Negra 2009). *Ostrea edulis* is a Mediterranean species, living in rocky bottoms of medium and low depths and feeding on phytoplankton and other particles through microfiltration. This species is highly adapted to its environment (Zobele and Negra 2009). It inhabits environments with salinity levels ranging between 16% and 34%, and temperatures between 5 and 25ºC (Hutchinson and Hawkins 1992), which makes them capable of living in a wide spectrum of habitats. The size of an adult specimen ranges between 100 and 120 mm, although the minimum size allowed for its consumption in the South of Spain is around 80 mm (Consejería de Agricultura y Pesca 2001). Oysters find several difficulties to their development; the presence of parasites such as *Bonamia ostreae* and *Marteilia refringens* detected in the 60's, and abrupt drops of temperature (Lapègue *et al.* 2006).

Finally, it is worth mentioning that reproductive processes in this species are highly efficient, because of the high synchronization between individuals and of the large number of gametes freed into the environment (Zobele and Negra 2009), together with their protandric hermaphrodite character (Lapégue et al, 2006). Even being eurohalyne organisms, for younger specimens the salinity range is narrower (Hill, 1980), from 20% (optimum) to less than 15% (Lapégue *et al.* 2006).

3. SEVILLE DEMOGRAPHIC EVOLUTION BETWEEN THE 14TH AND 18TH CENTURIES

Seville has undergone great population variations through its history (Collantes de Terán 2002, Fernández 2002), such as the presence of other important European populations. These differences lead to changes in the use of territory and the exploitation of natural resources. Molluscs are one of the elements having experienced these changes, which could be the reason for the changes in oyster size through the city's history. The record of *Ostrea edulis* in Sevillian archaeological sites increases from the 14th century onwards, and it is now that enough valves have been collected to carry on a statistically reliable research on oyster biometric trend. Before this period, Seville was inhabited by Muslims, whose culture forbids the consumption of shellfish (Coram 35, 13). Despite this, and although scarce, some records of this animal group have been found in Seville and Huelva deposits studied by our team (Bernáldez and Bernáldez 2005b, Bernáldez and García-Viñas 2008).

At the beginning of 13th century (1248) Fernando III conquered Seville, establishing the end of *Isbiliya* and the beginning of Seville (Collantes de Terán 2002). This brought an important increase in the commercial activities between the Atlantic Ocean and the Mediterranean Sea, which made Seville one of the most important and most populated cities in the Kingdom of Castile. The population of Seville was of 20,000 inhabitants at the end of 14th and beginning of 15th century, and of 40,000 at the end of 15th century. While Seville was the centre of commercial relations with

America its population continued growing; from 50,000 inhabitants in 1530 to 125,000 (150,000 according to Fernández (2002) and 140,000 in 1588 according to Domínguez (1989)).

However, several disasters, such as the bubonic plague in 1649, decimated the population, which reduced the number of inhabitants by 50%, resulting in an estimated population of between 60,000-80,000 inhabitants (Fernández 2002), and 63,000 in 1655 (Domínguez 1989). From this date onwards, the number of inhabitants varies between 75,000 and 80,000 (Dominguez, 1989), until the middle of the 19th century, when the number of 100,000 inhabitants was surpassed.

4. METHODOLOGY

For the purposes of this research we have used 213 *Ostrea edulis* right (upper side) valves in good condition from four Sevillian archaeological deposits. Two of these archaeological sites -Plaza de la Encarnación (Encarnación Square) and La Catedral (The Cathedral)- are located within the ancient wall of the city, and the other two -Las Reales Atarazanas (The Royal Shipyard) and El Castillo de San Jorge (Saint George's Castle)- are found outside the ancient walls (See: Fig. 2).

The location of these deposits –except for the one in Plaza de la Encarnación- in the seaboard area of the city between the late 14th and 16th century, could stand for their presence, although they are also found in different places with a different economic tradition.

We have used subfossil material extracted from 25 samples taken from three of the seven naves of the current building of Las Reales Atarazanas archaeological site. This material originates from urban activity between the 13th and 18th centuries (Bernáldez and Bernáldez 1997). In the archaeological site of La Catedral (Tabales *et al*. 1996, Tabales and Jiménez 1997) we have analysed three different cuts with paleorganic records dating from the 11th to the 18th centuries. In this case middens were formed by organic waste used for building the Cathedral (Bernáldez and Bernáldez 2002). Also, we have rescued material dating from the 4th to the 19th centuries out of several cuts in El Castillo de San Jorge archaeological site (Hunt 1998). Finally, elements dating from the 1st century to this day have been extracted from the Plaza de la Encarnación archaeological site. From a taphonomic point of view, the good condition of the specimens, together with the archaeologists' skills have prevented information losses due to fracturing, especially in smaller and more fragile elements.

After preparing the organic material at the IAPH Paleobiology Laboratory, the collected valves were subject to a biometric analysis, considering two measures: maximum length (LM) and maximum width (AM) in mm (See: Fig. 3), although only LM values are used for this research.

The Central Limit Theorem, defined by Laplace and Gauss in the 19th century –which we are considering for this research- states that samples always follow a normal distribution which adjusts better as the number of data increases (Milton 2007, Ramos 2006). Following the verification of homoscedasticity (Levene's test), we have applied the ANOVA test in order to verify if there are significant differences between the groups and, if so, we have used the Scheffé and Bonferroni's tests to determine during which concrete period or periods can they

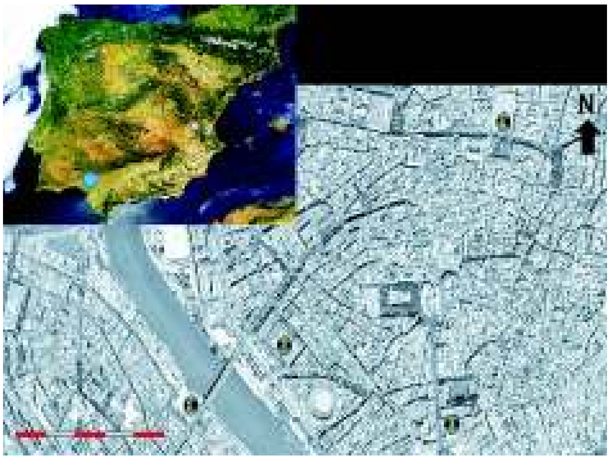

Figure 2. Settlement of the studied deposits in Seville (South of Spain): 1. Castillo de San Jorge (Triana market), 2. Reales Atarazanas, 3. Catedral, 4. Plaza de la Encarnación.

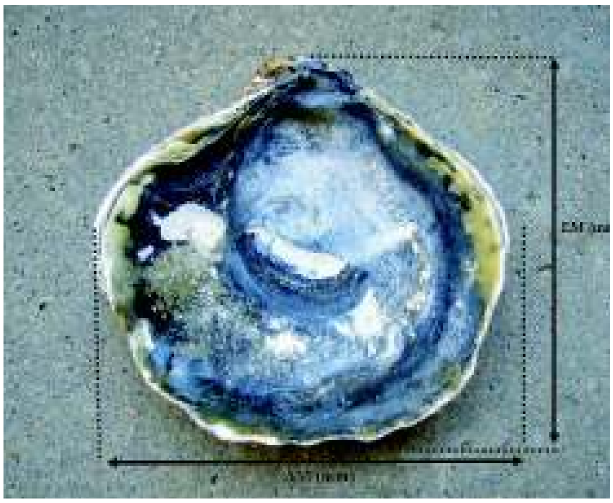

Figure 3. Measures (mm) of Ostrea edulis valves: LM (length) and AM (width).

be observed. In order to detect the existence of a relationship between oyster valves size and Seville's population through time we have applied Spearman's rank correlation coefficient.

5. RESULTS: VARIATION IN THE SIZE OF OYSTERS FROM SEVILLIAN ARCHAEOLOGICAL DEPOSITS DATING FROM THE 15TH AND 17TH CENTURIES

During the years of collection of malacological material, we have noticed that the average size of valves and snails reaches, at least, the optimum size when they are destined for consumption; and that, as has been proved in (Bernáldez *et al.* 2008), although the emplacement of the deposit can favour the mixture of elements from non anthropic activities, it is obvious that collectors picked the biggest elements if the energy balance –the ratio between the energy supplied by the food and the energy spent in obtaining it- is positive (Valverde 1967). Nowadays (2001), the Consejería de Agricultura y Pesca de la Junta de Andalucía (Andalusian Government on Agriculture and Fishing) determines the minimum consumption size for oysters from our coasts in 80 mm.

The first result observable in the biometric data base of oysters is that the average size is bigger than the current one stipulated by the Junta de Andalucía, and that it remains almost constant (see Figure 4) from the 15th to the 16th century (see Table 1). However, valves collected in late 16th century middens undergo an average reduction of 24 mm, only to rise up again in around 31 mm in 17th century middens. This detected decrease is statistically significant, and through the application of an ANOVA we obtain a p-value of 0.000, which makes us reject the H_0 of samples equity. Then, we compare the groups two by two through the application of the Scheffé and Bonferroni's tests, coming to the conclusion that the only group that is significantly different from the rest is the one made up of oysters dating from the late 16th century, with p-values of less than 0.05. In order to contrast this hypothesis, we have made two homogeneous subgroups (see Table 3), the first made up exclusively of valves from the 16th century. Even though the number of valves from this period at our disposal is low, available data allow us to show a tendency in this historical moment.

There are several possible explanations to a species decreasing significantly: physic- chemical changes in the environment causing a lack of saturation of nutrients, an increase in the intraspecific or interspecific competence for space in population (which would eventually be induced by the previous cause or, as it is a rupicolous species, by the lack of rocky substrates), -a change in the environment temperature,…

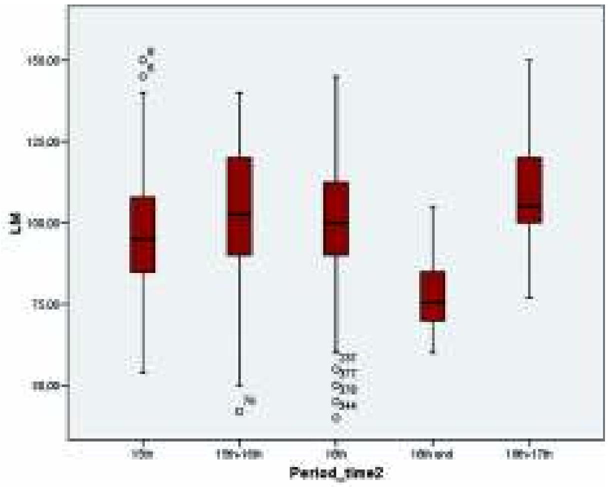

Figure 4. Size (LM in mm) of oysters from Seville archaeological sites in different periods of time. LM stands for the valves maximum length.

	DEMOGRAPHY
14th-15th	20.000
15th	40.000
15th-16th	40.000
16th	50.000
16th end	137.500
16th-17th	70.000
17th	70.000
18th	78.000

Table 1. Number of inhabitants in Seville in specific historical periods (Collantes de Terán, 2002; Fernández, 2002; Domínguez, 1989).

LM (MM)			
Levene's test	gl1	gl2	Sig.
1,778	4	380	0,132

Table 2. Test for homogeneity of variances. LM stands for the maximum length of the valve, gl for the degrees of freedom, and sig for the p-value Alpha=0.05.

LM (MM)				
	Period_time	N	Subgroup for alpha = .05	
		1	2	1
Scheffé (a,b)	16th end	14	77.8171	
	15th	63		97.8389
	16th	155		101.5275
	15th--16th	88		103.9443
	16th--17th	65		108.6723
	Sig.		1.000	.149

Table 3. Test of homogeneous subgroups. LM stands for the valves maximum length and N for the number of valves. Average measures for groups in homogeneous subgroups shown.

a. Using sample size of harmonic average = 41.493.
b. Groups sizes are not equal. Using harmonic average of groups' sizes. Type I error levels are not assured

Nowadays, the Guadalquivir River is undergoing a high index of salinity affecting faunal composition and the structure of its biocenosis; this situation will end up affecting the fishing of some species and the use of water in agriculture, two basic activities in the everyday life of Seville citizens in the studied centuries. The consequences have not been studied yet, but rice producers are demanding research on the causes of this extremely negative effect on food production. The same exact situation may have occurred in another historical moment of this river, as its low section is affected by tides. One of the consequences of this change could have become an advantage as the increase of salinity would make possible to install oyster beds close to the city, which, in turn, would have given oysters a reasonable price (Morales 1989: 146). The fact that oysters were not unaffordable for most of the inhabitants could stand for the existence of oyster beds -as in Roman Tarragona (Luján 1988), because travelling 70 km to the seaside (Arteaga and Roos 2005) to collect them would have increased their price considerably.

Besides, changes of temperature were generally drastic in those centuries, to such an extent that those times are called "the little Ice Age" (Fagan 2001), with four peak points in the middle of the 15th, end of the 16th and beginning of the 17th, end of the 18th, and middle of the 19th centuries (Martín & Olcina 2001). These changes would have altered salt and oxygen concentrations in the aquatic environment, but desalinating it, which, as a consequence, would not explain the installation of a close oyster bed. Even though Fagan (2003) establishes that there are not important changes in Europe to justify changes in biocenosis, he fails to explain if these justify size variations -in fact Sousa and García-Murillo (2003) point out that this period would have implied an increase in rainfall and floods in the South of the Iberian Peninsula. This, together with the capacity of absorbing temperature variations of the aquatic environments, and with the fact that peak points have been detected in periods other than those studied here, could justify the rejection of this theory as a justification of size change in studied oysters.

Finally, it could have happened that oyster size was marked by the degree of pressure exerted by predators on a population and that, as a consequence, the increase of captures reduced the regeneration time, limiting their size and vice versa. According to this theory, it is important to take into account changes in consumption preferences, marked either by culture or by the value of the product. That is, oysters have gone from appearing in archaeological sites before the 14th century to be found in -larger numbers in deposits after the Reconquista. The fact that large amounts of oysters have been found in the outskirts of the city means that this was a food for poor people, this theory being supported by documentation of those times. In order to strengthen the hypothesis posed to explain changes in oyster size, we shall study the amount of oysters collected indirectly, through demographic changes undergone by the city of Seville during this historical period, and for this purpose we are assuming that the bigger the number of inhabitants in a city, the higher is the probability that the consumption of this shellfish increases.

5. CONCLUSION AND DISCUSSION: HUMAN BEINGS AND OYSTERS: COHABITATION DURING 400 YEARS

If we compare the trend in oyster size variation to Seville demographic data in each historical period, it can be noticed that there is a coincidence between peaks of maximum number of inhabitants and minimum oyster size and vice versa. Although there is not a significative inverted proportional relation (Rho Spearman= -0.555, p-value= 0. 257 for α=0.05), possibly due to the small number of samples, it is not appropriate to reject the possibility of a relationship between demography in Seville and oyster size (see: Fig. 5).

This analysis shows size changes in these types of oysters between the 14th and 18th centuries, and their possible relation to demographic changes in the city of Seville. During the period of highest human population density, the late 16th century, valves average size was the smallest in comparison to other centuries. So, when the population of the city tripled, at the end of the 16th century, the average size of valves reduced by 23.71%, and in the 17th century, when there was a 50% decrease in the number of inhabitants, valves size increased by 23.89% (see figure 5). Although we also have data from the 17th and 18th century that follow this trend, they have not been included in the statistical analysis, as their number is smaller.

These trends entitle us to propose the existence of a relationship between oyster size and human population density from the end of 14th century to the 18th century, and we pose the hypothesis that the cause for these size variations may be human demand of this product when the population increases as spectacularly as as it did in Seville after the discovery of America, when it became the exit port for the colonization of that area, or to do business with emigrants. If this point was true, it would prove that paleobiologic records associated with human beings are an indispensable source of information to understand the evolution of the ecosystems and human behaviour called culture.

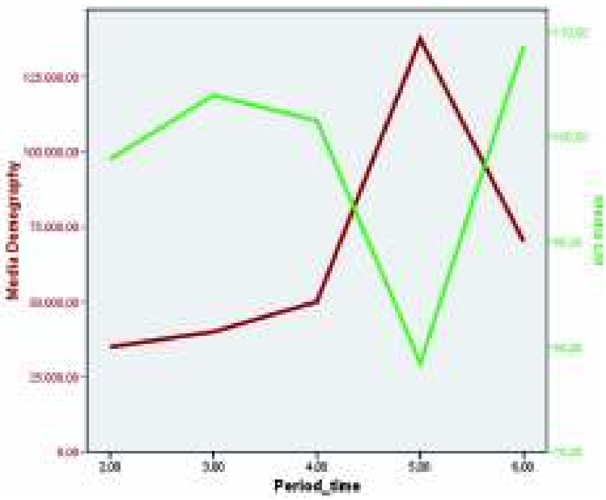

Figure 5. The graph represent the number of inhabitants in Seville and the LM of oysters from several archaeological sites related to a specific historical period. It can be noticed that there is a possible inverted relation in the late 16th century and the 17th century. 2: 14th -15th Centuries; 3: 15th Century; 4: 16th Century; 5: end of the 16th Century; 6: 16th-17th Centuries.

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Manufacturing techniques of Oliva pendants at Xochicalco (Morelos, México)

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Manufacturing techniques of Oliva pendants at Xochicalco (Morelos, México)

Técnicas de manufactura de colgantes de Oliva en Xochicalco (Morelos, México)

KEY WORDS: Shells, pendants, Epiclassic, manufacture, Xochicalco.
PALABRAS CLAVE: Caracoles, objetos de adorno-colgantes, Epiclásico, manufactura, Xochicalco.
GAKO-HITZAK: Barraskiloak, belarritakoak, Epiklasikoa, manufaktura, Xochicalco.

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ABSTRACT

At the Epiclassic (AD 650-900) site of Xochicalco, in the Western Valley of Morelos, México, archaeologists have recovered an abundance of Oliva shell pendants (also known as tinklers). These pendants had once formed necklaces and were placed in the most ancient offerings inside the main structures of the settlement. Through experimental archaeology and the analysis of manufacturing traces using Optic Microscopy (OM) and Scanning Electron Microscopy (SEM), I identified the different tools and techniques employed in shell production. Surprisingly, the pendants presented three different technologies, despite the fact that they were part of the same necklace and offering. This heterogeneity probably reflects different working groups or shell workshops, especially when considering that, in the later stages of the site, the shell objects present a stronger standardisation in their manufacture and seem all to come from one shell workshop at the Acrópolis in the Main Plaza.

RESUMEN

En el sitio Epiclásico (650-900 d.C.) de Xochicalco, en el Valle Oeste del estado de Morelos, diferentes arqueólogos han recuperado objetos de adorno elaborados a partir de caracoles de diferentes especies de Oliva (también conocidos como cascabeles), varios de ellos formando sartales en las ofrendas más antiguas enterradas en sus estructuras principales. A través de la arqueología experimental y el análisis de huellas de manufactura con Microscopía Óptica (MO) y Microscopía Electrónica de Barrido (MEB), pude identificar las diferentes herramientas y técnicas empleadas en la elaboración de las piezas. Llama la atención la identificación de la utilización de tres tecnologías diferentes para su elaboración, sin importar si formaban parte de un mismo sartal u ofrenda. Probablemente esta heterogeneidad se debe a que fueron producidos por distintos grupos de artesanos o talleres de concha, ya que en las etapas más tardías del asentamiento los objetos presentan una marcada estandarización tecnológica en su manufactura y que solo existe un taller de concha ubicado en la Acrópolis de la Plaza Principal.

LABURPENA

Xochicalco leku Epiklasikoan (K.o. 650-900), Morelos estatuko mendebaldeko bailaran, arkeologoek Oliva espezieko barraskiloz (cascabel izenez ere ezagunak) egindako apaingarriak berreskuratu dituzte, egitura nagusietan lurperatutako eskaintzak, sortak osatzen dituztela. Arkeologia esperimentalaren eta manufaktura-arrastoak Mikroskopia Optiko (MO) eta Ekorketako Mikroskopia Elektroniko (EME) bidez aztertuz, piezak egiteko erabiltzen zituzten tresnak eta teknikak identifikatu ahal izan dira. Deigarria da apaingarriak egiteko hiru teknika desberdin erabiltzen zituztela, sorta berekoa izan ala ez. Agian, heterogeneotasun horrek esan nahi du zenbait artisauk egin zituztela edo zenbait maskor-tailerretan egin zituztela, kokalekuko etapa berantiarrenetan, objektuen manufakturan estandarizazio teknologiko nabarmena ageri baita eta maskor-tailer bakarra baitago Plaza Nagusiko Akropolian.

1. INTRODUCTION

Shell productions were highly valuable prestige goods for, Mesoamerican groups, especially for those living inland, far away from the coasts, due to their foreign, rare and exotic character (Hohmann 2002: 4, Moholy-Nagy 1995: 7, 8). During the Middle pre-Classic period (1200-400 BC), great amounts of shell objects were used to visually manifest prestige and hierarchies within the settlements, as is the case in Teopantecuanitlán, Guerrero (Solís 2007). During the Classic period (AD 200-650), this tendency continued in Teotihuacan, where many shell objects have been recovered in different parts of the city (Kolb 1987). Therefore, it is not surprising that 2532 archaeological shell artefacts were found at Xochicalco (Fig. 1a), an important fortified site in the state of Morelos that dates back to the Epiclassic period (AD 650-900) (Sáenz 1963, 1967). This great quantity of shell materials, mostly of marine origin, is noteworthy because the site is located on a series of hills in the Morelos Valley, more than

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Figure 1. The localization of Xochicalco in Mexico (a) and the shell offerings at the site (b).

two hundred kilometres away from the Pacific Ocean coastline and more than three hundred kilometres away from the Gulf of Mexico. Moreover, these distances would have been even greater given the prominent mountain slopes between Xochicalco and the coasts, and the fact that circulation routes between the littoral and the Central Highlands followed the major rivers, like the Balsas river in the Pacific and the Blanco river in the Gulf of Mexico (Kolb 1987). These long distances likely increased the value of shells and esteem for them, as seems to be witnessed by the fact that most of the molluscs were found associated with offerings and tombs in the main structures. In addition, shells were found in middens that resulted from the looting and destruction of the most important part of the settlement before it was abandoned around AD 900-1000 (Garza and González 1995: 100, 2006: 125).

Of the shells recovered at Xochicalco, the pendants made out of the *Oliva* genus stand out for being the most ancient malacological ornaments (AD 650) that were placed in offerings (Fig. 1b). They, moreover, present the widest distribution within the site and are the only recycled objects subsequently used to elaborate inlays in the later contexts of the site (AD 750-900). For these reasons, it was relevant to determine what species had been used, from which littoral they came and what kind of objects were made out of them.

2. TAXONOMY AND TYPOLOGY

The shells´ taxonomical identification was conducted before undertaking a typological analysis. Taxonomical identification is based on the work of Myra Keen (1971) for Pacific species and that of Tucker Abbott (1982) for Caribbean ones. The mollusc reference collection of the Laboratory of Paleozoology at the INAH in Mexico City was used as well, with the guidance of specialists such as biologists Belem Zúñiga and Norma Valentín. The morphological and functional typological analysis follows the frame proposed by Lourdes Suárez (1977) and Adrián Velázquez (1999).

Three hundred *Oliva* pieces belonging to five different species were analyzed (Fig. 2), representing 11.86% of the total assemblage and 18.66% of the shell objects. Four species are from the Panamic-Pacific malacological province: *Oliva julieta, O. incrassata, O. porphyria* and *O. splendidula*, which extends from the Sea of Cortés to the North of Perú (Keen 1971). An additional species, *O. sayana*, originates from the Caribbean Sea which includes part of the Gulf of Mexico, Florida, and all of the Antilles, as well as the Atlantic coast of Central America, Colombia, Venezuela and northern Brazil (Abbott 1982).

Figure 2. *Oliva* species identified: *O. splendidula, O. sayana, O. porphyria, O. incrassata* and *O. julieta*.

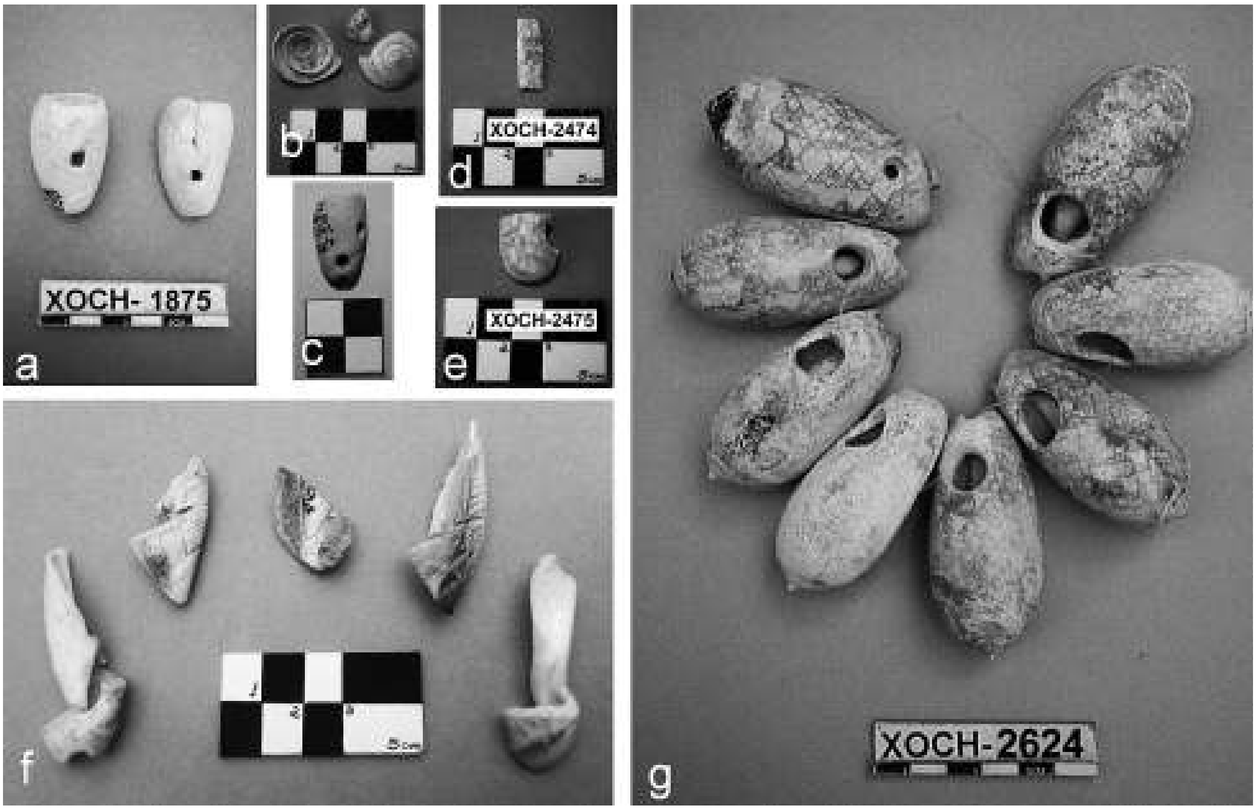

Figure 3. Objects and debris from *Oliva* shells: spireless pendants (a and c), debitage (b and f), geometric inlays (d and e), and complete automorphic pendants (g).

The 290 *Oliva* shell objects (fig. 3) were classified into two functional groups: ornaments and evidences of production. These were sub-divided into three categories: pendants, recycled pendants, and inlays as well as into two families, automorphic (the pieces which man-made modifications do not change too much the original shape of the mollusc) and xenomorphic (the pieces which man-made modifications do not maintain the original shape of the mollusc) and twelve types, full, spireless, half spireless, quadrangular, rectangular, triangular, trapezoidal, band, tooth, eccentric, undetermined, and debitage (table 1). The distribution of the shell objects showed seven major concentrations: one in the *Acrópolis* and derived contexts (Elements 1 and 77 of the Sector B, and the Drainage of the Sector A), other in the Plumed Serpents´ Pyramid, another in the Element 46 at the Structure 6 in Sector G, another one in the two temples of the Sector H, other in the Sector Museo, other one in the Altar at Sector I and the last one at the entrance of the site in Sector Loma Sur (Fig. 4).

Figure 4. Spatial distribution and quantity of *Oliva* pieces at Xochicalco (Map courtesy of the Xochicalco Project).

3. TECHNOLOGICAL ANALYSIS

The data about what shell species were used to manufacture what kind of objects show that *O.*

Category of object	Type of object	Species	Number of pieces	Contexts
Pendants				
	Complete	*Oliva porphyria*	50	Sector G, Plumed Serpents´ Pyramid
	“ ”	“ ”	1	Sector E, Structure 2
	“ ”	“ ”	36	Sector H, Structure C
	“ ”	“ ”	15	Sector H, Structure E
	“ ”	“ ”	6	Sector I, Altar
	“ ”	“ ”	5	Sector Acrópolis, sub-Structure
	“ ”	*Oliva incrassata*	2	Sector G, Plumed Serpents´ Pyramid
	“ ”	*Oliva julieta*	1	Sector G, Plumed Serpents´ Pyramid
	Spireless	*Oliva julieta*	2	Sector Loma Sur, Structure 1W
	“ ”	*Oliva incrassata*	2	Sector G, Element 46
	“ ”	*Oliva splendidula*	1	Sector A, Central Zone
	“ ”	“ ”	1	Sector Loma Sur, Structure 1W
	“ ”	*Oliva sayana*	1	Sector B, Courtyard 2
	“ ”	“ ”	1	Sector I, Altar
	Half spireless	*Oliva porphyria*	1	Sector Loma Sur, Structure 1W
	Undetermined	“ ”	1	Sector B, Element 1
	“ ”	“ ”	1	Sector B, Element 77
	“ ”	“ ”	12	Sector Museo, Structure 2
	“ ”	“ ”	1	Sector H, Structure 7
	“ ”	*Oliva sayana*	1	Sector Museo, Structure 2
	“ ”	*Oliva* sp.	1	Sector Museo, Structure 2
Inlays	Quadrangular	*Oliva porphyria*	2	Sector B, Element 1
		“ ”	1	Sector Loma Sur, Structure 1E
	Rectangular	“ ”	2	Sector B, Element 1
	“ ”	“ ”	2	Sector B, Element 77
	“ ”	“ ”	2	Sector A, Drainage
	“ ”	“ ”	1	Sector Loma Sur, Structure 1W
	Triangular	“ ”	2	Sector B, Element 1
	“ ”	“ ”	3	Sector B, Element 77
	Trapezoidal	“ ”	1	Sector A, Drainage
	Tooth	“ ”	1	Sector B, Element 1
	Band	“ ”	1	Sector A, Drainage
	Undetermined	“ ”	1	Sector A, Drainage
Recycled pendants	Debitage	*Oliva porphyria*	5	Sector Acrópolis, Structure 7
	“ ”	“ ”	12	Sector A, Drainage
	“ ”	“ ”	23	Sector B, Element 1
	“ ”	“ ”	20	Sector B, Element 77
	“ ”	“ ”	3	Sector B, Courtyard 2
	“ ”	“ ”	26	Sector G, Element 46
	“ ”	“ ”	1	Sector H, Structure C
	“ ”	“ ”	3	Sector Loma Sur, Structure 1W
	“ ”	“ ”	29	Sector Museo, Structure 2
	“ ”	*Olivas* sp.	1	Sector Museo, Structure 2
	“ ”	“ ”	1	Sector A, Drainage
	“ ”	“ ”	2	Sector G, Element 46
		Oliva sayana	3	Sector Museo, Structure 2
Total			**290**	

Table 1. Type, quantity and provenance of the shell objects

porphyria was preferentially used for elaborating full pendants in the earliest offerings (AD 650). Furthermore, these pendants were the only ones recycled and re-used for inlays in the later contexts (AD 750-900). Also noticeable is the fact that, in each string there are pendants with different type of holes.

In order to distinguish the shape and quality of such perforations, it was necessary to perform a technological analysis through experimental archaeology and manufacturing analysis research. According to the uniformity criteria of the experimental archaeology (Ascher 1961: 807), the production activities are normative in human societies, and artifacts are produced and used following rules that determine what specific features each object has. As a result, the use or production of similar objects, elaborated under the same rulings, should be characterized by identical attributes (Ascher 1961: 793, Velázquez 2007:7). Therefore, standardised attributes indicate the use of a certain tool, made from a determined material, employed in a specific manner and under certain conditions, all of which will leave characteristic and distinguishable traces on the worked materials, in this case, shells (Binford 1991: 22, Velázquez 2007: 7).

Since 1997, following this uniformity criteria, the same tools and manners are being reproduced at the Experimental Archaeology Shell Workshop in the Templo Mayor Museum with more than 600 experiments (Fig. 5), with similar tools as those recorded in several historical sources and archaeological contexts, which were supposedly used by the various groups in pre-Hispanic México. Such tools are flakes and blades of obsidian and chert, grindstones made of basalt, andesite, riolite, limestone, sandstone, granite, and slate, among others (Velázquez 2007: 57–58).

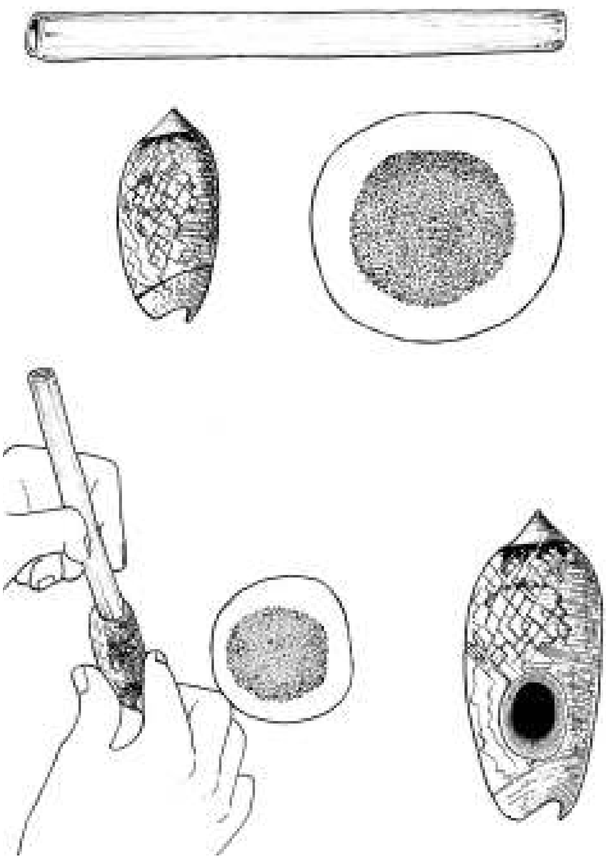

Figure 5. Experimental archaeology on shell pieces (drawing by Julio Romero).

Subsequently, the resulting traces of manufacture were compared with the archaeological material on three levels: macroscopic, stereoscopic microscopy (10X, 30X and 63X), as well as Scanning Electron Microscopy, or SEM (100X, 300X, 600X and 1000X).

All of the archaeological pieces (290) were checked macroscopically and stereoscopically and compared with the experimental ones drilled with flakes (obsidian and chert burins) and abrasives (sand, volcanic ash, powder of obsidian, and powder of chert) and reed, obtaining the following results (fig. 6):

1) Seven pendants had conical perforations without visible striations; they are similar to those ones drilled with abrasives.

2) Nineteen pendants had circular striations in the conical perforation, they match with those ones drilled with flakes.

3) Thirty-one pendants showed regular perforated edges with lines, they are similar to those ones drilled with flakes.

4) One-hundred-and-ten pendants had irregular edges with lines, they are similar to those ones drilled with flakes.

5) One-hundred-and-eight pieces (inlays, pendants and recycled pendants) showed parallel striations; they are similar to those ones cut with flakes.

For the analysis with the SEM, thirty pendants were chosen based on their good preservation and the representativeness of their modifications, four from each context, except two contexts that had only one piece (Sector A and Sector E). Five patterns were identified (Fig. 7):

1) Five pieces presented walls that were pierced by lines measuring approximately 1.3 μm wide, which united to form greater strokes, similar to the experimental perforations that had been made using sand and reed (Fig. 7a-b).

2) Nine pierced pieces showed fine lines measuring two μm, which resembled perforations made with obsidian flakes (Fig. 7c-d).

3) Nine pendants showed parallel bands of two to four μm, which are similar to drill holes made with chert burins (Fig. 7e-f).

4) Four presented walls that were crossed by fine lines measuring two μm, which resembled channeled perforations produced with obsidian flakes.

