THE DEPARTMENT OF NATURAL RESOURCES

mississippi geology

Bureau of Geology
2525 North West Street
Jackson, Mississippi 39216

Volume 3, Number 1
September 1982

NOTES ON MIDDLE ORDOVICIAN, MISSISSIPPI AND ALABAMA

Frederic F. Mellen
Jackson, Mississippi

ABSTRACT

Dark pyritiferous shales of Middle Ordovician age, rich in graptolites and conodonts, and giving high gamma radiation, are interbedded with argillaceous crinoidal limestone in Pontotoc County, Mississippi, and adjoining areas. The Middle Ordovician "Ottawa" is 300 to 400 feet thick, is petroliferous, contains local reservoir-quality rock, and is regarded as a locally favorable oil objective. Cobbles of volcanic rock have been cored, and other evidence of volcanism in the Middle Ordovician of this area is given. The shales are regarded as "Athens" Shale in type and approximate stratigraphic position. An analysis of a cored section of the shale is given. The regional geologic setting is reviewed and a short list of selected references is given.

DISCUSSION

In January, 1981, Florida Exploration Company cored the Silurian-Ordovician contact in its No. 1 Morrison, Sec. 20, T.11 S., R.1 E., Pontotoc County, Mississippi. The gritty Patterson Sandstone (Silurian) rests on eroded Middle Ordovician argillaceous crinoidal limestone (Fig. 1) lying above very dark-gray graptolitic shale which gave high gamma radiation. Partial composition of this shale is given as follows:

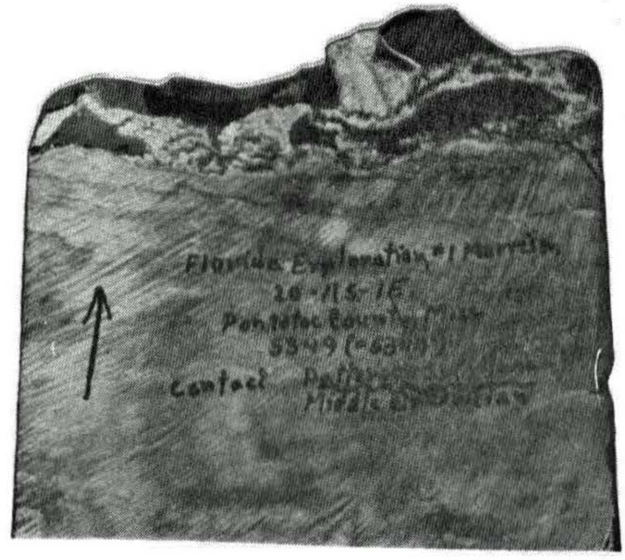


Figure 1. Dark-gray shaly slightly fossiliferous limestone (Middle Ordovician) overlain by lighter-gray gritty sandstone (Silurian) containing reworked Ordovician shale. This unconformity in the Florida Exploration No. 1 Morrison is at a corrected depth of 5344'.

Weighted average composition of
19' Middle Ordovician black graptolitic shale
core intervals: 5352-56, 5356-60,
5360-64, 5364-68 & 5368-71
Florida Exploration No. 1 Morrison
Sec. 20, T.11 S., R.1 E., Pontotoc County, Mississippi
Courtesy of Phillips Petroleum Company

Percent	
shale residue	98.28
gas + loss	.60
oil	.26
total organic carbon	2.02
H_2O (8 gpt)	2.06

parts per million					
U_3O_8	12.94	Mn	31.52	Zn	119.67
Ba	513.68	Ni	79.72	Cd	6.99
Ca	9,148.94	K	45,631.57	Co	12.65
Cr	237.10	Na	6,327.89	Ag	18.80
Cu	61.67	Sr	88.10	Mo	7.51
Fe	53,131.57	V	179.00	P	219.41
Pb	30.30	Li	49.40	Ti	4,918.42
Mg	16,100.00	TOTAL			136,986.15

Other wells in Pontotoc and in contiguous counties show on geophysical and sample logs similar shale bodies 5 to 20 feet in thickness. Where gamma ray logs are available, high radiation is recorded. The analysis above suggests the radiation is from potassium, whereas the radiation recorded from the Devonian Chattanooga Shale is generally believed to be from uranium.

In the Florida-Morrison core, many species of graptolites are abundantly represented. Conodonts are common. Among the taxa, the writer has identified the conodont genus *Bryantodina* and the graptolite genus ***Dicranograptus***, both diagnostic of Middle Ordovician. The full collection is reposited in the Dunn-Seiler Museum, Department of Geology and Geography, Mississippi State University.

In the British Isles, where thick sequences of Ordovician fossiliferous sediments are associated with thick deposits of volcanic rocks, numerous geologists have found graptolite biostratigraphy extremely useful. These studies have applications world-wide. Among her many publications, Gertrude L. Elles (1940) sketched her concept of paleo-ecology of the Ordovician, as shown in Fig. 2.

Charles E. Decker (1952) figured and discussed the stateside and worldwide distribution and stratigraphic significance of "Athens" type graptolites. The subsurface Mississippi locality, and a locality in Houston County, southeast Alabama, where "Athens" type graptolites were recovered in 1949 from cores in Union Producing Company's No. 1 Kirkland at depths of 7800-8100 feet (Bridge, 1949, 1950), supplement the graptolite distribution shown by Decker.

In the Kirkland well the lithology is shale-sandstone, rather than shale-limestone, as in north-central Mississippi. This locality may be on the southeast side of the Appalachian orogene. Josiah Bridge, of the USGS, wrote: ". . . . the section is of Middle Ordovician age - Black River to Trenton, possibly, but in all probability no higher. The graptolites are typical Normanskill forms, and represent a horizon equivalent to a portion of the Athens Shale of the Appalachian region, and the Womble . . . . of the Ouachita region in Arkansas and Oklahoma" (1949). Later Bridge wrote: "I have done considerable work on the graptolites and have exchanged several letters about them with Professor Decker. As a result, we have both

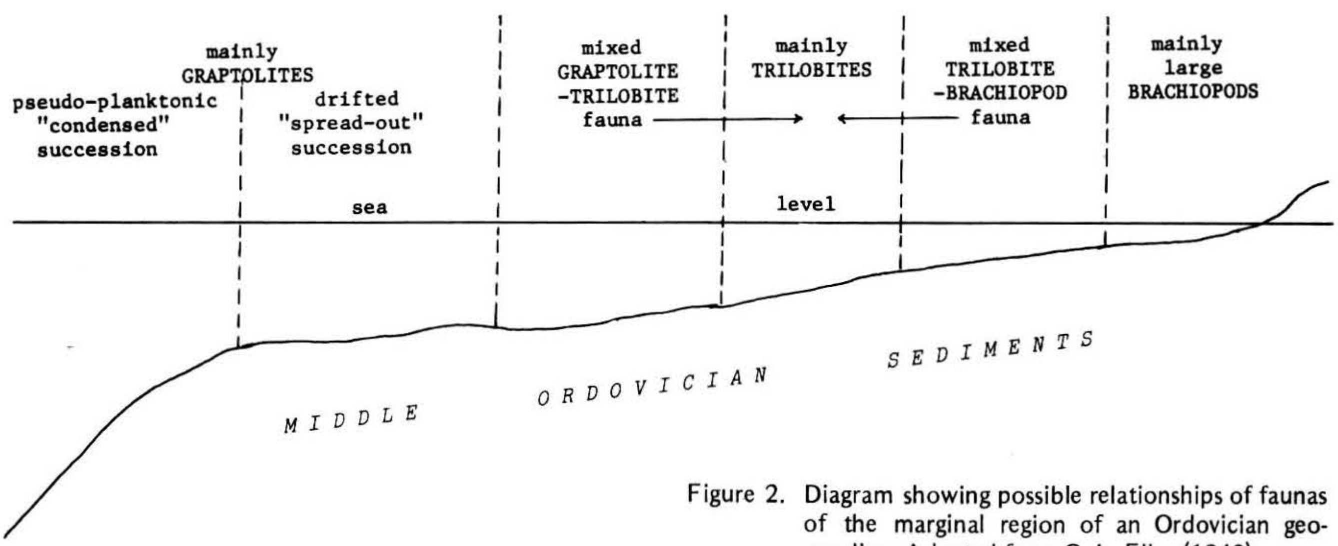


Figure 2. Diagram showing possible relationships of faunas of the marginal region of an Ordovician geosyncline. Adapted from G. L. Elles (1940).

modified our earlier ideas and now regard them as of late Beekmantown (Deepkill) age . . . . the fauna in this well is definitely of Lower Ordovician age" (1950). Thus it appears that the graptolite sequence in Houston County, Alabama, could be older than the graptolitic "Athens" Shale on the outcrop in northern Alabama and Tennessee and in the subsurface of north-central Mississippi.

