UNIVERSIDAD DE LAS PALMAS DE GRAN CANARIA

Braquiópodos Pliocenos y Pleistocenos de las Canarias Orientales con mención de los actuales

Pliocene and Pleistocene Brachiopods from Eastern Canary Islands with actual references

Máster en Oceanografía

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FACULTAD DE CIENCIAS DEL MAR
UNIVERSIDAD DE LAS PALMAS DE GRAN CANARIA

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En Las Palmas de Gran Canaria, a 3 de Diciembre de 2013.

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Autor: Eduardo González Álvarez

Abstract

The study of fossil fauna and the available literature, allows us to give an interpretation of paleoclimatic character to the presence of brachiopods, associated with their fossil state to weather conditions very different that nowadays, being equivalent to the present tropical regions of the planet.

It is studied, therefore, the faunal content from the fossiliferous sedimentary deposits of Pliocene (5-3 My) and Pleistocene (3 Myr-10 kyr) age present in Gran Canaria, Fuerteventura and Lanzarote -eastern Canary Islands- paying special attention to those observed fossil brachiopods. It has undertaken a review of previous work and the study of the deposits of Pliocene and Pleistocene age, as well as the revision of the fossil collections of the Laboratory of Paleontology at the University of Las Palmas de Gran Canaria. This has allowed the identification of 4 species of fossil brachiopods: *Terebratula sinuosa* (Brocchi 1814), *Lacazella mediterranea* (Risso 1826), *Terebratulina caputserpentis* (Zbyszewski, 1957) and *Thecidium cf. digitatum* (Sowerby 1823). These fossils have been identified in outcrops of Pliocene age from the eastern Canary Islands, described and illustrated in the work of Meco et al. (2005) and in outcrops interpreted as coming from an marine event of great energy or tsunami in Piedra Alta, Lanzarote, belonging to *Marine Isotope Stage* 11 (MIS 11) in circa 480 kyr.

Furthermore, in order to compare the fossil brachiopods with existing, it has been defined a reference collection with actual specimens obtained from the pickup of surface sediment samples made in Gran Canaria and Hierro, identifying 3 species: *Argyrotheca barrettiatia* (Davidson, 1866), *Megerlia truncata* (Linaeus 1767) and *Pajaudina atlantica* (Logan 1988).

Key words: Brachiopods, Pleistocene, paleoclimatic indicators, North Atlantic.

1. Introduction

1.1. Objective

Studies about brachiopods in the Canary Islands are rare. In fact, the only appointment on current brachiopods in the Canary Islands corresponds to the work of Logan (1988) and concerning fossil species were never mentioned in the scientific literature until recently in a doctoral thesis on Mio-Pliocene fauna of the islands (Betancort, 2012) where two species of this taxonomic group are mentioned. The objective of this paper aims to fill this gap, and to do a new line of research on the phylum of brachiopods in the context of paleontological research works carried out by the ULPGC (Universidad de Las Palmas de Gran Canaria).

1.2. Geological Context

On the other hand, Moreover, the marine deposits of the Canary Islands and its fossil content have been studied since the XIX century (Lyell 1865, Rothpletz & Simonelli 1898) and have resulted in numerous publications (see Meco et al., 2007).

In addition, the geological context of the archipelago is well known and already exists a number of radiometric dating (Carracedo et al., 2002).

Finally, the large marine fauna accompanying the few fossil brachiopods has allowed recreate the paleoclimate common to them. (Meco et al., 2005, 2006, 2008; Betancort 2012; Muhs et al, in press.).

1.3. Stratigraphic provenance of canaries fossil brachiopods.

The specimens studied are from fossiliferous marine deposits mainly constituted by sandstones and conglomerates of relatively low thickness with an average of a couple of meters but its extent is very large and appears in the three eastern islands: northwest of Gran Canaria, West Coast of Fuerteventura surrounding Jandía peninsula and southeast of Lanzarote (Fig. 6). These deposits are dated radiometrically at about 5 Myr (million of years) for a pillow lavas in Ajuí Ravine, Fuerteventura (Meco & Stearns 1981; Coello et al., 1992; Meco et al.; 2007), and others in Gran Canaria in about 4 Myr (Guillou et al., 2004) which set them in the lower Pliocene. The pillow lavas indicate rapid cooling in this case when take contact with seawater so it is considered that the age of the pillow lavas is the same of the marine deposits associated with them. The height of the marine deposits is more higher in Gran Canaria than the other islands, where it reaches 120 m, which has been inferred the existence of uplifts in the archipelago (Meco et al., 2007).

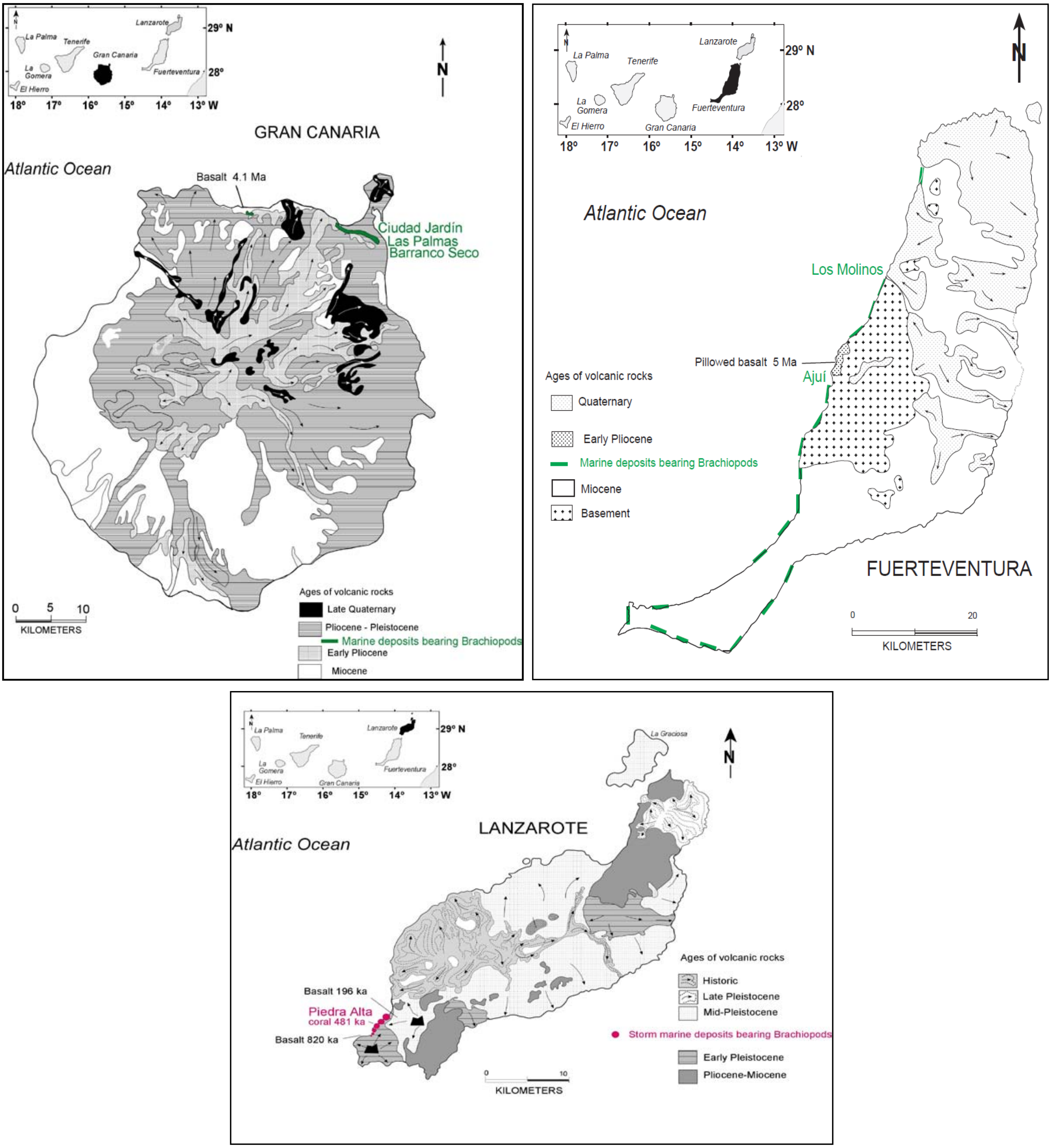

Figure 1. Geological maps of Gran Canaria, Fuerteventura and Lanzarote. In each of them is marked with a line or dots in the case of Lanzarote, where marine deposits braquiópdos were collected.