5) Three recycled pendants and inlays were also analyzed with Stereoscopic Microscopy and SEM. They revealed well defined parallel lines resulting from cuts made with stone tools; but the

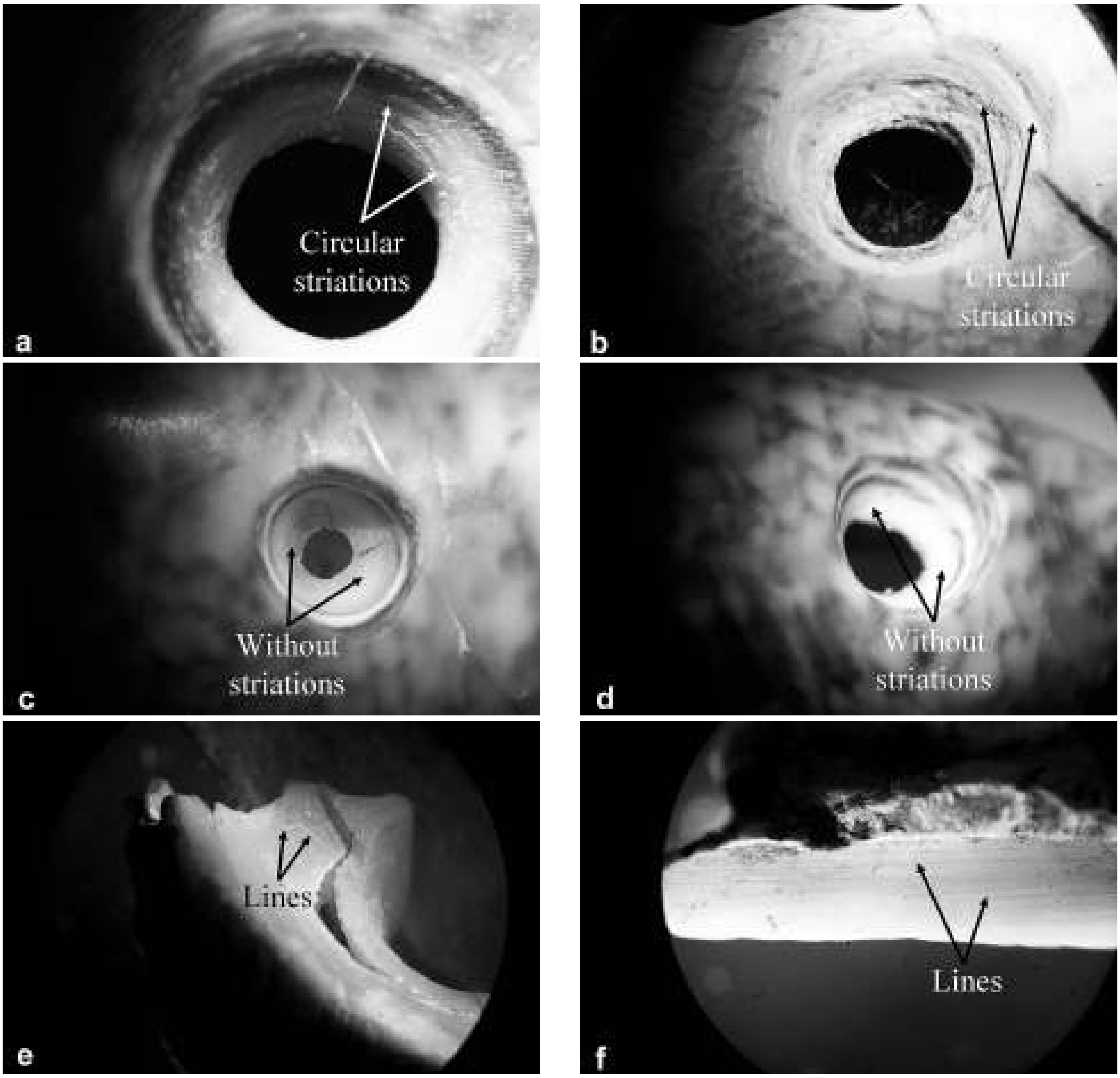

Figure 6. Stereoscopical comparison between experimentally drilled holes and archaeological ones: (a and b) using obsidian flakes; (c and d) using sand and reed; (e and f) edge made using obsidian flakes.

re-used pendants also showed flanges because their cuts were not regularized. With the SEM, all cases revealed walls that were crossed by fine lines measuring about two μm resembling cuts made with obsidian flakes.

Also, all of these traces are different if we compared them with other tools like powder of chert and reed or volcanic ash and reed (Fig. 7g-h).

4. DISCUSSION

Based on this information, it is clear that a great diversity of tools and techniques was used to pierce and perforate the *Oliva pendants*, whose distribution did not influence the conformation of each string in the earliest offerings. This could be a result of different groups of artisans or workshops that produce them, perhaps without any control by the elite. In contrast, only the *O. porphyria* pendants were re-used and recycled for inlays and all exhibit cuts made with obsidian flakes. The homogeneity of this technique coincides with the existence of a centralized workshop located in the *Acrópolis*, where the remaining shell objects analyzed with stereoscopic microscopy and SEM reflect a noticeable standardisation of tools and techniques: shell was abraded with basalt, cut with obsidian flakes, and drilled with chert burins (Melgar 2007).

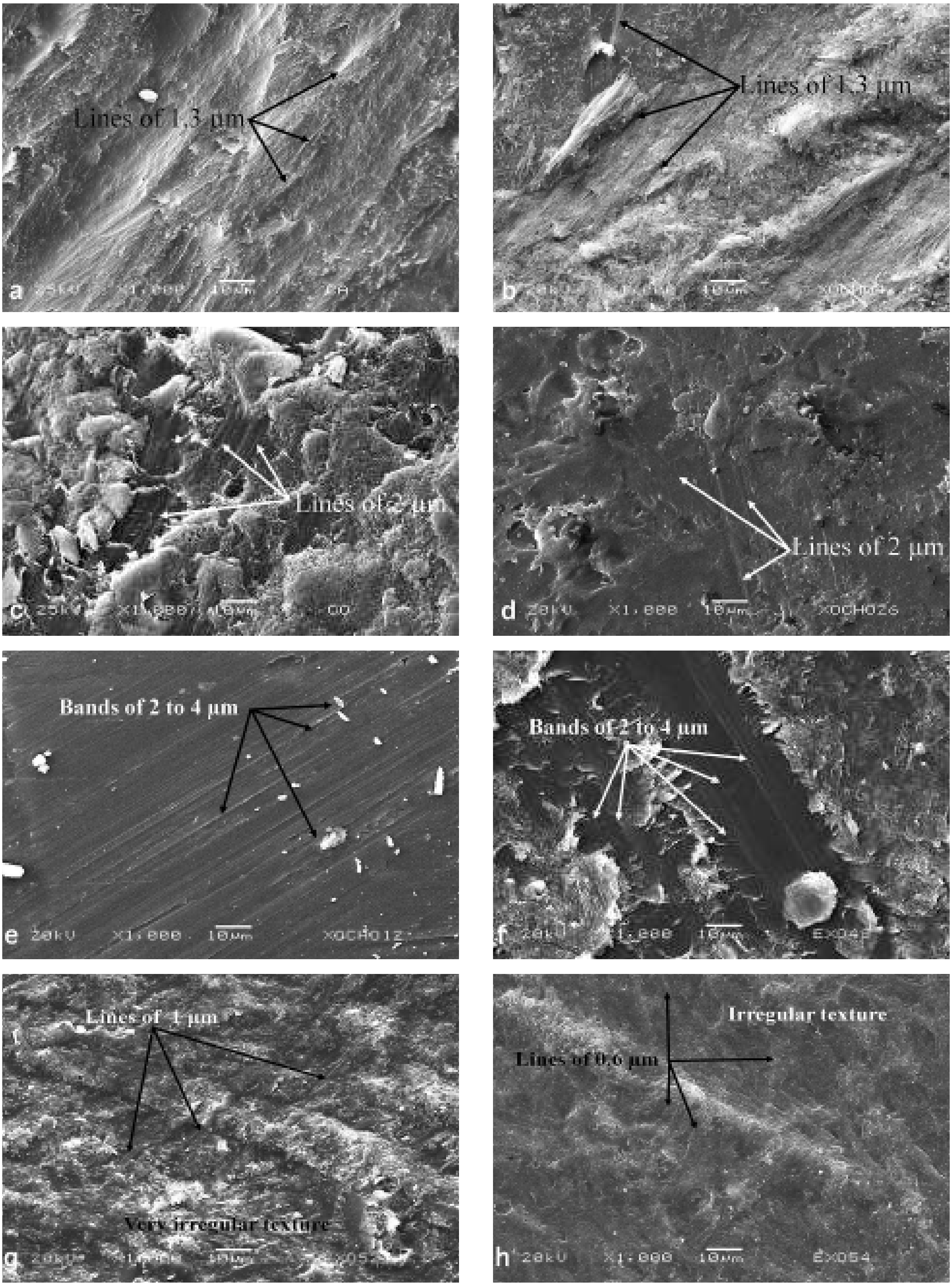

Figure 7. SEM comparisons between experimentally drilled holes and archaeological ones: (a and b) using sand and reed; (c and d) using obsidian flakes; (e and f) using chert burins; (g) using powder of chert, (h) and using volcanic ash with reed.

In addition, this analysis suggests that the wider distribution of *Oliva* pendants is a direct result of the fact that their production is less time and work consuming (2-15 hours of work) than that of other objects, such as inlays, beads, and pendants (50-100 hours of work).

Finally, attention is drawn to the fact that the only type of shell object which was re-used or recycled in the site is pendants. The *xochicalcas* reworked these pendants with transversal and longitudinal cuts that required much more time than during the production of the original object. However, none of the inlays were placed as offerings and they were treated more like garbage. A likely explanation may be that the pendants, which may have once been the prized possession of warriors, were reworked as a gesture of desecration. This is consistent with the more general pattern observable during the final years of the site's occupation, before the last great pillage and fire. At that time, there are evidence of conflicts between the leading groups and the destruction of objects of power such as the iconographically reliefs which were covered with stucco (Garza and González 2005: 202).

5. CONCLUSIONS

As it has been observed, the automorphic pendants made, as prestige goods, out of various species of *Oliva*, mostly originating from shorelines of the Pacific Ocean, are the most ancient shell objects placed in offerings at Xochicalco.

Each string of pendants displays different perforation manufacturing techniques. Thanks to experimental archaeology and the analysis of manufacturing traces using stereoscopic microscope and a scanning electron microscope, it was possible to identify three different processes employed in the elaboration of these pieces: sand with reed, chert burins and obsidian flakes. This heterogeneity of tools used to produce the same modification could be a result of different groups of artisans or workshops that made them, probably without any control by the elite. It also contrasts with a standardisation of tools identified in the later contexts, where all objects were abraded with basalt, cut with obsidian flakes and drilled with chert. In this way, only the inlays made from re-used pendants match this manufacturing tendency, all being cut with obsidian. Also these pendants stand out for being the only shell objects re-used at the site, possibly as a desecration of warrior insignias, as a reflection of conflicts operating then among leading groups, before the final abandonment of the site.

Finally, it is important to stress the necessity of this kind of study for other shell material collections in order to identify manufacturing patterns and to infer aspects of production and organization, and perhaps styles and technological traditions across time.

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The Maya nacreous shell garment of Oxtankah (Quintana Roo, México)

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La vestimenta maya de nácar de Oxtankah (Quintana Roo, México)

KEY WORDS: Garment, nacreous, Maya, manufacture, restoration.
PALABRAS CLAVE: Vestimenta, nácar, Maya, manufactura, restauración.
GAKO-HITZAK: Jantziak, nakarra, Maia, manufaktura, zaharberritzea.

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ABSTRACT

The aim of this paper is to demonstrate the existence of a Maya nacreous shell garment by analyzing more than 1600 shell objects from a tomb at Oxtankah, near Chetumal City in Quintana Roo, México. We showed the different techniques employed on this pieces (taxonomical identification, typology based on shape and function, and technological analysis with experimental archaeology and Scanning Electron Microscopy). Also, we compared the design of different garments from hundreds of images from 32 Mayan archaeological sites and the Calakmul reddish shell garment, appreciating in almost all of them the same semicircular shape. Finally, we showed how we restored the garment

RESUMEN

El propósito de este trabajo es mostrar la existencia de una vestimenta Maya conformada por más de 1600 piezas en nácar de concha halladas en una tumba de Oxtankah, cerca de la ciudad de Chetumal en Quintana Roo, México. Mostramos los diferentes análisis realizados a estos objetos (identificación taxonómica, tipología basada en forma y función y estudio tecnológico con arqueología experimental y microscopía electrónica de barrido). Así mismo, a partir de la comparación de los diseños de vestimentas en 32 sitios Mayas, pudimos apreciar que la forma más común de los objetos es la semicircular. Además comparamos esta con una vestimenta similar en concha rojiza recuperada en una tumba de Calakmul. Finalmente, señalamos los trabajos de restauración y conservación aplicados en el armado de dicha vestimenta.

LABURPENA

Oxtankah herriko hilobi batean, Chetumal hiritik hurbil, Quintana Roo estatuan (Mexiko), aurkitutako maskor-nakarrezko 1.600 pieza baino gehiagoz egindako jantzi maia baten berri ematea da lan honen helburua. Objektu horiei egindako analisiak erakusten ditugu (identifikazio taxonomikoa, forman eta funtzioan oinarritutako tipologia, eta arkeologia esperimentalaren eta ekorketako mikroskopia elektronikoaren bidezko azterketa teknologikoa). Gainera, 32 gune maiatako jantzien diseinuak alderatuz, objektuen formarik arruntena erdizirkularra dela hauteman izan ahal dugu. Eta hori Calakmuleko hilobi batean berreskuratutako maskor gorrizko jantzi batekin alderatu genuen. Azkenik, jantzi hori osatzeko zer zaharberritze- eta kontserbazio-lan aplikatu diren erakusten dugu.

1. INTRODUCTION

Oxtankah is a little coast town located 16 kilometres north of Chetumal City, in Quintana Roo México (fig. 1). It has been explored since 1996 by the archaeologist Hortensia de Vega Nova who directed the *"Research and conservation Project of the site of Oxtankah, Quintana Roo"* at the National Institute of Anthropology and History of Mexico. During the excavations between November 2000 and January 2001 inside the Structure VI of *Plaza de las Columnas*, three tombs of Late Classic period were discovered. Tomb 1 was remarkable because of the find of eight human burials, one of them with a shell garment. This garment consisted of more than two thousand jadeite and shell pieces which demonstrate the wealth and power of the inhabitants of the site. The major part of these elements were placed over the principal body of the burial- a male adult- but at these time, we could not have any interpretation of the meaning of the setting and its relation with the skeleton. It was noticeable that more than 1500 circular nacreous shell pieces were placed near the chest of the body. So, this paper is about the investigation, analysis and conservation applied to those items and their probable function.

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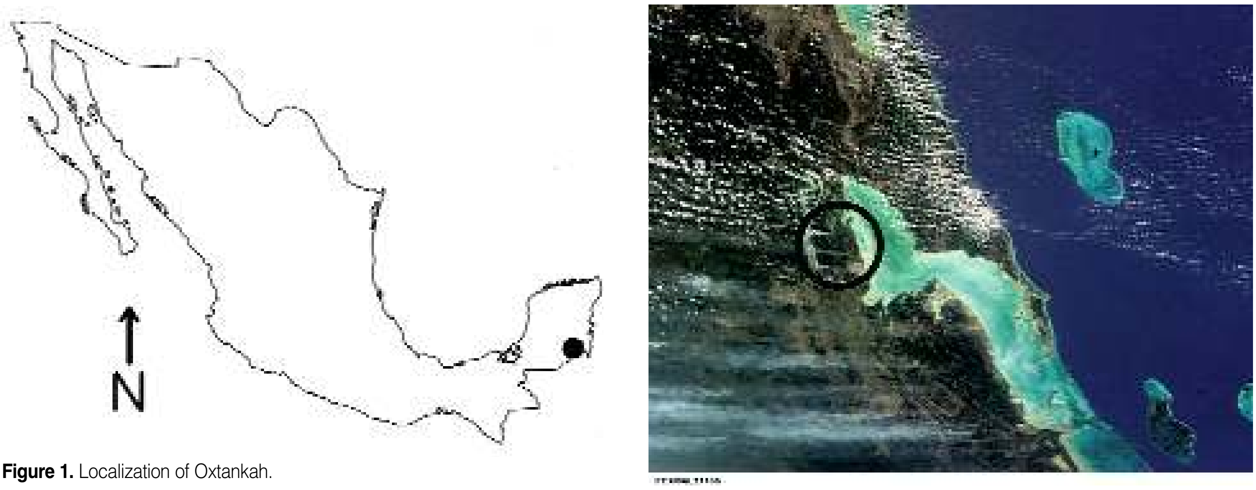

Figure 1. Localization of Oxtankah.

2. THE ARCHAEOLOGICAL RESEARCH AT OXTANKAH AND THE BURIAL CHAMBERS

Oxtankah and its surroundings had been investigated since 1996. Through Hortensia de Vega's project *"Research and conservation Project of the site of Oxtankah, Quintana Roo"* she reported more than 70 structures around ten plazas and two patios, two subterranean chambers, three *chultunes*, two *aguadas*, one cenote, and one well (fig. 2). After the analysis of the information obtained by her project, we could know that the Mayan people inhabited this area from Middle Preclassic (600-300 BC) to Terminal Classic (AD 800-110), and they reached their maximum social development in the Early Classic period (AD 200-600). They obtained political power and economical importance because they controlled the shorelines and diversified their activities (exploitation of marine resources, agriculture, hunting, gathering, salt production, and apiculture). Also, they employed their surplus for commercial purposes and acquiring exotic goods by sea and terrestrial trade.

Figure 2. The archaeological site of Oxtankah.

It is interesting that the seven burial chambers of the site were found only in two structures, two inside the Structure I at *Plaza de las Abejas* and five inside Structure VI at *Plaza de las Columnas*, both structures at the same eastern part of their plazas. The latter also had two stone boxes with human remains under the stairs of the temple at the top of this building, but the Tomb 1 is the most remarkable burial chamber with eight human remains and offerings of the site (fig. 3). Unfortunately, the upper layers of the chamber were looted in pre-Hispanic times and some stones of the roof fell over one of the burials (an adult male accompanied with a child) that has a shell garment with more than 1600 pieces near his chest, displacing some of them inside the chamber. To recover this huge amount of objects, we divided them in groups, labeling each one with numbers, and registering from which area or part of the body they came: centre over the chest, right or left over the shoulder, etc.

3. DESCRIPTION OF THE ELEMENTS: TYPOLOGY AND TAXONOMY

The first phase of the investigation was the taxonomic and the typological classification.

The taxonomical identification was based on the malacological manuals of Abbott (1982) for the Caribbean and Vokes and Vokes (1983) for the Yucatan Peninsula.

The typology consisted in the complete systematization of every single shell piece observing

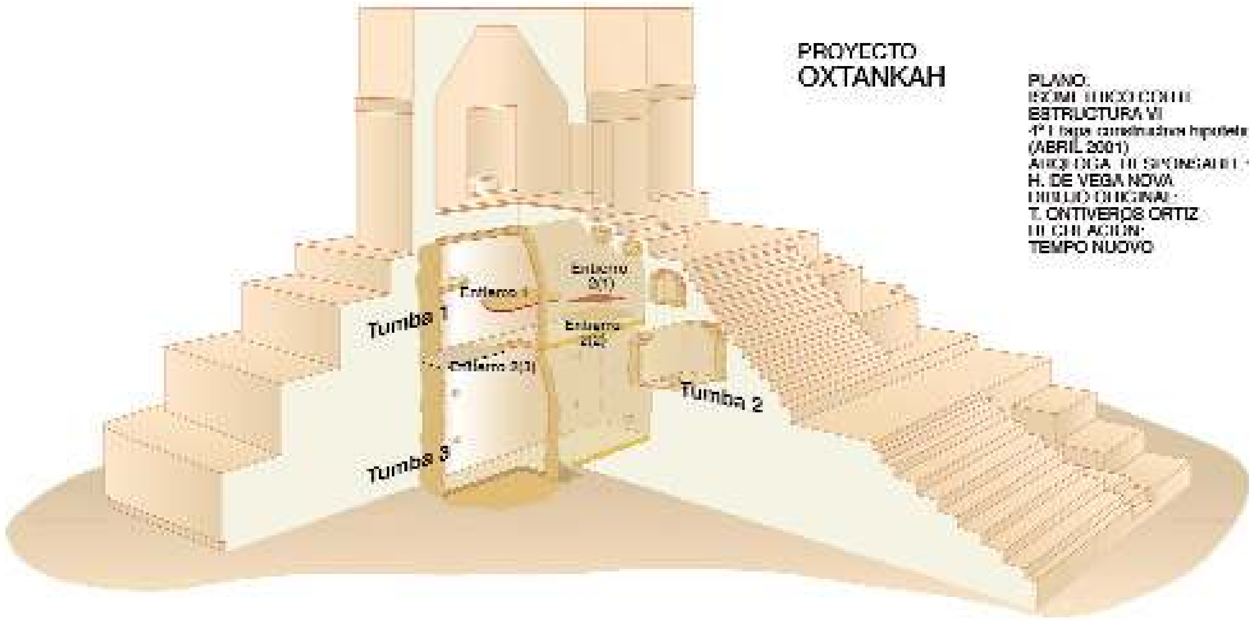

Figure 3. The tombs found inside the Structure VI.

functional and morphological aspects. We followed the model proposed by Lourdes Suárez (1977) and Adrián Velázquez (1999).

The 1664 shell pieces – 1547 complete and 117 fragments– were divided in two types of objects (beads and pendants), and four species, three Caribbean molluscs (*Pinctada imbricata, Strombus alatus, and Strombus gigas*), and one freshwater shell (*Unio* sp). The objects have three different shapes: circles, rectangles and "L" forms.

The biggest group has 1630 nacreous circular beads, 1513 are complete and 117 fragments. The objects were probably made from *Pinctada imbricata* and/or *Unio*. The pieces have only one polished surface. There are 612 with two plane surfaces and 895 have curved ones. Also, there are 1517 with a hole near the edge and 113 have a hole in the middle of the piece. Their dimensions are between 0.4 to 1 cm diameter, and 0.01 to 0.15 cm high.

There are 28 pendants made of *Strombus alatus*, with a rectangular shape. 17 have curved surfaces and 11 have irregular ones. Those characteristics are related with the natural shape of the shell they were made of. All have abrading and polished surfaces in one side in order to eliminate the natural irregularities of the spire. All have rounded corners, conic or biconic holes in the top and lateral cuts for its setting. Their dimensions are from 1.6 cm to 2.05 cm high, 2.2. to 2.9 cm long and 0.3 to 0.75 cm width.

There are also three pairs of *Strombus gigas* pendants. Three of them have "L" shape, and the other three have inversed "L" forms. They have only one polished surface. Three have a convex shape, two have one plain face and a convex one, and the last one has a curved shape. All have a conic or biconic orifice in the top. Their dimensions are from 2.4 to 3 cm high, 4.05 to 4.25 tall and 0.6 to 0.75 cm width.

4. STUDY AND INTERPRETATION OF THE SETTING

While all the shell pieces have at least one hole, in the beginning the unit was interpreted as necklaces. Otherwise, as we saw later, during the particular analysis and treatment, we observed some aspects that allowed us to consider a new hypothesis for the elements based in their formal characteristics, the iconographical data and with our own experience in the study or other shell prehispanic pieces, like the cuirass of Tula, and the aquatic circles of chamber two at the Templo Mayor of Tenochtitlan (Gallardo and Velázquez 2008). With those elements we could establish a new interpretation for the objects as a garment formed by the shell elements. In order to demonstrate our idea we analyzed the manufacture traces of the items, with special attention to the polished surfaces.

5. ANALYSIS OF MANUFACTURE TRACES

The analysis of the manufacture traces of the shell objects is based on the results of *"Proyecto* *de arqueología experimental en materiales conquiológicos"* and *"Proyecto de técnicas de manufactura del México prehispánico"*, both under the direction of Adrián Velázquez (2007).

The first project has an experimental archaeology workshop where different types of modifications of Ancient Mexico shell objects are reproduced (abrading, cuts, holes, incisions, and finishing), using tools and techniques referred in codexes and historical documents, or data recovered from archaeological contexts. In the second project, the manufacture traces are analyzed comparing them with archaeological specimens in three levels: macroscopic, using an optical microscope at 10x, 30x and 63x and with scanning electron microscopy (SEM) at 100x, 300x, 600x and 1000x in high vacuum mode (HV) with signal of secondary electrons (SEI), and voltage of 20 kV.

To avoid the need to apply a conductive coating over the pieces, detailed impressions were made with a thin tape of polymer with one drop of acetone, pressed it over the area that we want to analyze for one minute until it is dry. After that, we mounted each replica sample on 30 mm diameter aluminium stubs and coated all of them with an ultrathin coating of electrically-conducting material, commonly gold, by low vacuum sputter coating. By this way, we could analyze oversized pieces bigger than the 10 cm of the SEM chamber, avoid the movement of the objects from the museums to the lab, and optimize the time invested in the SEM by analyzing 20 samples per two hours. Following this technique, we had a 165 pieces sample of the 1664 total pieces for the stereoscopical microscopy, and 28 for the SEM, in order to observe the abrading, edges, holes and polishing.

The surfaces were abraded with lithic tools, without abrasives, because of the presence of intercrossed lines (Fig. 4). With the microscopical analyses we observed rounded bands of 100 microns width, that correspond to the ones produced experimentally with basalt (Fig. 5).

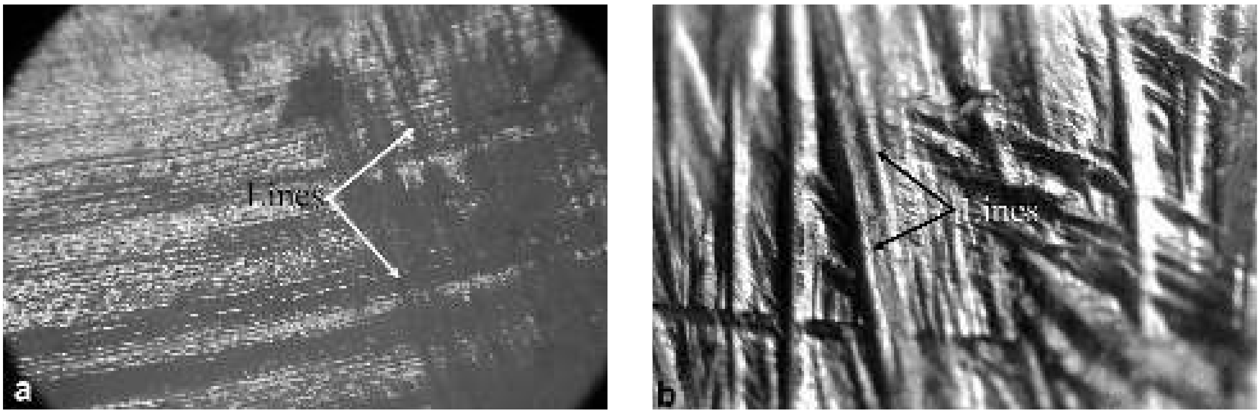

Figure 4. Archaeological surface (a) and experimental abrading with basalt (b) at 10x.

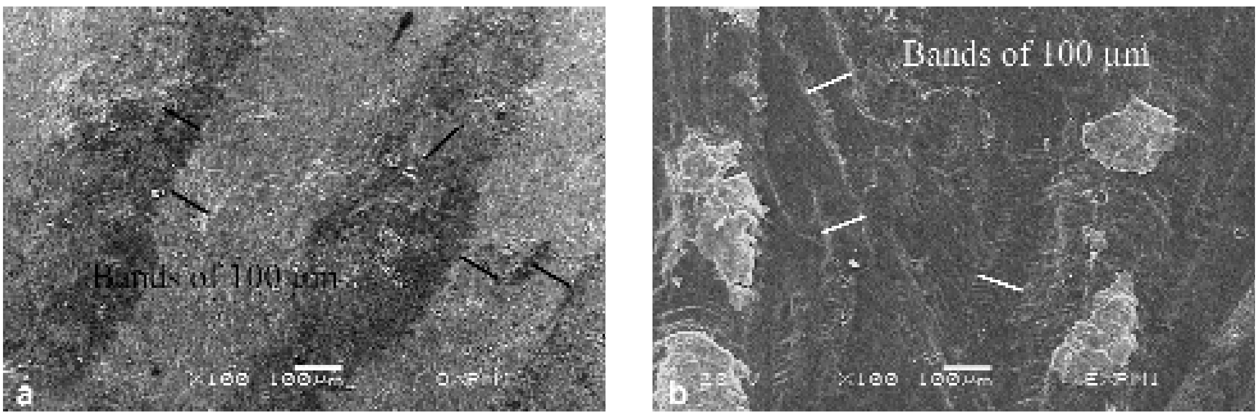

Figure 5. Archaeological surface (a) and experimental abrading with basalt (b) at 100x.

All the pieces have only one polished surface, in which the lines described before are softened by multiple fine and diffuse lines over the bigger ones (Fig. 6). In all the cases there are straight and parallel bands of 4 microns, they correspond to the experimental polishing made with a nodule of chert (Fig. 7).

The edges have straight-parallel-intercrossed lines well marked produced by lithic tools, like obsidian and chert flakes (Fig. 8). Every cut in the pieces was regularized. By the use of the SEM, in 14 pieces of *S. gigas* and *S. alatus*, we observed a succession of intercrossed bands of 4 microns width, with other diffuse ones of 100 microns, corresponding to the experimental ones made of chert flakes and basalt. The 14 pieces of *P. imbricata*, have straight or curved lines smaller than 2 microns width, similar to the

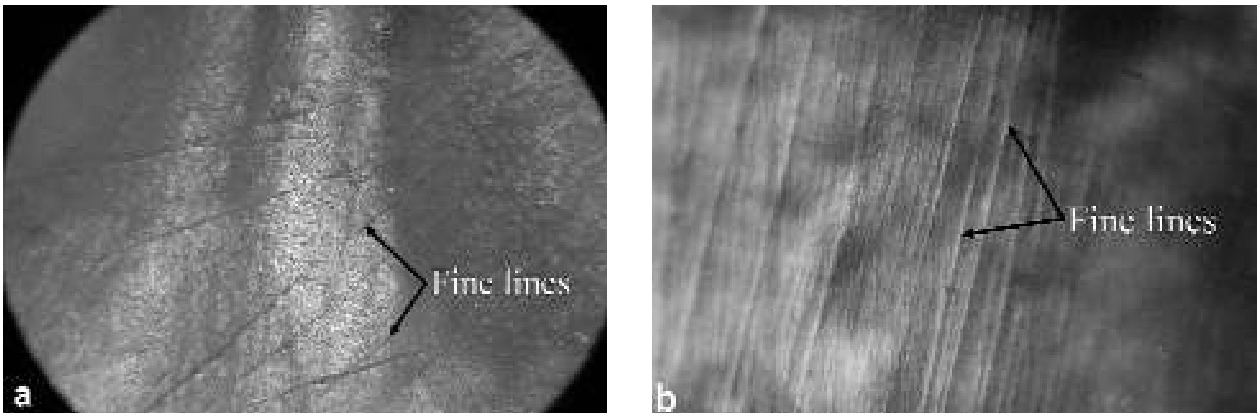

Figure 6. Archaeological polishing (a) and experimental polishing with chert (b) at 30x.

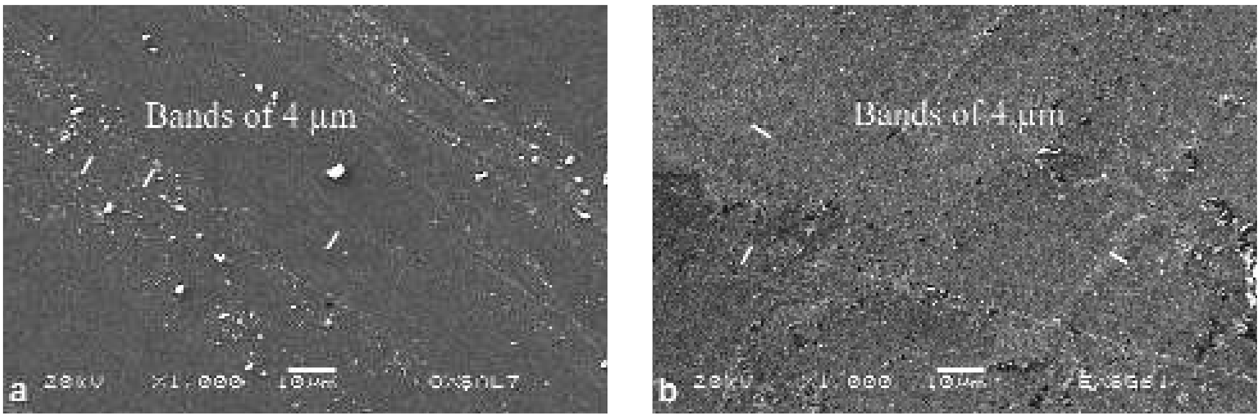

Figure 7. Archaeological polishing (a) and experimental polishing with chert (b) at 1000x.

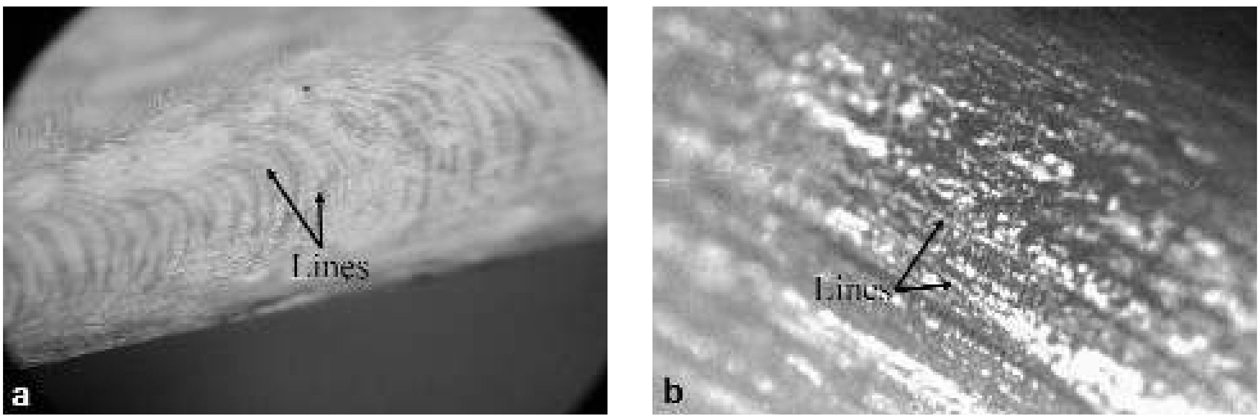

Figure 8. Archaeological edge (a) and experimental cutting with obsidian flakes (b) at 30x.

experimental ones made of obsidian flakes and basalt (Fig. 9).

Finally, the holes have well marked concentrical striations, corresponding to the experimental drills made of chert and obsidian (Fig 10). With the SEM we could observe concentric bands of 4 microns width, similar to the drills produced with chert (Fig. 11).

6. INTERPRETATION OF THE POLISHED SURFACES

We could observe that all the pieces have only one polished surface, the other one does not have any kind of finishing. It is easy to assume that this irregular surface corresponds to an additional support (Suárez 1977: 56, Velázquez 1999: 71). For the circle nacreous beads, the observations of the polished face, the location of the hole and the

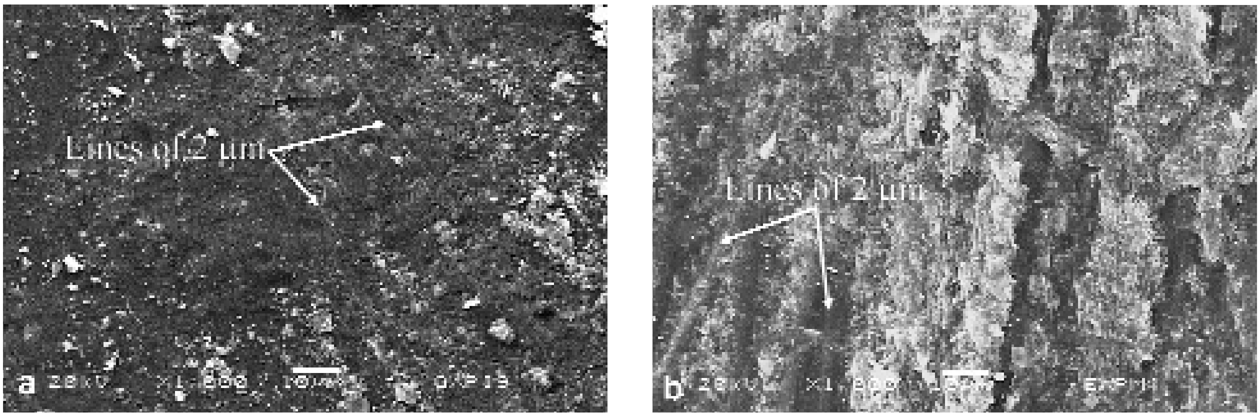

Figure 9. Archaeological edge (a) and experimental cutting with obsidian flakes (b) at 1000x.

