To the Graduate Council:

I am submitting herewith a dissertation written by Daniel Lee Frederick entitled "Eocene and Oligocene Benthic Foraminifera in the Eastern Gulf Coast." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Geology.

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EOCENE AND OLIGOCENE BENTHIC FORAMINIFERA IN THE EASTERN GULF COAST

A Dissertation

presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Daniel Lee Frederick

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ABSTRACT

Small benthic foraminifera from four localities were examined for the degree, and timing of faunal changes associated with the Eocene/Oligocene boundary in the eastern Gulf Coast region. A preliminary study of the development of the stratigraphic package straddling the boundary was constructed. In addition, preliminary tests of abundance variation in the fossil record to paleoecolgic analysis were conducted.

Four sections were examined. These sections represent a range of paleoecologic settings ranging from clastic shelf to carbonate bank. Analysis of the degree and timing of faunal change across the Eocene/Oligocene boundary in the eastern Gulf Coast indicate a low and inconsistent amount of change. The degree of faunal change observed is lower than previously reported with few common species becoming extinct at or here the boundary in the entire study area. The greatest change occurs in the clastic shelf and carbonate bank settings. However, a single causal mechanism can not be invoked to explain the observed faunal changes. Preliminary study of the development of the stratigraphic package in the study area indicates that the Eocene/Oligocene boundary is complete and the location of the major facies transition is a result of the interaction of sea level and the suppression of carbonate deposition by distal clastics. Analysis of abundance variation in the fossil record provides a potential tool for applying modern ecologic models to the past. Preliminary tests of fossil abundance variation were conducted to examine this possibility. The results indicate that the nature of the benthic foraminiferal record is such that meaningful patterns maybe recognized. In spite of the loss of large amounts of information to taphonomic processes.

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INTRODUCTION

The goal of this study is to examine the rate, degree and timing of change in the fauna of smaller benthic foraminifera fauna in response to late Eocene oceanographic and climatic changes. Using close spaced samples directly above and below the Eocene-Oligocene boundary. Secondary goals include: Development of a preliminary synthesis of the depsotional environments across the study area to provide a coherent set of paleoenvironemtal settings in which faunal change can be studied; Preliminary development and initial testing of methods for analyzing abundance variation in the fossil record.

The area studied encompasses the eastern portion of the Gulf Coastal Plain. Four sections were sample representing a variety of paleonenvironments.

Analysis of the benthic foraminiferal fauna across the boundary reveals a lower rate of faunal change than has been previously reported for foraminifera in the Gulf Coast (Gsaskell, 1991). In addition the rate degree and timing of the changes are all lower than those reported for other fossil groups in the same region. The degree of change in foraminifera is highly dependent on the setting examined and can be, in some sections, attributed more to local paleoenvironemtal change than to regional or global events. In addition, the difference in rate and timing of faunal change between benthic foraminifera and planktonic foraminifera and sporomorphs may indicate a lag in response time to climate change between surface water, land plants, and the marine benthos.

Preliminary synthesis of stratigraphic development indicates that the Eocene-Oligocene boundary is, contrary to some recent studies, represented by complete sections throughout the study area. Although the exact position of the boundary is often in question.

Analysis of the abundance variation in the fossil record of benthic foraminifiera indicates that it is possible to extract data consistent with predictions based on modern ecological models from the fossil record. Notwithstanding the large amount of information loss to taphomonic processes and sampling error.

Chapter 1 MATERIALS AND METHODS

Study area

The study area extends from western Mississippi to Peninsular Florida (Figure 1). The sediments in the western portion of the study area are composed of clays, marls and some sand. The sediments in the eastern portion of the study area are composed of a variety of carbonates (Figure 2).

Units studied

Four stratigraphic units were examined in this study,
the Shubuta Clay Member of the Yazoo Formation, the Red Bluff Formation in Alabama and Mississippi, the Crystal River and Bumpnose Formations and equivalent strata in eastern Alabama, Florida and southern Georgia (Figure 3).

Shubuta Clay Member:

Shubuta Clay Member, of the Yazoo Formation, crops out in Mississippi and western Alabama and the Crystal River Formation in Georgia and Florida. The Shubuta Clay was named by Murray (1947) in exposures located in a gully north of old U. S. highway 45 on the east bank of the Chickasawhay river just east of Shubuta, SW 1/4, Sec. 3, T. 10 N., R. 7 W Shubuta Quadrangle, Clark Co., Mississippi,.. In the type area the Shubuta consists of green-gray marls with some sandy units in the lower part. The type section of the Shubuta does not contain the upper unit boundary, thus is not included in this study (Waters, 1982). The upper boundary of the Shubuta is exposed in the type area at the Red Bluff type section located approximately 4.8 Km from the Shubuta type section . While there appears to be some overlap between the sections it is not clear how much (Waters 1982).

In eastern Mississippi the Shubuta is up to 27. 5 m (90 ft) thick and thins to the east reaching about 2 m in the area of Jackson County, Alabama (Murray, 1947, Waters, 1982). East of Jackson County, Alabama the Shubuta thickens again reaching a thickness of approximately

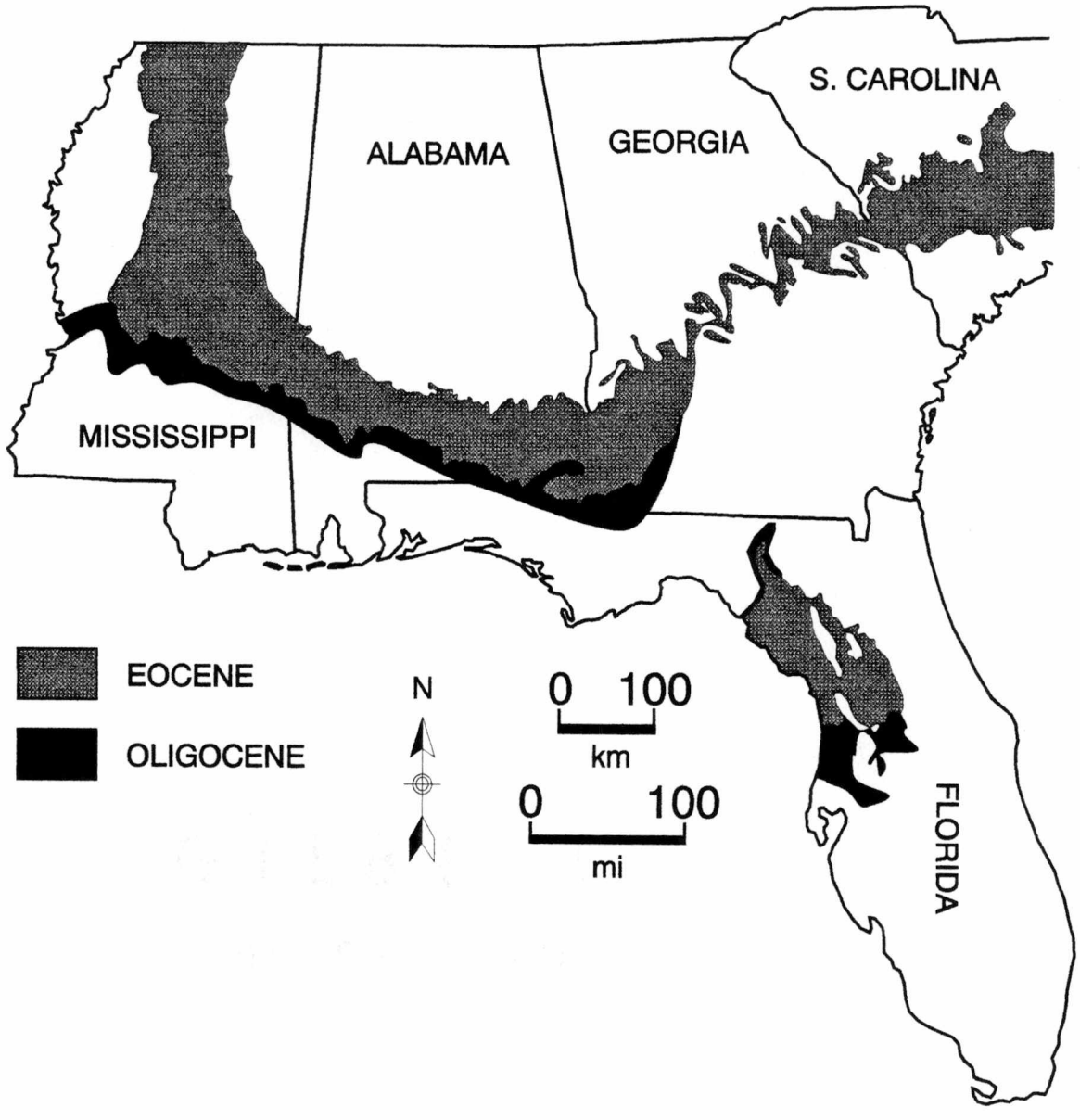


Figure. 1 Map view of study showing generalized outcrop area of Eocene and Oligocene strata (modified after King, and Biekman, 1974).

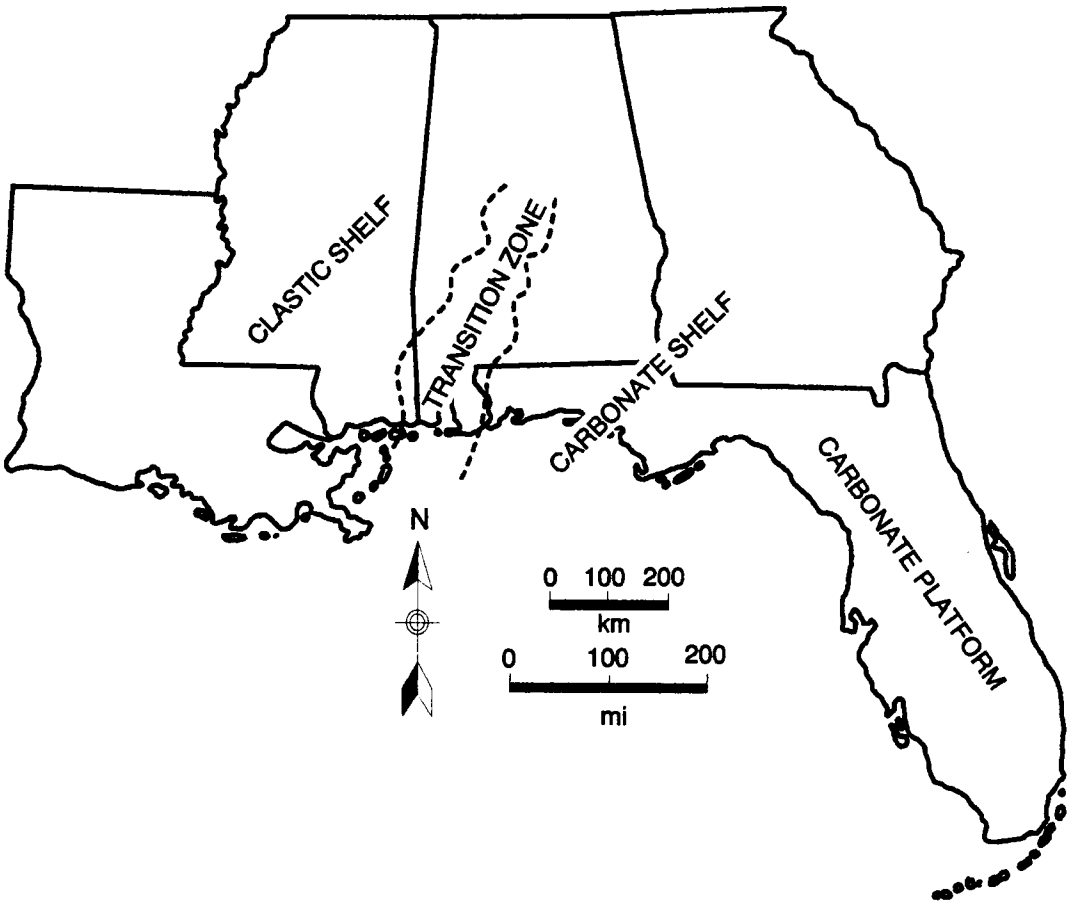


Figure. 2 Generalized lithofacies relationships in the study area.

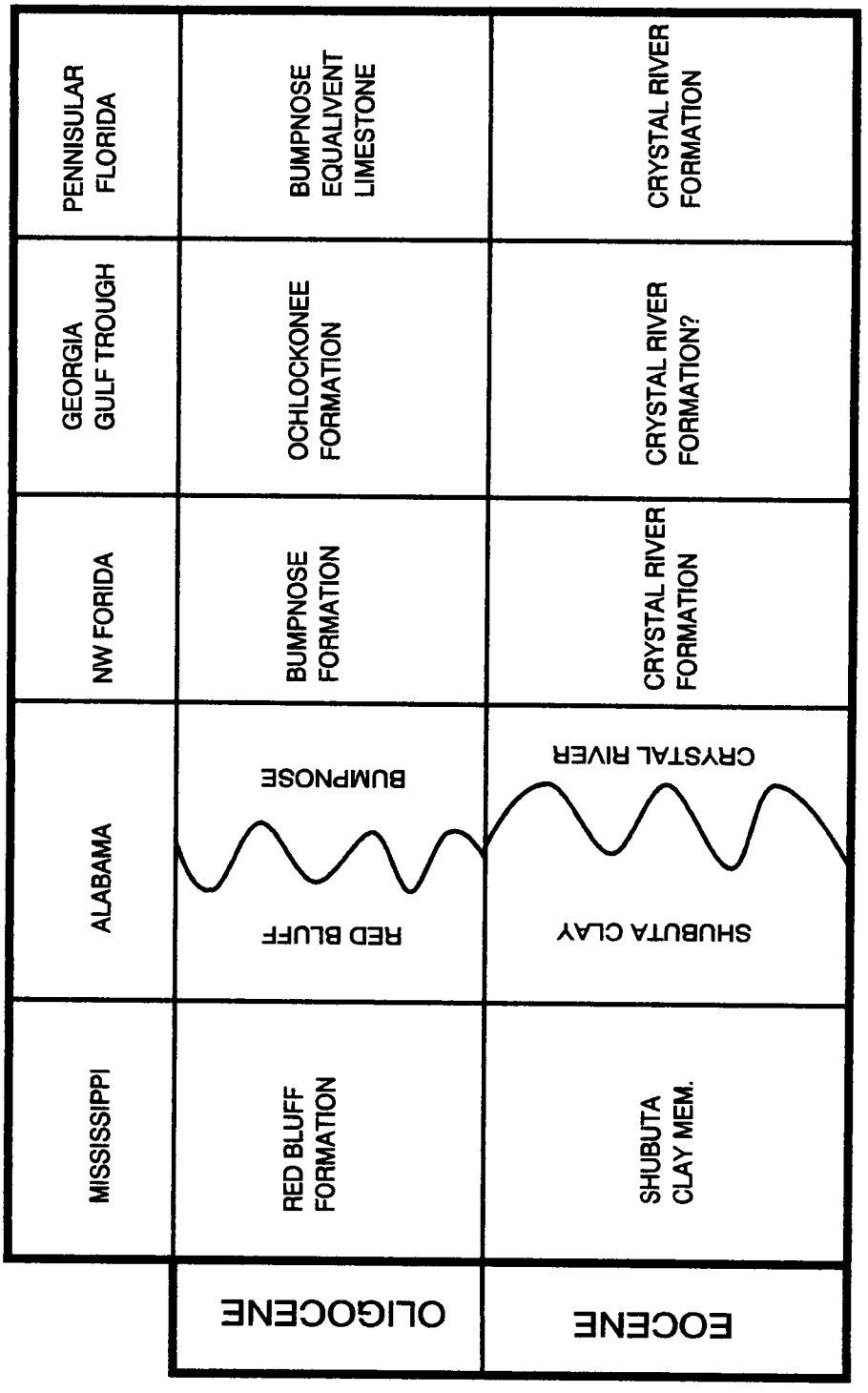


Figure. 3 Stratigraphic relationship of units studied (After Huddlestun, 1993).

5 m at Perdue Hill (Huddlestun, 1965; Sobba, 1976). However, the lithology becomes increasingly calcareous in nature over this distance (Huddlestun, 1965).

The Shubuta crops out from central Mississippi to central Alabama. To the east, the Shubuta interfingers with the Crystal River Limestone and is not found to the east of the Perdue Hill section in south central Alabama (Huddlestun, 1965; Sabo, 1976; Waters, 1982).

The Crystal River Formation:

The Crystal River Formation was named by Puri (1957) for upper most Eocene limestone exposed in the Crystal River Rock Company Quarry located in NE 1/4, SW 1/4, Sec. 6, T.19 S., R.18 E., Citrus County, Florida. The Crystal River is the uppermost Formation of the Ocala group in Florida (Puri 1957). In the type area the Crystal River consists of a uniform microcoquina made up dominantly of foraminiferal tests with varying amounts of macrofossil material (Puri, 1957). In other parts of Florida, the Crystal River has a similar composition, however, the amount of macrofossil material is quite high in many areas particularly in northern and central parts of the state (Puri, 1957; Hoganson, 1972; Nicol, and Jones, 1982). In these areas the upper part of the Crystal River contains a distinctive fauna and is termed the *Rotularia vernoni* zone (Nicol, et al., 1986; Hoganson, 1972). The Crystal River Formation was named for 33m (108 ft) of section at the type locality (Puri, 1957). The total thickness of the Crystal River is up to 92 m (300 ft) in Florida (Puri, 1957). To the west, the Crystal River thins to 17.4 m (57 ft) at Sepugla River (Huddlestun, 1965; Waters, 1982). Over much of the outcrop area the Crystal River has a fairly uniform and easily recognizable composition. The major variation being the presence or absence of the *Rotularia vernoni* zone in the Florida panhandle and its questionable appearance in southern Florida at the Brooksville locality. In the study area the Crystal River crops out from the Sepugla River east. In addition, the Crystal River is present in outcrop or the subsurface in Central and southeastern Georgia (Huddlestun and Hetrick, 1986; McFadden, et al. 1986; Huddlestun, 1993).

Red Bluff Formation:

The Red Bluff Formation, lower Oligocene was named by Hilgard, (1860) for the fossiliferous marls exposed at Red Bluff on the Chickasawhay river 2.4 Km (1.5 Mi) south of Shubuta, Wayne County Mississippi (Murray, 1961). Due to the poor nature of the original type section a reference section locality approximately 1.5 Km southwest of Hiwannee Mississippi on the cut bank of the Chickasawhay river was designated by Williamson (1975) as a paratype section.

The Red Bluff Formation is composed of a dark gray to yellowish brown fossiliferous, often glauconitic and partially indurated marl. In the type area the Red Bluff is approximately 6 m thick (MacNeil, 1944; Mancini and Waters, 1986). The thickness of the Red Bluff in eastern Mississippi and western Alabama ranges from approximately 3 to 10 m (May 1974). At the St. Stephens Quarry in Jackson County, Alabama the Red Bluff consists of approx. 4 m (14 ft) of olive-grey, glauconitic, fossiliferous, calcareous clay and limestone sometimes assigned to the Bumpnose Limestone (Glawe, 1967; Hazel et al., 1980). In the type area the lower Red Bluff is very glauconitic and contains several partially indurated, ironstone ledges, up section the amount of glauconite decreases and the unit becomes a grey to brown clay (Waters, 1982). Similar features are noted as far east as St. Stephens Quarry Jackson County, Alabama (Waters, 1982; Huddlestun, 1965; Hazel et al. 1980). Westward the Red Bluff grades into the Forest Hill Formation which is interpreted as a marginal to non marine unit (Mancini and Tew, 1991; Dockery, 1983; Murray, 1947). To the east, in central Alabama, strata equivalent to the Red Bluff become increasingly calcareous and grade into the Bumpnose Limestone (Huddlestun, 1965; Sobba, 1976; Waters, 1982; Mancini and Tew, 1991).

Bumpnose Limestone:

The Bumpnose limestone was named by Moore (1955) for exposures in the vicinity of Bumpnose Road, north of Marianna, Jackson County, Florida. Moore (1955) lists a quarry located "near the center W1/2 sec. 23, T.5 N., R.11 W.," Jackson County, Florida as the type

section of the Bumpnose Limestone member of the Crystal River Formation. This section is no longer accessible and other sections listed by Moore (1955) are difficult to find and may no longer exist (J. Bryan, personal communication). The Bumpnose crops out across the panhandle of Florida and into southern Alabama. It is well represented at the Sepugla River section and this area might be considered a paratype section for the unit replacing the original type section (Huddlestun, 1965).

Moore (1955) listed a thickness of 5m (15ft) at the type section. In the type area the Bumpnose consists of white soft somewhat granular limestone containing abundant Foraminifera and Bryozoa. To the west, at the Sepulga River section the Bumpnose consists of 5+ meters of white to tan, soft often chalky subcoquinoid, glauconitic, somewhat argillaceous limestone (Huddlestun, 1965; Waters, 1982; Mancini and Waters, 1986). West of the Sepugla River the Bumpnose becomes increasingly terrigenous and grades into the Red Bluff (Figure 3). The fossil content of the Bumpnose includes a varied small benthic foraminiferal assemblage, larger benthic foraminifera, bryozoa, bivalves and echinoids.

Bumpnose Equivalents:

In peninsular Florida and much of Georgia the units equivalent to the Bumpnose lose much of the distinguishing characteristics seen in the type area and west. These units are composed of varying lithology ranging from a soft white to tan fossiliferous limestone lacking glauconite or argillaceous material in southern Florida (Brooksville section) to laminated limestone and argillaceous marl (northern Florida and Gulf Trough).

In southern Florida the lower most Oligocene sediments have often been correlated with the Suwannee Formation (Randazzo, 1972; Sharpe, 1980). However, they do not fit the original description of this Formation in terms of either lithology and/or stratigraphic position (Cooke and Mansfield, 1936; Huddlestun, 1993). It is unclear how these units should be named. In this paper they are termed Bumpnose equivalent.

In northern Florida, east of the Gulf Trough, the strata equivalent to the Bumpnose are either the uppermost Crystal River *Rotularia vernoni* zone or the Ellaville limestone (Hunter, 1976: Huddlestun, 1993). The age of the *Rotularia vernoni* zone has been considered to be either uppermost Eocene or lowermost Oligocene (Hoganson, 1972; Hunter, 1976). However, as discussed below it may actually span the boundary.

In much of Florida the Bumpnose and related units have not been well studied and as they form the top of the section, the total thickness of these units is often not known.

In the Gulf Trough area the unit occupying the stratigraphic position of the Bumpnose consists of several meters of fine to medium grained limestone that is argillaceous at the base. Huddlestun (1993) has formally named this unit the Ochlockonee Formation. This unit occurs only in subcrop and is confined to the Gulf Trough area. To the north east the Ochlocknee Formation becomes more argillaceous and is termed the Priggon Limestone member of the Ochlockonee Formation by Huddlestun (1993).

Localities sampled

Four locations were sampled for this study spanning the major lithologic and environmental changes in the study area. These sections from west to east are: the Red Bluff type section; the Sepugla River section; the Colquitt county #9, Georgia Geological Survey core (GGS 3535); and the Brooksville Quarry section (Figure 4). Detailed section discriptions are in appendix 3.

The Red Bluff type section is located in the NE 1/4, Sec. 16, T. 10 N., R. 7 W., Shubuta quadrangle, Wayne County, Mississippi. On the left bank of the Chickasawhay river approximately 3.2 Km south west of Shubuta, MS. In this section the upper Shubuta and the exposed protion of the Red Bluff Formation were sampled (Figure 5).

The Sepulga River section is a composite of a series of cutbank sections located on the Sepugla river in south central Alabama. The cut banks are located in Sec. 28 & 33, T. 3 N., R.

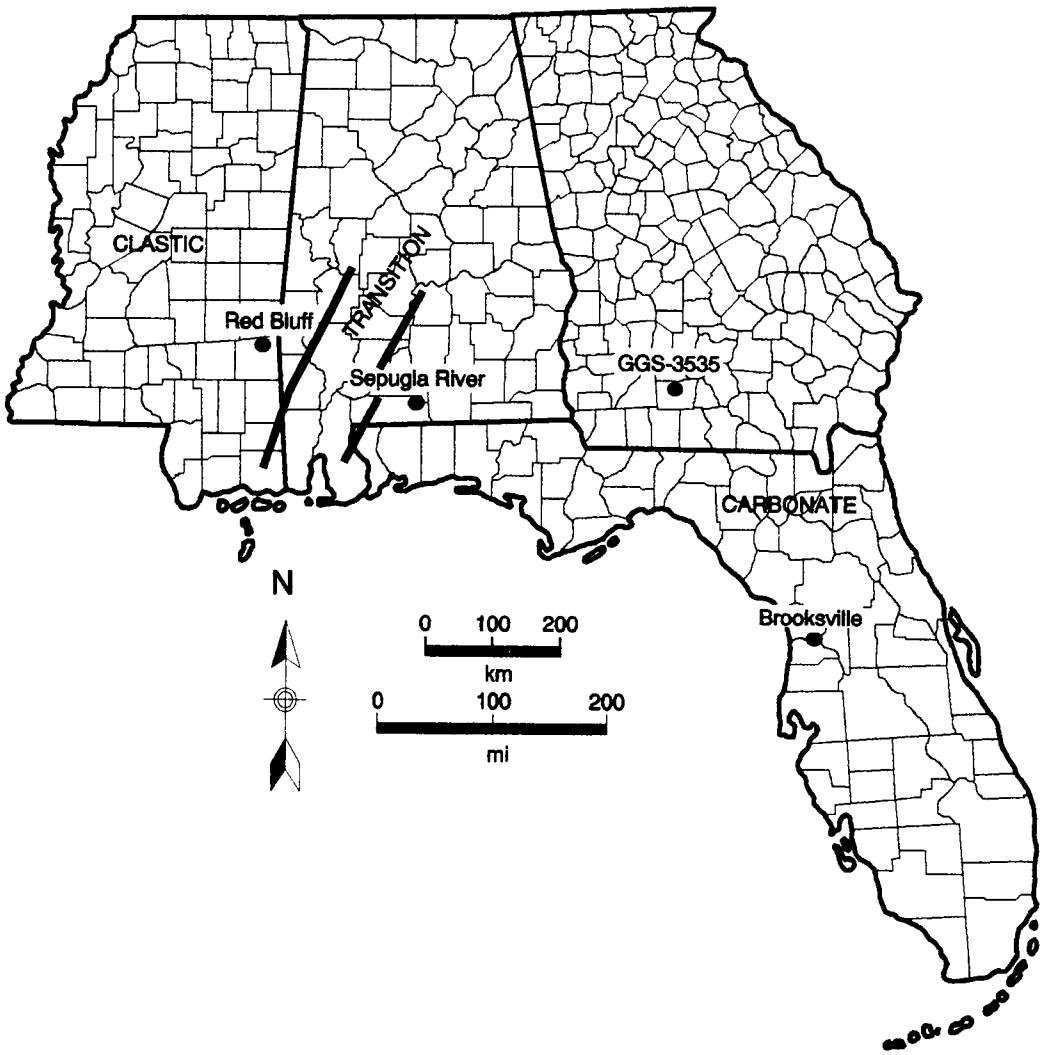


Figure 4. Localites sampled.

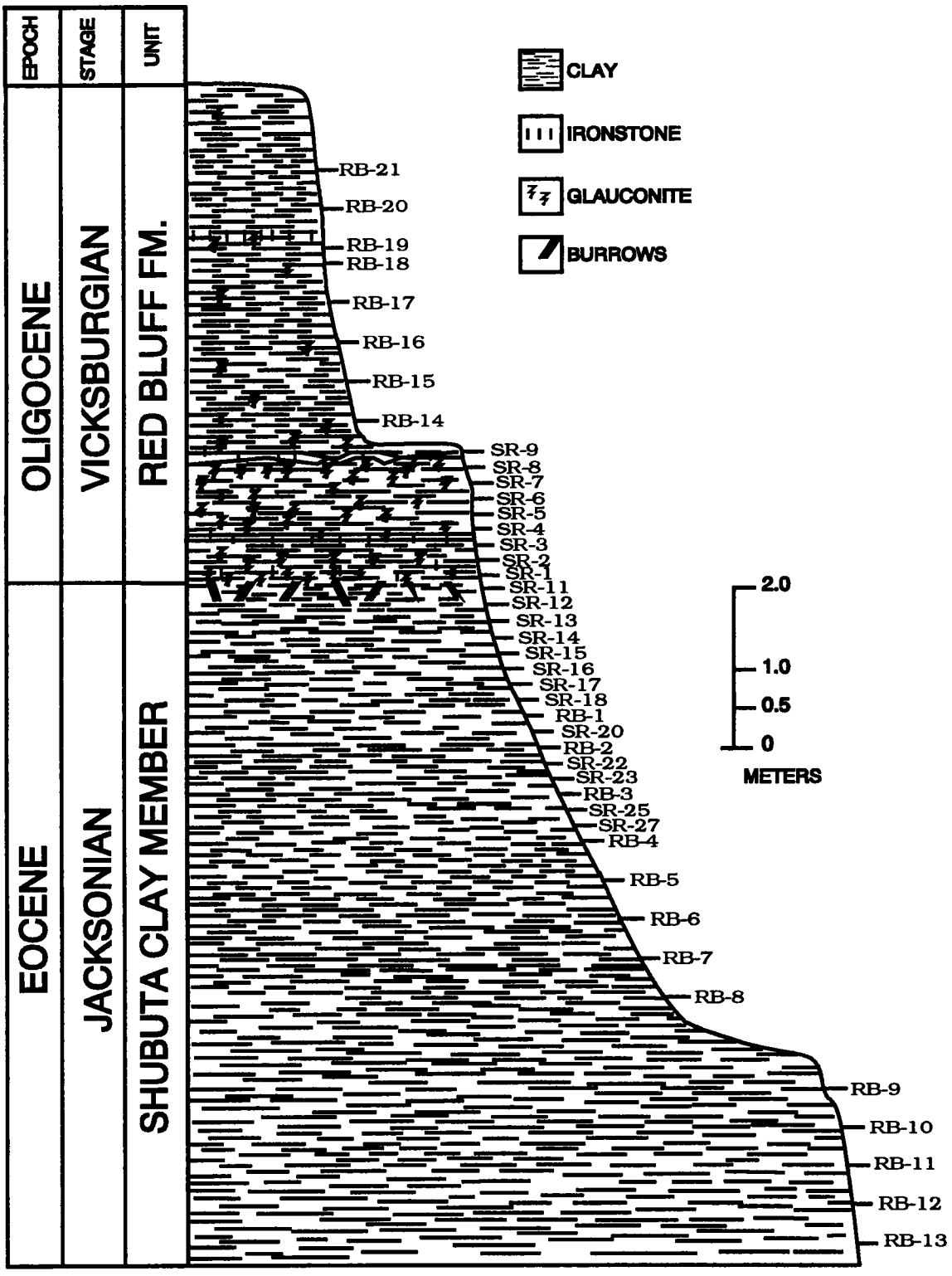


Figure 5. Measured section of the Red Bluff locality. Detailed section description in Appendix 3.

13 E., Damascus quadrangle, Conecuh County, Alabama . In this locality the entire Bumpnose limestone and upper half of the Crystal River Formations were collected. Due to the presence of a series of highly indurated to chert ledges in the upper Crystal River at this locality vertical sample spacing is not entirely even. In this locality the Crystal River is composed of tan to white fossiliferous limestone. Containing abundant foraminifera, bryozoans, algae and common macrofossils. The Bumpnose Limestone, on the Sepulga River consists of glauconitic, argillaceous tan to buff colored limestone. Fossils in the bumpnose in this locality include abundant smaller benthic foraminifera with common larger foraminifera, and bryozoans (Figure 6).

The single core, Georgia Geologic Survey 3535 (GGS-3535), studied for this report was drilled by U. S. Gypsum approximately 3.1 miles northwest of Moultrie, Colquitt CO., Georgia. This core contains both the Crystal River and Ochlocknee Formation. Drilled within the deeper part of a depositional low termed the Gulf Trough (McFadden, et al. 1986; Gelbaum, 1978; Hetrick and Vorhis, 1963; Huddlestun, 1993) or the Swannee Strait (Jordan, 1954; Hull, 1962; Chen, 1965). The core contains 18.5 m of Crystal River(?) Formation and 60 m of Ochlockonee Formation, of which 18.5 m of the Eocene and 20 m of the Oligocene were sampled. Both units consist of fine grained limestone with foraminifera, algae and some bryozoa present (Figure 7). The Eocene-Oligocene boundary in the core is marked by a thin layer of argillaceous limestone containing phosphatic material that maybe equivalent to the glauconitic horizons of the Bumpnose and Red Bluff Formations farther west.

The Brooksville section is located in a quarry in NE 1/4 Sec. 35 and NW 1/4 Sec. 36, T. 20 S., R. 15 E., Nobleton quadrangle, Critus County, Florida. This section is composed of the Upper Crystal River and a Lower Oligocene unit (Figure 8). The Crystal River contains the index fossils *Rotularia veroni* and the large benthic foraminifera *Lepidocylina. ocalana*. Indicating that this section is similar in age to those described in northern Florida (Hoganson, 1972). The nature of the Eocene- Oligocene boundary in this section and the exact correlation of the

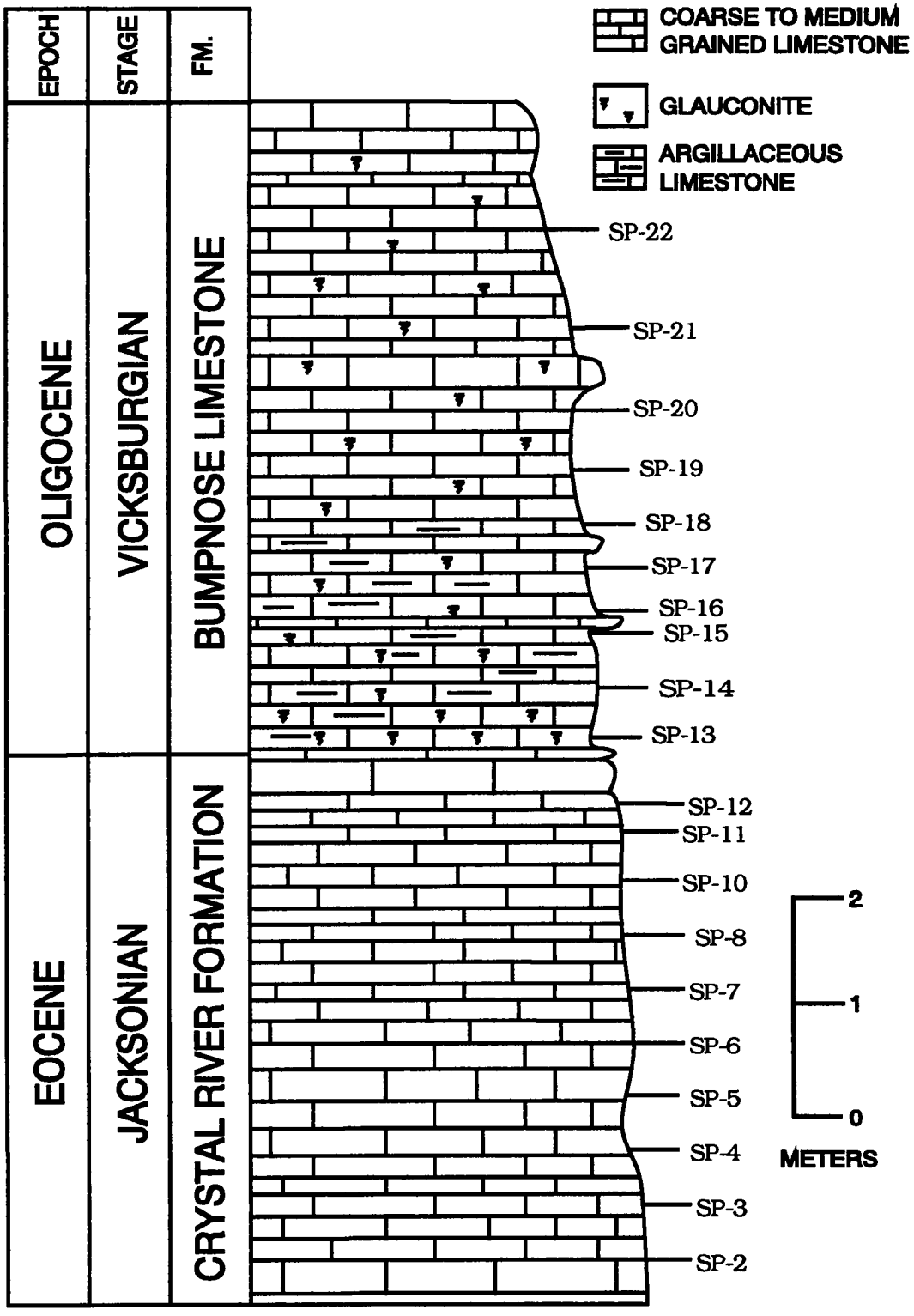


Figure 6. Composite measured section of the Sepugla River Locality. Detailed section description in Appendix 3.

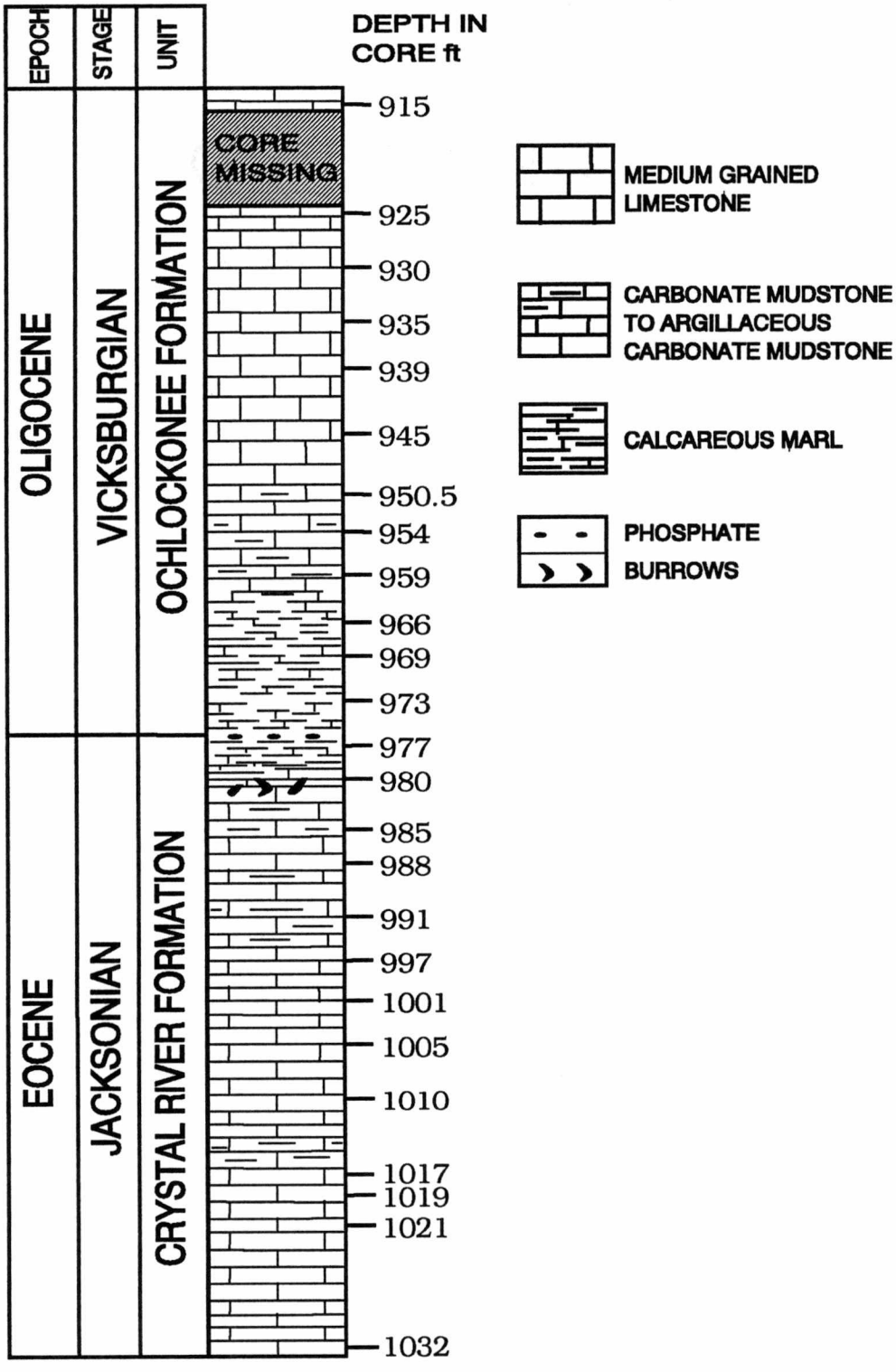


Figure 7. Measured section of the core GGS-3535. Detailed section description in Appendix 3.

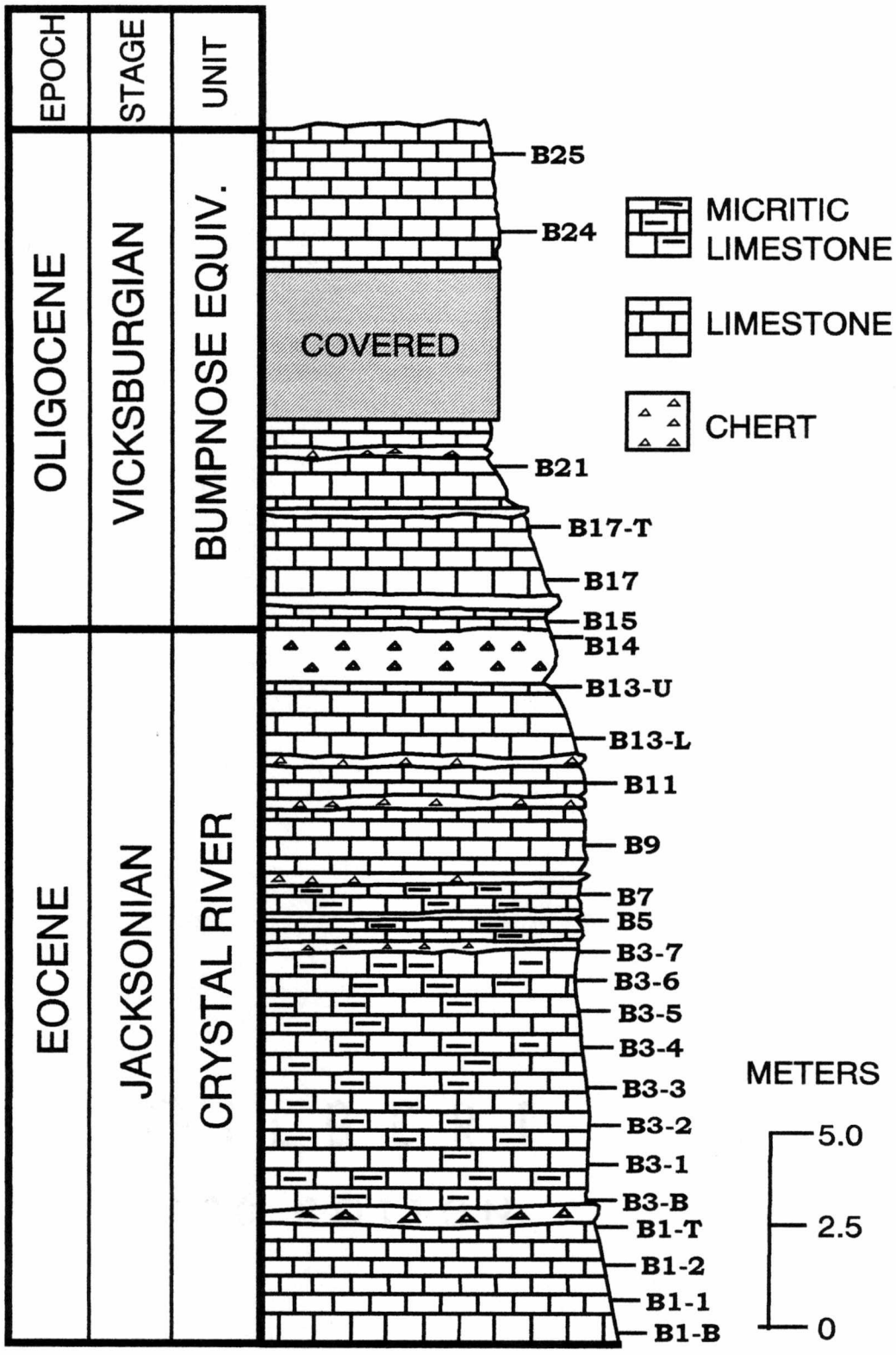


Figure 8. Measured section of the Brooksville locality. Detailed section description in Appendix 3.

presumed lower Oligocene unit(s) is not entirely clear. The Oligocene material is a chalky, occasionally chert rich, fossiliferous, white to tan limestone. Much of the appearance is similar to that of the Bumpnose Limestone, however a lack of glauconite and argillaceous material makes it distinct from the original description. This fact coupled with the presence of a large chert bed just below the presumed boundary and a lack of zonal microfossils renders judgment of the completeness of this section difficult. It may well be that in this section in contrast to the others in this study a significant unconformity exists at the Eocene-Oligocene boundary.

Sample collecting

Sample collection was in general based on the following scheme. In the area of the Eocene/Oligocene boundary the samples were collected at vertical intervals of 25 cm-100 cm and further apart away from the boundary. The spacing of samples was dependent on the lithologic conditions and in the core samples on the degree of recovery of material. In the Red Bluff type section the samples near the boundary were taken at 25 cm intervals to a distance of 2.5 meters above and 4.5 meters below the Red Bluff-Shubuta boundary. Preliminary examination of results from this section revealed little change between the samples away from the boundary at this scale thus other sections were samples at a larger interval. The Sepugla river samples were taken at an interval of 50 cm except when lithologic conditions prevented this (largely the presence of chert which prevents processing). In the GGS-3535 core the samples were taken at 1 meter interval near the boundary and at 2 meters away from the boundary in this case unequal sample interval is due to lithologic changes and/or to lack of recovery of core. The samples studied in the Brooksville section were archival and thus the sampling interval was pre-determined. This section was not resampled for this study due to lack of access. In the Brooksville section samples were taken at 1 meter intervals except at lithologic changes where samples were taken above and below the change. In this section, as with Sepugla River, the presence of chert in the section prevented equal sampling intervals.

Sample preparation

Sample from the clastic units were processed as follows. Moist sediment was tamped in a 25 ml beaker to the 5 ml line. The sediment was then dried in a oven for 48 hours, and then soaked in a larger (150 ml) beaker in a solution of Calgon for 48 hours to deflocculate the clays. The sample was then wet sieved on a 63 um sieve to remove clay and fine sediment. A 63 um sieve size was used because below this size most foraminiferal tests are juvenile and cannot be identified with any certainty (Murray, 1990). The residue was then dried and the process repeated until visual examination indicated all fines had been removed. The residue was then split into 1/8 using a sample splitter and all the benthic foraminifera in the sample removed and mounted on grid slides.

In the carbonate (limestone samples) samples were processed as follows. A small volume of the sample was crushed and boiled in a dilute solution of mirimine for one hour. The resulting material was wet seived on a 63 um screen to remove the fine material. The residue was dried and dry sieved on a 120 mesh screen to remove rock particles and large benthic foraminifera. 10 ml of the sieved material was split into 16^{ths} and all benthic foraminifera were picked and mounted on grid slides.

For all samples the foraminfera were identified either genus and species level or to genus level when degree of preservation prevented identification to the species level.

Test Preservation

Test preservation in this study varies from excellent to poor in general paralleling the changes in lithology in the region. In the clastic units (clay and poorly lithified marls), test preservation ranges from excellent to poor. In all but 6 samples preservation of tests was excellent. These six samples (SR-4 to SR-9) are all in the lowermost Oligocene (Red Bluff Formation) where the concentration of glauconite is the highest. While the Formation and significance of glauconite is not completely understood, it is authigenic and often develops in

areas of high organic matter (i.e. often in foraminferal tests and fecal pellets) and low sedimentation. In the samples with poor preservation many of the tests have been partially destroyed by glauconitic growth. In samples SR-6 and SR-7 this process, and other factors such as environmental conditions and diagenesis, have combined to completely destroy any foraminiferal tests in the samples.

In the Sepugla River samples, test preservation ranges from fair to poor. In general, the degree of preservation is directly related to the presence or absence of chert in the sample. In addition, some species with more delicate tests seen in the clastic units either have significantly poorer preservation or are not present possibly due to diagenetic alteration. In this section as with the clastic section the lowermost Oligocene samples contain glauconite and have a somewhat lower degree of preservation. Although the glauconite does not appear to have affected the tests to the same degree as in the clastic material.

In the core samples test preservation ranges from moderate to poor. Again the lower Oligocene samples have a lower degree of preservation than the Eocene samples. In this section there is little glauconite in the section except a thin layer at the boundary. However, there is some development of dolomite in the lowermost Oligocene samples that has effected test preservation and the rock is better lithified thus making extraction of clean tests more difficult.

In the Brooksville section test preservation ranges from moderate to poor. In this section test preservation is related to the presence of chert in the rock. In those beds where chert is abundant or makes up the majority of the rock, preservation is poor. In addition, the tests present and/or easily identified are those which are generally heavy well calcified species. As a result this section has the lowest species diversity of all those studied for this report. But, this may and probably does not, reflect the original biocoenose.

Data

Raw species counts are listed in Appendix 1. A total of 191 morphological forms were identified in the whole data set including species, forms identified only to the genus level and a single form which could not be assigned to described genera or species. No new taxa are formally described in this report, however, a significant number have been reassigned at the generic level to reflected changes in taxonomt since the last major revisions of benthic foraminiferal taxonomy in this region Bandy (1949) for clastic units, and Puri (1957) in the carbonate section. Many genera have either been shown to be invalid or limited by later workers (Loeblich and Tappen 1992). Generic definitions and higher level taxonomic assignments in this report follows that of Loeblich and Tappen (1992). Taxonomic descriptions are in Appendix 2

The Red Bluff type section (41 samples) contains a total of 186 forms of benthic foraminifera assigned to 60 genera. The Sepugla River section (21 samples) contains a total of 121 separate forms in 49 genera. The GGS-3535 section (26 samples) contains a total of 102 forms assignable to 101 genera. Finally the Brooksville section (25 samples) contains a total of 70 forms but only 67 forms were used in data analysis excluding unidentified and planktonic foraminifera which were not counted in the other sections.

Chapter 2. REGIONAL SETTING AND STRATIGRAPHIC RELATIONSHIPS.

Regional setting

During the Paleogene the eastern Gulf Coast shelf area was dominated by two large depostional systems a clastic wedge developing from the west and a carbonate blank/platform complex in the east and south. In addition several structural and/or depostional features influenced the development of the stratigraphic units. These features include the Peninsular Arch a structural high which trends North northwest in Peninsular Florida running north into southern Georgia where it influenced deposition in the Suwannee Strait/ Gulf Trough system (Huddlestun, 1988, Huddlestun 1993) (Figure 9).

The second major feature influencing deposition in the eastern portion of the Gulf Coast is the Suwannee Strait/Gulf Trough system (Chen, 1965; Sever, et al. 1967; Gelbaum, 1978, McKinney, 1984; Manker and Carter, 1987; Carter and McKinney, 1992; Huddlestun, 1993). This topographic low was present in northern Florida and/or southern Georgia through much of the Cretaceous and Tertiary (Carter and McKinney, 1992). Through the Paleogene this feature migrated to the north from a position oriented east-west along near the present state line to a position more northeast in orientation and running from the Apalachicola Embayment into southeastern Georgia where it apparently terminated (Huddlestun, 1988; Huddlestun, 1993) (Figure 5). This system lasted in different forms until the Miocene when progradation of clastic sediments from the rejuvenated Appalachians inundated the region filling the final remnant of the trough (Huddlestun, 1988; McKinney, 1984; Cater and McKinney, 1992).

The origins of the Suwannee system are not clear nor is the reason for its persistence as a topographic low, but its persistence may have been due to the Suwannee current that flowed across this feature slowing or stopping sedimentation (Pinet and Popenoe, 1985; Huddlestun, et al., 1988; Huddlestun, 1993). McKinney (1984) considered the Suwannee/Gulf Trough system to be a result of the interaction between clastic and carbonate sedimentary regimes. However, the

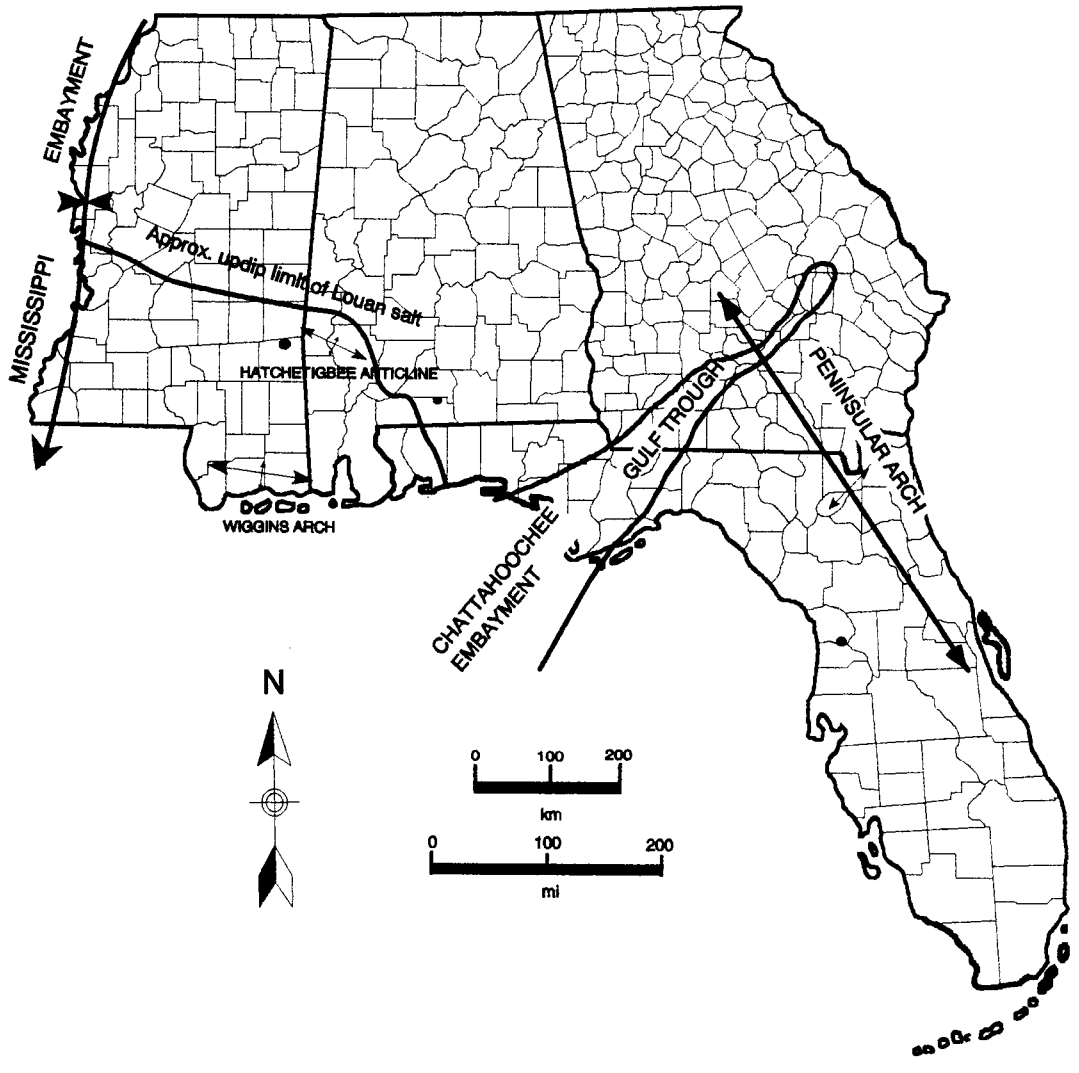


Figure 9. Features affecting sediment in the study area during upper Eocene and lower Oligocene

presence of carbonate facies on both sides of the low during the upper Eocene and lower Oligocene negate this argument for the late Paleogene. The original Formation of the Suwanee/Gulf Trough system may lay in the presence of ancient structural trends in the region resulting from the suturing of peninsular Florida on to the North American continent during the Late Paleozoic and Early Mesozoic (Huddlestun, 1993). Whatever the origin of and mechanism for maintaining the system this feature has had a profound influence on the development of sedimentary patterns and at times faunal distributions (Applin and Applin 1944; Moore, 1955; Chen, 1963; Carter and McKinney, 1992).

In the clastic-dominated regions to the west, the major features influencing depostional patterns and sediment types have been the Mississippi Embayment, Hatchetigbee Anticline, the Wiggins Arch and the possible influence of salt tectonics in related to the deep seated Jurassic salts in the Gulf of Mexico region (Manicini and Tew, 1991) (Figure 9).

The Mississippi Embayment is an elongate feature running north-south paralleling the coarse of the present Mississippi river. During the Tertiary this feature was a filling basin perhaps silled along the trend of the Ouachita Mountains (R. Flugeman, personal communication). Sediment input from rivers draining the North American Continent were the source for clastic sediments in the study area. This sediment input generally was from west to east in the study area (Moore, 1955; Mancicni and Tew, 1991)(Figure. 10). Variations in the amount and grain size of this clastic material was probably a function of the rate of input and water depth in any given spot. Changes in sediment input are a function of the denudation rate in the source region, which in turn is a function of climate and tectonic activity. Sea level would influence sediment delivery as follows: during low sea levels sediment would be transported across the shelf to the continental slope, conversely, when sea level was high, sediment deposition would mostly occur on the inner shelf and the outer shelf would be starved for sediment, resulting in formation of a condensed section and possibly a hiatus. See discussion of sequence stratigraphy below.

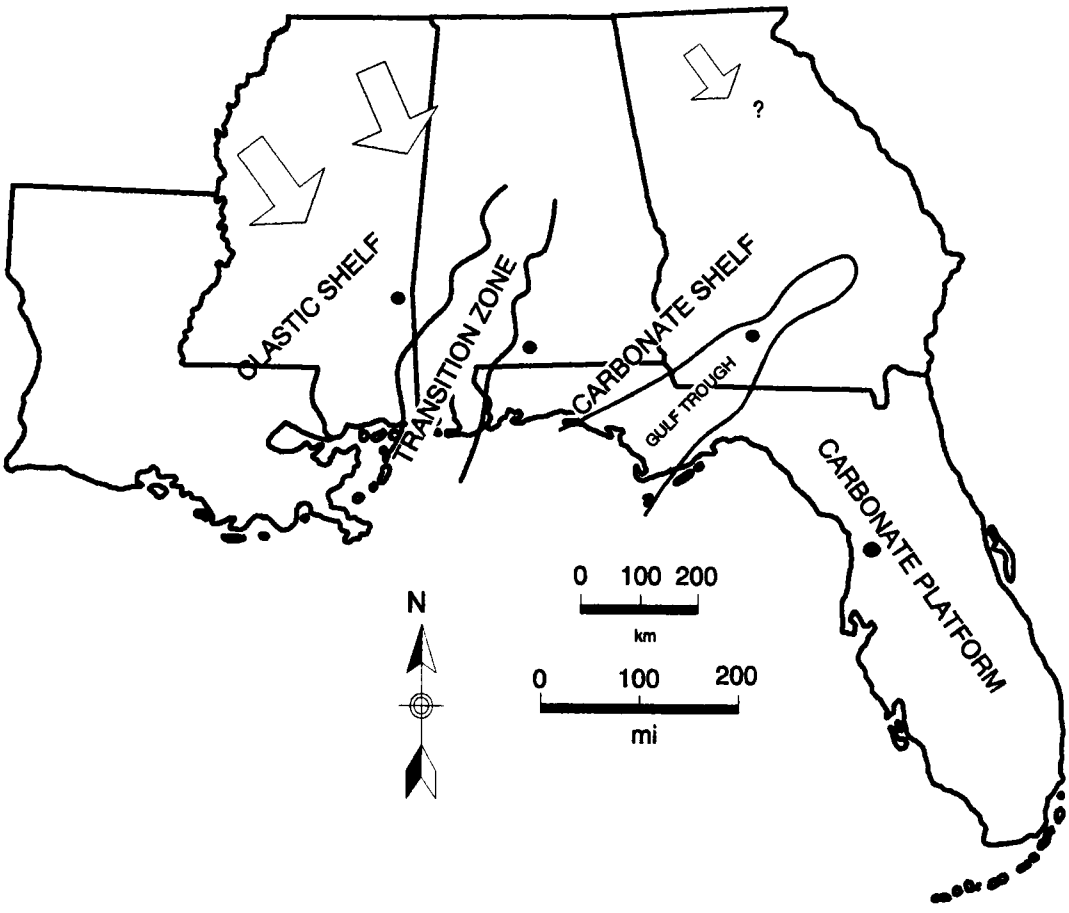


Figure 10. Direction of clastic input into the study area during the Late Paleogene. The eastern sorurce is spleculative based on lithologic occurrence

Lateral facies relationships

The lateral relationships between the units studied are as follows. In both the Eocene and Oligocene the clastic units thin to the east into a transition to the carbonate units. In turn the general trend of the carbonate units is thickening eastward away from the transition zone (Figure 11). Within the carbonate section lateral relationships are more complex. Whether the uppermost Eocene is present over the entire area and exactly which units correspond to which is unclear (Figure 12) (Hunter, 1977; Huddlestun, 1988; Huddlestun, 1993).