Stanley C. Finney (1980) published a paper on the Middle Ordovician "Athens" Shale and its graptolites from the well-known outcrops of the thrust belt areas of northern Alabama. The report is up-to-date and is rendered more useful by a well-selected list of 39 references.

Regional stratigraphic studies of samples and geophysical logs and surface mapping in Tennessee and Alabama show clearly that the Nashville Dome was repeatedly an area of emergence or near emergence during Middle and Upper Ordovician times. For details of stream channel deposits, reefs and other shallow marine features, see Wilson (1949) and Alberstadt et al. (1974), etc. Southwesterly, the Ordovician is progressively thinner due to truncation at the top, and possibly to retarded deposition at the tops of the Lower and Middle Ordovician. Mellen (1974a, Fig. 2) diagrammed the truncation and relationship of the three major Ordovician subdivisions to the overlying Silurian and Devonian sediments. The implication is that there developed a land-mass in west-central Mississippi during the Taconic orogeny, a source of the gritty Patterson Sandstone.

In the type area of Wales and elsewhere in the British Isles the abundant volcanic rock has led to the Ordovician being called "the age of fire." The extensive areas of Ordovician sediments, mostly marine, in North America were long regarded by some as being free of volcanic materials. The "Pencil Cave" bentonites of the Middle Ordovician in Alabama, Tennessee and Kentucky suggest ash falls from distant source(s). In 1955, L. E. Salmon's No. 1 Andrews, Sec. 3, T.9 S., R.2 E., Pontotoc County, Mississippi, cored igneous cobbles (Figs. 3, 4) at 2637 1/2, 2652 1/2 and 2654 1/2 feet. A possible nearby source of these *ejectamenta* might be discovered by geophysical studies and drilling.

Middle Ordovician volcanism in the Pontotoc County area is clearly unrelated to the Precambrian granite emplacement in contiguous Lafayette County, described by Riggs (1976), or to the Triassic-Jurassic intrusions along the Paleozoic structural hingeline a few miles southwest of Pontotoc County, described by Mellen (1979). Future studies of samples, cores and logs will define more clearly the paleogeography and extent of that activity.

Well cuttings, cores and mud-logs reveal oil and gas throughout much of the 300-400-foot thick Middle Ordovician in the Pontotoc County, Mississippi, area. Mellen discussed the possibilities for oil and gas production in Ordovician carbonate reservoirs (1974b). Subsequently, a few additional wells have drilled and tested these rocks, but the Middle Ordovician is not yet productive commercially in Mississippi or Alabama.

A splendid review of Middle Ordovician (Ottawa Megagroup - Champlainian) oil and gas potential of Region 9 (part of Arkansas, Kentucky, Illinois, Indiana, Ohio and Tennessee) by Bond et al. (1971) summarizes the stratigraphy, lithology, structure and production. The productive formations are called Trenton or Galena. "The Ottawa is a very petroliferous unit. Most of the gas produced in the province has come from it, and 489.4 million barrels of recoverable oil - 87.7 per cent of all recoverable oil credited to the province - has been found in it. It lies at shallow depths throughout the province; only in limited areas is it more than 1,500 feet deep. . . . . A small amount of Ottawa oil, 6.3 million barrels, is credited to small fields in the Cumberland saddle of Kentucky and Tennessee. Entrapment in these fields is stratigraphic and the reservoirs consist of bioclastic lenses.

"The Trenton Field of Ohio and Indiana accounts for most of the Ottawa oil and gas on the Cincinnati Arch. Entrapment in the Trenton Field is stratigraphic and results from a regional facies change in the Trenton Limestone from porous, and in some places, vuggy dolomite, to impermeable limestones, with very low porosity . . . . . The major Albion-Scipio Oil & Gas Field on the south side of the Michigan Basin, not far north of Cincinnati Arch province, is such an accumulation; in it, the porous dolomite reservoir averages about half a mile in width, is about 30 miles long and extends vertically through the entire Ottawa section. Linearly developed Ottawa carbonate reservoirs are considered good possibilities for significant future petroleum discoveries throughout the province."

In Pontotoc County, Mississippi, deeper marine shelf sediments of Middle Ordovician age are truncated by the Silurian unconformity. These sediments consist of dark, crinoidal, slightly brachiopodal (small), argillaceous

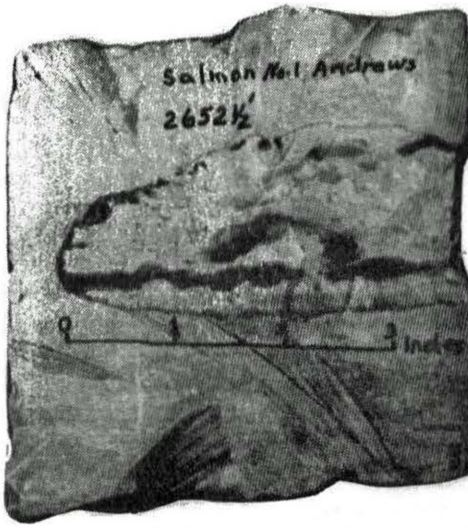


Figure 3. Core of Middle Ordovician limestone showing submarine volcanic clast, from the L. E. Salmon No. 1 Andrews at 2652 1/2'.

limestones, intercalated with 5-20-foot thick beds of graptolitic shales deposited under anoxic conditions. The 300-400-foot thickness of shale and limestone is petroliferous, especially throughout its upper part. Sample studies, core examinations and geophysical logs indicate that the shales are approximately equivalent to the "Athens" Shale of the Valley and Ridge thrust belt of southwestern Virginia, eastern Tennessee and northern Alabama. Within this sequence, the development of a dolomite reservoir has been found in L. E. Salmon's No. 1 Wilson, Sec. 29, T.9 S., R.3 E. It is possible the secondary dolomitization is related in some way to the igneous activity revealed in the L. E. Salmon No. 1 Andrews. The relationship between igneous activity and nearby secondary dolomitization in rocks precisely the same age merits further study.

Bioclastic reservoirs capable of producing small quantities of oil and gas are to be expected in extreme northeastern Mississippi and northwestern Alabama, at depths of 500-2500 feet.

Dolomite reservoirs capable of producing moderate volumes of oil and gas are to be expected in those parts of Mississippi and Alabama where the Middle Ordovician lies at depths greater than about 2500 feet.

Figure 4. Photomicrograph (X10) of the water-lain basalt at 2654 1/2' in the Salmon No. 1 Andrews well. Dark areas are glassy material around severely altered phenocrysts (feldspar?) and crinoidal fragment in bottom center of photograph. Photo by Harrelson.

Igneous reservoirs produced by Middle Ordovician or later volcanism are possible. Porosity might be due to serpentinization, subsequent selective leaching, or to primary development. Gravity and magnetic anomalies, probably associated with faulting, are numerous in the Pontotoc area. Such reservoirs have not yet been found in the eastern United States.