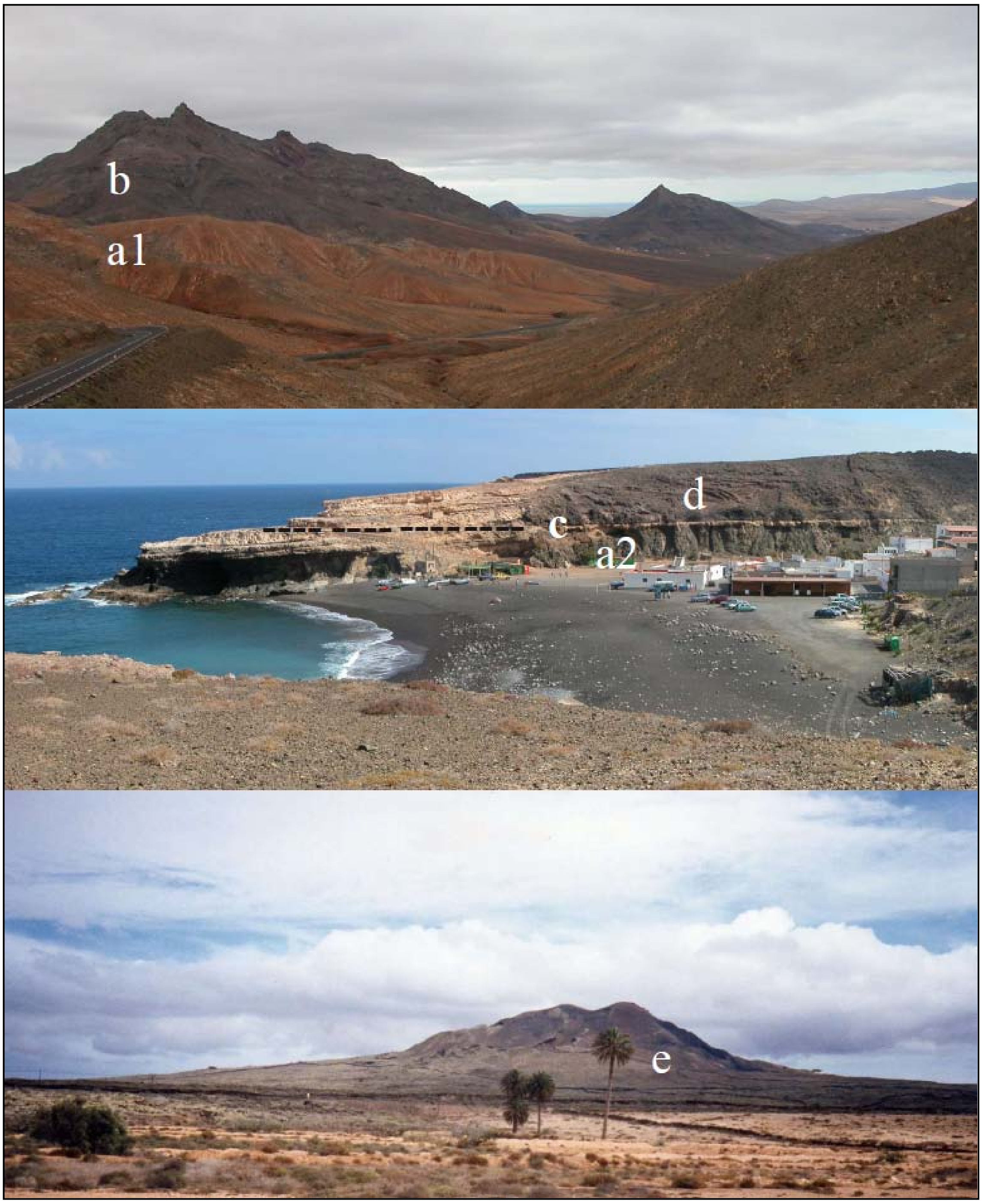

Figure 2. Summary of the geology of Fuerteventura in simplified form: a1) basal complex submarine volcanism, a2) basal complex almost metamorphosed sedimentary deposits, b) discordant Miocene basalts of the basal complex, c) marine deposits containing brachiopods and dated by the lava, d) Pliocene basaltic pilow lavas dated at 5.8 Myr, 5 Myr, 4.8 Myr and Pliocene-covered dunes, e) Mid-Pleistocene volcanism installed on Mid-Pleistocene dunes.

But they have also appeared other fossil brachiopods in marine deposits dated using uranium series on coral in 480 kyr (Muhs et al., In press). Deposits show a violent or storm character so they have been attributed to a possible tsunami (Fig. 5). The age obtained from corals and the whole fauna put the deposits in the Mid-Pleistocene, probably in the interglacial MIS 11 (Marine Isotope Stage).

Finaly, the present brachiopods come from surface sediment samples taked in Gran Canaria and El Hierro (Fig. 6 and Tab. 2) by the Laboratory of Sedimentology from the ULPGC and deposited in the Laboratory of Paleontology.

Sites where brachiopods were collected:

Gran Canaria

Pliocene fossiliferous marine deposits

- Ciudad Jardín (Fig. 3)
- Arenales
- Barranco Seco (Fig. 3)

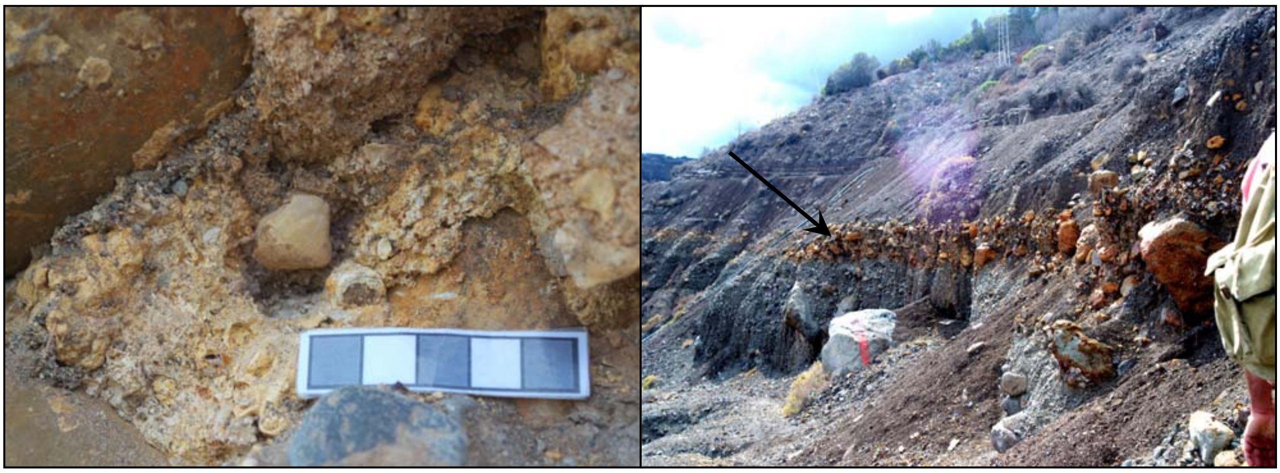

Figure 3. Left image: fossil brachiopod (*Terebratula sinuosa*) found in Ciudad Jardín; scale of 5 cm. Right image: Marine Pliocene conglomerate in Barranco Seco.

Fuerteventura

Pliocene fossiliferous marine deposits

- Coast of Barlovento: between Santa Inés and Los Molinos (Fig. 4)

Figure 4. Pliocene marine deposits in Fuerteventura. The image on the left shows the deposit located on the floor, on the right, Pliocene fossil life agglomeration.

Lanzarote

Fossiliferous marine deposits (tsunami or storm) of MIS 11 (Mid-Pleistocene)

- Piedra Alta (Fig. 5)

Figure 5. Marine deposits associated with a turbulent process or tsunami in Piedra Alta, Lanzarote, dated to MIS 11 (480 kyr).