Vertical stratigraphic relationships

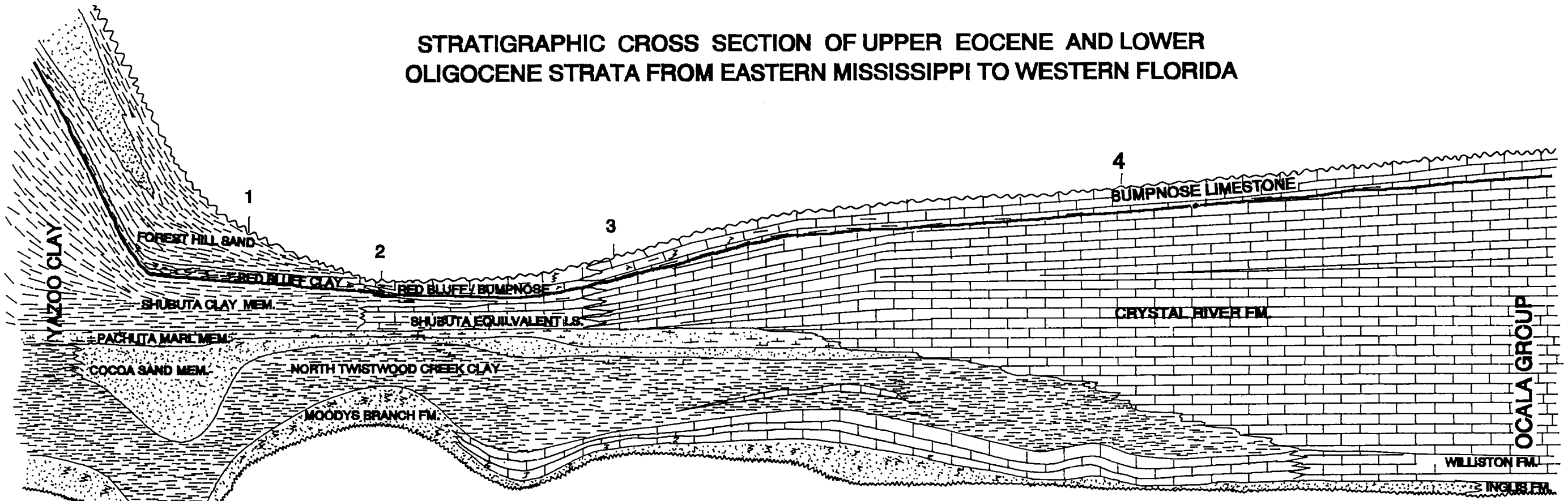
The nature of the contact between the Shubuta and the Red Bluff as well as the contact between the Bumpnose and Crystal River is somewhat uncertain. Many, if not most, workers traditionally have interpreted the contact to be at least somewhat disconformable (Figure 12)(Moore, 1955; Puri, 1957; Huddlestun, 1965; Waters, 1982; Dockery, 1983). In part this interpretation is based on lithologic change. The contact between the Shubuta and Red Bluff in eastern Mississippi is marked by an abrupt appearance of glauconite and a burrowed surface. In addition, the presence of some phosphate and quartz sand in the lower Red Bluff has led many workers to infer a diastem (Waters, 1982; Mancini and Waters, 1986; Dockery, 1992). In Alabama the boundary between the units is less clear. At St Stephen's Quarry, Jackson County, Alabama, the contact between the Shubuta and the overlying Red Bluff is more gradual, placed on the presence of shell hash, glauconite, and the more calcareous nature of the Red Bluff. Further east the amount of carbonate in the Red Bluff/Bumpnose increases and the contact is more abrupt. The contact between the carbonate units is also somewhat unclear. At the Sepugla River section, Huddlestun (1965) reported the presence of reworked Eocene fossils in the basal Bumpnose and interpreted this to indicate a diastem. Moore (1955) considered the contact between the Bumpnose and Red Bluff to be unconformable, but gave no reason for this. In peninsular Florida the Contact between the Crystal River and the overlying units is often

Figure 11. Lithofacies relationships and unit thicknesses of upper Eocene and lower Oligocene strata in the study area. Cross section runs from eastern Mississippi to western Florida. Numbers indicate areas examined by Author. 1) Wayne CO. Mississippi, 2) Jackson CO. Alabama, 3) Sepugla River Alabama, 4) Mariana Florida. Figure redrawn from Huddlestun (1965).

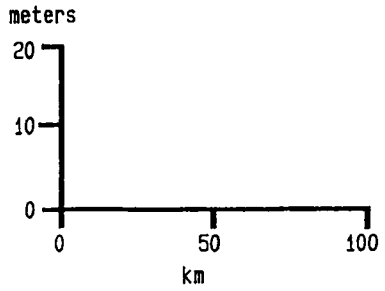
WEST

EAST

STRATIGRAPHIC CROSS SECTION OF UPPER EOCENE AND LOWER OLIGOCENE STRATA FROM EASTERN MISSISSIPPI TO WESTERN FLORIDA







CLAY

MARL

LIMESTONE

GLAUCONITE

SAND

A

EPOCH	STAGE	Huddlestun 1965	MANCINI AND WATERS, 1982	DOCKERY, 1985	MANCINI AND TEW, 1991
OLIGOCNE	VICKSBURGIAN	RED BLUFF FORMATION	RED BLUFF FORMATION	RED BLUFF FORMATION	RED BLUFF FORAMTION
			HIATUS	HIATUS	
EOCENE	JACKSONIAN	SHUBUTA MEMBER	SHUBUTA MEMBER	SHUBUTA MEMBER	SHUBUTA MEMBER

B

EPOCH	STAGE	Moore, 1955	Huddlestun 1965	Mancini and Waters, 1982	Mancini and Tew, 1991	Huddlestun, 1993	
OLIGOCNE	VICKSBURGIAN	Bumpnose Formation	Bumpnose Formation	Bumpnose Formation	Bumpnose Formation	Ochlockonee Fm.	Bumpnose equivalent
		HIATUS	HIATUS	HIATUS		HIATUS	
EOCENE	JACKSONIAN	Crystal River Foramtion	Crystal River Foramtion	Crystal River Foramtion	Crystal River Foramtion	Crystal River Foramtion	

Figure. 12 Interpretations of vertical stratigraphic relationships. A. In the clastic units B. In the carbonates.

considered unconformable (Hoganson, 1975). However, the lithologic change in this area may be more indicative of a change in water depth than any gap in time.

In part, the inference of an unconformable relationship between the Eocene and Oligocene was strengthened by the initial development of world wide eustatic sea level curves. In the early versions of these curves a rapid sea level fall was placed at or near the E/O boundary resulting the exposure of the shelf and Formation of a sequence bounding unconformity (Figure 13) (Haq and Hardenbol, 1979; Mancini and Waters, 1983). Thus, features observed at the lithologic boundary were interpreted to signify a diastem (Waters, 1982). In more recent versions of coastal onlap the E/O boundary is interpreted to correspond to a sea level high stand and thus the features observed at the boundary as a result of sediment starvation and development of condensed section (Figure 13) (Baum, Vail, and Hardenbol, 1982; Baum and Vail, 1988; Mancini and Tew, 1991). Thus the same features have been interpreted to mean almost opposite events. Partly this might be due to the nature of condensed sections, which are characterized by very low sedimentation rates, burrows and the development of authigenic minerals such as glauconite, pyrite and phosphate (Baum and Vail, 1988).

Interpretation of the E/O boundary on the carbonate platform is more vague. The lack of global biozone markers in much of this material and post-depositional erosion has made the location of the boundary difficult. However, if the eustatic sea level, curve interpretations are applied to the Florida Bank environmental setting a set of predictions can be developed. If the latest Eocene was a time of sea level fall the platform would have been exposed resulting in a slow down or stopping of carbonate production, and transport to deeper waters as production was confined to the margins of the platform (Schlager, 1989). This would result in the development of an uneven probably karstic surface on the exposed bank overlain by shallow water deposits of the following transgression(Schlager, 1989). If in contrast the E/O boundary was a time of sea level high stand followed by fall as suggested by Baum and Vail (1988), the

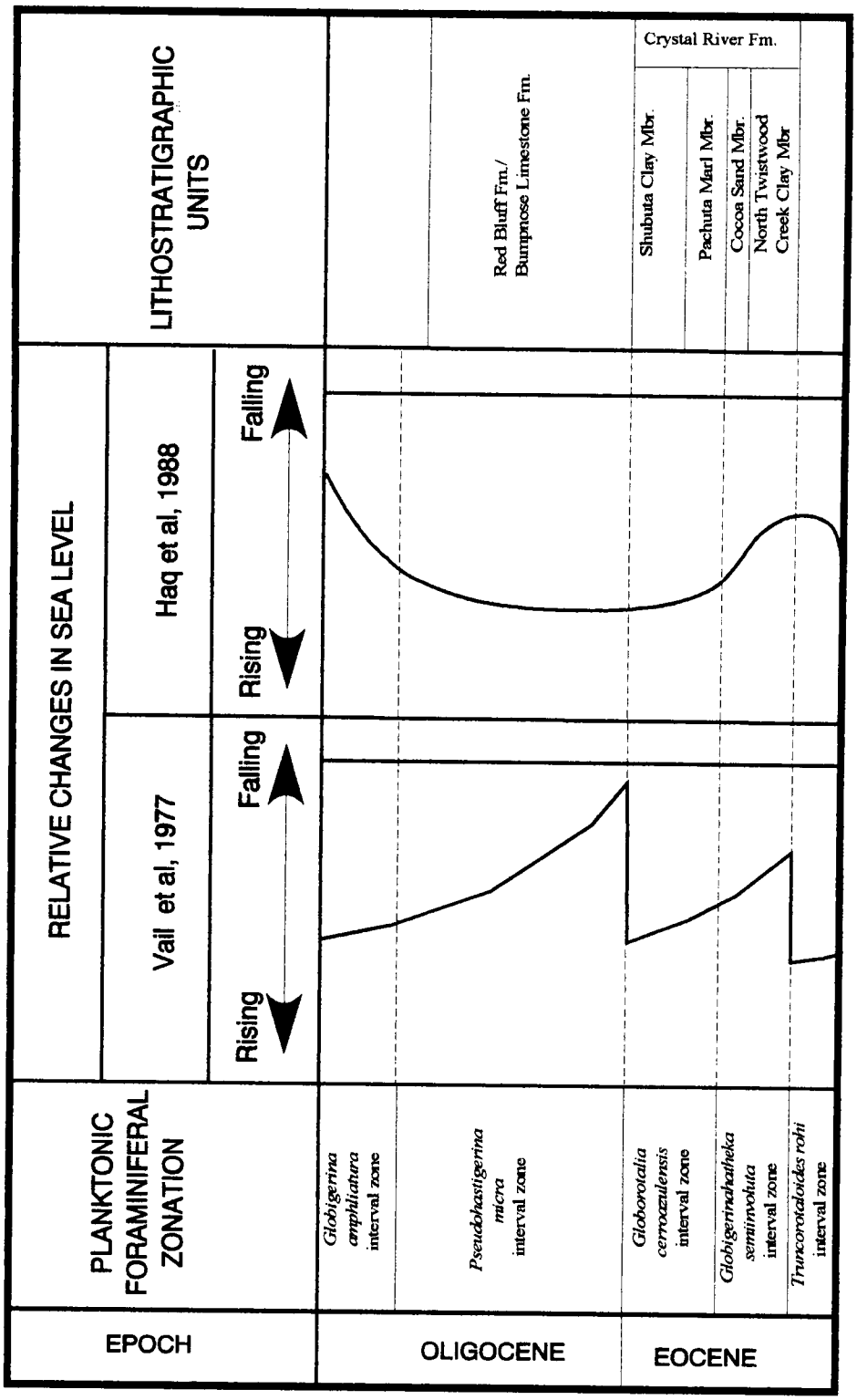


Figure 13. Relationship between postulated sea level curves, lithostratigraphic units and biostratigraphic zones in the eastern Coastal Plain.

platform would be expected to either maintain relatively shallow water production, become fragmented, or drown depending on its ability to keep up with sea level change (Schlager, 1990)

Biostratigraphy

At the stratotype of the Eocene/Oligocene the boundary is placed at the last occurrence (LO) of the planktonic foraminiferal genus *Hantkenina* (Berggren, et al. 1992). This is equivalent to the boundary between plankton zones P17/P18(Berggren, et al. 1992). In the study area the Red Bluff and Sepugla River sections contained relatively abundant, well preserved planktonic foraminifera. In the GGS-3535, core planktonic foraminifera were poorly preserved and identification was difficult. The paleoenvironmental setting of the Brooksville section (i.e. shallow water carbonates) makes the presence and/or preservation of planktonic foraminifera unlikely. They are only present in very low abundance in shallow water (Boersma, 1977); additionally, the diagenetic environment of shallow water, coarse grained carbonates is such that the more delicate tests of the planktonic foraminifers would be unlikely to sbe preserved. Thus the lack of good biostratigraphic markers forces one to rely on local zonations and extrapolation to sections containing planktonic foraminifera to locate the E/O boundary in this section.

The top of the P17 zone is defined by the LO of *Globorotalia cerroazulensis* (Stainforth et al. 1975). The base of the P17 zone is defined by the extinction of *Globigerinatheka semiinvoluta*. This is generally coincident with the range of *Cribrohantkenin inflata*. The extinction of the genus *Hantkenina*,first occurrences of *Globigerina gortanii* and *Globigerina ampliapertura* also characterize this zone (Figure 14).

The base of the *Pseudohastigerina micra* interval zone (P18) is marked by the extinction of all subspecies of *Globorotalia cerroazulensis* and the extinction of *Globigerinatheka*, *Hantkenina*, and *Cribrohantkenina* (Stainforth et al., 1975). *Globigerina ciperoensis* , *Globigerina gortanii* and *Globigerina ampliapertura* characterize this zone. However, of these species only *G. ciperoensis* first occurs in the Oligocene. The top of the *Pseudohastigerina micra* zone is

defined by the extinction of species of *Pseudohastigerina* (Stainforth and others 1975) (Figure 14).

The biostratigraphy of the study area has been studied by several workers ((Bandy, 1949; Cheetham, 1957;Huddlestun, 1965; Mancini, 1979; Stainforth and Lamb, 1981; Bybell, 1982;Waters and Mancini, 1982; Keller, 1985; Huddlestun and Hetrick, 1986; Mancini and Tew, 1991). These studies have resulted in a variation in the location of Eocene/ Oligocene boundary. In part this depends on the taxonomic group used to establish the boundary. In particular the upper most Eocene zone of planktonic foraminifera and calcareous nannoplankton do not coincide world wide with the nannoplankton boundary occurring somewhat before the foraminferal boundary (Berggren, 1992).

Although the standard for the E/O boundary has been established using planktonic foraminifera the placement of the boundary in the study area has been a source of debate. Most workers have placed the boundary at or very near the Shubuta/Crystal River- Red Bluff/Bumpnose contact (Bandy, 1949; Huddlestun, 1965; Stainforth and Lamb, 1981; Waters and Mancini, 1982; Huddlestun and Hetrick, 1986; Mancini and Tew, 1991). In contrast, other studies have placed the boundary at the contact between the Shubuta and Pachuta marls (Cheetham, 1957; Mancini, 1979; Bybell, 1982; Keller, 1985). Part of the disagreement about the placement of the boundary is inherent in the nature of the planktonic zonations. Both of the uppermost Eocene and lowermost Oligocene zones are interval zones based on the occurrence of several taxa, not the range of a single species (Stainforth et al. 1975). In part this is necessary due to environmental controls on the distribution of planktonic foraminifera. In addition, the top of zone P17 is defined by the extinction of a group of taxa (i.e. all subspecies of *G. cerroazulensis).* Dependence on extinction rather than origination as the marker for the base of a biostratigraphic zone results in less certainty in location of the zonal boundary. Reworking of specimens can in this case shift the boundary up section. Biostratigraphic zones based on first occurrences are often more accurate as reworking cannot shift the location of the boundary although delayed

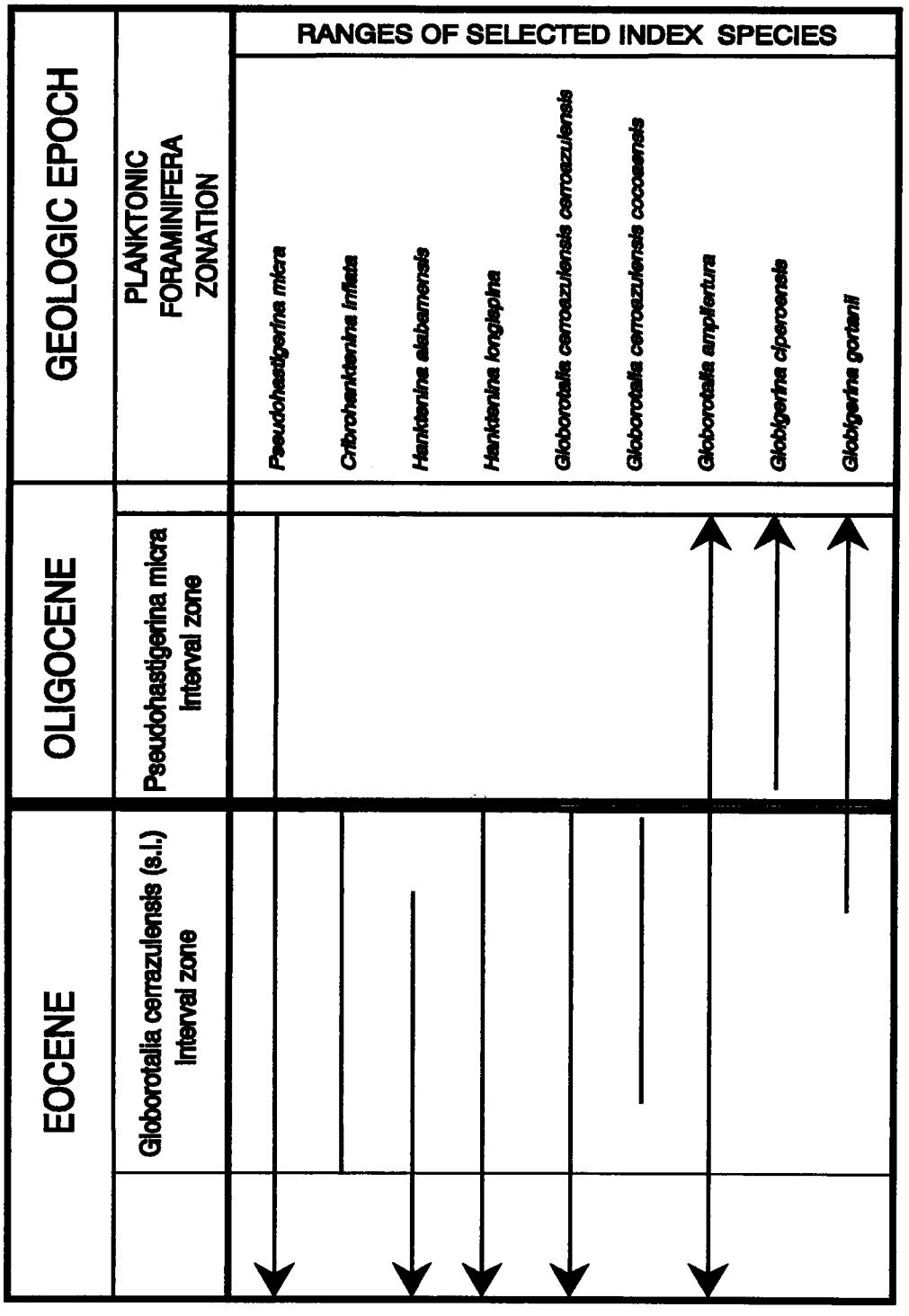


Figure 14. Ranges of selected biostratigraphicaly important foraminifera species (modified from Stainforth et al. 1975).

appearances can. Further complicating the identification of the zonal boundary in the study area is the lack of originations of biostratigraphicaly useful planktonic foraminifera in the lower Oligocene only 1 of the species (*G. ciperoensis*) characteristic of zone P18 has a FO near the boundary (Stainforth et al. 1975).

Keller (1985) contended that the presence of species characteristic of the P17 zone in the Shubuta clay are a result of reworking and thus the E/O boundary is actually well below the lithologic boundary between the Shubuta and Red Bluff.

In the sections examined in this study biostratigraphicaly important planktonic foraminifera were recovered from the Red Bluff, Sepugla River, and GGS-3535 sections. At Red Bluff well preserved specimens of *G. cerroazulensis* where identified in sample SR-13 and below. In addition, *G. cerroazulensis* was tentatively identified in the sample SR-11 just below the formation boundary. *Hanktenina alabamensis* is present over much of the same interval. Thus species characteristic of zone P17 are present to within 1 meter of the lithologic boundary between the Shubuta Member and Red Bluff Formation. Species characteristic of the *P. micra* zone where found in samples SR-2 and SR-3 establishing the assignment of the Red Bluff to zone P18. The most characteristic species of this zone *G. ciperoensis* was not noted in these samples but was noted further up section. The results from this study are in close agreement with those of Waters (1982). In that study the presence of *G. cerroazulensis* was noted to within 1 foot of the lithologic boundary in the same area. This places the Eocene/Oligocene boundary at or very near the lithostrtigraphic boundary.

At Sepugla River *G. cerroazulensis* was found in several samples including SP-11 approximately 1 meter below the Formation boundary. In addition, to the occurrences of *G. cerroazulensis* noted in this study Huddlestun (1965) noted the presence of this species to the top of the exposed Crystal River and in lower 2 feet of the Bumpnose Limestone. Waters (1982) reported the presence of *G. cerroazulensis* to the top of the Crystal River and *H. alabamaensis* in the lowermost 1.5 feet of the Bumpnose Limestone in this section, but considered these

specimens to be possibly reworked. This is in agreement with Huddlestun (1965) who considered Eocene macrofossil material in the lowermost Bumpnose to be reworked. However, it is possible that in this section the transitional nature of the E/O makes exact placement of the zonal boundary difficult. Also it should be noted that in this section the contact between the Crystal River and Bumpnose is difficult to locate except at very low river stages and the lowermost sample of Bumpnose in this study is somewhat above the Formation contact.

In the GGS-3535 core *G. cerroazulensis* was found close to the presumed (lithologic) boundary but in this case the preservation of planktonic foraminifera was of poor quality and zonal species were not found in either the uppermost Eocene or lowermost Oligocene samples. However, a study of this core by Huddlestun (1988) has noted the presence of zonal marker species for both P17 and P18 placing the zonal boundary near 976 feet down core at the lithologic break. The occurrence of *G. cerroazulensis* in sample S985 supports this assignment.

In contrast to the other 3 sections planktonic foraminifera are extremely rare in the Brooksville section and the zonal markers are mostly absent. *G. cerroazulensis cocoaensis* occurs in 2 samples in the lower part of the section. The other 2 planktonic species noted in these samples are long ranging, non-diagnostic species. In this case the E/O boundary has been placed on the basis of extinction of *Lepidocyclina oclana*, and on macrofossil zonations particularly the presence of *Rotularia vernoni* which is characteristic of the upper Crystal River and disappearance of Echinoids of the *Oligopygus* zone which marks the Oligocene (McKinney and Zachos, 1983). However, the *Rotularia vernoni* zone has been placed in both the Oligocene and Eocene (see Above) and macrofossil zonations tend to be of a coarser scale than microfossil zonations, thus the placement of the E/O boundary in this section may not correspond exactly to that in the other sections.

Eocene- Oligocene boundary placement

The placement of the Eocene/Oligocene boundary in the Gulf Coast has been uncertain. In the clastic units the boundary has been most often placed at the contact between the Shubuta and Red Bluff. In carbonates in Alabama the location of the boundary is, for the most part, placed at the contact between the Crystal River and the Bumpnose Formations (Huddlestun, 1965; Hoganson, 1972; Waters, 1982). This boundary represents the same lithologic boundary as seen in the clastic units and is also supported by the presence of Planktonic Foraminifera (Huddlestun, 1965; Mancini and Waters, 1983).

In peninsular Florida the Eocene-Oligocene boundary has usually been placed at the top of the Ocala group, the top of the Crystal River (Puri, 1957). However, there are several reasons for doubt about this placement. First, the age of the top of the Ocala is based almost exclusively on macrofossils (Hoganson, 1972). Second, what microfossil work that has been done is based on Benthic foraminifera and probably not correlatable with much of the rest of the Gulf coast (Puri, 1957; Mancini and Waters, 1982). For the most part these units do not contain the fossils on which most biostratigraphic zonations are based. Finally the range and even in some cases the age of the reference sections for some of the macrofaunal markers is uncertain (Nicol et al. 1989). In much of northern Florida, the upper part of the Crystal River is composed of a distinct faunal zone named for the spirobid worm tube *Rotularia vernoni* zone (Hoganson, 1972). The precise age of this zone is not clear. Much of the fauna is either definitely or presumed to be of Eocene affinities. However, enough is of Oligocene in character to cast uncertainty as to the age of the unit (Hoganson, 1972; Nicol and Jones, 1982). No published studies of this unit have contained inFormation on vertical fossil distribution within the unit, thus it is possible that it straddles the E/O boundary and those elements of the fauna that have Oligocene affinities are actually Oligocene in age (Hoganson, 1972; Nicol et al. 1976; Nicol et al. 1986). Puri (1957) included the Bumpnose, or units equivalent to it, in the upper Crystal River. However, the lack of *G. cerroazulensis* in this unit indicates it is of Oligocene age (Huddlestun, 1965).

Many authors have considered the contact between the Crystal River and the Oligocene units in the study area to be unconformable, although the duration of this presumed unconformity is uncertain, its existence in some areas seems to be based more on an assumption than on hard evidence or on the basis of minor lithologic changes (Hoganson, 1972). In part the assumption of an unconformity is apparently based on a traditional view that the E/O boundary is always represented by an unconformity and on the earlier versions of sequence stratigraphic models which called for a sea level drop associated with the E/O boundary.

Stable isotopic evidence

Stable isotopes of oxygen and carbon have been frequently used as stratigraphic markers in the deep sea and have the potential for use in shelf sequences. In the deep sea record there is a prominent positive shift in Oxygen isotope values occurring somewhat after the boundary (Miller, 1992)(Figure 15). The location of this feature in Gulf Coast shelf sections would provide an independent stratigraphic marker.

In the Red Bluff type section a positive shift of approximately 1 $^{o}/_{oo}$ occurs 2 meters below the lithologic boundary indicating that at least in this section the Jackson-Vicksburg boundary may not be equivalent to the Eocene- Oligocene boundary (Figure 15). The certainty of this shift is lessened by the use of *Siphonina spp* as a source for the isotopic data, a group not generally used and which may not yield reliable results. In the rest of the study region isotopic results on foraminifera from shelf sediments have yielded unusable data (Kegwin and Corliss, 1986). In addition, whole rock isotopic analysis was conducted on samples from 2 cores in the Gulf Trough region. The whole rock samples show a negative 1 $^{o}/_{oo}$ shift in cores from southern Georgia across the lithologic, and foraminiferal boundary (Figure 15). Thus the use of isotopic evidence for the placement of the E/O boundary in the Southeastern Gulf Coast is not at the present time possible. However, the potential is there.

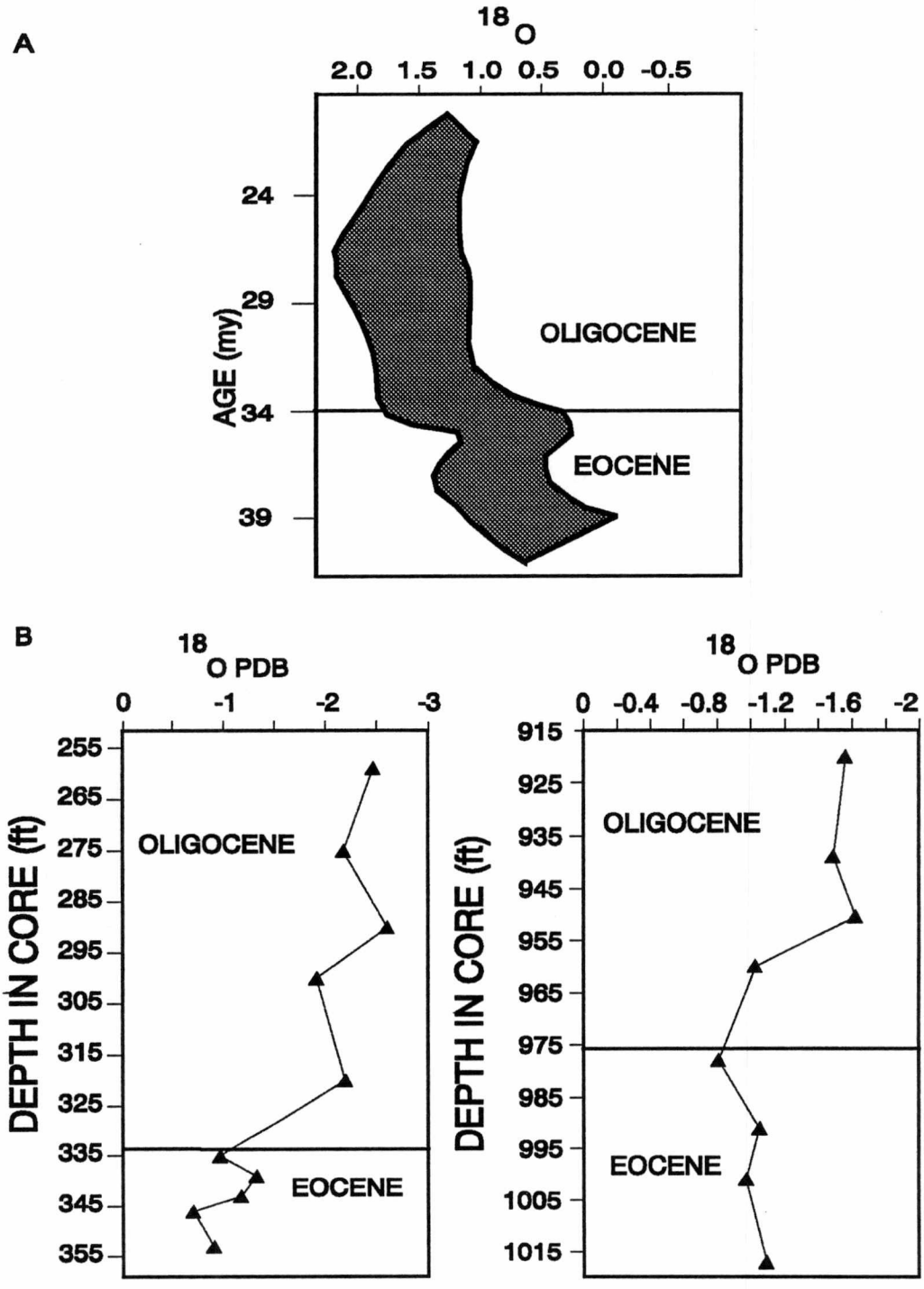


Figure 15. Changes in oxygen isotope composition across the Eocene/Oligocene boundary. A. Range of values recorded from the deep sea (after Kegwin and Corliss, 1986). B. Values recorded in two cores from southern Goergia (Frederick, Unpublished data).

Chapter 3 REGIONAL DEPOSITIONAL MODEL

Prevoius models

Depositional models for the region have been developed by several workers (Mancini and Tew, 1991; McKinney, 1984; Coleman, 1983; Waters, 1983; Huddlestun, 1965; Chen, 1963). Many of models for the Gulf Coast have been limited by being restricted to a portion of the region.

The thinning of the Shubuta and Red Bluff to the east and to some extent the thinning of Crystal River and Bumpnose to the west into the transition zone has important implications for interpretation of paleoenvironmental setting and models of stratigraphic development. Mancini and Tew (1991) have interpreted this transition as representing the influence limit of salt tectonics. The transition between lithofacies corresponds, in a general way, with the up-dip limit of deep seated Jurassic Salt (Mancini and Tew, 1990; Mancini and Tew, 1991)(Figure 9). Thus, they interpreted the transition as representing the dividing line between the lithofacies as separating an area of stable carbonate platform to the east from a more rapidly subsiding basin to the west. With the rate of subsidence controlled to at least some extent by salt movement and high clastic input. During the uppermost Eocene and lowermost Oligocene time the main source of clastic sediment in the study area was from a deltaic system to the west (Dockery and May, 1981). This system was well developed in the lower Oligocene as can be seen from the presence of the largely nonmarine Forest Hill Sand, the westward lateral equivalent of the Red Bluff, in western and central Mississippi (Dockery and May, 1981).

A second model for the location of the transition zone and its significance is one of sediment interaction. Walker and others (1983) proposed a model of carbonate suppression in which the influence of distal clastic input will suppress carbonate production (Figure 16). As a result, in areas of carbonate to clastic transition a region of thinned strata is present with both facies thickening away from the area. In addition, such zones are local deeps. This

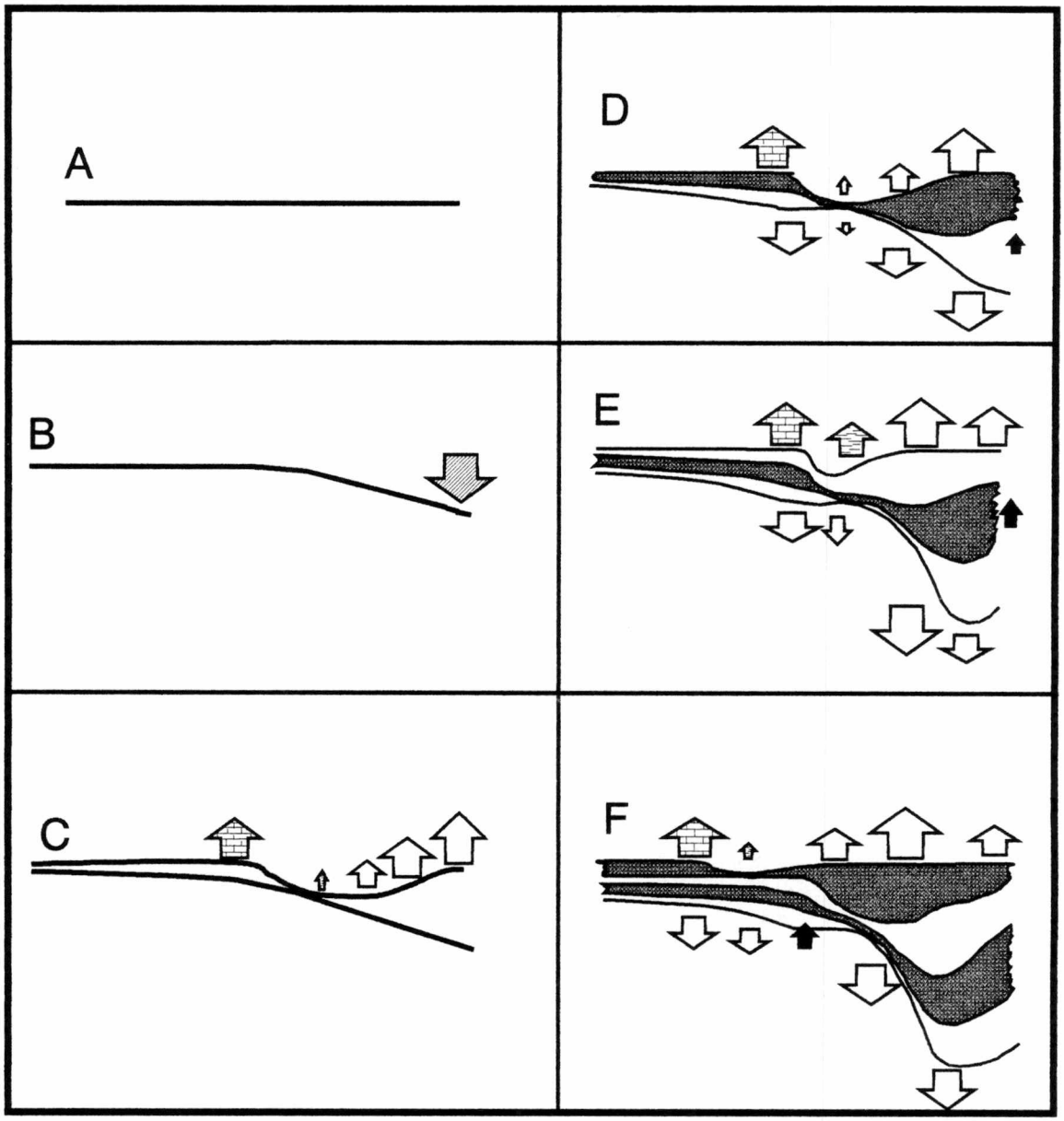


Figure 16. Graphical representation of the "carbonate suppression" model (modified from Walker et al. 1983). Up arrows indicate represent type and rate of sedimentation. Down arrows represent subsidence caused by sediment loading. Area of arrows is proportional to amount of sedimentation or loading. Letters indicate different times. This model shows a progressive retreat of the carbonate facies due to clastic influx.

interpretation would not only account for the presence of the thinned transition zone but the apparent differential subsidence in the transition zone and apparently contradictory trends in paleoecologic settings in the upper Shubuta (Sobba, 1975). McKinney (1984) used the carbonate suppression model to explain the development of the Suwannee strait/ Gulf Trough system. However, this model would be better applied to the transition zone between dominant facies in southern Alabama due to the presence of carbonate deposition on both flanks of the Gulf Trough during the late Eocene and early Oligocene (Huddlestun and Hetrick, 1989; Carter and McKinney, 1992).

Coleman (1984) modeled the Vicksburgian carbonate strata in the Gulf Coast, including the Bumpnose as a carbonate platform merging with clastic units to the west. While this model did not directly deal with the Jacksonian units, the implication seems to be that the environment was similar. In a similar vein is the work of Waters (1982).

Sabbo (1975) did not, as with many studies of the region, construct a complete depostional model for the Shubuta but indicated a outer shelf to slope setting with a minor regression in the upper Shubuta. However, the presence of deeper water faunas in the Shubuta at the type section and at St. Stephens Quarry, Alabama required the postulation of a cold water current resulting in deeper water appearance of the fauna in these sections as opposed to the area to the east. This trend would be explained by Mancini and Tew (1991) as increased subsidence to the west. Recent depostional and stratigraphic models of the study have been to a large degree based on concepts of sequence stratigraphy (Huddlestun and Hetrick, 1986; Waters, 1982; Mancini and Tew, 1990, 1991; Gaskell, 1991; Flugeman, 1989; Huddlestun, 1993).

The basic concepts behind sequence stratigraphy were developed by Vail et al. (1977). Simply stated, this model for the development of stratigraphic sequences depends on eustatic sea level change to control initiation, placement, and termination of depositional packages. This model predicts that shelf deposits, particularly clastic sediments, will form as conformable depositional packages separated by unconformities which can be traced basinward to correlative

conformities (Figure 17)(Vail et al. 1983). In this system several distinctive features will form. First, there are 2 types of unconformities depending on whether a drop in sea level reached the shelf edge or not. A type 1 unconformity develops when sea level drops below the shelf edge and thus the shelf is exposed to erosion and incision as streams adjust to the new base level. A type 2 unconformity develops when sea level does not reach the shelf edge but does drop enough that sediment is by passed across the shelf to the deep ocean basin (Figure 18). The second major feature which will develop a condensed section which forms during the highest sea level in a cycle. At this time, due to transgression the shore line will move relative far inland and sediments will be trapped on the inner shelf. As a result, most of the shelf will be starved for sediment resulting in a condensed section (Figure 18). Sea level changes occur at many different scales. As a result, the cycles of change postulated to control deposition of sediment packages can be arranged in a hierarchical pattern with several smaller cycles occurring within each large cycle. The postulated driving force behind cycles of sea level change depends on the scale. For the third and fourth order (small) cycles variations in climate driven by the Milankovitch cycle have been suggested (Vail et al. 1983). The large scale eustatic changes necessary for first and second order cycles probably require a driving force related to plate tectonic events.

Note that this model is dependent on sea level rise and fall as the overriding control on sedimentation, as opposed to tectonic events, changes in climate, sediment source or sediment type. In the strictest interpretation of this model, essentially all changes in depostional systems are tied to sea level but most workers would not adhere to this standard and allow for local modifying of the system by tectonic or climatic forcing.

Sequence stratigraphy should be particularly applicable to passive margin setting, such as the Gulf and Atlantic Coastal plains, where the tectonic setting is relatively quiet and sea level could have an important, if not dominant, influence on the patterns of deposition. Thus, the study area provides a classic area for the application and testing of sequence stratigraphic models

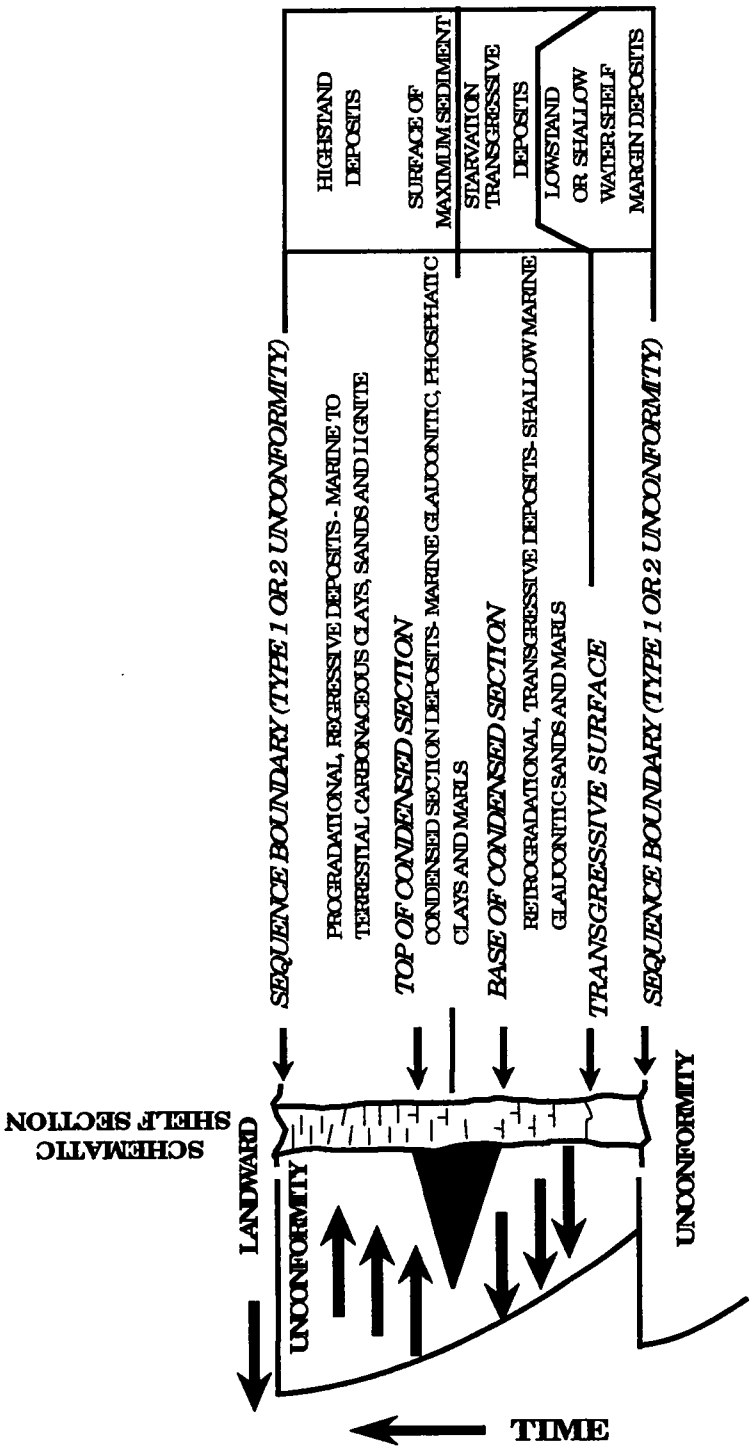


Figure 17. Typical shelf geologic section in relationship to a coastal onlap cycle (modified from Baum and Vail, 1988).

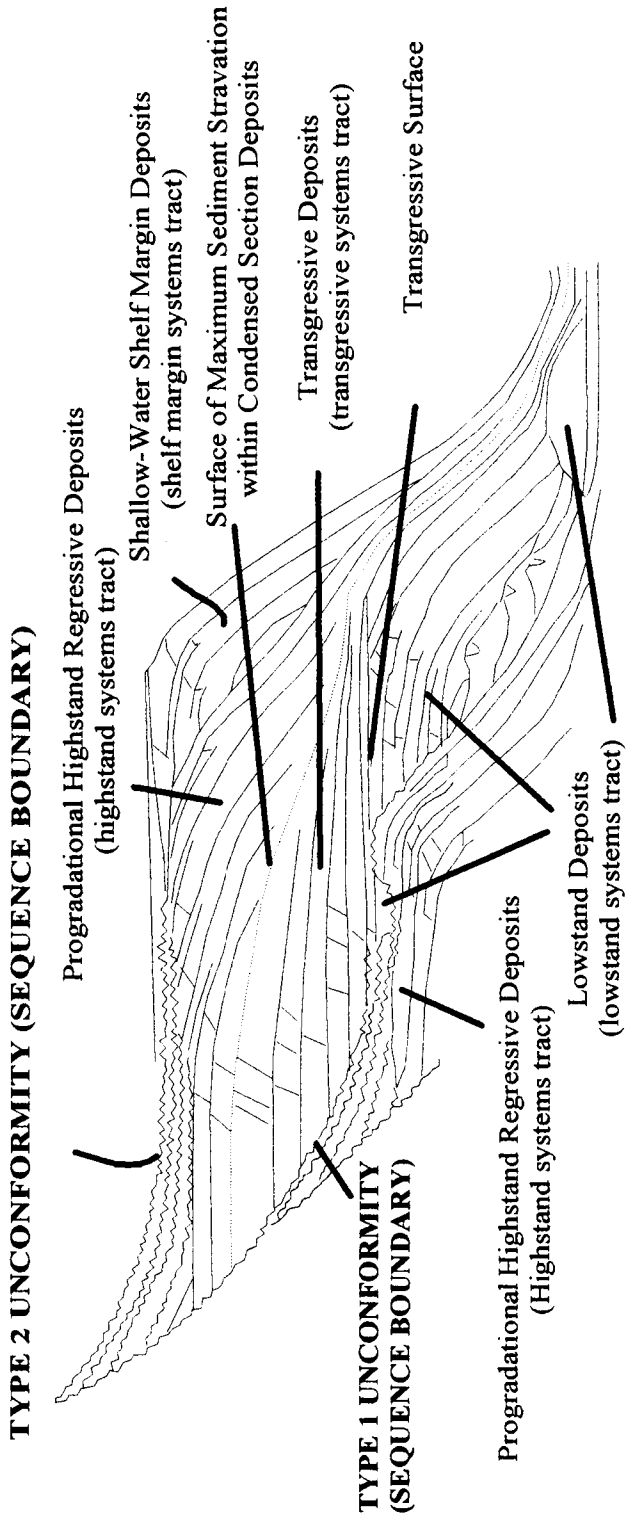


Figure 18. Type 1 and type 2 depositional sequence models illustrating erosional surfaces and depositional sequence components (from Baum and Vail, 1988)

(Baum et al. 1990). Of particular importance in the study area is the presence of both carbonate and clastic units. Carbonate sedimentation will react to sea level change independently of and with at least some differences from clastic dominated sedimentation. One major difference is the response to high stands. Schlager and Ginsberg (1981) have pointed out that particularly on carbonate banks and platforms high sea level will result in higher rather than lower rates of sedimentation since carbonate sediments are produced *in situ.* As a result, the amount of sediment delivered to deep water environments near the platform will increase, not decrease, during high stands opposite the pattern predicted for clastic sediments. In contrast, during low stands of sea level shallow water carbonate production will either be shut off completely or restricted to the edges of the steep sided platform/ bank. Thus, less, not more, material will be available for transport to the deep water environment. One additional factor separates carbonate from clastic dominated facies. Since carbonate production is restricted to the photic zone (<100m depth) and often the highest rates of production to the shallow photic zone, relatively small drops in sea level will result in exposure of the producing area (Schlager and Ginsberg, 1981). This combined with the relatively ease by which carbonates are weathered should result in the development of karstic and soil horizons during low sea level making excellent markers for regressional events.

In the study area, the presence of both shelf clastic units shelf carbonates and platform/bank carbonates means that any model which relies on sequence stratigraphic analysis and models has to be consistent in a range of environments. Development and testing of models of stratigraphic development can then be conducted in a single region with sedimentary environments which will react differently to sea level changes.

Early versions of sea level curves developed for sequence stratigraphy tended to have very abrupt regressions followed by slower sea level rises (Vail et al. 1977). In these models a small sharp regression was postulated spanning the Eocene/ Oligocene boundary followed by a sea level rise then a large (type one) regression in the early Oligocene (Haq, et al. 1983) (Figure

13). Using this model as a guide, Waters (1982) interpreted the E/O boundary in eastern Mississippi and southeastern and south-central Alabama to be disconformable. Also using the Haq et al (1983) curve, other workers have extended the geographic extent of this unconformity throughout the eastern Gulf coast (Huddlestun and Hetrick, 1986; Dockery and May, 1981; Huddlestun, 1993). However, recent revisions of the eustatic curves have omitted the regression at the E/O boundary and instead interpreted the boundary time as a high stand (Figure 13)(Haq et al. 1988). Following this model, Mancini and Tew (1991) and others, using the same evidence as previous workers, have interpreted the E/O boundary in the study area as a condensed section. These two different models can be tested by examining the nature of the E/O boundary throughout the study area in both shallow and deep water facies to see which is most consistent with the observed trends and data. From this, a depostional model and paleoenvironmental setting for the entire study area can be constructed.

Predicted Patterns

The data in the clastic and deeper water portions of the carbonate facies can and has been interpreted to support both models. Therefore the pattern of stratigraphic development in the carbonate dominated eastern portion of the study will be extremely important in determining which model best fits the regional patterns.

Following the Haq et al (1983) curve, a sea level rise in the late Eocene and a sharp drop at the E/O boundary the following features would be predicted on the Florida bank (Figure 19). First, a deepening upward cycle during deposition of the Crystal River Formation developed to varying degree depending on setting. In sections close to areas that were subaerially exposed, the presence of repeated exposure surfaces and small-scale cycles would be expected due to local facies shifts. This would be followed by a deepening upward trend as the shore line migrated away from the locality. In sections located further offshore only a deepening upward cycle would be present with occasional interruptions (Figure 19). Second, in both cases, the

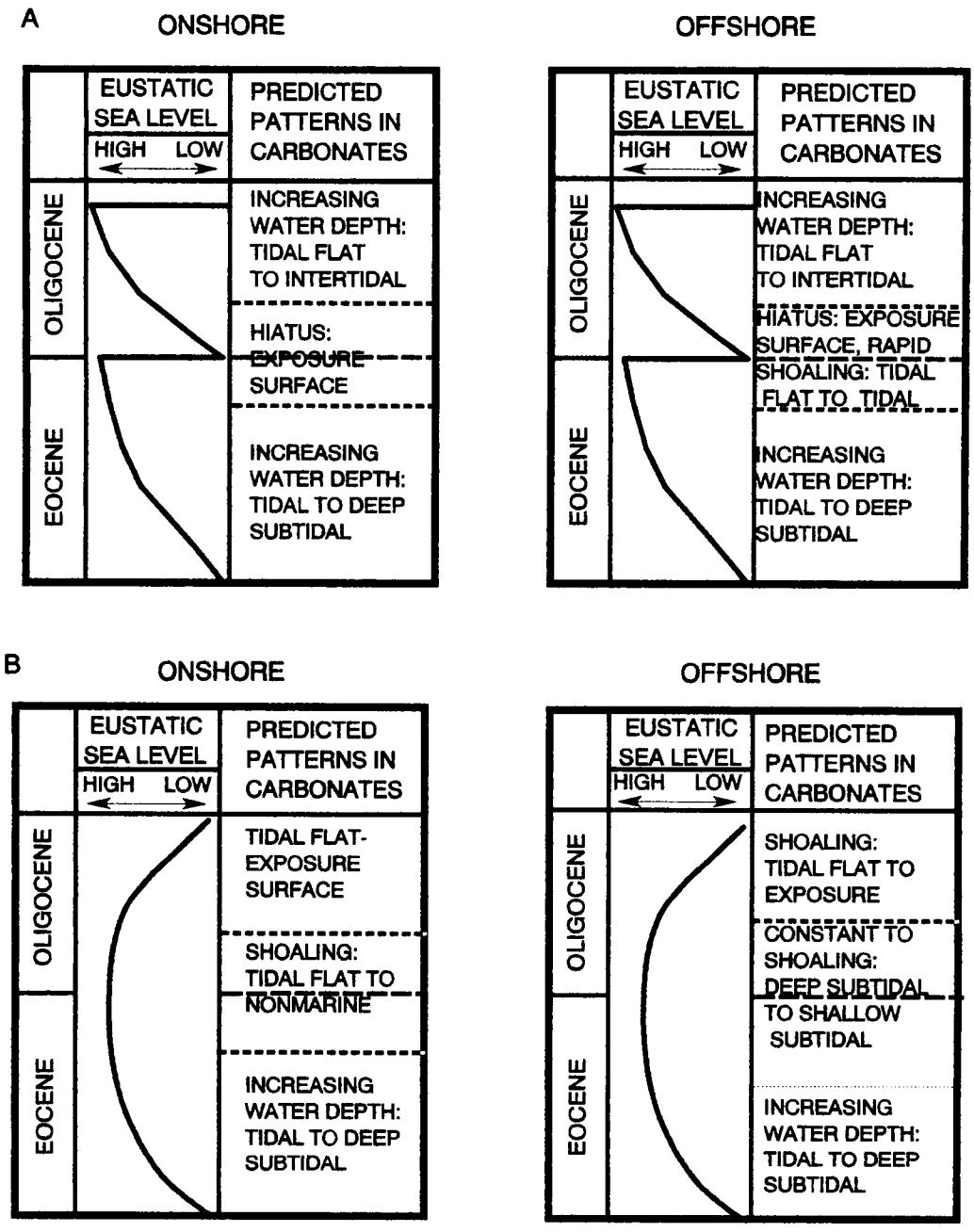


Figure 19. Predicted patterns of carbonate sedimentation on the Florida platform during the Late Paleogene. A. Using the sea level curve of Haq et al. 1983. B. Using the sea level curve of Vail et al. 1988.

upward deepening cycle would be abruptly terminated either by an exposure surface, karst or paleosol development or by rapid replacement by shallow water facies possibly showing signs of restricted circulation. Third, re-establishment of a deepening upward trend as sea level began to rise and finally termination of the package during the Lower Oligocene regression which exposed much of the bank (Figure 19).

In the second model, following the more recent Vail et al (1990) curve, a sea level rise in the upper Eocene with a prolonged high stand straddling the boundary followed by a large regression in the lower Oligocene (Figure 19). The following pattern would be predicted. In the upper Eocene a similar trend of deepening upward, again the exact pattern being dependent on the position of each section relative to a postulated landmass in central peninsular Florida (Sharpe, 1980). In this case the second part of the pattern would be a slowing of the deepening trend followed by either a relatively consistent depositional setting in which subsidence and transport accommodated the production of carbonate material or a slow reversal of trend as carbonate production caught up with the sea level rise and then filled in the available space causing a local regression (Figure 19). This pattern might be termed a "catch up carbonate sequence" where deposition catches up to and over takes sea level.

In the rest of the study a few predictions can be made for both models. First, in either case rising sea level in the upper Eocene would have resulted in progressive trapping of the clastic sediments to the west and north on the inner shelf. This factor combined with the potential of increased carbonate production during sea level high on the Florida platform would result in a progressive westward shift in the location of the transition zone. However, an additional factor of the sea level rise might be to enlarge the transition zone into a wide area of low sedimentation starved of clastic input but having low carbonate deposition rates due to the increased water depth removing the area from the source of carbonate sediment. The presence of the Gulf Trough and related features might have restricted the area available for increased carbonate production. Thus the transition zone would be starved for both clastic and carbonate

sediments. Predictions about the deep area of the Gulf Trough are more problematical. The narrow width of this feature and the probable presence of a strong current through it during the time period under consideration make prediction of its response difficult (Huddlestun, 1993). If carbonate production increased during the sea level rise one would expect increased rates of sediment transport in to the trough. However, the presence of a strong current may have prevented this. In addition, during the lower Oligocene at least there may well have been a buildup (reef?) on the northwest side of the Trough preventing or slow sediment transport (Bryan and Huddlestun, 1990).

Observed patterns

Florida Bank:

Sections examined by the author and data gathered from published and unpublished sources show the following trends in the upper Eocene and lower Oligocene of Peninsular Florida (Figure 20) . In Eocene outcrop belt and adjacent areas where cores of the boundary have been studied, the upper Eocene (Ocala group) shows a consistent trend of deepening upward (Sharpe, 1980; McKinney and Zachos, 1986). This is reflected in both lithologic and faunal analysis. Figure 20, shows representative lithologic columns. McKinney and Zachos (1986) interpreted the changes in the echinoid fauna in this region to represent a progressive shift from onshore to offshore (deeper facies). In this area particularly in sections located at some distance to the Ocala Arch the E/O boundary is not marked by a fairly rapid shift to shallow water facies (Sharpe, 1980). In sections closer to the Peninsular Arch, the top of the Ocala is marked by a hiatus and/or shallow water deposits (Sharp, 1980). At the Brooksville section, the E/O boundary is not clearly marked by either a lithologic or facies change, although there is a massive discontinuous chert bed just below the presumed boundary. In northern Florida along the Suwannee river, the upper Eocene Crystal River is fairly uniform in composition and shows little variation that can be directly interpreted as evidence of sea level influence (Hoganson, 1976). However, in this region

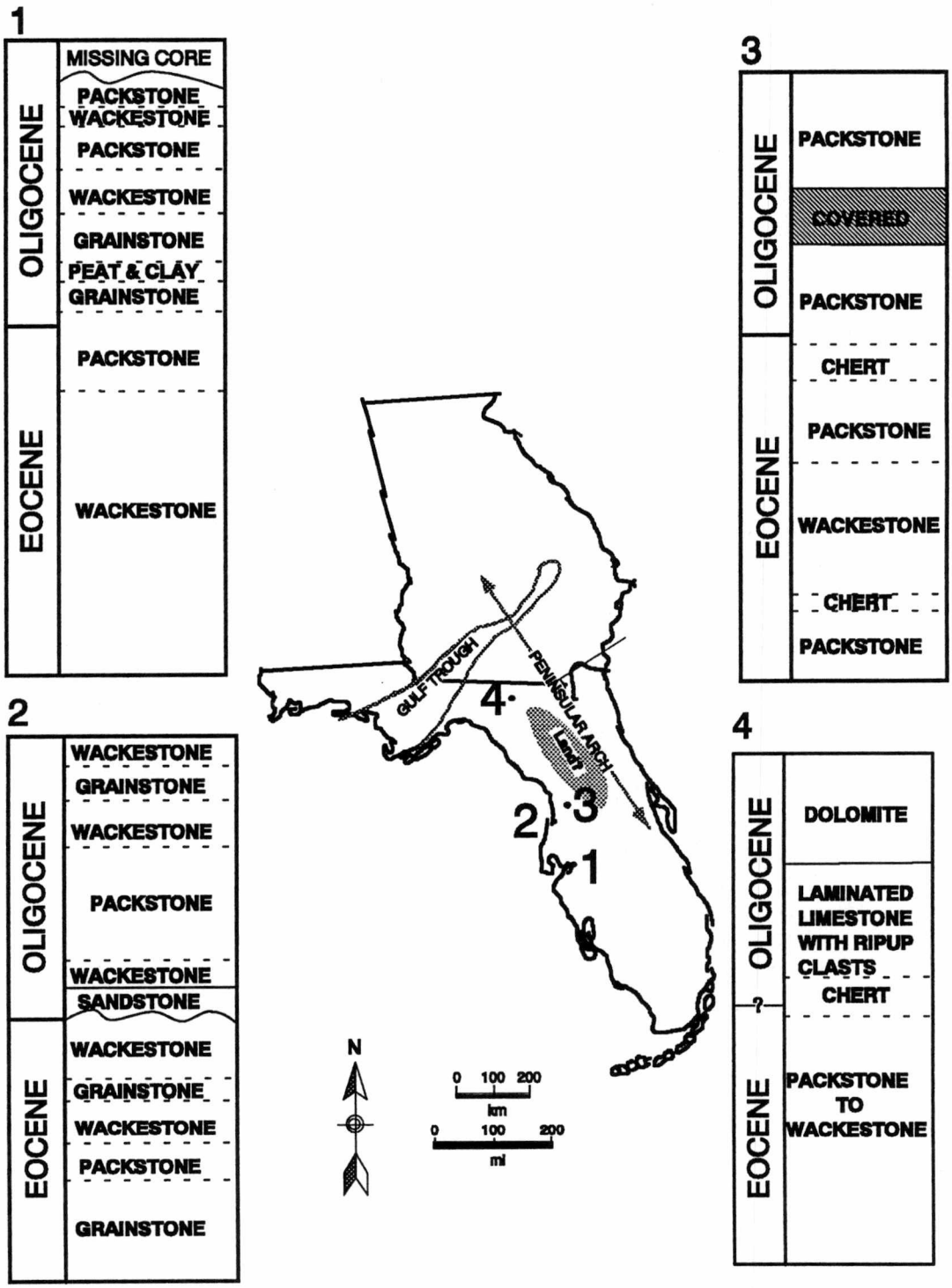


Figure 20. Schematic geologic sections of the upper Eocene and lower Oligocene in peninsular Florida. 1. Southwest Florida Water Management District (SFWMD) core # 13-1 (modified from Sharp, 1980). 2. SFWMD core # 97 (modified from Sharp, 1980), 3. Brooksville locality. 4. Exposures on the Suwannee River.

the top of this Formation is composed of an unusual lithology which contains the spirorbid worm tube *Rotularia vernoni*. This unit which has been interpreted as the uppermost Eocene in the region, but see Hunter (1976) for a different view, could be interpreted as a shoaling facies (Hoganson, 1976). The lowermost Oligocene in this area is composed of a laminated carbonate unit containing rip up clasts. This unit is chert rich and overlain by a sucrosic dolomite (Huddlestun, 1993). Hoganson (1976) interpreted this pattern as indicating a regression and disconformity. However, a lack of topography and clear signs of dissolution make this unclear.

Gulf Trough:

In the Gulf Trough the upper Eocene unit sampled in this study is similar to the Crystal River although finer grained and containing fewer macrofossils. Near the boundary the unit becomes increasingly argillaceous and the lowermost Oligocene is a marl. In this section the boundary is marked by the presence of phosphatic material. Huddlestun (1993) has interpreted this to indicate a hiatus. To the northeast in the Gulf Trough the Upper Eocene and lowermost Oligocene is more argillaceous in character (Huddlestun et al. 1989). On the margins of the Trough the uppermost Eocene unit is dolomitized and may be topped by an unconformity (Huddlestun, 1993) On the northwestern margin of the Gulf Trough a lower, Oligocene unit (the Bridgeboro Limestone) represents a carbonate buildup present somewhat later than the time period under consideration. However, it is possible that this unit is continuous with the upper Eocene strata thus indicating continuous deposition.

Transition zone and Clastic units:

The Crystal River and Shubuta thin into the transition zone as does the Red Bluff and to a lesser extent the Bumpnose (Huddlestun, 1965) (Figure 11). In addition, the units lower in the section also thin into the transition zone (Huddlestun, 1965). The location of the transition zone was not constant during the time period under consideration. The Pachuta Marl below the Shubuta is present at the Sepugla River section and is replaced by carbonates of the Ocala Group to the east (Waters, 1982; Huddlestun, 1965). As noted above, at the Sepugla River the

Shubuta has been completely replaced by a thickening wedge of Crystal River and is last seen at the surface in the area of Perdue Hill Alabama well to the west of transition of the Pachuta (Figure 11) (Huddlestun, 1965; Sobba, 1975). While the lower Oligocene Red Bluff Formation has been identified as far east as Perdue Hill in central Alabama implying the transition is in approximately the same place across the E/O. The strata equivalent to the Red Bluff are increasingly calcareous in nature from the vicinity of Jackson Alabama east (Huddlestun, 1965 Sobba, 1975; Waters, 1982). In fact the lower Oligocene in this area has been called both Red Bluff and Bumpnose (Mancini and Tew, 1991; Hazel et al., 1986) Thus, the lower Oligocene transition is further west and much more gradual than in the Eocene. A progressive retreat of the clastic input would seem the best explanation for the observed pattern of gross facies relationships.

Results

Throughout the study the E/O boundary is characterized by changes in lithology and/or facies. However, in few sections is there clear evidence for a disconformity. On the Florida Plateform these changes are neither consistent nor accompanied by well developed exposure surfaces. Where evidence for a post-Eocene hiatus, is present shallow water depths have been suggested for the latest Eocene, and, during a period of relatively constant eustatic sea level, simple migration of local facies could explain the features seen. In the Gulf Trough the E/O boundary is marked by agrillaceous material and slowed sedimentation and burrows. However, none is conclusive evidence for a fall in sea level. However, these features are consistent with the development of a highstand condensed section. On the northwest side of the trough the boundary has not been well studied. In the transition zone the E/O is marked by a slowing of sedimentation and the appearance of glauconite as is the case in the clastic units where burrows are also present at or near the boundary. It should be remembered that in all likelihood all of these units have been bioturbated extensively. Thus the presence of burrows is not unexpected

and the visibility of those near the boundary is more due to addition of new lithology than any length of, exposure submarine or not. Thus, in terms of the sequence stratigraphic models the second model is better supported by the available data from the entire region. This is not entirely unexpected since this region, particularly the clastic area has long been used as a test area for development of sea level curves. However, this exercise demonstrates the necessity for a model fitting all the available data and the dangers in using sequence stratigraphic models to test data, rather than the opposite.