The graptolitic "Athens" Shale is an indicator of deeper water deposition and is useful in regional, stateside and worldwide correlation, as suggested by Decker. The chemical analysis of this shale suggests that its high gamma radiation is due to potassium, rather than uranium, the source of gamma radiation in the Chattanooga Shale. The exceptionally high potassium recorded in the shale in Florida-Morrison well could be derived from orthoclase feldspar though no granitic rocks of Middle Ordovician age are yet known in this region. The presence of this radioactive "Athens" Shale could cause, and probably has caused, miscorrelations in the deep subsurface of Mississippi. The structural complications attendant with exploration where thrust faults are being encountered (as recently in Noxubee and Lauderdale counties, Mississippi) necessitate prompt and accurate identification of all lithologic units.

All cores from the Middle Ordovician should be preserved as intact as practicable for study of fauna, lithology and composition. Cores discussed in these notes are represented in the collections of the Mississippi Geological Survey Sample Library.

Further studies of the Pontotoc County cores or others that may be available, will, or should, include petrographic thin section analysis, radioisotope age-dating, and micro- and macro-paleontological identifications. Free discussion and interchange of these data should be encouraged, and comments invited.

The writer appreciates the criticism of John Rodgers, Yale University, and the suggestions and cooperation of Alvin Bicker, Mike Bograd and Danny Harrelson of the Mississippi Bureau of Geology during the preparation of these notes. Emmett Adams kindly examined the cores with the writer and is in agreement with the interpretations. The cores were provided by L. E. Salmon and Florida Exploration Company and the analysis by Phillips Petroleum Company: all are essential parts of this study. Murphy F. Shelton, Jr., of Pennzoil Producing Company (Union Producing Company) supplied detailed information on the Kirkland well. For these and contributions by others the writer is also deeply grateful.

SELECTED REFERENCES

Alberstadt, L. P., et al., 1974, Patch reefs in the Carters Limestone (Middle Ordovician) in Tennessee, and vertical zonation in Ordovician reefs: Geological Society of America Bulletin, v. 85, p. 1171-1182.

Bond, D. C., et al., 1971, Possible future petroleum potential of region 9, *in* I. H. Cram, editor, Future petroleum provinces of the United States: American Association of Petroleum Geologists, Memoir 15, v. 2, p. 1165-1218.

Bridge, J., 1949, August 10, letter to Wilbur H. Knight, Union Producing Company.

Bridge, J., 1950, June 17, letter to Wilbur H. Knight, Union Producing Company.

Decker, C. E., 1952, Stratigraphic significance of graptolites of Athens Shale: American Association of Petroleum Geologists Bulletin, v. 36, no. 1, p. 1-145.

Denison, R. E., and W. R. Muehlberger, 1963, Buried granite in Mississippi: American Association of Petroleum Geologists Bulletin, v. 47, p. 865-867.

Drahovzal, J. A., and T. L. Neathery, eds., 1971, Middle and Upper Ordovician stratigraphy of the Alabama Appalachians: Guidebook Ninth Annual Field Trip, Alabama Geological Society, p. 1-62.

Elles, G. L., 1940, The stratigraphy and faunal succession in the Ordovician rocks of the Builth-Llandrindod inlier, Radnorshire: Quarterly Journal of the Geological Society, v. XCV, pt. 4, p. 383-445.

Finney, S. C., 1980, Thamnograptid, dichograptid and abrograptid graptolites from the Middle Ordovician Athens Shale in Alabama: Journal of Paleontology, v. 54, no. 6, p. 1184-1208.

Gilbert, O. E., Jr., 1971, The Taconic orogeny in Alabama: Guidebook Ninth Annual Field Trip, Alabama Geological Society, p. 152-171.

Harrelson, D. W., 1981, Petrography of a core at 2654.5 feet in Salmon No. 1 Andrews Well, Mississippi Bureau of Geology, Open File Report.

Kidd, J. T., 1975, Pre-Mississippian subsurface stratigraphy of the Warrior Basin in Alabama: Gulf Coast Association of Geological Societies Transactions, v. 25, p. 20-39.

Mellen, F. F., 1974a, Patterson Sandstone, Ordovician or Silurian?: American Association of Petroleum Geologists Bulletin, v. 58, no. 1, p. 143-148.

Mellen, F. F., 1974b, Possible Ordovician carbonate reservoirs in Mississippi: American Association of Petroleum Geologists Bulletin, v. 58, no. 4, p. 870-876.

Mellen, F. F., 1979, Vardaman Triassic-Jurassic sill, Calhoun County, Mississippi: American Association of Petroleum Geologists Bulletin, v. 63, no. 11, p. 2103-2104.

Read, J. F., 1982, Geometry, facies, and development of Middle Ordovician carbonate buildups, Virginia Appalachians: American Association of Petroleum Geologists Bulletin, v. 66, no. 2, p. 189-209.

Riggs, K. A., 1976, Subsurface Precambrian granite, Lafayette County, Mississippi: American Association of Petroleum Geologists Bulletin, v. 60, no. 3, p. 455-457.

Rodgers, J., 1971, The Taconic orogeny: Geological Society of America Bulletin, v. 82, no. 5, p. 1141-1178.

Twenhofel, W. H., chairman, J. Bridge, et al., 1954, Correlation of the Ordovician formations of North America: Geological Society of America Bulletin, v. 65, p. 247-298. (See also Figs. 1 and 2)

Wilson, C. W., Jr., 1949, Pre-Chattanooga stratigraphy in central Tennessee: Tennessee Division of Geology, Bulletin 56, 407 p., pls.

INFRARED SPECTROGRAPHIC AND PETROGRAPHIC ANALYSIS OF THE WILCOX LIGNITES IN MISSISSIPPI**

FROELICHER, Franz, and PESCATORE, Jr., Frank
Department of Geology
University of Southern Mississippi
Hattiesburg, Mississippi 39401

It has recently been estimated that nearly ten billion tons of lignite are within reach of conventional strip mining equipment in Mississippi. Irregular and discontinuous lignite seams can be traced along the outcrop patterns of the Claiborne and Wilcox Groups. As part of a Mississippi Mineral Resources Institute study of these lignites, surface samples were collected along the Wilcox outcrop belts in Mississippi. Samples were taken from 0.5 meters or deeper into the seams to ensure minimum oxidation and placed in labeled glass sidewall core jars. At several localities, a vertical color gradation from black to brown was noted and sampled at three intervals within the seam. Subsurface samples (1500-2000 meters) were donated by several independent oil companies in Natchez, Mississippi. All of these were in the form of sidewall-cores and were consistently black in color. All samples were air dried and weighed periodically to confirm consistent weight. The samples were then pulverized and passed through a 250 mesh sieve so functional groups would be exposed and readily subjected to a series of chemical extractions. All fractions were recorded as to weight and weight percent and then analyzed by infrared spectroscopy.

Infrared spectroscopy was used on the bitumen and kerogen fractions of individual lignite samples to investigate the different types of functional groups present. Important groups considered in this study were the following: C=O, C=C, O=H, $-CH_2-$, $-CH_3$ and C–O. In both subsurface and surface samples, the bitumen fraction displayed purely aliphatic IR signatures denoted by the strong bands of 2965–2850 cm^{-1} and 1450–1385 cm^{-1}. The relatively higher maturation of subsurface samples is confirmed by their higher bitumen content, nearly twice as much as surface samples.

Kerogen fractions of both surface and subsurface coals reflect moderate aromaticity as indicated by absorption bands at approximately 3000 cm^{-1}, approximately 1600 cm^{-1} and 775–650 cm^{-1} on individual IR spectra.

Chemical studies on lignite samples discovered two important characteristics. First, bitumen fractions were always higher in subsurface samples, and second, surface samples contained greater amounts of phenolic compounds related to lignin and cellulose (precursors of vitrinite). Subsurface samples were found to be enriched in waxes and tannins, especially in bitumen fractions.

Reflectance and fluorescence studies revealed a sharp contrast in maceral type and dominance. A higher exinite content was found in subsurface samples, whereas surface samples contained abundant fusinitic materials.
Subsurface samples averaged R_o .41, which indicates a subbituminous rank and were significantly higher than surface sample reflectivities which averaged approximately R_o .31. Fusinite and semifusinite were more abundant in surface samples than subsurface samples. A clay matrix was apparent in most surface samples and sometimes contributed as much as 50% to the total coal weight, whereas subsurface samples contained less than 20% clay by weight, averaging 15%. Exinite macerals for subsurface samples were represented by sporinite and exsudatinite (wax resinite). Surface samples contained sporinite, cutinite and localized resinite as representative exinites.