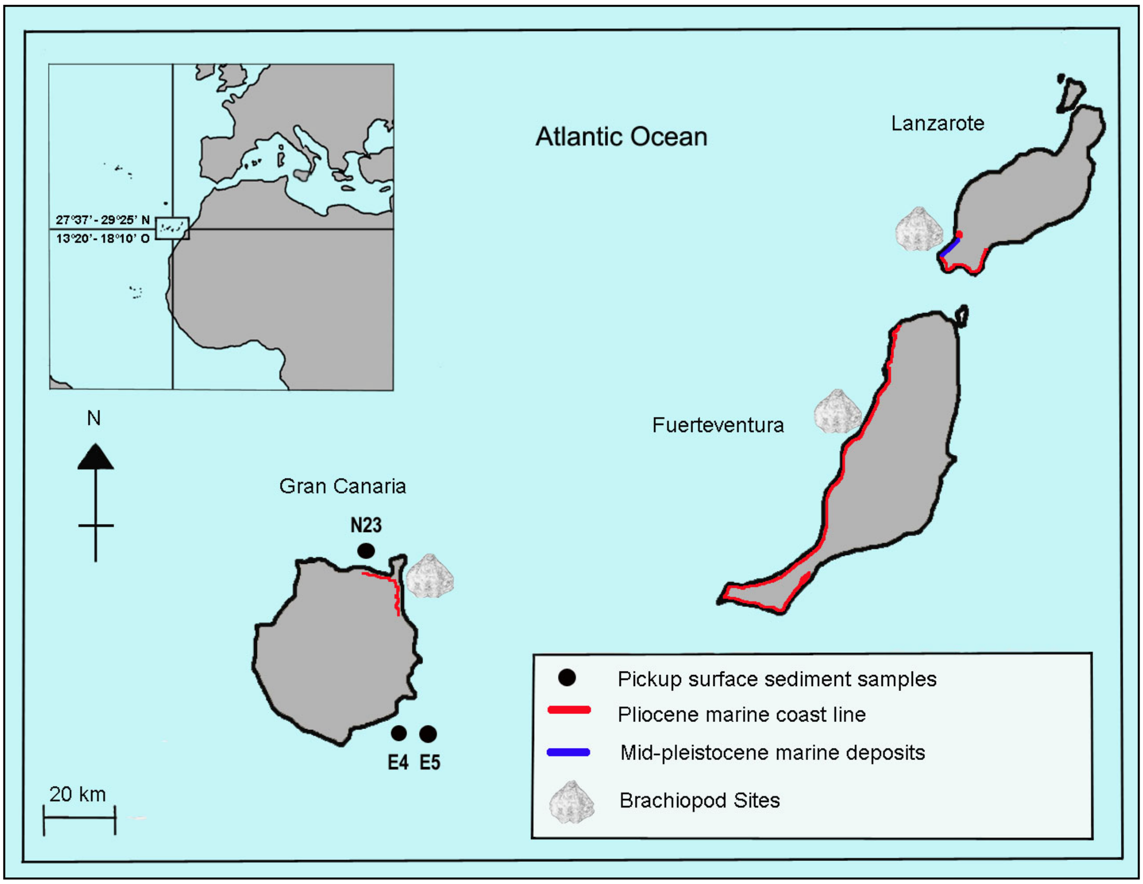

Figure 6. Location of Pliocene marine deposits (red) and Mid-Pleistocene (in blue) in the eastern Canary Islands. Spots shows pickup of surface sediment samples in the north and east of the island of Gran Canaria. The island of El Hierro is not listed because it does not have the location of the samples.

1.4. Paleoclimatical and paleoecological information

This information is obtained from faunas accompanying fossil brachiopods from the Canary Islands.

The Pliocene fauna found in the Canary Islands (Meco et al, 2005, 2008; Betancort, 2012) and Mid-Pleistocene from Piedra Alta (Muhs et al., in press) have a marked warm character (Tab. 1) revealed by the present genera. Nowadays, they are unique to the warmer seas of the Earth especially the Gulf of Guinea and the Caribbean in the Atlantic Ocean (Genus *Strombus*). In the case for the Mid-Pleistocene (MIS 11) some of the most characteristic species are still living today in the Gulf of Guinea (*Purpurellus gambiensis, Saccostrea cucullata*).

The accompanying fauna also contributes to brachiopods valuable information about littoral nature of deposits (Genus *Nerita*), its Pliocene age (*Ancilla glandiformis* species), its identity between islands (*Rothpletzia rudist* species appears in the three islands and is endemic in them) and, in the case of Piedra Alta, mixture of species of different depth and with terrestrial elements denoting a violent character occurred during an interglacial.

Pliocene (5-3 Myr.)	*Saccostrea chili* (Simonelli 1890), *Nerita emiliana* (Mayer 1872), *Strombus coronatus* (Defrance 1827), *Ancilla glandiformi* (Lamarck 1822), *Rothpletzia rudista* (Simonelli 1890), *Siderastraea miocenica* (Osasco 1897)
Piedra Alta MIS 11 (about 400 kyr.)	*Purpurellus gambiensis* (Reeve 1845), *Cerithium litteratum* (Born 1778), *Bursa jabick* (Fischer-Piette 1942), *Thais coronata* (Lamarck 1822), *Turritella ligar* (Deshayes 1843), *Drillia nicklesi* (Knudsen 1952), *Saccostrea cucullata* (Born 1780)

Table 1. Fauna of climate or stratigraphic interest of the deposits with fossil brachiopods of the eastern Canary Islands.

2. Methodology

On fossil brachiopods, it has visited the marine deposits in which they were found and examined existing specimens in the collection of the Laboratory of Paleontology from the ULPGC. Samples from which we have studied the present brachiopods were taken by box-corer. All individuals were studied and classified using a Celestron electronic magnifier and consulting the specialized literature.

3. Systematic and taxonomy

3.1. The brachiopods

They are defined as bilateral metazoan coelomates protostomes with the body contained in a dorsal-ventral bilaterally symmetrical bivalve shell. They live in a neritic environment, attached to the seabed and usually at depths from the range where the tide acts to approximately 200 m. They have a sedentary lifestyle, fixed to the substrate in which they live directly or by a pedicel that comes out through a foramen of the lower shell. In some species the peduncle is elongated, thereby permitting that may be buried in sandy substrates or sedimentary character. In other becomes shorter, atrophied in their adult stage and being replaced by a calcareous secretion adhering to the shell of the body only to a rocky substrate. His only mode of travel is by larval or embryonic stage. The shell consists of a ventral or dorsal lower valve and another (Fig. 8 and 7) or upper lobes enclosed by a mantle and provided with a kind of lophophore as the Bryozoans (Grassé, 1970; Melendez, 1982). This shell, as the well-known foraminifers, are opening a field in paleotemperatures proxies through the content in oxygen isotope and magnesium carbonate (Brand et al., 2013). The most typical structure is a pair of spiral appendages with they can breathe and attract food particles towards the mouth. These appendices tend to have an own skeleton of insertion called skeleton or apophyseal apparatus or braquidium (Fig. 9) which depends on the dorsal valve and it often remains fossil inside the shell.

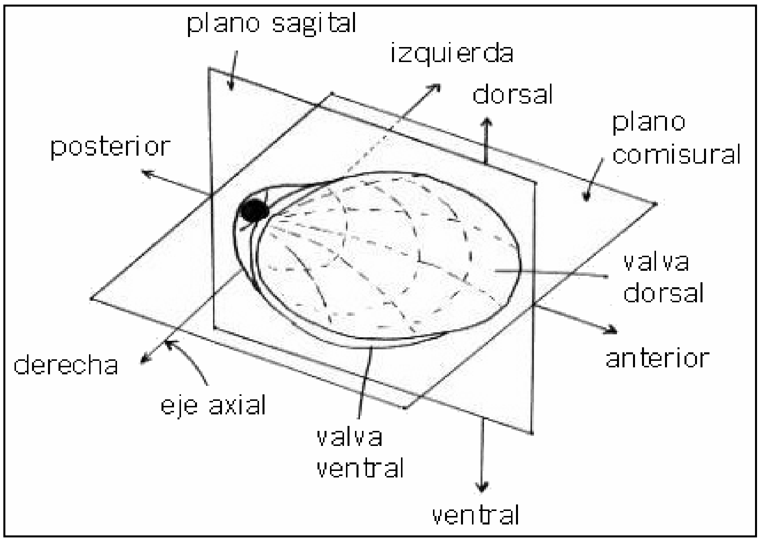

Figure 7. Common positions and classifications of brachiopods shell.

In the class of articulated exists a hinge formed by two teeth on the lower valva bent sideways that fits in respective pits of the upper valva. Hence the two valvas appear together in the fossils in most cases. Inside the shell it conserves diductor muscle, rotators, retractors, protractors and adductors prints that allow open, close, and rotate the valves and also the peduncular muscle print that allow contract the peduncle (Fig. 8). Another structure used in systematic in the ventral valve is the deltidium or pair of plates limiting the pedicle orifice (foramen) (Fig. 9).