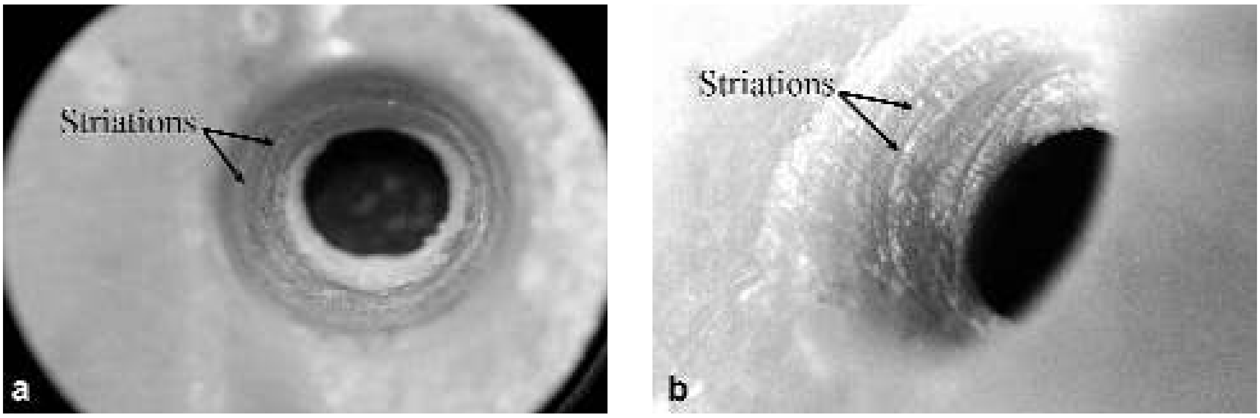

Figure 10. Archaeological hole (a) and experimental drilling with chert burins (b) at 30x.

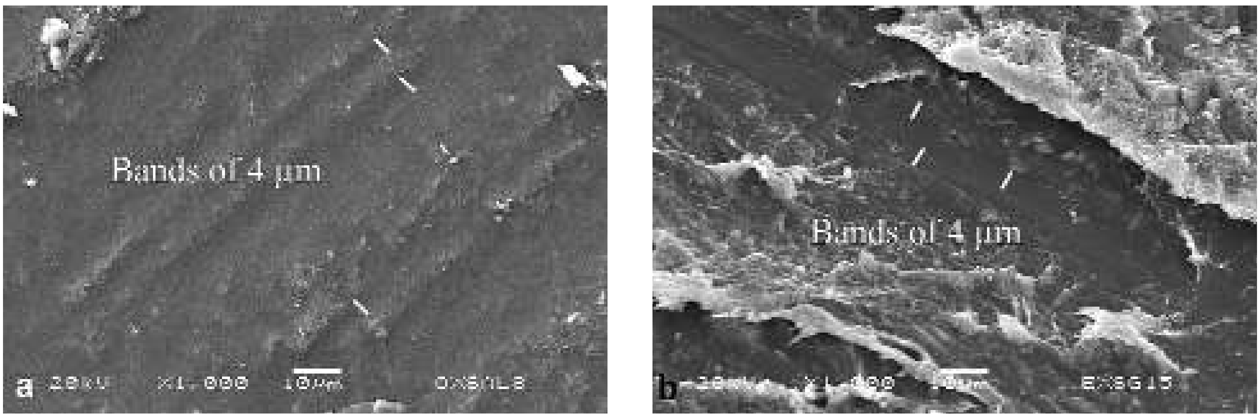

Figure 11. Archaeological hole (a) and experimental drilling with chert burins (b) at 1000x

different diameters, allowed us to propose a concentric setting, where the biggest pieces where located near the lower edge (fig. 12a). The pieces with a hole in the middle were few and seemed to be the lateral border of the garment. The big rectangular pendants seemed to be in horizontal position, getting smaller at the back of the garment. In the case of the "L" forms, distributed symmetrically in three intervals over the chest, the polished surfaces allowed us to distinguish the "L" forms from the inversed "L", one of each form in each pair (fig. 12b).

7. ICONOGRAPHICAL AND DOCUMENTAL INVESTIGATION OF DIFFERENT PRE-HISPANIC SHELL GARMENTS

The manufacture trace investigation allowed us to interpret the elements as a unit in a horizontal setting. We started a quite complete documental and iconographic research about prehispanic garments, specially the ones made with shell. After this investigation we noticed that in 32 mayan sites, as Tikal, Yaxchilan, Palenque, Calakmul, Naranjo, Bonampak, Copán, Uxmal and Chichén Itzá there are images in architectural elements and mural paintings with representations of semicircular chest garments that cover the shoulders as well (Greene *et al.* 1972; Schele and Miller, 1992). In most of them it is difficult to distinguish the constitutive materials of the garments because the circular, quadrangular or rectangular forms of their elements do not have any color. But in almost every one, we can observe a lower edge, maybe made of a different material because of the different form and dimension, that usually has unique or pairs of pendants, located in regular intervals in the lower part of the garment. This kind of garment is rarely shown in the Early Classic period, as in Tikal, then in the Post-Classic Period it became very common as in Yaxchilán, Tikal, Calakmul, Palenque, and Seibal, to finally almost disappear in the Early Post Classic as in Uxmal and Chichén Itzá.

In archaeological context there is a "cape" made of *Spondylus princeps* pendants over a female body located in the XV Structure of Calakmul (Patricia Meehan 2005: Pers. Comm.). Also, on the 16, 18, 26, 45 and 46 architectural lintels from Yaxchilán there are representations of shell vests. This type of garment had been recovered from *Garra de Jaguar* tomb, one of the Calakmul rulers in the Late Classic (García and Granados 2000: 33).

Related to the Colonial Maya linguistic dictionaries, we found two words related to garments: *kancotom* "garment with beads of Kan, for the chest" (Códice de Calkiní 1957: 118); and *yopat*, "a kind of garment of the ancient indians" (Arzápalo 1995: 375).

8. HYPOTHETICAL RESET OF THE UNIT AND ITS CONSERVATION

After excavation and analyses, all the pieces were taken to the conservation laboratory at the Museo del Templo Mayor for their treatment. In the first place, we observed the actual conservation condition of the pieces, in order to have a conservation procedure. All the pieces were cleaned after excavation at the archaeological site, using a solution of alcohol mixed with water 1:1. After that, all the *S. alatus* and *S. gigas* pendants were stable. But the nacreous beads were not.

The second phase of the treatment consisted in the setting of all the elements in one unit. In this phase our proposal was confirmed, because it was obvious

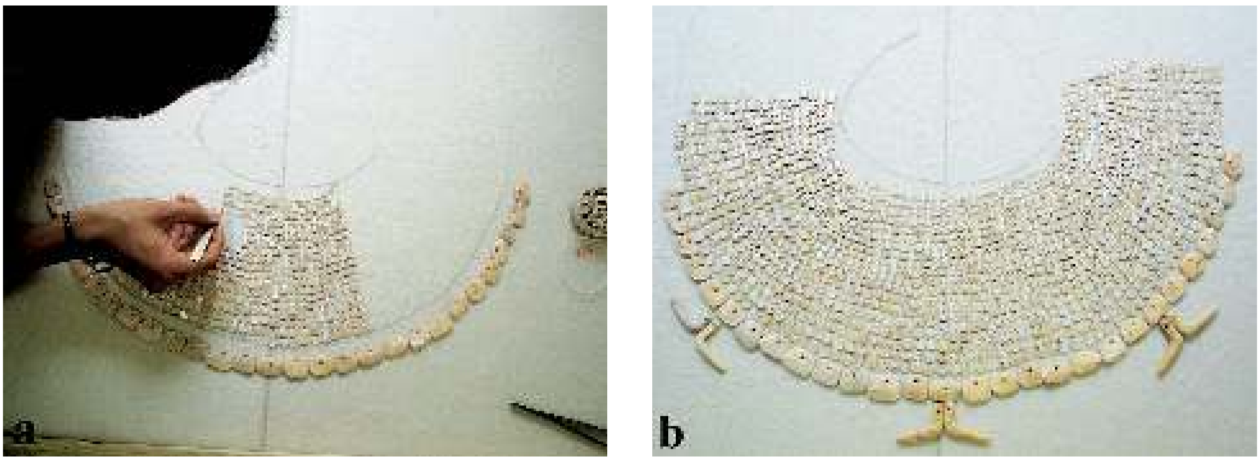

Figure 12. The restoration of the shell garment.

that all the pieces correspond to a horizontal setting. In this stage the interdisciplinary work determined our hypothesis and the next conservation procedure.

As we thought that the nacreous elements were imbricated in the original setting, we needed to protect the back part of each piece, locating a Japanese paper support (fig. 13a), that will also act as a reinforcement. This procedure took a long time and consisted in the union of an individual support for each bead. The support was made of Japanese paper glued with a cellulosic adhesive. The fragments with more than 50% of the original were treated with another Japanese paper to complete the original. When this procedure had been finished, we proceeded again to set all the elements in one unit with the lower edge of the rectangular shell elements. Also, we designed a paper model for the garment according to the normal male chest measurements that will define the final shape of our proposal. Then, we did the adjustments to get the garment in order to cover the chest and part of the shoulders as we saw in the iconographical investigation and in the particular characteristics of the archaeological objects (fig. 13b). After that, we proceeded to sew all the shell pieces to a cotton fabric set in a wooden rack. We used cotton thread in this procedure as well. Every stitch has a knot in order to secure every shell piece. When this treatment was finished, the fabric was cut according to the model (fig. 14).

Figure 13. The Japanese paper (a) and the shape of the paper model (b).

Figure 14. The shell garment of Oxtankah.

9. CONCLUSIONS

During this investigation we recovered a remarkable prehispanic garment as a result of an intense interdisciplinary work that allowed us to propose a new way to treat shell objects with holes, usually considered as necklaces. In this sense, we reinterpret the function of this shell assemblage of beads and pendants as a garment with only one polished side and a great technological standardization in the tools employed for its production. Also, during the restoration and sewing of the pieces we dealt with the shape and disposition of them. We proposed the semicircular shape and the imbricated patron after we displayed all the pieces, based on the detailed iconographical comparison, the final adjustments over the model and the functionality of the unit as a garment in relation to a human being.

By the way, in the future we will try to identify the symbolism of this garment, which imbricated pieces seemed to be the representation of fish scales and can be related with the most valued fish in the Chetumal bay: the *xihua*.

Finally, we want to point out the importance of including other experiences and the work of so many specialists in the study of other shell prehispanic pieces in order to enrich our hypothesis and study. In the same way we hope that the present work will help the study and interpretation of new findings in the archaeological contexts, and new approaches to the already excavated ones.

10. ACKNOWLEDGEMENTS

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Malacological Material from Pezuapan Archaeological site, Chilpancingo (Guerrero, Mexico)

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Malacological Material from Pezuapan's Archaeological site, Chilpancingo (Guerrero, México)

Materiales malacológicos del sitio arqueológico de Pezuapan, Chilpancingo (Guerrero, México)

KEY WORDS: Mexico, Chilpancingo, shells, production, manufacture.
PALABRAS CLAVE: México, Chilpancingo, conchas, producción, manufactura.
GAKO-HITZAK: Mexiko, Chilpancingo, maskorrak, ekoizpena, manufaktura.

Hervé V. MONTERROSA[(1)] & Reyna B. SOLÍS[(2)]

ABSTRACT

During the 2005-2007 seasons, in the area of Pezuapan, located in Chilpancingo city, Guerrero, various types malacological material of marine and freshwater origin were recovered. These mollusks correspond to the Epi-classic (AD 600-900) and early Post-classic (AD 900-1150) periods. The material presents a diversity of species that indicates the relationship of this area with groups settled on the Pacific Ocean shores that surely followed the beds of the main rivers like the Balsas, the Huacapa, and the Papagayo. Finally, this is a pioneer study in a relatively unknown known archaeological area such as the Chilpancingo valley and Guerrero in general.

RESUMEN

Durante las temporadas 2005-2007 en el sitio de Pezuapan localizado en la ciudad de Chilpancingo guerrero, fueron recuperados varios materiales malacológicos de origen marino y dulceacuícola. Estos moluscos correspondientes a los periodos Epiclásico (600-900 d. C.) posclásico temprano (900-1150 d. C.), presentan una diversidad de especies, que indican relaciones de este sitio con grupos asentados en la costa del Océano Pacífico, seguramente siguiendo los cauces de los ríos principales como el Balsas, el Huacapa y el Papagayo. Finalmente, este estudio es pionero en una región poco conocida arqueológicamente como el valle de Chilpancingo y el estado de guerrero en general.

LABURPENA

2005-2007 denboraldietan, Pezuapan izeneko lekuan, Guerrero estatuko Chilpancingo hirian, itsasoko eta ur gezatako zenbait material malakologiko berreskuratu ziren. Molusku horiek periodo Epiklasikoko (K.o. 600-900) eta posklasiko goiztiarrekoak (K.o. 900-1150) dira, askotariko espezieetakoak, eta Ozeano Barearen itsasertzean kokatutako multzoekiko harremanak adierazten dituzte, ibai nagusien ibilguei jarraituz seguruenik; esate baterako, Balsas, Huacapa eta Papagayo ibaiak. Amaitzeko, azterketa hori aitzindaria da, Chipancingo bailara eta Guerrero estatua, oro har, ez baitira oso ezagunak arkeologiari dagokionez.

1. INTRODUCTION

The archaeological site of Pezuapan is located 262 km south of Mexico City, 133 km north of Acapulco's tourist port; inside Chilpancingo City, the state capital of Guerrero (Figs. 1 & 2). It sits on the eastern slope of the Chilpancingo valley, strategically placing it at a vantage point to overlook the southern and northern portals to the valley, which are the passages towards the Pacific Coast and the Central Highland (Kolb 1987).

2. THE SITE

The archaeological vestiges found at the site cover an area of 4000 m^2. However, the main structure (fig. 3), which occupies most of the site, has a size of 50 m by 50 m approximately. It consists of a pyramidal foundation composed of three superposed storeys and joined rooms that correspond to separate construction stages. On the top portion of the foundation there is a series of rooms that were possibly used as storage and lodging accommodations (Fig. 4). Because of its similarities with other settlements, we know that this structure was not a temple, but rather a "Tecpan", which in Nahuatl –the Mexican native tongue- means palace. It is possible that the ruling group occupied the top of the structure, because to date no other site this large has been found in the Chilpancingo valley.

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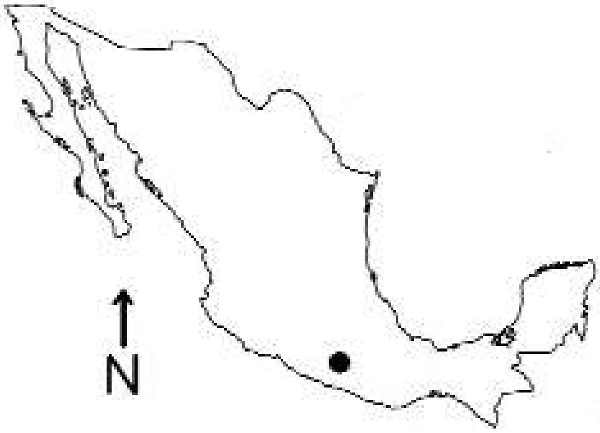

Figure 1. Localization of Pezuapan at Mexico.

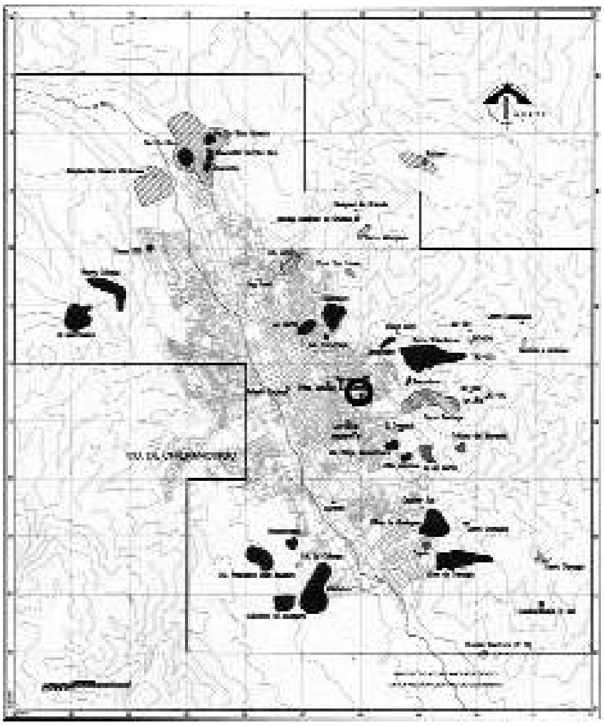

Figure 2. Pezuapan site in Chilpancingo drawing by Miguel Pérez Negrete.

The peak age of the site can be calculated during two periods: the Epiclassic (AD 650 to 950), where there may be a possible link with Xochicalco, and late Postclassic (AD 950 to 1150) as can be observed by the "toltechization" of some materials, such as the diagnostic figurines of each period. Nevertheless, an early occupation cannot be discarded since south of the site, on the other side of the ravine which gives its name to the site (Pezuapan), Middle Preclassic (900 to 400 BC) and Late Preclassic (400 BC to 200 BC) evidence was found with Olmec style materials, especially the ones from rescue work by the archaeologist Guadalupe Martínez (1989 and 1990).

Figure 3. Stairs of the main structure.

Figure 4. Rooms at the top of the main structure.

3. ARCHAEOLOGICAL INTERVENTIONS

The site's official discovery took place in the early 1980s, when the state government decided to urbanize that part of the Chilpancingo valley, leading to archaeological rescue work carried out by the National Institute of Anthropology and History (INAH) under the supervision of Carlos

Cedillo. This work allowed, at first, the size of the main structure to be identified (Cedillo 1982). After a relative abandonment, between 1999 and 2004, archaeologist Elizabeth Jiménez started sanitation and delimitation work, as well as consolidation work on the structure's west facade where the main access is located (Jiménez 1999).

By 2005, the systematic excavation of the site started under the supervision of archaeologist Miguel Pérez, and then a second season with archaeologist Hervé Monterrosa co-directing the project in 2007; the malacological materials this study focuses on emerged from those projects. Most of the material proceeds from the joined rooms located in the lower portion of the pyramidal foundation, whose function, while still unknown, could possibly have been for living accommodation; their use as workshops has been discarded due to the lack of evidence of production processes. However, some valves have also been found within the structural system of the building, inside the foundation core as in wall grouts.

4. PEZUAPAN MALACOLOGICAL MATERIAL

In our study, we considered separating the recovered material into two groups: the ones inside the site official perimeter and the ones outside the perimeter. This is because the contexts outside the official perimeter are exposed to greater alteration, due to urbanization and infrastructure works such as drains. On the contrary, inside the perimeter, the different elements which compose the site and their respective contexts can be defined more clearly.

During the 2007 season's excavation, 146 molluscs were recovered inside the Pezuapan site, belonging to the Bivalvia, Gastropoda and Polyplacophora class. Of the total material, 70% comes from the Panamic Malacological Province, that ranges from south of the Gulf of California to Tumbes in northern Peru (Keen 1971); 26% corresponds to coast lagoons possibly from the Pacific Ocean (Valentín 2007: personal communication) and finally 4% are from terrestrial habitats.

With the purpose of counting on a systematic study, the material was divided into different categories in order to separate the manufactured pieces from the raw pieces, as well as to classify production evidence and the finished objects. We should point out that most of the recovered molluscs do not present any cultural modification (figs. 5 & 6); among which the species *Pinctada mazatlanica, Chama echinata, Spondylus calcifer, Muricanthus princeps, Astraea unguis, Chiton centiculatus, Strombus gracilior, Turritella leucostoma, Oliva sp, Argopecten cf circularis, Periglypta multicostata* and *Crasostrea iridescens* stand out.

Figure 5. *Strombus gracilior.*

Figure 6. *Astraea unguis.*

As far as production evidence is concerned, only 16 valve fragments of *Pinctada mazatlanica* were identified whose external layer had been removed (fig. 7), possibly by means of shafting with a stone tool.

Figure 7. Worked pieces of *Pinctada mazatlanica.*

In the finished objects category, there are only 4 pendants, two of these are automorphic, in other words, they keep the natural shape of the biological specimen with which they were manufactured (Suárez 1977: 31, Velázquez 1999); these are from the *Conus* and *Turritella* species; and two xenomorphic, whose shape is different from the conch from which they were obtained (Ibid:21), in these cases *Pinctada mazatlanica* valves were used, and finally a bead of the latter species (fig. 8).

Figure 8. Finished objects of *Pinctada mazatlanica.*

5. CONTEXTS ASSOCIATED WITH THE MALACOLOGICAL MATERIAL

Prior to the 2007 project, rescue operations outside the site took place due to pavement construction by the city council on the streets that mark the site's limits in the north and west, and separate it from modern residential houses (Fig. 9).

On the north walkway 3 objects were recovered: a conch pendant, a *Pinctada mazatlanica* fragment and a full *Astraea unguis* specimen.

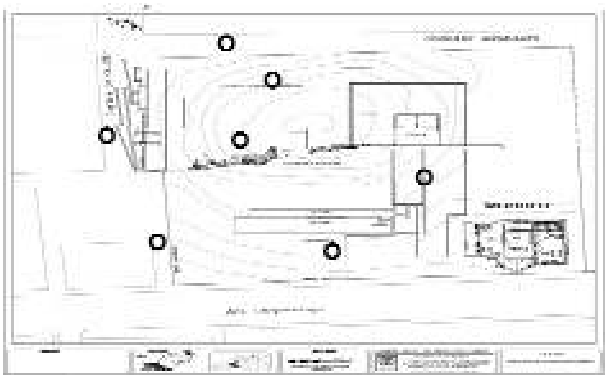

Figure 9. Spatial distribution of the contexts with shell objects drawing by Miguel Pérez Negrete.

These elements are associated with different sequences of stucco floors, which correspond to different stages of the north face on the third storey of the pyramidal foundation, which sustains the residential area of the elite.

On the west façade (fig. 10), 16 objects showing evidence of production were registered and a *Pinctada mazatlanica* pendant, as well as 16 specimens without cultural modification, among which we find the following species: *Chama echinata, Oliva* sp., *Muricanthus princeps, Spondylus calcifer, Euglandina* sp. and various species of Crassostrea sp. This material is associated with different sequences of rooms and floors that are joined to the second story of the pyramidal foundation, which is unfortunately badly degraded, due to the town's drainage and drinking water networks, which has made it impossible to determine its function.

Figure 10. West façade.

In the southwest portion (fig. 11) four fragments were found of the *Chama echinata*, *Euglandina* sp. and *Ostrea* species associated with supports and buttresses that protect the rooms from the Pezuapan, the fore-mentioned ravine that borders the site to the south. Here, we find a drainage canal that channels rain water through the foundation to prevent its destruction.

During the 2007 project, whose purpose was the excavation and consolidation of the west façade, where the main access is located, and of the rooms located on the upper part of the structure, four pieces of production evidence and four encrustation fragments of *Pinctada mazatlanica* were found within the site, as well as 14 elements without cultural modification of the following species: *cf. Turritella, Chama echinata* and *Crassostrea*. The molluscs are associated with the elite rooms, the

Figure 11. Southwest portion.

possible storage rooms and with construction filling. They are characterized by joined rooms and walls, some made with mud blocks, others with limestone and andesite blocks joined and flattened with stucco and mud. All the rooms have stucco floors, whose superposition leads us to believe they were continually maintained.

In the northern corner of the room area, five molluscs without cultural modification of the species: *Crasostrea* sp., *Strombus gracilior, Chama echinata* and *Spondylus* sp were found. This context is highly degraded, because for a long time it served as a dump, whose waste slowly covered the third level of the foundation.

As far as the east façade of the structure is concerned, seven unmodified elements of the species *Chama, Euglandina, Pecten* and *Chiton* were found; and in this same context a semicircular bead made with *Pinctada mazatlanica* was also recovered. This material is associated with two spaces, possibly domestic in nature, which were joined to the main facade of the third storey. In the same way, 29 units without cultural modification were registered, most of which were of the Crasostrea genus - surely modern, since they were recovered on the surface - and in smaller quantities we find *Chama*, as well as *Euglandina* sp. Two full pendants were also found, one automorphic of the *Turritella leucostoma* species and one xenomorphic manufactured from *Pinctada mazatlanica*.

6. COMMENTS CONCERNING PEZUAPAN'S CONCH MATERIAL. PRELIMINARY HYPOTHESIS

As we have seen, Pezuapan's malacological material appears in contexts with limited access, which is not surprising, since from early periods, shell was considered sacred by the people of the ancient Mexico, since it was associated with water and the underworld. In addition, its exotic origin and the difficulty with which it was obtainable promoted its use as a symbol to justify and maintain a high ranking position in the hierarchy.

Since the site's investigation has just begun, we cannot affirm that conch objects were produced there, because there is no hard evidence to sustain the idea; however, the large quantity of unmodified mollusks recovered in rooms and elite spaces remains interesting. This leads us to believe the inhabitants of the site possibly obtained the shells through trade networks with the Guerrero coastal settlements in order to be consumed in contexts of limited access.

Although the quantity of manufactured objects found is minimal, the large amount of species with no modifications whatsoever present at the site remains interesting. This helps us to think about the distance which the inhabitants would travel in order to obtain the molluscs and transport them back to the site; for if they were hardly consumed at Pezuapan it would have easier to acquire them already manufactured (Melgar, 2008: personal communication).

The latter points to the fact that the site did not acquire a significant amount of marine resources because it could have been a satellite to a more important site, possibly in Central Mexico. Situated on the trade routes between the coast and the Central Highlands, it absorbed a smaller amount of goods.

Another objective of this analysis is to define the tools used to manufacture these pieces. This is achieved through experimental archaeology and the analysis of the various modifications of the material with the Scanning Electron Microscope. This way it is possible to reconstruct the production process and determine if they were manufactured in a single or several workshops, depending on either standardization or diversity in tools and processes (Velázquez 2004).

For the reason, it is necessary to continue exploring the site and in doing so, contribute data about the settlement's functions and the activities that took place there, as well as the social, political, economic and religious organization of its inhabitants.

7. ACKNOWLEDGEMENTS

We give special thanks to archaeologists Miguel Pérez, Adrián Velázquez, Emiliano Melgar, and the biologist Norma Valentín and Belem Zuñiga, for their comments and suggestions and finally Ana Laura Solís, Victor Solís and Sandra Monterrosa for helping us with the English translation.

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Specialized Shell Object Production at Teopantecuanitlan Site (Guerrero, México)

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Specialized Shell Object Production at Teopantecuanitlan Site (Guerrero, México)

Producción especializada de artefactos en concha en el sitio de Teopantecuanitlan (Guerrero, México)

KEY WORDS: Mexico, Teopantecuanitlan, shell, production, manufacture.
PALABRAS CLAVE: México, Teopantecuanitlan, conchas, producción, manufactura.
GAKO-HITZAK: Mexiko, Teopantecuanitlan, maskorrak, ekoizpena, manufaktura.

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ABSTRACT

In the area of Teopantecuanitlan, located in the east-central region of Guerrero, the most ancient and abundant shell collection corresponding to the Mesoamerican formative period (1200-600 BC) has been recovered. Most of this material derives from the Pacific Ocean shores, and in less quantity from the Mexican Gulf and from rivers on the slope of the Pacific Ocean. Un-modified molluscs, pieces in process of work and finished objects have been identified. Through the use of experimental archaeology and the observation of the various modifications with optical microscopy (OM) and scanning electron microscopy (SEM), it was possible to deduce the techniques and tools used in their production, which should have been concentrated in one or in a few workshops controlled by the rulers of the site.

RESUMEN

En el sitio de Teopantecuanitlan, ubicado en la región centro-este del estado de Guerrero, se ha recuperado la colección de concha más abundante y antigua de Mesoamérica correspondiente al Periodo Formativo (1200-600 a.C.). Dicho material procede en su mayoría de las costas del Océano Pacífico, en menor cantidad del Golfo de México y de ríos de la vertiente del Pacífico. Se identificaron moluscos no modificados, piezas en proceso de trabajo y objetos terminados. Mediante el empleo de la arqueología experimental y la observación de las diversas modificaciones con microscopía estereoscópica (MO) y electrónica de barrido (MEB), fue posible inferir las técnicas y herramientas utilizadas para su producción, la cual debió ser concentrada en uno o pocos talleres controlados por el órgano de poder.

LABURPENA

Teopantecuanitlan izeneko lekuan, Guerrero estatuaren erdialde-ekialdeko eskualdean, Mesoamerikako maskorren bildumarik ugariena eta zaharrena berreskuratu da, Periodo Formatibokoa (K.a. 1200-600). Material gehiena Ozeano Bareko kostaldetik dator, eta gainerakoa, Mexikoko golkotik eta Ozeano Barean itsasoratzen diren ibaietatik. Ixturaldatu gabeko moluskuak, lantze-prozesuan zeuden piezak eta amaitutako objektuak identifikatu ziren. Arkeologia esperimentala erabiliz, eta itxuraldaketak Mikroskopia Estereoskopikoz (MO) eta Ekorketako Mikroskopia Elektronikoz (MEB) hautemanez, ekoizpenerako zer teknika eta tresna erabili zituzten ondorioztatu ahal izan zen, eta, itxuraz, botere-organoak kontrolatutako tailer batean edo tailer gutxi batzuetan egin ziren.

1. INTRODUCTION

Since the Mesoamerican formative period (1200-600 BC), there were contests between individuals and groups for acquiring and expanding their prestige and power, the development of a more centralized government and a less egalitarian social structure were already in place. Such aspects were related with the inherited kinship system and social stratification (Clark 1994: 192).

A potential power source to display prestige and social hierarchy were the prestige goods. Most of those goods are characterized by having been exotic or restricted circulation materials, although they could be products of external trade which worked as status symbols for the elite (Drucker 1981: 31).

An example of social stratification can be found in one of the most ancient Mesoamerican settlements, Teopantecuanitlan, a site with Olmec characteristics, located in the central region of the modern state of Guerrero (fig. 1), inside the Valley of the Copalillo District and close to where the Mezcala and Amacuzac rivers converge and give birth to the Balsas river (Martínez 1994: 145). According to ^{14}C dating, its occupation extends between 1200 and 600 BC (Martínez 1995: 60).

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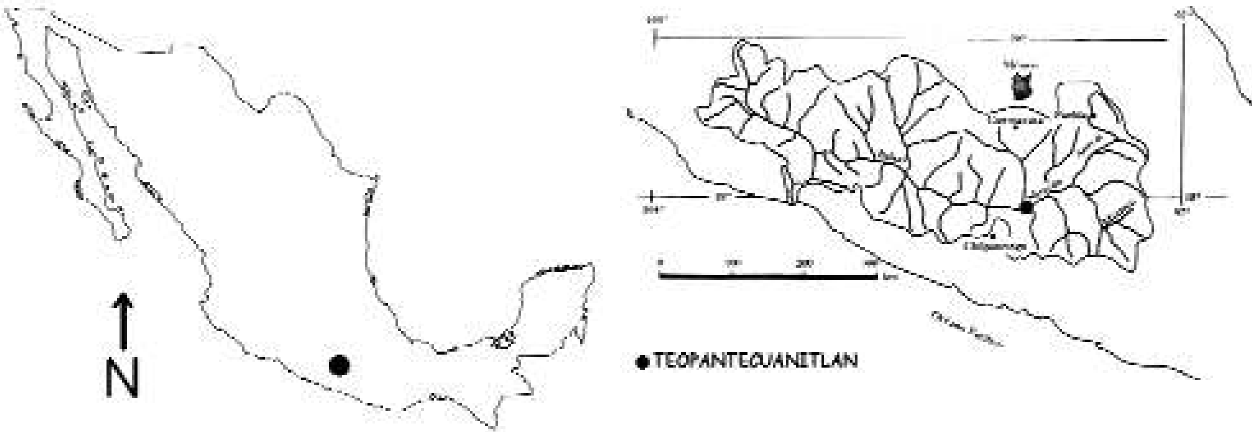

Figure 1. Localization of Teopantecuanitlan (a) and Balsas River (b).

It is from this Mesoamerican site where one of the most ancient malacologic collections has been recovered with 785 pieces (140 whole objects and 645 fragments). These specimens were found modified to serve as exotic and restricted access prestige goods.

2. ARCHAEOLOGICAL MATERIAL

The malacological material was recovered at different excavation stages. The material is composed of unworked shells (fig. 2), specimens corresponding to diverse phases of the production process (fig. 3), and finished objects (Solís 2007) (fig. 4). The molluscs used in this site derive mostly from the Panamic Province, 83% of the total collection; while 1.5% came from the Caribbean Province, 14% came from fresh water rivers, and finally there are 1.5% non-identified molluscs.

The distribution of the shell materials in the site is interesting, because 97.46% of the objects were

Figure 2. Unworked *Pinctada mazatlanica.*

Figure 3. Evidence of production.

Figure 4. Finished object of *Pinctada mazatlanica*

recovered in the main structure of the site, namely the Ceremonial Precinct located in the Unit A (fig. 5). In the same unit, the rooms located to the south of the Ceremonial Precinct, the South Terrace and the tombs share the most representative molluscs like *Pinctada mazatlanica, Strombus galeatus, Spondylus princeps* and *Chama echinata*, as well as *Cittarium* pica, *Pleuroploca gigantea* and the *Anadara* and *Mercenaria* genera, which were found in different stages of production.

In contrast with the concentration of recovered objects in the Ceremonial Chamber; Unit B and Unit C have fewer shell objects, with 1.61% and 0.95% respectively. *Pinctada mazatlanica, Strombus galeatus, Spondylus princeps, Chama echinata, Knefastia howelli, Lyropecten subnodosus, Hexaplex erythrostomus, Thais triangularis* and *Patella mexicana* came from the Panamic Province, whereas four *Crucibulum scutellatum* specimens, recovered in Structure 6 of Unit B, came from the Caribbean.

The strategic location of Teopantecuanitlan near the Balsas River could enable this community to control or influence the acquisition of mollusc species from the Pacific Ocean on the coasts of West Mexico to the sites of Central Mexico. The exercise of that control is a logical assumption based upon the access of the site to the coasts, especially the Guerrero state beaches. Large amounts of molluscs in sites along the Balsas River indicate it served as a conduit for trade and communication.

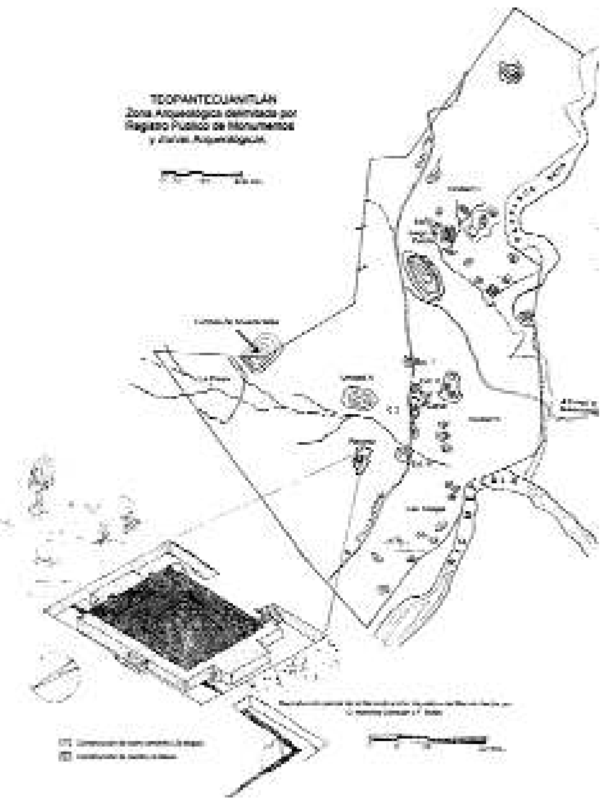

Figure 5. The site of Teopantecuanitlan.

3. OBSERVATION TECHNIQUES AND MANUFACTURING PROCESSES

The methodology of the technological analysis is based on the results of “Proyecto de arqueología experimental en materiales conquiológicos” and “Proyecto de técnicas de manufactura del México prehispánico”, both under the direction of Adrián Velázquez (2007).

In the first project there is an experimental workshop where more than 600 modifications of the archaeological shell objects are reproduced (fig. 6) (abrading, cuts, holes, incisions, polishing and brightening), using tools and techniques referred to in codexes and historical documents, or data recovered from archaeological contexts. In the second project, the traces of manufacture are analyzed comparing them with archaeological specimens in three levels: macroscopic, using an optical microscope at 10x, 30x and 63x and with Scanning Electron Microscope (SEM) Jeol JSM-6460lV, in High Vacuum mode (HV), Secondary Electron Imaging (SEI), 20 kV of energy, and 100X, 300X, 600X and 1000X of magnification.

Also, we follow one experimental archaeology postulate that goes: “the different work processes, tools and materials produce prints and characteristics that can be distinguished from each other” (Velázquez and Melgar 2006: 4; Velázquez 2007: 2), that is why the employment of a particular tool, made of a specific material, used in a specific manner and under certain circumstances will leave unique and differentiable features (Velázquez 2007: 15).

Figure 6. Experimental abrading with andesite.

4. RESULTS

For the analysis of manufactured objects, both, the *Pinctada mazatlanica* (29 whole objects and 418 fragments) and *Strombus galeatus* (6 complete and 27 incomplete) pieces were selected. The choice was based on two criteria, the abundance of these two species within the site in archaeological times (74.48% of the assemblage) and the number of modifications on these particular species occurred during the process of manufacture. The results of the handwork print analysis on the surface of the specimens obtained through the archaeologily allowed us to identify the homogeneity and standardisation in both techniques and tools.