Petrographic composition of a given coal is dependent on the following: (1) Ecological conditions of the swamp in which the peat is deposited, primarily the level of groundwater, the oxygen supply, the acidity and any marine influence. (2) The climate at the time of peat deposition. (3) The peat-forming plant communities, which in turn depend upon ecology and climate. (4) The degree of coalification.

The peat of a given swamp leads to a specific coal facies, which can be identified from its maceral constitution, its mineral content, and texture.

Upland coals generally contain more fusinite than other coals. Preservation of cell walls by fusinization indicates early charring, caused by forest fires or mouldering.

Phenolic properties of kerogen extracts from Mississippi lignites indicated by IR spectra strongly suggest that tannins and lignins serve as primary contributors to the formation of vitrinite. Conifers are usually richer in lignin than deciduous trees and plants which have made a major contribution to Tertiary coals and had barks enriched in highly aromatic tannins.

Optical and chemical properties of identifiable resinites in subsurface lignites indicate that they are lipid resinites. The spectra of bitumins, presumed to be mostly derived from reactive resinites, show the presence of aliphatic esters, or waxes, which serve as the precursors for wax resinites. Typical Tertiary shore plants, e.g., *Phragmites, Typha, Scirpus,* and others contain relatively high wax con-

**Abstract in program for NORTH AMERICAN COAL PETROGRAPHERS Meeting, December, 1981.

tents and consequently subaquatically deposited Tertiary coals are particularly high in wax resinites.

In some subsurface samples bituminite "drenching" is particularly noticeable. This "bitumen resinite" first becomes apparent in coal at the subbituminous stage of coalification and its genesis is related to that of fluid petroleum. It can be demonstrated that petroleum-like products also originate in coals from lipid constituents at similar rock temperatures encountered in the formation of crude oil from kerogen of minerogenic sediment (65° - 100°C).

This phenomenon suggests that vast oil production from the southwestern portion of Mississippi from Wilcox strata may be related to interbedded lignites with reservoir sands. Further investigations into the chemical affinities between crude oils and bitumen from Wilcox sediments is indeed warranted. No one district or county or seam has yet been sampled to the extent necessary to draw conclusions regarding the feasibility of lignite utilization, such as gasification and liquification.

Further work should concentrate, in a step-like manner, on in-depth studies from locality to locality and from seam to seam.

PETROGRAPHIC AND FLUORESCENT ANALYSIS OF WILCOX LIGNITES IN LAUDERDALE COUNTY, MISSISSIPPI**

FROELICHER, Franz, and WRIGHT, Michael,
Department of Geology
University of Southern Mississippi
Hattiesburg, Mississippi 39401

The study of maceral content is important in the general prediction of coal properties. Specifically, future liquefaction conversion predictions for the extensive Mississippi lignite deposits will allow coals to be selected for their optimum utilization by, among others, the electrical power and petroleum industries. Work in coal laboratories here and abroad indicates that petrographic studies are valuable tools in the prospecting for oil and gas.

The most recent petrographic analysis of the lignites was conducted by Pescatore (1981). His work, which characterized the maceral contents of the lignites throughout the state, has lead to this indepth analysis of three lignite seams in Lauderdale County, Mississippi.

The three seams (A, B and C) were sampled extensively for petrographic studies (including vitrinite reflectance), for moisture, volatile matter, ash and fixed carbon content. The macroscopic lignite seams with the sediments were closely examined, revealing a mixed array of depositional histories.

Seam A is five feet thick in the center and thins to three feet on the edges (where it is no longer traceable). The bed of silt below seam A grades into a silty carbonaceous clay and then rapidly grades into a blocky, dark brown lignite. A two-inch thick silty carbonaceous clay separates the upper half of the seam from the lower half and then becomes increasingly darker and more fusinitic. The upper contact of the lignite with the silty sand is very abrupt and irregular.

The upper part of seam A has a very high vitrinite content with an average vitrinite reflectance of R_o 32.4%. Telinite and corpocollinite are the most abundant vitrinite macerals and are usually found in association with vitrodetrinite. Inertinite macerals are less abundant than the vitrinite macerals; however, inertinite macerals are most abundant in the upper half of the seam. Fusinite is the most abundant inertinite maceral and it usually exhibits unbroken cell structure. Semifusinite, micrinite and macrinite are rare, but do occur occasionally in the upper half of the seam.

In the lower half of the seam vitrodetrinite is the most abundant maceral. Telinite is randomly dispersed in the vitrodetrinite matrix, and it usually exhibits unbroken cell structure which is often filled with corpocollinite. Inertinites are uncommon in the lower half of the seam, but where found usually consist of fusinite with unbroken cell structure. Exinites such as spores are rare to common in the seam. Resinite often occurs as fillers in fusinite cell structures. Other exinites, such as cutinite and alginite, are virtually absent.

Seam B is three feet thick and is relatively flat lying. The silty clay, which underlies the seam, forms an abrupt contact with the brownish-black lignite. In some areas the contact dips as much as 70°. This could indicate that deposition occurred in an abandoned channel. The lignite becomes increasingly darker and more blocky and fusinitic. The upper contact of the lignite is similar to that of seam A. It is very abrupt and is overlain by a nodular silty clay at one end and by a fine grained sand at the other.

**Abstract in program for NORTH AMERICAN COAL PETROGRAPHERS Meeting, December, 1981.

Seam B has the same basic maceral structure as seam A. The upper 2/3 of the seam has a high vitrinite content with an average reflectance of R_o 31.5% for the seam. Telinite and corpocollinite are the most abundant of the vitrinite macerals. Telinite usually has a well preserved cell structure which is filled with resin. Inertinite content is extremely high in the upper 1/3 of the seam. Fusinite is the most abundant inertinite and it almost always exhibits unbroken cell structure. Macrinite, micrinite and sporinite are concentrated in parts of the seam but are generally absent from the lower 1/3. Sclerotinite is most abundant in the upper part of the seam and consists of the single and multicellular types. Mineral content increases near the lower contact. Pyrite is very abundant in the lower part of the seam.

The brownish-black lignite of seam C is twelve feet thick and is separated from the underlying carbonaceous clay by an abrupt contact. The lignite becomes blocky and black towards the middle of the seam. It contains a large amount of "charcoalized" tree remains - including a conifer branch with needles which was found near the center of the seam. Above this blocky lignite is a layer of finely disseminated organics which appear to be of allochthonous origin. Clay content steadily increases in the upper six feet of the seam forming a gradational contact with the overlying silty clay.

A petrographic analysis of seam C has not been conducted; however, seam C was analyzed for moisture, volatile, ash and fixed carbon content.

The lens shape of seam A and the dipping contacts of seam B could indicate a typical channel fill. The gradational bottom contacts of seam A could indicate that it was deposited in a stream channel in which the sediment source was slowly cut off while at the same time an increase of organic deposition took place. The abrupt bottom contacts of seam B seem to indicate that it was deposited in an abandoned stream channel, such as an oxbow. The unbroken cell structure of the fusinite and the high fusinite content in the upper parts of seams A and B could indicate that the seams were deposited in highland swamp channels which were influenced by proximital forest fires. Rapid erosion after the fires could have caused clastic deposition in the topographic lows of the highland swamp channels.

The lateral extent of seam C is not known; however, the macroscopic analysis revealed that the lignite formed in a wooded swamp environment which was slowly terminated by increased sediment influx and increased water agitation.