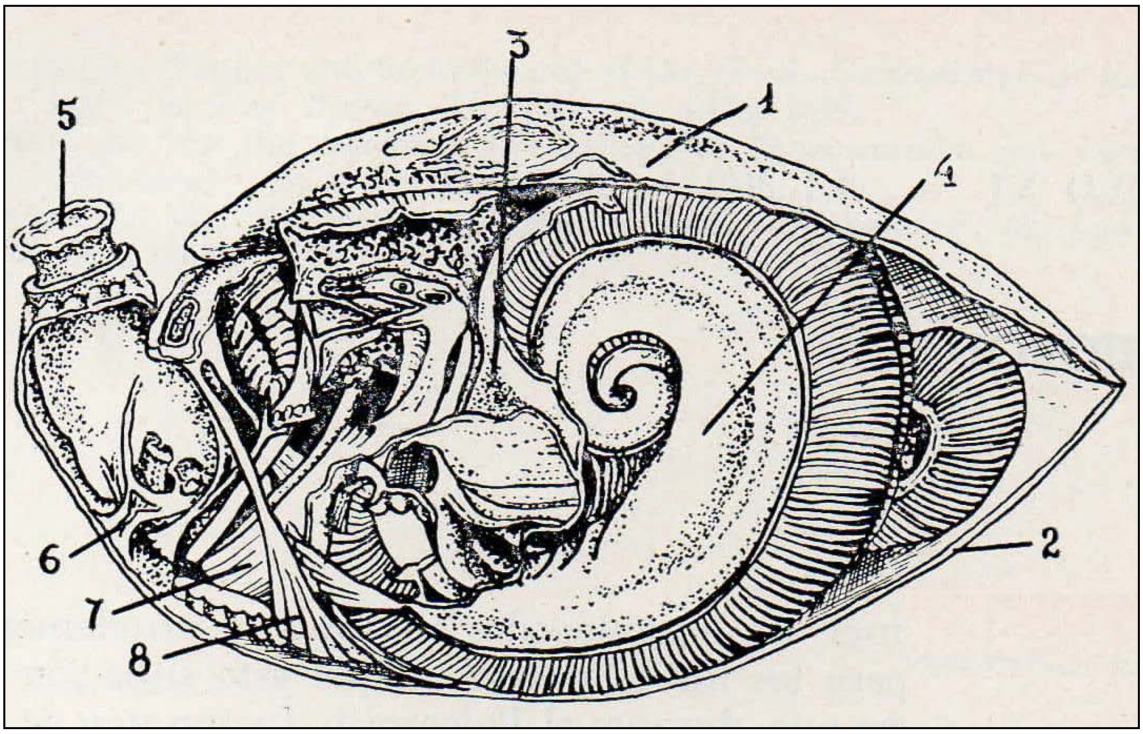

Figure 8. Picture of the internal anatomy of a brachiopod according to Camacho (1966). 1, Section of the dorsal valva. 2, Section of the ventral valva. 3, Diaphragm. 4, Braquia or lophophore. 5, Pedicle. 6, Pedicle muscle. 7, ventral part of the adductor muscle. 8, Diductor muscle.

The lophophore is an organ extending between the two lobes of the mantle, occupying most of the intermediate space. Its shape resembles that of two spiral arms, route the midline by a ciliated groove leading to the mouth. Water penetrates into the mantle cavity by two lateral streams and, stimulated by the cilia of the lophophore, comes to the mouth through the lophophoral groove, providing food. The metabolic products are, however, led out from a single central stream (Camacho, 1966).

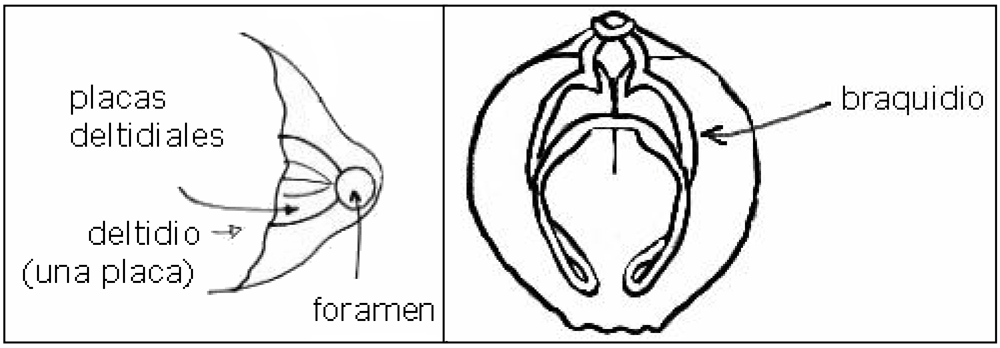

Figure 9. Left image, deltidium of the lower or ventral valva, showing the foramen. Image right, top or dorsal valva showing lophophore holder apparatus (braquidium).

The shell has bilateral symmetry and is composed of two parts or valvas, usually unequal. The dorsal or braquial valve carries the hoder apparatus from lophophore (braquidium), and the ventral valva serves fixing to the pedicle.

The contour of the shell can vary from roughly circular to elongated longitudinally or transversely. In this last case, certain shells do develop an aliform contour when meet at an acute angle to the side and posterior edge (Camacho, 1966).

The valva surface is usually smooth, showing growth only lines, or be radially traversed by a series of elevations and depressions. The first, when are soft are called folds, if they are acute, ribs. The depressions are called grooves, and is distinguished as within the middle groove bisected by the plane of symmetry, which can be wider than the remaining grooves and also show small folds. All grooves in a shell always corresponds to a fold in the opposite (Camacho, 1966, Figure 10).

The brachiopods fossilize very well and are very abundant since Cambrian. Its period was predominantly on the Paleozoic and are also abundant in the Mesozoic. In the Tertiary are scarce dwindling more in Neogene. In today's seas are residual.

The Neogene fossil brachiopods have been a group extensively studied from ancient times within the extensive and fundamental works carried for these levels in the Mediterranean. Classic works such as Sacco (1902) cite their presence in the levels from the Mediterranean Miocene and Pliocene. Over nearly 200 years, this group has been studied in detail being used as indicators of global changes.

In contrast, the information available on fossil brachiopods, and even on the current of North Atlantic and more specifically for the Canary Islands is scarce. Highlight the works of Logan (1988, 2004a, 2004b) on the identification of a new species and its ecology in Canary Islands, as well as the fossils brachiopods described for the Pleistocene of the West Indies, Jamaica, published by Harper & Donovan (2007) with a current living brachiopod in the Canary Archipielago.

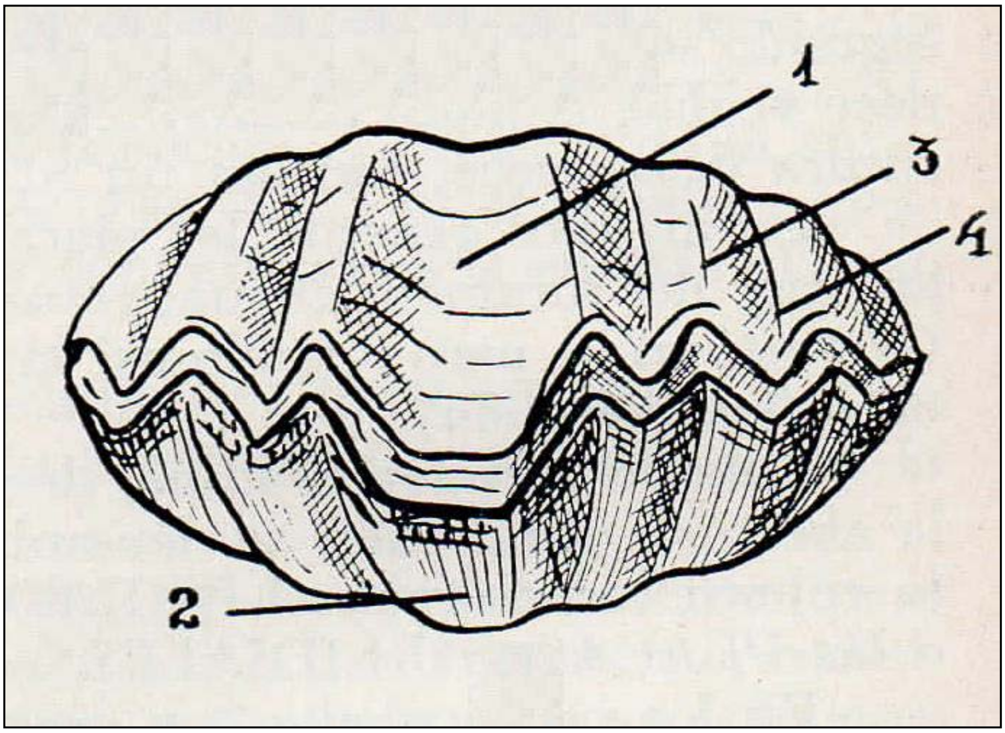

Figure 10. Anterior Plane of a brachiopod. 1 ventral sinus. 2 dorsal fold. 3 rib. 4 Groove. Picture according to Camacho (1966).