In respect to the abrading of the outer and medium layer of the shells, such as the regularization of the mollusc surface, at 30X very well defined lines on the surface were observed (fig. 7), at 100X there are wavy appearance flat bands of 64 μm wide (fig. 8), which correspond to andesite carving tools, coinciding with the ones found by the archaeological pieces; such tools were also used to give the objects a specific shape and to regularize the edges formed by cutting.

The edges observed at 30X show well marked parallel lines (fig. 9), while at 600X they exhibit parallel lines of 0.8 to 1.3μm, coinciding with the experimental prints produced with obsidian flakes (fig. 10). At 30X holes are characterized as having smooth surfaces with scarcely visible features (fig. 11), however at 1000X they show a rough surface with straight lines of 1.3 to 2.0μm, diagnostically characteristic of the employment of chert powder animated with a vegetal reed (fig. 12). Finally, at 30X the finishes are characterized by a fine and shiny surface (fig. 13), at 600X they exhibit flat and straight bands of 4.0-5.0μm with interior lines of 0.41μm, features experimentally left by a chert nodule and polishing (fig. 14), possibly made with a soft material similar to the leather employed in the experiments.

As we can see, a series of choices made in a systematic manner through the different stages of the operation chains by the craftsmen in charge of object production, indicate that tool usage is constant throughout the Teopantecuanitlan site.

It is also important to consider the contextual location of the objects, most of the production evidence can be found concentrated in an specific 100m^2 area within the North Square in the Ceremonial Chamber. The objects in production and the tools and techniques of the finished objects were found in tomb contexts and placed in the architectural structures of the site, as evidence of the regulation of the production of shell objects and the creation of standardized tools occurred during production within the site.

Thus so, the tools related to the material, which were located in the vicinity of the shrine, andesite, and obsidian flakes and blades, as well as chert nodules, corroborate the analysis results.

5. SHELL OBJECT SPECIALIZED PRODUCTION AT TEOPANTECUANITLAN

Teopantecuanitlan shell objects may be considered as prestige goods. Leaders in the region control the production and distribution of these objects to increase or extend their political power (Brumfiel & Earle 1987:3).

In this way, the elite members consciously and strategically employed this specialization in order to promote and maintain social inequity, strengthening and consolidating their political coalitions, as well as founding new control institutions over prestige goods elaborated by specific producers attached to the centralized power (*ibidem*).

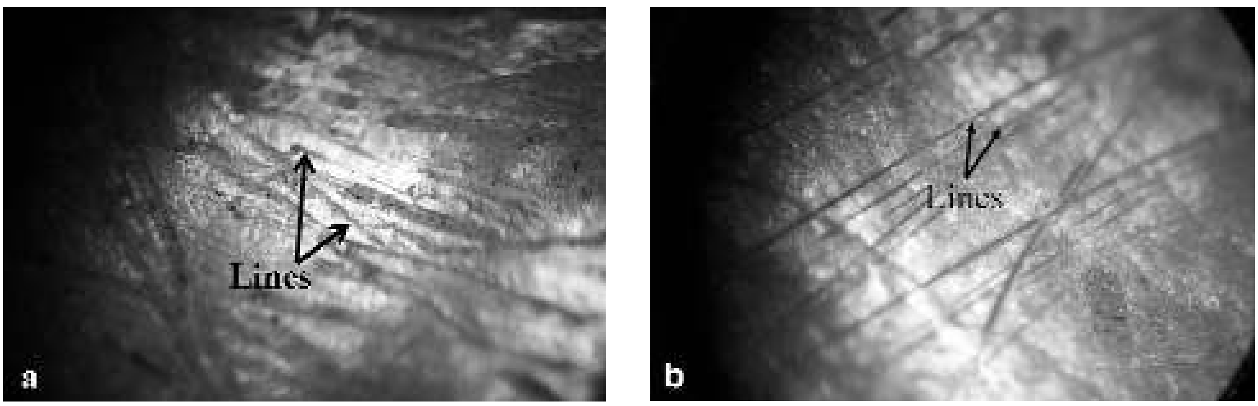

Figure 7. Experimental abrading surface of *Pinctada mazatlanica* (a) and archaeological one (b).

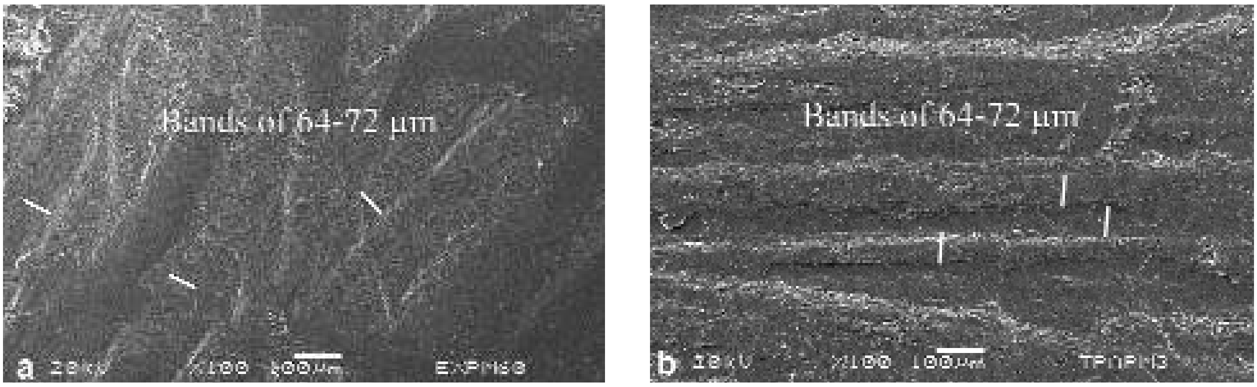

Figure 8. Experimental abrading with andesite (a) and archaeological one (b), both at 100X.

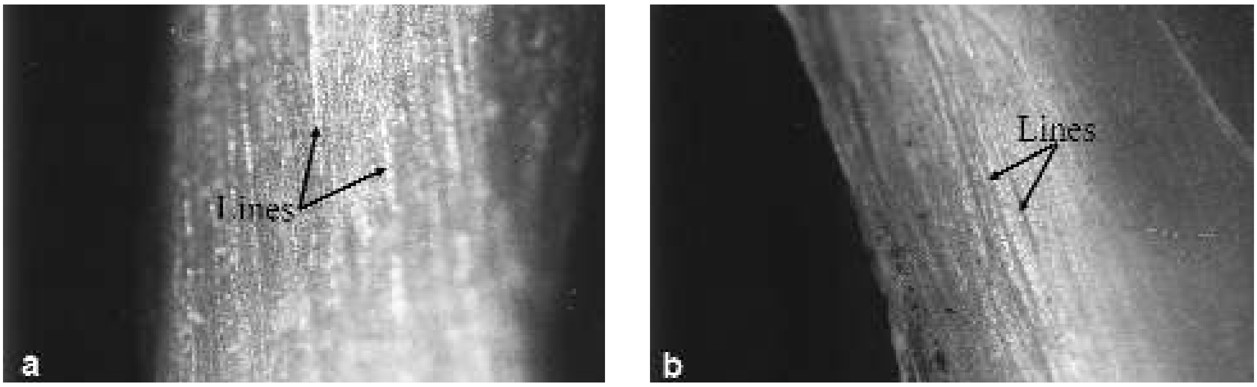

Figure 9. Experimental edge (a) and archaeological one, (b) both with parallel lines at 30X.

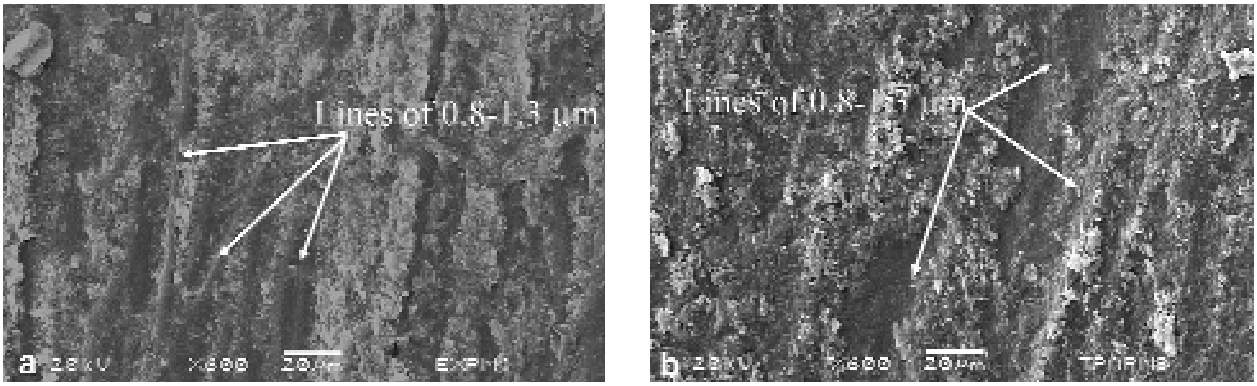

Figure 10. Experimental edge with obsidian flakes (a) and archaeological object (b) at 600X.

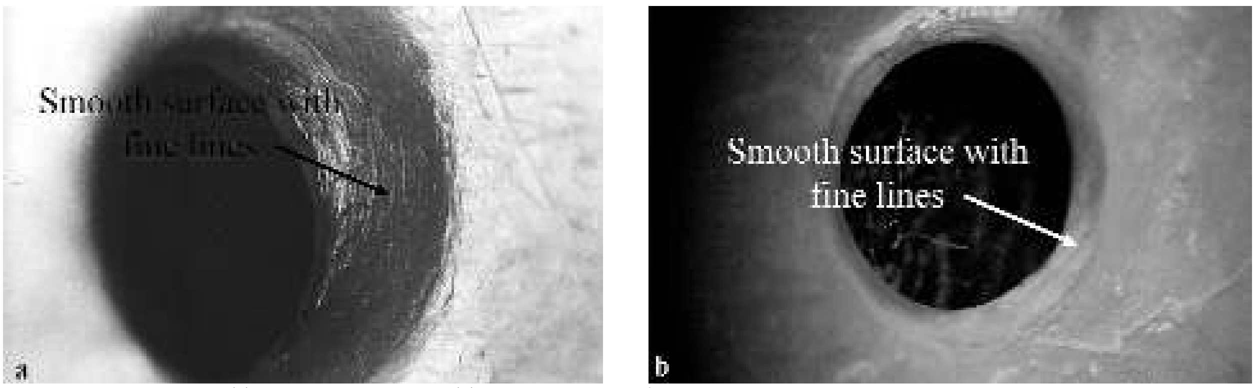

Figure 11. Experimental hole (a) and archaeological bead (b), both with smooth surface.

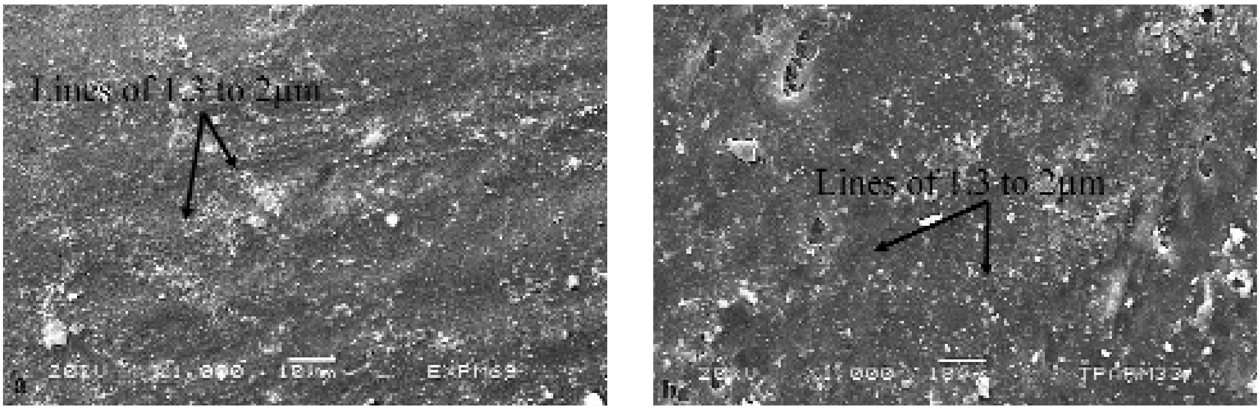

Figure 12. Experimental hole with chert powder (a) and archaeological one (b).

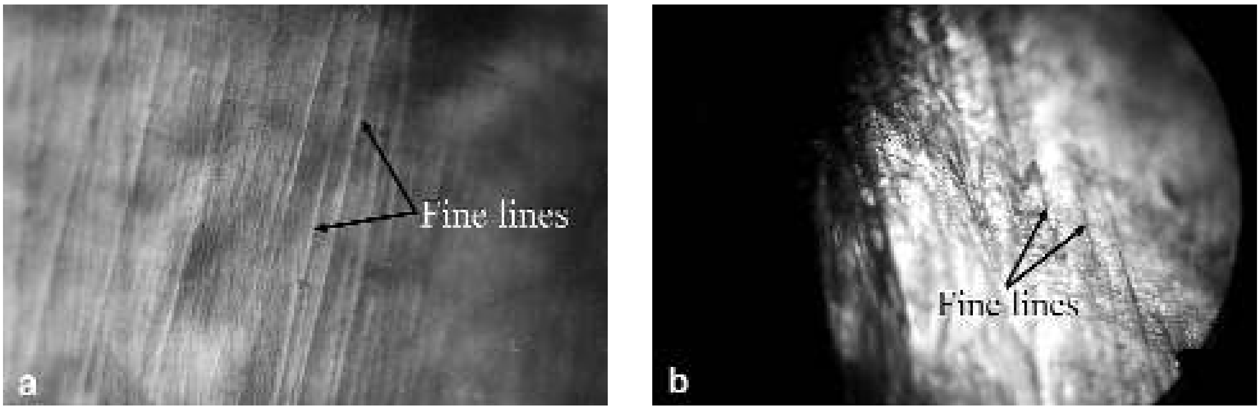

Figure 13. Experimental polishing (a) and archaeological one (b), both with fine lines and shiny surface.

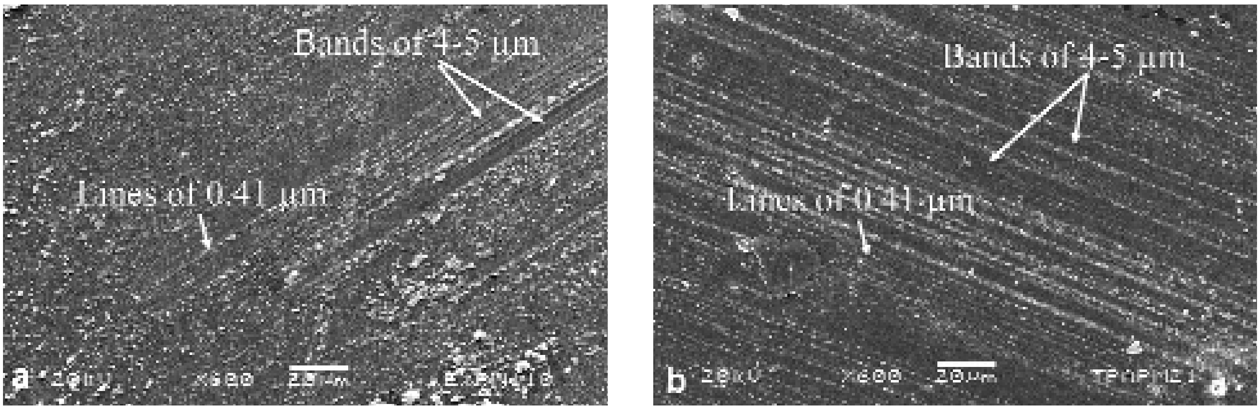

Figure 14. Experimental polishing with chert nodule (a), and archaeological one (b).

The privileged sector not only controlled the consumption, but intervened in the acquisition of raw materials, tools and production. This production had to be highly concentrated or centralized, whether in one or a few workshops within the site, even possibly within the ceremonial shrine, where craftsmen guilds who elaborated these goods were under strict supervision of the power core organ, therefore casting specific dictated techs formatted by tradition or cultural preferences (Brumfiel and Earle 1987: 1-5, Clark and Parry 1990: 298, Costin 1991: 25).

Given the evidence, there are diverse archaeological markers which provide data about specialization, production and producers, as well as the work prints on manufactured products, the pieces in different phases of production, and also the probable tools employed, all of them placed in certain locations. Namely, the standardisation and homogeneity within the processes and tools (abrading with andesite grindstones, cutting with obsidian flakes and blades, drilling with chert powder and polishing with chert nodules); this evidence allows us to define a centralization of the production units and a stricter control over the distinct stages of the manufacturing process (Velázquez 2007: 3). Also, this pattern of production controlled by the elite members was identified in Tenochtitlan (Velázquez 2007) and Xochicalco (Melgar 2009), analyzing the manufacturing traces as we did. In contrast, there are other studies in elite contexts at Piedras Negras and Aguateca, Guatemala, where the authors proposed the same production but by analyzing the use-wear traces of the tools, unfortunately, they could not distinguish the tools employed on shell or bone (Aoyama 2007, Emery and Aoyama 2007).

In short, these evidences can be considered as a specialized production markers made by dependent craftsmen, under close and strict government control, which demands this kind of goods to establish and maintain the social inequity inside the Preclassic site of Teopantecuanitlan.

6. ACKNOWLEDGEMENTS

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What about shells? Analysis of shell and lithic cut-marks. The case of the Paraná wetland (Argentina)

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What about shells? Analysis of shell and lithic cut-marks. The case of the Paraná wetland (Argentina)

What about shells? Análisis de conchas y de marcas de corte. El caso del humedal del Río Paraná inferior (Argentina)

KEY WORDS: Shell, cut-marks, lithic and bone tools, Low Paraná River wetland, technological integration.
PALABRAS CLAVE: Concha, huellas de corte, artefactos líticos y óseos, humedal del Río Paraná inferior.
GAKO-HITZAK: Kuskuak, ebakidura-arrastoak, harrizko eta hezurrezko tramankuluak, Paraná ibaiaren beheko zatiko hezegunea.

Natacha BUC[(1)], Romina SILVESTRE[(2)] & Daniel LOPONTE[(3)]

ABSTRACT

One feature that defines the archaeological deposits located in the Low Paraná wetland (Pampean Region, Argentina) during the Late Holocene is the abundance of malacological remains. Moreover, in the technological matter, assemblages are characterized by a low number of lithic tools and a great abundance of bone tools. In previous papers we stated that the technology in this region is defined by a strategy of complementation of both materials. The aim of this work is to include malacological remains as an alternative source of raw material, mainly in the use of cutting edges. For that purpose, we developed an experimental program in order to evaluate the technological possibilities of shells as tools used in bone processing. Particularly, we analyze the cut-marks made by shell and lithic edges. Our results show that it is possible to differentiate cut-marks made by both materials. However, to distinguish shell cut-marks in the archaeological record poses some problems, basically regarding bone tools and multiple taphonomical factors.

RESUMEN

Uno de los rasgos que define a los depósitos arqueológicos localizados en el humedal del Paraná inferior (Región Pampeana, Argentina) durante el Holoceno tardío es la gran abundancia de restos malacológicos. Por otro lado, en términos tecnológicos, los conjuntos se caracterizan por una baja cantidad de artefactos líticos y una gran abundancia de artefactos óseos. En trabajos anteriores planteamos que en el área la tecnología se define por una estrategia de complementariedad entre ambos materiales. Este trabajo tiene como objetivo integrar los restos malacológicos como una fuente alternativa de materia prima, fundamentalmente en el caso de la utilización de filos cortantes. Para ello, desarrollamos un programa experimental donde se evaluaron las posibilidades tecnológicas de las valvas como artefactos para el procesamiento de materiales óseos. En particular, se analizan comparativamente las marcas de corte producidas por filos líticos y de valvas. Los resultados indican que las marcas de corte producidas por ambos materiales son claramente diferenciables. Sin embargo, el reconocimiento de las huellas de valvas en el registro arqueológico es problemático, especialmente si tenemos en cuenta el conjunto de artefactos óseos y los múltiples factores tafonómicos.

LABURPENA

Paraná ibaiaren beheko aldeko hezegunean (Panpa eskualdea, Argentina) aurkitutako Holozeno berantiarreko depositu arkeologikoaren ezaugarri bat hondakin malakologikoen ugaritasuna da. Bestalde, termino teknologikoetan, harrizko tramankulu gutxi ageri da multzoetan, eta hezurrezko tramankulu ugari. Aurreko lanetan planteatu genuen, alor honetan, bi materialen arteko osagarritasun-estrategia gisa definitzen dela teknologia. Lan honen helburua da hondakin malakologikoak lehengaien iturri alternatibo gisa integratzea; batik bat, aho zorrotzen erabilerari dagokionez. Horretarako, programa esperimental bat garatu genuen, kuskuek hezurrak prozesatzeko zer aukera teknologiko dituzten ebaluatzeko. Zehazki, hezurrezko ahoek eta kuskuzkoek egindako ebakidura-markak aztertu eta alderatu genituen. Emaitzen arabera, material batez egindako ebakidura-markak eta beste materialaz egindakoak argi eta garbi bereizteko modukoak dira. Hala ere, erregistro arkeologikoan kuskuen aztarnak bereiztea ez da erraza; batik bat, hezurrezko tramankuluen multzoa eta faktore taxonomiko anitzak kontuan hartzen baditugu.

1. INTRODUCTION

This paper is framed in the general analysis of the technology of hunter-gatherer groups that inhabited the Low Paraná's wetland during Late Holocene (1100-700 years BP approximately). Micro-wear analyses carried out on bone and lithic materials from our study area support the idea of functional complementation: while lithic tools are related to bone tool manufacture, these are oriented to obtain and process resources (Buc Silvestre 2006). Surely, this scenario of technological integration would have included other raw materials as wood and shell. In fact, local historical chronicles make reference to the use of shells as tools in different activities (Dobrizhoffer *sensu*

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Furlong 1965, Paucke 1944). Nonetheless, the use of shells as artifacts is not evaluated in local archaeological studies.

Particularly, both archaeofaunal remains and bone tools recovered in the Low Paraná wetland present cut-marks which were traditionally associated to lithic edges. However, given the proved efficiency of shell edges (Choi and Driwantoro 2007, Toth and Woods 1989) and the high availability of *Diplodon* sp. in the area, shell edges must also be considered as mark agents. Shells would have been an important alternative raw material, basically, considering the scarcity of the lithic archaeological assemblage and the regional distribution of lithic sources (Loponte i.p. Sacur, 2009). Consequently, despite the general frame of lithic and bone investigations above mentioned, the main purpose of this paper is to evaluate the use of shells as cutting edges on processing -particularly on cutting- bone and antler. Our goals are twofold: on the one hand, we test the efficiency of shells as cutting edges for hard materials, such as bone and antler; on the other hand, we start to generate a database of cutting marks made by lithic and shell edges on bone, expecting to identify differences in morphologies that will serve to distinguish patterns in the archaeofaunal assemblage (following also Choi and Driwantoro 2007).

2. ARCHAEOLOGICAL BACKGROUND

The Low Paraná's wetland is located between 32º 05` LLS and 34º 29` LLS, in the central-west portion of Argentinean Pampean Region (Fig. 1). Hunter-gatherer campsites are located in fluvial banks that are the highest environmental points and are surrounded by inundated plains. The diet of these groups was based on the intensive and systematic exploitation of fishes (Silurids and Characiforms) and deer (*Blastocerus dichotomus* and *Ozotoceros bezoarticus*), and also of medium and small sized rodents (*Myocastor coypus* and *Cavia aperea*). Isotopic analyses on human remains suggest that almost 30 % of the diet involved vegetables (Acosta i.p., Loponte i.p.). This picture was finally completed with molluscs such as *Diplodon* sp. and *Ampullaria=Pomacea*, both annual resources grouped in fixed banks. This situation implies low costs of mollusc collection for human groups (Loponte i.p., for a detailed synthesis of the environment and resources bases).

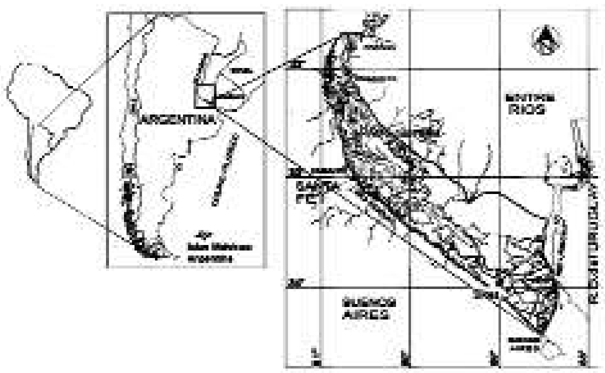

Figure 1. Study area: Low Paraná wetland (modified after Malvárez 1999).

All deposits have the same archaeological structure suggesting they were multi-activity areas with evidence not only of prey processing and consumption, tool manufacture and repair, but also of human inhumations (Loponte i.p.). The lithic assemblage is small, mainly composed of natural edged flakes, cores and grinding tools like manos and mortars (see Loponte i.p., Sacur). By contrast, there is a great quantity of different bone tools that include from harpoons, hooks of spearthrower and projectile points, to awls, pin-like tools and smoothers (Buc and Loponte 2007).

We think that lithic and bone material was worked in a complementary way (*vide supra*). Particularly, this paper is concerned on cut and sawing marks found in archaeofaunal bones. Even if most of the items are remains of faunal consumption, there are a great number of sawed bones interpreted as by-products of the manufacture of bone tools (see Acosta *et al.* i.p., Loponte and Buc i.p.). Moreover, in some cases, sawing was a technique used to decorate, or simply to mark bone tools (Fig. 2). Although it was traditionally assumed that bone incisions were done by lithic tools; in this work we explore the possibility of using shells as cutting tools.

3. MALACOLOGICAL REMAINS

The archaeological deposits of Low Paraná have thick lenses of *Diplodon* sp. Although most of them were recovered in their natural form, we also found some modified shells (Loponte i.p.). These include from symbolic items, such as *tembetás* (T shaped items used below lips) and beads, to apparently functional ones: shells with one or more right edges.

These accumulations are the result of relatively isolated discarding events during mollusc consumption made by hunter-gatherer groups. Consequently, shells would have been a raw material with high availability and no extra acquisition cost. In fact, historical chronicles mention the use of shells in different activities such as pottery

Figure 2. Bone tools with cut-marks as decoration.

manufacture, and leather or wood processing (Maradona 1974, Chiri 1972, Paucke 1944). Although several papers consider mollusc shells as raw materials for tools (Lammers-Keijsers 2007, Toth and Woods 1989),in our study area archaeological discussions have only emphasized their ornamental function (Chiri 1972), not considering their potential use as raw materials.

4. CUT-MARKS

Archaeological studies concerned in different subjects have dealt with the problem of cut-marks identification in bones. Considerable effort has been paid to analyze their morphology and patterning in order to discuss the presence/absence of certain human behaviours (e.g. Bunn and Kroll 1986; Shipman and Rose 1984, Binford 1981, Bunn 1981, Potts and Shipman 1981). Although the great majority of these papers are associated with lithic materials, a great number is focused on those features that can differentiate lithic from metal cut-marks (Christidou 2007, Greenfield 1999, Liesau von Lettow-Vorbeck 1998, Olsen 1988, Walker and Long 1977). Even if not only metal, but other materials were used as edges as well; much less attention has been paid to features left by shell edges.

Specifically on this matter, Toth and Woods (1989) made an experimental program cutting bone with shell knives and analyzed the traces they left. They conclude that "retouched molluscan shell knives are feasible butchery tools and can produce striations on animal bones that are similar to those produced by stone cutting edges" (Toth and Woods 1989: 254). Nevertheless, these conclusions are based on the analysis of retouched shells. Recently, Choi and Driwantoro (2007) performed an experiment testing natural shell edges, along with 12 lithic and non lithic materials (including dry bone flakes), in butchery activities. They used shells of a marine bivalve mollusc (*Veneridae*) from Florida. According to their work, in 60% of the cases, the natural fracture of shells produces blunt edges (nearly 90º) that can be used either in their cortex or inner surface. The authors distinguish two types of blunt edges that produce different cut-marks. One case is when the fracture forms an edge available both in the cortex and inner surfaces. In this case, the tool will be used in a tilted angle that will make a wide-open V groove in the surface (Choi and Driwantoro 2007: figure 6 C, H). The second case is when the edge is either on the irregularly broken cortex or the inner layer. This surface makes a wide, flat and shallow groove (Choi and Driwantoro 2007: Fig. 6D, I, L)[1].

Moreover, according to this work, shell striations are smooth (*sensu* Le Moine 1991) due to the pattern of perpendicular organized minerals in the shell cortex. This produces grooves with internal smooth bases, instead of longitudinal microstriations (Choi and Driwantoro 2007). Although the authors do not compare these marks with those left by lithic edges, we know that this is a differential aspect as lithic marks are well defined by their coarse striations (*sensu* Le Moine 1991). Multiple internal striations are product of the longitudinal movement made with rock grains which are randomly patterned.

None of both differences previously pointed out (morphology and profile of grooves) were recognized in Toth and Woods' (1989) paper because they used retouched shell edges that could have behaved like lithic ones. However, that work, like the one of Choi and Driwantoro, revealed that the performance of shell flakes is very efficient (almost as some lithic materials; Choi and Driwantoro 2007, Toth and Woods 1989). Therefore, for our study context of hunter-gatherers in the Paraná's wetland

[1] Because of their morphology, the inner layers produce thinner striations than those of the cortex (Choi & Driwantoro 2007).

during late Holocene, shell could have been an important raw material used to process animals for diet and technology; particularly to cut hard materials as bones and antler.

5. EXPERIMENTAL PROGRAM

For that purpose, we performed an experimental program cutting bones with natural shells and lithic flakes. Since lithic and shell are different materials, on the one hand, their edges have different morphologies; and on the other, they are composed of different elements singularly patterned. Therefore, the same activity (cutting) performed with different raw materials should leave distinguishable traces on the worked surface, bones in this case (see Fig. 3). Our hypothesis is that sharp lithic edges will leave V-shaped profiles and coarse striations; while, more brittle asymmetrical shell edges will leave wide open V profiles and smooth striations.

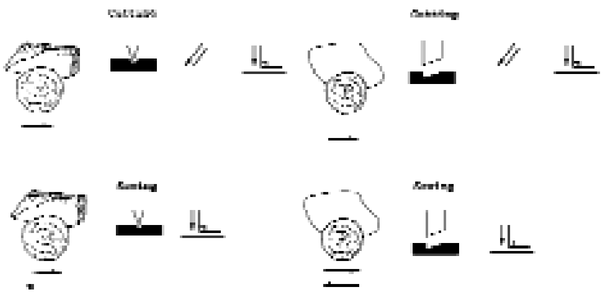

Figure 3. Cut-marks expectations (modified after Mansur 1986; Choi & Driwantoro 2007).

In this exploratory programm, we used a total of nine shell bivalve edges (*Diplodon* sp.) to cut dry and fresh sheep bones (*Ovis aries*). One shell was used in its entire form (not fractured), but the rest of them were fractured, resulting in triangular tools with one 90º edge and the two others varying between 20 and 45º. On the other hand, we used eight lithic edges[2] with symmetric – or almost symmetric – profiles, and acute angles (between 20 and 25º). Raw material used was chert, a siliceous cryptocrystalline rock from Sierras Bayas formation, a quarry located in the south of Buenos Aires province. Although this location is more than 400 km away from the archaeological sites under study, there is solid evidence that this raw material was used in the Low Paraná wetland during late Holocene times (Sacur 2009, Loponte i.p., Buc and Silvestre i.p.). Table 1 synthesises the experimental data for both lithic and shell material.

Despite describing groove morphologies, we also expected to test the shell effectiveness in cutting and sawing bones like those one presented in local archaeofaunal samples. Given the brittle nature of shells, their edges were readily modified

Piece Nr.	Material	Worked material	State	Activity	Use time	Active Edge	Edge Angle	Bone Nr.
A8	shell	Bone	wet	Sawing	10'	modified	± 90	vE1
A7	shell	Bone	wet	Sawing	15'	natural	35	vE2
A11	shell	Antler	wet	Sawing	20'	natural	42	E18
A13	shell	Bone	dry	Cutting	20'	natural	32	-
Nº1	shell	Bone	wet	Cutting	12'	natural	33	-
Nº2	shell	Antler	wet	Cutting	9'	natural	25	E18
Nº5	shell	Antler	wet	Cutting	8'	natural	26	E18
A12	shell	Bone	wet	Cutting	5'	natural	27	vE5
C3	lithic	Bone	dry	Cutting	2'	natural	20,5	B1
C3	lithic	Bone	dry	Sawing	2'	natural	20,5	B2
C3	lithic	Bone	dry	Sawing	1'	natural	20,5	B3
C6	lithic	Bone	-	Sawing	20'	natural	21	-
C8	lithic	Bone	wet	Sawing	15'	natural	22	-
C4	lithic	Antler	wet	Sawing	20'	natural	22	E18
B21	lithic	Antler	dry/wet	Sawing	15´	natural	24	E9
B4	lithic	Antler	dry/wet	Sawing	35´	natural	36	E9
B14	lithic	Antler	wet	Sawing	1h 15´	natural	43	E8
B13	lithic	Antler	wet	Sawing	10´	natural	23	E8
B23	lithic	Antler	wet	Sawing	35´	natural	26	E8
B2	lithic	Antler	wet	Sawing	25´	natural	23	E8
E16	lithic	Antler	wet	Sawing	25´	natural	24	E8

Table 1. Summary of the experimental collection.

[2] We performed two experimental instances in the case of lithic flakes. In the first one we used five flakes to saw fresh bone and antler. In the second one, we used three lithic flakes to saw and cut fresh and dry bone.

after some minutes of work, very quickly in comparison to lithic tools. However, despite shell edges becaming rounded after 10 minutes of work, they do not loose their cutting effectiveness. In fact, one tool (A13) preserved its efficiency after 20 minutes of work.

Brittle shell edges are more easily chipped and flaked than lithic ones; and instead of this being a problem, it increases the tools' efficiency since it not only revives edges before dulling but also provides shell particles, which act as abrasives and facilitate the cutting activity. Moreover, in bone cutting and sawing, natural shell edges proved to be more efficient than those asymmetric dull edges (nearly 90º) obtained by direct fracture.

6. MICROSCOPIC TECHNIQUES

The analysis was made using three microscopic devices. A binocular microscope (Arcano XTL 3400) working at magnifications between 5X and 50X was used for initial examination, to provide general information about the extent and distribution of traces. Secondly, we used an incident-light metallurgical microscope (Zeiss Axiovert 100A). This microscope, working with perpendicular light, let us distinguish contact and characteristics of micro surfaces. However, its very short depth of field was a problem in this study given the high size of striations. For that reason, pieces were better seen under 50X, and only rarely we used 100X magnifications. Transversal cuts were seen under binocular and metallurgical microscope, but the best images were obtained under the last one. In third place, we used an environmental scanning electron microscope (ESEM) at 100X-150X to explore patterns defined by optical techniques in complete pieces. As this microscope works composing the image through the scanning of electrons discharged against the surface, we can obtain clearer images of sectors that cannot be appreciated with the short depth of field of the metallurgical microscope. To describe the microscopic patterns we mostly follow the terminology defined by LeMoine (1991) and Choi and Driwantoro (2007).

7. RESULTS

Microscopic analysis of bones used in our experiments leds us to distinguish differences in lithic and shell cut-marks morphologies.

Lithic striations are coarse, deep and have sharp walls; ESEM images clearly show their V profile (Fig. 4 and 5). Indeed, our images are very similar to those presented by other authors (Greenfield 1999, Liesau von Lettow-Vorbeck 1998, D'Errico 1993, Olsen 1988, Walker and Long 1977).

On the other hand, shell traces are smooth, and in the ESEM we could see that they have staggered walls and open V profiles (Fig. 6 and 7). In this case, our images are quite different to those presented by Toth and Woods after cutting bone with shell edges (Toth and Woods 1989: Fig. 4-6), and maybe this could be explained because of differences in the experimental programs. Toth and

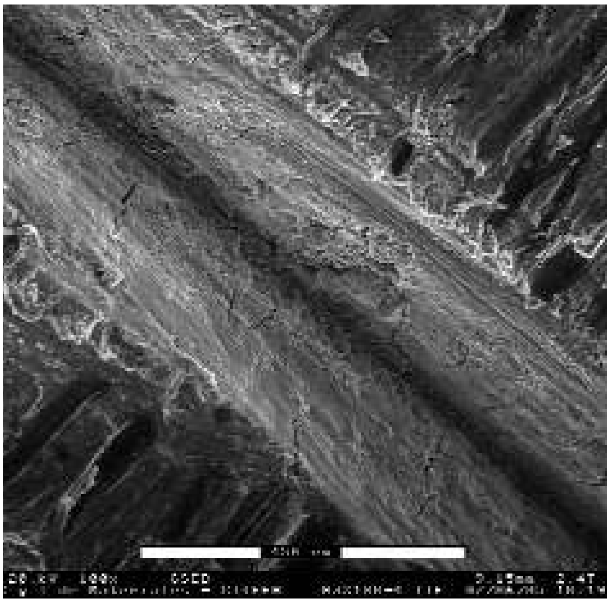

Figure 4. Lithic cut-mark left in bone (B3). Close V-shaped profile. ESEM. 100X.