The fit of the observed patterns to the second sea level curve makes development of a regional depostional model possible that places all of the sections sampled in this study in a coherent paleoecologic setting. This model combines the carbonate suppression model of McKinney (1984) although moved east with sequence stratigraphy and some tectonic features. Figure (21) shows a general depositional setting for the upper Eocene units in the study area. In the western clastic dominated area the depostional environment was middle to outer shelf with a relatively constant sedimentation rate as is seen by the lack of structure in the Shubuta clay. Eastward clastic deposition was lower to due increased distance form the source of sediment and carbonate deposition was very low due to suppression by clastic material. This region comprised local deep as a result although the degree is hard to estimate (*i.e.* it was still a shelf environment). On the eastern side of the transition zone middle to outer shelf carbonate sediments were deposited, probably both *in situ* and downslope transported material. This area formed a slope up to relatively shallow waters in what is now southern Georgia and northwestern Florida. To the east, the trend of shoaling carbonate deposition was interrupted by the presence of the Gulf Trough and Apalachicola Embayment, a regional topographic low, in which deeper water (middle shelf) carbonates are found. It is likely on the northwest margin of the Gulf Trough a carbonate build up was present, as is definitely present in the lower Oligocene (Bridgeboro Limestone) (Huddlestun and Bryan, 1990). On the southeast side of the Trough shallow water

conditions of the Florida bank where well established by the Mid Eocene. No evidence for a buildup has been noticed on the south side of the Trough (Huddlestun, and Hetrick, 1986).

Throughout the upper Eocene sea level was rising. The effect on the depositional patterns was as follows. In the western part of the study, the depositional environment remained relatively constant as sediment input nearly matched sea level rise. However, by latest Eocene time the transgressing sea began to isolate this region from the sediment source resulting in decreased sedimentation and a general fining upward section. The lack of clear signals of increased water depths in the Shubuta during this time is a result of slowed sea level rise. By earliest Oligocene time sea level rise had either stopped or nearly so and the sediment starved condensed section was forming. During the deposition of the lower Oligocene units studied in this report, sea level was either at a high stand or perhaps slowly falling (Vial et al. 1990). As a result the lower Red Bluff Formation represents a prolonged condensed section followed by increased clastic input from the prograding Forest Hill delta to the west. This can be seen in the presence of glauconite and scattered quartz sand in the lower Red Bluff and in the generally poor level of preservation of the foraminiferal tests for this interval.

To the east, in Alabama, during the late Eocene a progressive sea level rise resulted in a westward shift of the transition zone between the carbonate and clastic units (Figure 11). In addition, a local deep caused by the suppression of carbonate deposition would have also migrated to the east from the region of the Suwannee Strait in middle Eocene time to the region of Perdue Hill and Jackson, Alabama by latest Eocene time. The slowing probable stop of sea level rise at or near the E/O did not result in a rapid change in conditions. Over the interval studied in the lower Oligocene a wide area in southern Alabama and north western Florida made up the transition zone. The increased width in this time was due to lowering of deposition rates of both clastic and carbonate sediments. This is due to ponding on clastics on the inner shelf and lower of carbonate production by increased water depth over much of the transition zone. In addition, the presence of the Gulf Trough system and the Suwannee current in it would have

acted as a barrier to transport of shallow water sediment into the transition zone from the Florida bank. In the Gulf Trough itself there is little evidence for increased water depth during the late Eocene. However, the faunal differences between the deepest sample examined in the GGS-3535 core and the rest of the Eocene in this section may indicate some differences. As discussed above the E/O boundary in the southern part of the Trough is marked by the appearance of clastic material. This input of clastic material continued into the Lower Oligocene after which very similar conditions to the Upper Eocene were reestablished. While, this pattern can be used to argue for lowered sea level at the E/O, an alternative explanation is given here. During the uppermost Eocene and throughout the lower Oligocene in the Trough to the northeast of the location of GGS-3535 the strata are even more clastic in nature (Huddlestun, 1993). This occurs on the northeastern side of the northward extension of the Peninsular Arch. During the time period under consideration, the Gulf Trough had a northeast flowing current moving through it (Huddlestun, 1993). Huddlestun et al (1990) have suggested this current along with the Florida Current acted as the major currents moving from the Gulf of Mexico to the Atlantic Ocean. Reconstructions of Late Eocene time indicate that the presence of this current would have generated longshore patterns which would have moved clastic sediment from the shoreline to the northwest in a northeast direction (Huddlestun, 1993). However, during the sea level high stand straddling the E/O boundary, it is possible that this current instead of being channeled in the Gulf Trough may have dispersed out of it across the Florida Bank and carbonate shelf on the margin of the Trough. This dispersal may have in part been a resulted of the termination of the Gulf Trough short of the Atlantic shelf during this time period. In addition, the Suwannee current may have been decreasing in intensity during this interval (Huddlestun, 1993). As a result the terrigenous nature of the boundary interval may result from clastic sediment being transported across the shelf and/or to the northern end of the Gulf Trough by a secondary current. Whatever the origin of this sediment during much of the uppermost Eocene and lower Oligocene, the clastic material was trapped to the northeast of the topographic high created by the Peninsular Arch.

Only during the period of highest sea level was the amount of clastic input high enough or a reversed current high enough above the bottom and/or the Suwannee current weakened sufficient to permit transport of fine siliciclastic sediments over the Arch extension and into the southern portion of the Trough. As sea level fell or sedimentation began to catch up during early Oligocene time the earlier pattern was reestablished. The presence of phosphatic material at the boundary in this section may represent the condensed section when neither carbonate or clastic sediment input was very high, with the clastics being ponded near shore and the carbonate system adjusting to the sea level.

On the Florida Platform during late Eocene time as sea level rose, a transgressive sequence was developed as discussed above. During this time portions of the Bank in central Florida which had probably been at or above sea level were submerged and a carbonate shelf established (Huddlestun, 1993). As sea level rise slowed and then stopped from the latest Eocene to early Oligocene the carbonate system began to catch up. As a result, a reversal of trend was developed and shallow water carbonates were deposited across much of the bank. In northern Florida this process led to the deposition of the *R. vernoni* zone and then a tidal flat environment, the laminated carbonates and dolomites of the Ellaville Limestone. This gradual change has helped add to the confusion as to the location and nature of the E/O boundary in Florida since the type of contact and facies relationships across the boundary are strongly dependent on the local setting. In addition, the shoaling of the Florida bank during this time may help to explain the extinction of much of the large benthic foraminiferal and echinoid fauna seen in the upper Eocene. The progressively shallower waters would have moved much of the bank out of the optimal conditions for these organisms and potential development of restricted conditions would have further impacted this fauna. An interesting area of speculation is how the E/O boundary events affect the western portions of the Florida continental shelf. It possible that this area remaining in deeper water acted as an environmental refuge for some of this fauna.

Summary

The senerio described above gives a coherent pattern of paleoenvironmental conditions and depostional patterns for the entire study area. This senerio combines information and data from previous studies and sequence stratigraphy. In addition, this model also clarifies and avoids some of the weaknesses of the carbonate suppression model alone and of that proposed by Mancini and Tew (1991). First, the non- stationary nature of the transition is accounted for better than in the carbonate suppression model which would predict retreat of the carbonate facies in the face of encroaching clastic sediment, not the reverse as is seen in this study. A rise in sea level would cause the clastic facies to retreat, expanding the sediment starved transition zone and/or allowing progradation of the carbonate facies. In regards to the model of Mancini and Tew (1991), this model would explain the lack of significant depth increase across the boundary as recorded by faunal estimates in the transition zone, which would be expected in a rapidly subsiding basin that was trapping sediment to the west. Also the progradation of the Forest Hill marginal marine facies later in the lower Oligocene is accounted for by a slowing of sea level rise and thus less accommodation of the sediment. The relatively uniform nature and lesser thinning of the Bumpnose into the transition would be accounted for by increased water depths lowering carbonate production rates and thus rates of deposition. Note that this basic model does not preclude a role for local tectonic shifts, particularly those related to movement of Jurassic salt as proposed by Mancini and Tew (1991). Subsidence of the clastic basin to the west probably played a role in development of the original pattern in the Eocene and by accommodating sediment input may have preserved the lower Oligocene depositional pattern during progradation of the Forest Hill sand.

In the carbonate facies portion of the study area, this model explains the observed stratigraphic sequences stratigraphic section without depending on large changes in environment which have left little or no record. On the carbonate platform of peninsular Florida and southern Georgia there is evidence for shifts in paleoenvironmental settings spanning the E/O boundary.

In the Gulf Trough, the presence of argillaceous material and phosphate marking the boundary is harder to account for. This model is based on a speculative undefined mechanism delivering the clastic material to the Trough and trapping of carbonates on the platform to allow phosphate deposition. There is no direct evidence for the presence of such a mechanism or the source of the sediments and the trapping of sediment on the platform seems to run counter ideas of the response of carbonate platforms to sea level rise (Schlager, 1986).

The model described above allows for placing each of the four sections in which the benthic foraminiferal fauna was examined in context for evaluating the changes in faunal composition associated with the Eocene/ Oligocene boundary. Using this model as a pattern in each of the sections studied the overall environmental setting remained relatively constant throughout the time period studied. However, the presence of facies changes and lowered sedimentation rates resulted in environmental changes not dependent on water depth or water mass. Thus, not all faunal change can be attributed to global or regional events associated with the boundary. Small shifts in faunal abundance and composition may be more reflective local benthic conditions.

Chapter 4 ANALYSIS OF FAUNAL CHANGES

The late Eocene to early Oligocene has long been noted as a period of faunal change in many taxa (Berggren and Prothero, 1992). This faunal change has been attributed to extra terrestrial impacts and to climatic cooling associated with the progressive isolation of Antarctica, causing a shift from a "hothouse" to "icehouse" world (Alvarez, et al. 1982; Breggren and Prothero, 1992). The latter explanation has become more accepted as close examination of extinction patterns has revealed a stepwise pattern of change extending through the late Eocene and early Oligocene in many groups (Keller, 1985). Marine organisms showing high rates of extinction in the latest Eocene to earliest Oligocene include echinoids, mollusks and planktonic foraminifera (Hansen, 1987; McKinney, et al. 1992, Boersma, et al. 1987). In addition, terrestrial floras and faunas underwent a period of rapid change in this time period also. The sporomorph and plant record show an abrupt change in plant community composition indicating plant response to a climatic cooling in the latest Eocene (Frederickson, 1988, 1991; Wolf, 1992).

Previous studies of benthic foraminifera in the study area have noted changes in the fauna across the Eocene/ Oligocene boundary in the study area (Bandy, 1949; Sobba, 1976; Waters, 1982; Loutit, et al. 1988; Flugeman, 1989; Gaskell, 1991). Flugeman (1989) associated the faunal differences with a change from trangressive to high stand conditions. Gaskell (1991) working from compiled data indicated a high extinction rate in the Shubuta, a lower, but still elevated, rate in the Red Bluff and attributed this to a general climatic change in the Late Eocene and Early Oligocene. Gaskell (1991) and the other studies cited examined overall faunas or lumped faunal changes for lithostratigraphic units. In addition, no studies have examined benthic foraminiferal faunal change at E/O boundary across the entire study area. The major goals of this study are to examine faunal changes across the Eocene/Oligocene

boundary in several settings and to determine the degree, rate and timing of faunal change associated directly with the Eocene/Oligocene boundary.

Species abundance data was analyzed in several ways to examine faunal changes across the Eocene/ Oligocene boundary and provide information for paleoenvironmental interpretations. First to allow comparison with published data a compilation of the number of taxa last appearing in the Eocene and first occurring in the Oligocene was constructed for the entire data set and each section (Table 1). Second, plots of the most abundant species and those species which had significant changes in abundance across the boundary were constructed and examined for patterns. Third, the structure of the entire data set was examined using cluster analysis at both the species and genus levels. Fourth, principal

Table 1. Number and percent Last and First Occurrences in the entire data set and in each section.

Source	# L.O	% L.O.	# F.O.	% F.O.
Total data	49	21.1	40	17.9
Red Bluff	26	18.4	41	25.8
Sepugla River	6	7.1	21	19.3
GGS-3535	11	11.8	11	12.8
Brooksville	27	42.2	3	7.3

components analysis was conducted at both the species and genus levels to look for changes in faunal composition and structure associated with the E/O boundary in each section.

In an attempt to explain observed patterns of faunal change a new type of interpretative analysis was attempted. This analysis is based on benthic foraminifera inhabiting a range of depths on and below the sediment water interface and has been termed microhabitat analysis by Corliss (1985). The depth to which a species is found is dependent on a number of factors. Most species seem to have a preferred set of conditions which is often related to depth below the sediment surface. Test shape is a general indicator of the preferred depth range for benthic foraminifera (Corliss, 1991). As a result changes in the fauna can be related to changes in benthic habitat and changing benthic conditions.

Degree of Faunal change

The degree of faunal change was examined in two ways. First for each section the number of species last occurring in the Eocene and the number first occurring in the Oligocene was compiled. Second, a compilation of the data for the entire study area was constructed. In this case only taxa with first or last occurrences in all the sections were they appeared where counted. Differing patterns of first and last occurrence are most common in low abundance taxa whose presence is often discontinuous. Thus, the total data set has a lower number of both first and last occurrences than a simple sum of the numbers in each section.

Examination of Table 1 reveals several patterns. First, the degree of faunal change, whether first or last occurrences show considerable variation depending on the section examined. Such variation implies a nonuniform response to changing environment or a nonuniform set of environmental changes. Second, last occurrences are concentrated at Red Bluff and Brooksville with the highest rate at Brooksville. Third, first occurrences are highly concentrated in Red Bluff.

Overall the amount of change recorded in this study is lower than that reported by Gaskell (1991) for the uppermost Eocene and lowest Oligocene clastic units. This is particularly true for the carbonate shelf sections (Sepugla River and GGS-3535).

Faunal changes

Plots of species abundance versus sample position were constructed to evaluate the degree of faunal change associated with the E/O boundary. Plots were constructed for species which have either first or last appearance near the boundary and for those which exhibited large changes in abundance across the boundary. This allowed for qualitative assessment of the species level changes in faunal composition and gave some basis for interpreting the cluster and principal component analysis results. In this analysis I did not consider low abundance species which have first or last appearances. Thus, the number of taxa considered is somewhat lower than above.

Red Bluff Section:

In the Red Bluff section the number of species whose local last occurrence is either at or just below the boundary is quite small (Figure 21, Table 2).

Of these species only *Bulimina jacksonensis* comprises an important part of the total fauna ranging in abundance from 0-210 in the Eocene and from 0-27% of the assemblage (Figure 21a). The other species listed in Table 1 do not have abundances greater than 45 in any sample and thus make up a relatively insignificant, generally under 3%, part of the total assemblage (Figure 21a-d)

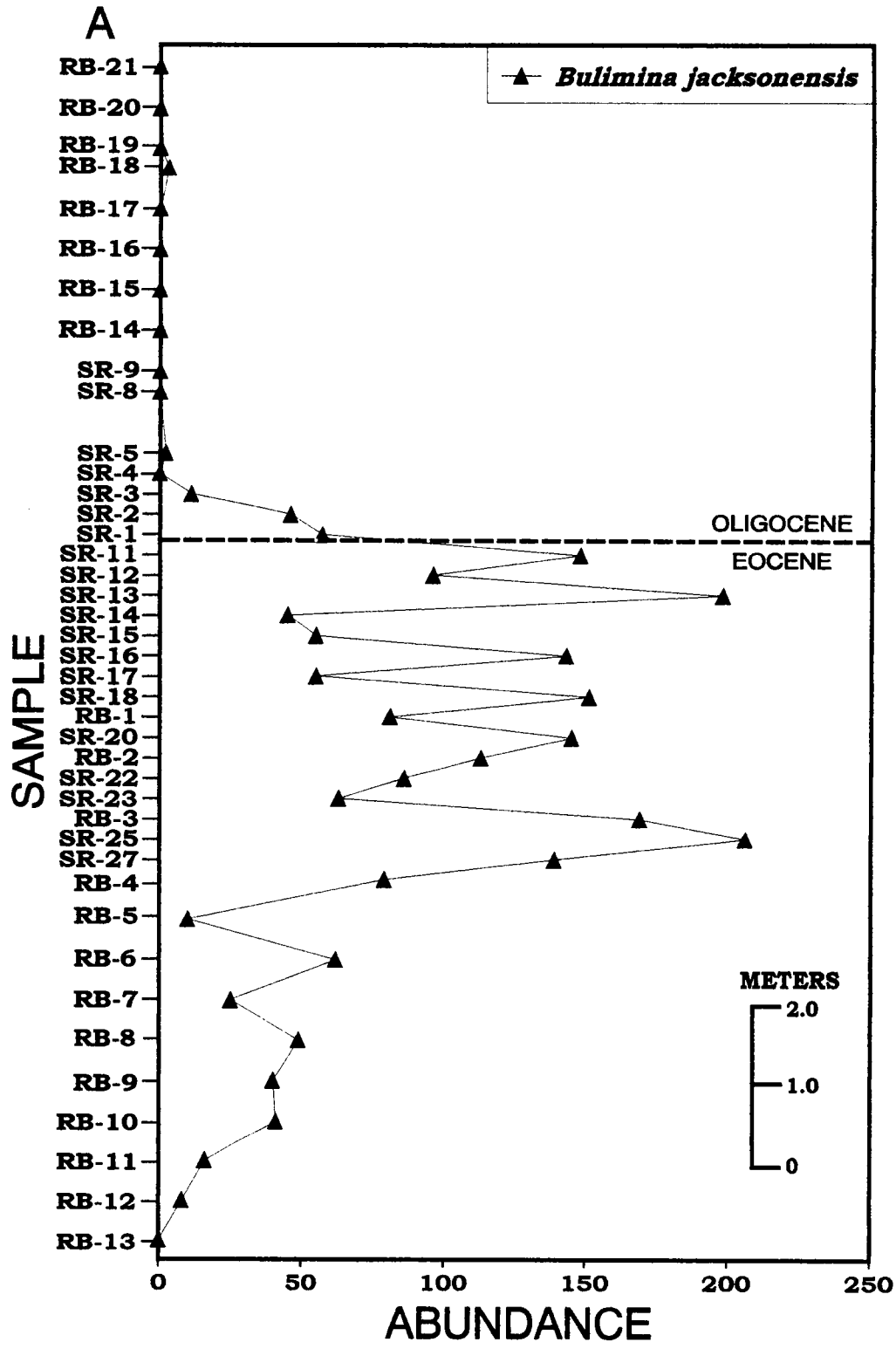


Figure 21. Species with last occurrences at or near the Eocene/Oligocene boundary at Red Bluff.

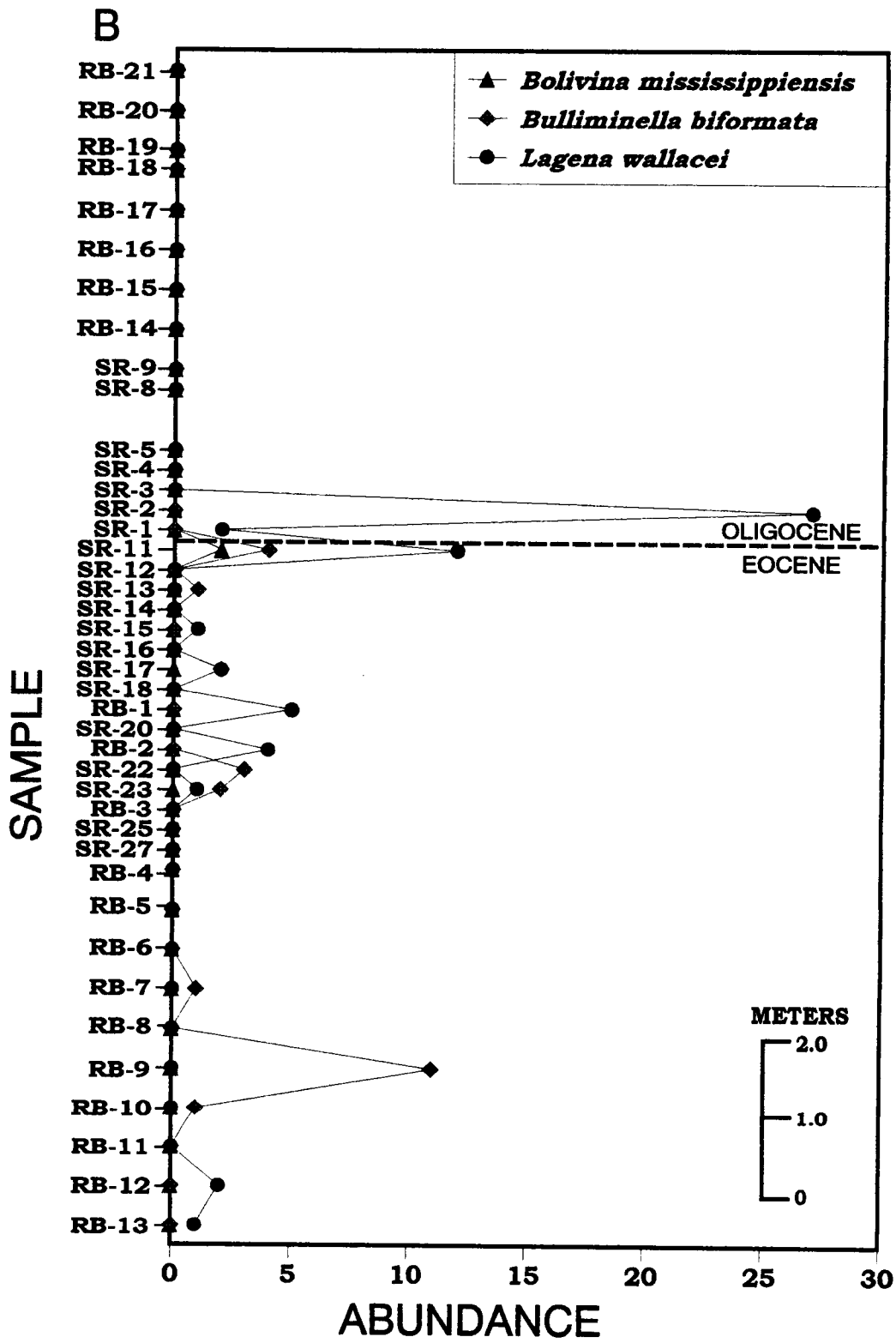


Figure 21. (continued).

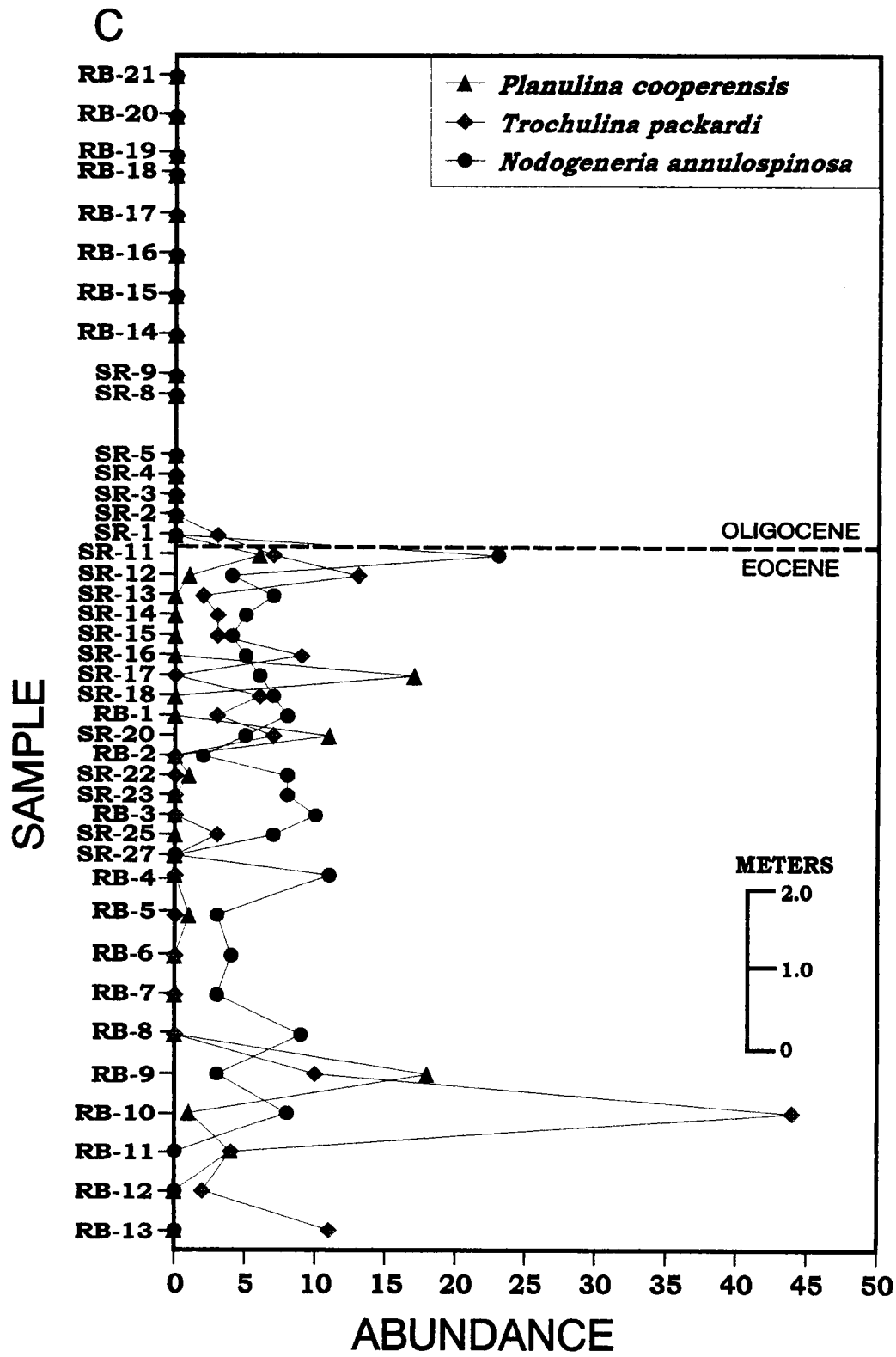


Figure 21. (continued).

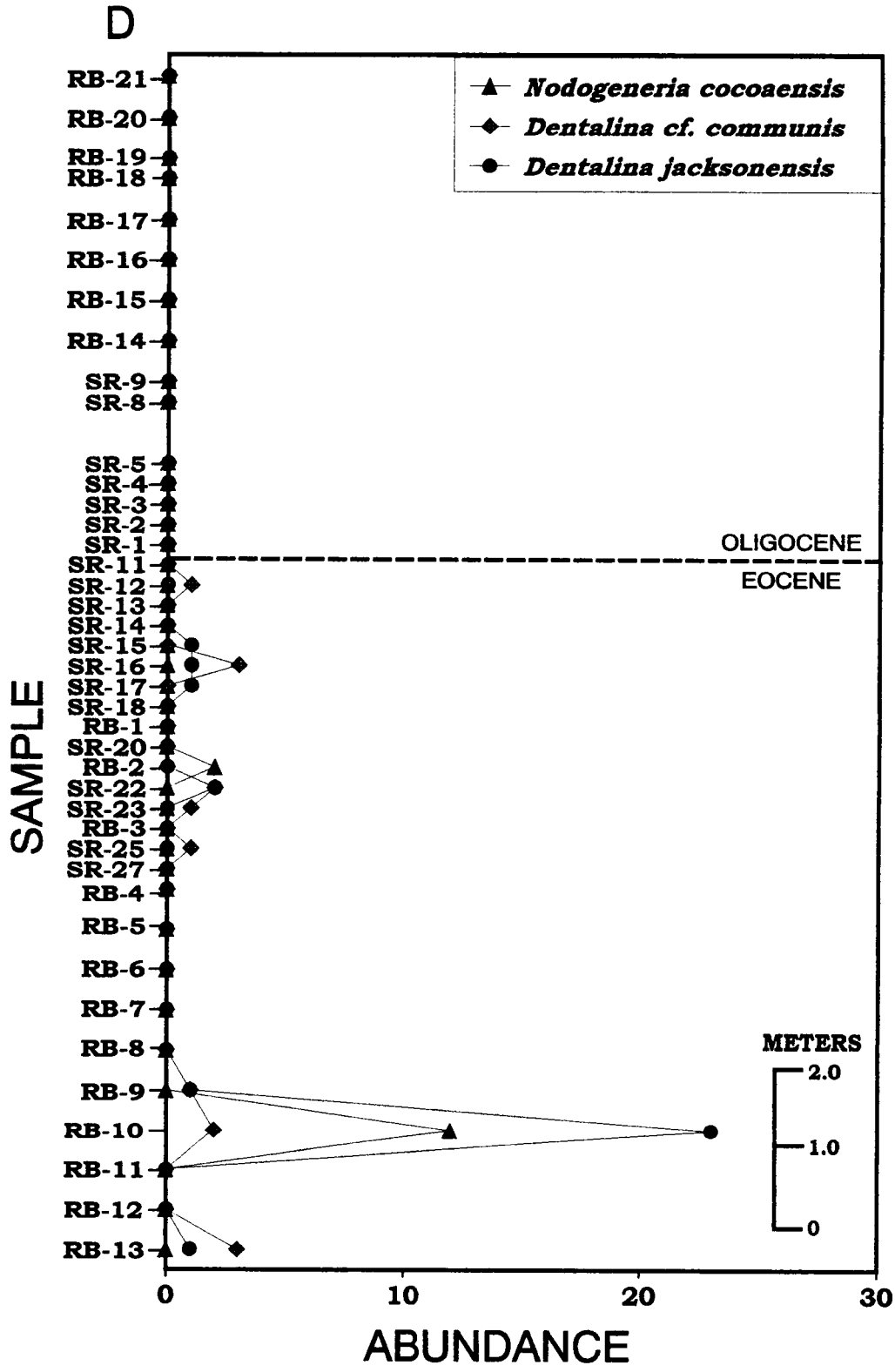


Figure 21. (continued).

Table 2. Species having last occurrence in Upper Eocene at Red Bluff.

Bolivina jacksonensis	*Dentalina cf. communis*
Bolivina mississippensis	*Lagena wallacei*
Bulimina jacksonensis	*Nodogeneria annulospinosa*
Buliminella biformata	*Nodogeneria cocoaensis*
Dentalina jacksonensis	*Trochulina packardi*

Species which occur in relatively high abundance in the Eocene and low abundances in the Oligocene part of the section are listed in Table 3. Of the species listed in Table 3, *Uvigerina jacksonensis*, *Spiroplectammina curta*, and *Bolivina dalli* are important components of the Eocene fauna with abundances ranging to over 200 per sample. *Uvigerina jacksonensis* comprises between 1.9% to 30.9% of the total assemblage in the Shubuta Clay and between 0.0% to 17.1% in the Red Bluff formation. However, abundances above 10% in the Oligocene occur in the first 3 Oligocene samples. *Bolivina dalli* comprises between 0 and 19.7% in the Eocene samples and no more than 2% in the Oligocene, as with *U. jacksonensis* the greatest abundances of this species in the Oligocene occur in the lowermost samples. Although the greatest abundance of *Spiroplectammina curta* occurs in sample SR-4 slightly above the boundary for the most part it is much less abundant in the Oligocene with only 2

Table 3 Species which decrease in abundance across the E/O boundary at Red Bluff.

Bolivina dalli	*Pseudoparrella danvillensis*
Lenticulina altolimbatus	*Spiroplectammina curta*
Lenticulina pseudovortex	*Uvigerina jacksonensis*
Loxostomum spp1	*Uvigerina gardnerea*

samples containing more than 50 specimens (Figure 22). In terms of percentage of the fauna *S. curta* has a peak in the lower Red Bluff where it is up to 20% of the fauna. The other four species which show large drops in abundance across the boundary are only minor components of the assemblage. However, the distinctive appearance and relatively large size of the *Lenticulina* species make them a visually, if not statistically, distinctive part of the Eocene fauna. Thus, in terms of at local extinctions and reductions in abundance the E/O boundary in this section does not show a marked loss of species.

Species which first occur in the lower Red Bluff Formation in this section are listed in Table 4. Abundance plots of these species (Figure 23) show that only *Cassidulina armosa* and *Reussella sculptilis* have abundances of more than 100 in any one sample. The next highest abundance is that of *Quniqueloculina mauricensis* which has a maximum abundance of 74 (Figure 23). Only *C. armosa* comprises a significant proportion of the assemblage (0- 21%) in

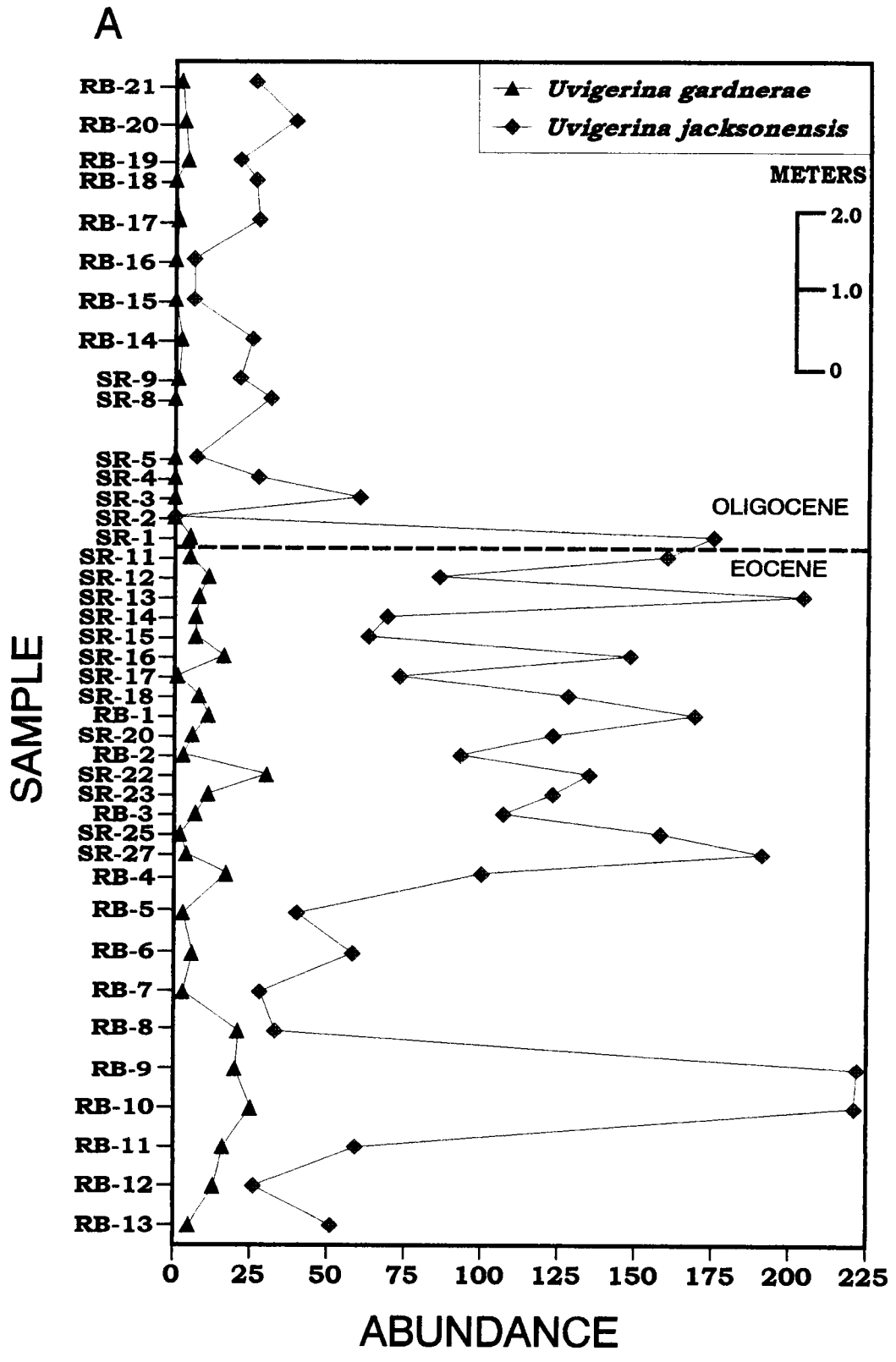


Figure 22. Species which decrease in abundance across E/O boundary at Red Bluff.

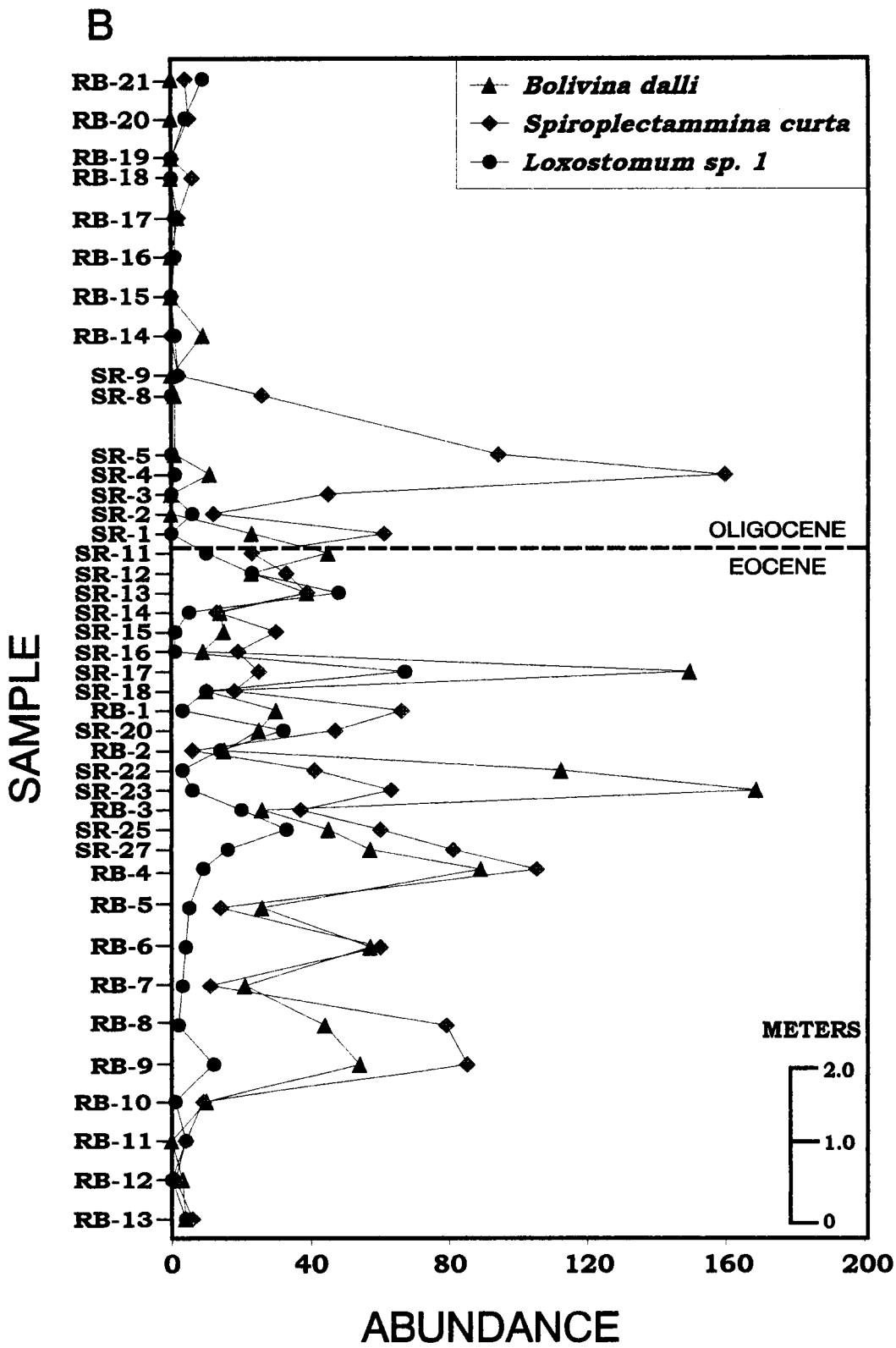


Figure 22. (continued).

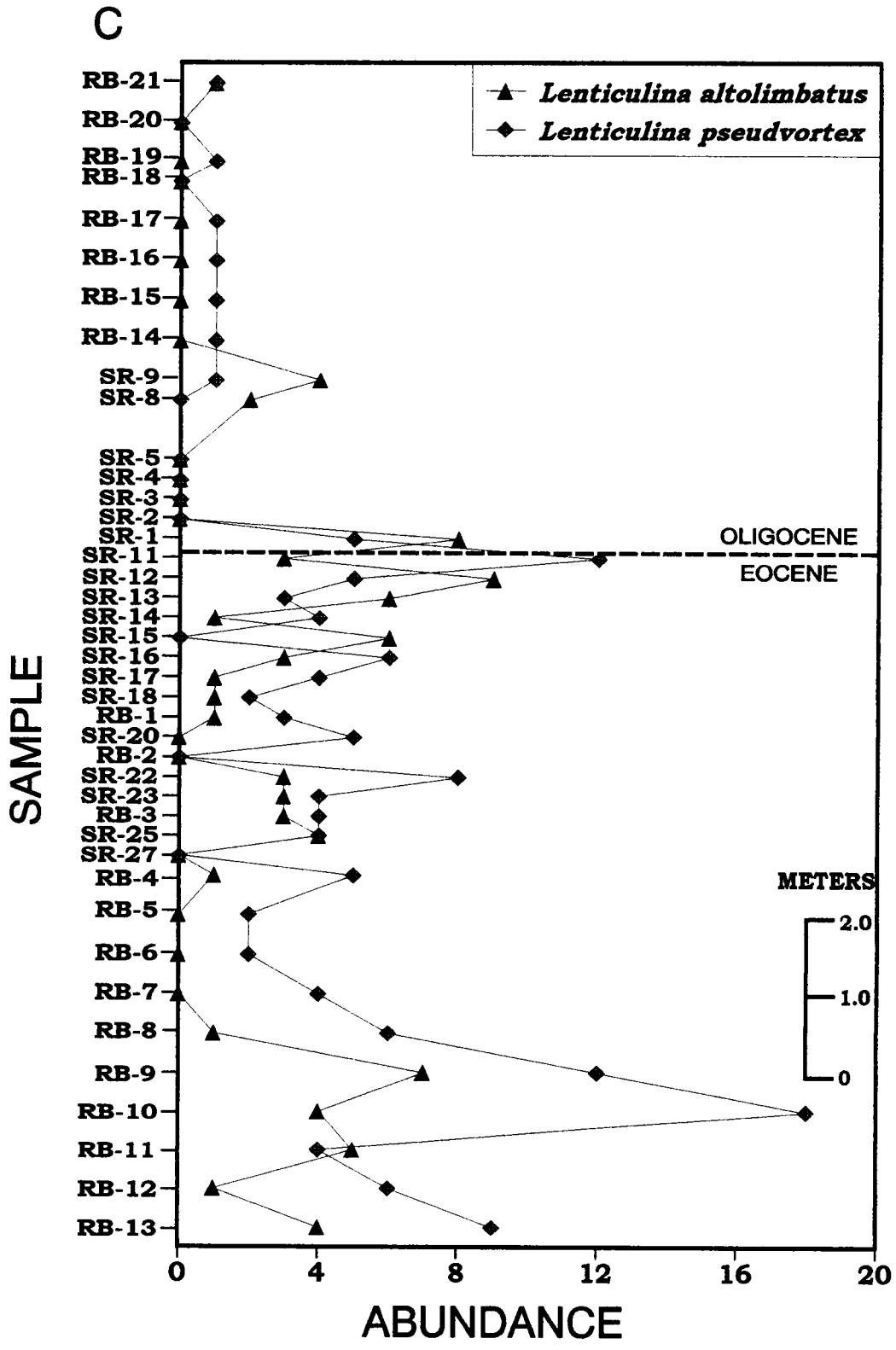


Figure 22. (continued).

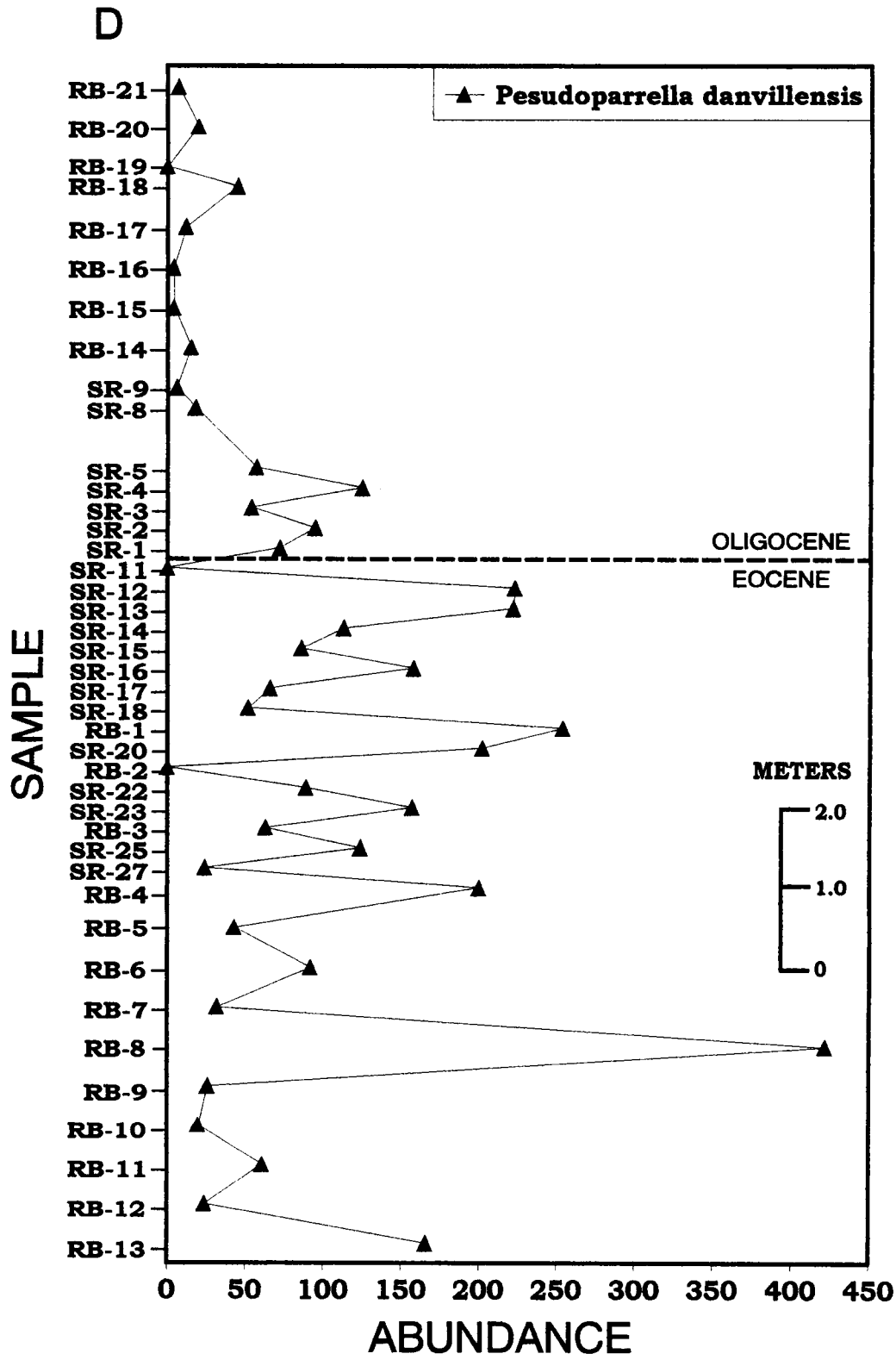


Figure 22. (continued).

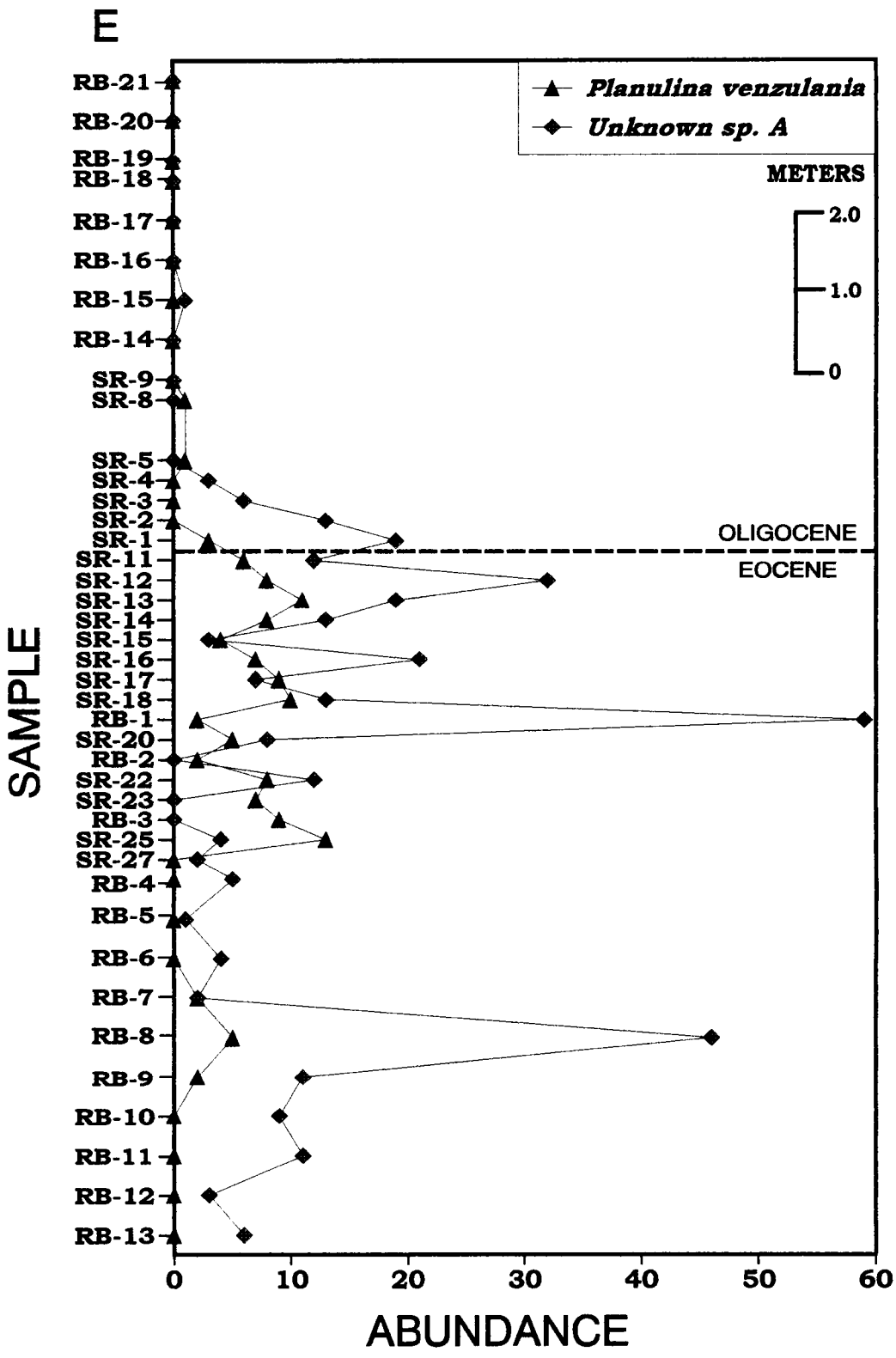


Figure 22. (continued).

Table 4 species with first occurrence in Oligocene.

Bolivinella rugosa	*Nonion inexcavatus*
Bitubulogenerina howei	*Quinqueloculina harrisi*
Cancris claibornensis	*Quinqueloculina mauricensis*
Cassidulina armosa	*Quinqueloculina substriata*
Cibicides lobatulus	*Reussella sculptilis*
Discorbis globulospinosa	*Spiroloculina lisbonensis*
Discorbis hemisphaericus	*Spirillina vicksburgensis*
Discorbis spp	*Triloculina subrotunda*
Gyroidina obesa	*Articulina advena*
Nonion advena	

the Oligocene. As discussed above some species which do not make up a significant percentage of the fauna are visually distinctive so increases in abundance across the boundary are noticeable. In particular species of the genus *Quinqueloculina* and *A. advena* are very distinctive even though the maximum abundance of any one species is 74 specimens and they never make up more than 4% of the assemblage (Figure 23). However, it has been suggested that, due to association with shell hash, some of these species are in fact transported elements which were carried down slope by gravity flows in the Shubuta and presumably in the Red Bluff (Smith and Zumwalt, 1987).

Species which show a significant increase in abundance from the Eocene to the Oligocene are shown in Table 5. Abundance plots of these species are shown in Figure 24. Those showing the greatest changes are *Cibicides pippeni, Spiroplectammina alabamensis, S. mississippiensis, Angulogerina byramensis* and *Discorbis alveatus* (Figure 24). In terms of

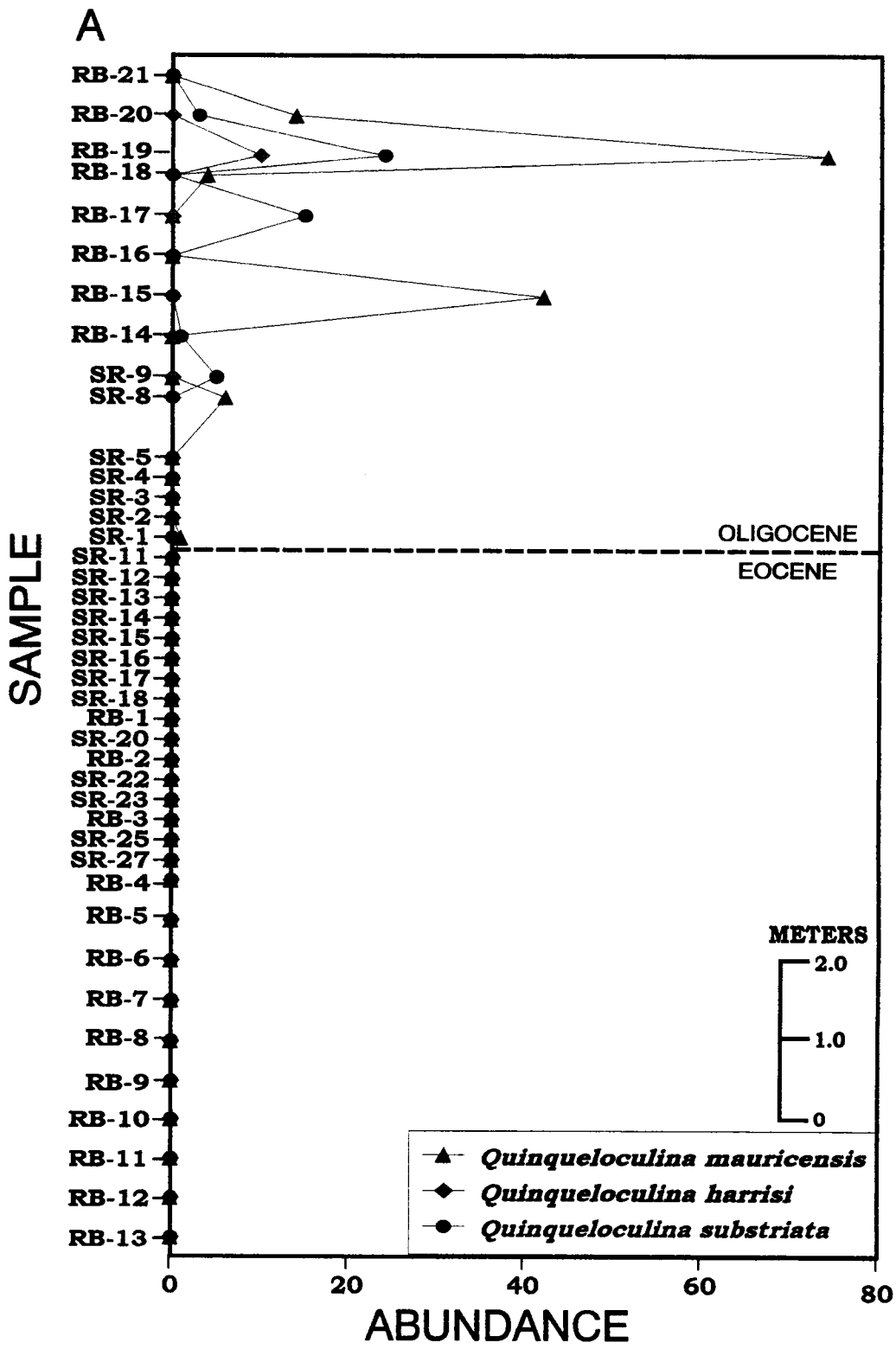


Figure 23. Species with first occurrence in lower Oligocene at Red Bluff.

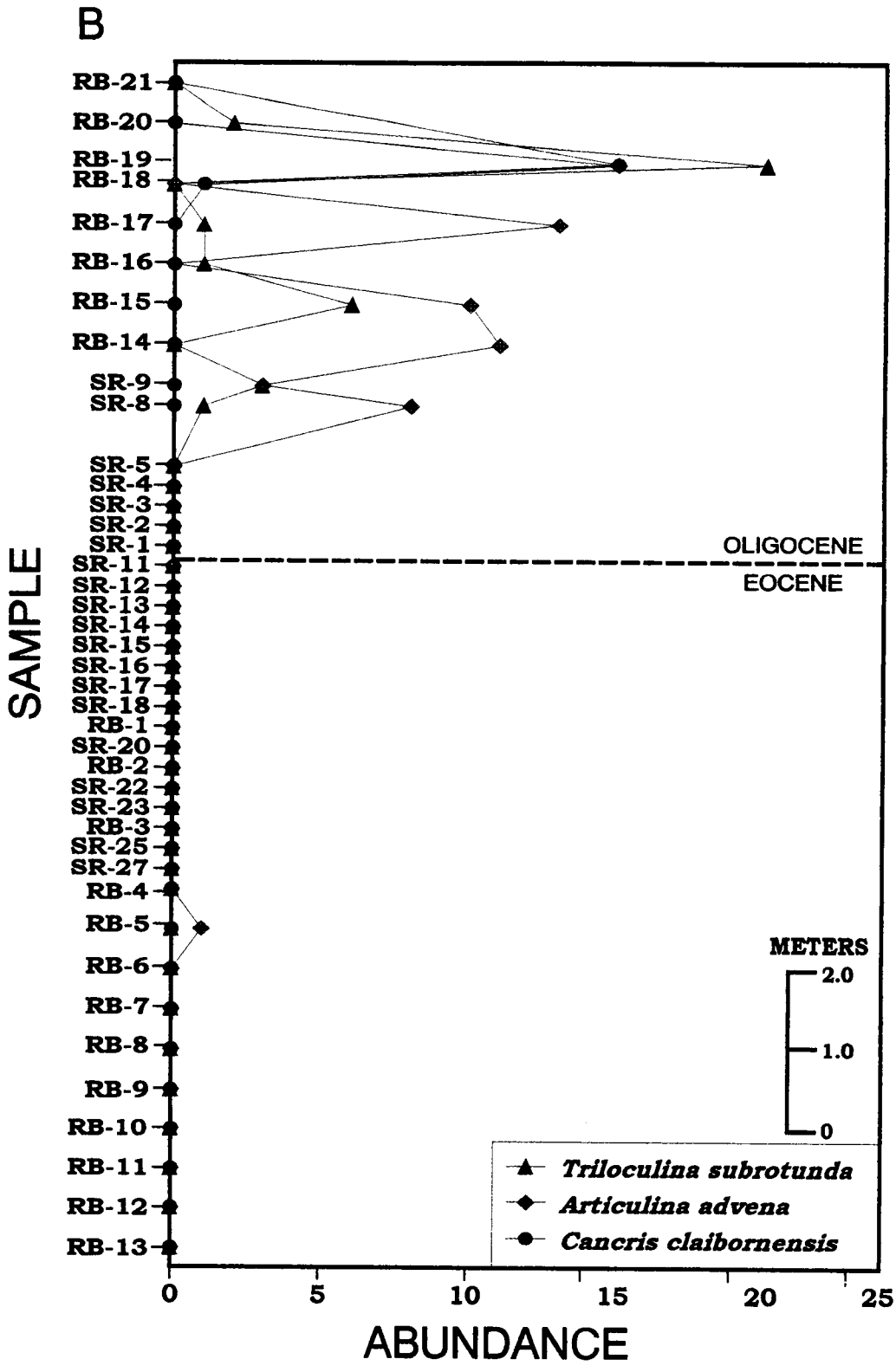


Figure 23. (Continued).