3.2. Fossil brachiopods

Phylum *Brachiopoda* Duméril, 1806.

Class *Articulata* Huxley, 1869.

Order *Terebratulida* Waagen, 1883.

Suborder *Terebratulidina* Waagen, 1883.

Superfamily *Terebratulacea* Gray, 1840.

Family *Terebratulida*e Gray, 1840.

Genus *Terebratula* Müller, 1776.

Terebratula sinuosa (Brocchi, 1814)

Plate I, Fig. 1a, 1b.

2012 *Terebratula sinuosa* Betancort, Lámina V, fig. 1-4

2004 *Terebratula sinuosa* García Ramos, D. A., Plate IV, fig. 1-8.

Material: 6 whole specimens and numerous fragments from many other animals in the Barranco Seco (Gran Canaria) were found. Full specimens of Barranco Seco were at the same sand level within the deposit; in the same strip of fine sand and very close to each other and the foramen to the substrate. Whole specimens have varying degrees of conservation but are totally enclosed, with two valvas and highlights one having a strange twist.

Canary locations: Gran Canaria: Barranco Seco, Ciudad Jardín.

Stratigraphic and geographic distribution: Species cited to the Miocene and Pliocene of the Mediterranean, especially abundant in the Italian basin deposits. It was first described by Brocchi (1814) for Piacenziens deposits (Late-Pliocene) of Northern Italy. Davidson (1870) also cited for the Miocene-Pliocene transit.

Original diagnosis: Original diagnosis obteined from Brocchi 1814: "*Testa oblonga, valva superiore uniplicata, altera biplicata, margne infero sinuoso, ápice perforato"*

Description: highlight characteristic of this species a remarkable development of the grooves on the valvas causing a bifolded anterior commissure (Calzada Badia, 1978). Considerable variation in outline, relative width, thickness and shape of the ribs. The curious concentration and agglomeration of the specimens found in Barranco Seco, undamaged and unmarked transport, partially covered in the same strip of very fine sediments, suggests some kind of "grouping in life."

Superfamily *Cancellothyroidea*

Family *Cancellothyrididae* Thomson, 1926

Subfamily *Cancellothyridinae* Thomson, 1926

Genus *Terebratulina* D'Orbigny, 1847

Terebratulina caputserpentis (Zbyszewski, 1957)

Plate I, Fig. 2a, 2b.

1887 *Terebratulina caput-serpentis* Fischer, P., Pl. XV, 3

1886 *Terebratulina caputserpentis* Granger, A., Pl. I, 2

Materials: One specimen, small, partially broken, only the dorsal valve.

Canary locations: Gran Canaria: Arenales (La Minilla).

Stratigraphic and geographic distribution: Relatively common and widespread. Cited since Miocene to the present. Actual since North Sea (Scandinavia) to the Mediterranean. Caribbean Sea and east coast of North America. Miocene deposits of the Mediterranean (Hungary, Spain) and Atlantic islands of Azores, Santa Maria. Pleistocene deposits in southern Taiwan, South China Sea.

Description: Subpentagonal-oval shell, longer than wide. Surface covered with fine radial striations. Opening the horseshoe-shaped lophophore. It is considered synonymous *Terebratulina retusa* (Linne, 1758). Emig (2002) cites the following synonyms:

Anomia caput-serpentis Linné, *1767*
Anomia pubescens Linné, *1767*
Terebratula retusa Retzius, *1788*
Criptoderma caputserpentis Poli *1795*
Terebratula aurita Fleming, *1822*
Terebratula costata Lowe, *1825*
Terebratula emarginata Risso, *1826*
Terebratula quadrata Risso, *1826*
Delthyris spatula Menke, *1830*
Terebratula caput-serpentis Sowerby, *1847*
Terebratulina caputserpentis d'Orbigny, *1847*
Terebratula striata Leach, *1852*
Terebratulina retusa Dall, *1920*

Nowadays, it often lives in vertical walls and hard substrates, mainly shells of bivalves (mainly *Modiolus modiolus* Linnaeus, 1758) and sponges on a very wide range of depths, from shallow water (3 m) to about 1500 m (Bitner & Doan, 2004).

Order *Spirifera* Waagen, 1883.
Suborder *Thecideidina* Elliot, 1958
Superfamily *Thecideacea* Gray, 1840
Family *Thecideidae* Gray, 1840
Subfamily *Lacazellinae* Backhaus, 1959
Genus *Lacazella* Munier-Chalmas 1881

Lacazella mediterranea (Risso, 1826)

Plate I, Fig. 3a, 3b.

1988 *Lacazella mediterranea* Logan, p. 550, fig. 2,4.

2005 *Lacazella mediterranea* Logan, p. 103, fig. 4.1.

2012 *Lacazella mediterranea* Betancort, Plate V, fig. 6-12

Material: Numerous ventral and dorsal valvas in poor condition.

Canary locations: Gran Canaria: Ciudad Jardín. Fuerteventura: Coast of Barlovento (between Ajuí Ravine and Los Molinos Ravine).

Original diagnosis: **"***Testa subrotundata, inaequali, lutescente pustulata interne candidísima".*

Stratigraphic and geographic distribution: Oligocene-Present stratigraphic distribution according Logan (2004b). It is present in the Miocene and Pliocene deposits of the Mediterranean. Almera (1907) cite it in the synonymy of Thecidea Mediterranean, Risso mentions it for the Pliocene deposits of Llano de Llobregat and Barcelona. Currently located on the Mediterranean Coast.

Description: Adult shell rarely exceeds 5 mm long, convex shell, dorsal valva usually flat, semicircular-shaped rather than round. Pale brown shell with irregular concentric lamellae that sometimes shown growth. Cardinal flat, triangular, with triangular flat belly deltidium area.

Subphylum *Rhynchonelliformea* Williams, Carlson y Bruton, 1996

Class *Rhynchonellata* Williams, Carlson y Bruton, 1996

Order *Thecideida* Elliot, 1958

Superfamily *Thecideoidea* Gray, 1840

Family *Thecideidae* Gray, 1840

Subfamily *Thecideinae* Gray, 1840

Genus *Thecidium* G.B. Sowerby, 1823

Thecidium cf. digitatum (Sowerby, 1823)

Plate I, Fig. 4a, 4b.

1823 *Thecidium digitatum* (Sowerby 1823, The Genera of Recent and Fossil Shells, for the use of students). PL. XXVI, fig. 16.

1867 *Thecidium digitatum* Urban Schloenbach, Tab. XXIII, Fig 14

2012 *Thecidium digitatum* Emig, C.C., Fig 3 y 5.

Material: one specimen, dorsal valva

Canary locations: west coast of Fuerteventura, Barlovento

Stratigraphic and geographic distribution: unknown

Description: This is a fossil specimen found to the Pliocene and which references are very scarce. Described in a catalog by Sowerby 1823, the specimen he describe has up to 6 lobes, whereas our sample represents only 4 although they are virtually identical in appearance. It is not known whether because our sample was in an immature stage or was perhaps either sex who present these features.

3.2. Actual brachiopods

Station (Sample)	Coordinates	Depth	Brachiopods	Observations
E4	27º46.98’ N 15º22.05’ O	80 m	*Megerlia truncata*	Specimens highly fragmented
E5	27º47.02’ N 15º21.06’ O	84 m	*Megerlia truncata, Argyrotheca barrettiana*	Good condition of conservation
N23	28º09.857’ N 15º31.961’ O	93 m	*Megerlia truncata*	Good condition of conservation
El Hierro		21 m	*Pajaudina atlántica*	Numerous specimens, agglomerated together

Table 2. Actual brachiopods identified in this work in Canary waters.