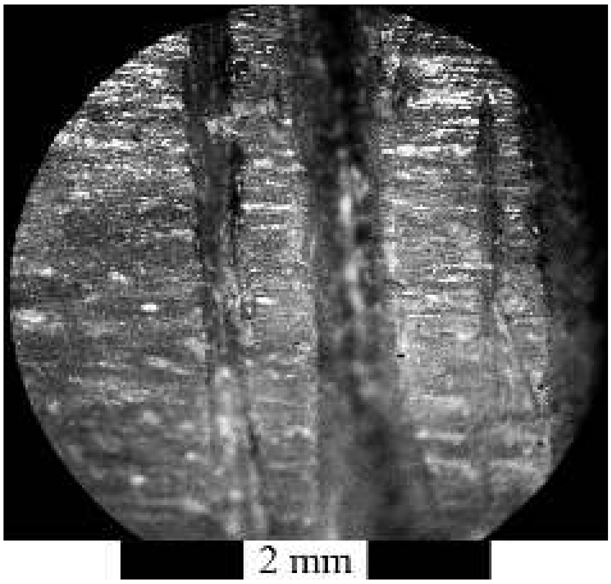

Figure 5. Lithic cut-mark left in bone (B3). Close V-shaped profile. Optical microscope. 100X.

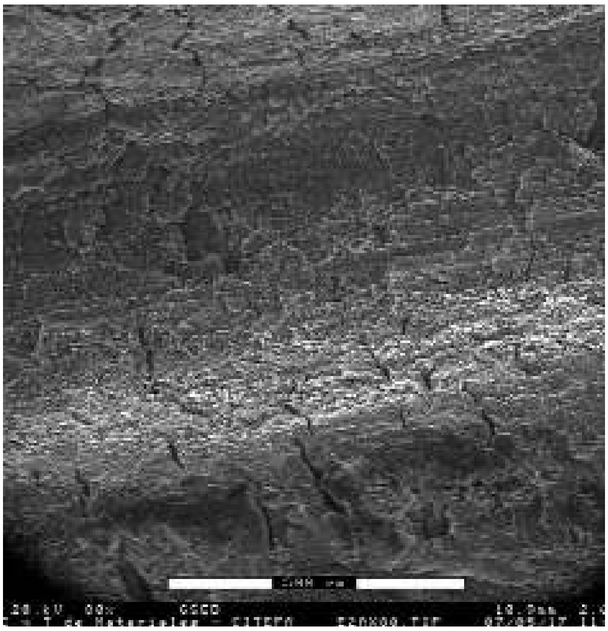

Figure 6. Shell cut-mark left in bone (VE2). Open V-shaped profile. ESEM. 100X.

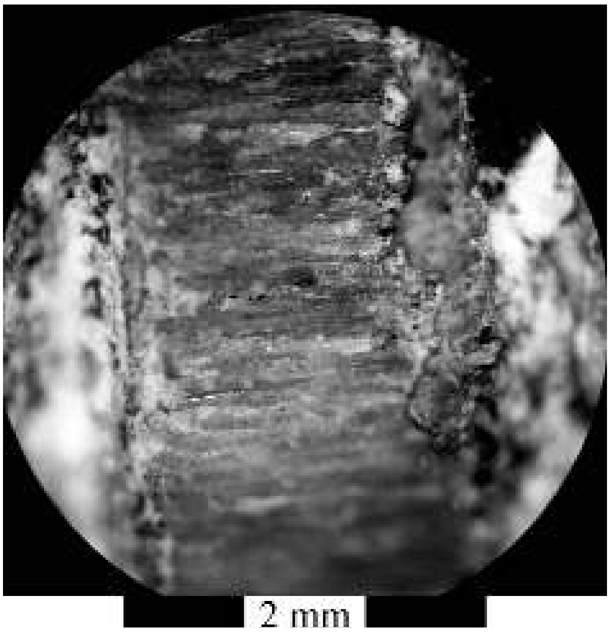

Figure 7. Shell cut-mark left in bone (VE2). Open V-shaped profile. Optical microscope 100X.

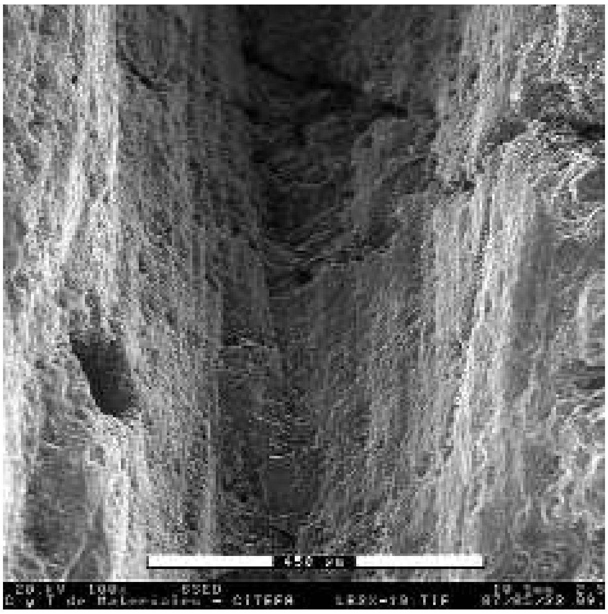

Figure 8. Archaeofaunal bone from LB2. Close V cut-mark. ESEM 100X.

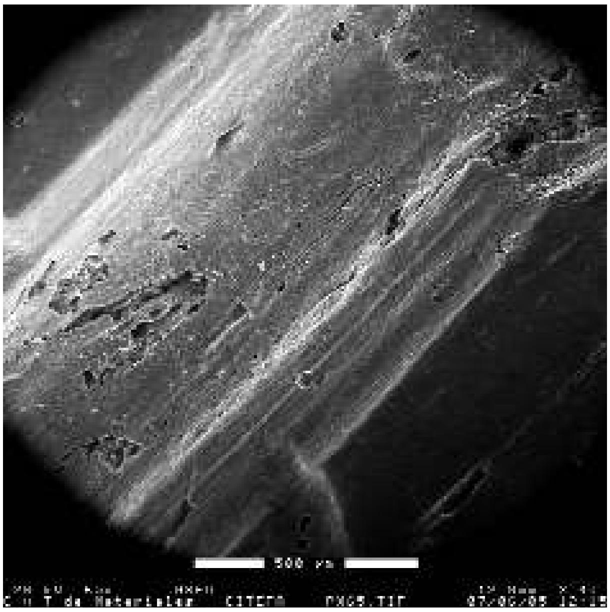

Figure 9. Archaeological bone tool (LB2 129). Open V-shaped cut-mark. ESEM. 100X.

Woods used American oyster and mussel as raw material, but retouched them to produce knives and this made edges with a very peculiar morphology. In our case, we used bivalve shells without modification. Therefore, our images are comparable with those presented by Choi and Driwantoro (2007), who also use natural shell edges. In fact, their figure L - a cut-mark made on bone with a blunt shell edge- shows exactly the same features that we recorded in our samples.

As we stated, like Choi and Driwantoro pointed out, most shell marks are either "wide open V grooves" or "flat and shallow canal groove" (Choi & Driwantoro 2007: 54). On the other hand, many authors defined lithic cut-marks as V-shaped (Greenfield 1999, Liesau von Lettow-Vorbeck 1998, D'Errico 1993, Olsen 1988, Walker and Long 1977). In order to test this idea, we made thin transversal cuts of both types of experimental cut-marks and performed a blind test. One of us analyzed the samples (n=5) in a metallurgical microscope and classified them as close or open V-shaped. Then, we confront these results with the experimental data, proving that those profiles classified as open V are associated with shells; while the close V-shaped marks were made by lithic edges (Fig. 10).

8. DISCUSSION

After these differences, we re-analysed some archaeofaunal bones and bone tools with cut-marks. We chose items from La Bellaca 2 (LB2), the site with the highest number of bone tools, and (paradoxically) the lowest quantity of lithic tools.

For example, the sawing mark of a metapodial from the La Bellaca 2 site, under the ESEM shows a close V profile, similar in depth and sharpness to lithic traces obtained in our experimentation (see Fig. 8 and compare with Fig. 4). On the other hand, we analysed one plat stemmed point (LB2 129, see Fig. 2) which preserves clear manufacture traces apparently not modified by use (see Loponte and Buc 2007). Under the ESEM these striations could be described as wide and with staggered walls, similar to shell traces obtained in our experimentation (see Fig. 6 and compare with Fig. 9). Nevertheless, in analysing bone tools, we must consider after-manufacture polishing: either final manufacture techniques or the wear formed by use might polish bone surfaces, even rounding previous cut-marks (Buc and Loponte 2007, Buc and Silvestre i.p., Buc 2005). Moreover, as these manufacture traces must have been made by scraping the surface – not cutting –, to define this kind of marks we need a deliberate experiment involving this action.

Therefore, the identification will be strong only in the case of cut-marks made on bones but not on tools, and should be linked to other lines of evidence, as the functional analysis of archaeological lithic and shell edges, for example. In our context study, the majority of lithic edges analysed show use-wear polish associated with bone and/or antler cutting (Buc and Silvestre 2006, Sacur 2004). In shell surfaces, on the other hand, it is known that their use on different materials left distinct traces (Lucero 2005, 2004, Lucero and Jackson 2005, Mansur and Clemente i.p., Schmidt *et al.* 2001). Although we could see that the natural laminar structure of shells was modified after use, this functional analysis will deserve a paper of its own. In this sense, opposite to other cases where the low quantity of bivalve shells on sites is assumed to represent only raw material acquisition (Lammers-Keijsers 2007), in our case study, it will be very difficult to identify natural shells used as cutting edges, given the great quantity of malacological remains present in archaeological sites. Additionally, despite the identification of use-wear patterns in shell experimental samples, analysis of archaeological remains must consider that not only the brittle nature of shells does not contribute to the preservation of features; but that there are taphonomic factors to contemplate as well.

9. CONCLUSION

In spite of difficulties mentioned in the analysis of archaeological samples (especially in the case of bone tool traces), in contexts like the Low Paraná wetland, it is very important to distinguish between lithic and shell cut-marks. Actually, in these contexts, considering shells as raw material

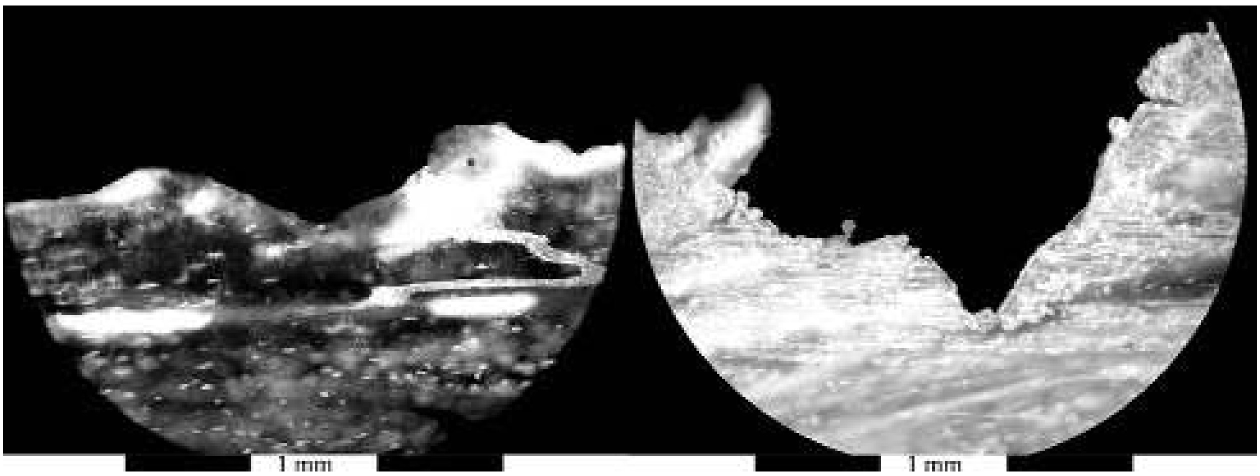

Figure 10. Transversal cuts of cut-marks. Shell open-V cut-mark on the left (made with A13); lithic close-V (B1) cut-mark on the right. Optical microscope 200X.

requires a specific study that should include other activities and materials that would have been linked in the technological system as a whole.

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Malacological artifacts in Argentine Patagonia

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Malacological artifacts in Argentine Patagonia

Artefactos malacológicos de la Patagonia argentina

KEY WORDS: Artefacts, malacofauna, spatial distribution, Patagonia, Argentina.
PALABRAS CLAVE: Instrumentos, malacofauna, distribución espacial, Patagonia, Argentina.
GAKO-HITZAK: Tresnak, malakofaunak, banaketa espaziala, Patagonia, Argentina.

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ABSTRACT

The Patagonian region is the southernmost continental portion of the world, and was the last continental crust to be colonized by humans –around 12,000 years ago. Along the prehistory of this region, there were various hunter-gatherer populations who exploited the available resources: guanacos on the land, and sea lions and molluscs on the sea shores. Throughout years of archaeological investigation, a great number of sites presenting malacofauna have been found. However, there is no general systematization capable of integrating this information. This paper presents the malacological artefacts recovered throughout more than 100 years of research in Patagonian archaeology, taking as a starting point the categories used by different researchers. On the other hand, the spatial distribution of these artefacts in the region will be discussed, since I believe this to be a useful analytical means to gain more insight into the role malacological resources may have played on Patagonian hunter-gatherer societies.

RESUMEN

La región patagónica representa el extremo continental más austral del mundo, y es la última masa continental colonizada por el hombre, hecho que ocurrió hace aproximadamente 12.000 años antes del Presente. A lo largo de la Prehistoria de esta región se suceden poblaciones cazadoras recolectoras, que explotaron los recursos disponibles: en el interior los guanacos, complementados en la costa con lobos marinos y moluscos. A lo largo de los años de investigaciones arqueológicas se han registrado gran cantidad de sitios con presencia de malacofaunas, sin embargo, no existe una sistematización general que integre esta información. En este trabajo se presentan los instrumentos malacológicos que se han recuperado a lo largo de más de 100 años de investigaciones en la arqueología patagónica a partir de las categorías utilizadas por los diferentes investigadores. A su vez, se discute la distribución espacial de los mismos en la región, ya que creemos que ésta es una vía analítica útil para avanzar en el conocimiento del rol que los recursos malacológicos pudieron haber tenido en las sociedades cazadoras recolectoras patagónicas.

LABURPENA

Patagoniako eskualdea munduko mutur kontinental australena da, eta gizakiak kolonizatutako azken masa kontinentala, duela hamabi mila urte. Historiaurrean, ehiztari-biltzaileen populazioak bizi izan ziren, eta eskura zituzten baliabideak ustiatu zituzten: barrualdean, guanakoak, eta, itsasertzean, itsas lehoiak eta moluskuak. Ikerketa arkeologikoak egin diren urteetan, malakofauna zuten leku ugari erregistratu dira, baina, hala ere, ez dago informazio hori bateratzen duen sistematizazio orokorrik. Patagoniako arkeologian 100 urtetik gorako ikerketetan berreskuratu diren tresna malakologikoak aurkezten dira lan honetan, ikertzaileek erabilitako kategoriak abiapuntu hartuta. Horrez gain, leku horien banaketa espazialaz hitz egiten da, Patagoniako gizarte ehitzari-biltzaileetan baliabide malakologikoen zereginaren ezagutzan aurrera egiteko bide analitiko erabilgarria dela uste dugulako.

1. INTRODUCTION

The Patagonian region is the southernmost continental portion of the world and was the last continental crust colonized by modern humans, approximately 12 or 13 thousand years ago (Borrero 2001).

In a general characterization this region can be differentiated in two main areas: the Andean Cordillera and the vast plateau and steppe-like plains of the East. Nowadays, the Andean Cordillera demarcates the Argentine-Chilean frontier and configures a major divide between the Pacific slope to the West and the Atlantic slope to the East.

The beginning of archaeological research on the Argentine Patagonia dates back to the Late 19th Century. Throughout the years, a great number of sites presenting malacological artefact remains have been discovered. However, there is no general systematization capable of integrating this information, and it is because of this that this paper attempts to present a general typology of malacological artefacts found in the Patagonian archaeological record, taking as a starting point the categories used by different researchers throughout the years. These categories were not created from functional studies, but rather, they were inferences made from the morphology of artefacts and direct

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ethnographic analogies (for example Deodat 1967). At the same time, the spatial distribution of the different types of malacological artefacts in the region is discussed, as well as their distance to the current coastline. Generally speaking, all evidence of coastal occupations disappears a few kilometres away from the Atlantic coast. For these reason sites situated with 5 km of from the coastline have been considered as coastal sites, while archaeological sites or findings located away from this limit have been classified as sites *inland*.

2. A SHORT SUMMARY OF PATAGONIAN ARCHAEOLOGY

The peopling of this vast territory was gradual. The first evidence of human presence was registered in the river valleys crossing the Santa Cruz plateau, and shortly after that, on the southern extreme of the continent, in the Chilean Magallanes region. Later occupations were registered all along the area neighbouring the Andes (Borrero 2001). There is direct evidence of human presence on the coast and exploitation of its specific resources dating from around 7400 years ago (Gómez 2007: 135, Castro *et al*. 2007).

In the late Holocene, there was a significant population growth, though densities remained low, and the use of the whole territory became evident, though there were regional differences in its intensity. This occupation process ended in the late 19th Century with the –virtually total– extinction of the native Patagonian inhabitants (Borrero 2001).

Throughout the millennia, Patagonian hunter-gatherers exploited for their consumption mainly the guanaco, and, to a lesser degree, other species: the choique (rhea), and the huemul (deer) in the Andes (Miotti 1998); and they supplemented their diet with the gathering of vegetables, and on certain coastal and river areas, molluscs (Caviglia and Borrero 1981, Gómez 2007, Prates Marsans 2007, Zubimendi 2007).

These human groups had a varied lithic technology, making use of high-quality raw materials available on the territory, and they manufactured various bone artefacts. Ceramic technology was adopted very late, about 2000 years ago (Borrero 2001).

3. MALACOLOGICAL ARTIFACTS IN PATAGONIAN ARCHAEOLOGY

Whereas the first references to malacological artefacts date from the late 19th Century (Strobel 1867, Moreno 1874), it was not until the middle of the 20th Century that the first systematization of this kind of artefacts appeared. It was the result of the research carried out by L. Deodat (1967) on the north coast of San Matías Gulf in the province of Río Negro. This amateur researcher makes diffusionist connections between the North Patagonian malacological industry and other regions of the world. More recently, very few malacological artefacts studies have been undertaken, but they were limited to specific Patagonian areas (Cassiodoro 2005, Damíani and Álvarez 2005). Also similar characterizations have been made recently for other regions of Argentina, specially the Pampean region (Bonomo 2007).

It is important to clarify at this point that the existing bibliographic data presents many limitations, since most of the records are surface finds or present unreliable chronologies. Unclear, ambiguous or general descriptions of the species or artefacts can be added, especially in older papers. In general, it is possible to reliably propound the existence of, at least, three types of malacological artefacts: *containers, shell beads* and *indeterminate artefacts*. These artefacts, their location along Patagonia and their relative distance to the coast –primary potential source of most of the shells used as artefacts– are described below (Fig 1).

3.1. Containers

Within this category, we could consider large shells of gastropods that belong to the *Volutidae* family. The function of these artefacts, according to their morphological interpretation and some evidence found on them, was to retain liquids or other flowing substances. Two types of containers have been defined, especially for the north coast of San Matías Gulf: *spoons* and *recipients* (Deodat 1967).

The former present a greater degree of formatization due to removing the whorl or the columella. They are concave containers formed by the longitudinal half of a whorl, where sometimes the spire is eliminated (Deodat 1967, see Fig. 2.a). They might also present burin-cut edges. They are numerous and exclusive of the north coast of San Matías Gulf; since no instances have been found outside this area. Spoons manufactured with the following species have been identified: *Adelomelon ancilla, A. beckii, Buccinanops* sp., *Pachycymbiola brasiliana,* P. *ferussacii, Odontocymbiola magellanica,* and *Zidona dufresnei* (Carcelles 1944, Deodat 1967, Damíani and Álvarez 2006, Favier *et al*. 2007). Most of these species have valves ranging between 10 and 20 cm long, and live in the sublitoral, inaccessi-

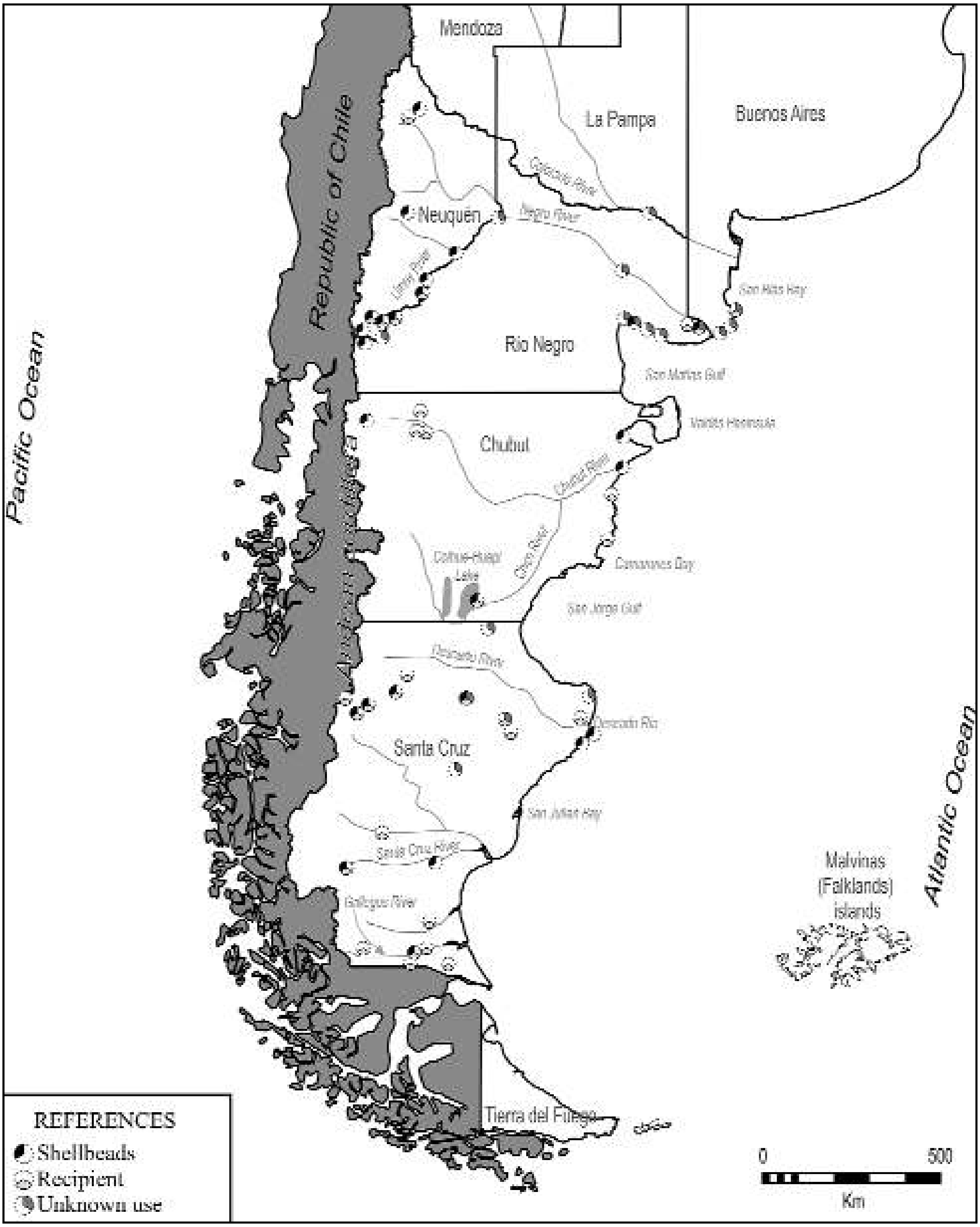

Figure 1. Map of Patagonia reflecting the locations where malacological artifacts have been found.

ble to direct human gathering, that is why it is assumed that they have been recollected when they are deposited naturally on the shore.

Recipients are shells with little or virtually no formatization, generally limited to the polishing and regularization of its siphonal aperture. They have also been found on the north coast of San Matías Gulf (Carcelles 1944, Deodat 1967) and in the center of the Province of Santa Cruz, on the Deseado River basin (Miotti 2006, Vignati 1953). They are not found in the Patagonian Andean area, with the exception of its north side, near Limay River (Politis *et al*. 2003: 23–24). Some of them present paint remains on the inside (Horovitz 2003, see Fig 2.b). They have been manufactured from the same species as the spoons, with the exception of *Buccinanops* sp., probably due to its smaller size. Large shells or fragments of the same species used as containers have been found near the Negro River estuary (Fisher & Nacuzzi 1992:204), in the central coast and in southern Patagonia (Borrero and Barberena 2008, Gómez 2007); but it cannot be proposed that they were used as containers.

3.2. Shell beads

Shell beads might be the most common malacological artefacts in Patagonia, especially inland. They are characterized by the presence of a hole in their centre, presumably to be threaded. Due to differences in the intensity of modifications shells have undergone, it is possible to distinguish two types. On the one hand, those that were used with slight shell modifications, mainly taking advantage of natural perforations. On the other, those that

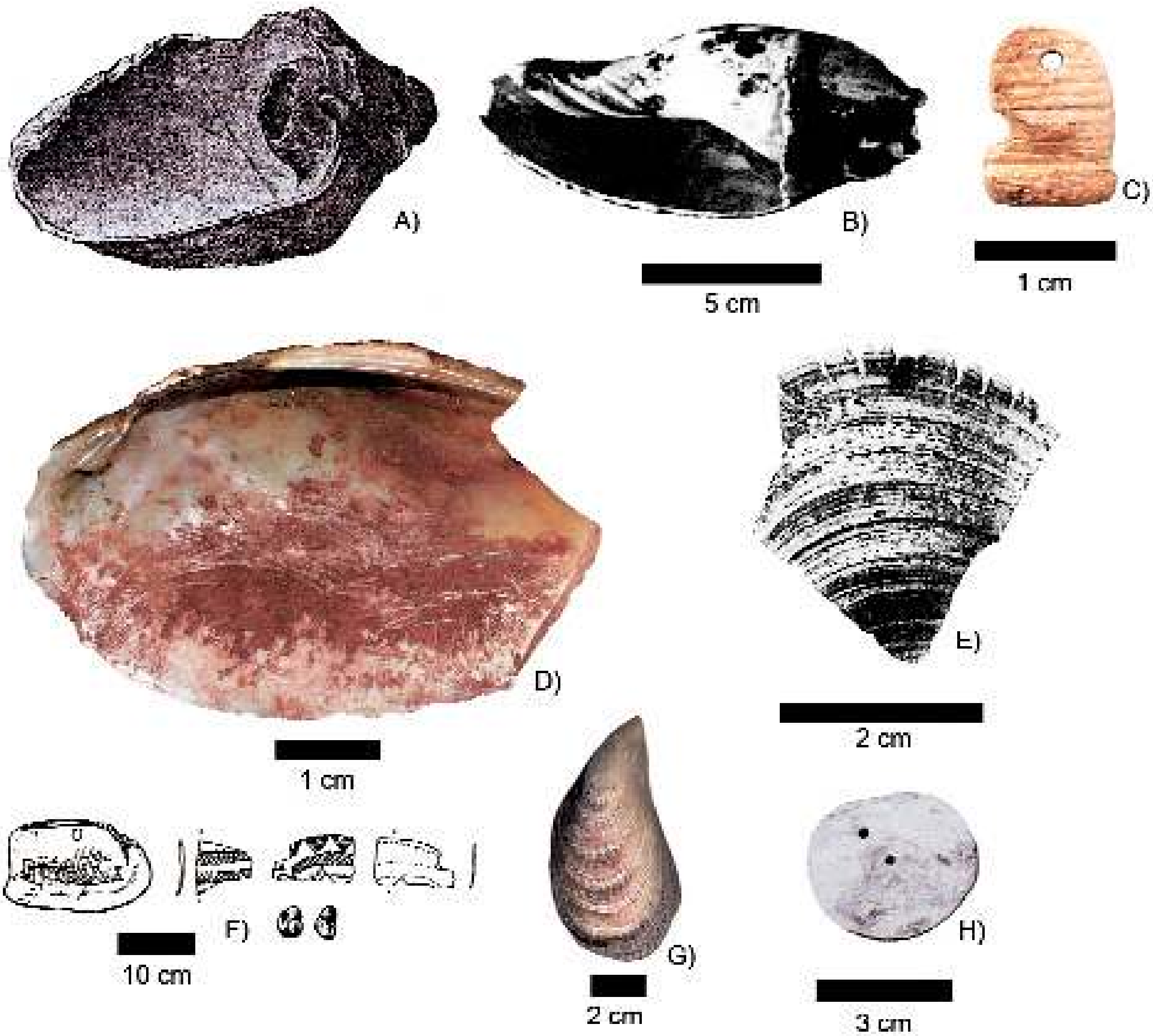

Figure 2. Examples of malacological artifacts. A) spoon made from Volutidae, found in San Blas Bay (Vignati 1953, picture XII, fig. 2); B) *Adelomelon ferussacili* valve presenting paint remains on the inside, found in Cueva 4 of La Martita (Horovitz 2003: 81); C) shell bead from an unidentified species recovered in Cueva del Negro (own material); D) *Diplodon chilensis* valve presenting paint remains in the inside found near Lake Pueyrredon (D. Bozzuto pers. com.); E) fragment of a *Choromytilus chorus* valve from the Pacific Ocean with a serrated edge -found in Cueva Traful I (Crivelli *et al.* 1993: 112); F) shell beads and decorated valves recovered in Cueva Valle Encantado I (Hadjuk and Albornoz 1999: 389); G) *Aulacomya ater* valve found in San Martin Lake, near the Andes, in the Province of Santa Cruz (Espinosa *et al.* 2007); H) large shell bead of an unidentified species presenting two holes registered in Chenque 4 of SAC2 site (Cassiodoro 2005: 259).

underwent considerable modifications to such an extent that it is no longer possible to distinguish the species the shell belongs to.

Beads of the first kind have been registered at various sites in eastern Patagonia, scattered in all the environments of this region: on the coast, as well as inland and in the Andes (for example, Gomez and Dahinten 1997–1998, Miotti 1998: 138, Cassiodoro 2005). They have been found at different types of sites: housing and domestic usage, and also associated with human burials as grave goods –being on many occasions the only present grave goods–, even over 300 km from the shore (for example Fig. 2.h). The species that have been identified belong to small gastropods: *Homalopoma cunninghami, Photinula coerulescens, and Fissurella* sp. (Gómez and Dahinten 1997-1998, Miotti 1998).

Most of the shell beads were manufactured from considerably modified shells. Great morphological variation has been found: round, oval, rectangular, and bell-shaped (Fig. 2.c). Most of them are small, but there were also some large ones. They abound in the Neuquén area, associated with occupations related to historical or post-contact. They are most often found in small quantities, except for human burial grave goods, where there can be hundreds of (Cassiodoro 2005) them. Due to considerable shell modification, few species could be identified, among them: the bivalves *Aulacomya ater*; *Choromytilus chorus* and *Diplodon patagonicus*, the second one coming exclusively from the Pacific Ocean, and the third one from fresh water (see Fig. 2.f). They were widely distributed along the river basins of the Patagonian Atlantic and Pacific watersheds (Cassiodoro 2005, Crivelli *et al.* 1993, Hajduk and Albornoz 1999, Sanguinetti de Bormida and Curzio 1996).

3.3. Indeterminate artefacts

Other malacological artefacts have been found at Patagonian inland archaeological sites, though their purpose is unknown and no specific usage of those items has been set out. It is very likely that they served a symbolic purpose or as ideational carriers among individuals or groups. Within this category can be included, fragments of shells or entire shells with different kinds of decorations or engravings, or unaltered shells found far away from the coast.

Within the first kind of unknown-purpose artefacts, entire shells or fragments of them presenting indentations, polishing, striation, engraved decorations on one of their sides are included. Their edges have been evenly shaped, polished or serrated by means of radial indentations (see Fig. 2.e and 2.f). They also present paint remains inside (D. Bozzuto, com. pers., Fig. 2.d).

Most of these findings come from the Provinces of Neuquén and Río Negro, where many sea shells have been found. Some belong to species that live only in the Pacific Ocean, which seems to indicate that they must have been transported across the Andes (Crivelli *et al.* 1993: 43). These remains provide evidence of contact with other populations on the other slope of the Cordillera and to the Pacific coast. This also could reflect that these groups must have had a high mobility along both sides of the Andes, at least ever since the middle Holocene. Similar findings have been reported along the mountain area, from Neuquén to the south of Santa Cruz. The species identified are mostly bivalves: *Aulacomya ater, Choromytilus chorus and Diplodon patagonicus* (Hajduk and Albornoz 1999).

The second kind of artefacts that may have served for an unknown purpose are isolated shells at inland sites, unique and generally whole. The most abundant species inland is *Aulacomya ater* (Fig. 2.g), since it appears on all Patagonian regions, especially in Santa Cruz (Miotti 2006, Espinosa *et al.* 2007, for example). Another very common Mytilidae is *Mytilus edulis*, which appears at inland sites of the Province of Santa Cruz, especially in the south (Borrero and Barberena 2008: 293). In the Neuquén area, *Choromytilus chorus* and *Protothaca thaca* –exclusive Pacific Ocean species– have been found. Whereas at the south of Santa Cruz, *Panopea abbreviata* (Carballo Marina *et al.* 2000-2002) –a species whose southernmost distribution is near Deseado ria– was found over 400 km away from its original location (Carballo *et al.* 2000-2002). Going down south, near the Chilean-Argentine frontier, a fragment of *Pecten* sp. was found (Gómez 1986-1987: 185). Within the Gastropod group, the species most commonly found is *Nacella* (*Patinigera*) *magellanica*, exclusively found at numerous inland sites of the Province of Santa Cruz. Other gastropods have also been found in this province: *Trophon* sp. and *Photinula caerulescens* from the Atlantic Ocean, among others (Borrero and Barberena 2008: 295).

Some authors have described findings of other artefacts, inferring an unsupported and very doubtful usage. In the early 20th Century, on the coast of Colhue-Huapi Lake a purported shell earring from an undefined species was found

(Verneu and De La Vaulx 1902: 138). In 1922, Torres said he found a *tembetá* –a button-like chin ornament– made of an *Adelomelon beckii* columella in San Blas Bay (1922: 517). Also an *Olivancillaria auricularia* shell was found with a perforation on its side, attributed to having been used as a whistle (Bormida 1949). A similar purpose was assigned by R. Brunet (1980: 121) to three *Odontocymbiola subnodosa* large shells presenting quadrangular perforations found on the central coast of the Province of Chubut.

3.4. Malacologcal artifacts in human burials

Shell bead and recipient findings in chenques –common Patagonian graves– deserve special consideration. In the north of Patagonia, several shell beads –some made from Pacific Ocean species– have been found (for example Della Negra and Novellino 2005: 169).

In burials with multiple individual in the coast of Chubut, little *Tegula* sp. seashells were found, as well as hundreds of shell beads considerably modified (Gómez and Dahienten 1997-1998: 109). On the north coast of Santa Cruz, a similar finding was observed in a looted grave (J. E. Moreno com. pers.). In the middle valley of Río Gallegos, in southern Patagonia, a tubular Scaphoda mollusc fragment of the *Dentaliidae* family was found (Ortiz-Troncoso 1973: 133). Finally, in the west centre of this province, in the Sierras Coloradas area, over 859 shell beads were found in several *chenques* (Cassiodoro 2005: 259–260). In the first half of the 20th Century some shell beads were found in graves on the banks of the Santa Cruz River (Vignati 1934: 89) and on the Colhue-Huapi Lake (Bormida 1953–1954: 33).

On the other hand, in graves close to the mouth of Negro River (Strobel 1867, Moreno 1874) and of the north coast of Golfo San Matías, large gastropod recipients were found arranged on individual graves (Carcelles 1944, Deodat 1967).

4. FINAL COMMENTS

In spite of being a subject barely discussed on Patagonian archaeological bibliography, the presence of malacological artefacts requires a deeper analysis. The great majority of artefacts are shell beads and recipients. The former have been distributed all across Patagonia, from the Province of Neuquén in the north, all throughout the inland, to the coastline area. Recipients are almost certainly limited to the north coast of San Matías Gulf and the area between this gulf and the middle and lower valleys of Colorado River, where containers and spoons have been found in residential as well as in burial grounds. They can also be found, though to a lesser extent, in the Deseado River basin, in the North Centre of Santa Cruz.