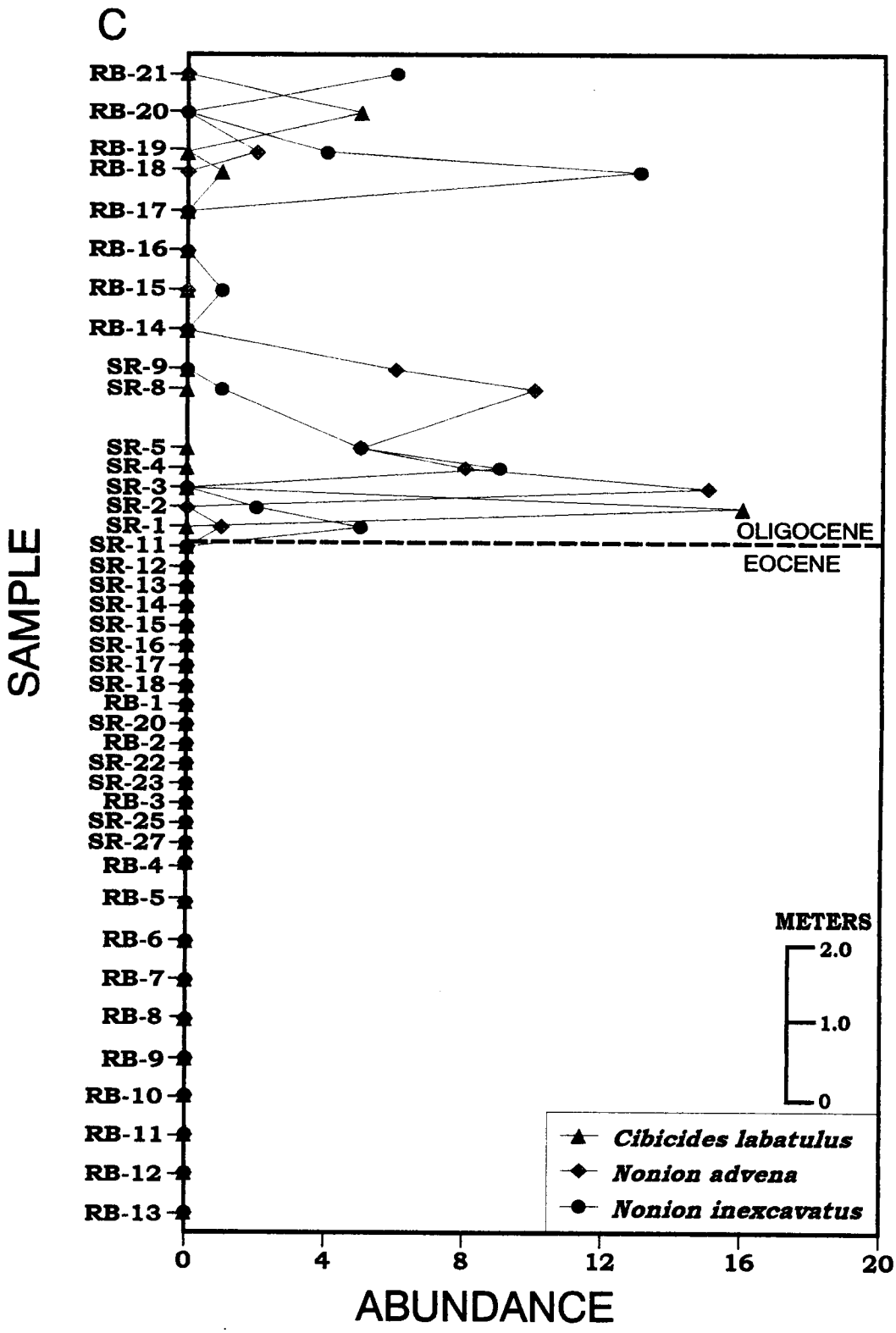


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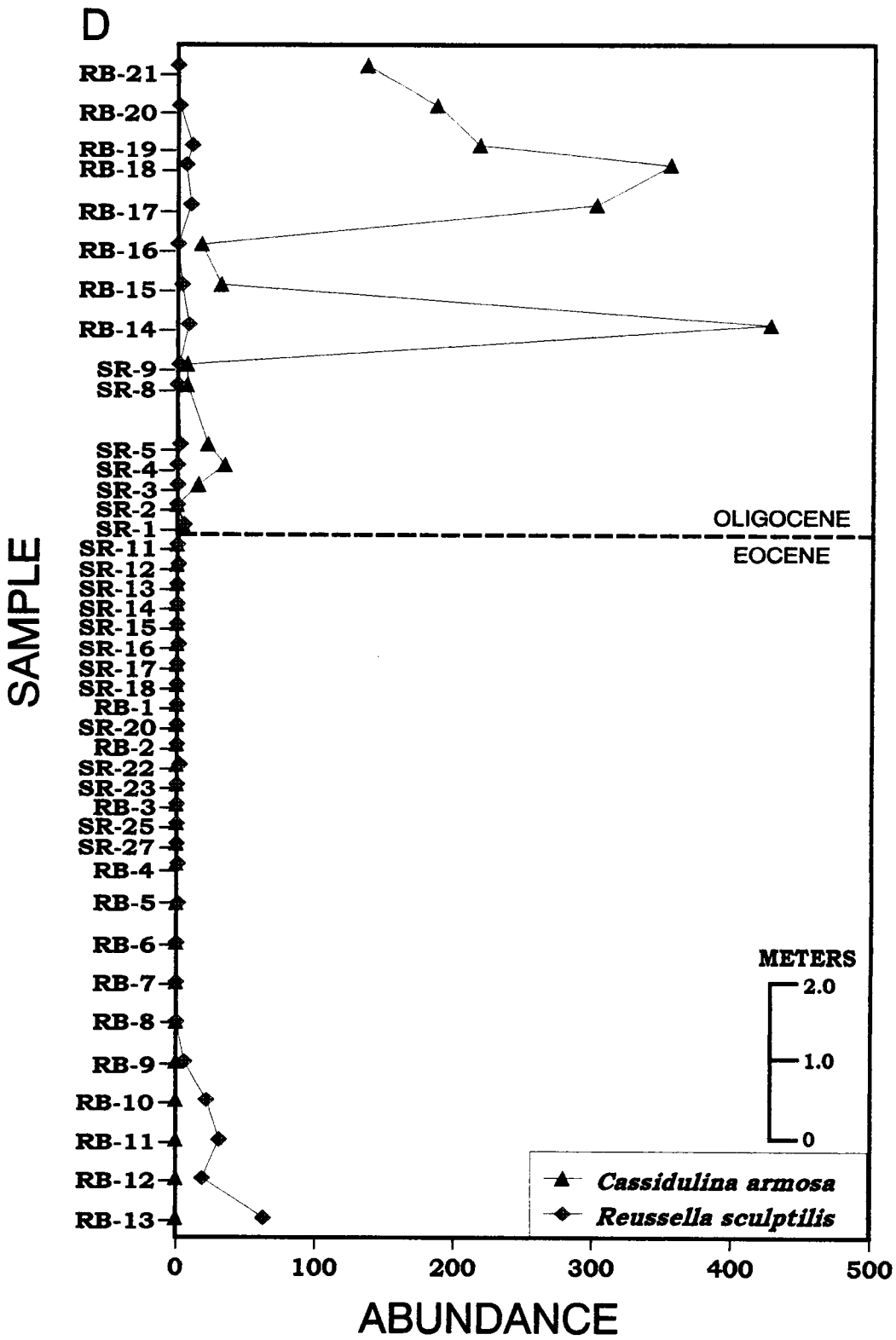


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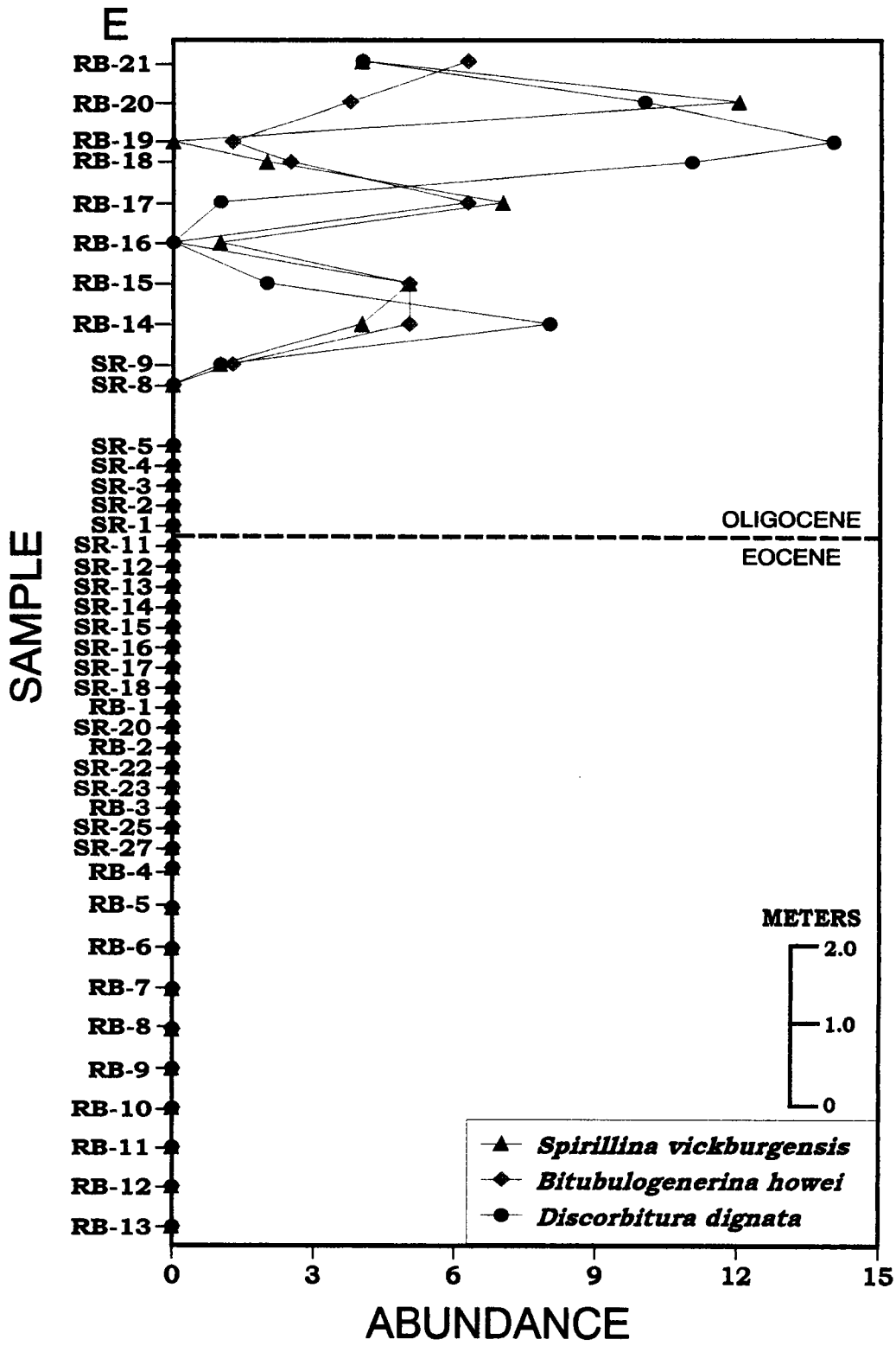


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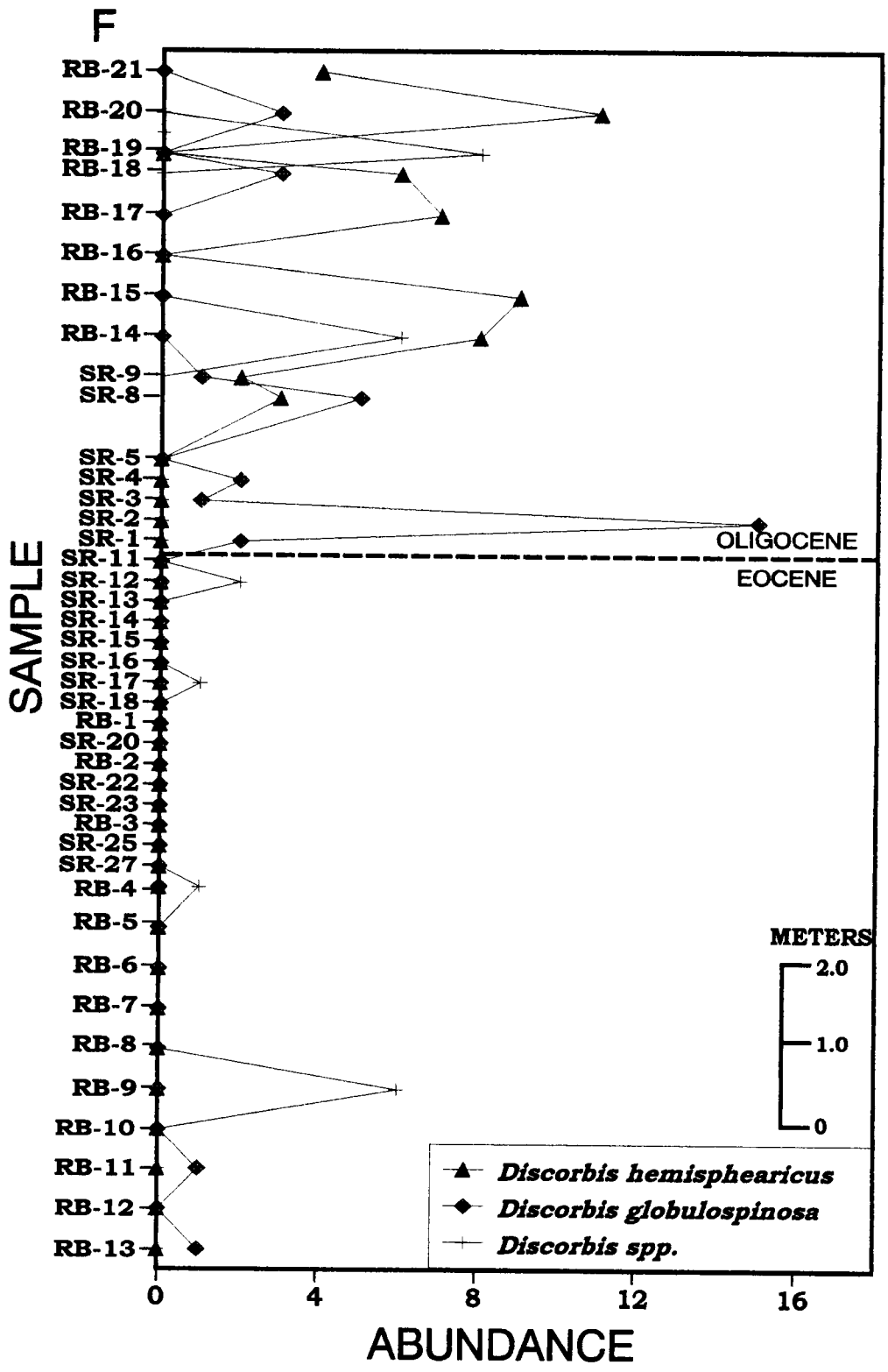


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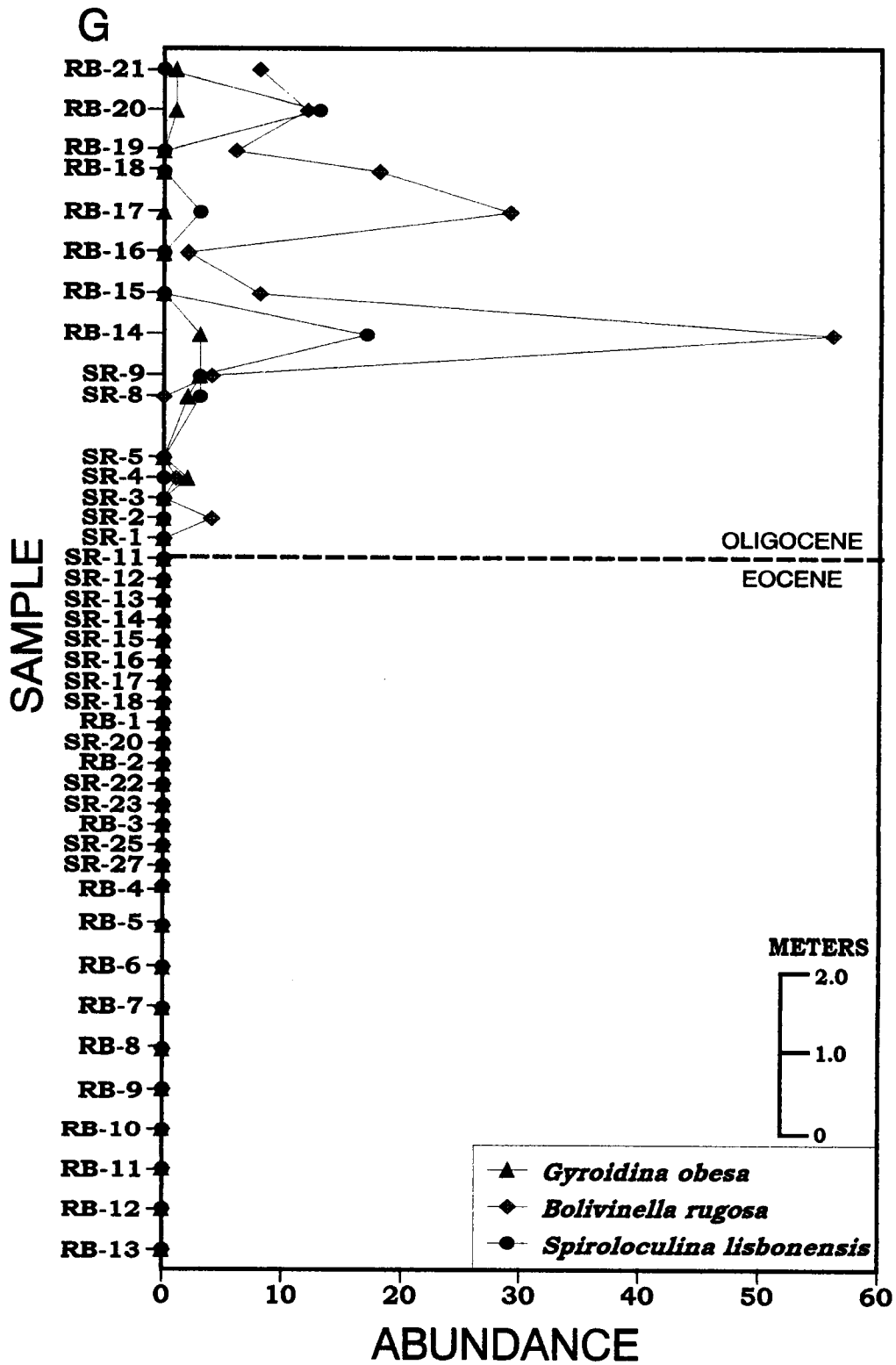


Figure 23. (Continued).

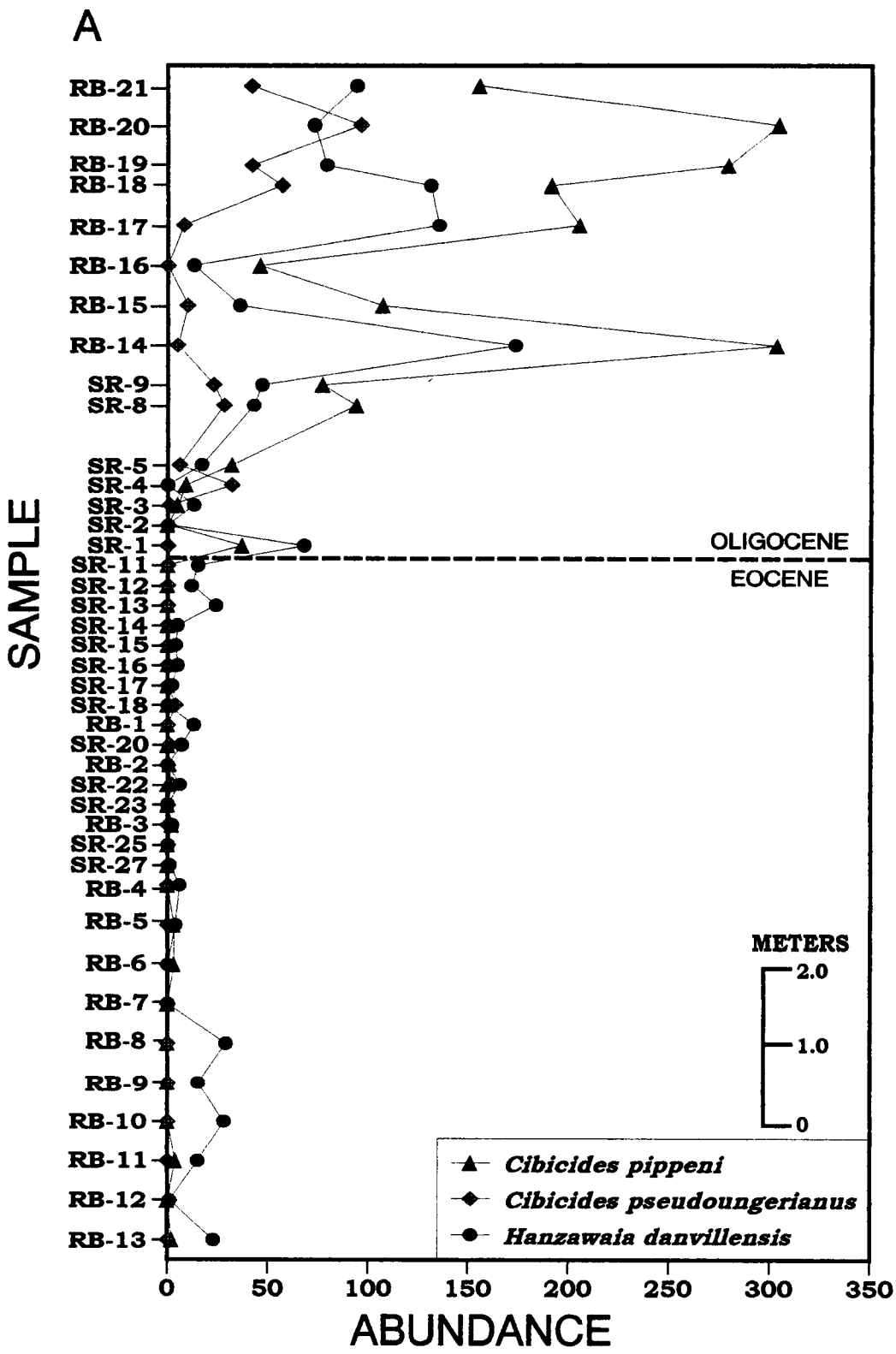


Figure 24. Species which increase in abundance across the E/O boundary at Red Bluff.

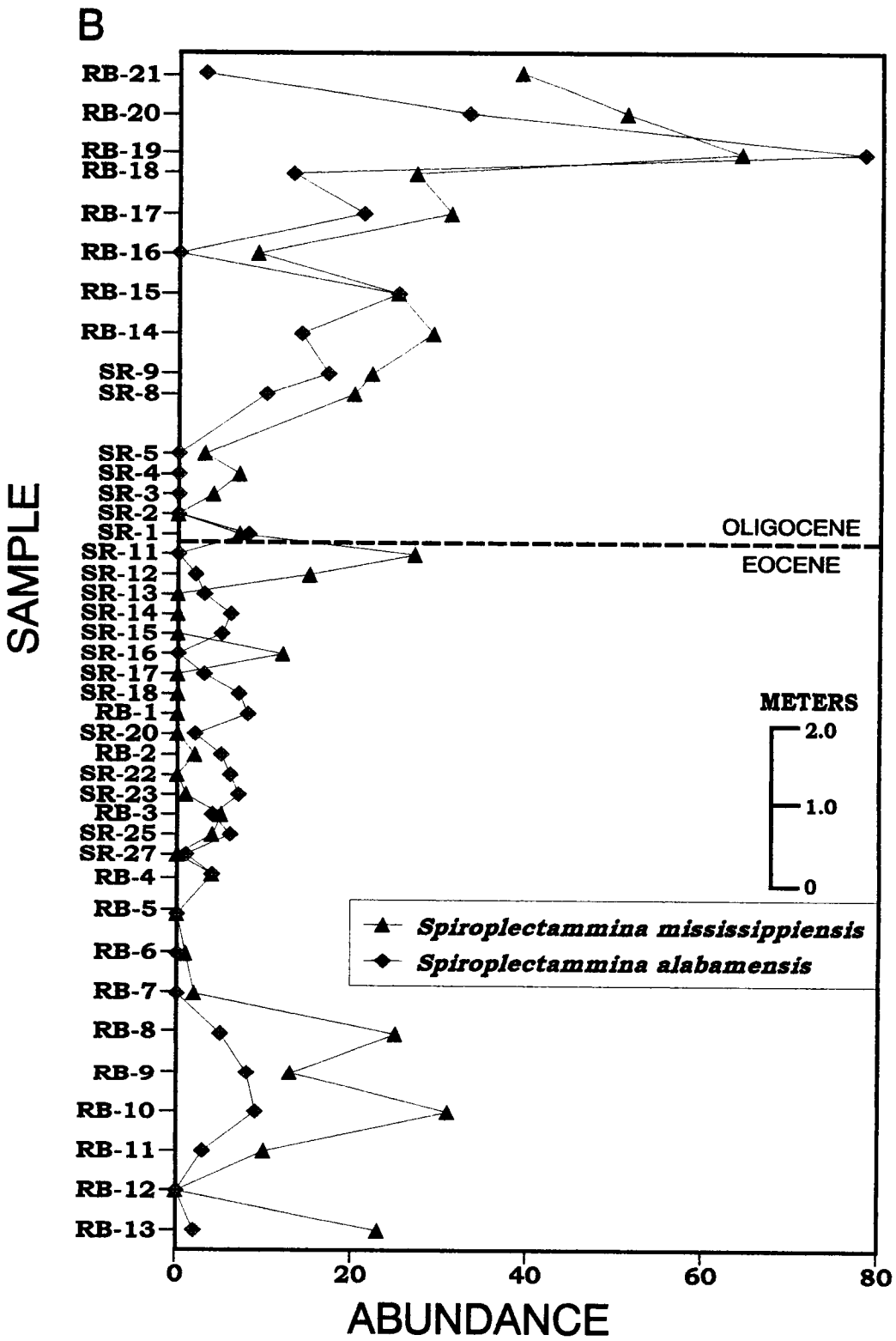


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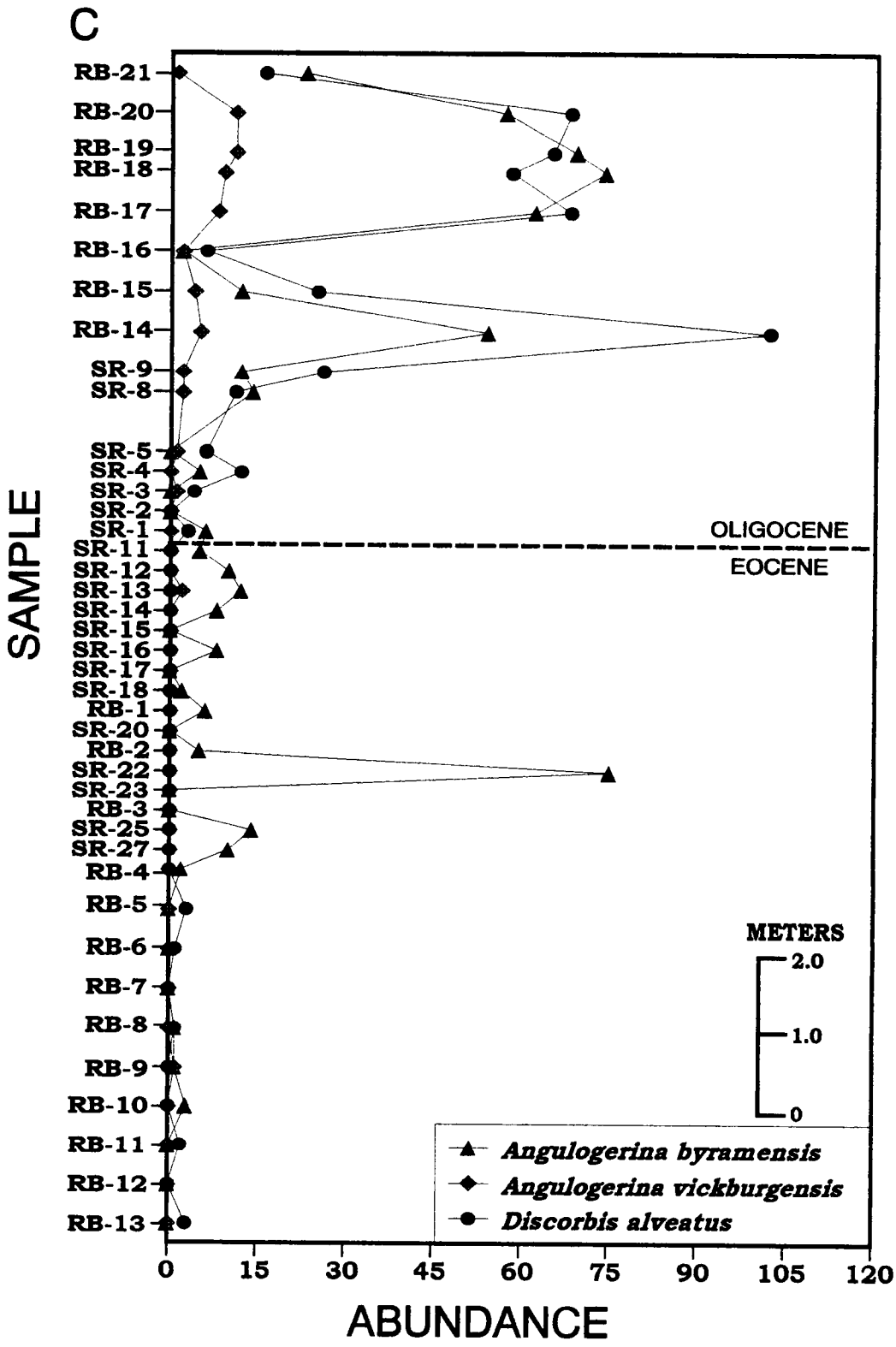


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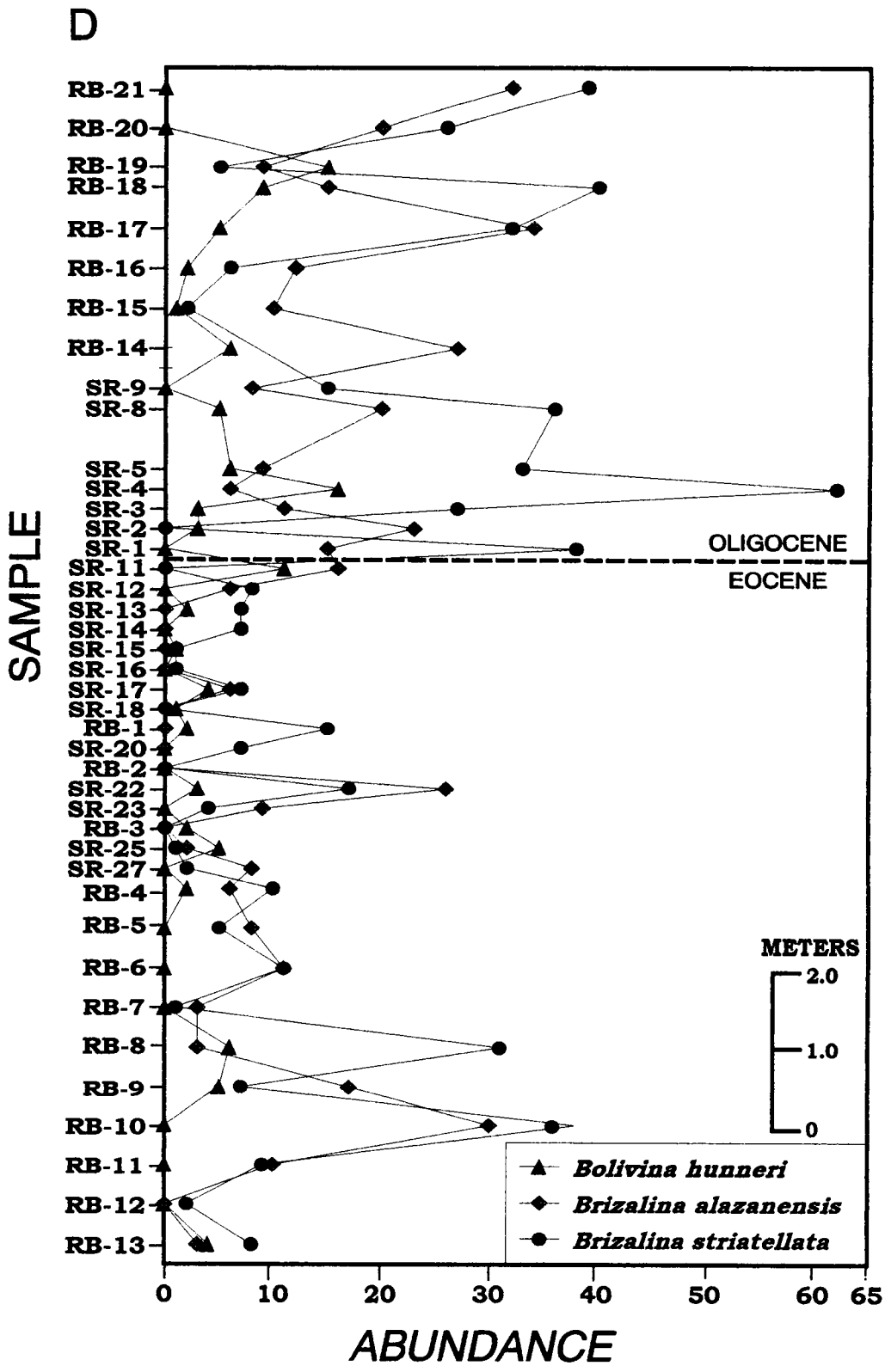


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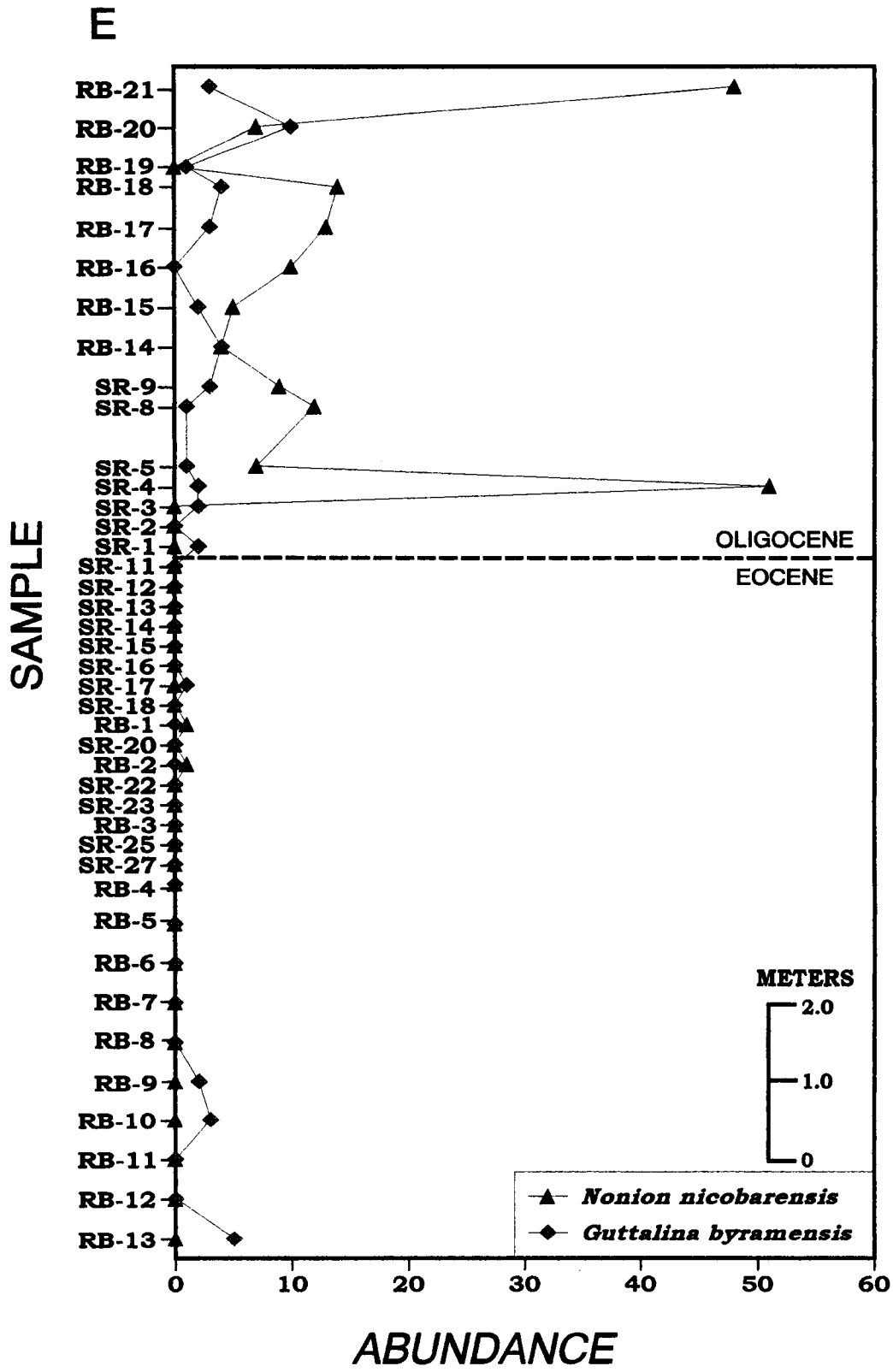


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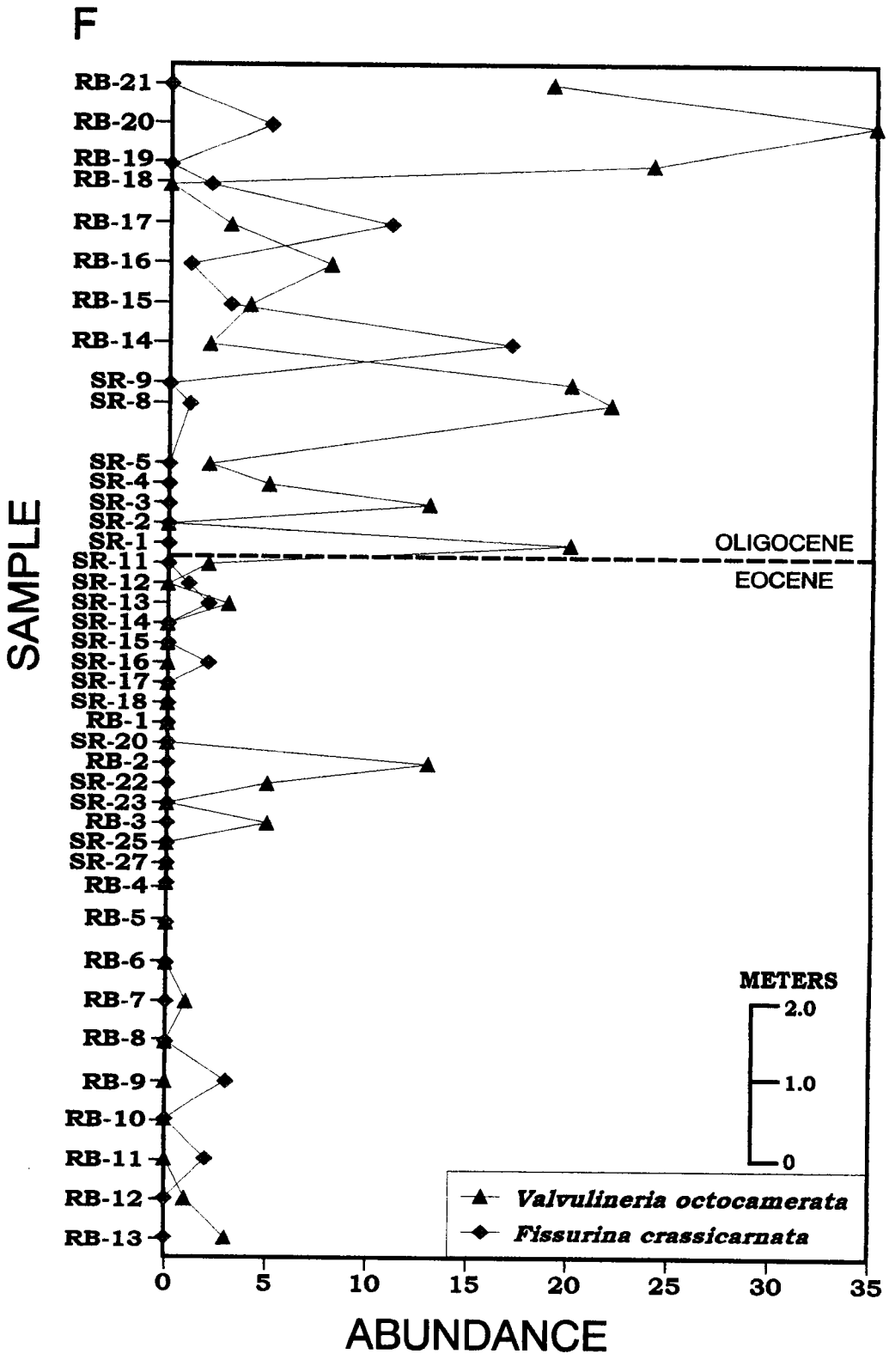


Figure 24. (Continued).

Table 5. Species showing significant increase in the Oligocene samples.

Angulogerina byramensis	*Discorbis alveatus*
Angulogerina vicksburgensis	*Fissurina crassicarnata*
Bolivina huneri	*Guttalina byramensis*
Brizalina striatellata	*Nonion nicobarensis*
Brizalina alazanensis	*Spiroplectammina alabamensis*
Cibicides pippeni	*Spiroplectammina mississippiensis*
Cibicides pseudoungerianus	*Gyroidina octacamerata*

percentage of the assemblage only *C. pippeni* comprises more than 5% of the assemblage in any one sample. This species increases from a maximum abundance of 3 in the Eocene samples to over a maximum of over 300 in the Oligocene sample (Figure 24). The percentage this species increases from a maximum of less than 1% to over 15% of the fauna in sample RB-15. In contrast, the next largest change in abundance is that of *Discorbis alveatus* which increases from a maximum of 2 in the Eocene to a maximum of 102 in the Oligocene. Despite this large abundance shift, *D. alveatus* makes up at most only 5% of the assemblage. All of the other species in this group make up only small percentages of the fauna. This can be seen in the abundance plots that show all of these species have less than 100 as a maximum abundance (Figure 24). Interestingly the species of *Brizalina/Bolivina* show a pattern of decreasing then increasing abundance across the boundary in terms of abundance (Figure 24), but a pattern of increasing percentage of the fauna in the same interval. This is due to the drop in total specimen per sample counts in the lowermost Red Bluff apparently associated with large amounts of glauconite.

Sepugla River Section:

Only two of the six taxa which have last occurrence in the Eocene occur in sufficient abundance to be considered (i.e. occur in more than 1 or 2 samples with abundance greater than 1), *Trifarina spp* and *Planulina kendrickensis*, have a local L.O. in the upper Eocene samples in the Sepugla River section (Table 6; Figure 25).

Of these two, only *Trifarina* species is present in any quantity and at that has a maximum of 15 specimens in a sample. In terms of percentage of the fauna these forms are insignificant, although *Planulina kendrickensis* is a distinctive form.

Species which exhibit large decreases in abundance across the boundary in this

Table 6 Taxa with last occurrences in the Eocene at Sepugla River.

Astacolus sublituus	*Oolina sphearica*
Bulimina jacksonensis	*Trifarins spp.*
Planulina kendrickensis	*Sigmorphina spp.*

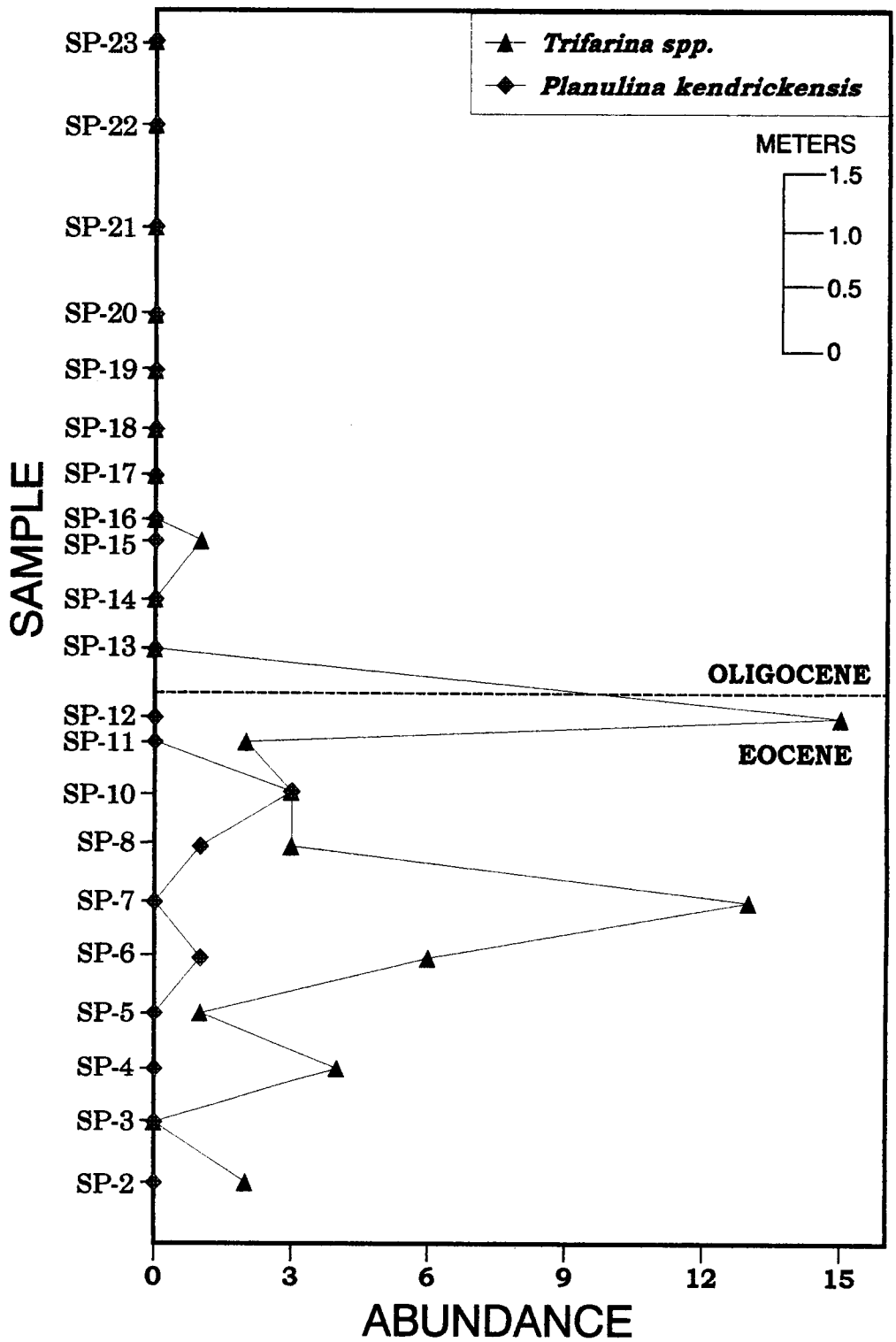


Figure 25. Species with last occurrences in the Eocene at Sepugla River.

section are listed in Table 7 with abundance plots shown in Figure 6a-c.

Of the 6 species in this group by far the most important in terms of faunal composition and visual recognition of the samples are *Cassidulina alabamensis* and *C. armosa* (Figure 26). These two species combined make up 13.6 - 42.64% of the Eocene fauna with a generally decreasing percentage up section. In the Oligocene samples of this section the combined percentage of these species ranges from 0.0-2.96%. Among the other species in this group only *Reussella sculptilis* occurs in high enough abundances to be statistically important making up between 1 and 6.9% of the Eocene assemblage (Figure 26). The other species are present in abundances of not greater than 27 in any sample and never make up more than 3% of the assemblage (Figures 26). However, as with many of the other species discussed in this section some of the rare species have a distinctive shape and are useful as visual makers. In this

Table 7 species having large decreases in abundance at Sepugla river.

Cassidulina alabamensis	*Reussella sculptilis*
Cassidulina armosa	*Reussella moodyensis*
Discorbis gloulospinosa	*Textularia distincta*

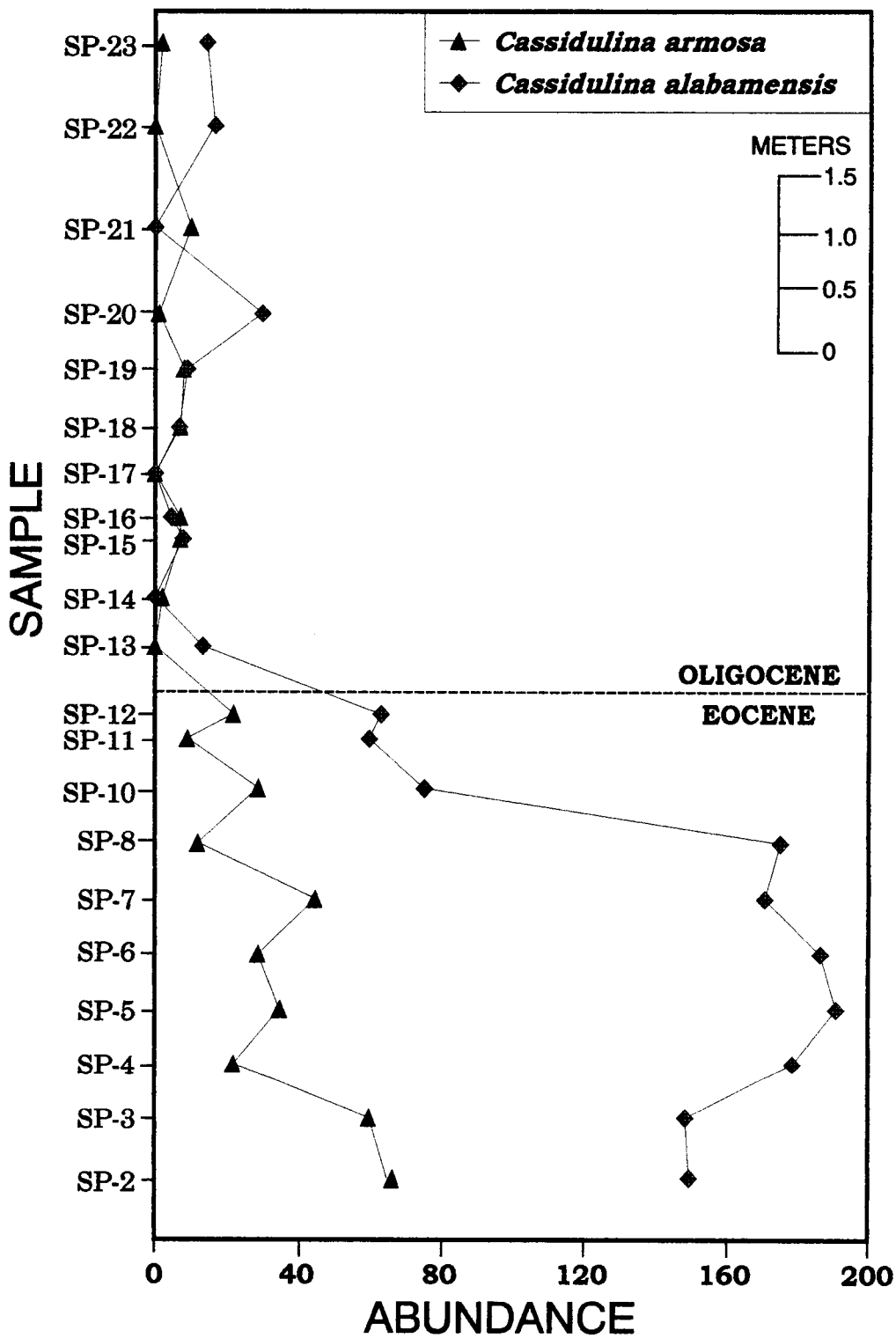


Figure 26. Species which decrease in abundance across the E/O boundary at Sepugla River.

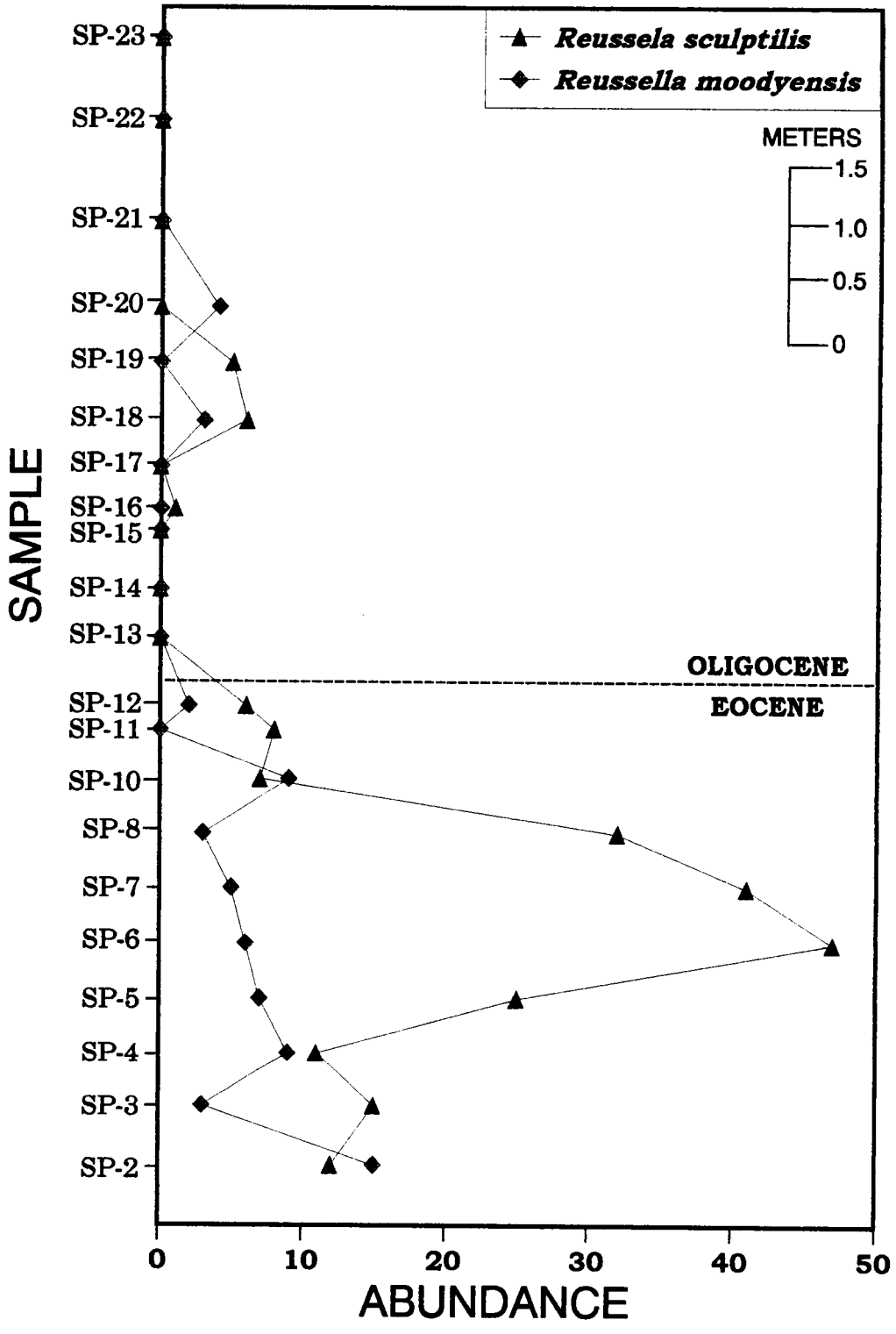


Figure 26. (Continued).

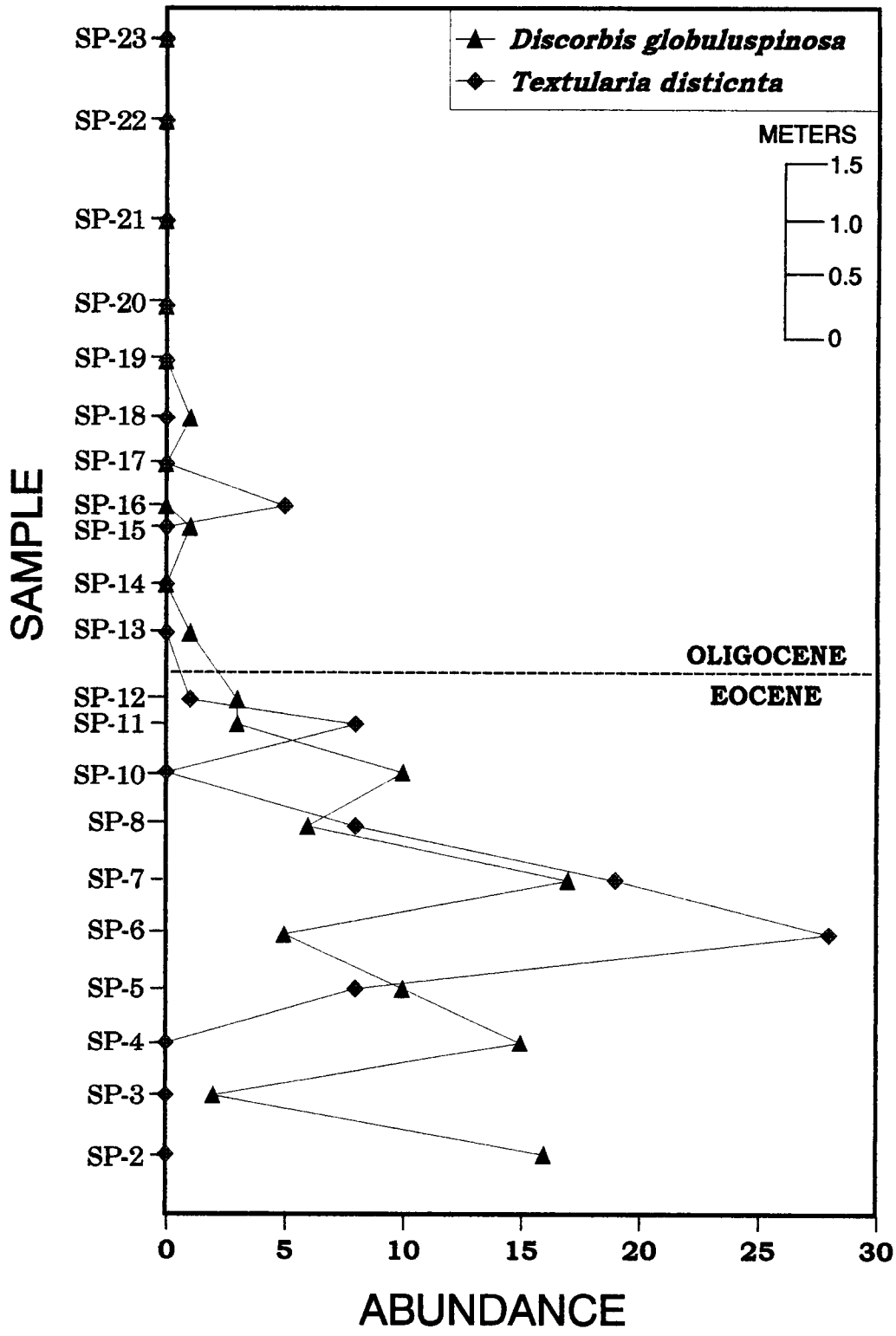


Figure 26. (Continued).

group, in addition to the *Cassidulina* and *R. sculptilis* which are both visually and statistically significant, *Discorbis gobulospinosa* is a very distinctive form and is either not present in the Oligocene or only occurs singly.

Taxa which have a First Occurrence in the lower Oligocene at Sepugla River are shown in Table 8 and Figure 27. None of these species occur in large abundances and/or make up a large percentage of the fauna. Only *Spirillina vicksburgensis* makes up more than 3% of any sample 3.5% in sample SP-18 and 4.3% in sample SP-17. With the exception of these two samples no species in this group makes up more than 2% of the fauna. While all of these taxa are distinctive in appearance and their presence marks the Oligocene it should be noted that they do not appear together or at the boundary only *B. dalli* appears in the first Oligocene sample (Figure 27).

Table 8 Species first appearing in the Lower Oligocene of the Sepugla river section.

Brizalina retifera	*Brizalina dalli*
Brizalina alazanensis	*Globocassidulina subglobosa*
Loxostomum baculum	*Spirillina vicksburgensis*
Bulimina trigona	*Cancris claibornensis*
Fissurina crassicarnata	*Fissurina maurciensis*
Pullena quinqueloba aplata	*Guttalina consorbia*
Bolivina mississippiensis	*Valvulineria octacamerata*
Leibusella byramensis turgida	*Spirillina vicksburgensis*
Quinqueloculina spp.	*Dimorphina danvillensis*
Dentalina indifferens	

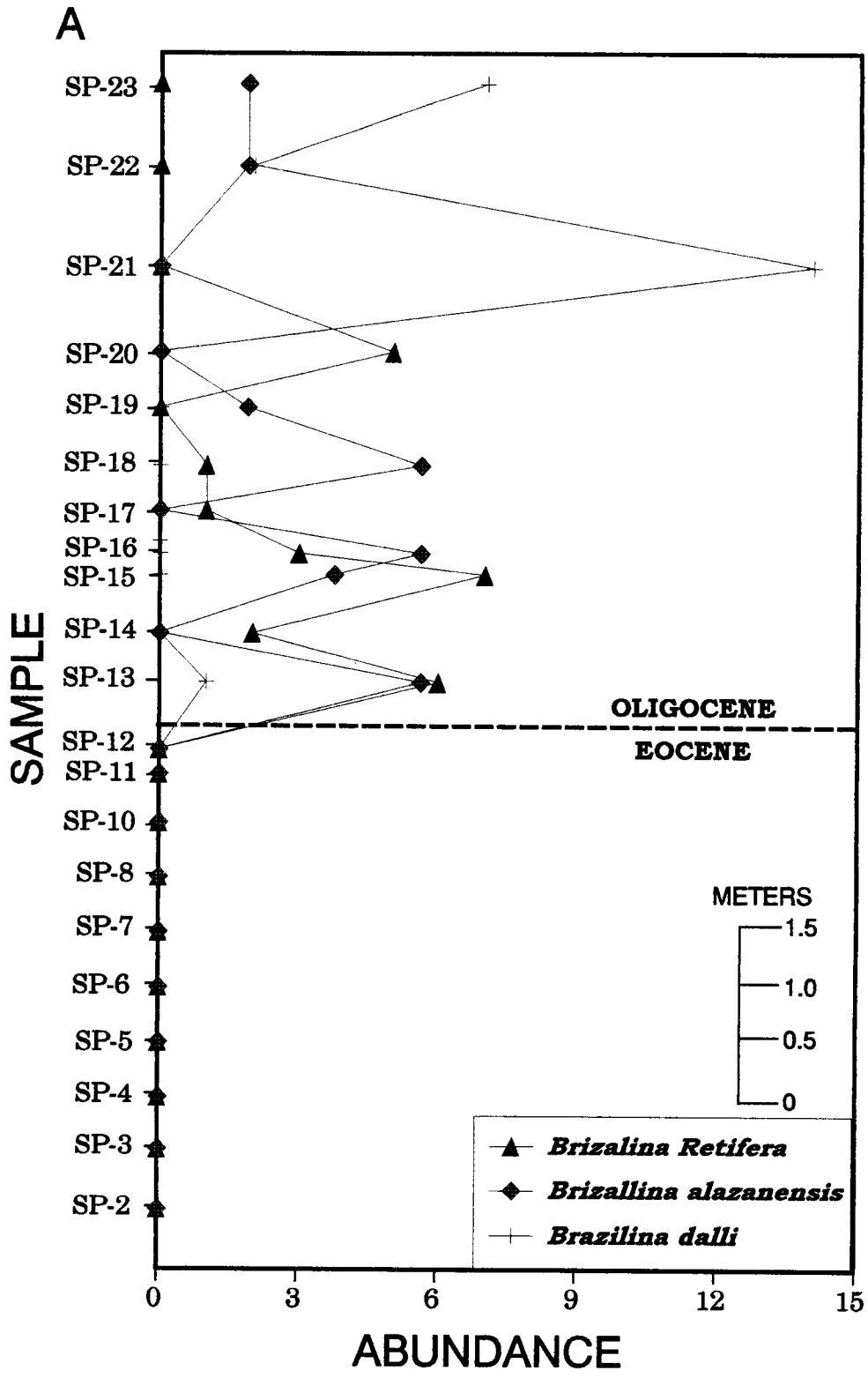


Figure 27. Species with first occurrences in the Oligocene at Sepugla River.