Subphylum *Rhynchonelliformea* Williams, Carlson, Brunton, Holmer y Popov, 1996

Class *Rhynchonellata* Williams, Carlson, Brunton, Holmer y Popov, 1996

Order *Terebratulida* Waagen, 1883

Suborder *Terebratellidina* Muir-Wood, 1955

Superfamily *Kraussinoidea* Dall, 1870

Family *Kraussinidae* Dall, 1870

Genus *Megerlia* King, 1850

Megerlia truncata (Linaeus, 1767)

Plate II, Fig. C, D.

1886 *Megerlia truncata* Granger, A., Pl. I, 3

1887 *Megerlia truncata* Fischer, P., Pl. XV, 9

1968 *Mühlfeldtia truncata* Luther & Fiedler Pl. XV, fig. 9

2004b *Megerlia truncata*. Logan, p. 165

Material: three whole specimens and one totally fragmented.

Canary Locations: Gran Canaria, North Coast (Station N23), East Coast (Station E4 and E5).

Stratigraphic and geographic distribution: currently found in the Mediterranean Sea, further to the west than the east (Spain, France, Italy), northwest Africa and Macaronesia fairly widespread in the region.

Description: ventral valve strongly arched, the dorsal with flat and presenting a slight longitudinal fold centrally located. Characterized by a biconvex shell ornamented with radiating ribs which are sometimes slightly nodular with irregular concentric lamellae, dotted growth.

Class *Articulata* Huxley, 1869

Order *Spiriferida* Waagen, 1883

Suborder *Thecideidina* Elliot, 1958

Superfamily *Thecideacea* Gray, 1840

Family *Thecideidae* Gray, 1840

Subfamily *Lacazellinae* Backhaus, 1959

Genus *Pajaudina* Logan, 1988

Pajaudina atlantica (Logan 1988)

Plate II, Fig. A, B.

1988 *Pajaudina atlantica* Logan, p. 549, fig. 4.

2004a *Pajaudina atlantica* Logan, pp. 210, 212. fig. 1,3.

2005 *Pajaudina atlantica* Logan, p. 103, fig. 4.2.

Material: many specimens, most of them agglomerated together, upper and lower valvas.

Canary localities: El Hierro, approximately 20 m depth

Stratigraphic and geographic distribution: Currently found only in the Canary Islands and the Holocene, without the presence of fossils anywhere in the world.

Diagnosis: "*Relatively large, elongate lacazellinin with prominet upraised and lobed median ramus complexy interdigitated with branches of minor interbrachial lobes*" by Logan (1988).

Description: Shell relatively large, elongated profile, longer than wide, biconvex. Long pedicle Valva. Interarea ventral valve flat, triangular and high pseudodeltidium. Small brachial valve.

Order Theceida Elliot, 1958

Suborder Terebratellidina Muir-Wood, 1955

Superfamily Megathyridoidea Dall, 1870

Family Megathyrididae Dall, 1870

Genero Argyrotheca Dall, 1900

Argyrotheca barrettiania (Davidson, 1866)

Plate II, Fig. E, F.

1866 *Argyrotheca barrettiana* Davidson, Pl. XII, fig. 3a, 3b, 3c.

2007 *Argyrotheca barrettiana* Harper & Donovan, Pl. 3, fig. 1a-1b.

Material: A single specimen, found in perfect condition.

Canary locations: East coast of Gran Canaria (Station E5).

Stratigraphic and geographic distribution: Currently described fossil for the West Indies, Jamaica, by Harper & Donovan (2007) for the Pleistocene and present, Holocene, to the Canary Islands.

Description: white color (calcareous) with medium sized with valvas ventribiconvexas with semicircular transverse profile. Rounded, sharpened or perpendicular cardinal extremities. Evenly convex lateral profile. Ventral interarea flat to slightly curved. Deltidium long and open. Quite marked, thick and pronounced radial grooves.

4. Discussion

In this study, 4 fossil species belonging for two different ages in the Canary Islands are distinguished. First, for the Pliocene deposits have been identified *Terebratula sinuosa Lacazella mediterranean*, *Terebratulina caputserpenteis* and *Thecidium cf. digitatum* species (Fig. 11 and Plate I). *Terebratula sinuousa* found in deposits of Gran Canaria (Barranco Seco and Ciudad Jardín) as well as *Terebratulina caputserpentis* (La Minilla) while *Lacazella mediterranea*, is well found in Gran Canaria (Ciudad Jardín) and in Fuerteventura (Barlovento Coast, between the Los Molinos ravine and Santa Inés) (Tab. 3).

While are appointments of fossils of *T. Sinuosa* and *L. Mediterranean* (Betancort, 2012), in this work are found in the deposits and identify *T. caputserpentis* and *Thecidium cf. digitatum* being, both first record for the Neogene of the Atlantic islands. While *T. caputserpentis* is current and fairly common in the Atlantic and the

Mediterranean, citing it in the Canary Islands, this fossil appointment is a contribution that extends its presence in the Atlantic and Canary Islands until at least the Pliocene.

Moreover *L. mediterranea* is present in the Mediterranean existing a big controversy with one of her closest relatives, *Pajaudina atlantica* (Logan, 1988). This paper adopts the criterion that *L. mediterranea* and *P. atlantica* are two different species. For this, the criterion was followed by the morphological examination of the inside of the valvas in both species (Fig. 11). These differ mainly in *L. mediterranea* presents a wider brachial valva while *P. atlantica* is longer reaching also in *L. mediterranea* larger sizes. Inside the valva, *L. mediterranea* lacks median ramus in the center, even though the specimen shown is pretty washed and eroded, as shown in Figure 11. *P. atlantica* not only presents this type of denticulated ramus, also has a well-defined ramulus of *L. mediterranea* lacks. Apparently the structure showing higher similarities are the major interbraquiales lobes, located at both ends of each valva.

Other fossils of L. mediterranea, appear in Piedra Alta, Lanzarote, dating from the Middle Pleistocene (Muhs et al., in press) during MIS 11 interglacial. Currently L. mediterranea is not cited in the Canary Islands but is restricted to the Mediterranean region. However, it is cited for the Canary Islands P. atlantica, found in surface samples of El Hierro, at an aproximatly depth of 20 meters. It therefore considers that L. mediterranea is more related to ecosystems of high temperature or tropical-subtropical environments, being these the prevailing conditions in the Pliocene and the MIS 11 interglacial. Ecological conditions were significantly different from today. This is denoted by the accompanying fauna (Tab. 1) typically from warm character.

There is no fossil records of brachiopods for the upper Pleistocene in the Canary Islands in the differents MIS 5.5 outcrops present in the islands: Fuerteventura, Lanzarote, Gran Canaria and Tenerife, have not been identified fossil brachiopods. It is accepted that the conditions of the Holocene (last 11.7 kyr) are sufficiently constant, so the current brachiopod fauna exists along the entire Holocene.