With regard to human burials, in Patagonia, most of them were performed with few grave goods, if any at all. However, malacological remains have been found in a great number of graves. They consist generally of shell beads inland and on the central coast; and of large shells of the *Volutidae* family on the north coast

The spatial distribution of the malacological artefacts defines a series of patterns that should be considered. There is considerable evidence of the presence of Pacific Ocean shells in Neuquén and the west of Río Negro. Within this area there are numerous passable tracks across the Andes, which became rare and more difficult in the South. There is no evidence of this kind of artefacts southwards, up to the Chilean Magallanes region. Probably the shell artefacts found in the Andes area at the South of Neuquén, with the exception of those made with fluvial molluscs like *Diplodon chilensis*, have come from the Atlantic coast.

A considerable number of malacological remains lack a temporal context. However, only a few finds have been registered in the middle Holocene, most of them belong to the late Holocene. This could be correlated, according to some authors, with a growth in Patagonian population density, and with the emergence of large interaction networks (Borrero 2001, Gómez 2007, among others). Malacological artefacts have also been found at later times, after natives established contact with European sailors and travellers. In this last historical period, many remains were found in the Neuquén area. They come mainly from the Pacific Ocean, thus reflecting the constant movement of people on both sides of the Andes and the occupation of this territory as a unity (Adan and Alvarado 1999: 247).

Even when the presence of shells at inland sites is not large in number, it is interesting that in virtually all researched areas, malacological artefacts or intact shells have been found in stratigraphy. We can note a greater presence of this kind of remains in the centre and west sides of the Province of Santa Cruz. There have been found species commonly consumed on the coast – such as *Aulacomya ater, Mytilus edulis* and *Nacella (P.) magellanica* (Gómez 2007, Zubimendi 2007)– as well as species barely depicted in the coastal archaeological record, such as *Panopea abbreviata, Pecten* sp., *Photinula coerulescens and Trophon* sp.

The meaning these shells have reached the different sites are unknown: they may have been transported by the human groups themselves, or they might have been the product of large exchange networks across the Patagonian territory. Their transportation cannot have been coincidental, but rather, it must have been planned –the conservation of some specimens found inland probably indicates that they had been handled with care.

Finally, and beyond certain bias and limitations in the existing data, the available information allowed us to prove that malacological artefact constitute an important part of the Patagonian archaeological record. I strongly consider its examination to be necessary to thus deepen the knowledge on the way of life of the hunter-gatherer societies of the past.

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Of Shell and Sand: Coastal Habitat Availability and Human Foraging Strategies at Punta Candelero (Humacao, Puerto Rico)

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Of Shell and Sand: Coastal Habitat Availability and Human Foraging Strategies at Punta Candelero (Humacao, Puerto Rico)

Entre arena y caracoles: accesibilidad de hábitats costeros y estrategias de subsistencia humanas en Punta Candelero (Humacao, Puerto Rico)

KEY WORDS: Habitat availability, foraging practices, fishing technology, Puerto Rico, Caribbean.
PALABRAS CLAVE: Accesibilidad de hábitats, estrategias de subsistencia, tecnología de pesca, Puerto Rico, Mar Caribe.
GAKO-HITZAK: Habitaten irisgarritasuna, bizirauteko estrategiak, arrantza-teknologia, Puerto Rico, Karibe itsasoa.

Isabel C. RIVERA-COLLAZO[(1)]

ABSTRACT

In this article I analyse regional habitat availability and human foraging practices at Punta Candelero (located at Humacao, Puerto Rico), using multiproxy data derived from archaeomalacological and geoarchaeological analyses. The different species within the mollusc assemblage are evaluated with regards to the possible gathering technologies they might represent, as well as possible activities and practices aside from sustenance. This study concludes that all the locally available environments were being actively exploited, including rocky shores, sandy intertidal, consolidated and unconsolidated subtidal and riparian habitats. Gathering practices reflect hand selection as well as en masse and opportunistic collection. Some of the gastropods might reflect other activities aside from sustenance, including trap cleaning practices and bait preparation.

RESUMEN

En este artículo analizo la existencia y accesibilidad a hábitats regionales, y prácticas de subsistencia humana en Punta Candelero (localizado en Humacao, Puerto Rico), combinando evidencia multiaxial de estudios arqueomalacológicos y geoarqueológicos. El análisis de las especies que componen las muestras malacológicas considera las posibles tecnologías de recolección utilizadas, así como la posible representación de otras actividades y prácticas en adición a consumo directo. El estudio concluye que todos los nichos ambientales disponibles localmente fueron explotados de manera activa, incluyendo costas rocosas, zonas arenosas intermareales, ambientes sumergidos consolidados y no consolidados y ambientes fluviales. Las prácticas de recolección de moluscos incluyen selección manual, recolección "en masa" y toma oportunística. Algunos gasterópodos podrían representar otras actividades complementarias a la subsistencia, tales como limpieza de trampas y preparación de carnadas.

LABURPENA

Eskualdeko habitaten existentzia eta irisgarritasuna aztertzen ditut artikulu honetan, bai eta Punta Candelero (Humacao, Puerto Rico) aztarnategiko gizakien bizirauteko jarduerak ere, ikerketa arkeomalakologikoen eta geoarkeologikoen ardatz anitzeko ebidentziak konbinatuz. Lagin malakologikoak osatzen dituzten espezieen analisiak kontuan hartzen ditu bilketarako erabil zitezkeen teknologiak, bai eta beste jarduera batzuk adieraz ditzaketenak ere, zuzenean kontsumitzeaz gain. Azterketaren ondorioetan adierazten da tokian-tokian eskura zeuden txoko ekologiko guztiak aktiboki ustiatu zituztela, kostalde harritsuak, marearteko hareazko guneak, urpeko ingurune finkatuak eta finkatu gabeak, eta ibai-inguruneak barne. Moluskuak zenbait modutan biltzen zituzten: eskuzko aukeraketa, pilaka biltzea eta hartze oportunista. Zenbait gastropodo, bizirauteko erabiltzeaz gain, beste zenbait jardueratarako erabil zitezkeen; esate baterako, tranpak garbitzeko eta beita prestatzeko.

1. INTRODUCTION

Molluscs and their shells have been used by humans for thousands of years. Scientists studying shell remains in archaeological contexts have used them for various analyses, such as habitat and landscape reconstruction, documentation of climate change, reconstruction of aquatic habitats, determination of changes in salinity, tidal range, shoreline position and sea-level change; changes in shore morphology, determination of seasonality in human settlements, dietary reconstructions, and others (*e.g.* Claassen 1998, Gassiot-Balbè 2005, Mannino and Thomas 2001, 2002, Quitmyer *et al.* 2005, Serrand and Bonnisent 2005, Vellanoweth and Erlandson 2004).

In this article I intend to analyse regional habitat availability and human foraging practices at the Punta Candelero site, located at Humacao, Puerto Rico, based on the results of the archaeomalacological analysis of the shells recovered during the 2006 season (Rivera-Collazo 2007a), and incorporating the results of the geoarchaeological study performed in 2007 (Rivera-Collazo 2007b). Given their dynamic nature, coastal landscapes and ecology vary through time. It is unwise to assume that all the modern habitats and ecological niches were extant and available for exploitation in the past. The reconstruction of ecological niches through

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the analysis of exploited species in the past can shed light on these changes, indicating which type of habitats were available in landscapes contemporary to ancient human occupation.

Puerto Rico is the easternmost and smallest of the Greater Antilles (Figure 1). The archaeological site under study is located on, and named after, Punta Candelero: a coastal foreland on the east-southeast coast of Puerto Rico (Figure 2). It lies approximately 3km south of the modern mouth of Humacao River, the largest in the area, on the shore of the Candelero River valley. The Candelero River was canalized in the 1940s, and currently flows into the sea about 800m north of the foreland (Ramos-Vélez *pers. comm.* 2007). Two rocky headlands, Punta Morrillos and Punta Guayanés, are located about 2km north and south of Punta Candelero respectively.

1.2. Punta Candelero

The archaeological site on the foreland (Figure 3) was first reported in the 1980s by archaeologist Miguel Rodríguez. In general terms, the site consists of two occupational periods: an earlier Hueca deposit identified on the discrete accumulations in linear disposition and a later Cuevas (Late Saladoid) occupation arranged in concentric ring or horse-shoe shape some of which is superimposed on the Hueca deposits (Pagán-Jiménez 2007, Ramos-Vélez *et al.* 2007, Rodríguez-Lopez 1988, 1991). According to previous research, the site has discrete houses (identified by postholes), activity areas (including possible 'shell middens') and a cemetery (Ramoz-Vélez *et al.* 2007, Rodríguez-López 1991). The shell discussed here were collected from an archaeological mitigation project developed by Marlene Ramos Velez during 2006 –

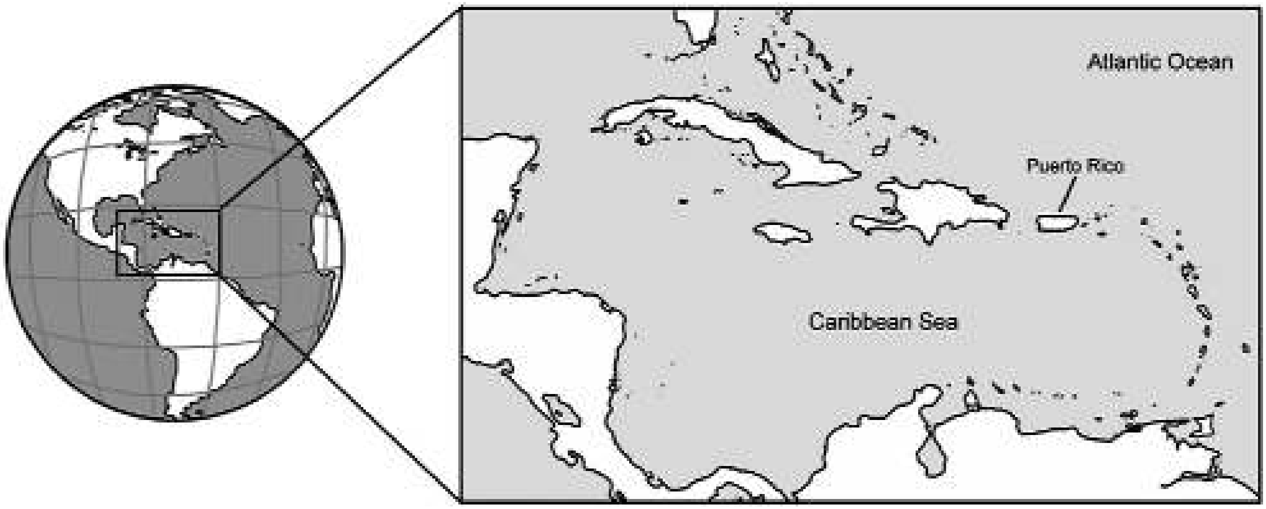

Figure 1. Location of the Caribbean Region and Puerto Rico.

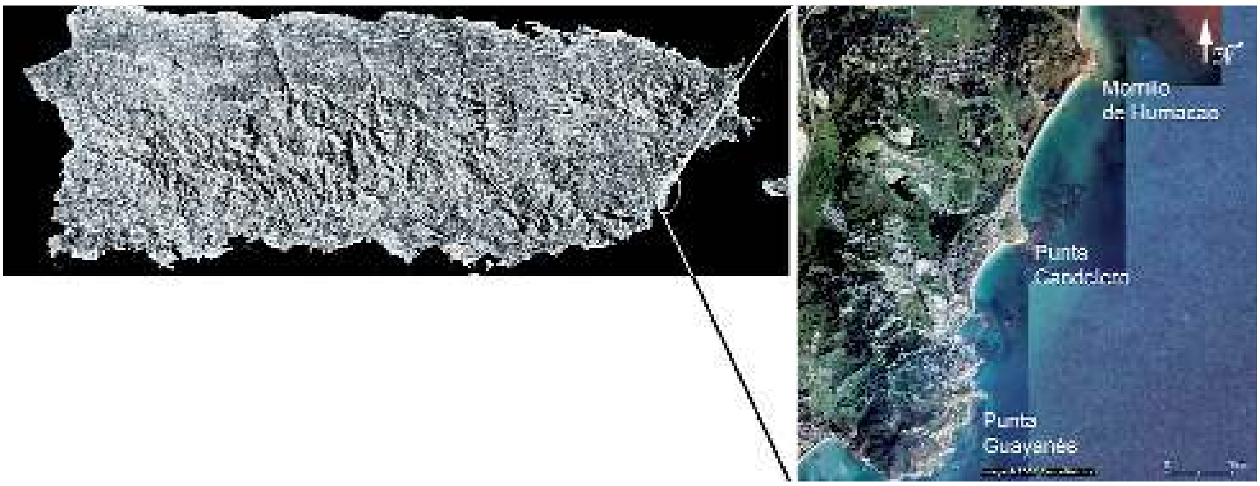

Figure 2. Puerto Rico, showing Punta Candelero location. Humacao River flows north of Morrillo de Humacao, its mouth can be seen just north of the headland. (Topographical map modified from USGS Punta Guayanés Quadrangle, 1982)

Figure 3. Punta Candelero showing the location of the suggested 'shell middens'. White dots mark the sampled units for this study (Satellite image modified from Google Earth 2004 image, 18°05'33.50"N 65°47'26.76"W).

2007 due to proposed development on the land plot. This project intervened only on the north section of the site, which had been identified by Miguel Rodríguez as "Cuevas zone" of the Late Saladoid Period, estimating its date to 400 – 800 AD (Rodríguez-López 1991).

Radiocarbon dates from charred wood samples from features excavated during the 2006 project range between 660 – 1020 Cal AD (Beta Analytic Laboratory, 2σ calibration) (see Ramos-Vélez *et al.* 2007 for details on the dates and their calibration). All samples were within Cuevas Period context. During his excavations in the late 1980s, M. Rodríguez obtained a similar date range, but he found the dates confusing (Rodríguez-López 1991) because they are too late compared with the accepted Saladoid chronology established by Irving Rouse (Rouse 1992). The radiocarbon dates obtained by M. Ramos confirm the late character of the Saladoid occupation on Punta Candelero (Ramos *et al.* 2007). Similar dates have been obtained from other characteristically Saladoid sites, which challenge Rouse's chronology based on ceramic typology (see Ramos-Vélez *et al.* 2007 for discussion).

1.2. Modern Context

The modern ecological conditions of the foreland are degraded. Most of its surface was levelled using heavy machinery after Miguel Rodríguez's archaeological intervention in the late 1980s and early 1990s, and was then covered with a thick layer of rubble fill (up to a metre thick in some areas). Recent development has widely impacted the region, and the original topography has been severely modified. The shoreline is classified as of moderate to high erosion risk, based on wave intensity.

The littoral presents a wide and rich mosaic of habitats very close to the shore. Modern benthic habitats, as classified by the National Oceanic and Atmospheric Administration's Biogeography Team (NOAA 2001), include various types of consolidated substrates such as bedrock, corals and other reefs, as well as sandy shores, sea grass habitats and patches of macroalgae (Figure 4).

1.3. Palaeolandscape

According to the geoarchaeological study (Rivera-Collazo 2007b), Punta Candelero's environmental and landscape setting contemporaneous with the occupation at the site was complex and rich. The foreland was formed as part of the depositional processes of Candelero River mouth, forming a deltaic environment with a possible sandbar separating the river from the sea and making it flow south. Although more data is necessary, the available information suggests that the sea level at the time of occupation could have been about 20 – 30cm lower than today. Swampy deposits between the site and the sea seem to be associated with the ancient river channel, contemporary with the site's occupation. The immediate landscape included riparian, estuarine and marine environments within just a few minutes walk. Terrestrial resources were not far away either, possibly consisting of dense tropical forests.

Deltas are excellent examples of ecotonal conditions, presenting the conjunction between marine, terrestrial and riparian environments. Ecotones yield a very high ratio of different types of resources, maximizing returns and minimizing risks for foragers (Dincauze 2000). According to the Optimal Foraging Theory (OFT) (Borgerhoff Mulder 2004, Cronk 1991, Pyke 1984), site location inside an ecotonal resource patch would facilitate the exploitation of local microenvironments with minimum risk and time investment (Binford 1980, Perlman 1980, Raab 1992, Thomas 2007). If the inhabitants of Punta Candelero were behaving in accordance with the OFT, then the shells of Punta Candelero should evidence exploitation of environments in the immediate vicinity of the site.

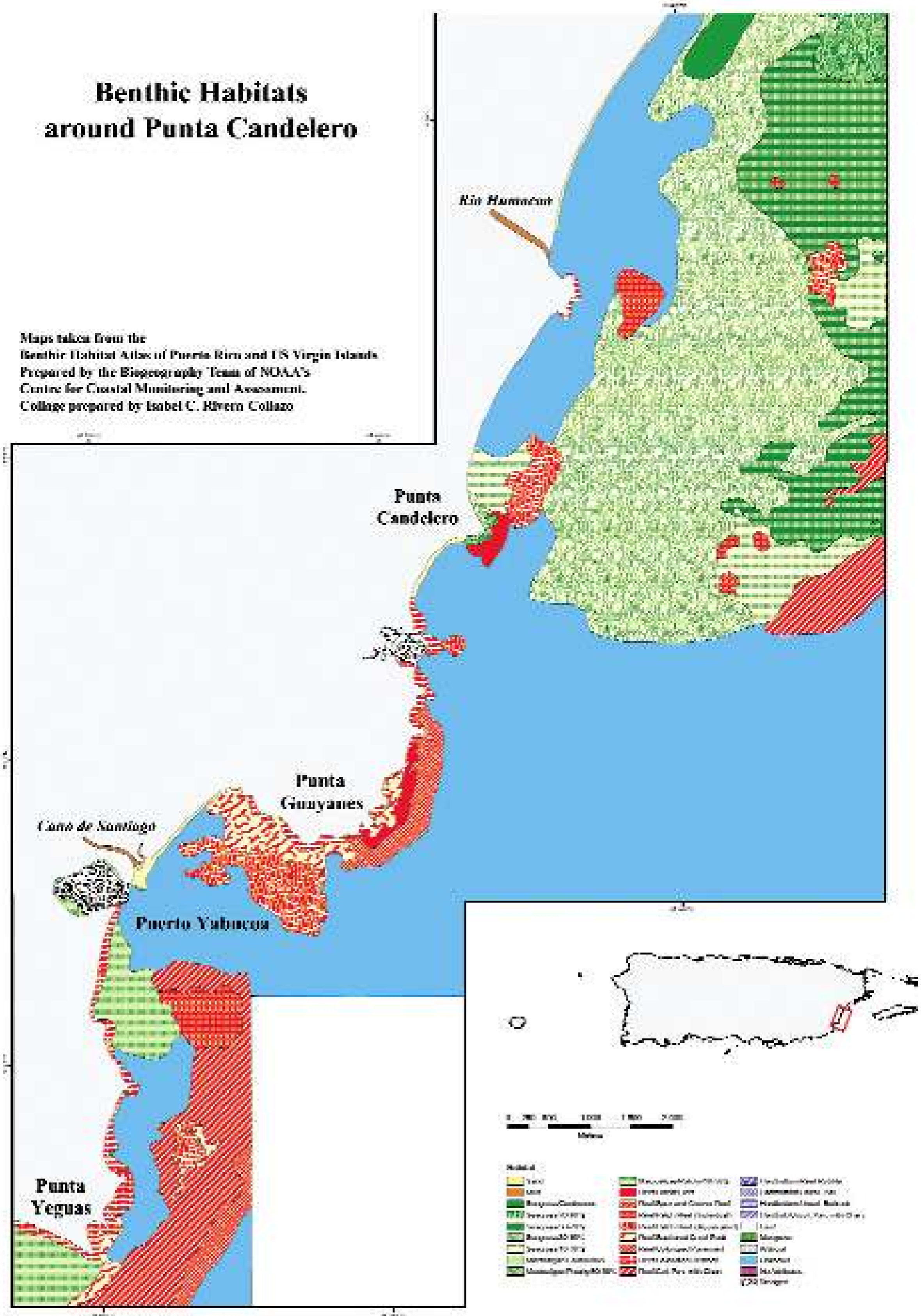

Figure 4. Map of modern benthic habitats around Punta Candelero. Maps taken from the Benthic Habitats Atlas of Puerto Rico and US Virgin Islands (NOAA 2001), prepared by the Biogeography Team of NOAA's Centre for Coastal Monitoring and Assessment. Collage prepared by the author. Original map prepared by NOAA's Biogeography Team. Reproduced with authorization.

2. DATA AND RESULTS

The 2006 and 2007 archaeological intervention at Punta Candelero, preceded development plans for the area. Shells were recovered from the sedimentary matrix of the archaeological deposit using 6 mm and 3 mm mesh sieves (1 mm mesh sieves were also used in some instances). No specific shell *midden* or shell lens was identified, but the shells were recovered from within the sediment. Species identification was performed by technician Edmarie Pagán in Puerto Rico. No additional measurements were taken on the individual shells, and no direct details were recorded on the tabulated information, but the author did some preliminary observations on the field and the laboratory in Puerto Rico. The results (MNI/species, strata and sieve size) were collated and analysed by the author at the Institute of Archaeology, University College London. Although hundreds of terrestrial specimens were also collected and identified, only the aquatic mollusca from the archaeological strata are used in this study (see Ramos-Vélez 2007 for details on the other faunal remains). Only 2% of the shells recovered during excavation were used at tools. The artefacts were generally excluded from the analysis because, being an object of workmanship, they could have been specifically sourced from outside the area and may not reflect local species availability.

The sample consists of 11,201 specimens of Bivalvia and 7,230 specimens of Gastropoda; most were identified to species level.

2.1. Bivalvia

Despite being more numerous than Gastropods, Bivalves were less diverse (Table 1). A total of 25 species were identified, but the assemblage is overwhelmingly dominated by just one genus: *Donax* (98.2% of the total) including *Donax denticulatus* and *Donax variabilis*.

Most of the habitats documented for the Bivalvia represent unconsolidated intertidal areas, with occasional sea grass and other habitats in very low percentages. *Donax* are infaunal inhabitants of intertidal sandy environments and can be found today in high density on the Island's coasts. In modern contexts, García (2005) indicates the presence of up to 500 individuals per square metre at the Humacao beach just north of the site.

Donax adults can reach 35mm, individuals smaller than 6mm are very young. In Punta Candelero, even though most of the individuals (96%) were recovered from the 6mm sieve, 4% of the sample passed through the 6mm mesh and were trapped in the 3mm sieve. Even though individual sizes were not recorded, the presence of extremely small (and young) individuals suggests size variability, which in turn can reflect the collection method used. If individuals were hand-selected, size uniformity would be expected with a bias towards larger individuals (Gassiot-Balbè 2005). The presence of small, very young individuals suggests that these molluscs were collected *en masse*, probably using some sort of sieve or basket. Similar conclusions were drawn by Gassiot-Balbè (2005) with his *Donax* sample from Nicaragua.

The other bivalve species, such as *Parvilucina costata, Strigilla sp*. and *Tivela mactroides*, are infrequent and might have been collected incidentally to the gathering of *Donax*. Species from *Thalassia* beds, such as *Anadara* sp., *Codakia* sp. and *Purberella intapurpurea* might represent opportunistic gathering associated with trap setting. The assemblage of Punta Candelero would still need more detailed measurements on the individual specimens to statistically support these conclusions.

2.2. Gastropoda

A total of 59 Gastropoda species were identified (Table 2). Nine species are dominant throughout the strata: *Lithopoma caelatum, Cittarium pica, Fissurella nodosa, Nerita tessellata, Neritina clenchi, Neritina virginea, Neritina punctulata, Tectarius (Cenchritis) muricata* and *Turbo castanea*. Of these species, only one artefact of *C. pica* and one of *N. virginea* were identified in Stratum A. Otherwise, it seems that none of these species were collected for making tools. The large number of opercula, both in the 6 mm and the 3 mm sieve size (but particularly on the 3 mm size), attest to the collection of living specimens brought back to the site for processing (Figure 5A).

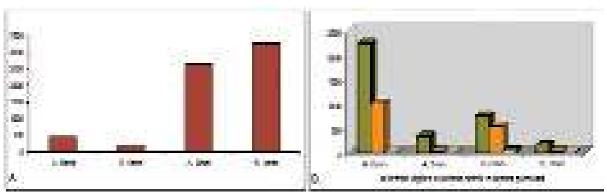

Figure 5. A. Number of opercula by stratum and sieve size. B. Number of neritids by species, stratum and sieve size.

BIVALVIA	Habitat	Salinity tolerance	Present on Stratum	MNI stratum A	%	MNI Stratum B	%	MNI Stratum C	%	TOTAL MNI
Anadara lineosa (Say 1832)	10	4	B	0	0	1	<0.1	0	0	1
Anadara notabilis (Röding 1798)	2	1	B	0	0	1	<0.1	0	0	1
Angulus merus (Tellina mera) (Say 1834)*	10	4	B	0	0	7	0.2	0	0	7
Botula fusca (Gmelin 1791)	10	4	A, B	1	<0.1	1	<0.1	0	0	2
Brachidontes exustus (Linnaeus 1758)	6	1	A,B	1	<0.1	3	0.1	0	0	4
Chama macerophylla (Gmelin 1791)	7	1	C	0	0	0	0	7	3.3	7
Chama sp.	10	4	B	0	0	2	0.1	0	0	2
Chione cancellata (Linnaeus 1767)	1	1	A	1	<0.1	0	0	0	0	1
Codakia orbicularis (Linnaeus 1758)	5	1	B,C	0	0	2	0.1	29	13.7	31
Ctena orbiculata (Montagu 1808)*	3	1	A,B	5	0.1	6	0.2	0	0	11
Ctena pectinella (C.B. Adams 1852)*	10	4	A	3	<0.1	0	0	0	0	3
Crassinella lunulata (Conrad 1834)	4	1	B	0	0	1	<0.1	0	0	1
Donax denticulatus (Linnaeus 1758)	2	1	B,C	0	0	84	2.7	163	77.3	247
Donax sp (Linnaeus 1758)	2	1	A, B	7849	99.1	2907	94.6	0	0	10756
Parvilucina costata (d'Orbigny 1846)*	3	1	A,B	5	0.1	24	0.8	0	0	29
Periglypta listeri (J.E. Gray 1838)*	10	4	B	0	0	1	<0.1	0	0	1
Phacoides pectinatus (Gmelin 1791)	3	1	A	1	<0.1	0	0	0	0	1
Pitar dione (Linnaeus 1758)	10	4	A, B	1	<0.1	2	0.1	0	0	3
Plicatula gibbosa (Lamarck 1801)	6	1	A, B, C	1	<0.1	2	0.1	2	0.9	5
Pseudochama radians (Lamarck 1819)*	6	1	B	0	0	1	<0.1	0	0	1
Scapharca brasiliana (Lamarck 1819)*	1	1	A	1	<0.1	0	0	0	0	1
Strigilla carnaria (Linnaeus 1758)	4	1	A, B, C	1	<0.1	7	0.2	6	2.8	14
Strigilla pisiformis (Linnaeus 1758)	4	1	A, B, C	3	<0.1	15	0.5	4	1.9	22
Tivela abaconis (Dall 1902)	10	4	A, B	41	0.5	2	0.1	0	0	43
Tivela mactroides (Born 1778)	2	1	A, B	3	<0.1	3	0.1	0	0	6
Transennella cubaiana (d'Orbigny 1853)	10	4	A	1	<0.1	0	0	0	0	1
TOTAL				**7918**		**3072**		**211**		**11201**

Table 1. Bivalves of Punta Candelero. See end of table for habitat and salinity tolerance key (For general reference see Carpenter 2002 and Warmke and Abott 1975).

* Most recent taxonomic classification. For previous classification see http://www.malacolog.com and http://www.itis.gov.

Key	Habitats	Key	Salinity Tolerance
1	Sandy Bottom, Sea grass beds, subtidal	1	Marine
2	Soft bottom (sand, mud) intertidal	2	Brackish
3	Soft bottom (sand, mud) intertidal - subtidal	3	Freshwater
4	Soft bottom (sand, mud) subtidal (incl. estuaries and mangrove)	4	Not enough published data
5	Sea grass, subtidal		
6	Rocky shores, intertidal		
7	Consolidated bottom, intertidal - subtidal		
8	Consolidated bottom, subtidal (including reef, mangrove roots and others)		
9	Ubiquitous, subtidal		
10	Data too general or not available		

The ecological association of the gastropods suggest exploitation of four main environments: rocky intertidal to shallow subtidal (*Fissurella* sp., *C. pica*, *F. nodosa*, *N. tessellata*, *T. muricata*, *T. castanea*, and Polyplacophora); shallow reefs (*L. caelatum* and *T. muricata*); sea grass (*Astraea* sp., *Strombus* sp.) and estuarine / freshwater habitats (*Neritina* spp.) (Hughes 1971, Robertson 2003, Rodríguez *et al.* 2003).

The dominance of the *Neritina* throughout the assemblage (67% of the total) suggests an interesting situation regarding habitat availability and niche exploitation. *N. punctulata* and *N. virginea* are diadromous species that have been documented to migrate several kilometres upriver (Blanco and Scatena 2005, 2007, Pyron and Covich 2003). Pyron and Covich (2003) found adult *N. puctulata* up to 15.3km upstream of the ocean, to elevations as high as 200m above sea level. These species also show increase in mean size (up to 40mm in size) with increased distance from the ocean. *N. virginea* has been widely documented in estuarine conditions, and exhibits seasonal migrations of juveniles upriver, generally associated with flood events (Blanco and Scatena 2005, 2007). *N. virginea* has a very wide salinity tolerance, being found in environments ranging from hypersaline ponds to freshwater rivers (*e.g.*

GASTROPODA	Habitat	Salinity tolerance	Present on Stratum	MNI stratum A	%	MNI Stratum B	%	MNI Stratum C	%	TOTAL MNI
Acteocina bullata (Kiener 1834)*	10	4	B	0	0	1	<0.1	0	0	1
Astralium phoebium (Röding 1798)*	5	1	A, B	14	0.3	19	1	0	0	33
Astraea sp.	10	4	A, B	25	0.5	1	<0.1	0	0	26
Bulla striata (Bruguiere 1792)	4	1	B	0	0	1	<0.1	0	0	1
Cassis tuberosa (Linnaeus 1758)	5	1	A	1	<0.1	0	0	0	0	1
Cerithium eburneum algicola (C.B. Adams 1845)*	5	1	A, B	22	0.4	13	0.7	0	0	35
Cerithium litteratum (Born 1778)	5	1	A, B	2	<0.1	4	0.2	0	0	6
Cerithium sp.	10	4	A, B	10	0.2	17	0.9	0	0	27
Chicoreus brevifrons (Lamarck 1822)*	4	1	A, B	1	<0.1	1	<0.1	0	0	2
Cittarium pica (Linnaeus 1758)	7	1	A, B	66	1.3	30	1.5	0	0	96
Columbella mercatoria (Linnaeus 1758)	7	1	A	4	0.1	0	0	0	0	4
Crepidula aculeata (Gmelin 1791)	6	1	A	1	<0.1	0	0	0	0	1
Cymatium cynocephalum (Lamark 1816)*	9	1	A	3	<0.1	0	0	0	0	3
Cymatium nicobaricum (Röding 1798)	7	1	A, B	1	<0.1	1	<0.1	0	0	2
Cymatium parthenopeum (von Salis 1793)	6	1	B	0	0	1	<0.1	0	0	1
Cymatium pileare (Linnaeus 1758)	9	1	B	0	0	1	<0.1	0	0	1
Cymatium cingulatum (Lamarck 1822)	10	4	A, B	1	<0.1	1	<0.1	0	0	2
Cymatium sp.	10	4	A	3	<0.1	0	0	0	0	3
Cyphoma gibbosum (Linnaeus 1758)	8	1	A	3	<0.1	0	0	0	0	3
Cypraecassis testiculus (Linnaeus 1758)	1	1	A, B	1	<0.1	1	<0.1	0	0	2
Diodora arcuata (G.B. Sowerby II 1862)	9	1	A, B	1	<0.1	1	<0.1	0	0	2
Diodora cayenesis (Lamarck 1822)	8	1	A, B	1	<0.1	2	0.1	0	0	3
Diodora sp.	10	4	A, B	7	0.1	2	0.1	0	0	9
Diodora variegata (G.B. Sowerby II 1862)	8	1	A	1	<0.1	0	0	0	0	1
Diodora viridula (Lamarck 1822)	6	1	A, B	6	0.1	3	0.2	0	0	9
Echinus nodulosus (Pfeiffer 1839)*	6	1	B	0	0	10	0.5	0	0	10
Engoniophos unicinctus (Say 1825)	4	1	A, B	2	<0.1	2	0.1	0	0	4
Fasciolaria tulipa (Linnaeus 1758)	1	1	A, B	1	<0.1	1	<0.1	0	0	2
Fisurella nimbosa (Linnaeus 1758)	6	1	A	4	0.1	0	0	0	0	4
Fisurella nodosa (Born 1778)	6	1	A, B, C	203	3.9	55	2.8	1	5	259
Fisurella sp	10	4	A	2	<0.1	0	0	0	0	2
Haminoea elegans (J. E. Gray 1825)	10	4	B	0	0	2	0.1	0	0	2
Hemitoma emarginata (de Blainville 1825)	10	4	A, B	6	0.1	1	<0.1	0	0	7
Hemitoma octoradiata (Gmelin 1791)	9	1	A, C	2	<0.1	0	0	1	5	3
Hemitoma sp.	10	4	A	2	<0.1	0	0	0	0	2
*Latirus brevicaudatus**	10	4	A	1	<0.1	0	0	0	0	1
Leucozonia nassa (Gmelin 1791)	7	1	A, B	12	0.2	3	0.2	0	0	15
Lithopoma tuber (Linnaeus 1797)*	5	1	A, B	21	0.4	14	0.7	0	0	35
Lithopoma caelatum (Gmelin 1791)*	8	1	A, B, C	131	2.5	42	2.2	1	5	174
Littoraria nebulosa (Lamarck 1822)*	7	1	B	0	0	1	<0.1	0	0	1
Lucapinella limatula (Reeve 1850)	10	4	A	2	<0.1	0	0	0	0	2
Mancinella deltoidea (Lamarck 1822)*	10	4	A, B	20	0.4	4	0.2	0	0	24
Modulus modulus (Linnaeus 1758)	5	1	A, B	9	0.2	1	<0.1	0	0	10
Nassarius albus (Say 1826)	4	2	B	0	0	1	<0.1	0	0	1
Naticarius canrena (Linnaeus 1758)*	8	1	A, B	3	<0.1	6	0.3	0	0	9
Nerita peloronta (Linnaeus 1758)	6	1	B	0	0	2	0.1	0	0	2
Nerita tessellata (Gmelin 1791)	6	1	A, B	57	1.1	26	1.3	0	0	83
Nerita versicolor (Gmelin 1791)	6	1	A	2	<0.1	0	0	0	0	2
Neritina clenchi (Russel 1940)	6	3	A, B	980	18.6	476	24.4	0	0	1456
Neritina puctulata (Lamarck 1816)	6	3	A, B	3	<0.1	43	2.2	0	0	46
Neritina virginea (Linnaeus 1758)	7	2	A, B, C	2525	48.0	795	40.8	18	85	3338
Oliva sp. (Brugiere 1798)	2	1	A, B	243	4.6	4	0.2	0	0	247
Phyllonotus pomum (Gmelin 1791)*	9	1	A	2	<0.1	0	0	0	0	2
Pilbryspira leucocyma (Dall 1884)*	3	1	A	1	<0.1	0	0	0	0	1
Polinices hepaticus (Röding 1798)	5	1	A	1	<0.1	0	0	0	0	1
Polinices lacteus (Guilding 1834)	7	1	A	2	<0.1	0	0	0	0	2
Stramonita haemastoma (Lamarck 1822)*	7	1	A, B	18	0.3	17	0.9	0	0	35

GASTROPODA	Habitat	Salinity tolerance	Present on Stratum	MNI stratum A	%	MNI Stratum B	%	MNI Stratum C	%	TOTAL MNI
Strombus (Estrombus) gigas (Linnaeus 1758)*	1	1	A, B	2	<0.1	1	<0.1	0	0	3
Strombus sp.	10	4	A	1	<0.1	0	0	0	0	1
Synaptocochlea picta (d'Orbigny 1842)	10	4	A, B	3	<0.1	2	0.1	0	0	5
Tectarius (Cenchritis) muricata (Linnaeus 1758)*	6	1	A, B	62	1.8	30	1.5	0	0	92
Tectura antillarum (Sowerby 1831)*	6	1	A	11	0.2	0	0	0	0	11
Tegula excavata (Lamarck 1822)	3	1	A, B	6	0.1	1	<0.1	0	0	7
Tegula fasciata (Born 1822)	9	1	A, B	45	0.9	13	0.7	0	0	58
Tegula lividomaculata (C. B. Adams 1845)	9	1	A, B	11	0.2	5	0.3	0	0	16
Thais sp.	10	4	A	1	<0.1	0	0	0	0	1
Turbo canaliculatus (Hermann 1781)	8	1	B	0	0	8	0.4	0	0	8
Turbo castanea (Gmelin 1791)	9	1	A, B	690	13.1	282	14.5	0	0	972
TOTAL				**5261**		**1948**		**21**		**7230**

Table 2. Gastropoda of Punta Candelero. See end of table for habitat and salinity tolerance key (For general reference see Carpenter 2002 and Warmke and Abott 1975).