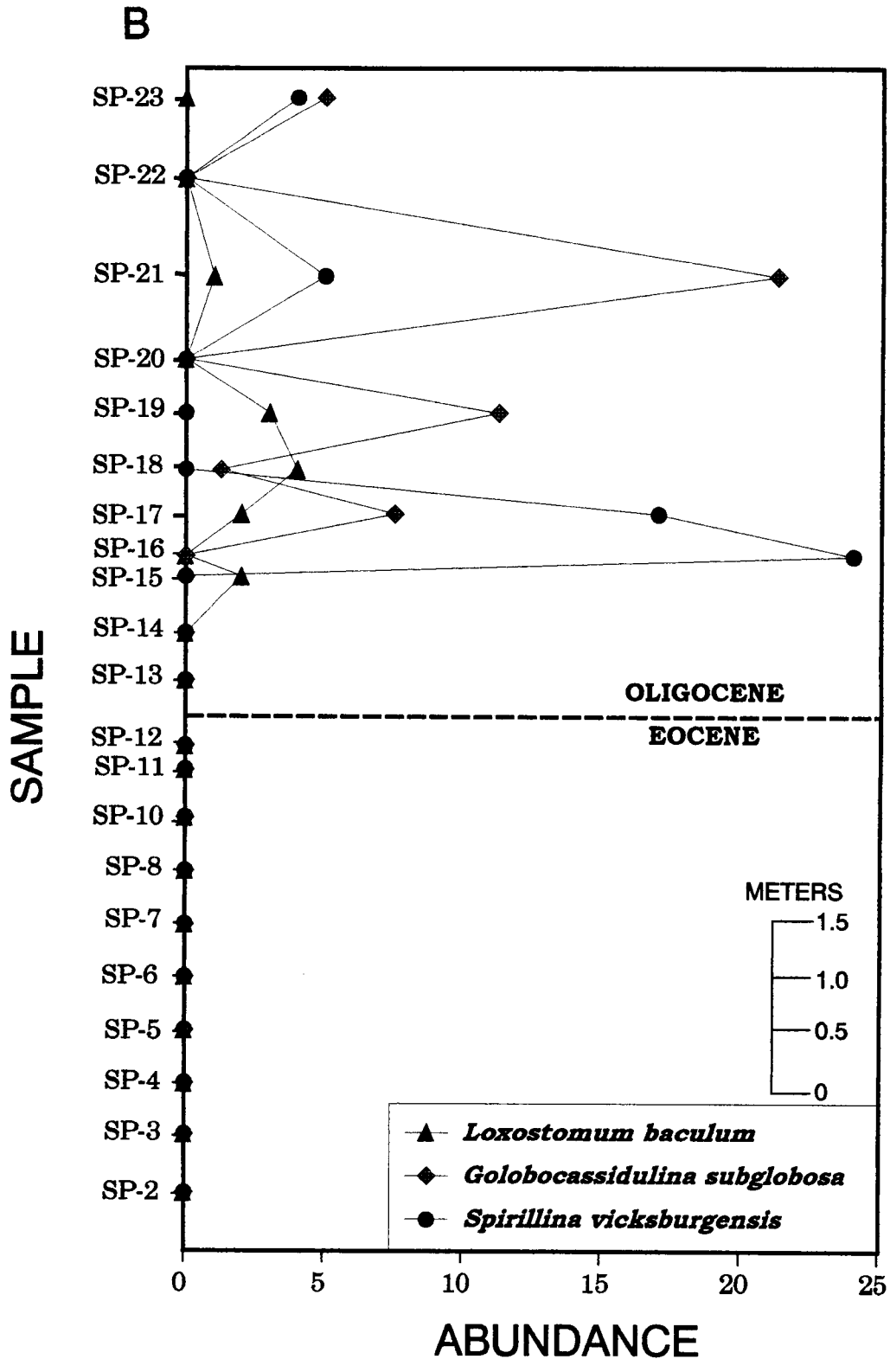


Figure 27. (Continued).

Forms which show a marked increase in abundance across the E/O boundary in this section are listed in Table 9 and shown in Figure 28a-c. In this group the most important species is *Angulogerina byramensis* followed by *Eponides lotus* and *Brizalina salbrosa*. As group however the most notable of these are the *Brizalina-Bolivina*'s. This taxonomic plexus (which may or may not belong in a single genus) shows a increase from an average from 0.9% in the Eocene to an average of 8.5% in the Oligocene samples. The other species in this group are not significant in terms of abundance. Only *V. octacamerata* has a distinctive shape. However, the increase in abundance of this species is not great (Figure 28c).

Table 9 Species increasing in abundance across the boundary at Sepugla river.

Angulogerina byramensis	*Discorbis hemispaericus*
Brizalina salebrosa	*Discorbis alveatus*
Brizalina striatellata	*Eponides lotus*
Cibicides lobatus	*Valvulineria octacamerata*

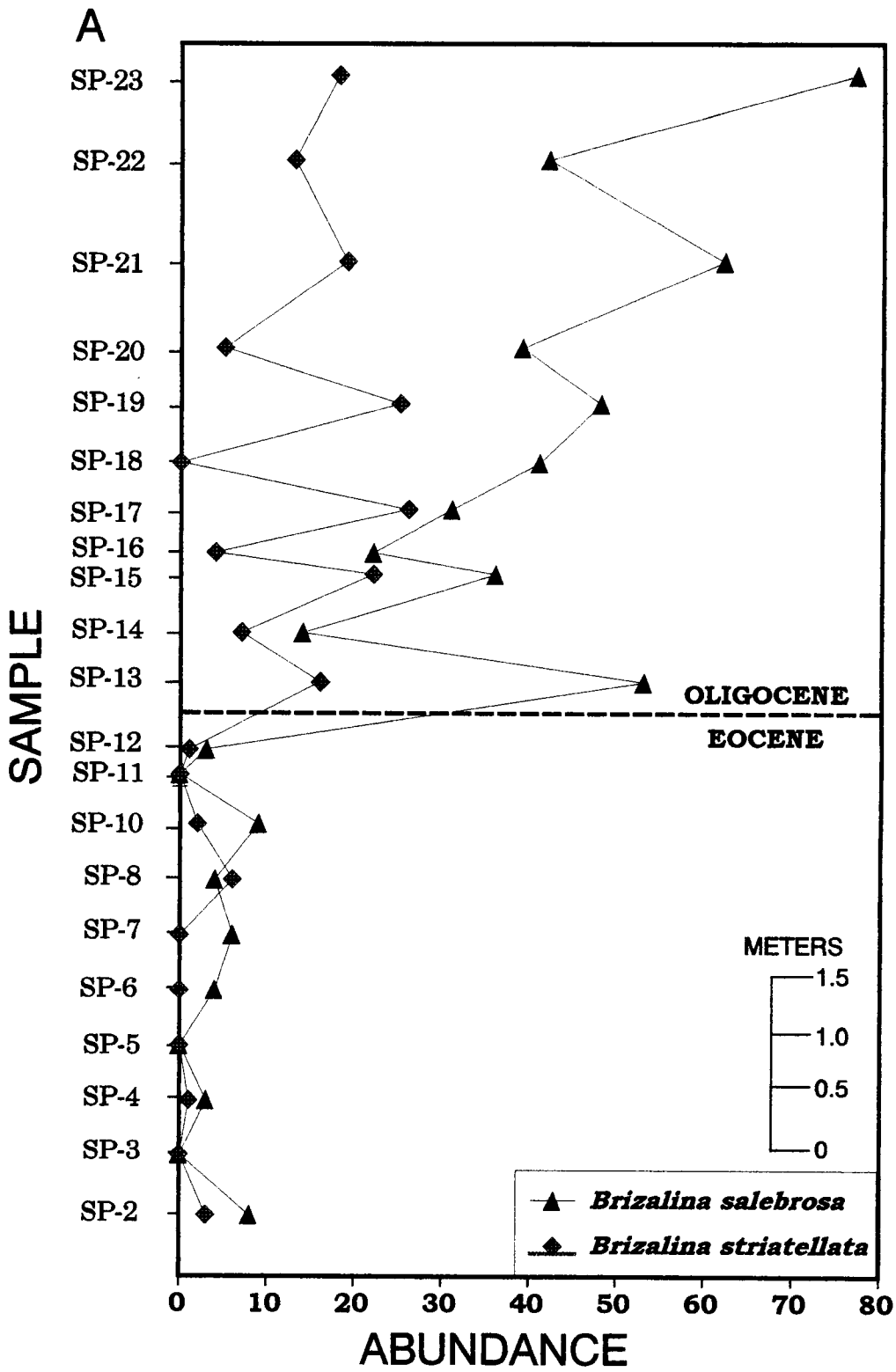


Figure 28. Species which increase in abundance across the E/O boundary at Sepugla River.

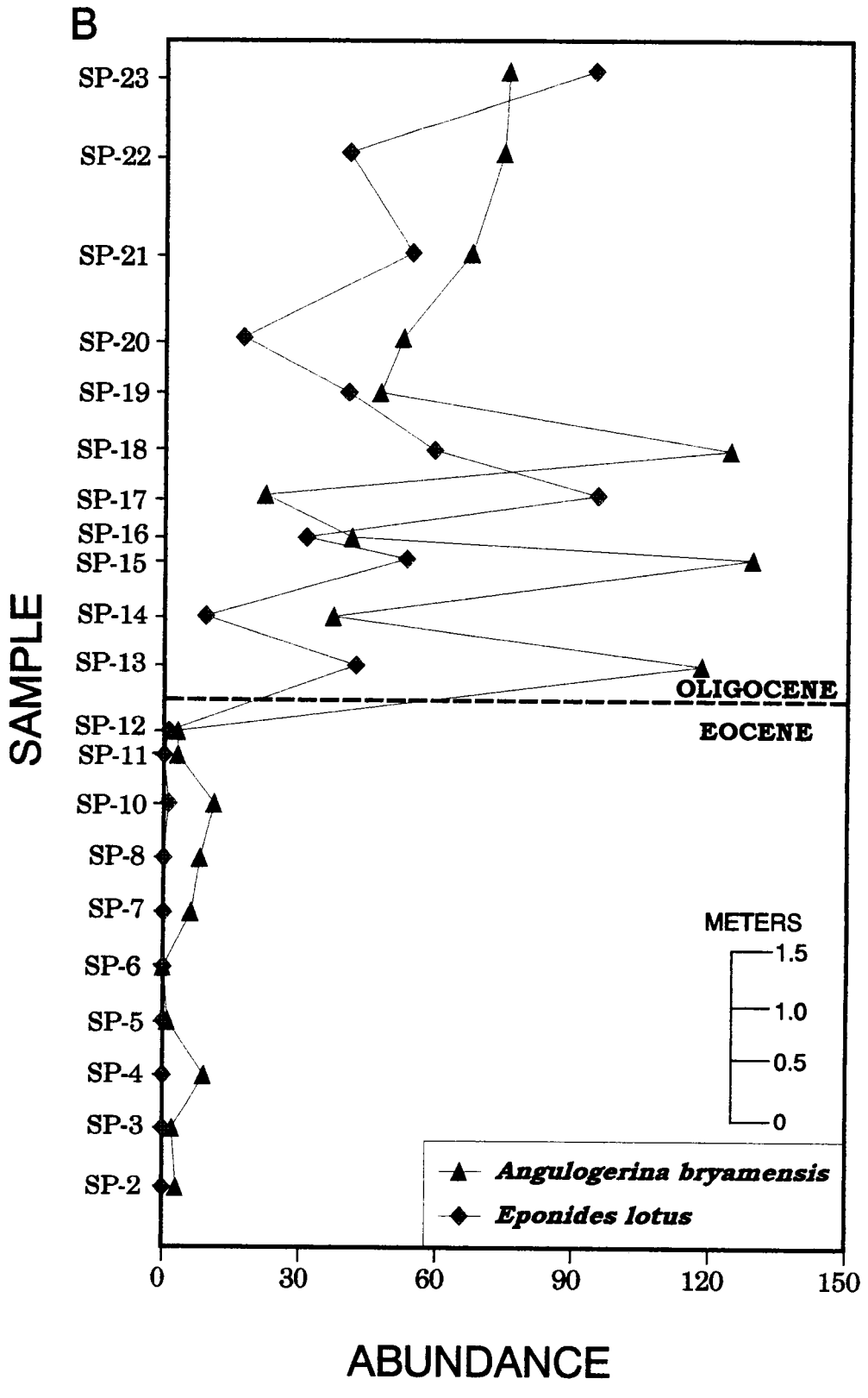


Figure 28. (Continued).

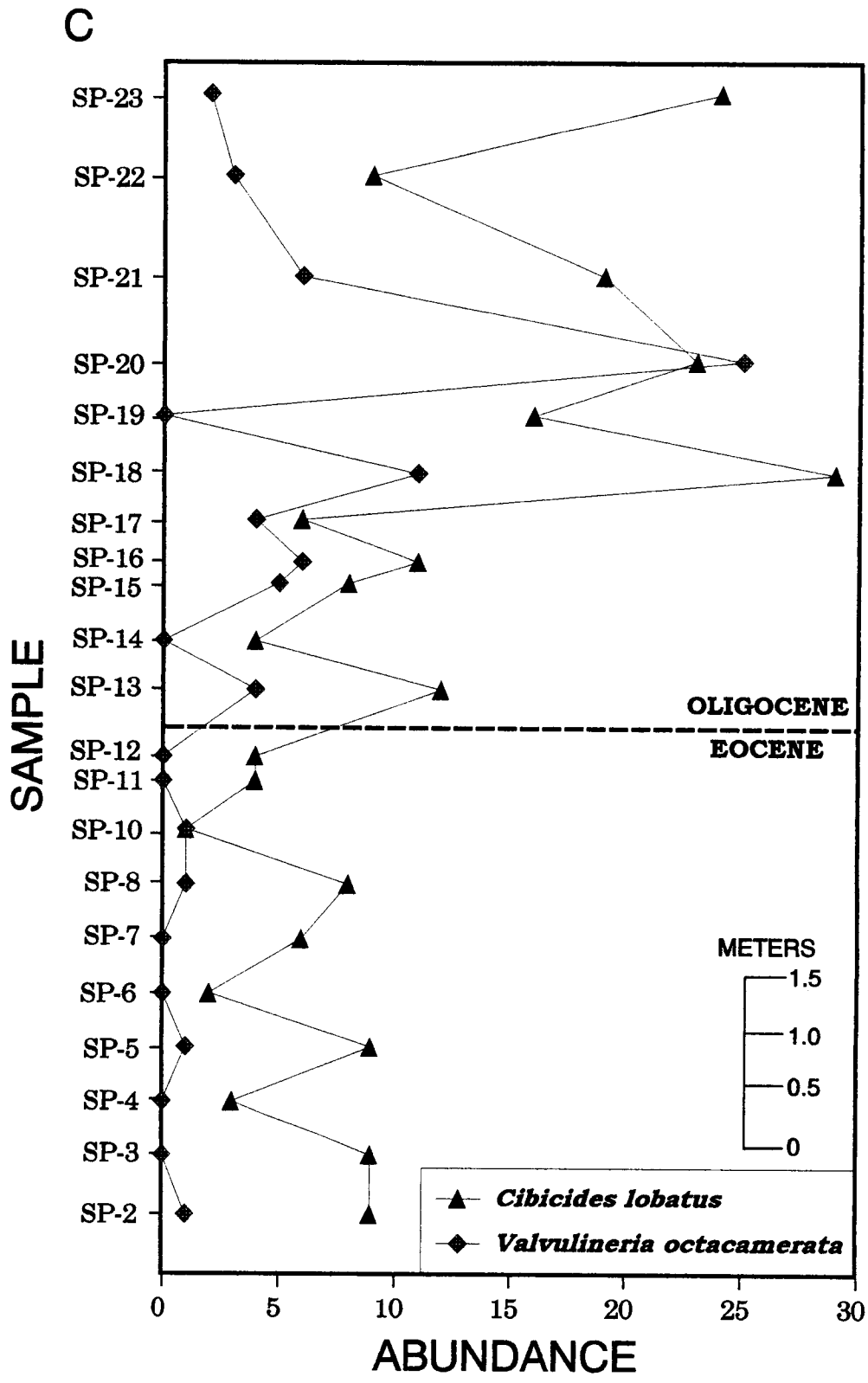


Figure 28. (Continued).

GGS-3535:

Species which have local last occurrence in the Eocene are shown in Table 10. None of these taxa have abundances of greater than 1 or 2 in any sample and/or occur in more than 2 or 3 samples have a last occurrence at or near the E/O boundary. However, fourteen taxa, which occur in sufficient abundance, show decreases in abundance across the boundary. These species are listed in Table 11 and abundance plots are shown in Figure 29.

In contrast to the Sepugla river section in the core the *Brizalina/Bolivina's* make up a larger percentage of the fauna in the Eocene than in the Oligocene although they are significant components in both times. In the Eocene, the percentage of *Brizalina/Bolivina* in the fauna ranges from 6.5-28.9 and form 8.3-17.9 in the Oligocene with the difference being largely due to the near absence of *B. straitellata* and *B. huneri* in the Oligocene (Figure 29). The change in abundance of *Cibicides pseudoungerianus* is even more dramatic (Figure 29). This species drops from comprising a minimum of 17.9% of the fauna in the Eocene to a maximum of 9.8% of the fauna in the Oligocene. Looking at the genus *Cibicides* as a whole the change is less dramatic but still noticeable. In part this may be due to somewhat lower total specimen abundances in the Oligocene. In addition, to the 2 groups above *Cassidulina alabamensis* and *C. armosa* separately and combined comprised a relatively small but consistent part of the Eocene assemblage but nearly disappear in the Oligocene (Figure 29). In particular *C. alabamensis* which reaches abundances of 40 in the Eocene but is present in only one Oligocene sample. *Ruessella sculptilis* and *R. moodyensis* show a similar pattern (Figure 29). Comprising up to 4% of the fauna in the Eocene and nearly disappearing just below the boundary. The final two species in this group never comprise over 3% of the Eocene fauna and

Table 10. Taxa with local last occurrence in the Eocene in GGS-3535.

Saracenaria ornatula riga	*Saracenaria spp*
Lenticulina euglypheus	*Lenticulina insitatus*
Lenticulina jugosus	*Lenticulina spp2*
Astocolus sublituus	*Globulina gibba*
Loxostomum spp1	*Trifarina*
Cancris claibornensis	

Table 11. Species which decrease in abundance across the boundary in the GGS 3535 core.

Brizalina striatellata	*Cibicidoides bilateralis*
Brizalina huneri	*Dentalina spp*
Cassidulina alabamensis	*Discorbis globulo-spinosa*
Cassidulina armosa	*Reussella moodyensis*
Cibicides pippeni	*Reussella sculptilis*
Cibicides pseudoungerianus	*Siphonina spp*
Cibicides spp	*Uvigerina jacksonensis*

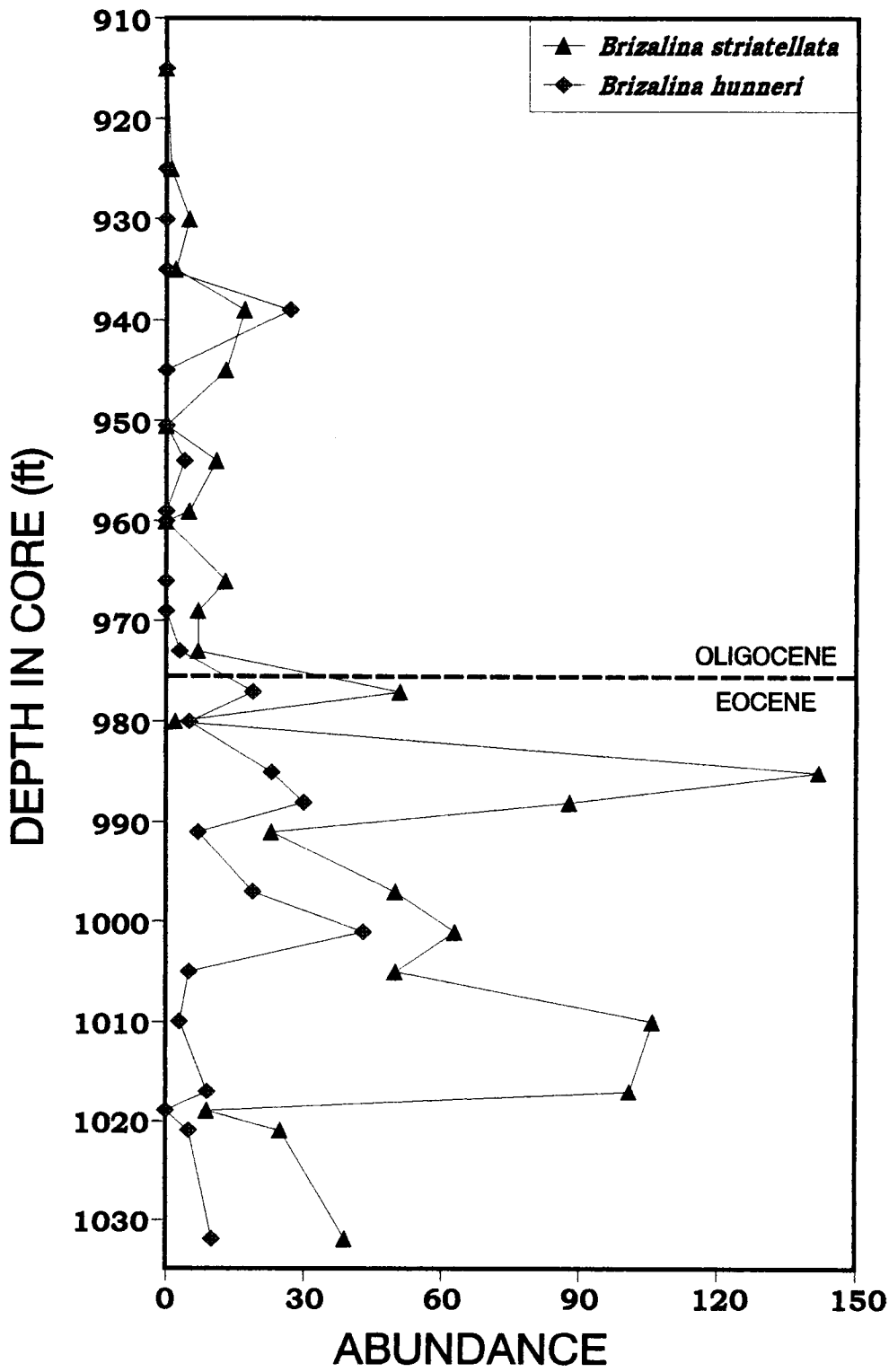


Figure 29. Species which decrease in abundance across the E/O boundary in GGS-3535.

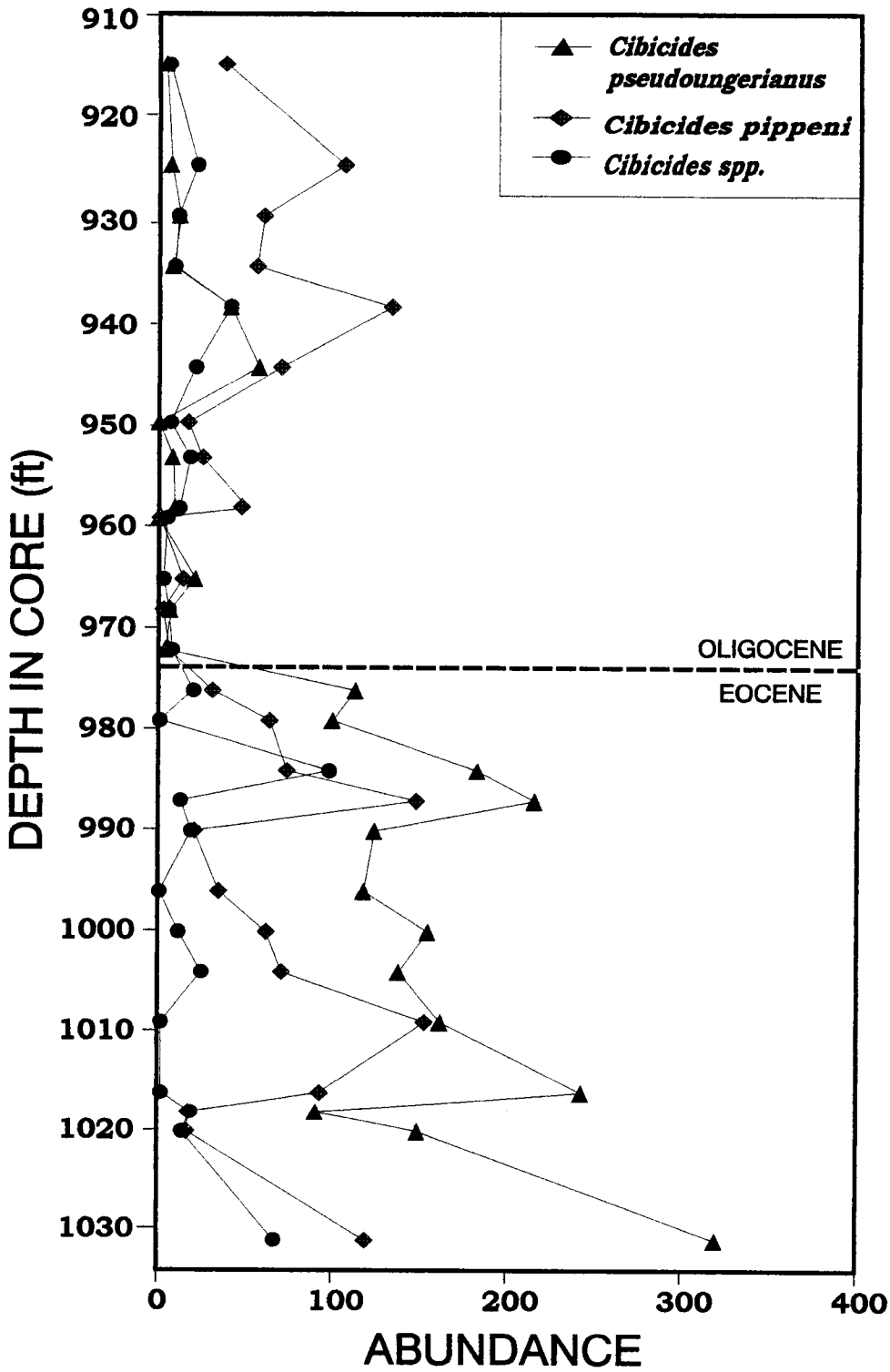


Figure 29. (Continued).

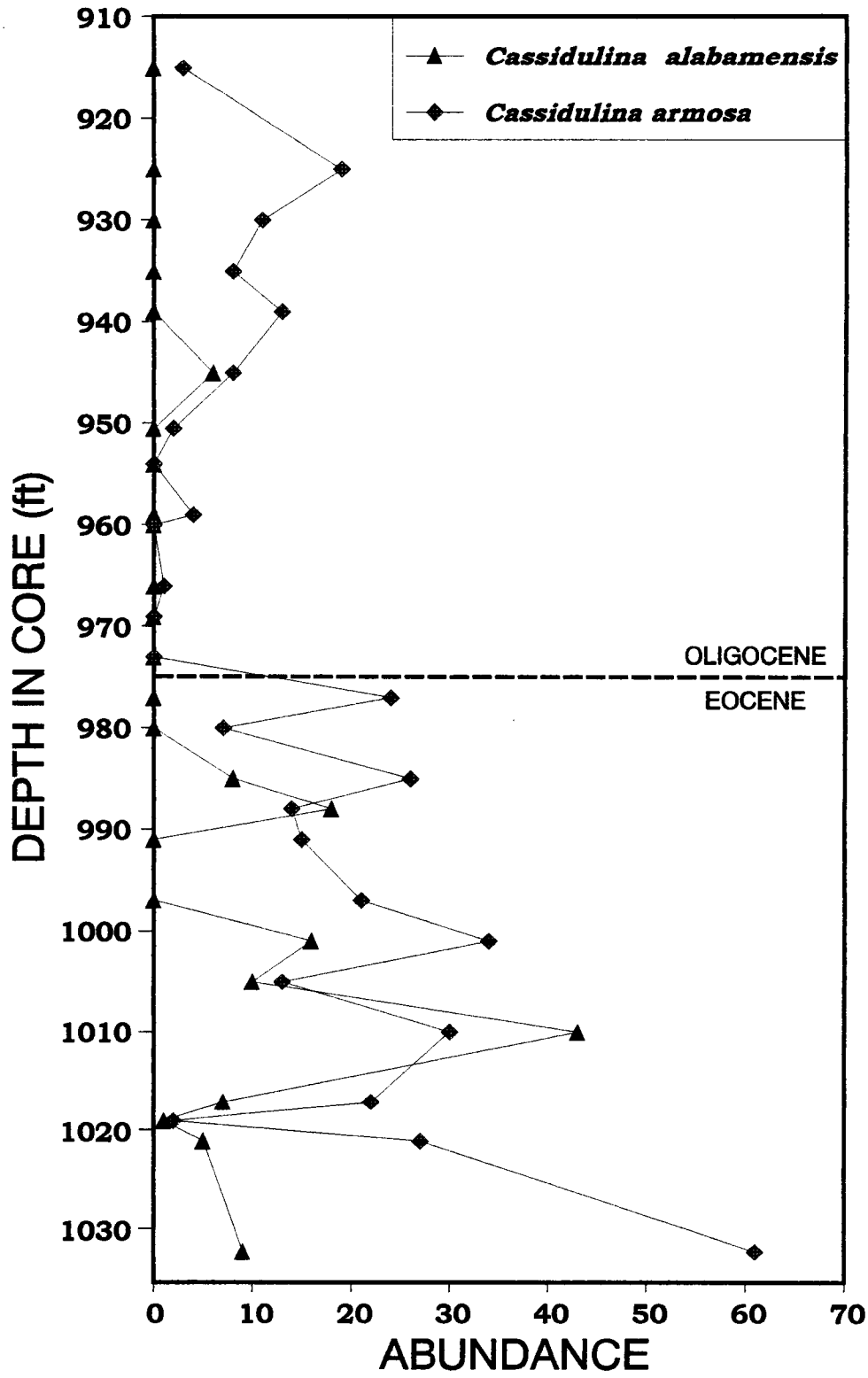


Figure 29. (Continued).

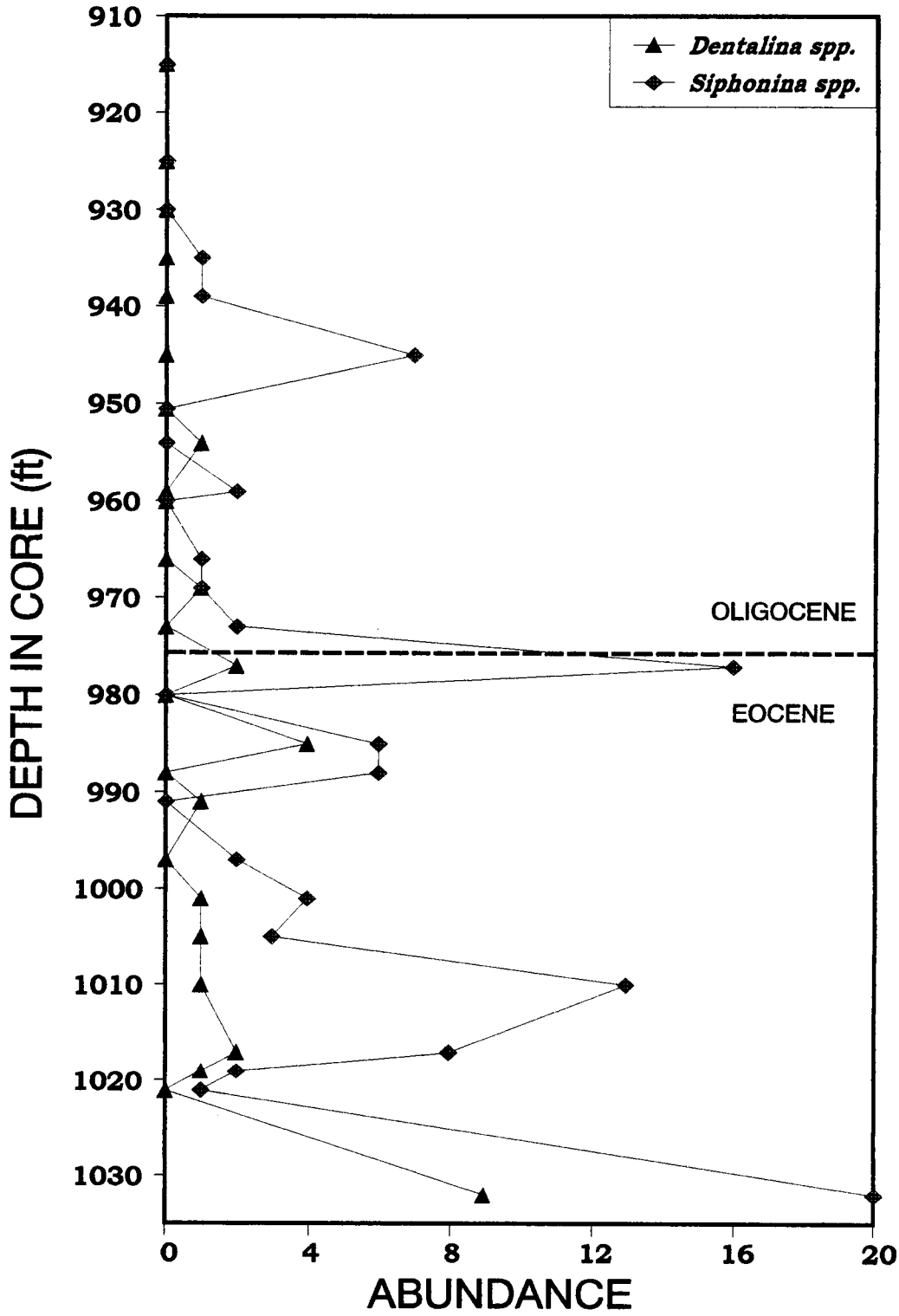


Figure 29. (Continued).

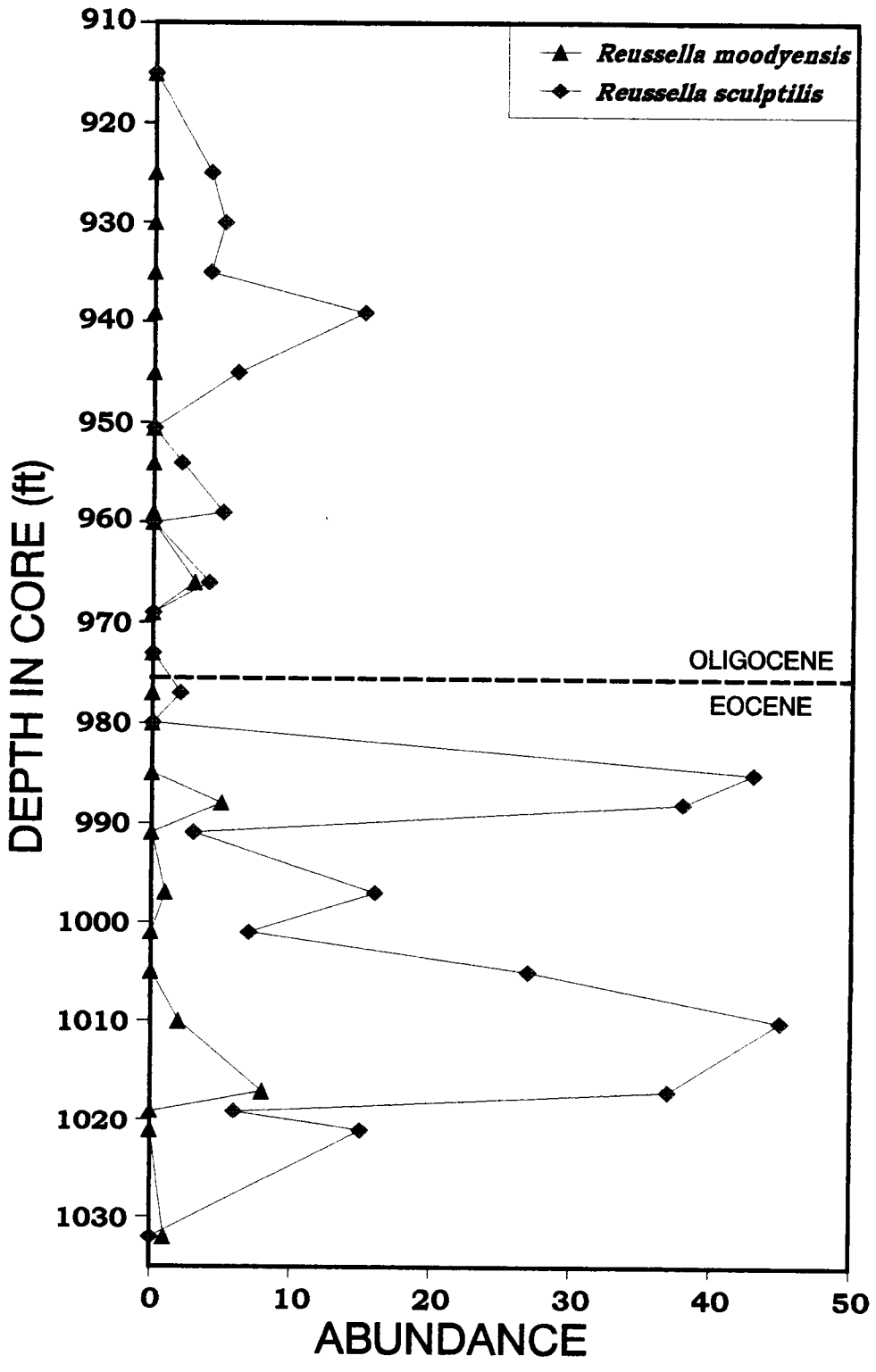


Figure 29. (Continued).

never occur in more than 10 specimens above the boundary, particularly *U. jacksonensis,* which is present in only 2 Oligocene samples (Figure 29). However, as with species in the other sections *U. jacksonensis* is a very distinctive form and it's disappearance is visually, if not statistically, readily apparent.

Eleven species first occur in this section at or near the boundary (Table 12; Figure 30). None of these taxa are particularly abundant. *Bolivinella rugosa* is the only one which has abundances which exceed 30 and in addition is the only one that makes up more than 2% of any sample (Figure 30). *B. rugosa,* along with *V. octacamerata,* are the 2 most visually distinctive of this group but the very low abundances of *V. octacamerata* make it a poor marker of the Oligocene samples (Figure 10b). In contrast, *B. rugosa* is a very distinctive species which makes a very good maker of the base of the Oligocene wereever it occurs.

Table 12. First occurrences in the Oligocene of GGS 3535.

Bolivina sp. 3	*Guttalina spp.*
Bolivinella rugosa	*Gryoidina octacamerata*
Cibicides lobatulus	*Spirillina spp.*
Fissurina spp.	*Bifarina spp.*
Bitubulogenerina howei	*Cibicides sp. 3*
Planorbulina spp.	

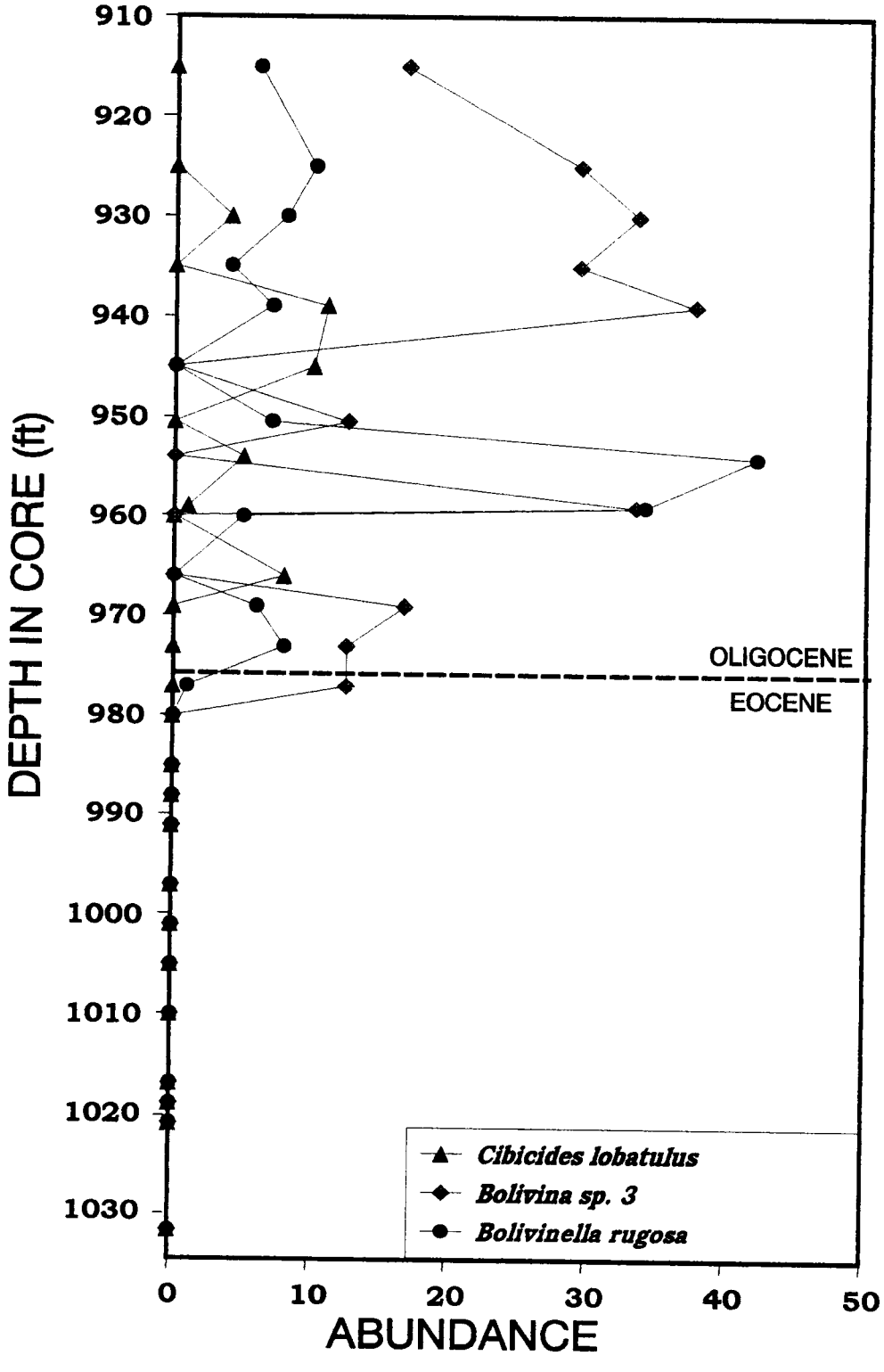


Figure 30. Species with first occurrences at or near the E/O boundary in GGS-3535.

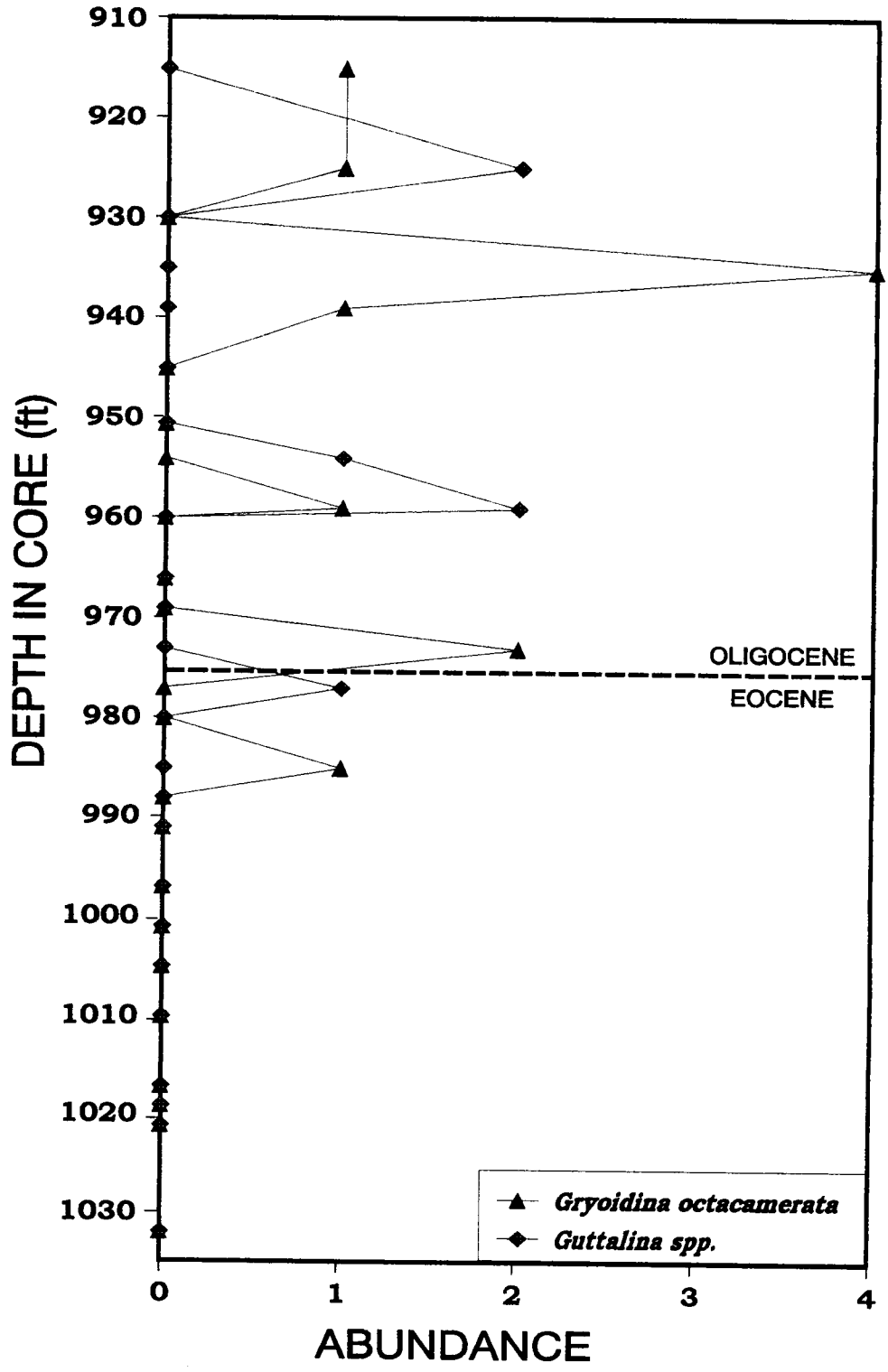


Figure 30. (Continued).

In GGS-3535, 13 forms show relatively large increases in abundance across the boundary in this section (Table 13; Figure 31). Of these the genus *Discorbis* is by far the most important, treated as a group here due to preservation problems and similar abundance patterns (Figure 31). This group of taxa increases from a maximum combined abundance of less than 60 in the Eocene to a maximum of well over 200 in the Oligocene. In terms of percentage of the fauna they increase from a max. 6.9% in the Eocene to range between 13.8 and 42.2% in the Oligocene. The only other species which comprises a significant part of the fauna in this group is *Rotalia similas* which has a maximum abundance of 90 and highest percentage in the same samples of 15.7. In no other sample does this species exceed 22 specimens or 3% of the assemblage (Figure 31). None of the rest of the species in this group exceed 35 specimens per sample or 2% of the fauna (Figures 31).

Table 13 Species showing large increases in abundance from the Eocene to Oligocene.

Angulogerina byramensis	*Discorbis globulospinosa*
Angulogerina spp.	*Discorbis hemisphaericus*
Bulliminella pulchra	*Discorbis spp.*
Cibicides lobatus	*Planulina kendrickensis*
Cibicides sp. 4	*Pullenia danvillensis*
Hanzawaia spp.	*Rotalia similas*
Discorbis alveatus	

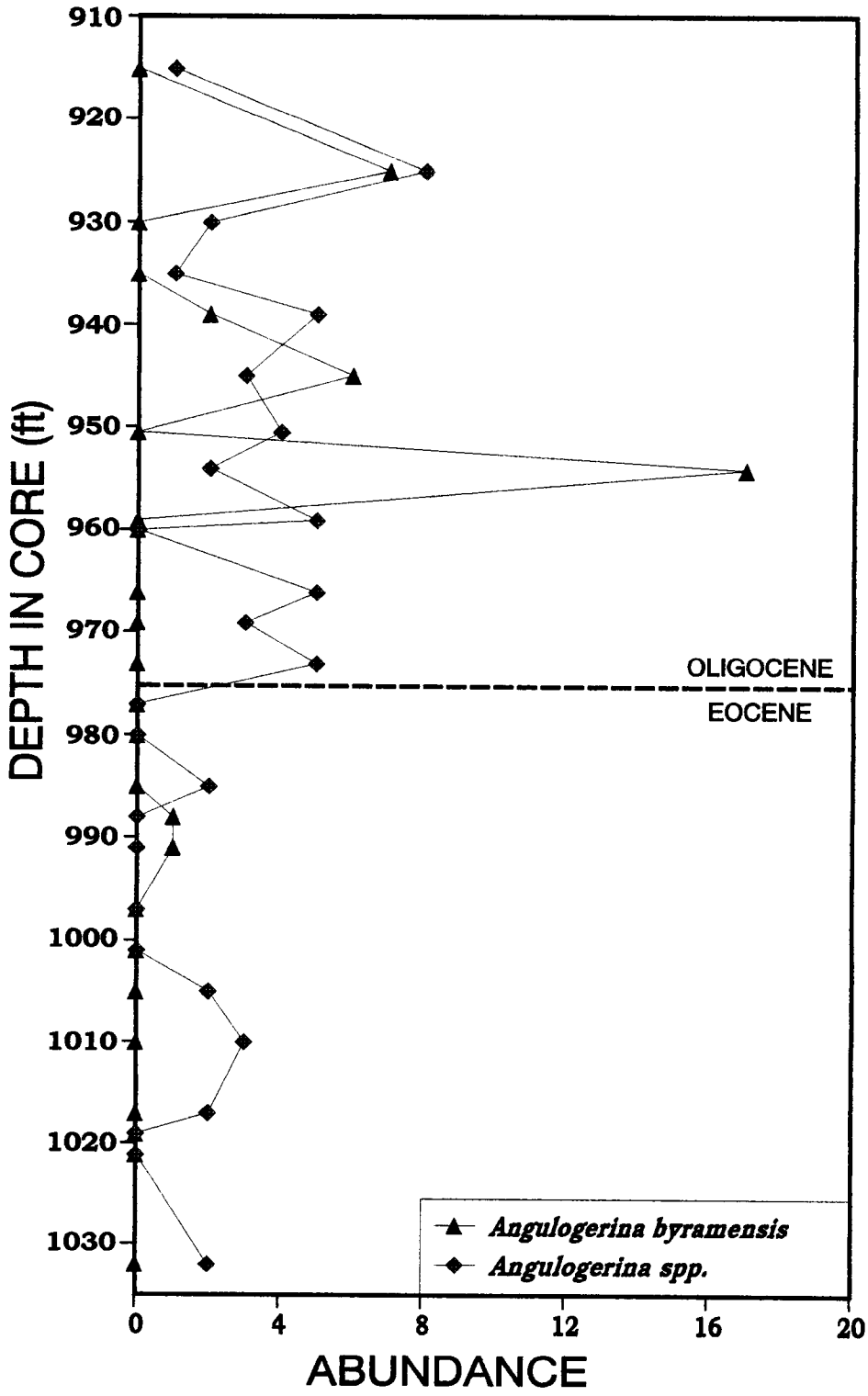


Figure 31. Species which increase in abundance across the E/O Boundary in GGS-3535.

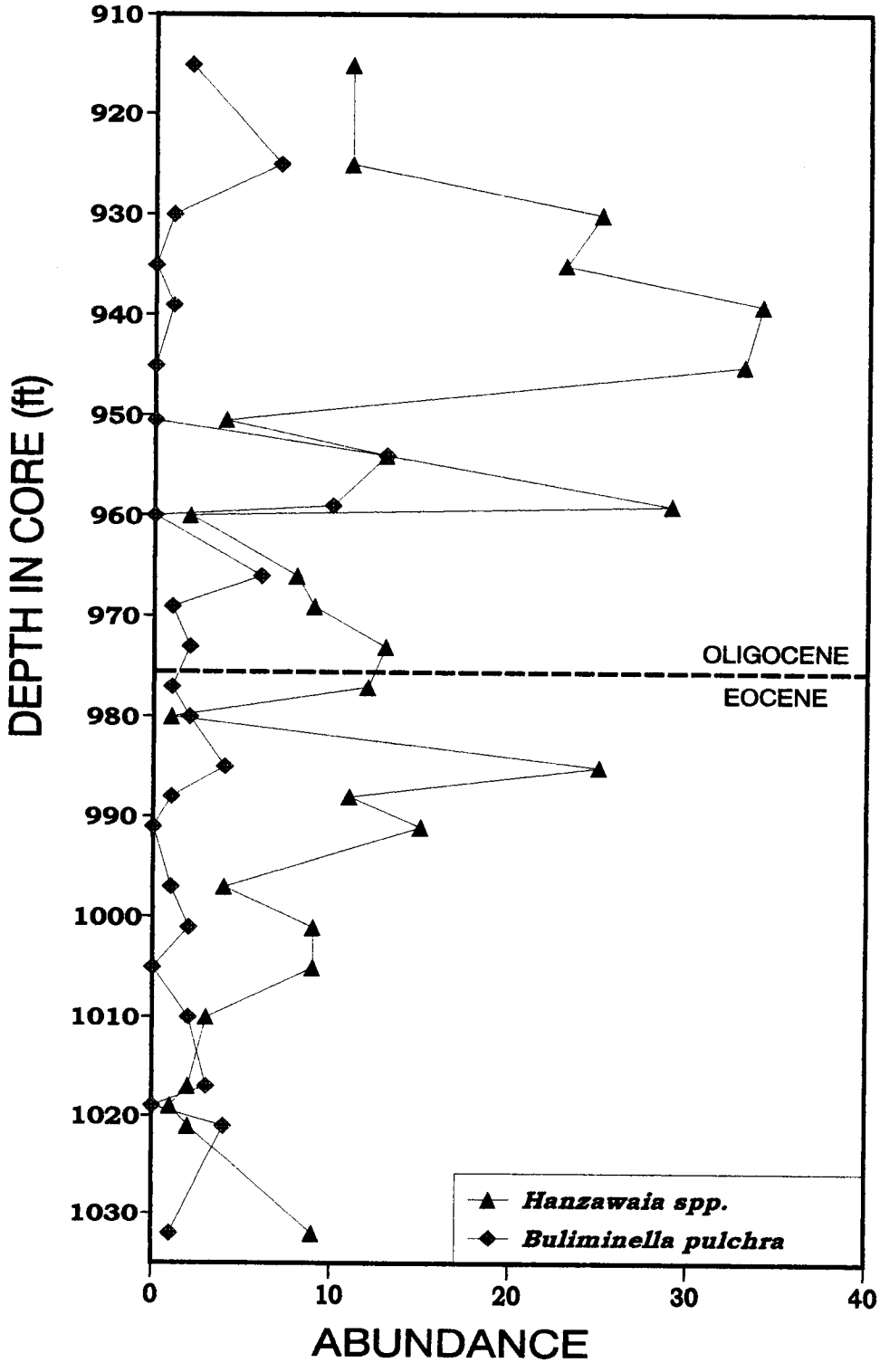


Figure 31. (Continued).

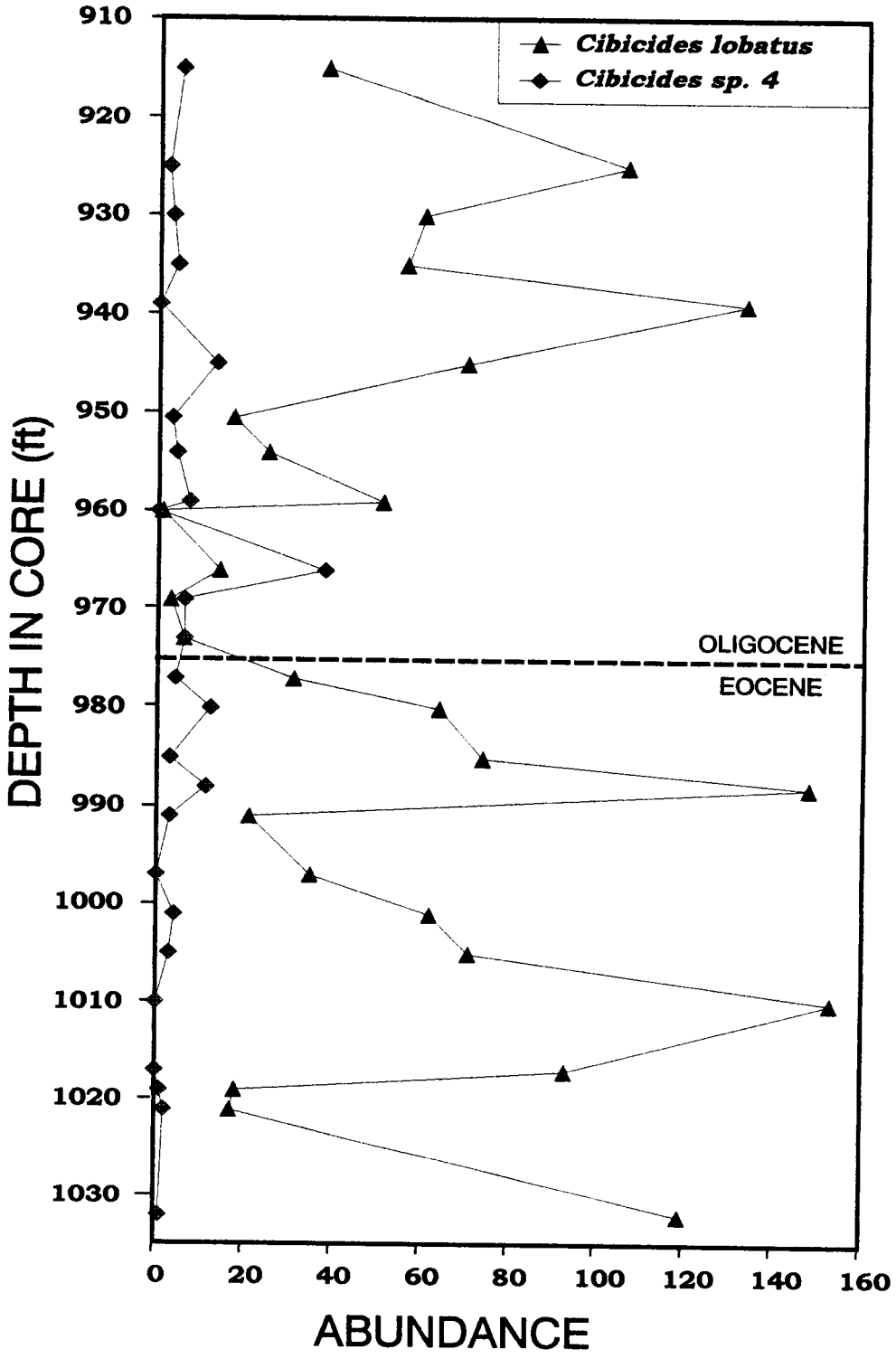


Figure 31. (Continued).

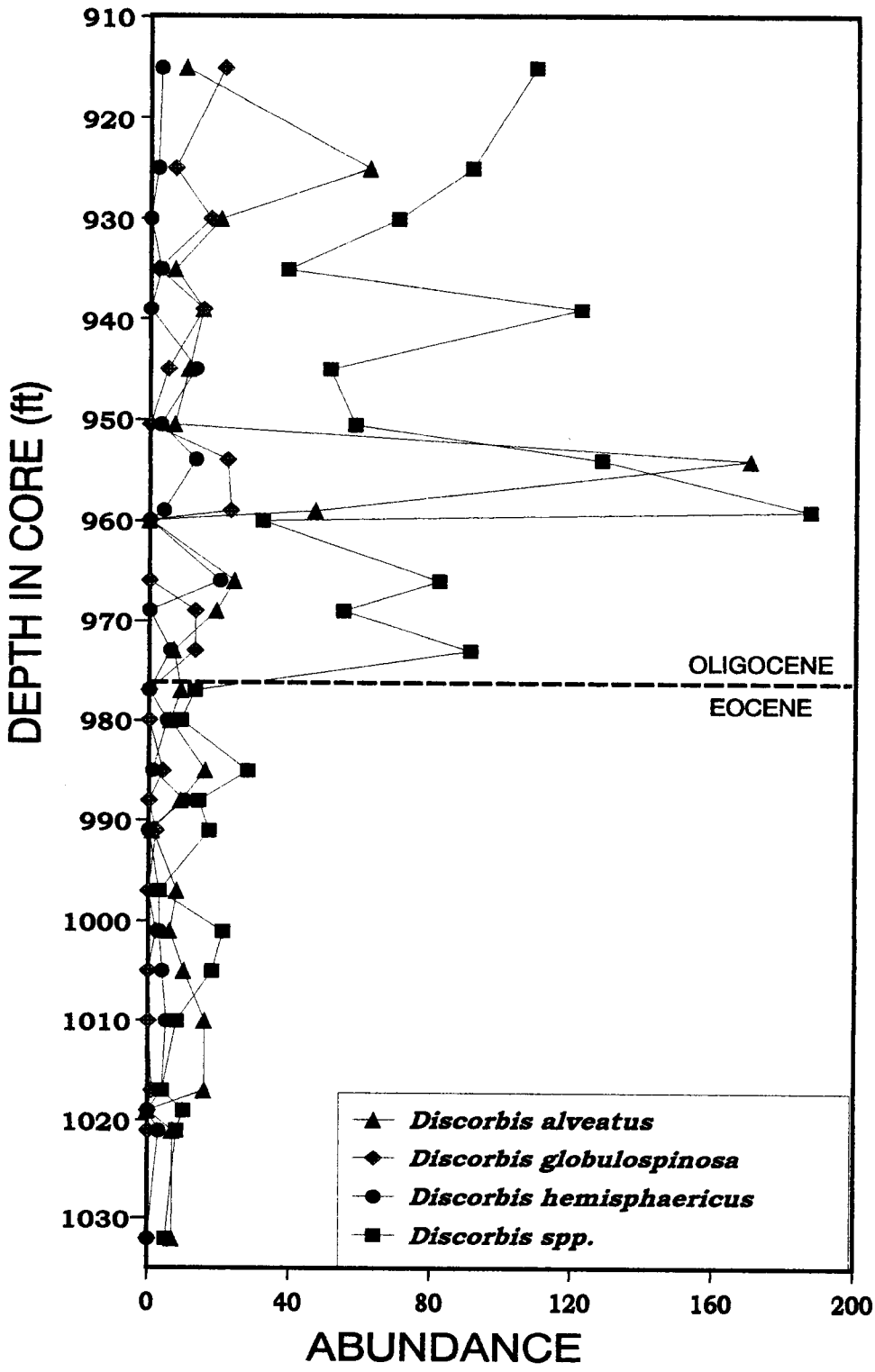


Figure 31. (Continued).