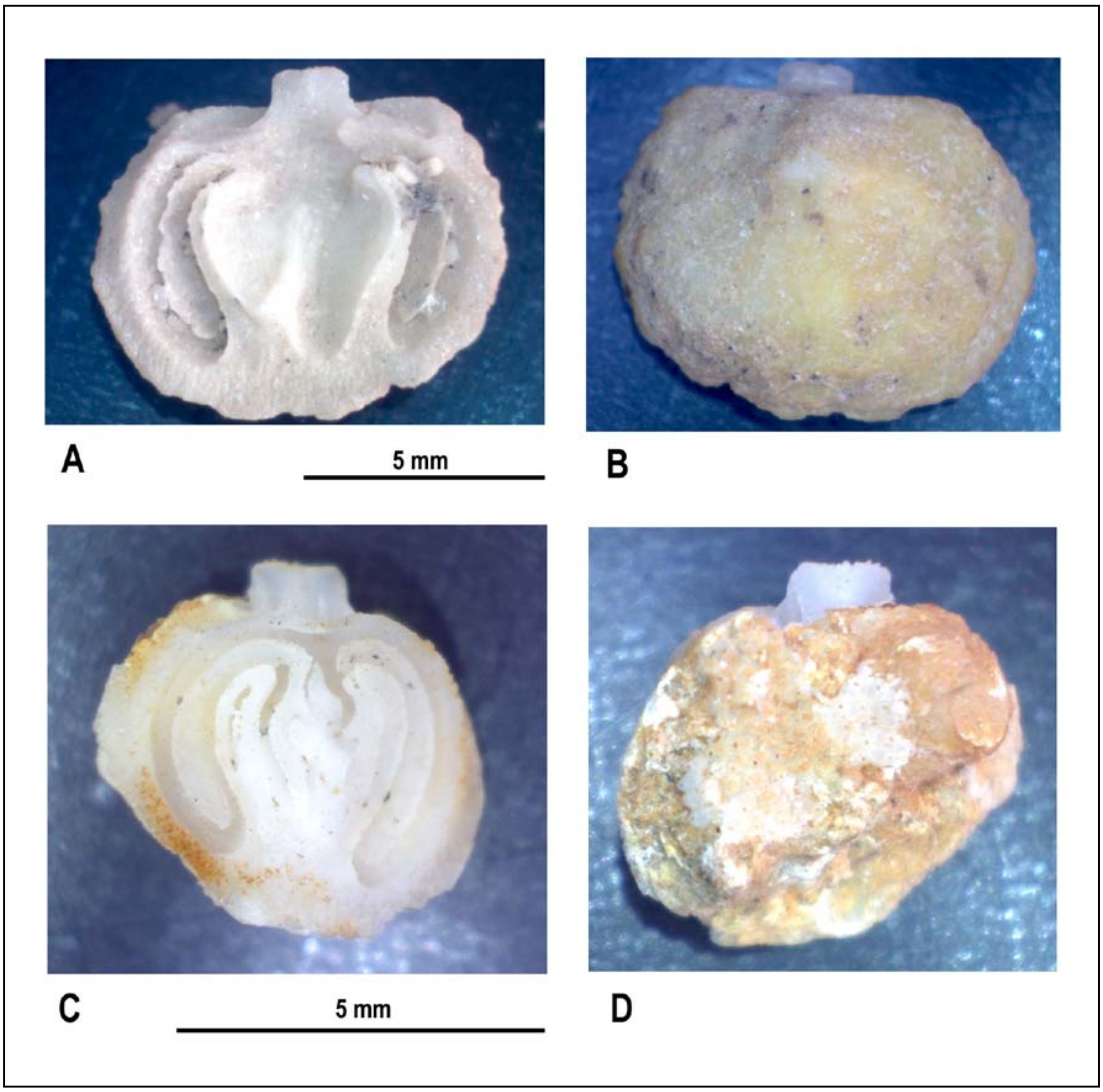

Figure 11. A-B *Lacazella mediterránea*; C-D *Pajaudina atlántica*; Specimen *L. mediterranean* belongs to deposits of Piedra Alta, Lanzarote (MIS 11). It Can be perfectly differentiated the morphology of both species in the ramus and ramulus, which *L. Mediterranea* lacked it.

The study of materials from surface samples collected in Marine Sedimentary Environments practices, Faculty of Marine Science, by Professor Ignacio Alonso Bilbao in 2002 in the east and north of Gran Canaria (Tab. 2), allowed us to cite other actual species of brachiopods for the Canary Islands accompanying *P. atlantica*. These present species of brachiopods are *Argyrotheca barrettiana* and *Megerlia truncata*. *A. barrettiana* have been found fossil in the Pleistocene of the West Indies, Jamaica (Harper & Donovan, 2007), so in the Pleistocene may have a climate in Jamaica like we have today in the Canary Islands. Therefore oceanographic implications exist between the Atlantic and the Mediterranean region, remaining reaffirmed that the North Atlantic Subtropical Gyre is able to function as a migration route for certain species.

5. Conclusions

1. Two new records of fossil brachiopods are contributing to the Pliocene from the Canary Islands that are also new records for the macaronesic region: *Terebratulina caputserpentis* (Zbyszewski, 1957) and *Thecidium cf. digitatum* (Sowerby 1823).

2. Furthermore of these species, two species mentioned above are confirmed, so there are now four known species for the Pliocene from the Canary Islands:

   Terebratula sinuosa (Brocchi, 1814)
   Lacazella mediterranea (Risso, 1826)
   Terebratulina caputserpentis (Zbyszewski, 1957)
   Thecidium cf. digitatum (Sowerby, 1823)

3. It contributes three actual citations for Canary brachiopods: *Argyrotheca barrettiana* (Davidson, 1866), *Megerlia truncata* (Linaeus 1767) and *Pajaudina atlantica* (Logan 1988). Also, the first two are first records for the archipelago.

4. This study use a criteria to resolve the controversy between the species *P. atlantica* and *L. mediterranean*. The morphological differences between them show that both species are not only different, but also belong to different genus.

5. The last fossil record in the Canary Islands of *L. mediterranea* is MIS 11 deposits from Piedra Alta, Lanzarote. Thereafter nothing is known about its presence in the archipielago. The present presence of *P. atlantica* suggests an affinity for ecological-climatic conditions different from today by *L. mediterranea*, which appear related to a warmer climate than the present judging by its accompanying fauna (Fig. 3; Tab. 1).

6. The Canary Islands because their situation on the southwest door of the Mediterranean Sea and because they are in the route of the North Atlantic Subtropical Gyre, is a strategic crossing point from different species throughout its geological history, as described brachiopods.

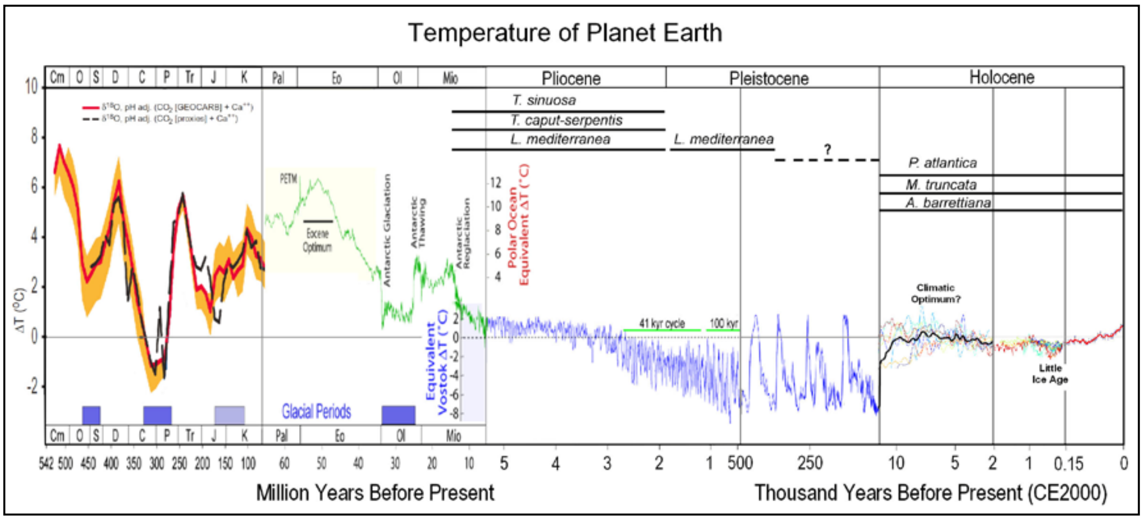

Figure 12. Fossil and present species of Canary brachiopods and duration. The dashed line with question symbol indicates the time when *L. mediterranea* desappears and its descendant *P. atlantic* appears as a result of severe climatic oscillations. Modified from several authors: EPICA Community (2004), Hearty & Kauffman (2000), Moberg et al. (2005), Lisiecki & Raymo (2005). Petit et al. (1999), Zachos et al. (2001).

Fossil and actual Canary brachipods				
Species	**Pliocene**		**Mid-Pleistocene**	**Actual (Holocene)**
	GC	**FV**	**LZ Piedra Alta**	
Terebratula sinuosa	**Barranco Seco, Ciudad Jardín**			
Terebratulina caputserpentis	**La Minilla**			
Lacazella mediterranea	**Ciudad Jardín**	**Coast of Barlovento (between Ajuí Ravine and Los Molinos Ravine)**	**Tsunami Deposits Piedra Alta MIS 11**	
Pajaudina atlantica				**North of Hierro.**

Table 3. Summary table of the fossil deposits and their ages.