A NEW SPECIES OF *BALANUS* DA COSTA, 1778, (CIRRIPEDIA) FROM THE UPPER OLIGOCENE CHICKASAWHAY FORMATION OF MISSISSIPPI AND ALABAMA

by

Victor A. Zullo
Department of Earth Sciences
University of North Carolina at
Wilmington, North Carolina 28403

ABSTRACT

Balanus conopeoides new species, an abundant barnacle in the upper Oligocene Chickasawhay Formation in Washington County, Alabama, and also found in the same formation in Wayne County, Mississippi, is the oldest representative of the genus *Balanus* Da Costa, 1778, and the family Balanidae Leach, 1817, in the Gulf Coastal Plain. This new species is particularly interesting because it possesses features of the shell and opercular plates that are reminiscent of the gorgonian-inhabiting archaeobalanid genus *Conopea* Say, 1822. The porous, bilamellar shell wall, porous basis, a tendency to attach to cylindrical objects (echinoid spines?), the broad, septate radii, the absence of a scutal adductor ridge, and the broad, basally truncate tergal spur of *Balanus conopeoides* are features shared with extant *Conopea calceola* (Ellis, 1758). The new species differs from *C. calceola* in lacking a "boat-shaped" shell formed by the elongation of the rostrum or

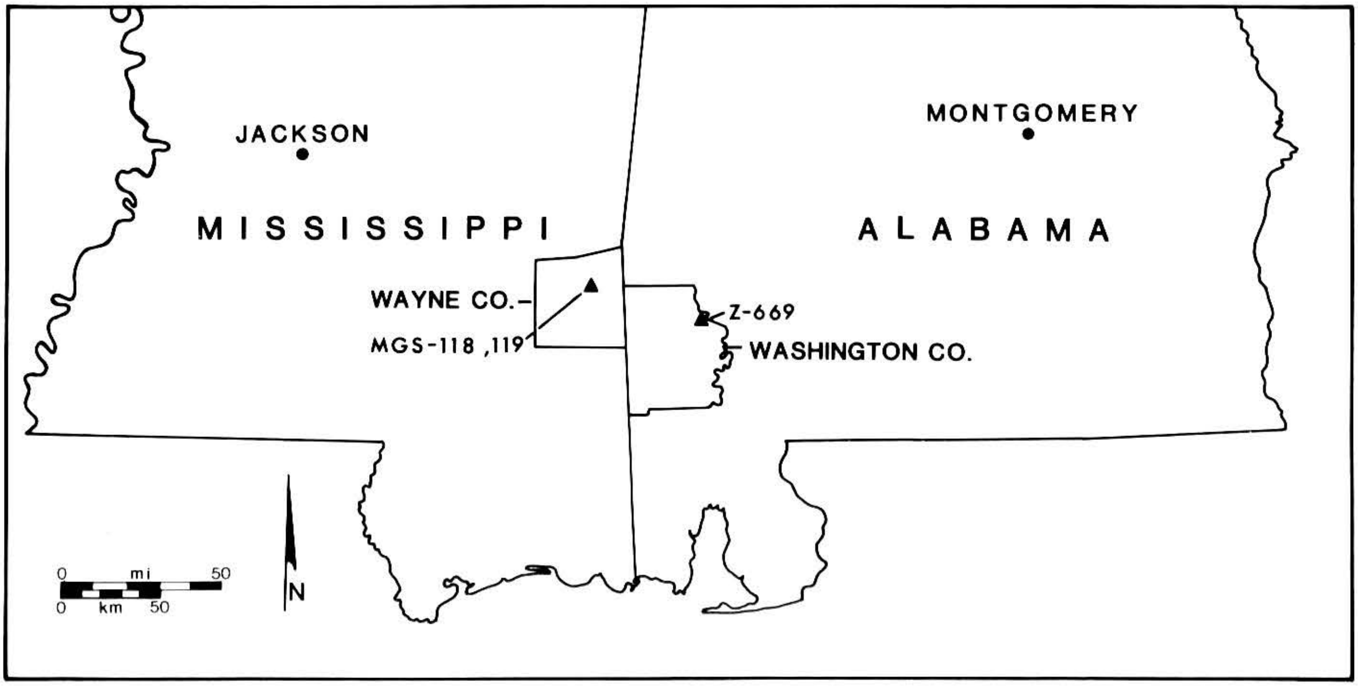


Figure 1. Approximate location of collection sites for *Balanus conopeoides* in Wayne County, Mississippi, and Washington County, Alabama.

carina. Among balanids, *Balanus conopeoides* most closely resembles members of the *B. trigonus* Darwin, 1854, group, from which it is most readily distinguished by the lack of radial striations on the exterior of the scutum.

INTRODUCTION

The barnacle genus *Balanus* Da Costa, 1778, characterized by a porous, bilamellar shell wall, has been recorded from Eocene and Oligocene rocks in Europe, North Africa, and South America (e.g., Alessandri, 1906; Pilsbry and Olsson, 1951; Kolosvary, 1955; Davadie, 1963), but is not known to occur in units dated older than late Oligocene in North America. The oldest previously described species is *B. connelli* Cornwall, 1927, from the Sooke Formation of Vancouver Island, British Columbia. This species appears to be a member of the *B. concavus* Bronn, 1831, group, but a definite group assignment must await discovery of the opercular plates. The Sooke Formation is assigned to the upper Oligocene to lower Miocene Juanian Molluscan Stage of Addicott (1976). According to Dr. Ellen J. Moore (personal communication, 1982), the precise position of the Sooke Formation within the Juanian Stage cannot be determined at present.

The first appearance of *Balanus* on the Atlantic coast is in the Belgrade Formation of Baum and others (1978) in North Carolina. The undescribed Belgrade species, known both from shells and opercular plates, is a member of the *B. concavus* group, and appears to be ancestral to *B. chesapeakensis* Pilsbry, 1916, from the middle Miocene Choptank and St. Marys formations of Maryland (Zullo, 1979). Ward and others (1978) consider the Belgrade Formation (their upper River Bend Formation) to be an upper Oligocene unit correlative with the Chickasawhay Formation of the eastern Gulf Coast, whereas Baum and others (1978) and Zullo (1979) regard the Belgrade Formation as a lower Miocene Tampan Stage unit.

The purpose of this paper is to describe the oldest species of *Balanus* presently known from the Gulf Coastal Plain. This new species, represented by numerous shells and several opercular plates, is found in the upper Oligocene Chickasawhay Formation of Mississippi and Alabama (Figure 1). Unlike *B. connelli* and the North Carolina Belgrade species, the Chickasawhay *Balanus* is unrelated to the *B. concavus* group. Rather, it bears a remarkable resemblance to certain species of the archaeobalanid genus *Conopea* Say, 1822, and, to a lesser degree, the new species is similar to members of the *Balanus trigonus* Darwin, 1854, group. The Chickasawhay species was first brought to my attention by David T. Dockery III, who obtained specimens from the St. Stephens quarry in Washington County, Alabama. Subsequent collection at St. Stephens quarry, together with additional material provided by Dockery from the Chickasawhay Formation in Wayne County, Mississippi, and by Mary Yonkers from the St. Stephens quarry form the basis of the following description.