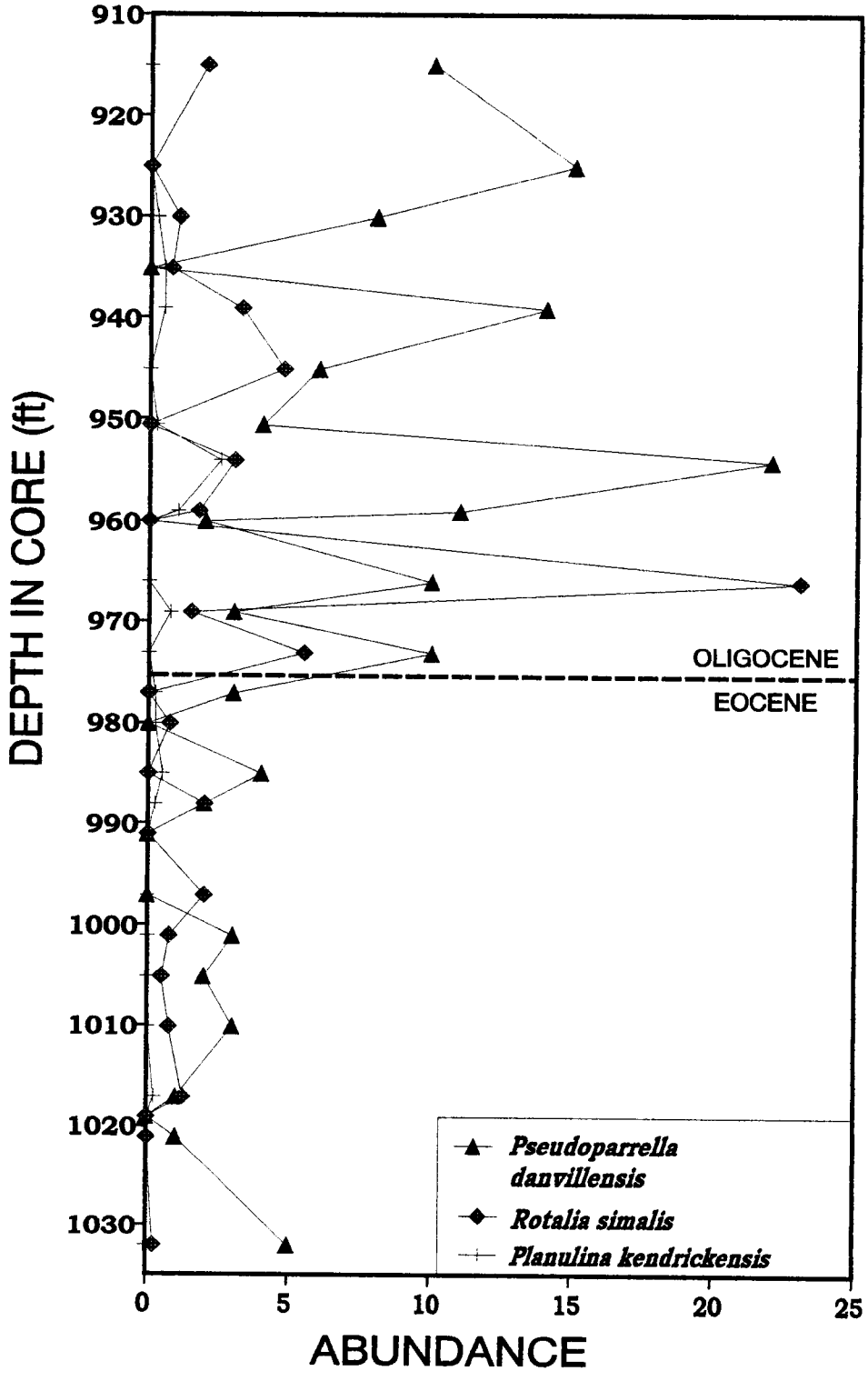


Figure 31. (Continued).

Brooksville section:

In contrast to the other sections examined in this study, 27 species have last occurrences below the E/O boundary at Brooksville (Table 14; Figure 32). However, 5 of these species are large benthic foraminifera which either did not occur or were not counted in the other sections. Of the remaining species, *Textularia ocalana* and *Cibicides mississippiensis* make up significant proportions of the Eocene assemblage. As much as 12.5% in the case of *C. mississippiensis* and up to 6.95% in the case *Textularia ocalana*. The other 2 species never have abundances above 5 per sample and are statistically insignificant (Figure 32).

Table 14 Species with Last occurrences in Eocene at Brooksville.

Alabamina abtusa	*Nummulites vanderstocki*
Articulina zuberensis	*Operculinoides ocalanus*
Cibicides mississippiensis	*Operculinoides willcoxi*
Lepidocyclina ocalana	*Textularia ocalana*
Lepidocyclina chaperi	*Mississippiana monsouri*
Archaias withacoochensis	*Leibusella byramensis turgida*
Dentalina spp	*Lagena acuticosta*
Nonionella spp	*Spirloculina newberryensis*
Gyroidina crystalriverensis	*Gyroidina nassauensis*
Guttulina spicaeformis	*Reussella sculptilis*
Planulina kendrickensis	*Discorbinopsis gunteri*
Epistomaria semimarginata	*Epistomaroides spp*
Heterostegina ocalana	*Operculinoides spp*
Operculinoides moodyensis	

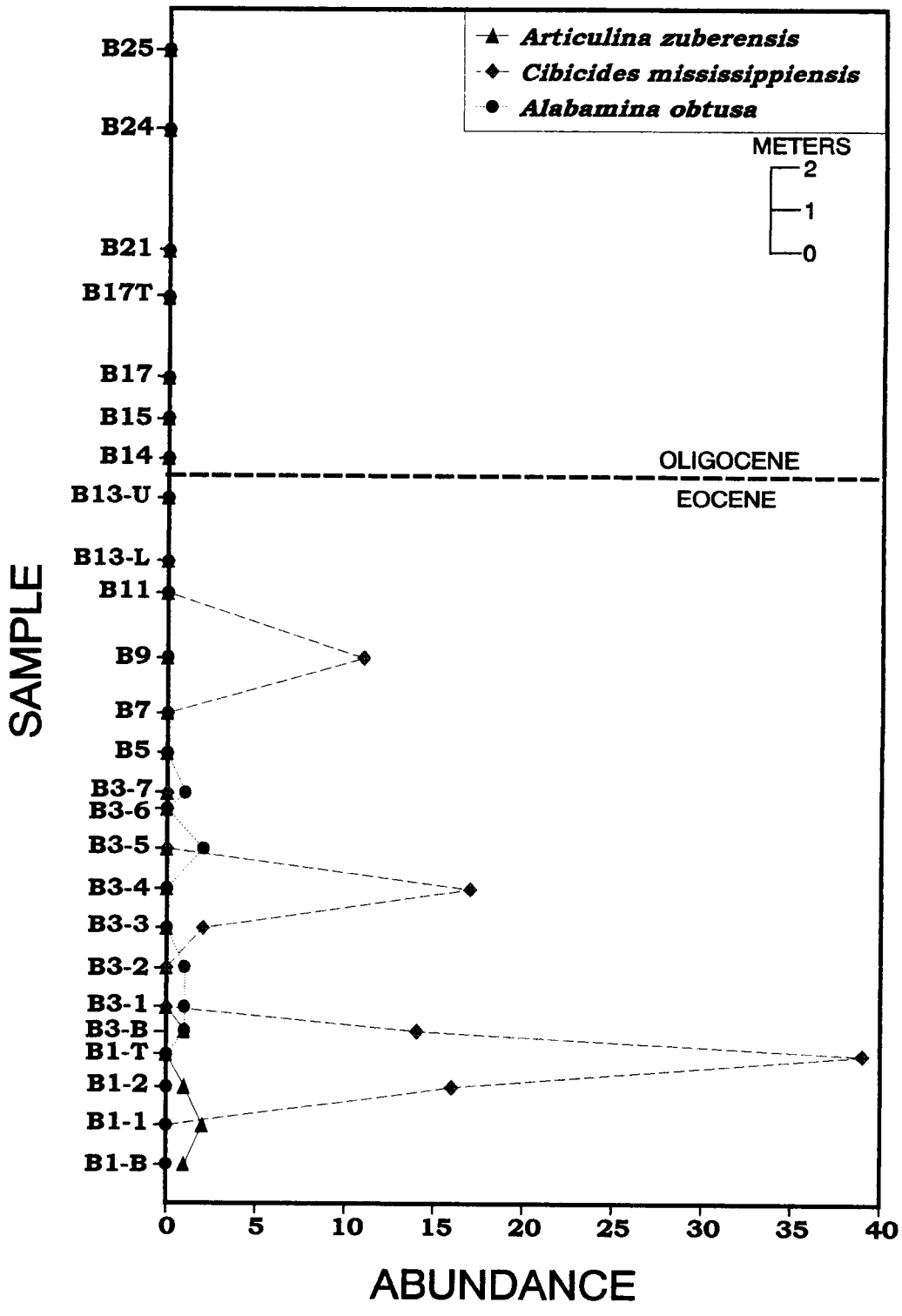


Figure 32. Species with last occurrences in the Eocene at Brooksville.

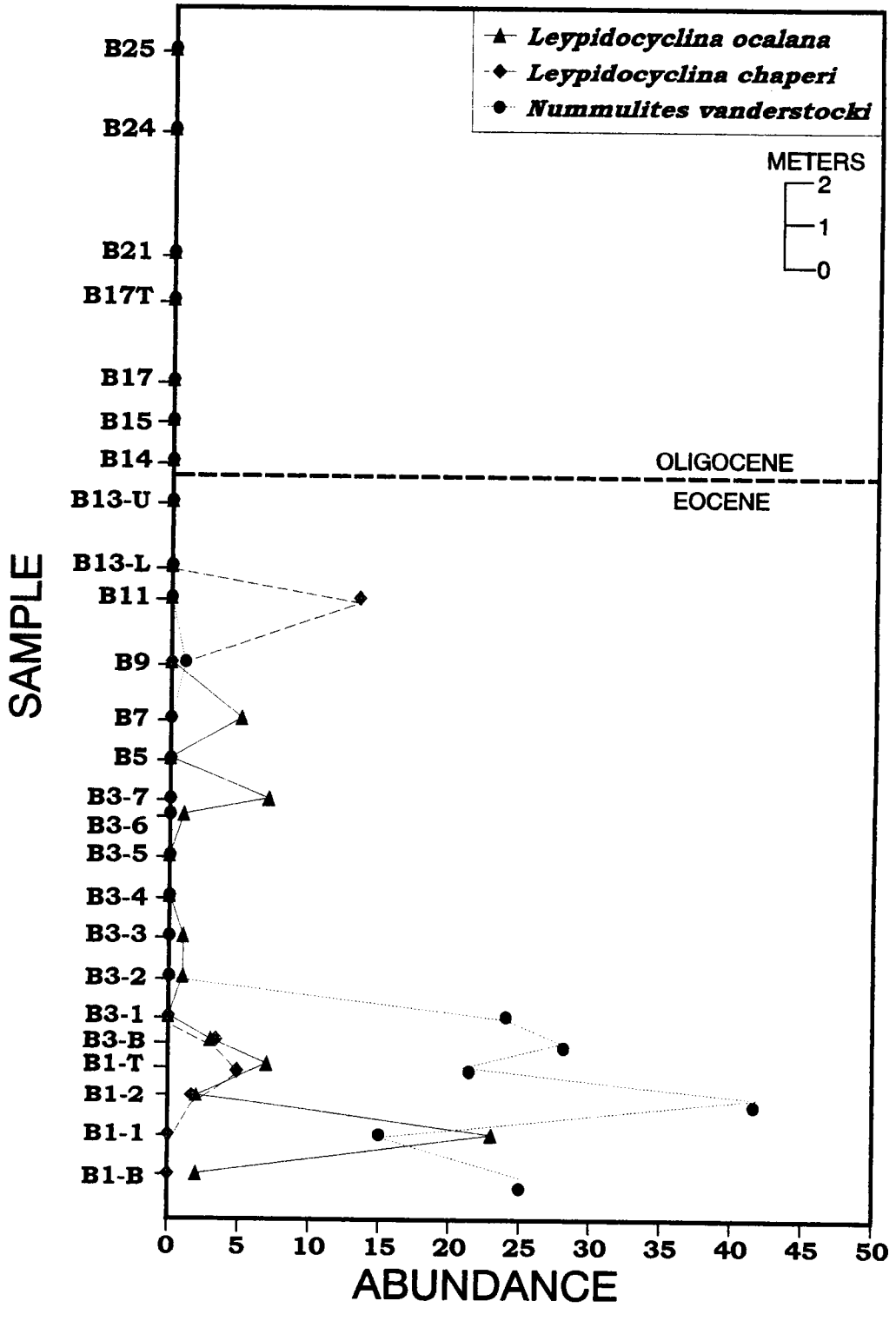


Figure 32. (Continued).

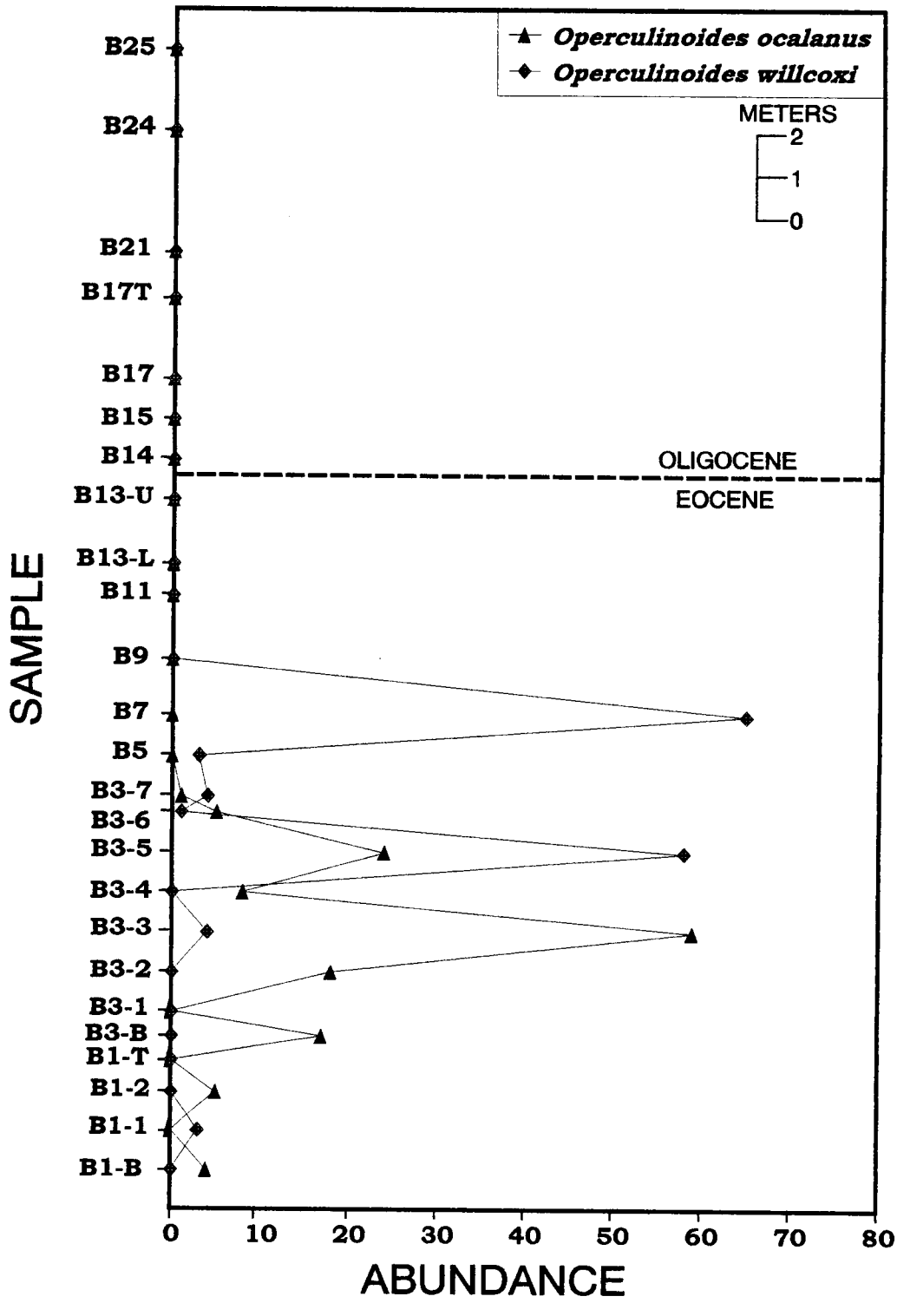


Figure 32. (Continued).

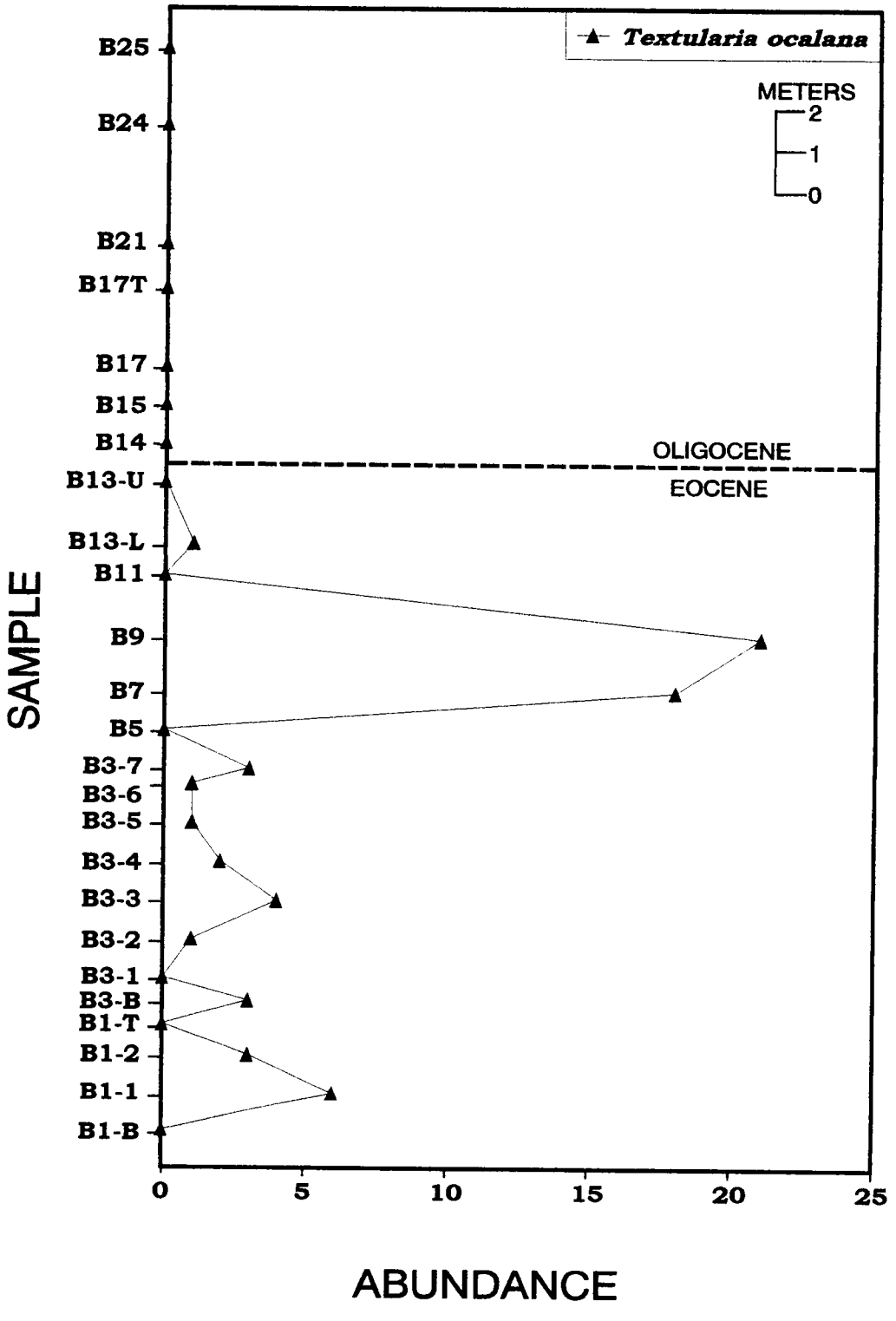


Figure 32. (Continued).

Species which decrease in abundance in the Oligocene of this section are listed in Table 15. Of these species *Cibicides pseudoungerianus* and *Eponides jacksonensis* are the most important both of which have abundances greater than 100 (Figure 33). In particular *C. pseudoungerianus* comprises up to 46% and averages over 10% of the fauna in the Eocene and a maximum of 9% in the Oligocene samples. *E. jacksonensis* exceeds 20% of the sample in 4 cases and exceeds 40% in 2 cases, but overall makes up a much smaller percentage in the rest of the samples. The remaining 6 species in this group all have peaks of abundance around 20 specimens in particular samples. However, for the most part they do not makeup more than 3% of the samples.

Table 15 Species exhibiting abundance decrease across boundary at Brooksville.

Cibicides pseudoungerianus	*Nonion advena*
Eponides jacksonensis	*Reussella eocenea*
Guttalina irregularis	*Siphonina jacksonensis*
Gyroidina nassauensis	*Sphaerogypsina globula*

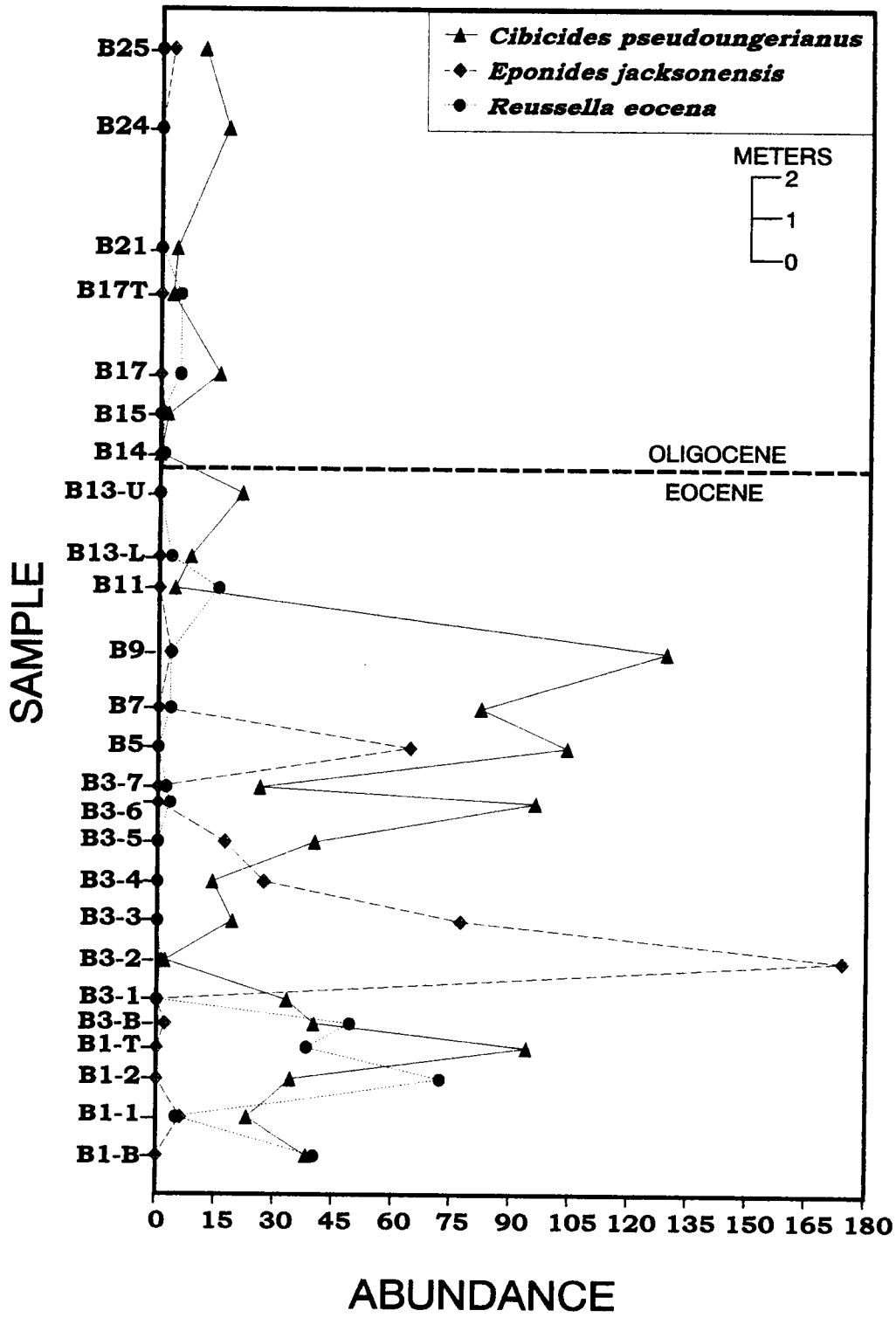


Figure 33. Species which decrease in abundance across the E/O boundary at Brooksville.

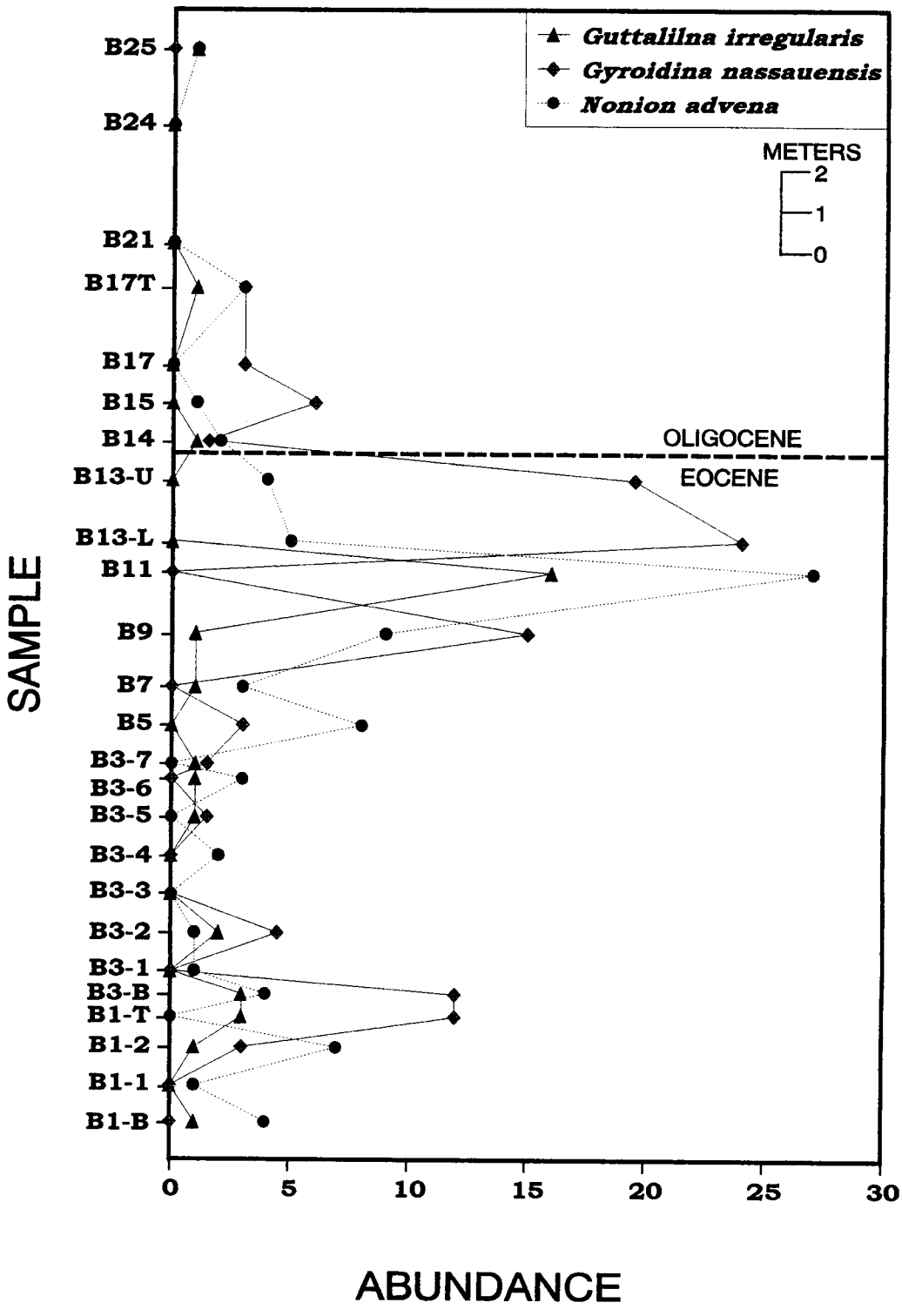


Figure 33. (Continued).

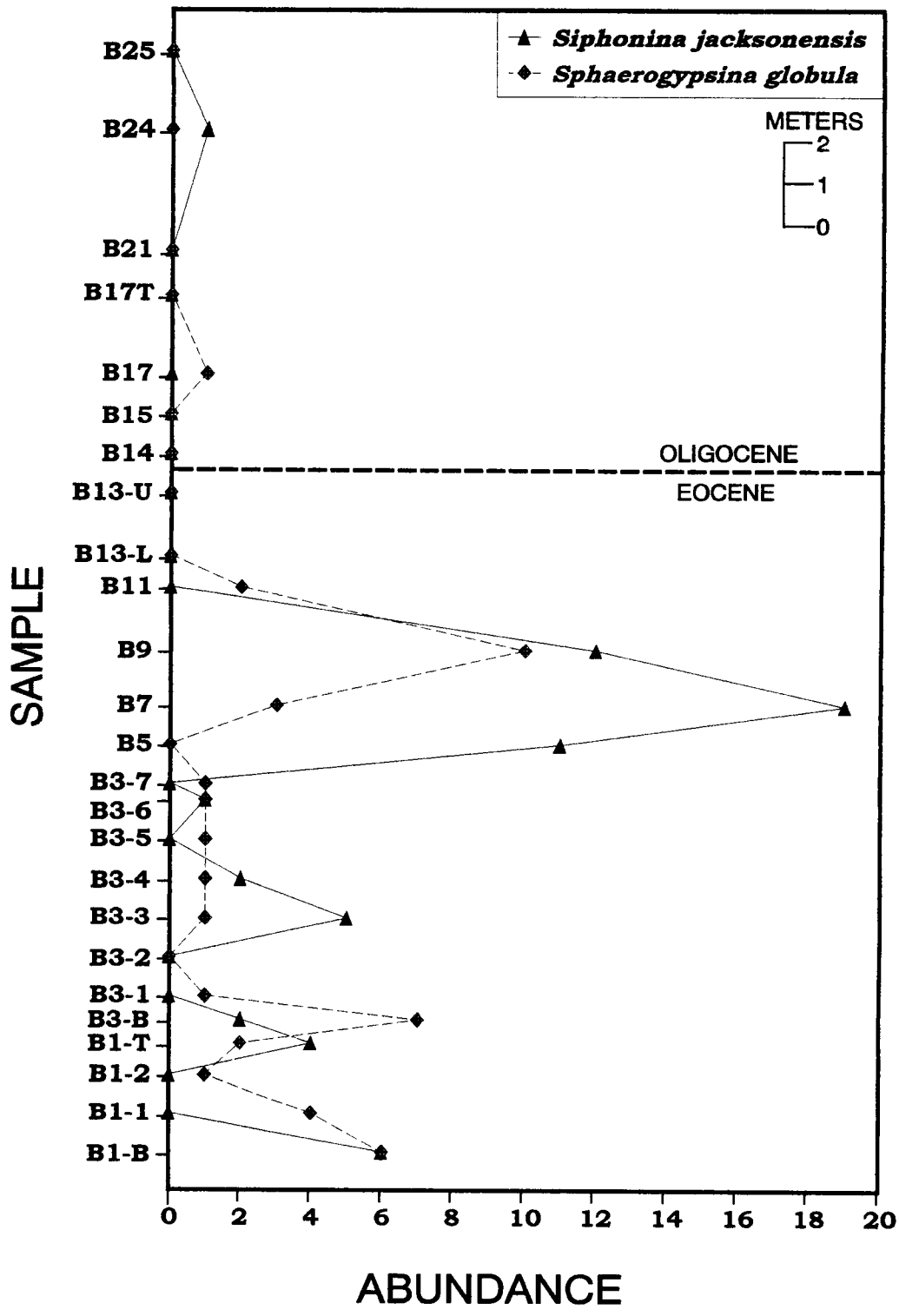


Figure 33. (Continued).

Three species in this section have first appearances in the Oligocene (Table 16; Figure 34). Only *Cibicides cooperensis* in this group is important in the samples making up as much as 9% of the sample. The others are either planktonic *Globoratalia spp.* or have very low abundance *Linderina sp.*.

Five species have an increase in abundance form the Eocene to Oligocene (Table 17; Figure 35). *Pyrgo inornata* is the most abundant of these with an average Oligocene abundance of 164 as compared to 38 in the Eocene although the highest abundance occurs in the Eocene (Figure 35). In terms of percentages, although the change is gradual and some the highest percentages occur in the Eocene. They are ,on average, much higher in the Oligocene samples. *Discorbis bulla* is also an important component of the Oligocene as compared to the Eocene, making up as much 40% of the assemblage in the Oligocene. *P. ?inglisana* has a peak abundance in sample B14 were it makes up 14.6% of the sample (Figure 35). However, it never exceeds 6% in any other sample. The other 2 species in this group never have abundances of more than 10 in any sample and very low percentages of the samples.

Table 16. First occurrences in the Oligocene of the Brooksville section.

Cibicides cooperensis
Globorotalia spp
Linderina spp

Table 17. Species showing increases in abundance in the Oligocene of the Brooksville section.

Camagueyia perplexa	*Pseudophragmina spp*
Discorbis bulla	*Pyrgo inornata*
Plectofrondicularia ?inglisana	

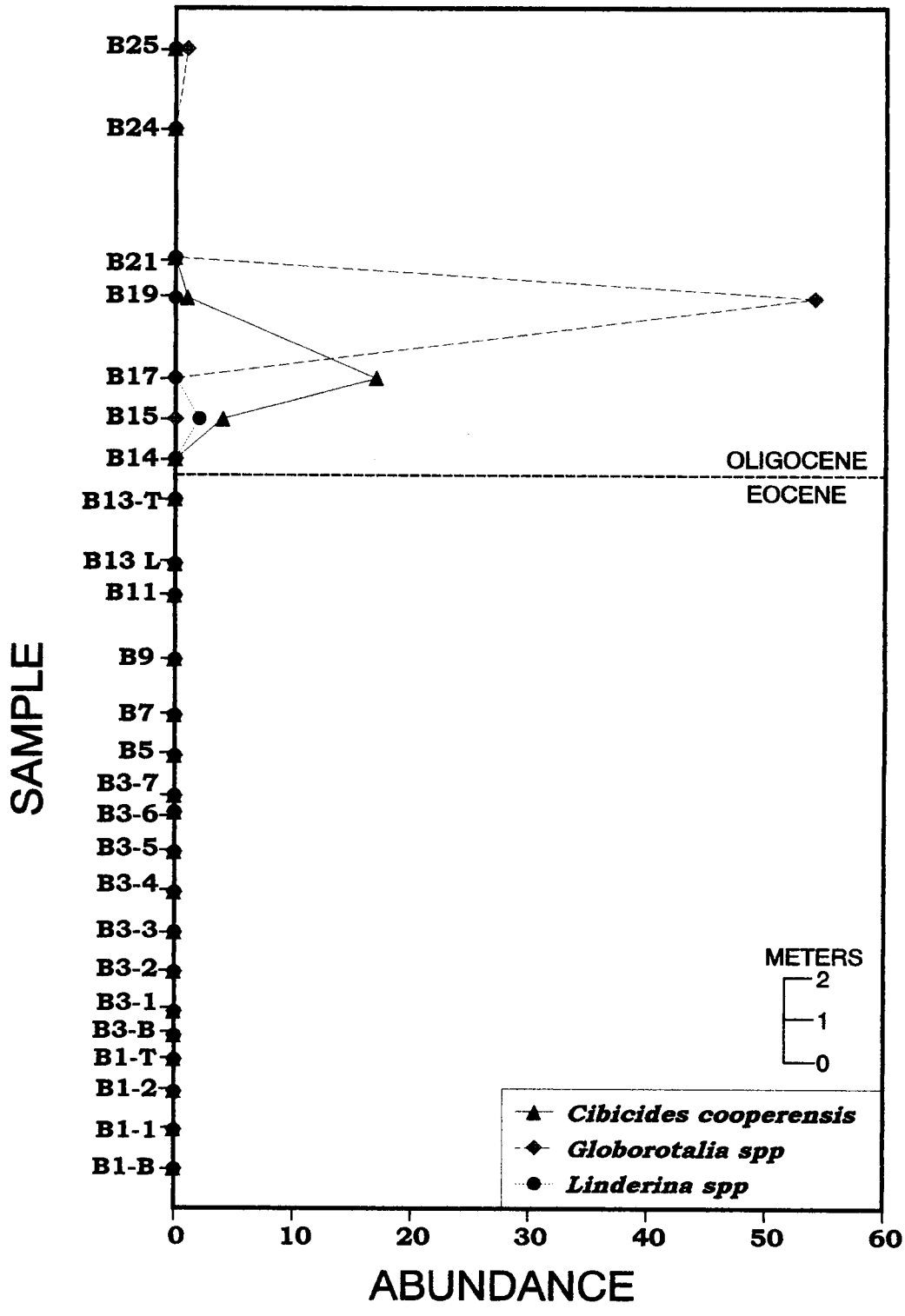


Figure 34. Species with first occurrences in Oligocene at Brooksville.

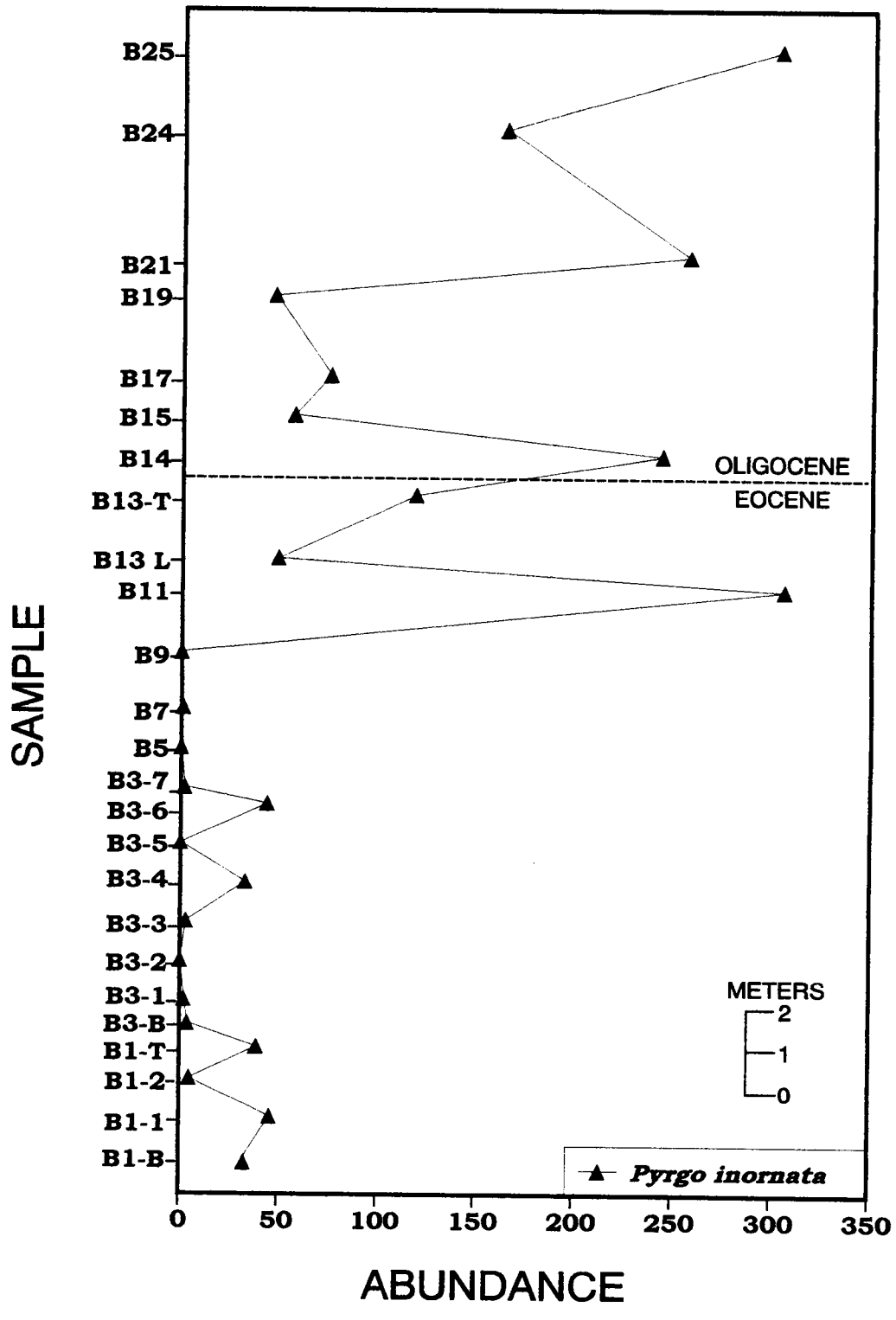


Figure 35. Species which increase in abundance across the E/O boundary at Brooksville.

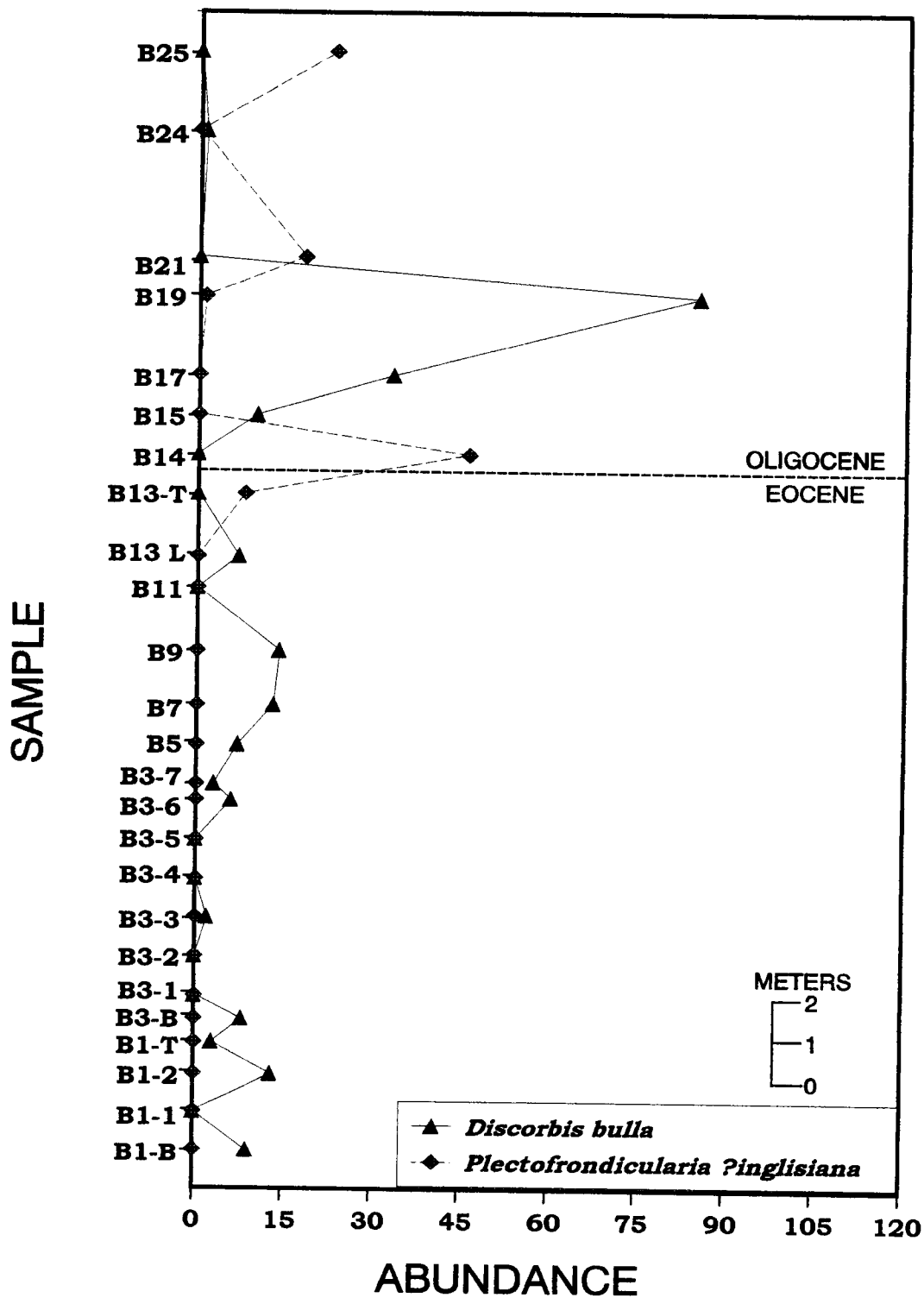


Figure 35. (Continued).

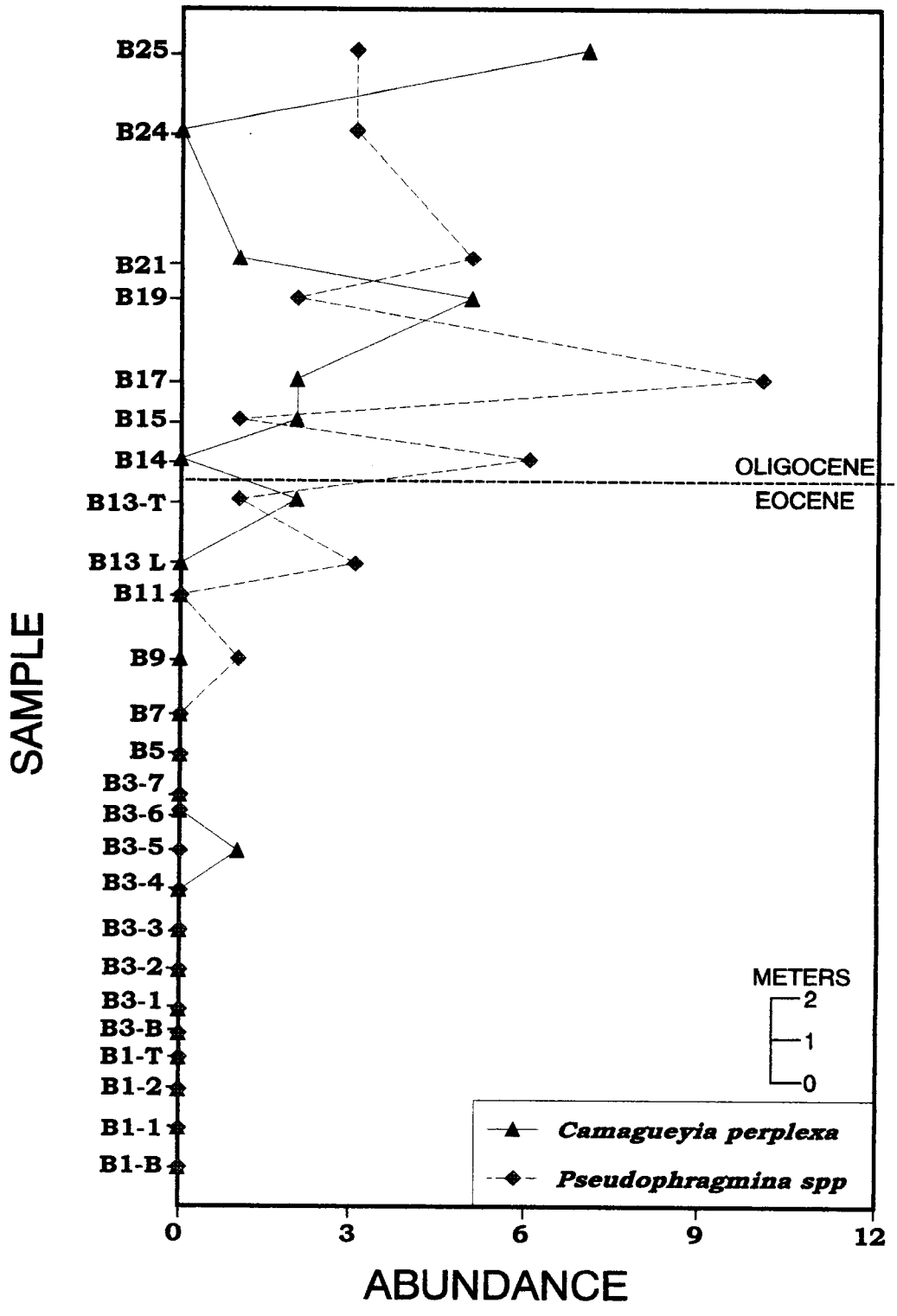


Figure 35. (Continued).

In summary, although each of the section in this study shows individual pattern of species and/or generic changes there is a certain degree of commonality between them. In Table 18 are listed species which decrease in abundance in 2 or more sections. The inclusion of *Reussella eocena* is due to a uncertainty in the taxonomic status of this species. As described by Puri (1957) it may be conspecific with *R. sculptilis*. All of these taxa are important or at least distinctive components of the fauna. In particular *C. alabamensis* and *C. armosa* make up high percentages of the fauna in the Sepugla River and GGS-3535 sections in the Eocene although they are not important at Brooksville and Red Bluff. In the clastic units at Red Bluff *Uvigerina jacksonensis* is often either the most or second most abundant species (Appendix 2) in the Eocene, comprising up to 30% of some samples. In contrast in the Oligocene this species is much less common and only abundant in the lowermost samples. Species of *Reussella* are never large parts of the fauna in any section, however, their distinctive shape is important.

Table 18 Species which decrease in abundance in at least 2 sections.

SPECIES	SECTIONS
Cassidulina alabamensis	Sepugla River, GGS 3535
Cassidulina armosa	Sepugla River, GGS 3535
Reussella moodyensis	Sepugla River, GGS 3535
Reussella sculptilis	Sepugla River, GGS 3535
Reussella eocena	Brooksville
Uvigerina jacksonensis	Red Bluff, GGS 3535

A second consistent trend is the increase in abundance from the Eocene to the Oligocene of several taxa (Table 19). Of these the most important are *Angulogerina byramensis* which comprises a significant proportion of the fauna in the carbonate sections and species of the genus *Discorbis* which shows an increased abundance in all the sections, although not always in the same species. *D. globulospinosa* and *D. bulla* were included in this list to show a general increase in the abundance of the entire genus. In 2 sections Sepulga River and Red Bluff *D. globulospinosa* decreases in abundance across the boundary.

Few taxa show any common first occurrence in the lower Oligocene in the study area. Only 2 species first appear in more than 1 section, *Bolivinella rugosa* in the Red Bluff and GGS 3535 sections, and *Spirillina vicksburgensis* in the Red Bluff and Sepugla River sections. This lack of common first appearances may be either a result of differences in environmental tolerances and/or reflective of the general lack of major faunal change seen throughout the study area. This is contrary to other published studies which have indicated an increase in first occurrences in the lower Oligocene (Gaskell, 1991).

Table 19 Species showing increases in abundance from the Eocene to the Oligocene.

SPECIES	SECTIONS
Angulogerina byramensis	Red Bluff, Sepugla River, GGS 3535
Brizalina huneri	Red Bluff, Sepugla River
Brizalina striatellata	Red Bluff, Sepugla River
Valvulineria octacamerata	Red Bluff, Sepugla River
Cibicides lobatus	Sepugla River, GGS 3535
Discorbis alveatus	Red Bluff, Sepugla River, GGS 3535
Discorbis bulla	Brooksville
Discorbis globulo-spinosa	GGS 3535
Discorbis hemisphaericus	Red Bluff, Sepugla River, GGS 3535

Of the 49 taxa which have last occurrences in all the sections in which they appear, by far *Bolivina jacksonensis* is the most important. This species has been used as an indicator to the E/O in section where planktonic foraminifera are not common (Huddlestun, 1965). However, its lack of occurrence in 2 sections and low abundance in the carbonate units casts doubt on this.

With the exception of Brooksville, changes in benthic foraminifera across the E/O boundary are more in dominance of taxa rather than make up of the assemblage and even changes in dominance vary widely.

Results of Cluster Analysis

Single Linkage cluster analysis was conducted at 2 levels on the data. First, the species level data for each section was clustered. Second, a genus level cluster analysis was run on the data for each section. The genus level data were analyzed to account for any errors in species assignment and to account for the fact that the number of forms only identified to the genus level is significantly higher in the carbonate units than in the clastic units, due to generally lower quality test preservation.

Red Bluff Section:

The results of this analysis for the Red Bluff section are shown in Figures 36 &37. The species level clustering of samples for this section shows a distinct lack of grouping of samples (Figure 36). Several small clusters are apparent, however none of more than 8 samples and the largest does not separate samples by stratigraphic position and may be a reflection of abundance of *Cibicides* in the samples. The next largest cluster separates five Eocene samples. In the rest of the data no significant clusters occurred and samples are added in a stair step fashion. Clustering of the Red Bluff samples at the generic level reduces the number of variables to 60, but does not result in an improvement of the output(Figure 37). As discussed above the lack of large numbers of First and Last occurrences of taxa indicate a slow

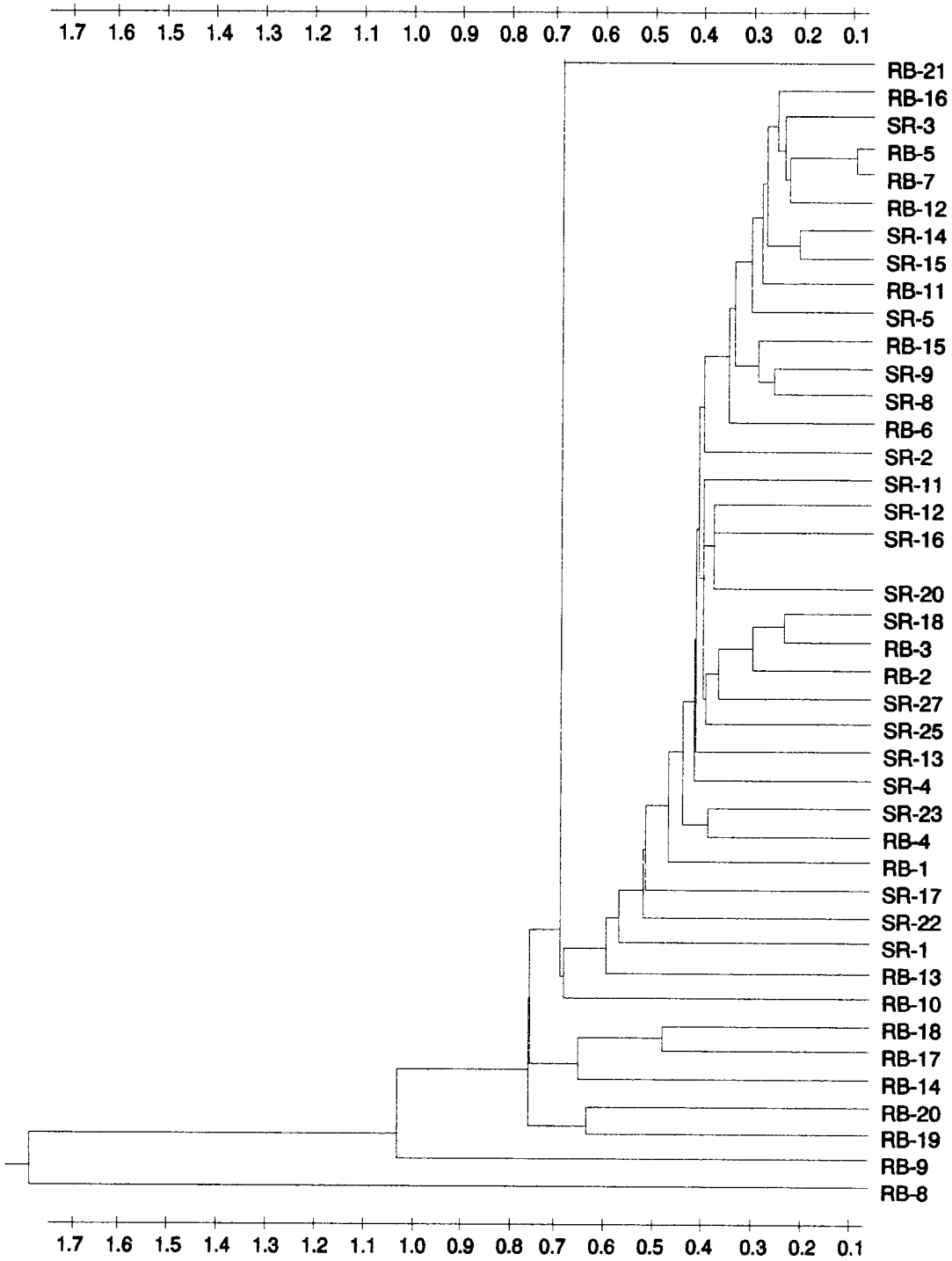


Figure 36. Results of cluster analysis on the Red Bluff species data.

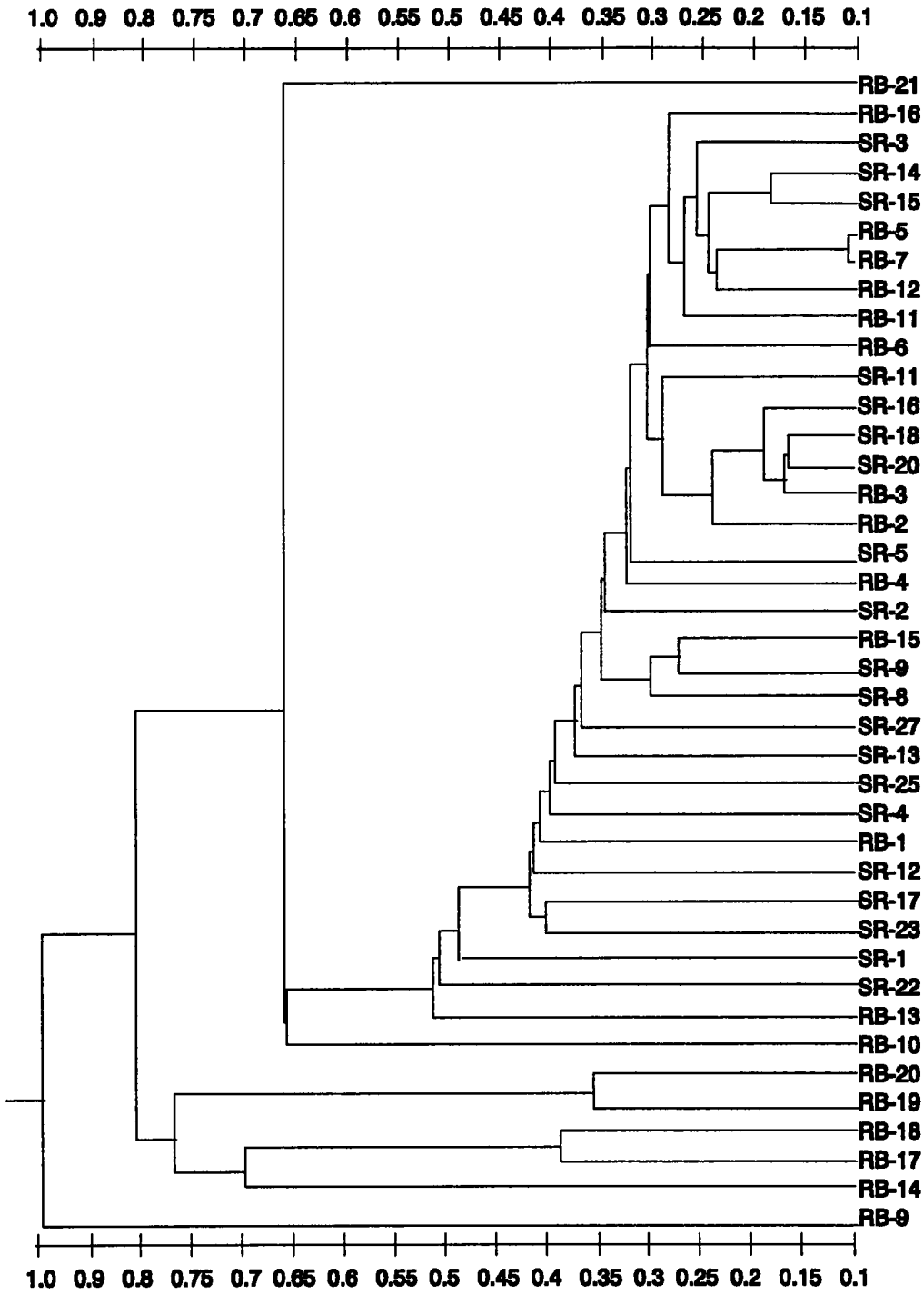


Figure 37. Result of cluster analysis on the Red Bluff genus data.

turn over of species in this interval. Thus a poor separation of the samples by stratigraphic position in a cluster analysis is somewhat to be expected. In addition, as discussed above the major difference between the Eocene and Oligocene samples in this section is often a change in abundance of taxa. However, these changes frequently involve species which do not make up a large percentage of the fauna and/ or are changes in average abundance, thus often there is overlapping values in the Eocene and Oligocene for a particular species further decreasing the quantitative difference in the faunas. As only one species, which makes up a major part of the fauna (*Bulimina jacksonensis*), becomes extinct near the boundary, the result is not surprising. An additional complication of this analysis is the possibility of reworking of species into Oligocene samples. As noted, *B. jacksonensis* is the only major taxa to become extinct near the boundary in this and other sections (Huddlestun, 1965). However, it is present in the lower Oligocene samples either as a result of a slow decline or reworking due to bioturbation of which there is abundant evidence in this section. In Red Bluff, the only clastic dominated section, test preservation is good to excellent for most samples, thus dissolution is not considered to be a major factor. The presence of large numbers of absences in the raw data may also cause an apparent lack of structure in the data set.

One additional factor which may affect the results of this analysis is the introduction of shallow water species into the Red Bluff section by gravity flows. This has been suggested a source for shell concentrations in both the Red Bluff and Shubuta (Smith and Zumwalt, 1987). In the material studied in this report this process is deemed to be more likely in the Red Bluff Formation as is shown by a more varied lithology and the presence of shell lags. This would add variance to the samples and bias the result of the cluster analysis.