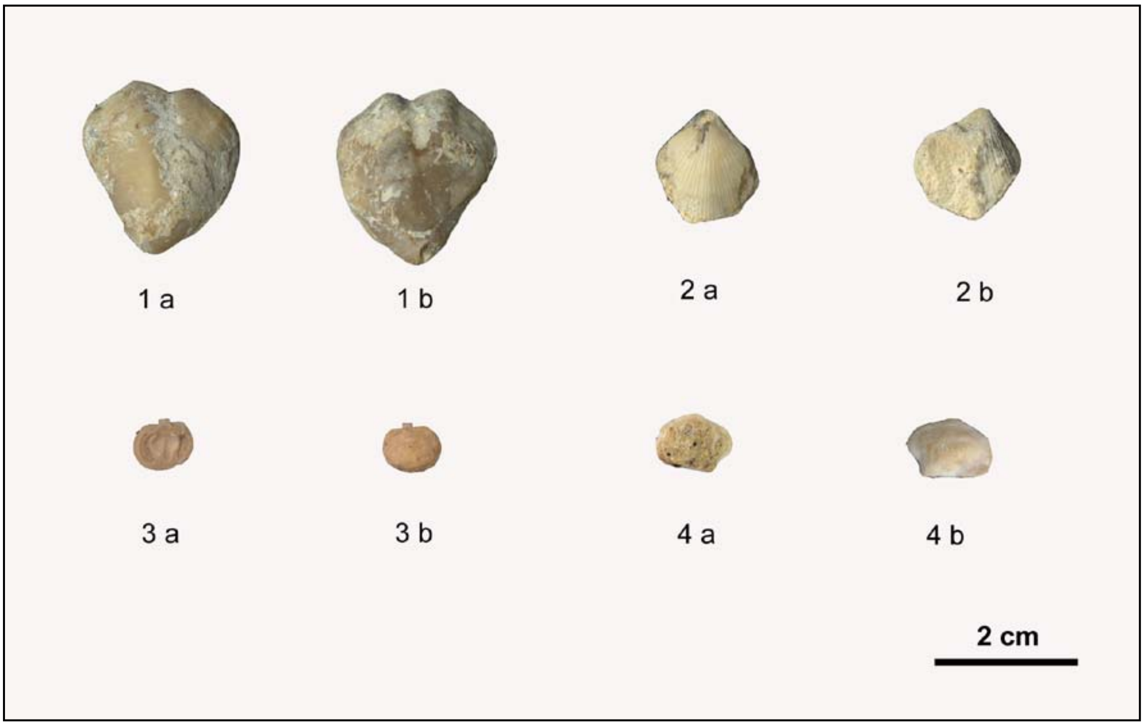

Plate I. Fossil brachiopods: 1a dorsal valva of *Terebratula sinuosa*; 1b ventral valva of *T. Sinuosa*; 2a dorsal valva exterior of *Terebratulina caputserpentis*; 2b dorsal valve interior of *T. caputserpentis*; 3a dorsal valva interior of *Lacazella mediterranea*; 3b dorsal valva exterior of *L. mediterranea*; 4a dorsal valva interior of *Thecidium cf. digitatum*; 4b dorsal valva exterior *Th. cf. digitatum*.

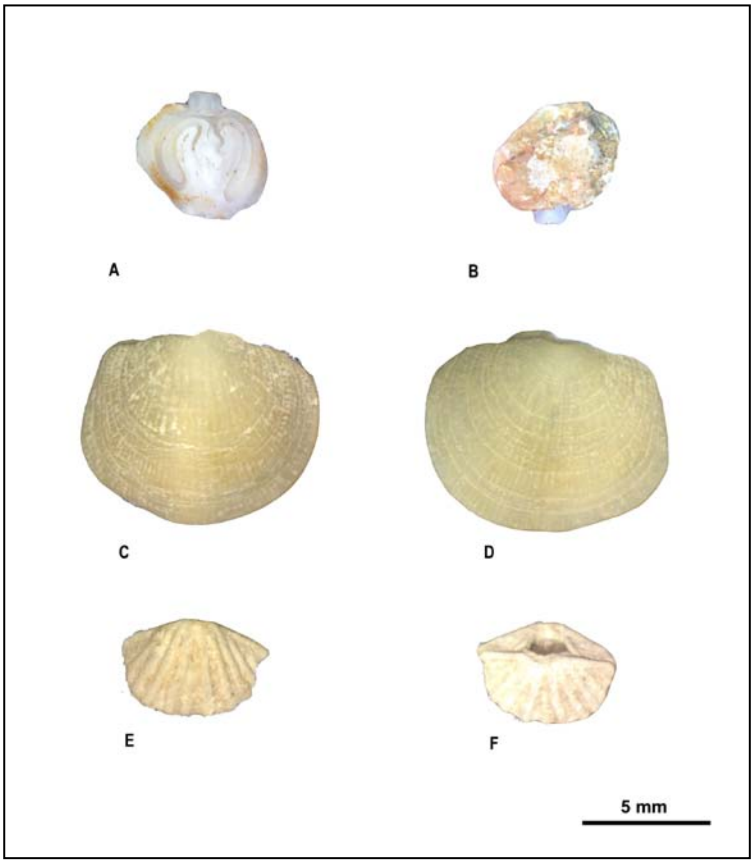

Plate II. Actual brachiopods: A-B *Pajaudina atlantica*, interior and exterior of dorsal valva respectively; C ventral valva of *Megerlia truncata*; D dorsal valva *Megerlia truncata*; E ventral valva of *Argyrotheca barrettiana*; F dorsal valva *Argyrotheca barrettiana*.

Acknowledgments

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D. Eduardo González Álvarez , con DNI 45330221G, y direcciona efectos de notificación: Paseo de las Canteras, nº70 1er piso, autor del TFT denominado “Braquiópodos pliocenos pleistocenos y de las Canarias orientales con mención de los actuales” para obtener el título de máster dentro del programa de Oceanografía, hace constar:

1-.Para la elaboración de este trabajo se han realizado las sientes actividades:

a) Estudios taxonómicos y sistemáticos sobre ejemplares fósiles y actuales.
b) Estudios geológicos sobre los diferentes afloramientos fosilíferos dentro del marco geológico de los edificios insulares.
c) Trabajo de campo, recolección de especímenes, catalogado y deposito en la colección de fósiles de la ULPGC.
d) Fotografiado de especímenes fósiles.
e) Estudios bibliográficos

Estas actividades se han desarrollado a lo largo de los últimos 15 meses dentro el laboratorio de Paleontología, Paleoclimatología y Paleoceanografía del Departamento de Biología de la Facultad de Ciencias del Mar (ULPGC)

2-. Formación recibida.

A lo largo de este periodo de trabajo, desde el Laboratorio de Paleontología de la ULPGC se ha pretendido dotar D. Eduardo González Álvarez de los conocimientos, aptitudes y recursos básicos para afrontar un estudio de tipo paleoclimático, paleoceanográfico y paleontológico. Estos recursos abarcan desde capacidades relacionadas con la taxonomía y la sistemática hasta tratamiento de la información y soportes y herramientas informáticas.

3-. La perspectiva de este trabajo es sentar las bases de colaboraciones futuras. Una primera derivada de este trabajo es la publicación y difusión de sus resultados dentro del marco de las revistas paleontológicas. Esto supone una serie de trabajos futuros que recalcan la integración dentro de este grupo de investigación. Durante este periodo la relación ha sido fluida, considerándose desde este grupo D. Eduardo González Álvarez como un activo más del mismo y que puede aportar conocimientos y trabajos en un campo de gran interés. Es necesario destacar que el grupo de paleontología presenta un tamaño muy reducido, estando actualmente integrado por el profesor emérito Dr. Joaquín Meco Cabrera y el Dr. Juan Francisco Betancort Lozano como colaborador externo. La integración de un nuevo colaborador supone un refuerzo para las estructuras y proyectos de este grupo.

4-. Algunos aspectos positivos de la realización de un TFT de este tipo, supone la ampliación de conocimiento de aquel campo que a uno le inquiete y en el que se quiera profundizar. Algún aspecto negativo podría llegar a ser el hecho de rebuscar o indagar en algún tema o 'subtema' del que existe poca información. Gracias a la ayuda de internet, de numerosos trabajos publicados y de la formación recibida, hace posible que lleve a cabo el objetivo.

5-. La paleontología, así como sus campos más próximos como la paleoceanografía y la paleoclimatología, son ciencias que actualmente en las islas son de poca divulgación y conocimiento. Realizar este trabajo supone, no sólo un nivel formativo de un grado elevado, sino que también inicia a la persona a involucrarse con el medio ambiente, interpretar las formaciones geológicas que lo rodean, pensando y sobretodo captando la curiosidad de todo aquel que presta un mínimo de atención de esta extraordinaria ciencia.

Para que conste afectos oportunos.

En Las Palmas de Gran canaria, a 3 de diciembre de 2013

Eduardo González Álvarez