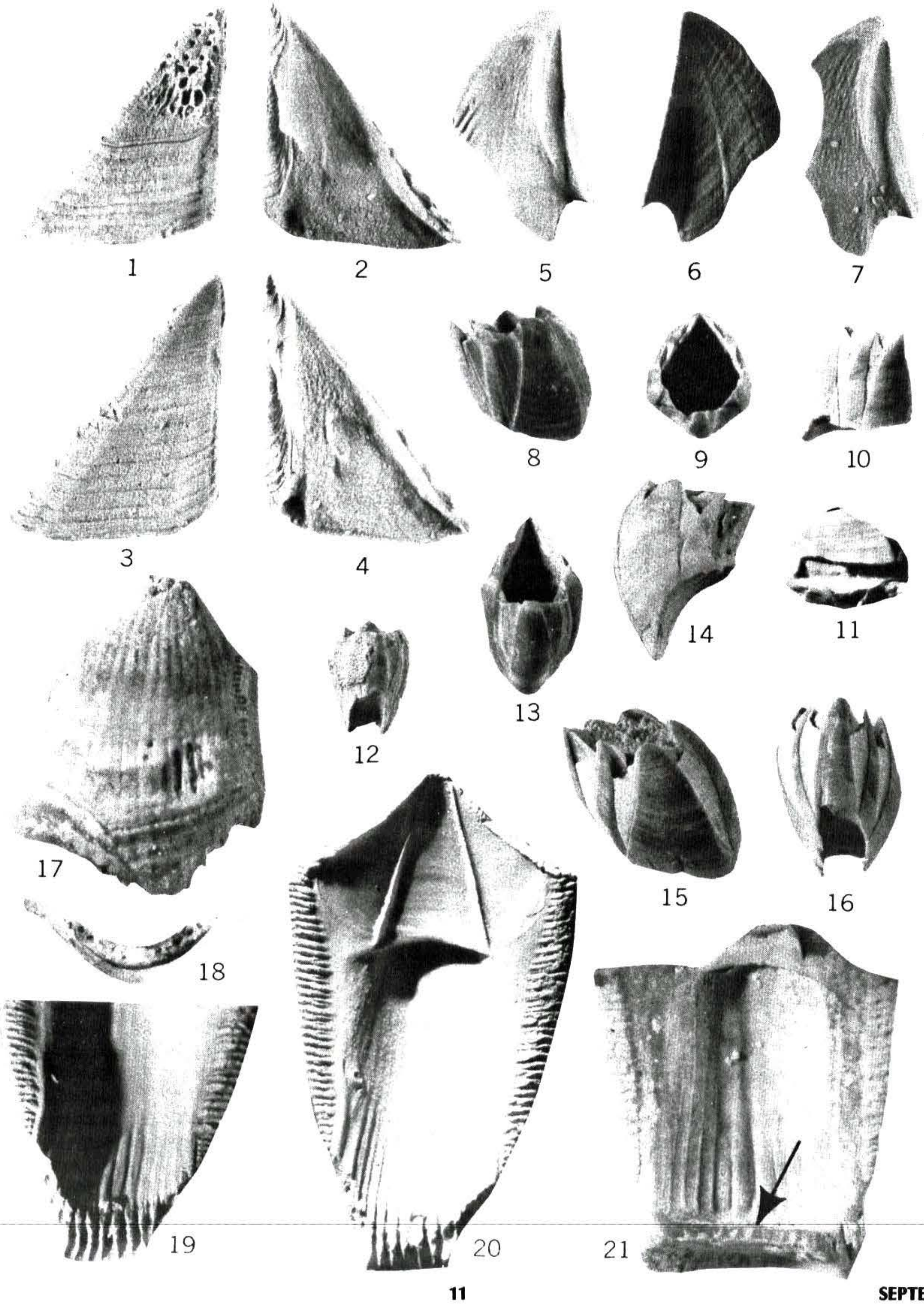
SYSTEMATIC ACCOUNT

Subclass CIRRIPEDIA Burmeister, 1834
Order THORACICA Darwin, 1854
Suborder BALANOMORPHA Pilsbry, 1916
Superfamily BALANOIDEA Leach (Newman and Ross, 1976)
Family BALANIDAE Leach (Newman and Ross, 1976)
Subfamily BALANINAE Leach (Newman, 1980)
Genus *BALANUS* Da Costa, 1778
Balanus conopeoides new species
Plate 1, figures 1-21

Plate 1

Figures 1-21, *Balanus conopeoides* new species. (1-2), exterior and interior of scutum, paratype MSU 3266, UNCW loc. Z - 669; (3-4), exterior and interior of scutum, paratype MSU 3267, UNCW loc. Z - 669; (5-6), interior and exterior of tergum, paratype MSU 3269, UNCW loc. Z - 669; (7), interior of broken tergum, paratype MSU 3270, UNCW loc. Z - 669; (8-9, 11), side, orifice, and basal views of shell, holotype MSU 3271, UNCW loc. Z - 669; (10), side view of shell not exhibiting lateral compression or a clasping basis, paratype MSU 3272, UNCW loc. Z - 669; (12), carinal view of shell with clasping basis, paratype MSU 3275, MGS loc. 120; (13), orifice view of shell, paratype MSU 3274, MGS loc. 120; (14), side view of shell that was attached to gastropod, paratype MSU 3273, UNCW loc. Z - 669; (15-16), side and carinal views of laterally compressed shell with clasping basis, paratype MSU 3276, MGS loc. 120; (17), exterior of decorticated lateral plate showing parietal tubes, paratype MSU 3281, MGS loc. 118; (18), ground section of rostrum showing small parietal tubes, paratype MSU 3279, UNCW loc. Z - 669; (19), basal view of rostrum showing parietal ribs and tubes, paratype MSU 3277, MGS loc. 118; (20), interior of paratype MSU 3277 rostrum showing sheath and septate radii; (21), interior of rostrum with portion of porous basis attached (arrow), paratype MSU 3278, UNCW loc. Z - 669.
SCALE: Figures 1-7, x7; figures 8-16, x2; figures 17-21, x7.

PLATE 1



Holotype

Complete shell without opercular plates, MSU no. 3271.

Type locality

Upper Oligocene, Chickasawhay Formation, St. Stephens quarry, east of St. Stephens, Washington County, Alabama; Section 33, T.7 N., R.1 W.

Diagnosis

Small to moderate-sized, cylindric to subglobose to laterally compressed shell with large, subtriangular orifice, smooth, usually porous parietes, and broad, solid radii with oblique summits and septate sutural edges; basis thick, irregularly porous, and often deeply concave because of attachment to small-diameter cylindrical objects. Scutum bowed between apex and basis, without external radial striae, internal rugosities, or adductor ridge; articular r'dge short, erect; depressor muscle pit small, deep, triar gular; tergal margin narrowly reflexed 45° . Tergum wit ι short, moderately broad, basally truncate tergal spur and long, erect, articular ridge; spur furrow not depressed; depressor muscle crests and internal rugosities lacking.

Material

Thirty-one complete shells, two partial shells, nine isolated compartmental plates, six scuta, and three terga from the type locality; three isolated compartmental plates from MGS locality 118; four isolated compartmental plates from MGS locality 119.

Disposition of types

Holotype shell, MSU no. 3271, paratype shells, MSU nos. 3272-3276, paratype rostra, MSU nos. 3277-3280, paratype lateral, MSU no. 3281, and paratype opercular plates, MSU nos. 3266-3270 are deposited in the paleontological type collection of the Department of Geology and Geography, Mississippi State University.

Dimensions of holotype

Greatest height of shell, 15.1 mm; carinorostral diameter of shell, 12.7 mm; lateral diameter of shell, 10.6 mm; carinorostral diameter of orifice, 10.3 mm; lateral diameter of orifice, 7.4 mm.

Description

Shell (Pl. 1, figs. 8-21) cylindric, laterally compressed when attached to cylindrical objects, with large, subtriangular, toothed orifice; exterior of parietes smooth, slightly and irregularly plicate in specimens attached to highly irregular surfaces, preserving fairly regularly-spaced white to reddish horizontal color bands as borders of darker-hued growth increments; parietal tubes very small, widely-spaced, open, circular; some rostra are devoid of parietal tubes (e.g., paratype MSU no. 3280); radii broad, solid, thick, with oblique (30° to 45°) summits, and septate sutural edges; septa of sutural edge with inconspicuous secondary denticulae best developed on lower half of radius; surface of paries articulating with sutural edge of adjacent radius distinctly denticulate; alae thick, with oblique (45°) summits and indistinctly denticulate sutural edges; sheath occupying one-third to one-half of interior of shell wall; lower edge of sheath dependent, with a narrow, moderately deep cavity between lower sheath margin and parietes; interior of parietes below sheath with indistinct to well developed, low, broad, irregular and usually approximate parietal septa; basal edges of parietal septa coarsely and indistinctly denticulate; basis thick, especially near margins, with small, rounded, irregularly and sparingly distributed pores.