Sepugla river:

Results of the cluster analysis of the Sepugla River samples are shown in Figures 38 & 39. At the species level, the samples in this section clusters are defined much better in regard to stratigraphic position than those in the Red Bluff section. Three clusters separate out. The

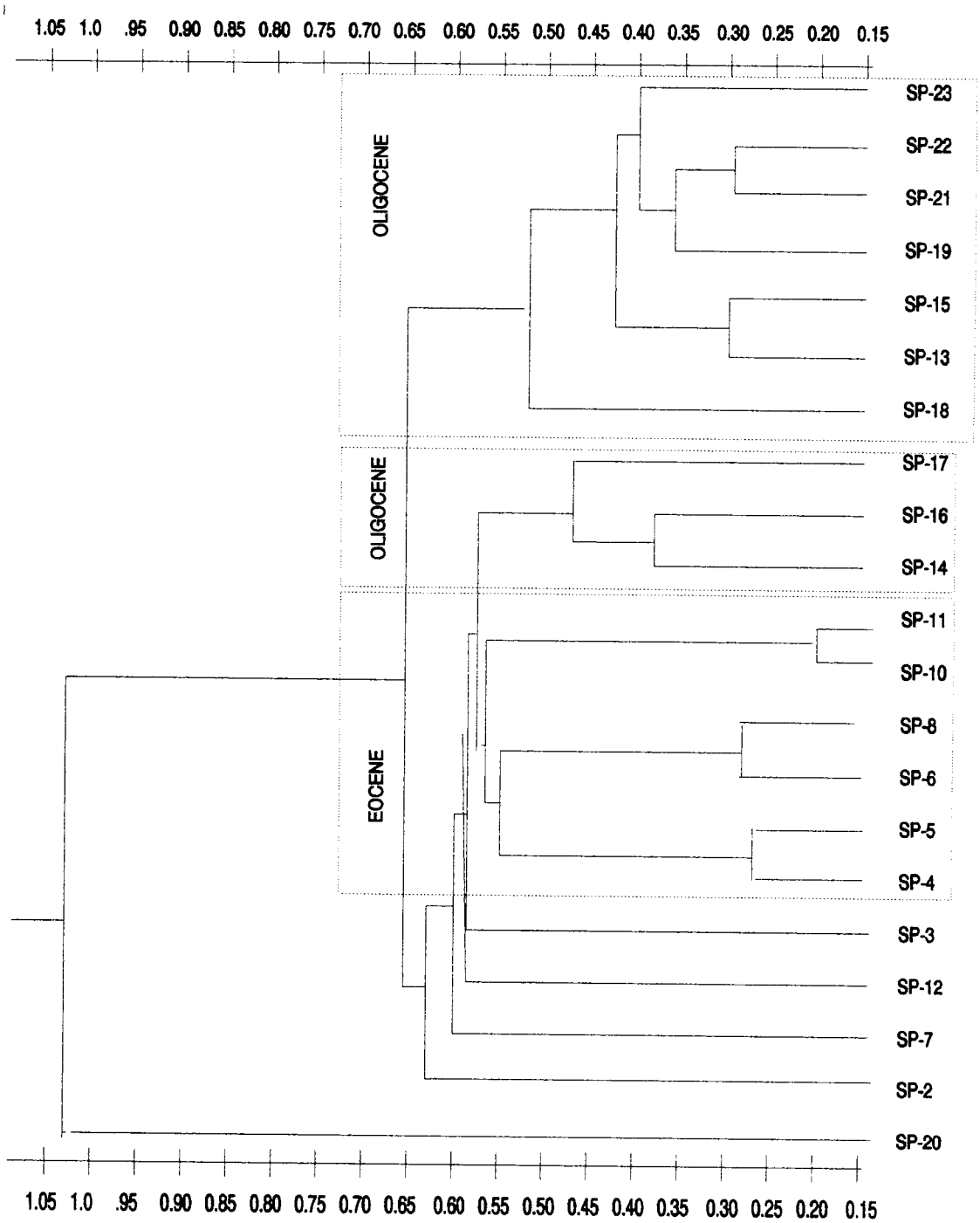


Figure 38. Results of cluster analysis on the Sepugla River species data.

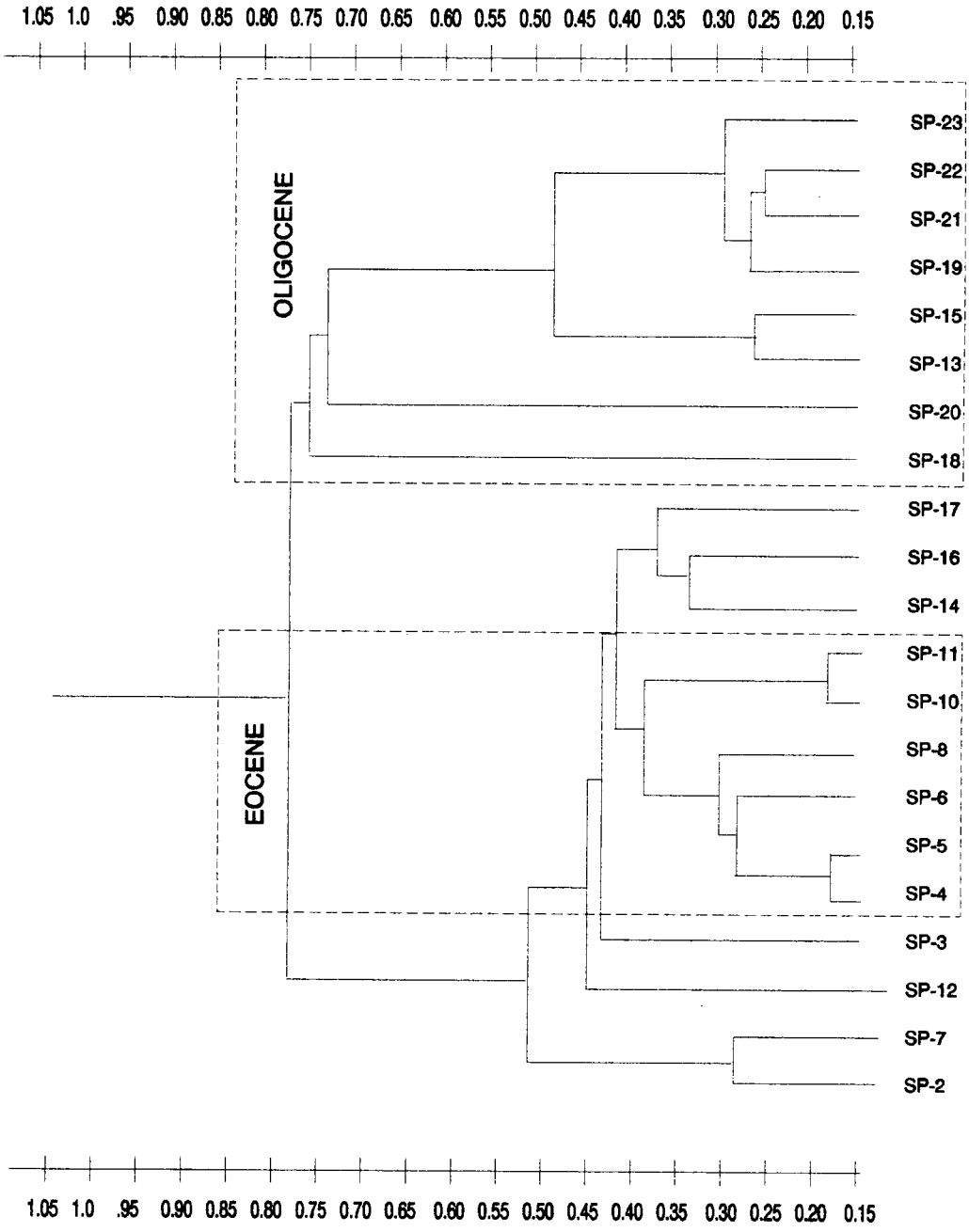


Figure 39. Results of cluster analysis on the Sepugla River genus data.

first comprised of 7 Oligocene samples separates at a distance of 0.65. The second cluster is less well defined, it is composed of 6 Eocene samples separated at a distance of 0.57. A final cluster in this data is composed of 3 Oligocene samples falling between the first clusters (Figure 38).

Cluster analysis of the Sepugla River data at the generic level resulted in an improvement of the ordering by stratigraphic position. The same clusters described for the species level data occur but sample SP-20 is added to the first cluster. Thus, in this case the samples divide into 2 large clusters one containing only Oligocene samples and the other containing Eocene samples plus 3 Oligocene samples (Figure 39). Note that the third cluster described for the species level data containing the final 3 Oligocene. samples is now a sub-cluster of the Eocene samples. The improvement of the clustering at this level of analysis may be a result of the number of specimens identified only to the genus level and the consistent pattern some genera in this section show as compared to the Red Bluff section.

GGS 3535:

Cluster analysis results of the cores samples are shown in Figures 40 &41. As at Sepugla River, the samples are to some extent clustered by stratigraphic position. Two fairly large clusters containing 9 and 8 samples respectively separate out of the data at a high level. One consisting of 9 Oligocene samples and the other of 8 Eocene samples (Figure 40). In addition, a small cluster of 3 Eocene samples separates out of the rest of the samples. In this case the samples which contain the highest species numbers and total specimen abundances tend to be those which do not cluster together. Thus, the presence of spikes in abundance of 1 or 2 species in combination with the occurrence of rare species in these samples may be the cause of the weakness of the results. In the case of generic level clustering the results are less clear (Figure 41). In this case, the large clusters contain 7 samples each with a separate cluster of 4 Eocene samples. The decrease in cluster size in this analysis may be a result of species of the same genus increasing and decreasing across the boundary. For example two species of

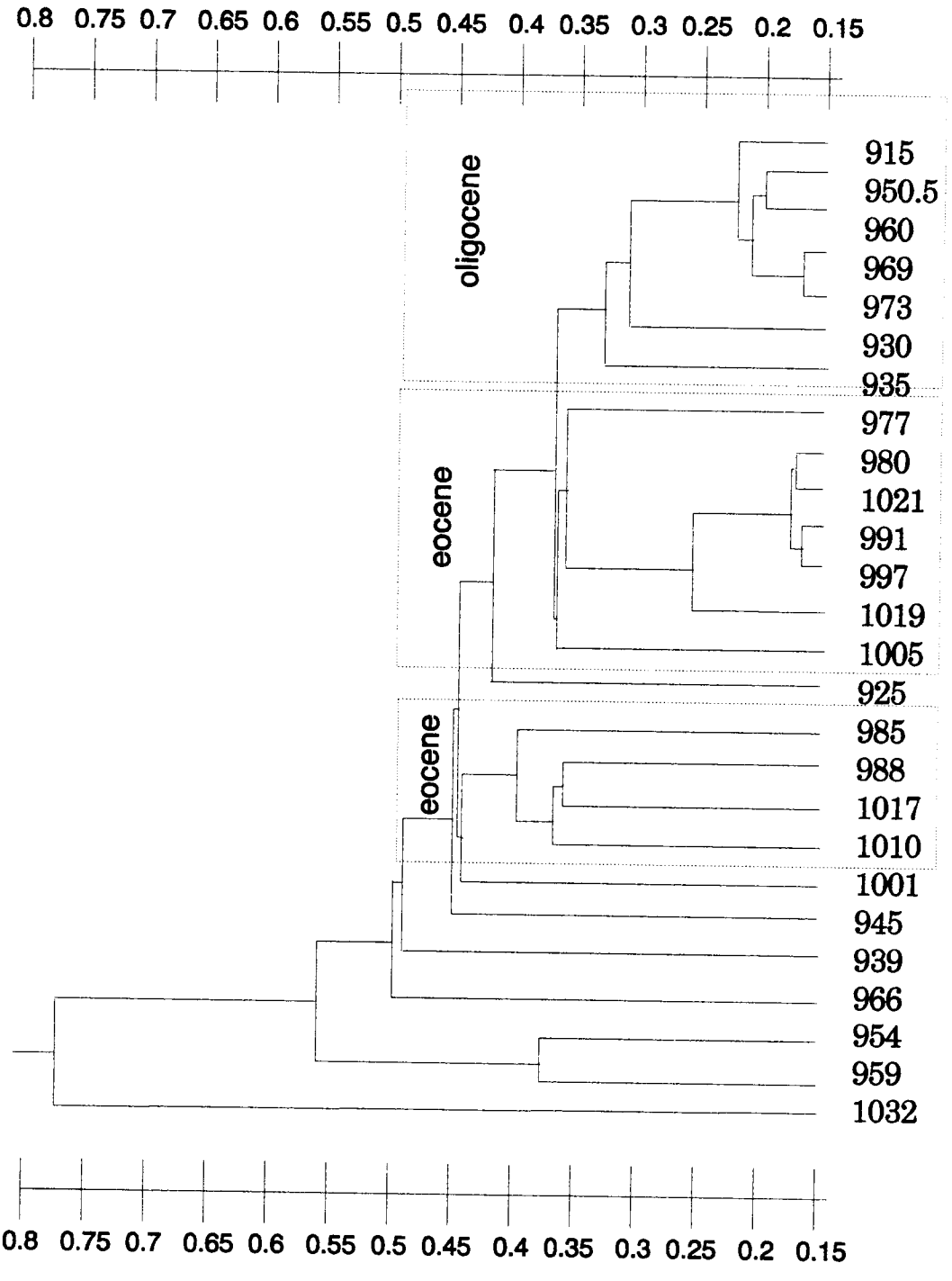


Figure 40. Results of cluster analysis on the GGS-3535 species data.

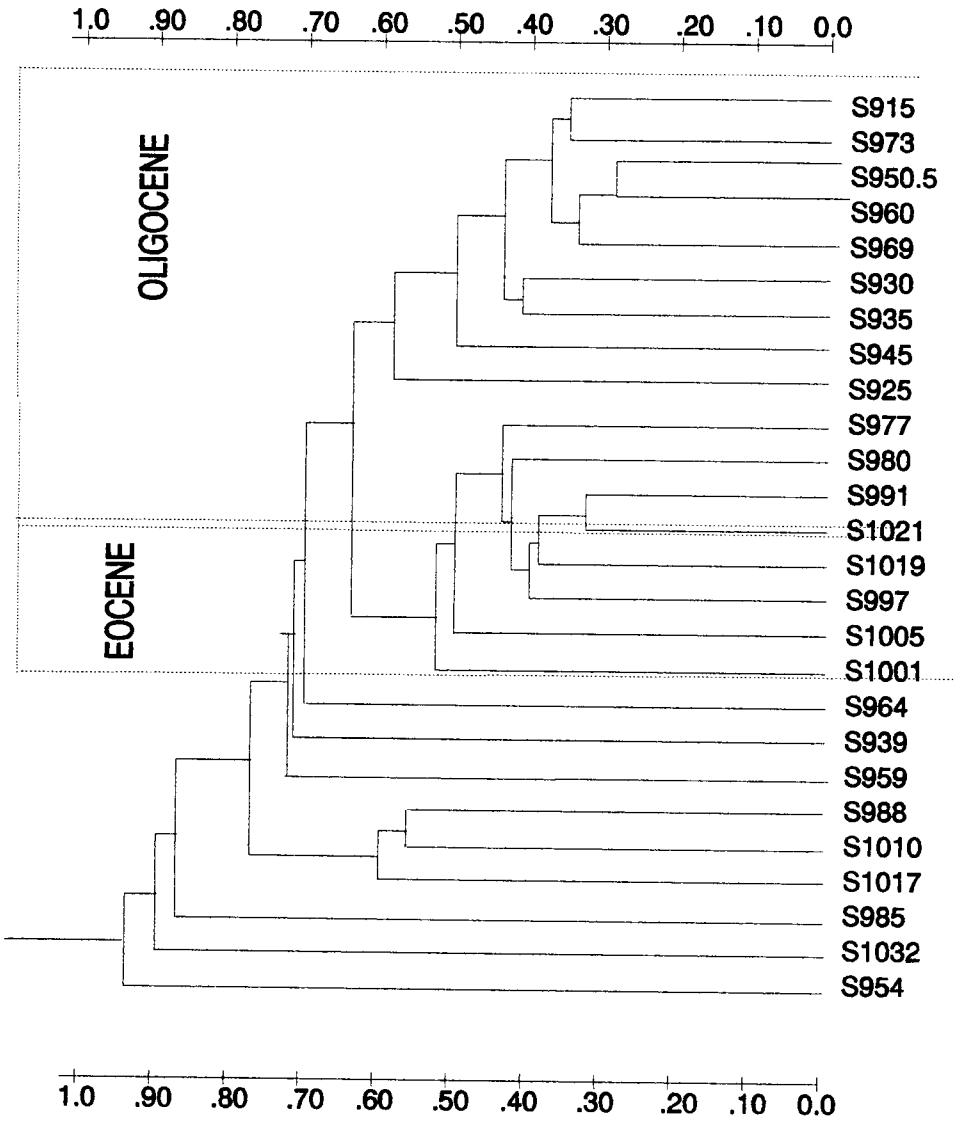


Figure 41. Results of cluster analysis on the GGS-3535 genus data.

Cibicides increase across the boundary and two species of the same genus show decreases in abundance in the same interval. While the abundances of the species are not similar the combining of the data to genus level may obscure the changes across the boundary resulting in less ordering by stratigraphic position.

Brooksville Section:

The results of the cluster analysis for Brooksville are shown in Figure 42 & 43. In contrast to the other carbonate sections the cluster analysis yielded very poor results in terms of stratigraphic position even though this section has the greatest number of local last occurrences in the Eocene. At the species level, one large cluster and one small cluster separate out (Figure 42). Neither of these is composed of samples from either of the sample groups. At the genus level, the clusters are virtually identical but with some reordering of the positions (Figure 43). The lack of stratigraphic ordering in this data set may have several origins. The number of specimens in these samples are often low (*i.e.* less than 200). In addition, often the changes in abundance and faunal composition in this section straddle the boundary instead of occurring regularly above or below it. A third possibility in the low number of Oligocene samples.

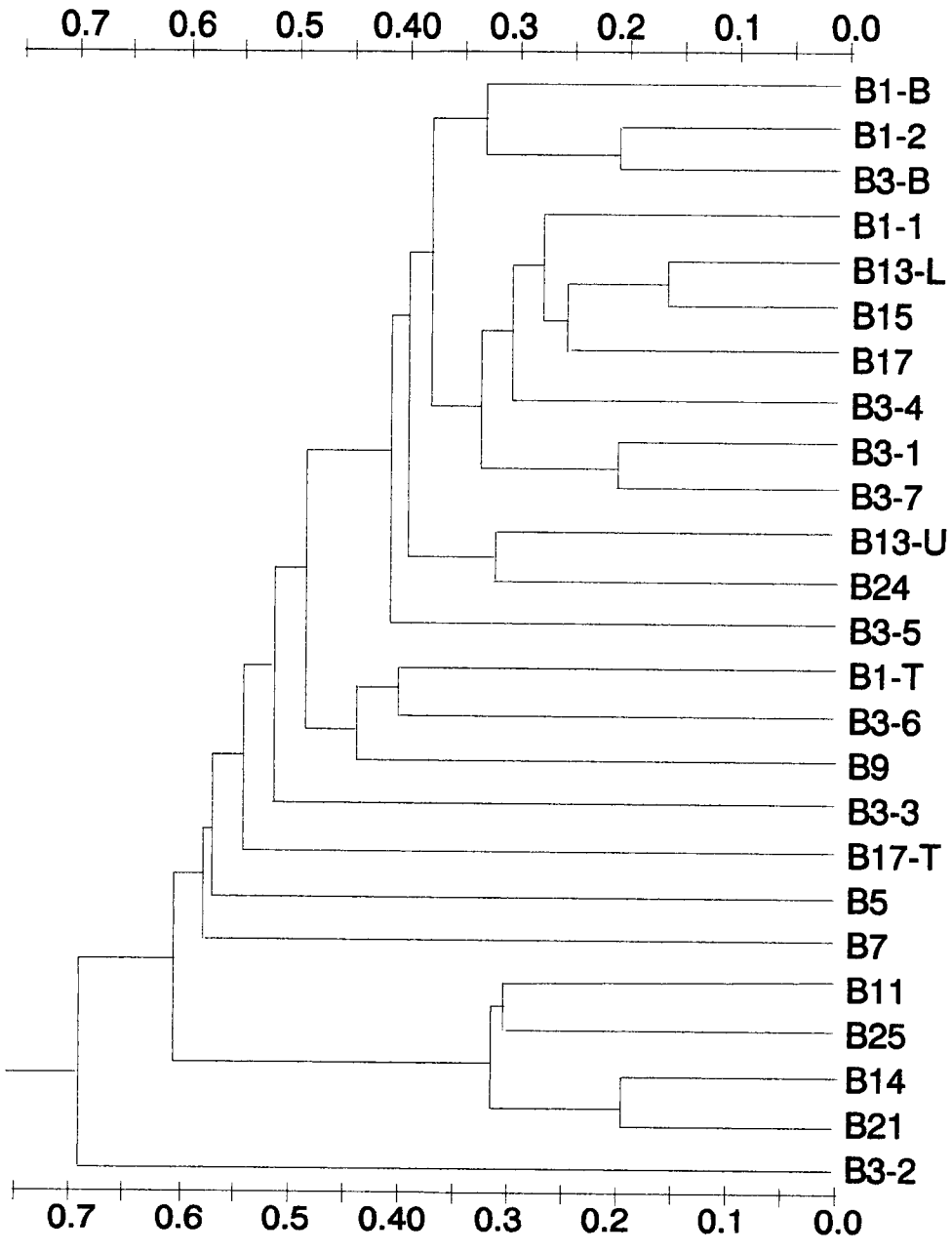


Figure 42. Results of cluster analysis on the Brooksville species data.

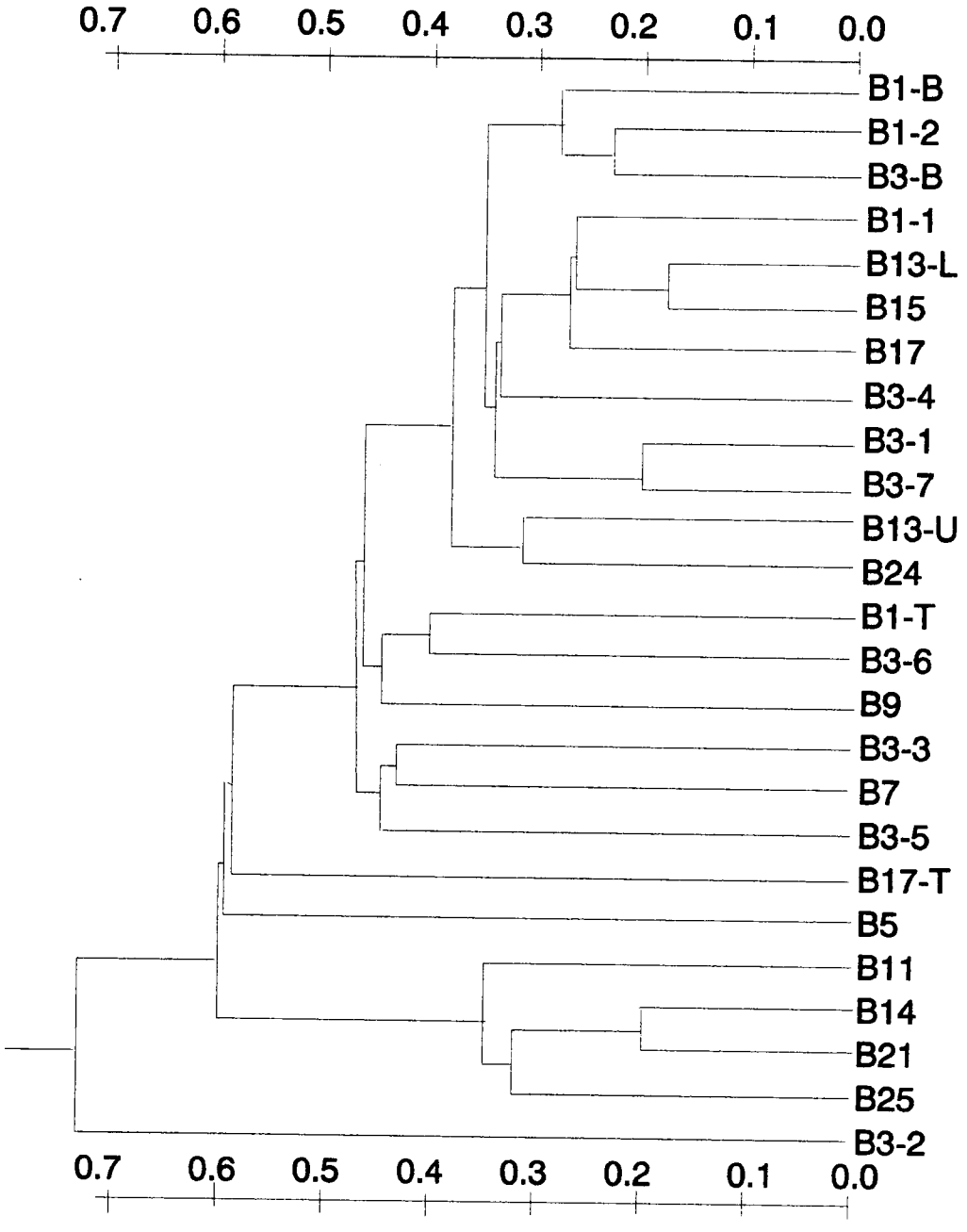


Figure 43. Results of cluster analysis on the Brooksville genus data.

Principle Component Analysis

Both r and q mode principal component analysis was conducted on the raw species data and on the data collapsed to the generic level. For each analysis 5 P.C.A axes were extracted from the data plots of the first and second axes constructed.

Results of r-mode analysis of the Red Bluff section samples are shown in Figure 44 a & b and Table 20. For the species level data the first 5 axes account for a little over 50% of the variance in the data with the first axis account for 17.5% of the variance. This axis appears to be stratigraphic position a plot of the first and second axes (Figure 44a) exhibits a 2 distinct, but somewhat overlapping groups of samples based on stratigraphic position. In general the samples plotting near the convergence of the 2 groups are those closer together in the stratigraphic section. The degree of spread on the first axis is due to the presence or absence of some of the rarer species which characterizes the Oligocene in this section. The second thorough fifth axes appear to represent variation in species abundances, in essence, noise in the data due to the high degree of fluctuation in abundance of many species. R-mode analysis of the generic data for the Red Bluff section is shown in Table 21. At this level the first axis accounts for 27.5% of the variation in the data set and the first 5 axes account for 64.9% of the variation. As with the species level analysis the first axis separates the samples by stratigraphic position. Reflecting the pressence of 2 distinct but poorly differentated faunas (Figure 44b). Again the additional axes of the P.C.A. seem to represent noise due to high variance in the generic abundance. The higher degree of variance accounted for by the first axis in this analysis compared to the species level may result from the combination of species strengthening the separating of the faunas and dampening the amount of variation due to random fluxes in species population.

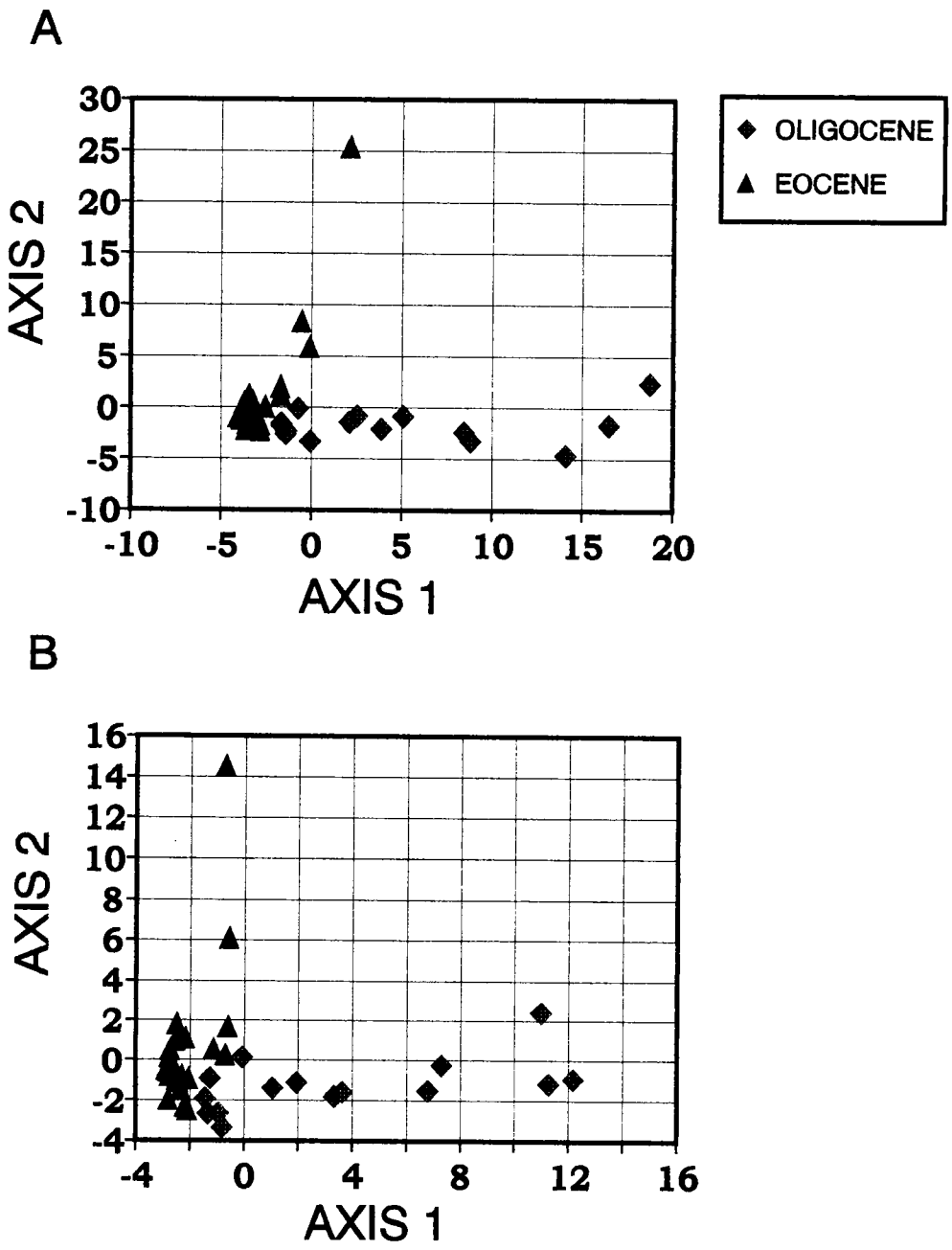


Figure 44. Results of r mode PCA of Red Bluff data. A. Species data. B. Genus data.

Table 20. Result of P.C.A. for species level data at Red Bluff..

	EIGENVALUE	DIFFERENCE	PROPORTION	CUMULATIVE
PRIN1	31.9053	10.1071	0.175	0.175
PRIN2	21.798	5.264	0.120	0.295
PRIN3	16.535	4.368	0.091	0.386
PRIN4	12.167	2.10	0.067	0.453
PRIN5	10.071	0.0	0.055	0.508

Table 21. Result of P.C.A. for genus level data at Red Bluff.

	EIGENVALUE	DIFFERENCE	PROPORTION	CUMULATIVE
PRIN1	16.4891	7.555	0.275	0.275
PRIN2	8.934	3.303	0.149	0.424
PRIN3	5.630	1.370	0.0938	0.517
PRIN4	4.261	0.607	0.071	0.589
PRIN5	3.655	0.0	0.061	0.650

Sepugla river:

The results of the r-mode species level P.C.A. are shown in Figure 45 a & b and Table 22. In this case the first 5 axes account for 53.3% of the variation in the data set with the first axis accounting for 18.5% of the variance. As with the Red Bluff the first axis in this analysis separates the samples by stratigraphic position. Although there is again some overlap between the Eocene and Oligocene samples along this axis. A plot of P.C.A. scores of the first and second axis results in 2 distinct and fairly well separated clumps of samples based on stratigraphic position (Figure 45a). The second axis, which accounts for 11.6% of the variance in the data set also divides the samples by stratigraphic position to some degree. Eocene samples have positive values on this axis and Oligocene samples with 2 exceptions have negative values on this axis.

Results of the genus level P.C.A. for Sepugla river are shown in Figure 45b and Table 23. In this analysis the first 5 axes account for 60.3% of the variance. Of this the first 2 axes account for 35.2% with the first axis accounting for 23% and the second accounting for 12.2% of the variance. As with the species level, and not surprisingly, the first and second axes of this analysis separate the samples by stratigraphic position. The first axis scores clump the Eocene samples better in this analysis although some overlap with the Oligocene samples is still apparent. It should be noted that the overlapping samples are both very near the boundary. However, in this case the second axis does not separate the samples as well as in the first analysis of this data. The results of these 2 analysis indicate as for the Red Bluff section the presence of 2 distinct faunas which account for the greatest amount of the variance on any axis (i.e. the first axis) the significance of the other axes is less clear. In large part the second axis in this data set also represents variation due to the faunal change across the boundary. The decrease in separation in the genus level analysis may be a result of combining species which have opposite patterns of variation. Thus the genus level analysis in this case has reduced variation by stratigraphic position as compared to the species level analysis.

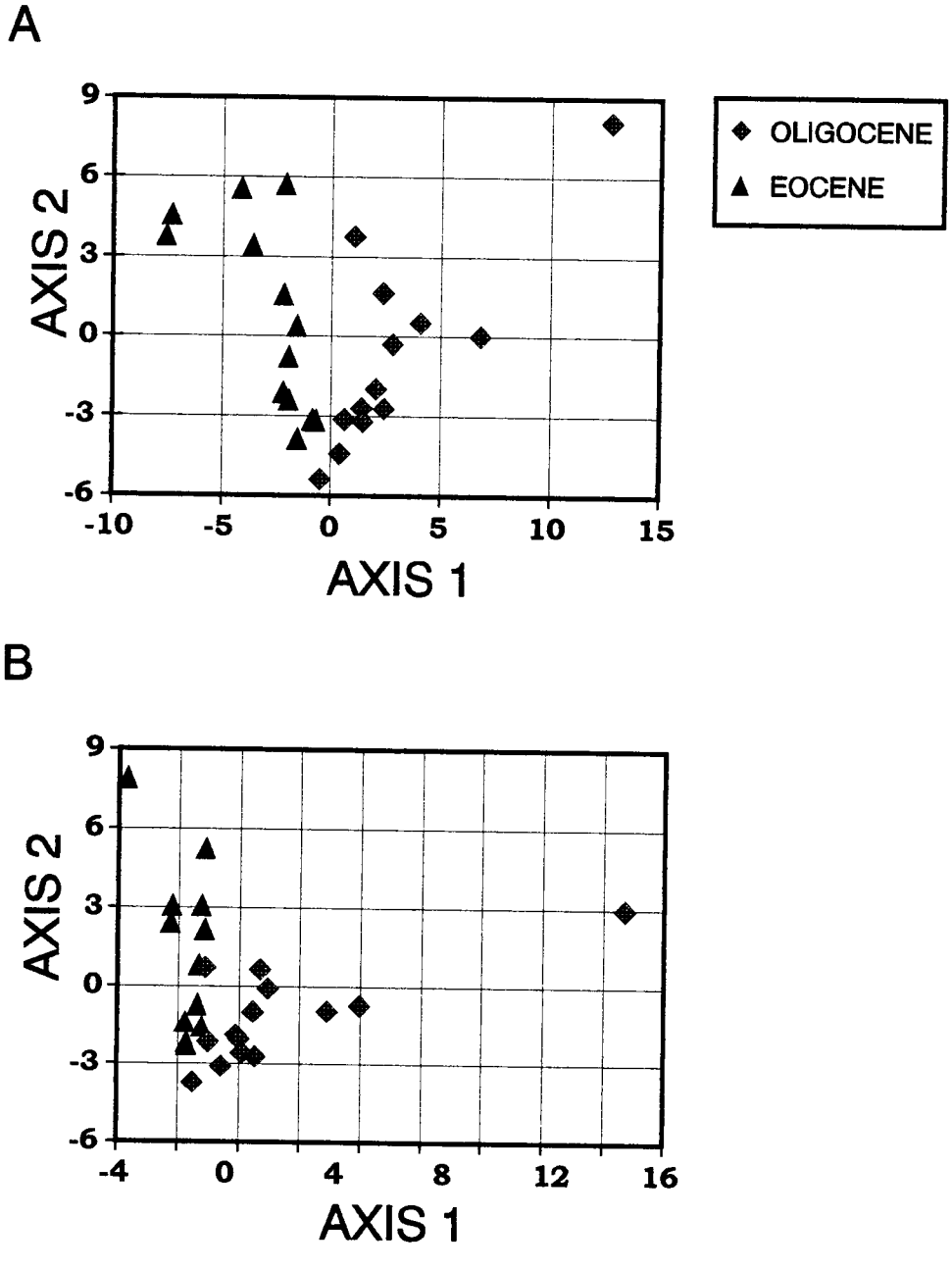


Figure 45. Results of r mode PCA of Sepugla River data. A. Species data. B. Genus data.

Table 22. Sepugla River r-mode species data.

	EIGENVALUE	DIFFERENCE	PROPORTION	CUMULATIVE
PRIN1	21.081	7.812	0.185	0.185
PRIN2	13.269	3.088	0.116	0.301
PRIN3	10.180	1.762	0.089	0.391
PRIN4	8.419	0.582	0.074	0.464
PRIN5	7.837	0.0	0.069	0.533

Table 23. Results of r-mode P.C.A. Sepugla River genus level.

	EIGENVALUE	DIFFERENCE	PROPORTION	CUMULATIVE
PRIN1	11.291	5.337	0.230	0.230
PRIN2	5.954	1.278	0.123	0.352
PRIN3	4.676	0.320	0.095	0.447
PRIN4	4.356	1.066	0.089	0.536
PRIN5	3.290	0.0	0.067	0.603

GGS-3535:

P.C.A. analysis of the raw data in the core section is shown in Figure 46a and Table 24. In this analysis the first 5 axes account for 54.8 % of the variance and the first and second axes accounting for 16.4 and 12.9%respectively. As with the other analysis discussed above the first axis separates the samples by stratigraphic position with all Eocene samples having negative scores and all but one Oligocene samples having positive scores. The second axis in this analysis is less clear and does not separate the samples by stratigraphic position. Thus while the first axis yielded positive results the second through fifth axes seem to represent variation in species abundances not related to the stratigraphic position or in a clear manner by sample. It is possible that part of this variation may be due to differing specimen totals and/or number of species in the samples.

Combining the data in this section to the genus level again resulted in a P.C.A. analysis in which the amount of variance explained by the first 5 axes increased (Table 25) the first axis accounts for 20.4% of the variance and the second axis for 18.5%. Compared to the species level analysis and the other sections discussed above, this analysis did not result in improved or even as good a separation of the samples on the first
axis by stratigraphic position as the species level analysis. As before, the second axis in this section is not easily interpreted, the samples are not separated by stratigraphic position and show no other readily apparent pattern (Figure 46b).

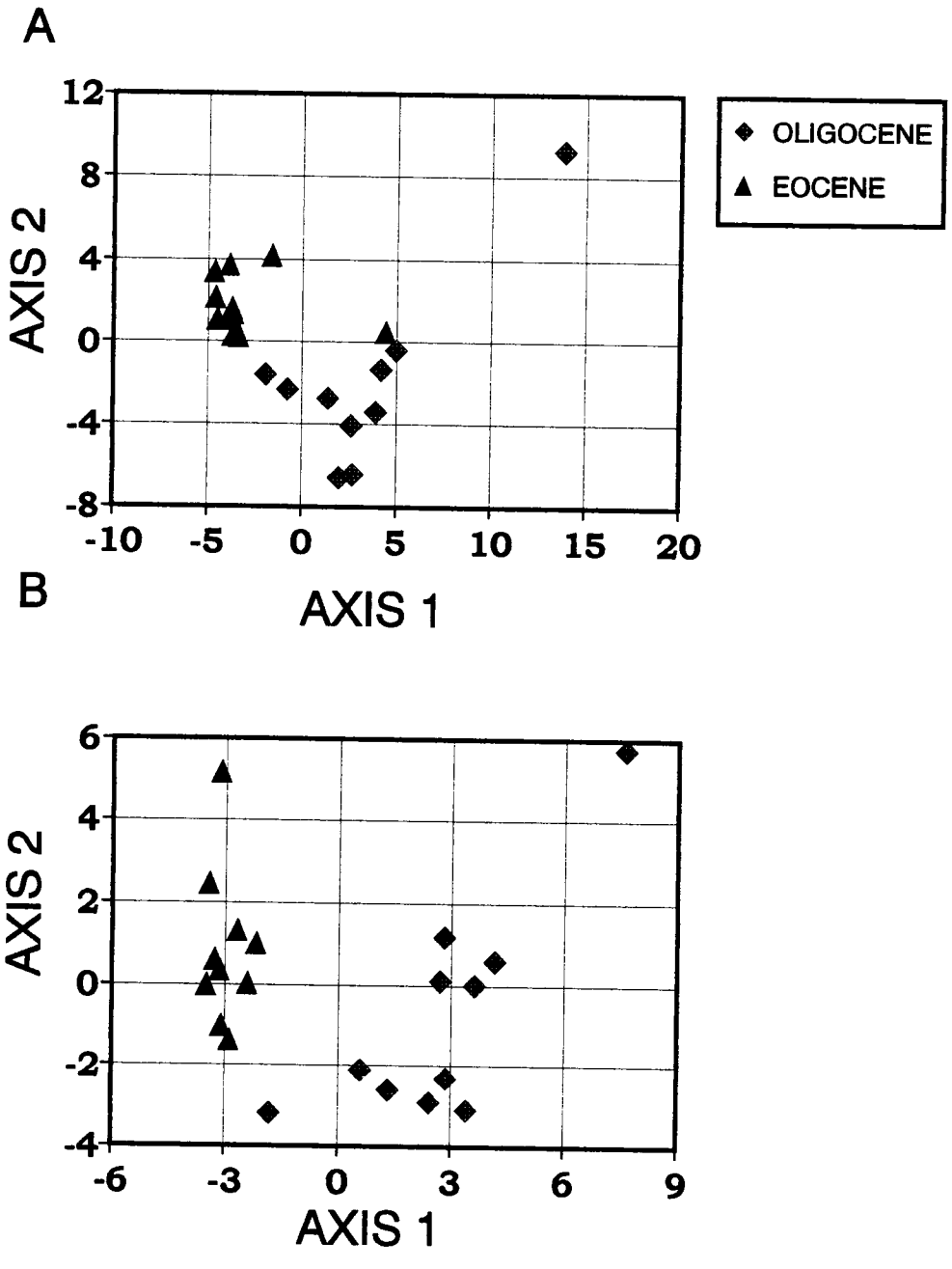


Figure 46. Results of r mode PCA of GGS-3535 data. A. Species data. B. Genus data.

Table 24. P.C.A. species data at GGS-3535.

	EIGENVALUE	DIFFERENCE	PROPORTION	CUMULATIVE
PRIN1	16.427	3.550	0.164	0.164
PRIN2	12.877	2.841	0.129	0.293
PRIN3	10.036	1.1817	0.100	0.393
PRIN4	8.219	0.950	0.082	0.476
PRIN5	7.269	0.0	0.073	0.548

Table 25. Results of GGS-3535 r-mode genus P.C.A.

	EIGENVALUE	DIFFERENCE	PROPORTION	CUMULATIVE
PRIN1	8.365	1.095	0.121	0.121
PRIN2	7.270	0.310	0.105	0.226
PRIN3	6.960	1.878	0.100	0.326
PRIN4	5.081	0.199	0.074	0.400
PRIN5	4.882	0.0	0.071	0.472

Brooksville:

P.C.A. analysis of the Brooksville section samples at the species level is shown in Figure 47a and Tables 26. The first 5 axes account for 47.2% of the variance in the data set, with the first axis accounting for 12.1% and the second axis for 10.5%. In contrast to the other sections studied the results in this case are much less clear. Despite the largest number of last occurrences in the Eocene of any of the section in the study. The first axis in this case does not separate the samples by stratigraphic position very well (Figure 47a). Although the Oligocene samples all group around -2 on the first axis and -1 on the second axis they overlap with the Eocene samples on both axes. Note that in this analysis the first axis accounts for the smallest amount of the total variance of any of the sections studied. One possible reason for this lack of separation is the small specimen numbers in these samples. At Brooksville, in contrast, to the others there are several samples with total specimen numbers of less than 150 (Appendix 2).

Results of the P.C.A. analysis for the generic level analysis of this section are shown in Figure47b and Table 27. The first 5 P.C.A. axes in this analysis account for 52.3% of the variance in the data with the first axis accounting for 14.3 % and the second accounting for 12.1%. As with the species level data, the first axis in this section does not account for as much as the first axis in the other analysis and the separation by stratigraphic position is poor with even more overlap than at the species level. The second axis in this analyses does not separate the samples very well and may be a reflection of specimen or species number in the samples as opposed to taxonomic composition. The lack of separation between stratigraphic sample groups in these 2 analysis is difficult to explain in light of the significant faunal change in this section. However, as discussed above in regard to the cluster analysis results most abundant species which show changes in abundance across the boundary in this section have a more gradual change than seen in other sections. In addition, the small number of Oligocene samples in this section (7) may have resulted in poor characterization of the Oligocene fauna.

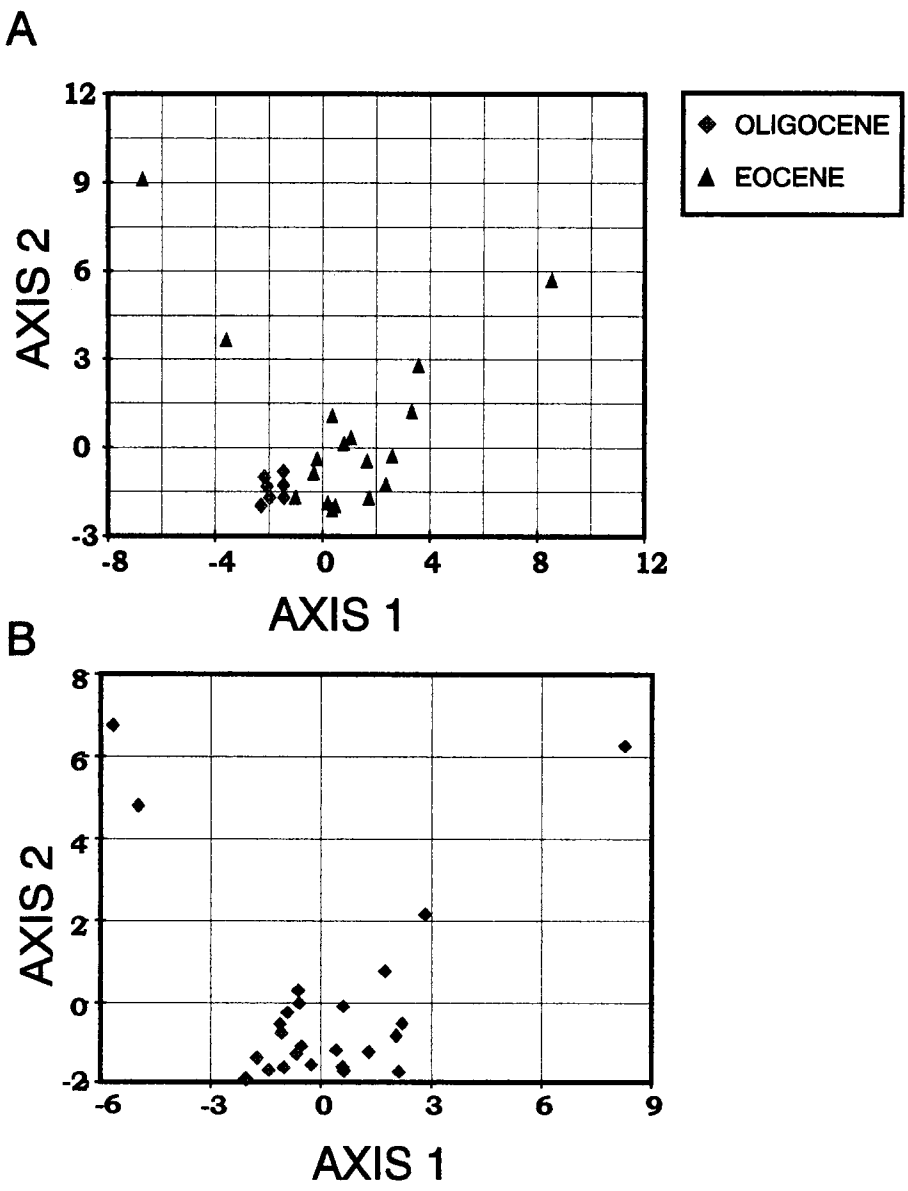


Figure 47. Results of r mode PCA of Brooksville data. A. Species data. B. Genus data.

Table 26. Brooksville r-mode species P.C.A.

	EIGENVALUE	DIFFERENCE	PROPORTION	CUMULATIVE
PRIN1	8.365	1.095	0.121	0.121
PRIN2	7.270	0.310	0.105	0.226
PRIN3	6.960	1.878	0.100	0.326
PRIN4	5.081	0.199	0.074	0.400
PRIN5	4.882	0.0	0.071	0.472

Table 27. Brooksville PCA r-mode genus.

	EIGENVALUE	DIFFERENCE	PROPORTION	CUMULATIVE
PRIN1	6.987	1.039	0.143	0.143
PRIN2	5.947	0.921	0.121	0.264
PRIN3	5.026	0.840	0.103	0.367
PRIN4	4.187	0.693	0.085	0.452
PRIN5	3.493		0.072	0.524

In the other sections often species which are characteristic of the Oligocene do not appear or increase in abundance until some distance up section in the Oligocene units. Conversely, some species characteristic of the Eocene do not disappear or drop to low abundance until well in to the Oligocene *(e.g. S. curta* in the Red Bluff section which is characteristic of the Eocene up whose highest single sample abundance is in the lowermost Oligocene sample).

In conclusion, it should be noted that in all of the genus level analyses the first 5 axes accounted for a higher proportion of the variance than the species level analysis did, while not showing significantly improved sample groupings. This difference in variance explained may arise from several factors. The chief among these is the presence of fewer variables. For example in the Red Bluff section there are 184 species and forms but only 60 groups at the genus level, thus a lower total variance to explain.

Q-Mode PCA analysis

Q-mode analysis was conducted on the species and generic data for each section and for the entire data set to attempt to find recurrent species and generic associations. In every case a large amount of variation is accounted for by the first 5 P.C.A. axes often over 90%. However, examination of plots of the first and second axes and P.C.A. scores for each species and genus show that much of the spread and thus the variation explained by these axes is based on 1 or 2 species. Most often these species are those which occur in the highest or near highest average abundances. Thus, this set of analyses contain little information due to the distortion caused by the high abundance species. Therefore this set of analysis is not discussed in detail except for the Sepugla river section as an example.

Sepugla River section:

The q-mode P.C.A. analysis of the species present in the Sepugla river section resulted in the first axis accounting for 67.3% of the variance in the data set (Table 28). This axis can be described as separating the following species from the rest: *Cibicides pippeni* and *Cassidulina alabamensis*.(Figure 48a) These 2 species are nearly, if not the most abundant species in the fauna, and thus axis 1 seem to be largely an abundance axis. The second P.C.A. axis accounts for 18.6% of the variance. This axis may separate those species which are more abundant or only occur in the Oligocene (negative values from those which occur in the Eocene (positive values).

Results at the generic level are similar with *Cibicides* having the highest values on the first axis which explains 77.7% of the variance Table 29. Again, as with the species level analysis, much of the difference on this axis is due to a single species in this case Cibicides (Figure 48b). The second axis again shows some separation of faunas.

Table 28. Result of q-mode P.C.A. of Sepugla River species data.

	EIGENVALUE	DIFFERENCE	PROPORTION	CUMULATIVE
PRIN1	14.138	10.237	0.673	0.673
PRIN2	3.901	2.957	0.186	0.859
PRIN3	0.945	0.394	0.045	0.904
PRIN4	0.551	0.196	0.026	0.930
PRIN5	0.355	.	0.017	0.9471

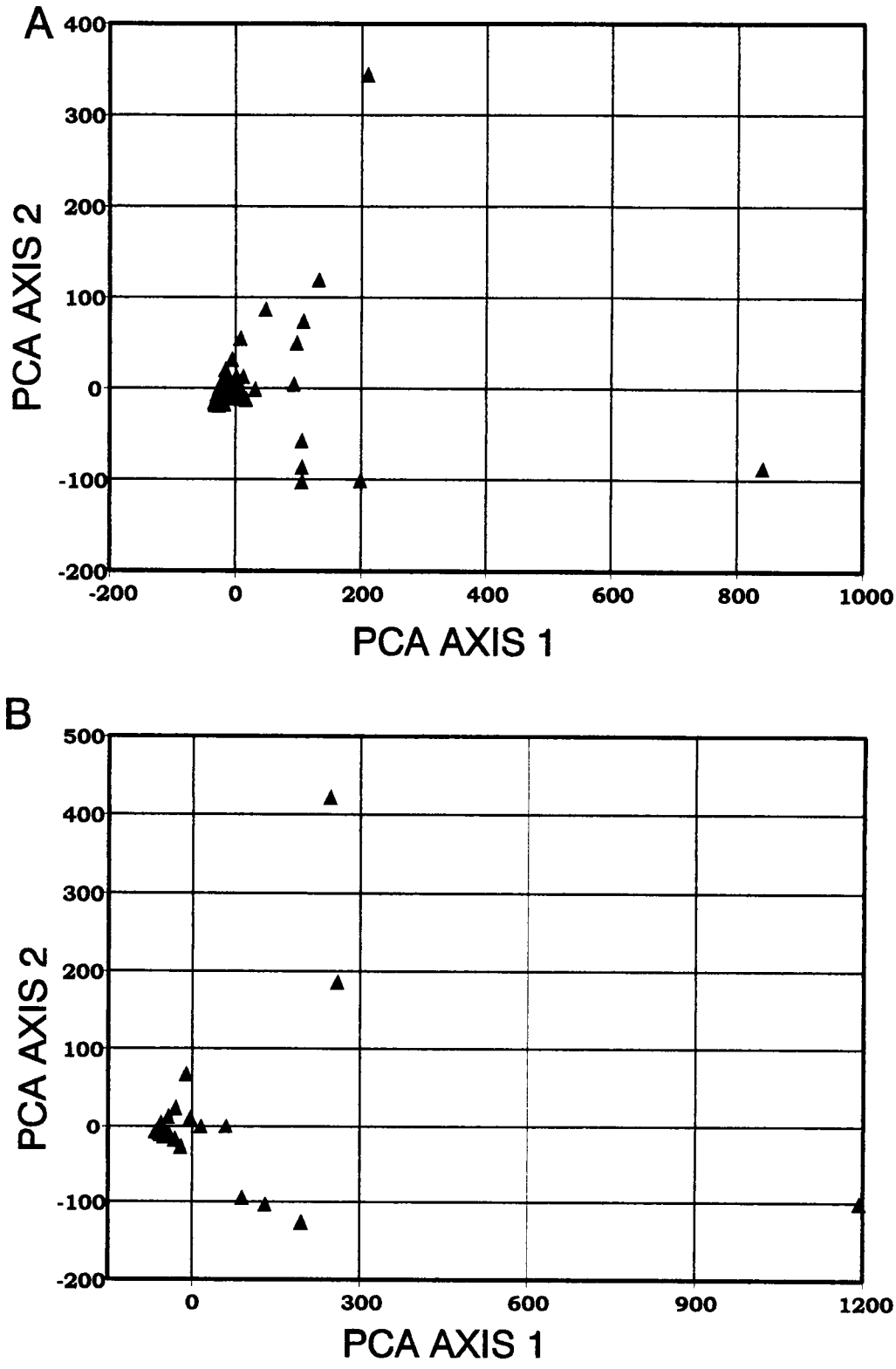


Figure 48. Results of q mode PCA of the Sepugla River data. A. Species data. B. Genus data.

Table 29 P.C.A. q-mode Sepugla River genus level.

	EIGENVALUE	DIFFERENCE	PROPORTION	CUMULATIVE
PRIN1	16.319	13.324	0.777	0.777
PRIN2	2.996	2.163	0.143	0.920
PRIN3	0.833	0.492	0.040	0.960
PRIN4	0.341	0.135	0.016	0.976
PRIN5	0.206	0.0	0.010	0.986

Microhabitat characteristics of benthic foraminifera

Analysis of both species and fanual data in all the sections has shown that each section has responded in a unique manner. An additional method of examining the changes in benthic foraminifera associated with the Eocene/ Oligocene boundary is to look for changes in the structure foraminiferal fauna in terms of life habit. This analysis allows for examining the possibility of change bottom conditions and perhaps a measure of paleoproductivity (Corliss and Chen, 1988; Corliss, 1991).

Although benthic foraminifera were originally thought to live only on or above the sediment water interface, studies of modern populations have shown them to inhabit a range of setting in and above the sediment(Buzas, 1968; Thiel, 1975; Collison, 1980; Kitazato, 1984; Snider, et al. 1984; Corliss, 1985, 1991; Jones and Charnock, 1985; Jorissen, 1987; Corliss and Chen, 1988; Macksen and Douglas, 1989).

Shape has been the most commonly used method to determine microhabitat preference for benthic foraminifera. This has been complemented by observation data of living specimens from cores (Severin, 1983; Jones and Charnock, 1985; Bernhard, 1986)(Table 30). This method has been modified by the use of coiling patterns and the presence or absence of pores (Corliss and Chen, 1988; Corliss, 1985, 1991)(Table 31).

Corliss (1991) divided these two basic groups into four micro habitat divisions: **Epifaunal** including those which live attached to sea weed or other substrates above the sediment water interfaced and to depths of about 1 cm; **Shallow infaunal** species which live within the first 2 cm of sediment; **Intermediate infaunal** which inhabit mostly the depths form 1-4 cm; and **Deep infaunal**, those species which live deeper than 4 cm, based for the most part on the distribution of living specimens (Kitazato, 1984; Corliss, 1985, 1991). In each of these divisions typical test shapes are dominate(Table 31). In additional the vertical distribution of agglutinating foraminifera was examined by Jones and Charonock (1985). These authors divided living taxa into four morphogroups which represented variation in microhabitat and feeding mechanisms. These morphogroups appear to be at least in part distributed by depth similar to that seen in macrofauna (Jones and Charnock, 1985) (Table 31).

The shape of epifaunal taxa is believed to be related to attachment and stability on the sediment water interface. Test shape of infaunal taxa is thought to be related to mobility in the sediment and the distribution of pores related to the need for more efficient gas exchange in infaunal taxa (Corliss, 1991). It should be noted that in studies of modern benthic foraminifera, it is rare that live specimens of a given species are confined to a single level in the sediment and the interpretation of habitat is usually based on the occurrence of a maximum abundance (Jones and Charnock, 1985; Corliss, 1991; Barmawidjaja et al. 1992). In addition, it is by no means definite that taxa always live at the same depth in the sediment column. For example those species which are tolerant of, or preferring, low oxygen environments may live at greater

Table 30. Shape characteristics of benthic foraminiferal microhabitats.

Habitat	Characteristics	Refs.
Epifaunal	Rounded trochospiral Plano-convex Milioline Biconvex trochospiral	Severin, 1983 Corliss, 1985 Corliss and Chen, 1988
Infaunal	Rounded planispiral Flattened ovoid Tapered and cylindrical Spherical Flattened tapered	Severin, 1983 Corliss, 1985 Corliss and Chen, 1988

Table 31. Characteristics of benthic foraminifera in by microhabitat preference (after Corliss 1991).

Microhabitat	Test characteristics
Epifaunal	Biconvex, planoconvex, and planispiral shapes, lack large surface pores or present on one side.
Shallow infaunal	Rounded planispiral, spherical, with pores and frequent ornamentation
Intermediate infaunal	Rounded, ovate, and cylindrical shapes with well developed pores
Deep Infaunal	Rounded, ovate, or cylindrical shapes with more evenly spaced pores

depths in well bioturbated, oxygen rich environments and closer to the surface in low oxygen environments (even to the point of being epifaunal). Bioturbation and other sedimentary processes will move foraminifera out of the preferred habitat. Corliss (1991) reported deep infaunal taxa are found at decreasing depths in the sediment as the water shallows and the organic carbon content of the sediment surface increases. In contrast, other studies have indicated few or contrary trends in benthic foraminiferal distribution (Ellison, 1972; Buzas, 1977; Barmawidjaja, et al. 1992). These studies have emphasized a lack of systematic mircohabitat differentiation, and suggested that factors other than test shape may be controlling at least some microhabitat choices. It is likely that many foraminiferal species are not restricted to a single microhabitat but can live in a variety of environments under favorable conditions particularly in areas with seasonal changes in bottom conditions(Barmawidjaja, et al. 1992). However, the basic trends have been observed in enough studies to use this type of analysis with some confidence as the microhabitat preferences described are based on

With these noted differences in shape and texture of the tests, it is possible to examine the distribution of habitats in the fossil record and to attempt to relate changes in faunal composition to environmental conditions or potentially postmortem changes. Using modern ecologic information to interpret fossil assemblages is often tenuous at best as the taxa may change ecologic tolerances over time. However, in this case the basic assumptions of attachment and motility in the sediment may be sufficiently broad to make good analogs. In addition, many of the genera present in modern assemblages, and in some cases species, are also present in the material studied (Table 32).

For each genus listed in Table 32, all species present in the data set were assumed to occur in the microhabitat listed. In the cases where more than one habitat was listed, either the most recent assignment was used or by using overall test shape. For example *Lenticulina* was placed in the epifaunal group by Corliss and Chen (1985) and in the shallow infaunal group by Corliss (1991). On the basis of the latest grouping and the presence of ornamentation on

Table 32 Habitat preferences of genera in the data set with living representatives

Genus	Epifaunal	Infaunal	Deep infaunal.	References
Cibicides	X			1,2,4
Cibicidoides	X	X		1,3,4
Discorbis	X			1
Planulina	X			1,3
Miliola	X			1
Hanzawaia	X			4
Triloculina	X			
Bolivina	X	X		2,4
Gyroidina	X			1,4
Quinqueloculina	X	X		2,4,5
Brizalina		X		1,4
Bulimina		X		1,
Lenticulina	X	X		1,4
Pullenia		X		1, 3
Fissurina		X		4
Cassidulina		X		4
Lagena		X		4
Globocassidulina		X		4
Trifarina		X		1,4
Uvigerina		X		1,4
Florilus			X	1
Fursenkoina			X	1
Nonion		X	X	1,4
Nonionella		X	X	1
Eponides	X			4
Textularia		X		6
Spiroplectammina		X		6
Leibusella		X		6
Gaudryina		X		6

References: 1. Corliss, 1991; 2. Kitazato, 1984; 3. Corliss, 1985; 4. Corliss and Chen, 1988; 5. Collison, 1980; 6. Jones and Charnock, 1985.

some, species this genus were placed in the infaunal category. Other species were assigned on the basis of the criteria listed in Tables 30 & 31. Some taxa were not clearly assignable to a category and were thus excluded from the analysis. Most of these species are minor components of the fauna and in no case did unassigned species account for more than 20 percent of the fauna. In each analysis the raw data from each section was arranged according to habitat. For each habitat, the percentage of the total fauna was then plotted on cumulative percentage plots.