* Most recent taxonomic classification. For previous classification see http://www.malacolog.com and http://www.itis.gov.

Key	Habitats	Key	Salinity Tolerance
1	Sandy Bottom, Sea grass beds, subtidal	1	Marine
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5	Sea grass, subtidal		
6	Rocky shores, intertidal		
7	Consolidated bottom, intertidal - subtidal		
8	Consolidated bottom, subtidal (including reef, mangrove roots and others)		
9	Ubiquitous, subtidal		
10	Data too general or not available		

Andrews 1940, Blanco and Scatena 2005, 2007, Metcalf 1904). Apparently, higher salinity affects the shell coloration patterns and size of this snail, with dwarf variations associated with hypersaline conditions.

The three species of *Neritina* prefer rocky substrata on which to migrate and live. Analysis of a micromorphology monolith from the site (Rivera-Collazo and Cross-Marsh 2007) revealed the presence of a juvenile neritid in the natural sandy deposits. This suggests that these mollusc species could have used the ancient river mouth for juvenile development, but would have had to find consolidated substrates to travel upstream and find their ideal conditions for effective reproduction at the headwaters of local streams. Headwaters are ideal places for rocky accumulations. The area where hills meet the plain presents a drastic shift in energy flow, limiting the transport capacity of steam flow and stimulating the deposition of larger boulders and rocks.

Most of the neritid specimens (90.2%) were recovered from the 6 mm mesh sieve, many of which were clearly within the adult size range. In modern ecological contexts this larger size is usually found farther from the ocean, which suggests inland venturing for neritid collection.

Juvenile migration requires consolidated substrata, nevertheless the geoarchaeological evaluation of the area suggests medium to low energy schemes dominant on the delta, with the river channel composed of unconsolidated fine sand to mud sediments. The low gradient of the river and the deposition of fine-grained sediments along its flood plain also suggest that the river had rather low-energy flow, insufficient for the transport of large stones or boulders that could have provided consolidated surfaces for neritid seasonal migration. Hypothetically, it could be possible for juveniles to use mangrove roots to migrate upriver. However, the absence of the mangrove oyster (*Crassostrea rhizophorae*) from the mollusc assemblage casts doubt on the existence of a local mangal habitat. This oyster is well documented as a food resource in other settlements of this period. Its absence in Punta Candelero might suggest either the lack of mangals or that oyster shells were not being brought back to camp.

3. DISCUSSION

The shells from Punta Candelero evidence exploitation of a range of aquatic environments that exist in the area today: riparian, sandy beach, rocky shores, offshore shallow reefs and sea-grass beds; although it is possible there were other environments available that are not represented in the shell assemblage. The fact that *Neritinas* were intensively collected raises the question of energy and foraging time devoted to the gathering of these brought back to camp alive (as suggested by the numerous small opercula). *Neritinas* are a common occurrence in most periods throughout Caribbean prehispanic archaeology. It is a widely accepted idea that these (and all other small gastropods) were cooked as soups, where the molluscs were added in bulk to boiling water. No direct experimentation or testing has been carried out to evaluate this speculation but it is as strong among Caribbeanists as Irving Rouse's cultural-typological scheme. Nevertheless, small gastropods can also represent evidence of other activities, aside from the possibility of soup making.

According to the Prey Choice Model of Optimal Foraging Theory, people would select food or prey types that maximize their short-term harvest rate, minimizing the time spent foraging while increasing the revenue of such investment (Raab 1992, Perlman 1980, Thomas 2007). In food-terms, *Neritina* does not present a reasonable food objective. Given its relatively small size and the amount of work needed to extract the mollusc, this species is not likely to have been gathered for consumption, especially considering the large number of more productive species closer to the site in habitats known to have been exploited; and the existence of similar molluscs (*Nerita* sp.) closer to the site. The fact that *Neritina* were still collected is "economically irrational" (Bird *et al.* 2001) and seems at odds with the Prey Choice Model terms of direct use as human food.

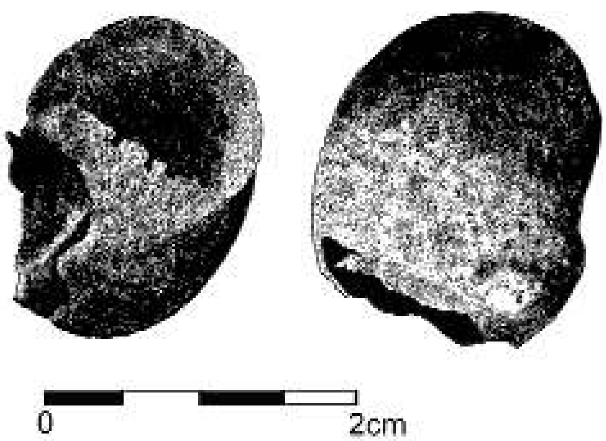

Figure 6. Example of neritid pattern of shell fracture. (Drawing by Isabel C. Rivera-Collazo).

Many of the *Neritina* of Punta Candelero show impact on the dorso/ventral area, detached apertures and aperture fragments, with very little or no burning (Figure 6) Similar breakage patterns have been observed at other archaeological sites of different periods in the Caribbean (Serrand 2001, Serrand and Bonnissent 2005). This type of breakage would effectively break the snail's attachment muscle, facilitating its removal from the shell without cooking. It is possible that the *Neritina* were collected to be used as bait either in fish traps or on hook lines (Claassen 1991: 253, for ethnographical evidence of this practice see Claassen 1998: Chapter 7). Seen isolated from other sustenance activities that require inland venturing, collecting neritids for fishing could seem to increase significantly the cost of fishing according to the Prey Choice Model, an aspect that needs further research.

Personal communication with local fishermen also suggests the possibility of gathering the neritids as snacks during trips, where they could be consumed while walking. Similar behaviour was observed in India by Arati Deshpande-Mukherjee, where people would remove the snail from the shell using sharp sticks and consume it raw (Deshpande-Mukherkee, pers comm. 2008). Nevertheless, neritid collection for snacking does not explain the presence of so many opercula on site.

The possibility of using molluscs as bait invites an examination of other evidence for line-fishing during the Late Saladoid. In Punta Candelero there is faunal evidence for the exploitation of pelagic and deep sea carnivorous fish (Ramos-Vélez *et al.* 2007); however, no fish hooks were recovered. This scenario is common throughout the Caribbean. It is possible fish hooks were made of perishable materials, such as wood or thorns. Buse (1981: 20) documented the use of fishing hooks in Peruvian coastal groups made from thorns that were shaped while still green and flexible. This kind of material would not readily survive in terrestrial archaeological contexts. The study of proxy evidence that suggests line fishing allows further understanding of the application of this technology in the Caribbean.

Regarding the rest of the Gastropod assemblage, many of the species identified are too small to be consumed (eg. *Cymatium sp., Polinices sp., Diodora sp., Tegula sp.*), but appear consistently throughout the site, although in low percentages (<1%). It is possible some of these shells reflect the presence of terrestrial hermit crabs (*Cenobita* *clypeatus,* (García 2005: 371), which periodically move into abandoned mollusc shells and are very common on modern Puerto Rican shores.

The ubiquity of these shells throughout the site might also indicate another anthropic subsistence activity. Claassen (1991, 1998) documents that periodical cleaning of fish traps in the Bahamas brought to shore molluscs and other remains that were not intentionally collected for economic or other sustenance activities. It is possible that fish traps were placed in *Thalassia* or other sea grass beds, or close to reefs, where fish could hide and be caught. The documented species are scavenging or grazing gastropods that could have crawled into the traps and be brought ashore with the catch and subsequently discarded during cleaning, providing proxy evidence of the use of this technology.

4. CONCLUSION

The shell remains from Punta Candelero support the conclusions suggested by the geoarchaeological analysis regarding the deltaic origin of the foreland. The present analysis suggests the occupants of the site used all the locally available environments, including rocky shores, sandy intertidal, consolidated and unconsolidated subtidal, and riparian habitats. The apparent absence of mangal habitat needs further examination.

The assemblage also documents particular foraging practices. Rocky shores were exploited by collecting individual specimens, selecting them according to size. Sandy beaches were used for collecting *Donax en masse* probably using baskets or sieves. Subtidal environments (rocky and seagrass habitats) were exploited by the gathering of individual specimens. It is also possible that some of the molluscs were collected opportunistically during fishing trips.

The data seems to suggest not all the shells in the assemblage were collected for sustenance. Some of the gastropods might represent fish trap cleaning practices. The neritids could have been consumed, but could also have been used as bait in traps or on hooks. Other shells could have been brought to shore accidentally, such as the *Brachidontes exustus* associated with large coral fragments that were being used for surface stabilization before erecting structures (Rivera-Collazo and Cross-Marsh 2007).

The analysis of the faunal remains collected during the 2006 excavations suggests the inhabitants of Punta Candelero were maritime-oriented but had ample use of the terrestrial hinterland (Velez-Ramos *et al.* 2007). This shell analysis supports that observation, through the documentation of use of marine, estuarine and freshwater environments.

This study sheds light on the complexity of maritime culture and the need to study in more detail the relationship between people and their contemporary landscapes. Further research is needed to challenge traditionally accepted ideas with high resolution data. In humid tropical regions, perishable organic materials are readily available, easy to use and resistant enough to survive everyday and long-term use. Nevertheless, this raw material is usually absent from the archaeological record, as the hot and wet tropical soils do not favour its long-term preservation. Thus, archaeological assemblages are dominated by shell, stone and ceramic tools that might reflect more the taphonomic than the anthropogenic processes. However, it is possible to use proxy evidence to support the use of particular technology that otherwise would be absent from the record. This approach will foster the deeper understanding of early human occupation on the Caribbean and their use of island landscapes.

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Archaeological shell middens and shellfish gathering on La Gomera island (Canary Islands, Spain)

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Archaeological shell middens and shellfish gathering on La Gomera island (Canary Islands, Spain)

Concheros arqueológicos y recolección de moluscos en la Isla de La Gomera (Islas Canarias, Spain)

KEY WORDS: Shell middens, prehistory of La Gomera, Canary Islands, pre-europeans Gomerans, ethnoarchaeology.
PALABRAS CLAVE: Concheros, Prehistoria de La Gomera, Islas Canarias, Gomeros pre-europeos, etnoarqueozoología.
GAKO-HITZAK: Maskortegiak, Gomerako Historiaurrea, Kanariar uharteak, Europa aurreko Gomerakoak, etnoarkeozoologia.

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ABSTRACT

We present the preliminary results of the research project "Surface Study of the Archaeological Shell Middens of La Gomera (2006 – 2008)". The remarkable level of preservation of La Gomera´s littoral, where the shell middens are situated, allows exhaustive study. The work has been based on an exhaustive fact-gathering of territorial and surface information about the shell middens existing on the island. In order to obtain data and search for ways to interpret them, a series of interviews was conducted among other island residents (60 to 95 years old) who have been related to the sea. We also re-examined malacological remains to be found in the island´s Archaeological Museum collection. All of these sources allow us to understand the role played by shellfish gathering among the pre-European Gomerans, as well as to make a general evaluation of the shell middens for both their heritage and scientific interest.

RESUMEN

Se presentan los resultados preliminares del proyecto de investigación "Estudio superficial de los Concheros arqueológicos de La Gomera (2006-2008)". El importante nivel de conservación del Litoral de La Gomera, lugar en el que se ubican los concheros, permite su estudio exhaustivo. La investigación está basada en una recogida sistemática de información de los concheros isleños. Para obtener información e investigarlos se han efectuado series de entrevistas a gentes, (con edades comprendidas entre 60 y 95 años) que han vivido del mar. También volvemos a estudiarlos restos arqueomalacógicos de la Isla conservados en el Museo Arqueológico. A través de esta investigación pretendemos comprender qué papel jugó la explotación de los moluscos marinos en los grupos pre-europeos de La Gomera, así como hacer una evaluación general de los concheros desde el punto de vista patrimonial y científico.

LABURPENA

"Gomerako maskortegi arkeologikoen azaleko azterketa (2006-2008)" ikerketa-proiektuaren atariko emaitzak aurkezten dira. Gomerako itsasertza oso ongi kontserbatu denez, bertako maskortegietan ikerketa sakona egiteko aukera dago. Ikerketaren oinarria uharteko maskortegietan informazioa sistematikoki biltzea da. Informazioa lortzeko eta ikerketa egiteko, itsasotik bizi izan diren pertsona batzuk elkarrizketatu dira (60 eta 95 urte artekoak). Museo Arkeologikoan jasotako uharteko hondakin arkeomalakologikoak ere berriro aztertu ditugu. Ikerketaren bidez Gomerako Europa aurreko taldeetan itsas moluskuek zer zeregin zuten jakin nahi dugu, bai eta maskortegien azterketa orokorra egin ere, ondarearen eta zientziaren ikuspegitik.

1. INTRODUCTION

La Gomera, one of the smallest of the Canary Islands at 378 sq. km., is nevertheless one of the most rugged. Although it has a volcanic origin (11.5 my old) (Herrera *et al.* 2008), the island has not suffered volcanic activity since the Pliocene, and erosion has been determinant in the landscape of this island´s geography, which features a steep topography showing deep ravines and coastal cliffs.

There is a clear geographic difference between the north and the south of the island, with direct influence on the shellfish gathering; the large ravines are concentrated in the south, ending in wide stony beaches; the main part of the prehistoric population inhabited this extensive area. The north was mostly forested, humid and with fewer beaches, so it offered worse conditions to live.

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Pre-European people of the Canary Islands came from the North of Africa; probably the first arrival was around 500 B.C. Many authors (Navarro 2001) believe that possibly there were several waves of settlers. These groups, known as Berbers or Amazhigues, based their economy on livestock; gathering and agriculture were less important. At the end of the 13th century the islands were "discovered" by the European nations, who began their expansion into the Atlantic. The period of the conquest of the archipelago, carried out as private enterprise –as in the case of La Gomera– or by the crown of Castilla, took place during the 15th century and produced the destruction of the islanders´ social and political structure, causing deep changes and ending the historical phase known as the "Prehistory" of the Canaries.

The steep topography of La Gomera, its isolation, and the scarce funding for scientific research in the Canary Islands have produced only a small number of archaeological studies. However, surveys of the archaeological shell middens have been of some importance (Mesa 2006). J. Bethencourt (1882) studied and described the large shell midden of Playa del Inglés in Valle Gran Rey, and later L. Diego (1953) excavated one at Puntallana. P. Acosta, M. Hernández and J. F. Navarro excavated another two shell middens in 1974 in Arguamul (Acosta *et al.* 1975–76) (Fig.1). Navarro carried out research between 1974 and 1975, recording the main part of the shell middens located on the island (Navarro 1975). Recently surveys have been done in the most important concentration of shell middens located in the Natural Protected Area of Puntallana (Navarro 1999).

Figure 1. Stratigraphy of the shell midden nº1 of Arguamul (Vallehermoso).

2. THE PROJECT "SURFACE STUDY OF THE ARCHAEOLOGICAL SHELL MIDDENS OF LA GOMERA (2006-2008)"

The shell middens constitute by their location, morphology, and nature one of the most homogenous archaeological units to be found throughout the entire island. The homogeneity is very clear in their boundaries, which are easily established, and the scarce biodiversity of materials found in them, if we compare these shell middens with others elsewhere in the Canary Islands. This type of site has been investigated, sporadically, since the 19th century.

We have performed this project, but all the information collected has not yet been processed. Therefore, this papel gives a preliminary report about the state of research into shell middens on La Gomera island.

We believe that in the archaeological research on the island, the "surface" and monographic study of the shell middens could be highly profitable, bearing in mind variables such as invested costs/energy and the potential quality of the conclusions to be obtained. Moreover, the project would allow us to raise points of debate on what is already "known" about the archaeological shell middens of La Gomera, both historical and prehistoric, and what is more we would try to set up an island register dealing with the state of conservation of the same. On a more interpretative front, hypotheses could be established about the socio-economic models/guidelines followed by the island inhabitants as far as the exploitation of the shellfish resource is concerned.

Therefore, the objectives of the project have been to:

1). Establish the different categories of shell and to prepare a complete inventory overall the island.

2). Understand the characteristics of prehistoric shellfish gathering and its territorial patterns.

3). Establish guidelines for further research.

Our project has three categories of analysis with different methodologies of study:

a) Territory: the island as a whole. We use information provided from previous research projects, such as the Archaeological Inventory (1995-96) and the Bachelor´s Degree essay of J. F. Navarro (1975). The data were complemented by the work done in the context of this project. The study of archaeological remains offers multiple possibilities for establishing hypotheses of interpretation and planning future investigations to obtain answers about specific questions.

b) Archaeological sites: Until now few excavations have been carried out (Diego 1953; Acosta *et al.* 1975-76), but a detailed study of all known sites will be made establishing a difference between primary deposits (shell middens) and secondary ones (domestic refuse). In order to establish typologies which adapt themselves to the reality of the island, we will analyse different types of archaeological sites, including shell middens and funerary sites where the shells appear. In this way the fieldwork would be essential, because little information about this topic exists.

We have made a surface study of known shell middens. We created a file to record each feature of the middens helping identify different patterns between them. To complete the field research a survey was conducted in the area close to these sites.

c) Material: The malacological materials were analysed *in situ* in each shell midden; samples were taken of two species of *Patellidae sp.*, namely *Patella ulyssiponesis* and *Patella tenuis crenata*, which are the most common types of limpets found around the coast of La Gomera and make up the majority of the shells in the middens. A biometrical analysis was made of the selected whole samples (ECOM) and measurable apical fragments (FRAPIM), taking as reference the maximum length (longitudinal axis) and the height of the shell (apex- edge), up to a maximum of 30 individuals; in previous studies this number has been shown to be adequately representative for statistical purposes (González *et al.* 2006, Galván *et al.* 2004). However, in some cases the number of samples was slightly less because the level of fragmentation was high. All the information was duly recorded.

Moreover, all archaeological specimens of malacofauna in the collection of the Archaeological Museum of La Gomera will be identified, counted, biometrically studied and corresponding taphonomic analysis made, not only for those coming from archaeological excavations in pre-hispanic contexts but also the ones from historical sites, with special attention given to the malacological samples from the shell middens.

3. DESCRIPTION OF THE WORK PROGRAMME

3.1. Stage 1: Territorial analysis

The prehistoric shell middens of La Gomera have common features such as spatial distribution, location, and the materials found. Today there are 14 prehistoric shell middens documented (Table 1), located entirely in the northern sector of the island (Fig.2), whereas on the opposite side, there is a significant absence of these archaeological sites. However, the presence of abundant malacological remains in domestic settings in the south area allows us to infer the practice of shellfish gathering there.

The reasons that explain this distribution of shell middens have not yet been explained. Nevertheless, at present we are following two different research lines: first, the biological-shellfish factor, associated with the higher shellfish gathering potential on the north coast in contrast to the south; second, all those cultural issues which may explain the origin of the shell middens, given that the shellfish gathering was a systematic activity and therefore not at all casual or opportunistic.

As to their location in the territory, one spatial constant is evident, for all the shell middens are to be found close to the coastline, not more than 50 metres away, with altitudes ranging from 15 to 25 metres above sea level. All of them are in the open air and occasionally they are built up against rocky outcrops which protect them from the dominant north-easterly winds. Most are situated on the top of debris slopes or on the lowest part of the slopes, as in the case of the shell middens of

TABLE GROUPS SHELL MIDDENS	
GROUPS	LOCALITIES
Puntallada	San Sebastián de La Gomera
El Águila	San Sebastián de La Gomera
Majona	San Sebastián de La Gomera
Los Lajiares-Punta Gorda	Vallehermoso
Arguamul-Bejira	Vallehermoso
Muñoz	Vallehermoso
Playa del Inglés	Valle Gran Rey

Table 1. Groups of shell middens.

Figure 2. Location of shell middens in La Gomera.

Arguamul (Vallehermoso) (Fig.3), always on small flat areas or spaces near the horizontal, which are not very common in the rough terrain of the north coast. Occasionally, there is evidence of the construction of protective structures, either free-standing or attached to rocky outcrops. These low walls, made of dry-stone, tend to be oval or circular in shape and have a basal diameter of between one or two metres.

All of these structural elements confer a temporary character to the shell middens as far as their use is concerned, as evidenced by the objects found at the sites. These archaeo-sedimentary structures show a stratigraphy always less than 0.5m in depth, and they are characterised by the superposition of shell remains and a small amount of sediment.

From a quantitative point of view, the malacological remains stand out, as they represent 95% of all the recorded archaeological material found in the shell middens. In La Gomera there are abundant species of limpets: *Patella tenuis crenata, Patella ulyssiponensis* and *Patella piperata*. Second in importance are the "burgados", gastropods of the families *Trochidae* (top shells) and *Muricidae* (murex or rock shells) represented by *Osilinus atrata* and *Stramonita haemastoma*. Finally, other species of malacofauna are often recorded but they are less than 1% of specimens found. They are *Littorina striata, Haliotis coccinea, Columbella adansoni* and *Erosaria spurca*, with a poor nutritional value.

Together with the shell midden materials appear other archaeological evidences of diverse nature. This is the case of the remains of lithic carvings made on basalt, pottery, and occasionally, remains of ichthyofauna and mammals.


Figure 3. El Remo shell midden (Vallehermoso).

These data allow us to define the first hypotheses to explain the origin, use, and function of the shell middens in pre-European Gomeran society. The pattern of distribution of the middens, the structural characteristics defining these sites, the predominance of remains of malacofauna in contrast with other archaeological evidence, the selection of species more adequate to eat, as well as the presence of other elements such as pottery and the lithic industry associated with the shellfish gathering activity and its posterior processing, suggest the possibility that this activity may have developed to the point of producing a surplus.

The shell middens would have been, then, the places to which the molluscs would be taken for shelling or processing, so as to later transport the meat more easily to the inhabited areas where it would be redistributed or exchanged with other groups, or consumed by the local community.

3.2 Stage 2: Malacological analysis

The malacological study was tackled in two main stages. First, the samples were collected from the surface of each of the registered shell middens. Thirty specimens were selected ranging from complete shells (ECOM) to measurable apical fragments (FRAPIM) of the two species of limpets predominating in these areas, namely *Patella tenuis crenata* and *Patella ulyssiponensis*. The principal objective of this sample-taking was to establish the biometry of the analysed specimens, so as to evaluate the surface biological-shellfish situation during the final stage of the pre-European Gomerans´ occupation of the island in the area where shell middens have been found.

Second, we carried out an analysis of the prehistoric malacological remains from the collection of the Archaeological Museum of La Gomera (MAG). In this case we found a series of difficulties of a quantitative and contextual order. From a quantitative point of view, the malacological collection deposited in the MAG includes 3,901 pieces from diverse archaeological contexts and obviously with different functionality. Although *a priori* this could be of great advantage, actually almost all this malacological material has come from private contributions and the source area provenences are unknown, except in the case of the shell midden of Arguamul and the group of hut dwellings at Era de los Antiguos (Navarro 1992), which were excavated between the 1960s and ´70s.

In its first stage, the macroscopic analysis of the malacological samples focused on the identification and quantification of the different taxa present, taking into account the different categories of fragmentation. In a second stage, the state of conservation of the remains was evaluated, identifying the taphonomic processes, both of natural and man-made origin, which had affected the conservation of the finds. Thus, it was found that the shells from caves were in a better state of conservation than those which had been in the open air, exposed to the weathering and erosional processes.

It was also possible to observe the existence of two very different assemblages of malacological remains. First, the one which had its origin in the processing and consumption of shellfish, which generated a whole series of remains and waste shell material left over after consumption, being present in these cases taphonomic evidence such as shells affected by fire. Similar remains have been registered in domestic and funerary contexts, although they are most commonly found in the shell middens. By contrast, there is another malacological assemblage related to the elaboration of instruments and objects of "decoration" or clothing accessories (Fig. 4), the aesthetic and symbolic value of which is not pertinent to the present study. Nevertheless, it is worthy of note that the totality of these objects has been found in domestic and funerary contexts, being notably absent in the shell middens. This fact supports the hypothesis regarding the main function of these sites, linking them with shellfish processing for clearly nutritious purposes.

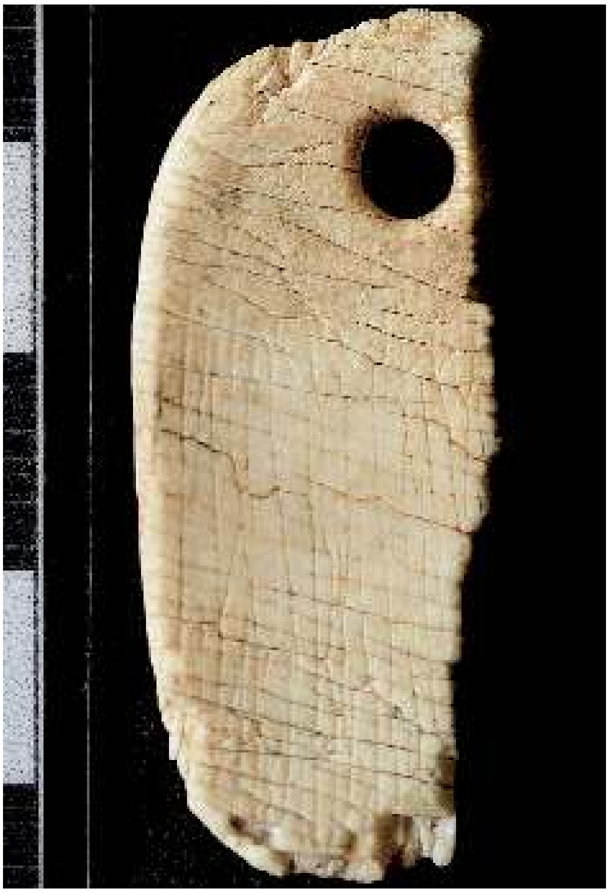

Figure 4. Pendant made from shell (*Conus* sp.)

3.3 Stage 3: Zoogeographic study (shellfish biological analysis)

The characteristics of the habitats where the shellfish are gathered and the oceanographic conditions which determine the productive capacity of the waters, can be divided into two clear coastal areas around La Gomera, coinciding approximately with the north and south sectors of the island.

La Gomera´s coastline and sea floor have special characteristics directly related to the erosive processes which have taken place since the last eruptions almost 3 million years ago. These conditions have meant that in the north there is a clear predominance of coastal cliffs, and less important wide, stone beaches (Fig.5) and shallow rock platforms (Fig.6). The most exposed nor-

Figure 5. Big pebbles beach or "callao", Lepe (Hermigua).

Figure 6. Shallow rock platform of Arguamul (Vallehermoso).

thern part of the island is an ideal habitat for shellfish, in contrast to the sea bed built up on the more sedimentary south coast.

The oceanographic conditions also show marked difference between north and south. The north coast is pounded by waves and lashed by winds, and also has a lower water temperature and higher productivity due to nutrient-rich upwelling, which encourages the development of marine resources. Meanwhile in the south the waters tend to be calmer, warmer and less productive.

3.4. Stage 4: Ethnoarchaeological study (Interpretative analysis)

The aim of the ethnoarchaeological study was to learn about the traditions concerning shellfish gathering and the surroundings in which it took place. This gave us the key to understanding some cultural or technical issues of the prehistoric activity, as well as diverse questions related to the location of shell middens, the conditions of the shellfish gathering areas and which of them were more productive, the behaviour and influence of the tides, the animal species, the size of the specimens collected, the effects of the moon on the species etc., all of which help with the interpretation of the archaeological shell middens, from historical or prehistorical times. Thanks to the interviews, new shell middens were located and we were able to understand much better what shellfish gathering involved, including its opportunities and its difficulties. Finally, we looked into the more recent uses of the seashore in the traditional economy (Fig. 7 y 8), using oral information which occasionally extended back to the end of the 19th century.

The ethnoarchaeological study relied mainly on 33 interviews which were conducted over all the island. The interviewees had an average age of 74 (having been born in the 1930s), although some of them were over a decade or two older than that. Both the interviews and the transcriptions were made following a controlled, previously established method, and were carried out using a questionnaire elaborated for this purpose.

A brief summary of the general characteristics of traditional shellfish gathering would be as follows: Shellfish gathering was a non-professional and hardly ever exclusive occupation. It actually formed part of the chain of activities which were carried out to exploit all the potentially edible resources to be found in the surrounding area. Therefore, it was mainly a seasonal harvest taking place between May and October, which, on occasions, was combined with fishing "from land" (with a fixed rod from the shore). When this activity took place in a semi-professional way those who took part always belonged to the least well-off levels of Gomeran society, which until the last third of the 20th century were mostly landless peasants with a very low income, many of whom lived in abject poverty.

4. DISCUSSION

The current project is unfinished, as the last phase of work which corresponds to the general analysis and final interpretation has not yet been completed. Despite this, we can advance some preliminary issues which we consider to be of maximum interest to the advancement of these studies on the island.

Archaeological shell middens exist almost everywhere in the Canary Islands, situated preferably close to the coast, where the molluscs were extracted from

Figure 7. Palm frond bag employed for collecting shellfish.

Figure 8. Tools for limpets gathering or "laperos".

their shells, which in turn were habitually discarded in the same place (Mesa 2006). We know that in the Canary Islands and more specifically in La Gomera, these shellfish were processed, be it to preserve them, improve them for consumption, and/or to transport them more easily. This process, which we have not been able to determine with exactitude, consisted in grilling or boiling the molluscs and/or treating them with other products so as to dry or salt them, etc. The fact is, the ancient shellfish gatherers made occasional or systematic "stops", which might have been *en route* from the place of extraction of the resource (the coast) to the inhabited areas. This appears to be *a priori* an energy-saving measure, mainly to avoid carrying a load of hundreds of shells to where they would be consumed in the settlements.

The majority of the archaeological shell middens are found on the northern half of the island although it was the south which was more highly populated. In spite of the lack of shell middens in the south, an abundance of mollusc shells has been found in the prehistoric settlements there. In fact, great differences exist between these two kinds of deposits, as far as the situation, content, and morphology are concerned. In addition, the old shellfish gatherers coincide in stressing the profound differences between shellfish gathering and fishing in the north – where the yield is higher and better – and the south. The questions we must ask ourselves next are obvious: Were the shellfish taken from the north to the south? Was this resource exploited by the few inhabitants of the north and exchanged for other products with the people of the south? The oldest informants interviewed (but not the younger ones) had heard stories in their youth that confirmed the existence of similarities in cultural behaviour between the prehistoric shell gathering and that carried out in historical times, especially as far as the shelling on the coast itself is concerned, which in the case of the ancient inhabitants would have been the origin of the shell middens. Does this mean that the tradition was lost at the end of the 19th century?

Lastly, objects made from shells, both ornaments and tools, have been found at burial sites and prehistoric dwellings. The ornaments were made from whole shell or fragments of inedible malacofauna, whereas the tools were limpet shells, the flesh of which had been previously consumed. Why have none been found in the shell middens?

All the above questions constitute the starting point and the direction of the archaeomalacological research to be carried out on the island of La Gomera in the coming years, with which we aim to confirm or refute the hypotheses raised here.

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Molluscs as sedimentary components. Another perspective of analysis

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Moluscos como componentes sedimentarios. Otra perspectiva de análisis.

KEY WORDS: Shell midden, molluscs, sedimentary samples, Beagle Channel, building material
PALABRAS CLAVE: Concheros, moluscos, muestras sedimentarias, Canal Beagle, material constructivo
GAKO-HITZAK: Maskortegiak, moluskuak, jalkitze-laginak, Beagle itsasartea, eraikuntza-materiala

Ester VERDÚN[1]

ABSTRACT

The study of shell middens through representative and significant sedimentary samples from every stratigraphic subunit, gives us a different approach to archaeological sites. The statistical study of the components of each sedimentary sample shows spatial differences in the site Túnel VII (Tierra de Fuego, Argentina). This is a shell midden located at the coast of the Beagle Channel. It was occupied in the last decades of the 19th century by the Yamana, a hunter-fisher-gatherer society that lived along the Beagle Channel until the arrival of the European expeditions. There are some chronicles and ethnographic testimonies of Yamana occupation. The spatial differences observed in this site, give information about the activities carried out in the settlement and about the use of the shell as building material.

RESUMEN

El estudio a partir de muestras de sedimento significativas y representativas de cada una de las subunidades estratigráficas, permite un acercamiento distinto al estudio de los conchales. El estudio estadístico de los componentes de cada muestra sedimentaria permitió reconocer diferencias espaciales en el yacimiento Túnel VII (Tierra del Fuego, Argentina). Éste es un conchero localizado en la costa del Canal Beagle. Fue ocupado en el siglo XIX por los Yámana, una sociedad cazadora-pescadora-recolectora que vivió a lo largo del Canal Beagle hasta la llegada de las expediciones europeas. Por esta razón hay algunas crónicas y testimonios etnográficos sobre esta sociedad. Las diferencias espaciales detectadas en este yacimiento, a su vez, ofrecen información sobre las distintas actividades llevadas a cabo en el asentamiento y sobre el reaprovechamiento de las valvas como elemento constructivo.

LABURPENA

Azpiunitate estratigrafiko bakoitzaren jalkin-lagin esanguratsu eta adierazgarrien azterketari esker, beste era batera azter daitezke maskortegiak. Jalkin-lagin bakoitzaren osagaien azterketa estatistikoak Túnel VII (Suaren lurraldea, Argentina) aztarnategian desberdintasun espazialak hautemateko aukera eman zuen. Beagle itsasarteko kostaldean dago maskortegi hau. XIX. mendean, Yamana indioek okupatu zuten, europar espedizioak Beagle itsasartera iritsi arte bertan bizi izan ziren ehiztari-arrantzale-biltzaileek. Horregatik daude gizarte hari buruzko zenbait kronika eta testigantza etnografiko. Gainera, aztarnategi horretan hautemandako desberdintasun espazialek bertan garatutako zenbait jarduerari buruzko informazioa eta kuskuak eraikuntzarako erabiltzeari buruzkoa ematen digute.

1. INTRODUCTION

When we work with archaeological molluscs, usually most of us think of these animals as an alimentary resource or as ornamental goods (necklaces, pendants, bracelets…). But in a *special* archaeological context as a shell midden like Túnel VII site, the study of molluscs is a bit more complicated due to the big amount of remains. The formation of shell middens must be seen as the result of different social activities: firstly, the carrying of molluscs to the settlement due to food consumption; secondly, the fact of reusing the food residues (shells) for different aims. Once the food residues are left, they start to become part of the sedimentary matrix. They can also give us some new information about other activities carried out in the archaeological site. Those activities give us also new information referring to other activities or social relations in the group itself. In Túnel VII it is necessary to evaluate the molluscs focusing on the food consumption, also on the activities carried out during their gathering and the reuse of valves for different purposes.

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In order to estimate the quantity of molluscs captured and the work involved in these activities it was necessary to develop a method based on samples. There are two different analysis aspects in the Yamana hunting-gathering-fishing society. On the one hand, the food consumption of molluscs must be evaluated, and on the other hand the use of their residual shells can also be evaluated.

2. TÚNEL VII

Túnel VII site is a shell midden located in the north coast of the Beagle Channel, in the south limit of the Isla Grande de Tierra del Fuego (Argentina). Its coordinates are 54º49'15'' latitude south and 68º09'20'' longitude west (fig. 1).

Figure 1. Location of Túnel VII.

The excavations at Túnel VII site made evident a ring of shell deposits (of 3m in diameter) on the surface of the land. The ring is constituted by an accumulation of sediments, molluscs and other organic and inorganic consumption residues (fig. 2). This depression of the surface is where the hut is located. Túnel VII is just one example of the other similar structures along the beaches of the Beagle Channel coasts. We can find groups of many relief structures like those extended along broader beaches (Estévez and Vila 1995a, Orquera and Piana 1999).

Figure 2. Túnel VII

The climatic and geographic conditions of Isla Grande restrict the local resources which could be exploited by the indigenous people. The climate is cold and wet in this area of the Beagle Channel and the wind is constant. The vegetation surrounding the site is composed basically by species of the genus *Nothofagus*. The animal resources that can be found nowadays in the area are marine animals like fishes, molluscs, pinnipeds and cetacean; the terrestrial animal resources are foxes, guanaco and some rodents (but proceeding basically from the north of the Island); the avifauna is very rich in the area too (Massoia *et al.* 1993).

This zone was occupied by the Yamana/Yaghan society until their disintegration after the arrival of the Europeans in the 19th century. The site was dated by dendrochronology and the results showed that it was occupied in the 19th century. This means that Túnel VII corresponds to the period when the contact between the two societies began (Piana and Orquera 1995).