Scutum (Pl. 1, figs. 1-4) higher than wide, of average thickness, slightly bowed between apex and basal margin; exterior ornamented by regularly-spaced growth ridges; alternating growth ridges forming prominent teeth on occludent margin; tergal margin narrowly reflexed about 45° ; basal margin sinuous; basitergal angle truncate; adductor ridge absent; adductor muscle pit large, shallow, circular, centrally located on plate, and often with a low, raised lip on interior margin; articular ridge short, broad, erect, one-half to two-thirds length of tergal margin; articular furrow moderately broad, deep; depressor muscle pit small, triangular, deep, located in angle formed by reflexed part of tergal margin with remainder of plate.

Tergum (Pl. 1, figs. 5-7) of average thickness and width; length of basal margin equal to 75% of total height of plate; spur short, moderately broad, occupying 60% of basal margin, placed a distance equal to half its scutad side length from basiscutal angle, and truncate basally; scutad side of spur forming slightly greater than a right angle with basal margin; carinad side of spur joining basal margin in a smooth curve; scutal margin very slightly concave; carinal margin convex; spur furrow not depressed, bounded by deeply impressed groove on scutal side; articular ridge prominent, rounded, erect, extending nearly to basal margin; articular furrow broad, shallow; depressor muscle crests absent; apical part of tergum prominently striate horizontally, but remainder of plate interior smooth.

Discussion

The shell and opercular plates of *B. conopeoides* resemble those of both the archaeobalanid genus *Conopea* Say and the balanid genus *Balanus*. The smooth parietes, broad, denticulate radii, and the absence of an adductor ridge, internal rugosities and external radial striae on the scutum, and the lack of depressor muscle crests in combination with a basally truncate spur on the tergum are features commonly found in *Canopea*. More specifically, the extant species *C. calceola* (Ellis) has porous parietes and a porous basis, features not typical of archaeobalanids, but characteristic of many balanids. The attributes that distinguish *C. calceola* as a *Conopea* are its commensal relationship with gorgonians and the extension of its rostrum to form part of the boat-shaped basis that clasps the gorgonian branch. It is in these latter features that *Balanus conopeoides* differs most markedly from *Conopea calceola*. Although 19 of the shells, including the holotype, were attached to narrow, cylindrical objects (probably echinoid spines), the remaining shells were attached to gastropods and in two cases to another *Balanus conopeoides* shell, and none of the shells exhibits any tendency towards extension of the rostral plate or development of a boat-shaped basis.

Unfortunately, these latter characteristics are not definitive for all the extant species of *Conopea*. The western Atlantic and Caribbean species *C. merrilli* Zullo was assigned to *Conopea* with some reluctance (Zullo, 1966), primarily because it lacks a boat-shaped basis and tends to attach to objects besides the branches of living gorgonians. The decision to regard *C. merrilli* as a *Conopea* was supported by mouth part and cirral morphology and the subsequent discovery of complemental males by McLaughlin and Henry (1972), features essentially unavailable in the study of fossils. The opercular plates of *C. merrilli* bear a great deal of resemblance to those of *Balanus conopeoides*, but the parietes of *Conopea merrilli* are solid rather than porous, and its rostral sheath is modified as a site of attachment for the male.

"*Balanus*" *inclusus* Darwin, 1854, is a fossil species with solid parietes and a porous basis from the Pliocene of England that is similar in many respects to *B. conopeoides*, and presents many of the same problems in generic assignment. Currently, "*B.*" *inclusus* is included in the archaeobalanid genus *Actinobalanus* Moroni (Moroni, 1967; Newman and Ross, 1976), but it is clearly not an *Actinobalanus*. "*Balanus*" *inclusus* has broad radii with septate sutural edges and lacks an adductor ridge, features inconsistent with *Actinobalanus*. Davadie (1963) and Zullo (1963) assigned "*Balanus*" *inclusus* to *Armatobalanus* Hoek, but its broad radii, smooth parietes, porous basis and tergal spur are not characteristic of *Armatobalanus*. "*Balanus*" *inclusus* is most readily viewed as a *Conopea*, particularly because of its morphological similarity to *C. merrilli* from which it is distinguished on details of opercular plate morphology. As with *C. merrilli*, *C. inclusa* can be distinguished from *Balanus conopeoides* by its solid rather than porous parietes. The rostral sheath of *C. inclusa* has not been described.

My decision to place the new species in *Balanus* rather than *Conopea* is based on a combination of features (usually porous parietes, normal development of the rostrum and rostral sheath, no indication of attachment to gorgonians) not known to occur in *Conopea*, and on the very subjective basis of the extreme antiquity of the new species. To my knowledge, the only valid fossil occurrence of *Conopea* is that reported by Darwin (1854) for *C. calceola* from the Pliocene Coralline Crag of England. The specimens attributed to this species by Alessandri (1906, pl. 17, figs. 5-7) from the Helvetian of the Turin Hills, Italy, represent *Megabalanus* Hoek as is readily apparent from the figured opercular plates. Detailed examination of Cenozoic marine deposits on the Pacific, Gulf, and southeastern Atlantic coasts of the United States has uncovered numerous examples of free-living archaeobalanids, but with the possible exception of a Pleistocene specimen of *C. galeata* from South Carolina, no specimens of *Conopea* have been encountered. Yamaguchi (1977, text fig. 14) in his summary of the stratigraphic distribution of Japanese balanoids, reported no fossils of *Conopea*, although five extant species are known to occur in the region. The fossil record suggests that *Conopea* and, perhaps, many of the commensal archaeobalanids evolved relatively recently (Neogene). The resemblance of the shell and opercular plates of *B. conopeoides* to those of *Conopea inclusa*, *C. merrilli* and *C. calceola* remains disconcerting, however. Although these similarities may represent convergent evolution, it is possible either that *Balanus conopeoides* is a *Conopea*, or that *Conopea*, rather than being an archaeobalanid derived from some free-living Paleogene archaeobalanid stock, is a balanid derived from a *Balanus conopeoides*-like ancestor through the secondary attainment of archaeobalanid-like characteristics.

Among species of *Balanus*, *B. conopeoides* most closely resembles species of the *B. trigonus* group. *Balanus trigonus* is distinguished by its ribbed parietes, radiating rows of pits on the exterior of the scutum, and more rectangular tergal spur placed closer to the basiscutal angle. *Balanus spongicola* Brown, 1844, differs in its scutum, which has deeply incised external radial striae that cut the growth ridges into beads, and internal rugosities and ridges on the upper part of the plate. *Balanus calidus* Pilsbry, 1916, differs in its prominently plicate shell, fine radial striae on the exterior of the scutum, and more rectangular tergal spur. The shell of *B. conopeoides* is externally similar to that of *B. caribensis* Weisbord, 1966, from the Pliocene Playa Grande and Mare formations, Cabo Blanco, Venezuela, but the scutum of *B. caribensis* has a well-developed adductor ridge.

Derivation of specific name

The specific name is a combination of the generic name *Conopea* and the suffix *-oides* from the Greek *eides*, meaning like or resembling. The name refers to the general resemblance of the new species to species of *Conopea*.

ACKNOWLEDGMENTS

I thank David T. Dockery III, Mississippi Bureau of Geology, for specimens of *B. conopeoides* from Mississippi and Alabama, Mary Yonkers for the loan of specimens from Alabama, Paul F. Huddlestun, Georgia Geologic Survey, for helping me in the collection of specimens from Alabama, and Ellen J. Moore, U. S. Geological Survey, for information on the age of the Sooke Formation. This research was funded by the Marine Sciences Program of the University of North Carolina at Wilmington.

LOCALITY DESCRIPTIONS

MGS localities (Mississippi Bureau of Geology)

118. Chickasawhay Formation, a basal, calcareous, sandy, clay unit (118a) overlain by the "*Chione* limestone" (118b): in Taylor Creek just below and above the Highway 45 bridge; SE/4, Section 36, T.9 N., R.7 W., Wayne County, Mississippi.
119. Chickasawhay Formation: dirt road and eroded field on hill top in the W/2, SE/4, SW/4, Section 13, T.9 N., R.7 W., Wayne County, Mississippi.
120. Chickasawhay Formation: the south quarry, upper level at St. Stephens quarry, west bank of the Tombigbee River east of St. Stephens in Section 33, T.7 N., R.1 W., Washington County, Alabama (same location as UNCW locality Z - 669).

UNCW locality (University of North Carolina at Wilmington)

Z - 669. Chickasawhay Formation, St. Stephens quarry, west bank of Tombigbee River east of St. Stephens, Section 33, T.7 N., R.1 W., Washington County, Alabama; Victor A. Zullo, collector, 8 March 1981.

REFERENCES CITED

Addicott, W. O., 1976, Neogene molluscan stages of Oregon and Washington, *in* Neogene Symposium: Society of Economic Paleontologists and Mineralogists, Pacific Section, San Francisco, California, April 1976, p. 95-115.

Alessandri, G. de, 1906, Studi monografici sui Cirripedi fossili d'Italia: Palaeontogr. Italica, v. 12, p. 207-324.

Baum, G. R., W. B. Harris, and V. A. Zullo, 1978, Stratigraphic revision of the exposed middle Eocene to lower Miocene formations of North Carolina: Southeastern Geology, v. 20, p. 1-19.

Darwin, C., 1854, A monograph on the fossil Balanidae and Verrucidae of Great Britain: Palaeontogr. Soc., London, 44 p.

Davadie, C., 1963, Etude des Balanes d'Europe et d'Afrique. Systématique et structure des Balanes fossiles d'Europe et d'Afrique: Editions du Centre Natl. Rech. Sci. (C.N.R.S.), Paris, 146 p.

Kolosvàry, G., 1955, Über stratigraphischer Rolle der fossilen Balaniden: Acta Biol. Szeged (n. ser.), v. 1, pt. 1-4, p. 183-188.

McLaughlin, P. A., and D. P. Henry, 1972, Comparative morphology of complemental males in four species of *Balanus* (Cirripedia: Thoracica): Crustaceana, v. 22, p. 13-30.

Moroni, M. A., 1967, Classificazione sottogenerica ed affinita di *Balanus actinomorphus* Moroni, 1952: Rivista Ital. Paleontol., v. 73, p. 919-928.

Newman, W. A., and A. Ross, 1976, Revision of the balanomorph barnacles; including a catalog of the species: San Diego Soc. Nat. Hist. Mem. 9, p. 1-108.

Pilsbry, H. A., and A. A. Olsson, 1951, Tertiary and Cretaceous Cirripedia from northwestern South America: Proc. Acad. Nat. Sci. Philadelphia, v. 103, p. 197-210.

Ward, L. W., D. R. Lawrence, and B. W. Blackwelder, 1978, Stratigraphic revision of the Eocene, Oligocene, and lower Miocene - Atlantic Coastal Plain of North Carolina: U. S. Geological Survey Bulletin 1457-F, 23 p.

Yamaguchi, T., 1977, Taxonomic studies on some fossil and recent Japanese Balanoidea (part 2): Trans. Proc. Palaeont. Soc. Japan, n. ser., no. 108, p. 161-201.

Zullo, V. A., 1963, A review of the subgenus *Armatobalanus* Hoek (Cirripedia: Thoracica), with the description of a new species from the California coast: Annals and Magazine of Nat. Hist., ser. 13, v. 6, p. 587-594.

Zullo, V. A., 1966, Thoracic Cirripedia from the continental shelf off South Carolina: Crustaceana, v. 11, p. 229-244.

Zullo, V. A., 1979, Biostratigraphy of Eocene through Miocene Cirripedia, North Carolina Coastal Plain, *in* G. R. Baum, W. B. Harris, and V. A. Zullo, eds., Structural and stratigraphic framework for the Coastal Plain of North Carolina: Field Trip Guidebook, 1979, Carolina Geol. Soc. and Atlantic Coastal Plain Geol. Assoc., p. 67-72.

CALENDAR OF EVENTS

1982 September - December

September 22-24 - Ground-water quality, symposium, Atlanta. (Kathy Butcher, National Water Well Association, 500 W. Wilson Bridge Road, Worthington, Ohio 43085. Phone: 614/846-9355)

October 4-8 - Modern deltas, field seminar, Baton Rouge, La. (James Coleman, Coastal Studies Institute, Louisiana State University, Baton Rouge, La. 70803. Phone: 504/388-2395) All sedimentary processes in the delta environment, field study from Baton Rouge to New Orleans. To be repeated March 21-25.

October 12-15 - Sea-floor stability of continental margins, meeting, Bay St. Louis, Miss., by Society of Economic Paleontologists and Mineralogists and Naval Ocean Research and Development Activity. (Myron Webb, University of Southern Mississippi - Gulf Park, Dept. of Conferences, Long Beach, Miss. 39560. Phone: 601/688-3054)

October 17 - Foraminifera, short course, New Orleans (before GSA's annual meeting), by Paleontological Society. (Martin A. Buzas, Dept. of Paleobiology, National Museum of Natural History, Washington, D. C. 20560) Biology/paleobiology. Classification. Ecology of modern benthic/planktic forams. Biogeography of modern benthic forams. Cenozoic/Mesozoic/Paleozoic benthic and planktic forams. Paleozoic fusulinids.

October 18-21 - Geological Society of America, annual meeting, New Orleans, with associated societies: Cushman Foundation, Geochemical Society, Geoscience Information Society, Mineralogical Society of America, National Association of Geology Teachers, Paleontological Society, Society of Economic Geologists. (GSA headquarters, 3300 Penrose Place, Boulder, Colorado 80301. Phone: 303/447-2020)

October 26-31 - Gulf Coast Section, American Association of Petroleum Geologists, annual meeting, Houston. (AAPG headquarters, Box 979, Tulsa, Oklahoma 74101. Phone: 918/584-2555)

November 5-6 - Alabama Geological Society, field trip to Black Warrior Basin. (Lawrence J. Rheams, Alabama Geological Society, Box 6184, University, Ala. 35486) Depositional setting of the Pottsville Formation (Pennsylvanian).

November 10-13 - American Institute of Professional Geologists, annual meeting, Pasadena, California. (AIPG headquarters, Box 957, Golden, Colorado 80401)

November 28-December 1 - Gulf Coast Section; Society of Economic Paleontologists and Mineralogists, annual meeting, Baton Rouge. (William Ventress, Chevron USA, 935 Gravier St., New Orleans, La. 70112. Phone: 504/521-6761)

November 29-December 3 - Clastic depositional systems, short course, New Orleans. (Patrice Cunningham, Research Planning Institute, 915 Gervais St., Columbia, S. C. 29201. Phone: 803/256-7322)

PETROLEUM NEWS

MISSISSIPPI OIL AND GAS STATISTICS, FIRST QUARTER 1982

Oil

	Bbls. Produced	Severance Tax	Average Price Per Bbl.
January	1,098,437	$ 2,200,686.65	$ 33.39
February	4,488,078	8,430,529.53	31.31
March	3,422,064	6,080,113.70	29.61
Totals	9,008,579	$ 16,711,329.88	$ 30.92

Gas

	MCF Produced	Severance Tax	Average Price Per MCF
January	8,630,114	$ 2,524,016.16	$ 4.87
February	29,046,407	6,837,541.06	3.92
March	16,253,545	3,553,745.44	3.64
Totals	53,930,066	$ 12,915,302.66	$ 3.99

source: State Tax Commission

MISSISSIPPI GEOLOGY
Department of Natural Resources
Bureau of Geology
Post Office Box 5348
Jackson, Mississippi 39216

Mississippi Geology is published quarterly in March, June, September, and December by the Mississippi Department of Natural Resources, Bureau of Geology. Contents include research articles pertaining to Mississippi geology, news items, reviews, and listings of recent geologic literature. Readers are urged to submit letters to the editor and research articles to be considered for publication; format specifications will be forwarded on request. For a free subscription or to submit an article, write to:

Editor, Mississippi Geology
Bureau of Geology
P. O. Box 5348
Jackson, Mississippi 39216

Editors: Michael B. E. Bograd and David Dockery
Typesetter: L. Michele Morphis