Due to these particularities we have some ethnographic chronicles which are testimony of how Yamana people lived. The most important ethnographical testimonies about Yamana are, for example, the work of Martin Gusinde (1986), from the Mission Scientifique and from the missionary Thomas Bridges who lived with the natives. This constitutes a very useful tool to compare with the archaeological results and get a complete reconstruction of the Yamana social organisation. In this sense, the ethnographic information helps us, as archaeologists, to test our methodology and to develop new techniques or methods in order to go further with our social interpretations of the archaeological record (Estévez & Vila 1995b, Vila *et al.* 2007).

Until the arrival of the Europeans, the Yamana economy was based on the hunting- gathering-fishing activities, but they were basically focused on the exploitation of marine resources: marine mammals (pinnipedia, cetacean), birds (penguins, cormorant…), fish and they had a high dependence on molluscs (Estévez *et al.* 1995, Mameli and Estévez 2004). Molluscs are the only resource abundantly present during all year and with no interruption. That is why the Yamana society had a high level of mobility, following the available resources along the Channel coast.

The site was reoccupied at least ten times during the 18th-19th century. The different occupation periods can be detected by the superposition of fire places and thin sedimentary layers which cover them during a non occupation period. We find those layers repeatedly in the same depression area. The area where the Yamana group would probably have located the huts is delimited by a ring composed by sediment and archaeological remains. Some post holes from the huts were identified during the excavation. That produced a complex sequence of occupation and non-occupation processes of the site which is reflected in the stratigraphic matrix (Orquera 1995, Vila *et al*. i.p.). Moreover, every occupation unit is formed by several stratigraphic subunits which can be distinguished one from the other; those subunits are the basic analysis units.

3. MALACOLOGICAL ANALYSES

Due to the complexity of the stratigraphic matrix, the design of a method to evaluate the formation process of the site and the quantity (MNI) of molluscs consumed in the settlement was necessary.

Túnel VII was excavated extensively, isolating very thin depositional subunits (inner stratification layers) (Orquera and Piana 1992). The isolation of each subunit followed a strict standardised and objective protocol. The study of the shell midden was done through sedimentary samples from every stratigraphic subunit. Each sedimentary sample was homogenized within their whole components of the sedimentary matrix, therefore they reflected the composition of each stratigraphic subunit. These samples consisted of a standard measure, 4 litres of sediment (4dm^3) from each subunit, independently of their total volume, which was proved to be statistically representative enough and could be extrapolated to quantify the total composition of each subunit, considering their measured total volume (Orquera and Piana 2000; 2001).

The study of the components of each subunit let us evaluate the existence of differences among them. These differences could be attributed to the activities carried out in the settlement. In this case, it could be possible to get social information and see the molluscs not only as food. Furthermore, we can get information about the formation processes of the site which is also directly related to the management of the residues by the Yamana. The information that we can obtain is equally important for the reconstruction of the social relations because it refers to other aspects of the social activities.

4. MATERIALS AND METHODS

We selected random samples of 35 subunits corresponding to different episodes of occupation and coming from different places in the site. Their whole volume and weight were measured and then they were separated into their individual components: *valves, bones, flints, charcoal, soil* and *pebbles*. In turn, each component was weighed and the volume was measured as well (Orquera 1997, Orquera and Piana 2000). Moreover, the fragments of valves were identified taxonomically and counted in order to estimate the MNI.

To estimate possible significant relations among these components, we considered the *weight* a variable of each component of the sediment as indicator of differences in the contents of one or another component. We applied inferential statistics tests as Correspondence Analysis and Principal Component's tests to see if there was any correlation between the components and their *weight* (fig. 3).

After some data readjustments, the results obtained are significant and very conclusive. There are significant associations between the *soil* and *pebbles* variables and they are completely opposite to *valves* (fig. 4). That means that actually a non-random relationship exists among some of the components: the dynamics between the variables *soil* and *pebbles* is similar between them, while it differs from the dynamics of the variable *valves*. The general tendency of the sample is that the subunits with high content of sediments and pebbles contain low quantity of valves and vice versa (Orquera 1997, Verdún 2006).

These differences are related to the location of each stratigraphic subunit *inside* or *outside* the place where the hut would have been located in the site: the subunits with higher content of *pebbles* and *soil* are 100% and 87,5% respectively, located *inside* the hut; whereas the subunits with higher content of *valves* are *outside* the hut (88,89%) (fig. 5).

At the same time, we calculated the density of molluscs MNI/dm^3 for each subunit. This is the reason why the recount of MNI from the samples was taken into account. If we consider the density of molluscs/dm^3 and the location of each subunit in the site, the obtained results were similar to the ones obtained through inferential statistics. The range width of densities calculated from the subunits goes from 19.75 individuals/dm^3 to 224.25 indiv/dm^3. The general mean is 89.56 individuals/dm^3. In the density calculation all the identified taxa are taken into account.

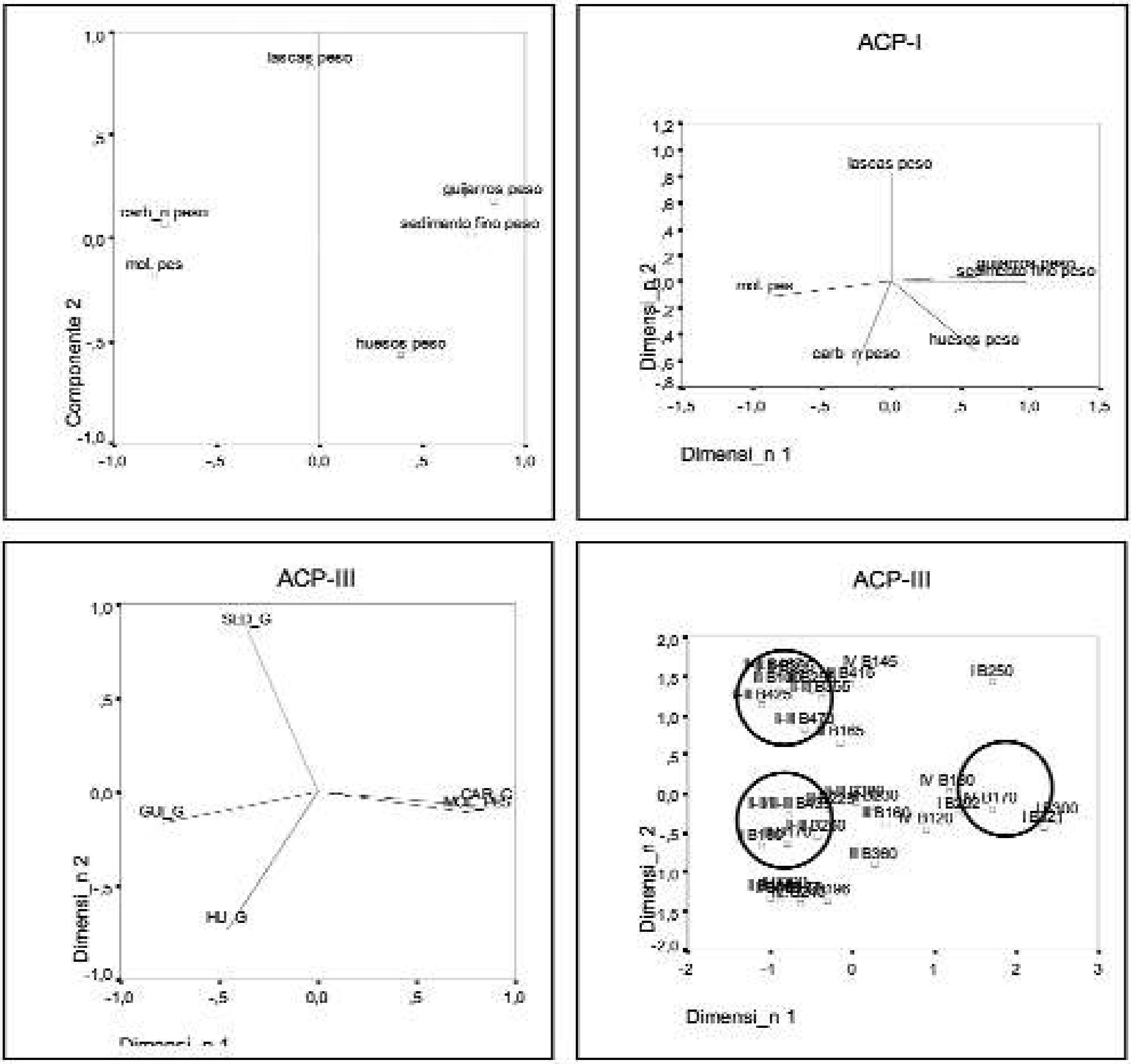

Figure 3. Graphs with the results from Correspondence Analysis and Principal Component. We can see the relations among the weight of each variable; especially, between molluscs (moluscos), soil (*sedimento*) and pebbles (*guijarros*).

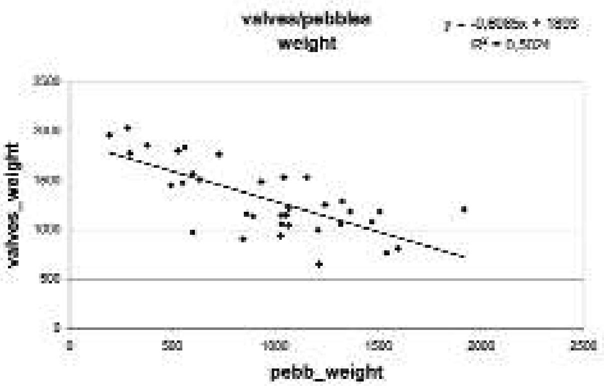

Figure 4. Correlation between valves and pebbles.

	LOCATION	
	inside	**outside**
pebbles	100%	0%
valves	11,11%	88,89%
soil	87,5%	12,5%

Figure 5. Location.

We divided the subunits in two groups: the ones which presented densities under the general mean and the ones which had higher densities than the general mean. The subunits with higher densities represent 34.29% of all the subunits, whereas the subunits with lower densities represent 65.71% from all the analysed subunits. In order to relate those data with the location of every subunit in the site and more concrete, in relation to the hut, we divide the area in three categories: F (outside the hut); CU (inside the hut); T (last subunits of each occupation units). A non random relation between the positions of the subunits is established depending on the density of molluscs contained. 75% of the subunits, which have higher content of valves than the mean (89.56 individuals/dm3) are concentrated outside the hut, whereas at the same place are located only 21.74% of the subunits with lower valves content than the mean. On the contrary, 52.17% of subunits with lower content of valves than the mean in the sediment are in the centre of the hut, whereas just 16.67% subunits with higher content of molluscs are located in this place (fig. 6).

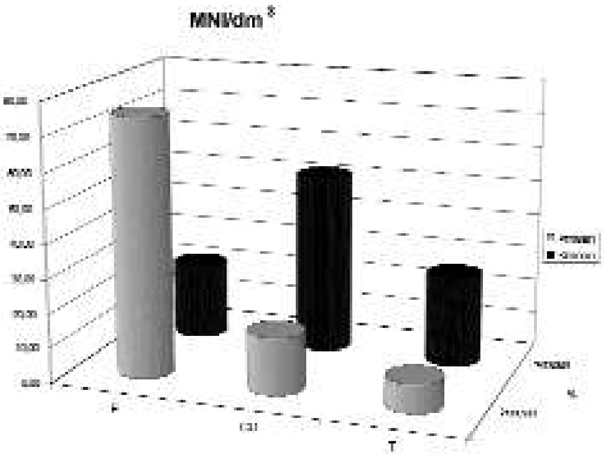

Figure 6. F= Fuera (Outside); CU= Centro Unidad (Inside); T= Tapa (last subunities of each ocupation unity).

To work with samples allows us to make estimates about the MNI consumed to the whole of each stratigraphic subunit. During the excavation we recorded the whole volume of sediment of each stratigraphic subunit; on the other hand, the fragments of shell were separated from the other components of the samples, they were identified taxonomically and the MNI counting was based on identifiying characteristics and discriminative parts between individuals.

The total MNI was calculated extrapolating the results obtained from each sample (4 dm^3), to the total volume of their corresponding subunit (Orquera and Piana 2000). In general, the results obtained from the 35 samples analysed show that the most important consumed species in the settlement were mussels (*Mytilidae*) (92.4% of the total MNI); limpets (*Nacella (P.) magellanica, Nacella (P.) deaurata*) (5%) and whelks: *Trophon geversianus* (0.3%) and *Acanthina monodon* (2.3%) (Verdún 2006).

Thinking about the results obtained from the inferential statistic and those obtained from the calculation of the valves density in the sediment, we can observe a clear difference on the location of the stratigraphic subunits in the site in relation to its composition. To explain this phenomenon we have two possibilities. They can be due to taphonomic factors or to social activities.

Related to taphonomic factors we could think that inside the hut, where the site is busier, actions like trampling could have caused a high level of fracture in molluscs. This could explain the loss of molluscs in this area compared to the area outside the hut. Nevertheless, this explanation was rejected for two reasons: the first one is that, in this case, we should record a high level of calcium carbonate inside the hut but it is not like this. The second reason is that activities such as butchering were recorded out of the hut (Estévez and Clemente unpublished). This supports the idea that the area out of the hut is also busy; therefore it must be affected by trampling too.

Taking this data into consideration it is empirically proved by statistic analysis that the differences in the matrix composition constitute evidence of the management and differential use of space in Yamana society. Those differences are materialized in the valves, pebbles and soil content in every stratigraphic subunit and, on the other hand, can also be evidence of the carrying out of activities related with it, such as setting up and maintenance.

On the other hand, the valves and residue accumulation around the hut can have a double function, as some reports suggest. Some ethnographic testimonies report the use of the valves as a constructive element and also as a protection against the wind. The presence of residues, valves and others, around the hut is described by some authors such as C. Wilkes (1844), G. P. Despard (1859, 1863), P. Hyades (1885), L. F. Martial (1888), R. Dabbene (1911) (references cited in Orquera and Piana 1989-1990; Orquera and Piana 1999). Moreover some of them suggested that this is a skirting board against the wind (L. F. Martial 1888; L. Bridges 1947; P. Hyades and J. Deniker 1891; M. Gusinde 1937; G. P. Despard 1863) (references cited in Orquera and Piana 1999) (Fig. 7).

Those data reinforce the hypothesis of the space management and residue distribution while adapting zones depending on the activities or

Figure 7. Yamana's hut and shells around it. (Mission Scientifique du Cap Horn, 1882).

needs of the Yamana. This is materialized by the use of valves and molluscs first consumed as food and reused as *building element*.

5. CONCLUSIONS

According to the traditional point of view, which is still in use, archaeological shell middens are still *only* considered as residue accumulations. The study of molluscs has been often focused on its caloric value as an alimentary resource (e.g. Bailey 1975, Meighan 1980, Erlandson 1988, Orquera 1999). Besides this point of view on the molluscs' evaluation, it is also possible study to the different and *less common* uses of those resources. As happens in Túnel VII, the use as raw material means the reuse of those food residues for different purposes.

In this report the molluscs study is focused on the mollusc consumption evaluation seen from another perspective: as a sign of other less obvious activities carried out in the settlement. This aim has been possible using the application of statistics and study of molluscs as component of the sedimentary matrix. We see its presence as the result of the actions carried out by the society living in the settlement. The differential distribution of some remains, which are taken as the base of the sedimentary matrix, shows us a series of actions. Those actions can be deliberate or not, following concrete purposes or taphonomic actions derived from the settlement occupation. Said actions might have probably gone unnoticed.

The results obtained from the application of the inferential statistics as well as the results obtained from the calculation of the density show a significant difference in the location of some sedimentary components; that difference is not due to random reasons. The difference is focused basically on the *valves*, *soil* and *pebbles* content in each stratigraphic subunits: the stratigraphic subunits with a proportional higher content of shells are located outside the occupational centre, where the hut would be situated; the ones with a higher content of *soil* and *pebbles* would be located inside the hut.

These differences can be explained associated to social activities such as:

a) The Yamana society carried out maintenance activities of the settlement, like cleaning the inner part of the hut and throwing the residues outside the hut. Some chronicles describe this activity, for example: E. L. Bridges (2005: 67): *"All residues such as clams, limpets and bones were thrown outside, next to the door. As time went by, a two metre high protective ring was formed all around the hollow where those people lived."* (Translated by the author)

b) The preparations of the ground or the fire place inside the hut: the inner hut was set up with sediment and pebbles which can be easily found on the beach, or they could be also used for the building of the fire place (Verdún 2006).

c) Moreover, they reused these residues (shells) as building elements and protection against the wind. They built something similar to a skirting board with them whereas the hut was being located in a hollow. Ethnographic evidences prove this idea.

In summary, the study of the malacological remains from another perspective allows us to obtain a better knowledge of the social organization of a society from the past.

6. ACKNOWLEDGEMENTS

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The U.S. Freshwater Shell Button Industry

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The U.S. Freshwater Shell Button Industry

La industria de botones de conchas fluviales en los Estados Unidos

KEY WORDS: Naiads, harvesting, buttons, industry, United States.
PALABRAS CLAVE: Náyade, recolección, industria, Estados Unidos, botones
GAKO-HITZAK: Naiadea, bilketa, industria, Ameriketako Estatu Batuak, botoiak.

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ABSTRACT

Two industries have relied on freshwater bivalves fished from the rivers of the United States—the shell button industry of 1891-1950, and the Japanese cultured pearl industry since 1950. In this paper I document the key species and criteria for selection, the size of the beds, the yields, their sustainability, the yields from different harvesting techniques per person, and the industrialized process of making buttons. Industries based on molluscs are well known but poorly quantified which denies us knowledge of the food and industrial potential of these resources today and in the past.

RESUMEN

Dos industrias de concha del agua dulce se utilizaban en los Estados Unidos, la industria de botones de los años 1891-1950 y la industria de perlas cultivadas japonesas desde 1950. En este artículo describo las especies clave y los criterios dominantes para su selección, sus tamaños, la producción, su sostenibilidad, las diversas técnicas de extracción de moluscos y el proceso industrial de la fabricación de los botones. Las industrias basadas en los moluscos son bien conocidas, pero están mal cuantificadas, lo que nos niega el conocimiento de su potencial alimenticio e industrial hoy y en el pasado.

LABURPENA

Ameriketako Estatu Batuetan, ur gezatako maskorren bi industria zeuden: 1891-1950 urteetako botoi-industria eta Japoniako perla landuen industria, 1950etik aurrera. Artikulu honetan, espezie gakoak deskribatzen ditut, bai eta aukeraketarako irizpide nagusiak ere, eta neurriak, ekoizpena, iraunkortasuna, moluskuak ateratzeko teknikak eta botoiak fabrikatzeko prozesu industriala. Moluskuetan oinarritutako industriak ezagunak dira, baina ez dira behar bezala kuantifikatu, eta, beraz, ez dakigu zer elikadura- eta industria-potentzial zuten iraganean eta duten gaur egun.

1. INTRODUCTION

Industries based on molluscs are well known but poorly quantified. The molluscan resources of the intertidal zone and rivers are under-utilized today, particularly their food potential for local coastal populations and a better understanding of which species have been useful in the past and their yield potential are essential to reintroducing them now. Furthermore, archaeologists are handicapped by the lack of similar knowledge—specifically the size of molluscan populations, the yields by different harvesting methods, and the daily yields by commercially motivated human collectors. In this paper I present such quantification from the historic U.S. freshwater shell button industry. Similar quantification efforts are needed for all historic industries which will benefit not only historians but prehistorians as well.

The progenitors of the U.S. freshwater shell button industry were the European freshwater button guilds and U.S. and European producers of saltwater shell buttons made from cowries, volutes, queen conch, helmets, *Pinctadas*, pink snail, green snail, chambered nautilus, pen shell and abalones. Button cutters formed guilds as early as the Middle Ages. Birmingham, England was a centre of shell button production by 1689 (Longstreth 1906:1). The founder of the U.S. freshwater button industry had been a button maker in Ottesen, Germany where he used European freshwater shells.

The ideal freshwater shell for buttons needed a completely white nacre, to be iridescent and of firm texture, have a smooth exterior, uniform thickness, subtle umbones, and have a large oval

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shape (Coker 1916: 16). The ebony shell (*Fusconaia ebena*) was the best suited to button production and in the early years was the only species sought (Fig. 1). Some rivers yielded 80% or more of ebony shells such as the upper Mississippi, the St. Francis River in Arkansas, and the Pearl River in Louisiana and Mississippi (Coker 1919). By 1920, however, approximately 40 different freshwater species had commercial value in the US industry.

Figure 1. Ebony shell (*Fusconaia ebena*).

2. BEDS AND SHELL DENSITIES

In 1912, 57 rivers in 18 states were contributing shells to the button industry. By 1950, at least 108 rivers had been harvested for shell button needs. Naiad beds were often of considerable size and yielded considerable numbers of individuals. For example, that section of the Mississippi River around Muscatine, Iowa, yielded 500 tons of shell (open, meatless) in 1896, 3502 tons of shells in 1897, and 3641 tons in 1898 (Townsend 1901). Another bed in the vicinity of New Boston, Illinois, was measured to be 1.5 miles long by 330 yards wide. From 1896 to 1898 it produced 10,000 tons of shells. The rapids above Keokuk, Iowa, produced 1600 tons in 1910. Lake Pepin reports indicated 804 tons from one section of the upper lakeshore and 1160 tons from a section of the lower lakeshore in 1924 (Fig. 2)

The early catch records from the Illinois River in the state of Illinois are also informative about animal density and industrial potential. The town of Chillicothe had in 1912 a 65 ton shell pile. A man in the Spring Bay area in 1909 gathered 14 tons in 17 days. In the Peoria area one sheller gathered 10

Figure 2. Shell Piles along the Mississippi River (Used with permission of the Musser Public Library, Muscatine, Iowa, Oscar Grossheim Collection, No. 567.)

tons in 6 months in 1912. A 50 ton pile was recorded in the Pekin area. Havanna had a 30 ton pile in 1912, and "hundreds of tons" were shipped from the Bath area that year. Four thousand tons were harvested in the beds from Meredosia to Naples in 1909, while in 1912, 850 tons were gleaned. From the Valley City area came 200 tons in 1910 and 93 tons in 1912. Bedford had 28 tons in 1912, Pearl had 168 tons, and 30 tons were sold just north of Kampsville in 1912. Buyers bought 1000 tons in 1908 from Hardin, but only 5 tons in 1912, 122 tons at Grafton; 600 tons in 1911 and at least another 600 tons in 1912 from Gatlin (Danglade 1914).

While I have been presenting the hauls in individual years, it is important to realize that many small and large rivers sustained continuous harvesting for more than two decades. The harvest records are not easy to find. For Iowa rivers I can say that, for instance, the Skunk River was exploited from at least 1920 to 1936, the Des Moines River from 1920 until 1941, and the Cedar River from 1920 to 1941. The yields from the each river are contained in Table 1.

The variation in yields had little to do with the size of the molluscan population. Instead, it was heavily determined by the factory interest in this river as a source of shells expressed in the presence of a mussel buyer on the river. Prior to 1920 the principal button shell was the ebony. As the ebonies were depleted below the numbers necessary for a sheller's income, shellers and buyers moved to other rivers. By 1920 and for the next 30 years the species mix viewed as acceptable for button cutting changed nearly yearly renewing factory interest in "old" river sources. The price the buyers offered per ton was also significant in the number of musselers willing to work. Some musselers harvested mussels even when no buyer was present and either left them in piles for future sale or transported them to a buyer on another river. So the variation in harvest yield is due to the presence of buyers, the price being offered, the number of individuals of a targeted species, the number of musselers, and the technique employed. There were far more species and individuals in these rivers than were of interest to the commercially motivated individual.

3. HARVESTING TECHNIQUES

The techniques used to harvest mussels from their beds were adopted from the musseling industry of Europe and varied in their efficiency and damage to the beds. Most common were hand collection, raking, brailing, and the use of dredges. Brailing and hand collecting began in the late 1880s. Brailing refers to the dragging of multi-

Year	Mississippi	Cedar	Iowa	DesMoines	Wapsipinicon	Skunk
1920	1,866,580	696,257	8,600	145,100	67,210	31,430
1921	1,430,894	89,500	15,660	149,005	157,210	6,000
1922	1,200,355	70,150	32,940	466,400	83,705	27,540
1923	1,424,933	9,410	36,369	553,786	155,641	43,297
1924	1,165,667	9,100		193,390	29,340	
1925	1,144,687	100,366	26,000	231,271	100,040	57,149
1926	2,058,626	1,225,456		228,633	1,205,692	24,252
1927	888,982	663,848		205,663	322,603	14,490
1928	2,422,897	669,128		64,665	236,384	136,861
1929	1,020,484	NR	79,705		172,015	24,860
1930	1,482,679	76,281	81,181	43,293	41,362	7,700
1931	858,334	386,947	10,130	856,906	61,173	17,500
1932	299,181	87,277	91,652		1,890	2,010
1933	NR	NR	NR	NR	NR	NR
1934	435,269	186,227	4,150	87,257	2,830	7,240
1935	324,344	130,296	20,917	46,316	7,385	12,704
1936	128,499	24,240	2,000		7,999	300
1937	192,438	94,117	1,468	390,062		
1938	266,449	8,310		1,906	226,118	
1939	148,665	7,590		7,298	7,800	
1940	296,735	6,300		180	21,183	
1941	225,960	6,600			39,830	
1942	365,852					
NR=no record						

Table 1. Mussel Poundage Taken from Iowa's Rivers 1920-1942 (from Claassen 1994).

ple hooks over the beds from behind a boat (Fig. 3). Naiads close up when the mantle is stimulated so they grip the hook and hold on for the ride into the boat. The idea for brailing came from the practice of Indians and Canadian loggers dragging branches over the river bottom to harvest shellfish and freshwater shrimp. These hooks often damage the soft tissue and can "plow" the bed.

Hand collecting, which probably was the major way prehistoric people collected shellfish is more productive than some might imagine. Theler (1987:50–52) made two timed collections on the Wisconsin River and three on a tributary the Mukwonago River. From the shallow water (0.7 to 1.1 meter) of the larger river he collected 234 shellfish/hour and 216/hour. From the stream the harvests yielded 492/hr, 324/hr and 443/hr.

Coker (1919) reported that about 500 tons of shells a year were taken by hand. A state commissioned study of diving efficiency in Ft. Gibson Lake, Oklahoma, found hand harvest by diving 10 to 20 percent efficient. By this estimate then, hand gathering of Indians would have been quite inefficient meaning that their ability to "overharvest" was quite limited.

The 300 to 1000 lbs a day per person harvested for the button industry are figures generated using the braile bar behind a drifting or gasoline motor powered boat. But even brailing did not manage to bring up 100% of the molluscs in the beds. Guessing that brailing is 75% efficient would mean that the musseler passed over a potential 400 lbs to 1350 lbs of shells. Of the 51,571 tons of shells taken in selected portions of the country from 1912 through 1914, crowfoot hooks captured 70% of them, forks 10.5%, tongs 7.8%, hands 5.3%, dip nets 3.3%, dredges 1.2%, and rakes 1.2% (Smith 1898: 59). The recorded number of crowfoot bars in use on the lower Ohio in 1922 was 3,292 and, in 1931, 986. For mussel forks and tongs these figures were 675 for 1922 and 511 for 1931 (Lund 1983: 171). It would appear then than very little of the harvest was generated by hand collecting.

Although naiads are essentially immobile (they can move distances of up to 100 ft.), their capture is not certain. A number of species were known to only very rarely bite the crowfoot hook. Brailing, raking, tonging, and wading "secured an unduly large number of some species and an unduly small number of other species" (Wilson and Clark 1914:

Figure 3. Braile Boats at work on Kentucky Lake, 1989 (Photo by author.).

20). Some species colonize the edges of beds where a brail was least likely to drag. Furthermore, when the water is low the musseler gets a very different proportion of species and even different species from when working in high water (Wilson and Clark 1914: 20). Cold water, such as occurs seasonally in streams or a flush of water from snow melt, will cause the mollusc to close up and be inaccessible to brailing. When the water is very warm they also close up. Lund's informants told him that from mid-July to early September the mussels close up and are impossible to catch with crowfoot hooks, except before 8:00 A.M. (Lund 1983: 641).

Modern musselers (working since 1950 to send shells to Japan for the cores in cultured pearls) have used 30 foot long rakes, tongs and dredges to remove shells from beds 10-20 feet deep in colder rivers and lakes. Toe-digging and free diving allow motivated individuals to get shells from 5' to 20' deep, and branch dragging would probably work for beds as deep as 7'.

4. THE SHELLFISHERS

4.1. Modern yields per person

During the days of the button industry, the various types of equipment used had much to do with the yield per person. At the LeClair bed, one person could rake up to 800 lbs. daily. One worker on Lake Pepin reported getting 80 buckets a day by brailing (or 2000 lbs) when the lake reopened in 1924 and then slipping to 40 buckets a day (1000 lbs) late in the season. Over 1000 tons of shells were removed by 80 musselers over 10 weeks in 1924 from Lake Pepin for an average of 12.5 tons each person.

Shellers were gathering 15-20 tons of shells a season in 1911 on the Fox River (Eldridge 1914). The number of recreational pearlers on some Sundays was estimated at 500. In the Five Island bed in 1911, after two years of shelling, the average take was 10-12 tons per person that year. North of Carpentersville on the Fox River, 15-20 tons of shells were the average haul per sheller the first year this area was worked (1911). Below Yorkville, a 7 ton take by one person in 1911 was considered excellent. On the Millington-Sheridan bed, four tons per sheller was average in 1911, after two years of heavy shelling.

In 1912, from Kampsville to the mouth of the Illinois River, there were about 150 boats operating with a daily yield of 500 to 700 pounds of shell per musseler.

Musseling for the modern cultured pearl industry is conducted by diving or by brailing. A husband and wife team worked 10 hours brailing daily to bring up 300 to 800 pounds of shell around Harper's Ferry (Mississippi R.) after 1951. In 1962, the average Tennessee River musseler brought in 400 lbs. of shells daily.

"I buy seven days a week from about 130-140 divers. Have 13 men at the home base. Monday I bought 23 tons, Tuesday 20 tons, Wednesday 17.5 tons—it lessens each day of the week as people get tired" (interview with Butch Ballinger 1987). Ballinger's figures mean that 130 divers were bringing up 353 lbs on Monday, and less through the week, declining to 269 lbs per day.

The various authors report a range of 300 to 1000 pounds per day per boat, and a range of 10-20 tons per season or year with rewards as low as 4 tons in long harvested areas. It would appear from these observations that a yield below 300 pounds daily or 4 tons annually during the button industry days would cause the musseler to loose interest and a stream to be declared unproductive by industry buyers. Today's buyers pay well enough that a daily win of 269 pounds proves profitable to a sheller.

This intensive harvesting by musselers did have its impact on the populations of species being exploited. Musselers however, knew that they simply could move to a different section of river or to a different river to continue to harvest shells when their income fell below their own standard. However, the standards for the button businesses often changed thus changing the definition of a marketable shell. In the initial years only four or five species were considered usable for button production. As the supply of these shells dwindled at the favoured beds (closest to the factories), companies experimented with other species and upon finding them suitable, enlarged the list of shell species they were willing to buy. In some cases this redefinition of a usable shell made it possible to return to rivers earlier pronounced "exhausted". An unusual export demand would cause high prices for the best shells, forcing the companies to use lower-quality shells for domestic button production. Rivers where the shells had been pronounced inferior subsequently could support a mussel fishery. These changes in the national and international markets produced a rather complex mosaic of musseling history and economics in a region.

4.2. Collecting Pressure

Where human predation presumably caused a decline in shellfish, their numbers did recover and recover rapidly. Naiads reproduce by spewing glocidia (larvae) into the water current and are immediately carried downstream from the spawning parent. These glocidia for most species of naiads then attach themselves to the gills of fish where they pass through a parasitic stage before detaching and settling to the bottom as a shelled creature. Therefore, the propagation of molluscs is most dependent on the host fish population. If runoff is too little to allow fish to swim through an area, shellfish will not be able to settle there in appreciable numbers. If the fish population is exterpated in a section of river or in an entire river, new shellfish will not be able to settle there. If the river bottom or water conditions change drastically, shellfish will not be able to live there. Otherwise, given fish and sexually mature shellfish somewhere in a stream, new shellfish will establish in old and new beds the following season. Population recovery is very fast.

4.3. The Button Production Process

Following the harvest, the shells had to be opened and meats removed. This process, involving cooking the shells, was conducted at the riverside. Next the shells were either cut in the same location, or shipped by barge to a cutting works shop on the same or a different river. Button blanks were cut to reduce the shell weight before shipping. In many cases, however, the piles of cooked shells were shipped by rail to be cut at a factory in Muscatine, Iowa, the home of this industry. When the shells arrived at the factory they were soaked in barrels for several weeks and then cut with dies of different diameters by men. This process produced button blanks, failed blanks and wasted shell (Fig. 4). Wasted shell constituted a significant inefficiency in the industry. Blanks were then transported to a finishing factory or section of a factory where they were polished, pierced, and carded, mostly by women. Losses during the finishing process were also fairly high as the shells would break or exfoliate.

Shell buttons were produced in different sizes for use on men's pants and overcoats, women's dresses and men's shirts, long underwear, and women's shoes. Since 1940 a weak demand for

Figure 4. Button production waste and button blanks (Photo by author).

shell buttons has been driven by the use of buttons on button blankets made by Indians of the Pacific coast of Canada and the U.S.

5. THE PROBLEMS WITH SHELL BUTTONS

There were numerous problems with either producing or using shell buttons that left the U.S. industry extremely vulnerable to the imported Filipino and Japanese shell buttons that began flooding the U.S. market in 1910 and which received favorable tariff treatment. These problems were the wastage of shell, the production of low-grade buttons during the manufacturing process, and the yellowing and breaking that occurred during their use on clothing. Home dryers produced enough heat to cause the buttons to exfoliate and commercial detergents and dryer heat yellowed the buttons. While the Japanese and Filipinos had these same production losses, shells and labor were much cheaper for those foreign industries and the cheaper product was produced for export, not home consumption. It was worse still for the U.S. freshwater shell button industry when after 1928 low priced composition buttons began to give freshwater shell button serious competition and marine shell and metal buttons were gaining favor. Marine shell buttons from the Philippines were given exemption from tariffs and button import quotas were loosened. After 1939 plastic buttons began making serious inroads into the world button markets and by 1954 had killed shell button production.

6. CONCLUSIONS

Freshwater shellfish were extremely abundant in historic times and continue today to support a fishery for the Japanese cultured pearl industry even in the wake of deteriorating habitat quality. The shell button industry of the United States provides archaeologists and environmental historians with much evidence for the variety of shellfish in a river, the size of shellfish beds, the harvest potential by hand and with other means, and the ability of this fauna to withstand harvest pressure and recover rapidly. This evidence, in fact, has made it possible to correct interpretive errors made by archaeologists considering the significance of Archaic (8000-4000 BP) freshwater shellheaps on rivers in Kentucky and Tennessee (Claassen 1991). Assuming that shellfish could only be found in a few rivers, archaeologists have constructed scenarios of research defense. The data presented here undermine such an assumption. Some archaeologists have assumed that the abandonment of these shell heaps reflected overharvesting (by hand collecting) in those locations. The data presented here also undermine this assumption. Other examples could be collected but the point remains that documenting historic industries that use shell or pearls will greatly aid archaeologists in understanding the use of this resource by older cultures. It will also help in modern efforts to reintroduce shellfish as food and as a commercially viable raw material.

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(Bogotá, Colombia) obtained her bachelor degree in Anthropology at the Universidad Nacional de Colombia (National University of Colombia) in 1999 with a dissertation about the use of mollusks at Cerro Juan Diaz, Central Pacific Panama and her PhD degree in Archaeology at the University of Calgary (Canada) in 2010 with a thesis about fish remains from Cueva de los Vampiros on the Pacific coast of Panama. She worked for several years at Smithsonian Tropical Research Institute as an archaeologist.
Diana has work experience in Panama, Nicaragua, Canada and Colombia. Currently she is working in Colombia on faunal remains. She is a specialist in the analysis of fish and mollusk remains, and the reconstruction of the Pre-Columbian diet, environment, and economics.

(Bogota, Kolonbia) Kolonbiako Unibertsitate Nazionalean eskuratu zuen antropologiako titulua 1999an, Panamako Pazifiko Erdialdeko Cerro Juan Diaz gunean, moluskuen erabilerarekin lotutako tesi bati eta Calgaryko Unibertsitatean (Kanada) arkeologia arloan egindako doktoretzari esker. 2010eko doktoretza horretan Panamako Pazifikoko kostaldeko Cueva de los Vampiros delakoan egon ohi diren arrain-arrastoei buruzko hitzaldia eman zuen. Urte askoan arkeologo lanetan aritu izan da Ikerketa Tropikaletako Smithsonian Institutuan. Dianak esperientzia oparoa du ikertzaile modura Panama, Nikaragua eta Kolonbian. Egun Kolonbian lan egiten du arkeologia-faunaren arrastoak ikertzen. Gai hauek jorratzen ditu bereziki: arrain eta moluskuen ikerketa, kolonaurreko dieten berregituraketa, ingurumena eta ekonomia.

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