Results of this analysis are shown in Figures 49-52. The Red Bluff section exhibits a significant increase in epifaunal taxa across the E/O boundary, a change from and average of 22.5% in the Eocene to 47.2% in the Oligocene. This change is fairly abrupt although there is a trend to increasing epifaunal percentages in the lower Oligocene (Figure 49). Spikes of epifaunal abundance in the lower part of the section are due to concentrations of single species. The increase is the result of both abundance and diversity of epifaunal taxa. This increase in epifaunal taxa may be the result of one or a combination of several processes. Corliss and Chen (1988) correlated increased abundance of epifaunal taxa with increased organic carbon in surficial sediment. This may be a function of increased productivity. A second process is the downslope transport of shallow water, mainly epifaunal, species into the area. Many of the epifaunal taxa seen only in the Oligocene portion of the section are commonly found in shallow water. Evidence for down slope transport is seen in the shell lags in the Red Bluff formation and to the west in the Shubuta (Smith and Zumwalt, 1987; D. Dockery, personal communication, 1990). A final process which may have acted to increase the percentage of epifaunal species is a lower sedimentation rate in the Oligocene (see above discussion of regional depositional model). Reduced rates of sedimentation (*i.e.* slow enough to permit glauconite formation) would have resulted in a firm substrate favorable for epifaunal colonization. In addition, lowered sedimentation increases the amount of coarse grained material in the sediment providing more

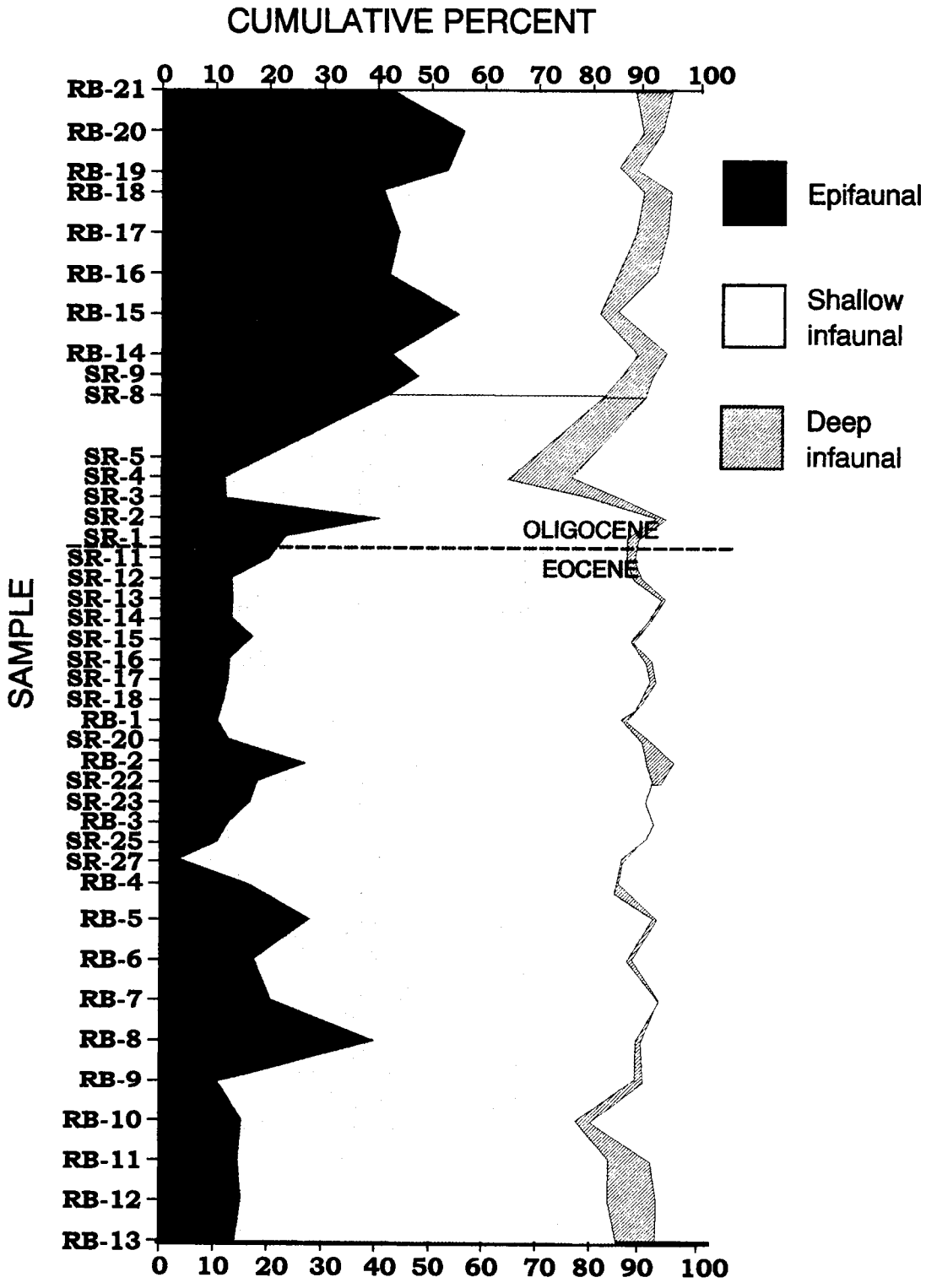


Figure 49. Results of microhabitat analysis of the Red Bluff data.

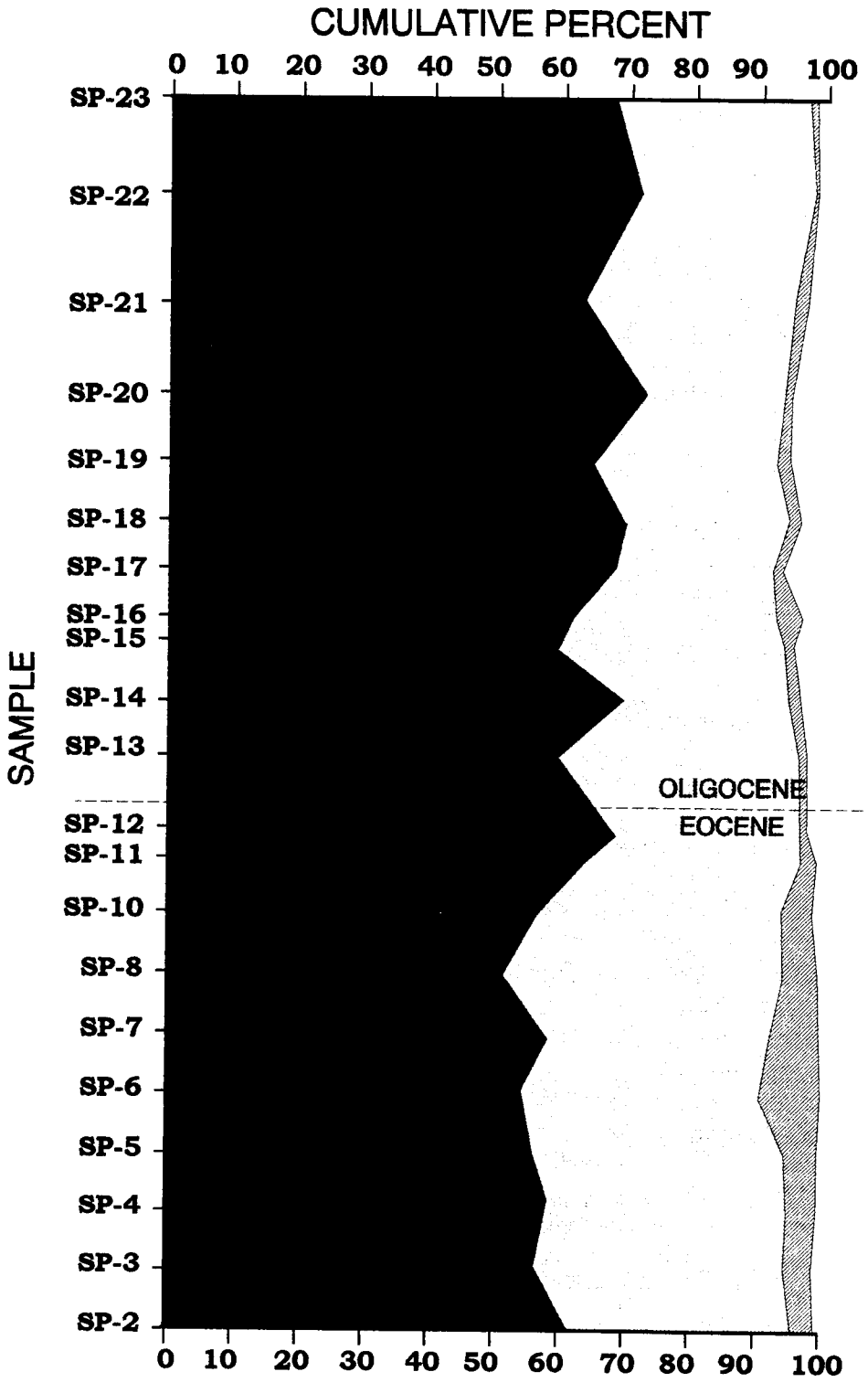


Figure 50. Results of microhabitat analysis of the Sepugla River data. Patterns are same as in Figure 49.

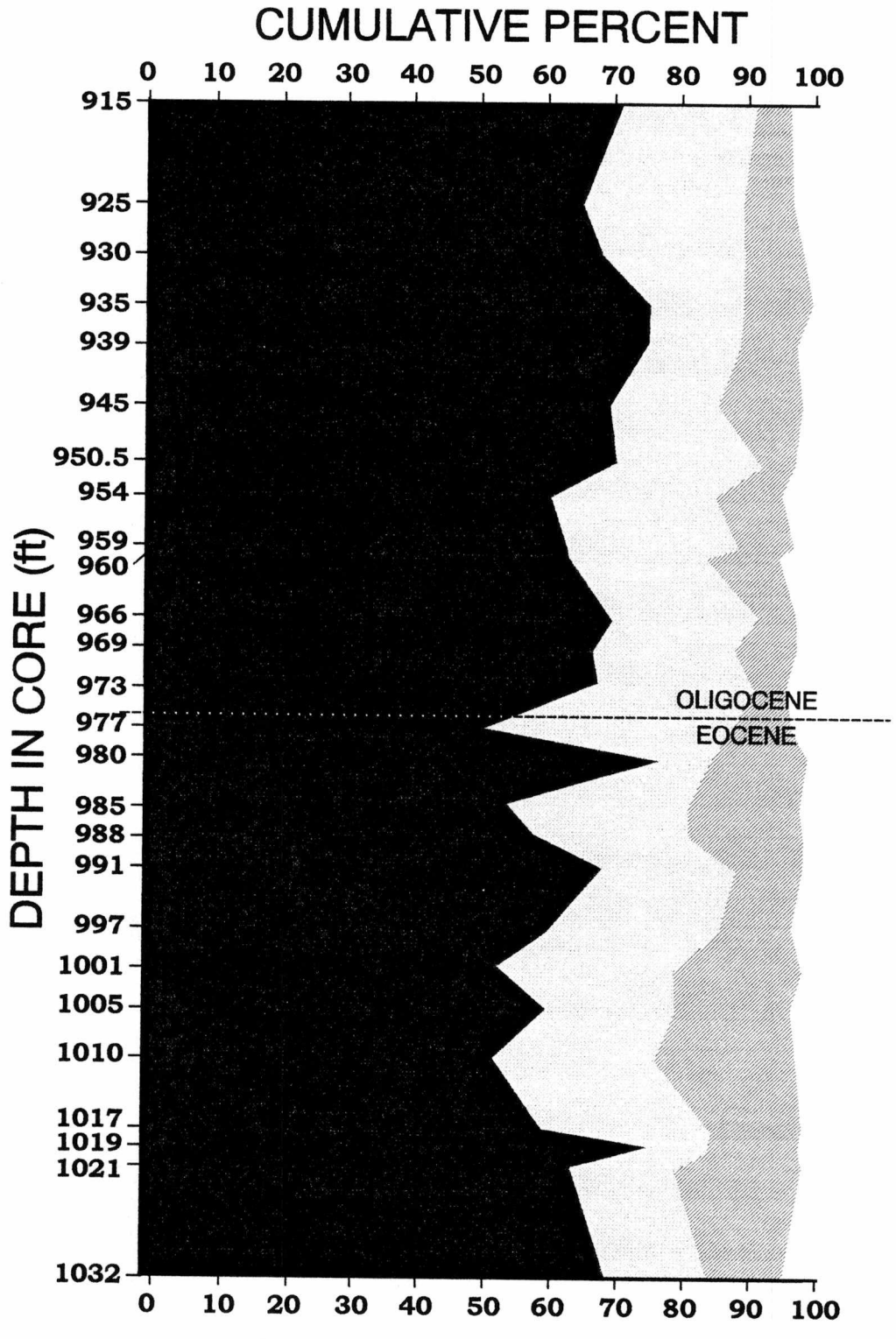


Figure 51. Results of microhabitat analysis of the GGS-3535 data. Patterns are same as in Figure 49.

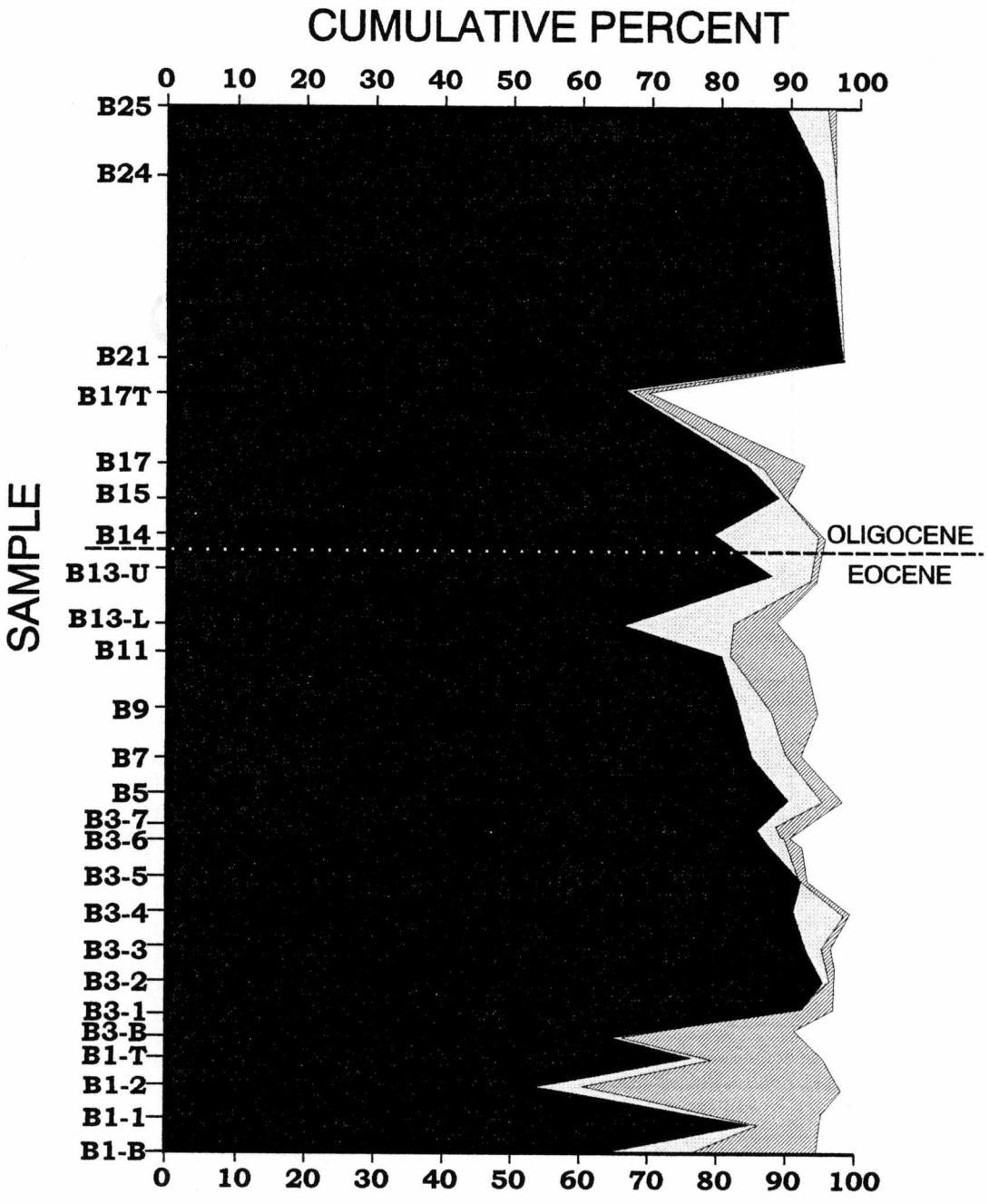


Figure 52. Results of microhabitat analysis of the Brooksville data. Patterns are same as in Figure 49.

attachment sites for epifauna. Deciding between these various processes in difficult when looking at a single section in isolation.

In the Sepugla River section, species which are interpreted to have epifaunal habitat make up a large amount total fauna throughout the sampled interval (Figure 50). As in the Red Bluff section the percentage of epifaunal species increases across the E/O boundary. This increase is much smaller than that seen in the Red Bluff section from an average of 57.4% in the Eocene to 63.7% in the Oligocene. Therefore, assuming some ecologic significance to this trend, the forcing factor was less intense or perhaps fewer causes were involved. It should be noted that there is little evidence in this section for down slope transport of shallow water sediments (Huddlestun, 1965; Water, 1982). However, the presence of glauconite points to a lower rate of sedimentation.

The GGS-3535 section has a similar increase in percentage of epifaunal species across the boundary (Figure 51). The amount of change is similar that at Sepugla River (5.9 vs. 6.2%). However, the overall patterns are different at Sepugla River. The Eocene and Oligocene sample sets show a smaller amount of variation than in GGS-3535 where the range of values is higher(Figures 50 & 51). In addition in GGS-3535 there is some indication of a decline of epifaunal taxa in the upper Eocene followed by a recovery in the Oligocene. A further complication in the comparison of this section with the others is the presence of more forms placed in the deep infaunal category by Corliss (1991) than in the other sections. As a result some of the lower percentages of epifaunal may be an artifact of the analysis resulting from using percentage data. Precentages can lead to problems with closure where two variables appear to have a negative correlation, when in fact they are independent of one another. Examination of Figure 51 reveals that samples with high portions of deep infaunal taxa tend to be those with the lowest proportion of epifaunal taxa, so that closure may be a problem in the analysis of this section.

The Brooksville section is dominated for the most part by epifaunal taxa (Figure 52). This might be expected as this section was deposited in the shallowest water and contains high abundances of species thought to have harbored photosythentic symbionts. These taxa were naturally restricted near to the sediment surface. In addition, this section contains high numbers of *Miliola* which are epifaunal but may be infanual in shallow water carbonates. However, this interpretation is based mostly on data from studies in other environments. Therefore the possibility exists that taxa such as *Quinqueloculina* which are epifaunal in other environments are actually infaunal in shallow water carbonate settings. This section also had the largest number of taxa which were not assigned to any category and the most variation in specimens per sample. That being said, there does seem to a slight trend to increased epifaunal taxa up section. However, lack of reliable data makes this section the hardest to interpret.

The proportion of epifaunal taxa in the data set reveals two trends. First, there is aa increase in epifaunal taxa from west to east. The average proportion of epifaunal taxa increases from 30% at Red Bluff to 61% at Sepugla River, 65% at GGS-3535 and 84% at Brooksville. This trend mirrors the change in lithology across the study area from clastic dominated to pure carbonates. Second there is an overall increase in the proportion of epifaunal taxa at Red Bluff and Sepugla River and at least a tendency for increase at GGS-3535 and Brooksville.

The causes of these trends are not completely clear. The increase from west to east may be a result of substrate conditions. The diferent processes of sediment deposition detrital verus autoochthonous may lead to carbonates being more favorable for epifaunal taxa. However, no direct correlation has been shown between sediment type and epifaunal proportion (Corliss, 1991; Barmarwidjaja, et al. 1992). The only correlation demonstrated to date is an increase in infaunal numbers in coarse grained sediments attributed to the higher oxygen level in the more porous coarse material (Boltovsky, 1966). Comparative studies of microhabitat

preferences in areas with differing lithologies but similar water mass conditions are lacking. But, higher oxygenation in the carbonate sediments may allow otherwise epifaunal species to live below the sediment water interface. This may well translate into an increase in nominally epifaunal species.

The increase in epifaunal taxa from the Eocene to Oligocene has been discussed in regard to the Red Bluff section. The presence of this trend in the Sepugla River section, coupled with its questionable presence in the GGS-3535 core, require at least part of the explanation to be regional in scope. Of the possible explanations listed above downslope transport fits the Red Bluff section but lacks support in the other two. Lowered sedimentation in the uppermost Eocene and lower Oligocene probably occurred over most of the study area thus provides a regional explanation. In addition to the formation of new substrates, a thinning of the oxygenated layer as input of organic matter resulted in reducing conditions. Corliss and Chen (1991) related increased epifaunal component to increase organic carbon in the sediment and suggested that this might be a method for tracking paleoproductivity. Increased ocean productivity would result in more carbon being transported to the ocean floor. Applying this model at least the Red Bluff section records an increase in ocean productivity. But the carbonate section do not record such an increase.

A final possible model for the changes in faunal distribution is the migration of the oxygen minimum zone on to the shelf as a result of the sea level highstand straddling the E/O boundary. In modern and presumably Paleogene oceans the concentration of oxygen decreases with depth as respiration and decomposition remove it. In the modern ocean this low oxygen zone is located from about 400-800 meters water depth with the low point at about 800m (Duxbury and Duxbury, 1991). Thus is below the shelf edge. During the late Eocene sea level rise it is possible that the oxygen zone migrated on to the shelf following the rising sea level (R. Flugeman, personal communication). This scenario is weakened by the lack of substantial change in GGS-3535 which may have been the deepest water section studied.

In all likelihood, more than one process was at work in the study area causing the observed changes in benthic foraminferal proportion. There is clear evidence for decreased sedimentation rates in the sections showing the largest changes, for at least some downslope transport in the Red Bluff section, and for worldwide increases in the rate of ocean mixing. Given the weak nature of the increase in epifaunal taxa at GGS-3535, and other evidence for ecologic stability in this section it seems like the observed changes are mostly of local origin. Local events include downslope transport of shallow water species at Red Bluff and shoaling at Brooksville.

Chapter 5 ANALYSIS OF ABUNDANCE VARIATION IN THE FOSSIL RECORD

One criticism of much of the literature on evolutionary processes and patterns in the fossil record is the lack of studies on species level patterns on time scales (<500 year resolution) approaching that of biologic populations (McKinney and Allmon, in press; Sepkoski, 1991). This need becomes particularly clear when one attempts to apply models and concepts developed in the fields of modern ecology and evolutionary biology to the fossil record or the reverse. A major part of the difficulty in extrapolating between these fields is the differences in time series length and resolution. Many ecological and evolutionary studies of modern populations involve time series which are 20 years or less in duration with a resolution of months to years. In contrast many evolutionary and paleoecologic studies of the fossil record involve times series which are centuries, millenia to millions of years in length and have resolutions on the scale of 10's to 100's of thousands of years at best and involve taxa above the species level (Delcourt and Delcourt, 1988; McKinney, in press). Thus, the relationships between population size, species area, and population duration, matters of growing interest in the fields of ecology and evolutionary biology, are beyond the resolution of many studies of the fossil record. Conversely, the time series length of many studies of modern populations are almost insignificant in duration when compared to estimates of probable rates of evolutionary change (Gingerich, 1993). The exceptions may be extinction or rapid changes in population structure caused by human intervention.

The prevailing view in many quarters is the fossil record is too incomplete for the study population dynamics, or in many cases even the determination of evolutionary patterns (Eldredge and Cracraft. 1982; Kidwell, 1992; Flessa et al. 1993). However, there is some evidence that at least coarse-scale features of populations can be determined in fossil populations and that some patterns observed in the modern populations may be found in the fossil record (Delcourt and Delcourt, 1991; McKinney and Frederick, 1992).

This chapter examines the requirements that must be met for population level patterns to be preserved in the fossil record, what patterns might be expected to be preserved in the record, and applies these expectations to the data collected in this study. In order to examine the possibilities of population studies in the fossil record of benthic foraminifera. In may ways foraminifera, and benthic foraminifera in particular, are ideal for this type of study. They are very abundant in both modern and ancient sediments, have a fairly well understood life cycle, are often well preserved, and at least on the broad scale show clear patterns of ecological zonation (Murray, 1991).

Modern Populations of Benthic Foraminifera

Populations of most species occur in semi-isolated patches distributed throughout the range of the species (*i.e.* metapopulations)(Hanski, 1986, 1991)(Figure 53). Patches density and spacing is controlled by conditions. Dense, closely spaced patches will occur in optimal environments and more spread out near the edge of the range of the species. The duration of the any given metapopulation patch will, in general, be shorter than that of the species as a whole as local environmental disasters destroy the population. The duration of any given patch will be determined by the local rate of production, recruitment of immigrants, and environmental stability (Hanski, 1986; 1989).

Each patch will have an unique history. Small patches and those located in sub-optimal conditions will be more dependent on recruitment of new individuals than reproduction for patch continuity. In contrast, larger population patches and/or those located in optimal conditions will provide migrates as reproduction exceeds mortality. As a result, large patches located in optimal conditions may endure nearly as long as the species and those located in marginal conditions will have a duration much less than that of the

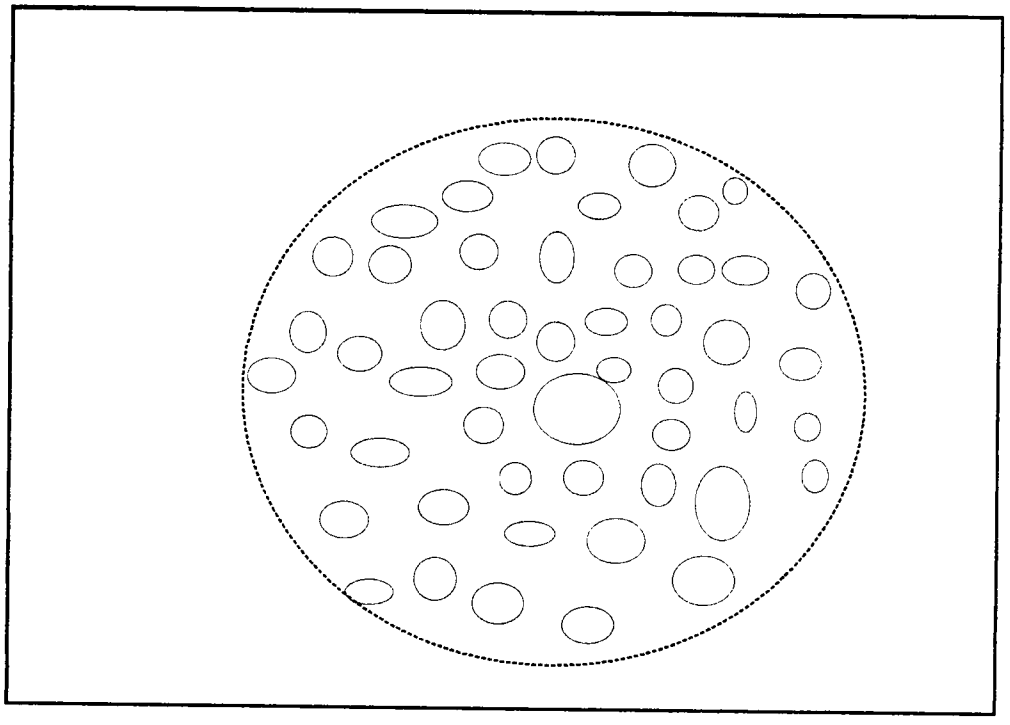


Figure 53. Diagrammatic view of typical species range. The large dashed circle represents the entire range and each smaller circle represents a local population.

species. Thus, the amount of and type of information which can be obtained from any given population will be determined to some extent by where that population occurs in terms of the total species range (Hanski, 1986).

Another feature of modern species that has been noted in the general relationship between abundance, patch size and duration (Hanski et al. 1993). More abundant species occupy larger areas and larger patches and therefore would be expected to have longer duration's. Conversely low abundance species tend to have smaller species areas, fewer and smaller patches thus a shorter expected duration. This is the classic species area model (*i.e.* a species which occupies a large area is more resistant to extinction due to random environmental flux).

Distribution and population structure of modern benthic foraminifera seems to correspond to the above generalizations. Most studies on the distribution of living and dead benthic foraminifera have focused on broad scale distribution patterns useful in paleoenvironmental studies and on the degree to which standing crop corresponds to the death assemblage (Culver and Buzas, 1983; Murray, 1991). However, several studies have noted the presence of clumps of individuals (*i.e.* patches), in at least some species, with estimates of patch size ranging from 5-2500 m^2 Schifflet, 1961; Lynts, 1967; Buzas, 1968; Schafer, 1971; Murray, 1983). Murray (1991) has noted that some benthic foraminifera show population patterns that can be modeled as patches, with high abundance species having larger patches (Figure 54). Studies of lateral distribution in the fossil record have shown that many species to be randomly but not evenly distributed (Smith and Buzas, 1986; Buzas and Gibson, 1989). The degree to which this population pattern is independent of environment remains unclear, but there is some evidence that foraminifera are more evenly distributed in deeper waters (Buzas, 1965; Schafer, 1971).

The same pattern is seen in a series of studies on modern benthic foraminifera occurrence by Buzas and Culver (1986; 1991) These studies concluded that there is a

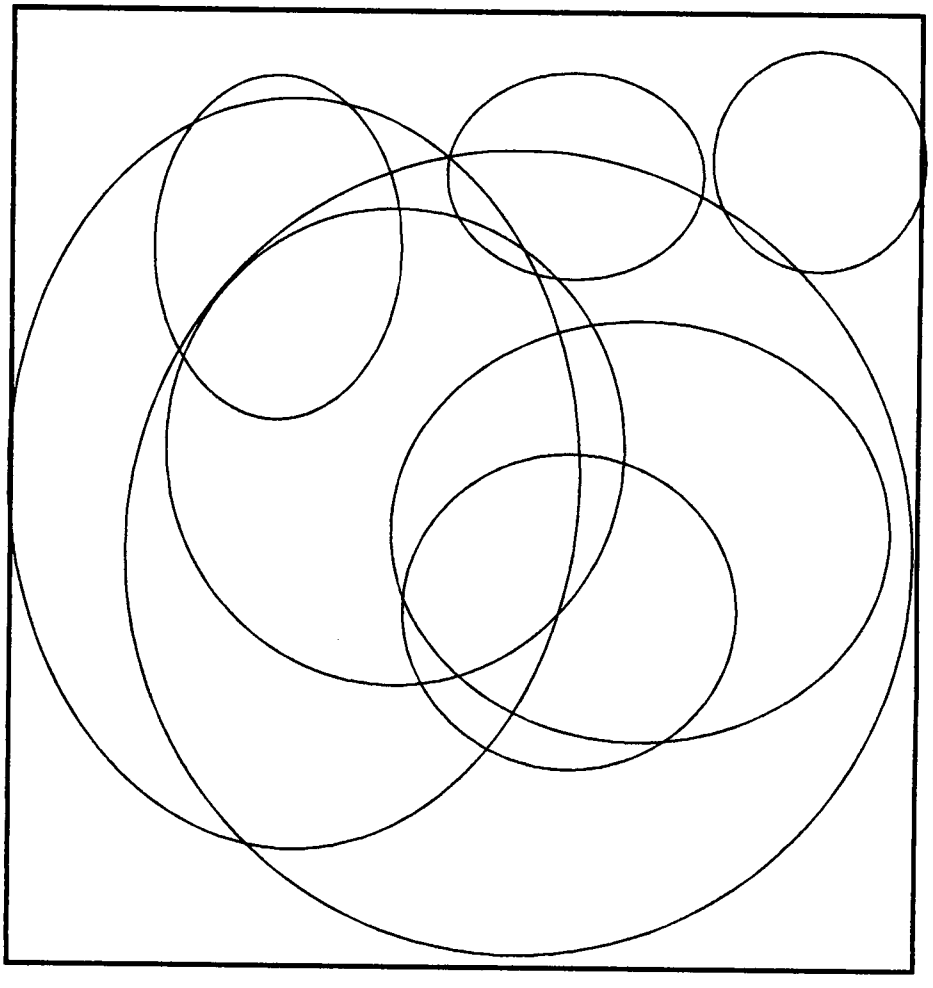


Figure 54. Occurrence of modern foraminiferal populations. Each circle represents the overlapping population of a different species (Modified from Murray, 1991).

correlation between abundance and species range. Species which occur in low abundance have small geographic ranges and are frequently not found in samples within their known range (Buzas and Culver, 1991). This supports both the patch size and abundance trends expected from metapopulation theory. Low abundance species have small geographic ranges, small patch sizes, low patch numbers making the probability of any sample encountering them low.

In addition, most of these rare species have little or no known fossil record (Buzas and Culver, 1991). Again this is consistent with the metapopulation model. Low abundance species occurring few small patches should have a short history. The small patch size and short duration of these species lowers the probability of preservation and sampling. Thus both ecologic patterns and sampling error will have the same effect rare species will have short patchy fossil records.

Development of Fossil Assemblages of Benthic Foraminifera

The question of how well fossil assemblages of benthic foraminifera reflect the living populations has been reviewed by Murray (1990, 1991), concluding that "in the majority of cases the difference between the living and ideal dead assemblages... are not very great" (Murray 1991, p. 46). In studies of modern benthic foraminiferal populations the volume of tests contributed to the sediment and thus potentially to the fossil record is a function of: 1) the standing crop of living forms; 2) the rate of production of tests (directly related to the generation time); 3) sediment accumulation rate; 4) time averaging of populations by sediment mixing; 5) addition or removal of tests; 6) postmortem changes in the assemblage (dissolution and destruction of tests) (Murray, 1991).

The standing crop refers to the number of individuals living in an area at any one time.

"Production is defined as the number of tests contributed to a unit area of the sea floor during a specific period of time" (Murray 1991, p. 44). Thus, production is a function of the

standing crop and reproduction rate of the species. Those with high standing crops and high reproductive rates will have high production of tests. High rates of reproduction (short generation time) may in some cases overcome low standing populations. If a species reproduces several times a year it may produce as many tests as a species which has a larger population at any given time but longer generations. Thus, accumulation of tests has a strong, but species specific, biological component.

Sedimentation rate has a greater effect on the density of tests rather than the volume or number of tests available for preservation. High sedimentation rates would act to dilute the density of tests as the proportion of sediment grains to test increased. Low sedimentation rates would concentrate tests increasing, their density relative to other sediment grains. The effect of sedimentation rate on the preserved or potentially preserved assemblage is fairly complex. On one hand, high rates of sediment accumulation will dilute the density of tests decreasing the probability of a test, or population of tests, being encountered in a sample. On the other hand elevated sedimentation rates increase the probability of preservation by isolating the tests from the environment more quickly. The concentrating action of low sedimentation rates has the opposite effects, increasing density but lowering preservation potential. A final effect sedimentation rate will have on the development on death assemblage is the depth and degree of time averaging by mixing. In environments of very low sedimentation rates the sediment surface (0-1cm) may represent 10's to 1,000's of years of accumulation. In addition, nearly all sediments are mixed by bioturbation to some degree, in many shelf environments this mixing may reach 10's of centimeters below the sediment surface (Flessa et al. 1993). The degree of mixing is directly related to sedimentation rate. The higher the rate the smaller the time interval represented by the mixed sediments as the depth of bioturbation is reached faster. The result of sedimentary time averaging is that a sample taken of well mixed sediment will contain not only representatives of the population which existed when the sampling point was at the sediment surface but some amount of time before and after (Martin, 1993) (Figure 55).

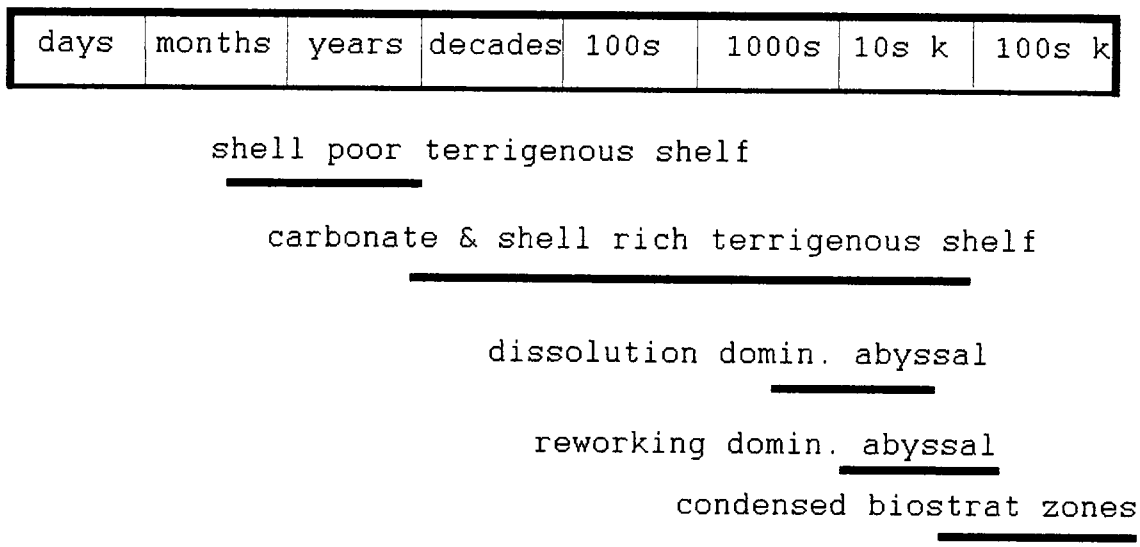


Figure 55. Estimated intervals of time-averaging for benthic foraminiferal assemblages in different environments. The samples in this study are either carbonate or terrigenous shelf deposits. (After Martin, 1993)

Time averaging of populations and population patches directly influences the degree to which the living foraminiferal assemblage resembles the dead assemblage. The assemblage of empty (dead) tests usually has a greater diversity of species than the living assemblage, due to the incorporation of more rare species in the death assemblage (Murray, 1979; 1991). This relationship is often most noticeable in areas which have distinct seasonal variations in water temperature and/or chemistry. Causal factors are readily apparent, under changing conditions different species will inhabit a locality and as long as the rate of environmental change is greater than the sedimentation rate several species will appear to gather in the dead assemblage. The migration of population centers or patches (metapopulations) will result in the same pattern. The living assemblage will record only those species presently occupying the sampling point and the death assemblage will record many of the species which have occupied that point for some x amount of time. With the value of x ranging from months to thousands of years, depending on rate and frequency of environmental change, rate of patch migration, and sedimentation rate (Murray, 1979; Jorissen et al. 1992; Flessa et al. 1993; McKinney and Allmon, in press).

Postmortem changes in the foraminiferal assemblages can also affect the relationship between living and dead assemblage in several ways. The transport of tests into and out of the sampling locality way produce dramatic changes in the faunal composition of the sample. In an environment where there is large amounts of sediment transport addition and removal may result in a death assemblage which has little correspondence to the original biocoenose (Murray, 1976, 1991). Destruction of test by the processes of dissolution will also change the degree to which the death assemblage resembles the living assemblage. The degree of dissolution is a function of the lithology, $CaCO_3$ input, rates of bacterial reduction, and organic and oxygen content of the sediment (Martin, 1993) An additional factor which will effect the composition of the final fossil assemblage of benthic foraminifera in any given sample will be the diagenetic environment in which that sample has been. The migration of diagenetic fluids

through a sediment may selectively dissolve tests, particularly in sediments with high porosity. Finally, the degree of lithification of the rock will influence ones ability to extract tests. All of these factors will effect the development and recognition of a fossil assemblage each altering the living assemblage as it becomes a death assemblage and/or a fossil assemblage.

Each of these processes alter the living assemblage (Figure 56). Most, with the exception of transportation, will act to remove information about population structure. Thus, one way of looking at the fossil record of benthic foraminifera is to view each sample as a somewhat blurred snapshot of a series of generations. As a result, a series of samples becomes a series of snapshots in which the outlines of the broad scale population processes may be visible, but the details remain obscure (somewhat like an old movie where the frames are in sequence but the time between each frame is uneven and the focus is slightly off).

The loss of information in the development of fossil assemblages is unquestionable. However, the above discussion and published studies indicate at least the broad outlines of population structure may well be preserved (McKinney and Frederick, 1992). The proper concern for studies attempting to study population level dynamics in the fossil record is not how much was lost, but what information is retained.

Recording Population Patches in the Fossil Record:

The goal of recognizing populations dynamics in the fossil record is dependent on the recognition of population patches in the fossil record. The possibility of such recognition follows from the relationship between lateral shifting populations, environmental boundaries, and deposition of a vertical stratigraphic sections. A set of vertical samples taken from a stratigraphic section will encounter the environmental conditions which inhabited that position over time. Simply stated this is Walther's law of lateral facies being preserved in vertical sequence. A vertical stratigraphic section is a point with a sequence of conditions and

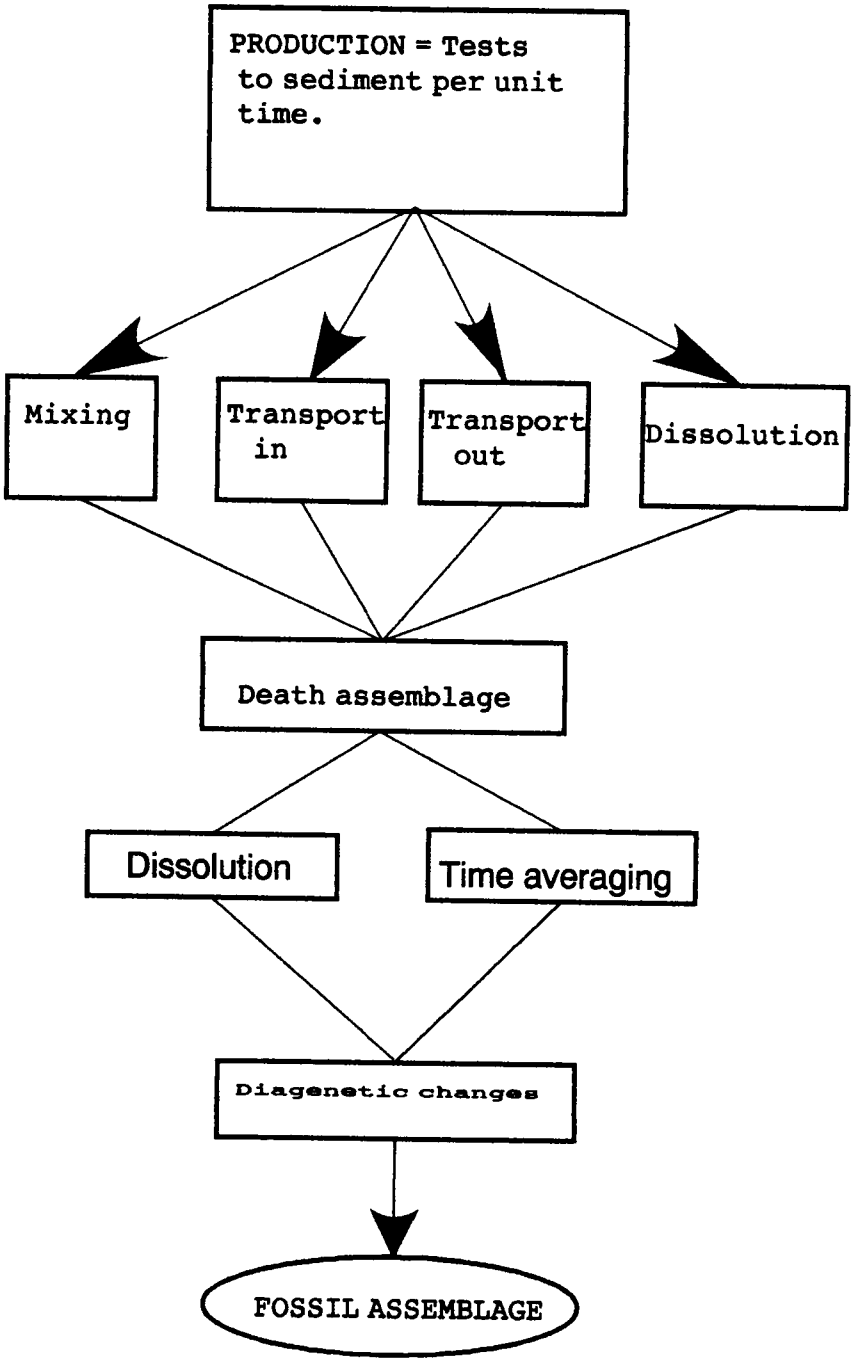


Figure 56. Schematic flow chart of factors influencing the development of foraminiferal fossil assemblages.

inhabitants moving past it (Figure 57a).

Given that foraminiferal populations appear to occur in patches and that these patches move with time, a series of vertical samples will encounter different patches as they pass the sampling point. The larger a patch the longer it will remain on the sampling point before moving off, thus the longer that population will contribute tests to the sediment. Smaller patches will occupy the sampling point for a corresponding lesser time and contribute tests for a correspondingly shorter time. For example, if species A has population patch that is 5 m across and is moving in a linear direction at a rate of 1 meter per week will occupy the sampling point for 5 weeks. If another species B has a population patch that is 10 times larger with the same rate of movement it will occupy the sampling point for 50 weeks (Figure 57b). In this case the larger patch will not only leave a longer record but has a greater chance of being sampled. Production rate of tests is also important in consideration of recording patches. Using the same example, if the production of tests for species A is 10 tests per week 50 tests are available for potential preservation. If species B has the same rate of production, it will provide 500 tests on the sampling point before the patch migrates away. Thus, if the probability of preservation is identical for both species B has 10x higher likelihood of at least one test being preserved at that point and time.

Rate of sedimentation is important in determining the vertical thickness a patch will contribute specimens to the record. In the above sample assuming that all tests are preserved and a sedimentation rate of 1 cm per week species A will leave a record 5 cm long and species B a record 50 cm long (Figure 58a). The effect of time-averaging would be to extend the length of each record while concurrently lowering concentration. In case of species A if we assume a depth of mixing of 10 cm the potential record is at least 25 cm long. Specimens mixed down 10 cm when the patch first migrated into the area, and extending at least 10 cm above where the patch migrated off the point and probably higher (Figure. 58b) The higher the rate of sedimentation the less smearing of the occupation of the point will occur (Martin, 1993).

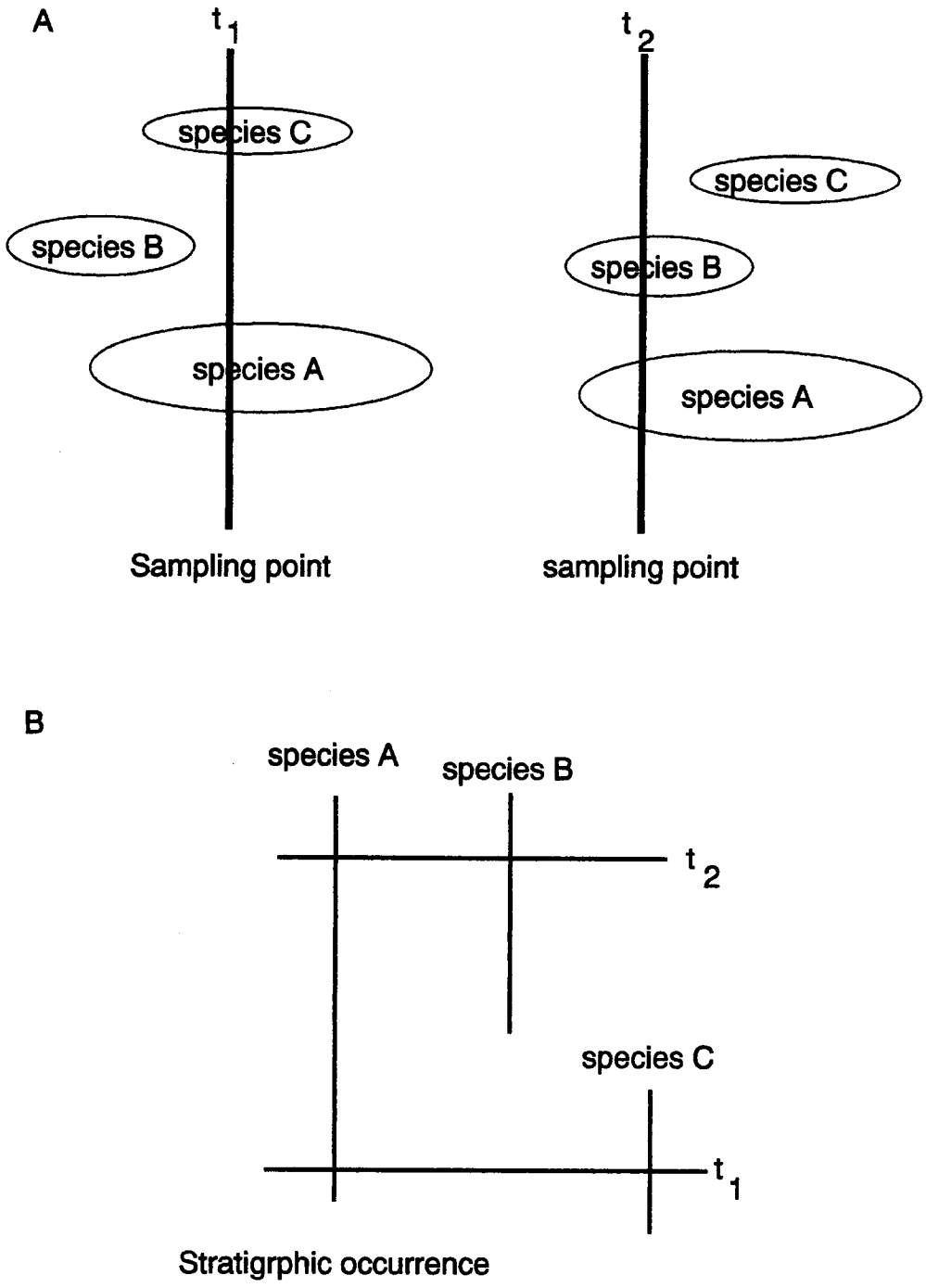


Figure 57. Potential stratigraphic record left by migrating patches of 3 species. A. Populations patches present at the sampling at 2 times. B. Stratigraphic record of the 3 species between t_1 and t_2.

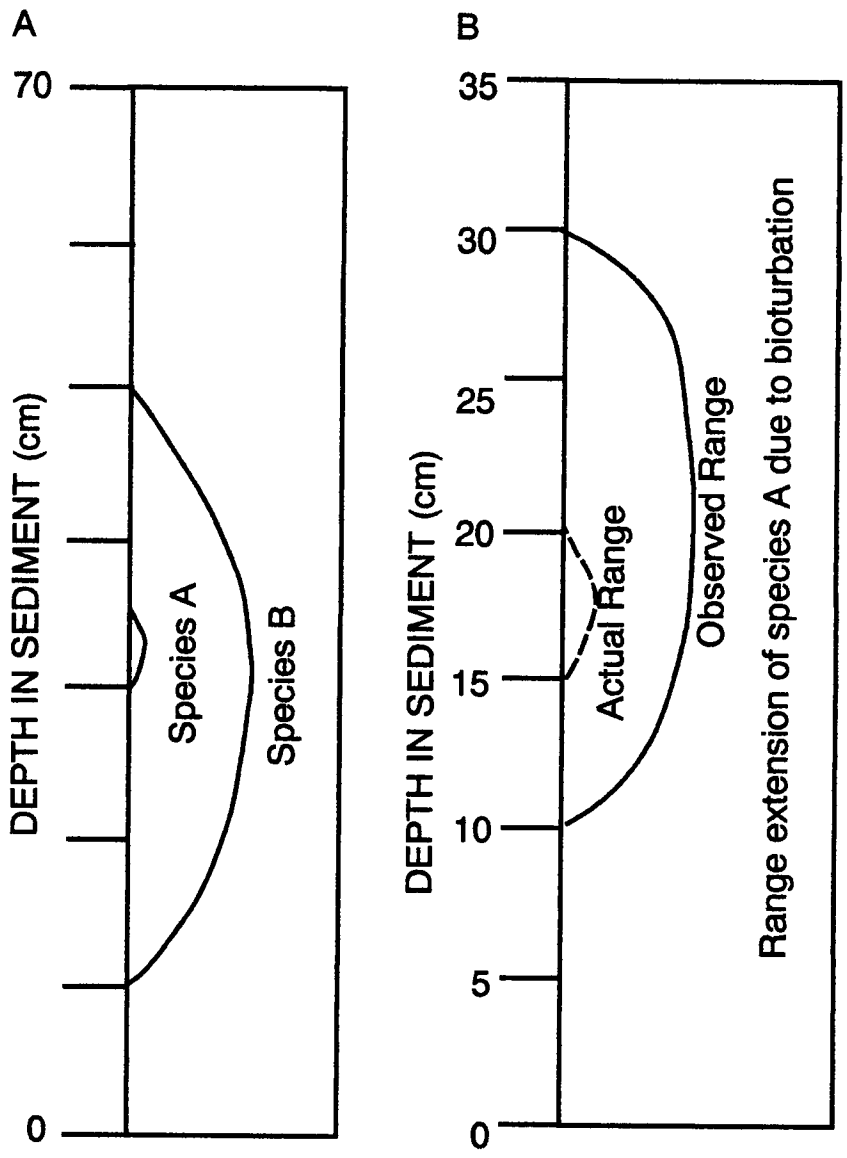


Figure 58. Development of fossil record of species with different population patach sizes. A. Difference in recorded range due to patch size. B. Potential smearing effeect on the record of species A due to bioturbation.

The example used above shows that the number of tests (N) deposited on the sampling point per unit time is a function of, patch size (P), test production (T), rate of patch migration (r) and sedimentation rate (s). Therefore N= f(P,T,r,s) and can be written as

$$N = (P\ T/r)*f(s) \quad \text{equation 1}$$

The form of equation one follows from the nature of deposition. Increases in patch size and production rate will result in more tests deposited per unit time. Increased rate of patch migration will lower the amount of time the patch remains on the sampling point. Sedimentation rate acts in several ways: first periods of scour or nondeposition will reduce N to zero; second increased or decreased rates may effect patch migration rate and preservation potential.

The above is based on the assumption of directional movement of the patches of species. In an environmentally stable setting migration of population patches is more likely to be random (*i.e.* non directional). As a result the amount of time a patch occupies the sampling point will be higher. Random movement of the patch allows for modeling the duration of the sampling point on a patch in a different way. Random migration of population patches over a point is the equivalent of the sampling point migrating over a series of patches in a random manner. In this case the movement of the particle can be modeled using a two-dimensional random walk (Figure 59). The result of a two-dimensional random walk model is the sampling point much move a long distance to achieve much lateral movement. In fact the mean displacement of point from the origin on a two-dimensional random walk is (2 x total distance traveled)$^{.5}$ or approximately the square root of the distance traveled (Berg, 1981). The result of this is the duration of the sampling point becomes a function of the area of the patch. Over time a sampling point will thoroughly cover the group of superimposed patches which or in the area. Thus, even allowing for periods of nondeposition, the slow migration of population patches away from the sampling point will allow each to be sampled repeatedly. In addition the very process of time averaging and mixing will increase the likelihood of encountering a population. Breaks in the sampling of a species will come when no population of that species

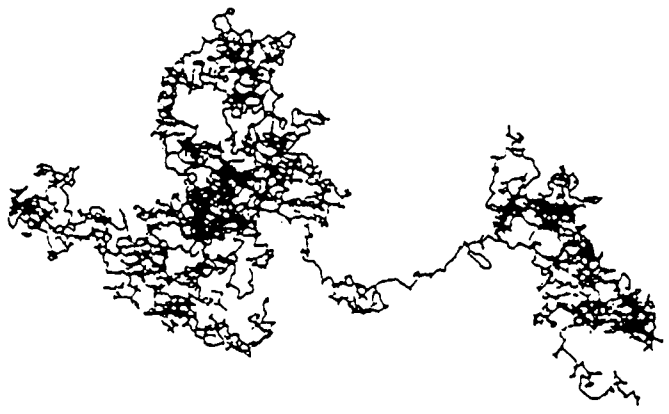


Figure 59. Example of a 2 dimensional random walk of 1,000 steps.

occupies the patch for some time. Abundant species with large patches and/or those which have many small closely spaced patches will have long records and those with small isolated patches short records.

Can abundance variation in the fossil record of benthic foraminifera be analized in a meanful way? If the processes involved in the development of the fossil record described above are close to reality then several predictions about the nature of population patches in the fossil record can be made and tested using the data set assembled for this paper.

Prediction One: Species occur in patches and are not continuously occupying any given point. If these patches are recorded in the fossil record, most species will have discontinuous occurrences, and the length of the continuous record will be a function of the patch size. Patch size will also affect the distance (time) between occurrences, smaller more widespread patches will have large gaps between occurrences.

Results from prediction one: Most species in the data set show discontinuous distributions (i.e. few species are present in every sample in any section) (Table 33). While the

Table 33. Species which range throughout the section in GGS-3535

A. species present in all samples.	B. Species present throughout the section allowing gaps of one sample..
Brizalina slabrosa	*Brizalina slabrosa*
Globocassidulina subglobosa	*Brizalina striatellata*
Cibicides pippeni	*Globocassidulina subglobosa*
Cibicides spp.	*Cibicides pippeni*
Hanzawaia danvillensis	*Cibicides pseudoungerianus*
Hanzawaia spp.	*Hanzawaia danvillensis*
Discorbis alveatus	*Hanzawaia spp.*
Discorbis hemisphearicus	*Discorbis alveatus*
Discorbis spp.	*Discorbis hemisphearicus*
	Discorbis spp.
	Pseudoparrella danvillensis
9 of 102 or 8.8%	12 of 102 or 11.8 %

variation in gap length shows considerable variation the predicted pattern does seem to be present. The longer the duration of a species in the section the shorter the stratigraphic gap between runs (Figure 60). Care must be taken in interpretation this result as given the relatively small number of samples in this section as run length increases gap length must decrease, however no species with a maximum run of more than 5 of 26 samples has a maximum gap length of greater than 3. In addition, sampling error could result in gaps which do not reflect actual absence.

Prediction two: Patch size and abundance are positively correlated. The more abundant species should appear in longer sample runs. Thus it follows the higher the mean abundance over a sample run the larger the patch. The test of this is the relationship between the stratigraphic duration of a species in the sampled interval and its mean abundance over that duration. For this study continuous presence has been defined in 2 way. First, any sample in which the abundance of a species goes to 0 is considered to mark the end of a population duration. Second, gaps of more than 2 samples for any species was considered a break in the population. The second method of calculation was used to account for possible breaks due to preservation differences between samples such as dissolution of the specimens-- this may particularly be a problem for less abundant species. The results are show in Figures 61-64. In all four sections there is a correlation between increasing mean and duration of population although there is a fair amount of scatter.

The second method of determining population duration results in a better correlation between mean abundance and duration. Correlation is also improved by ignoring a few species

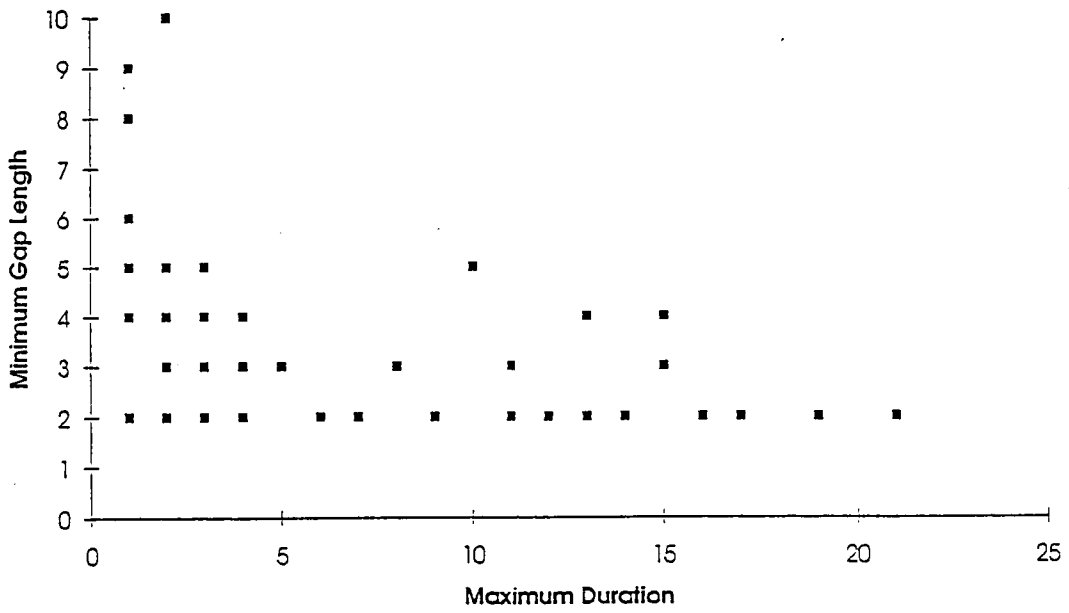


Figure 60. Plot of minimum gap length versus maximum duration . As the population duration increases the gap between populations decreases. Although some of the pattern may be due to sampling error the pattern is the same that would be expected from discontinuous populations migrating across a sampling point.

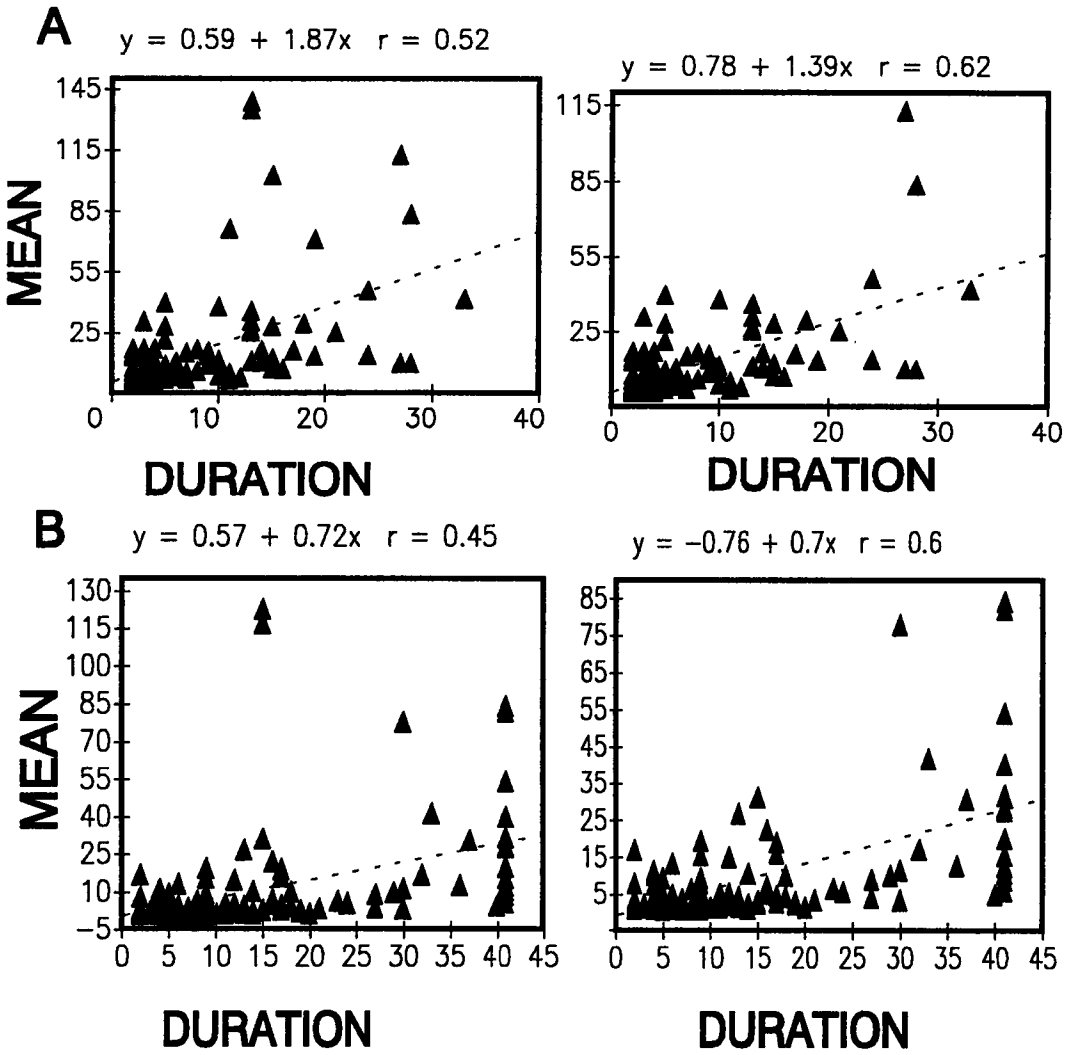


Figure 61. Mean versus duration for Red Bluff data. A. No gaps in sample run allowed. B. Gaps of 2 samples or less allowed. The right hand plot in each case is all the data the left hand with outliers removed.

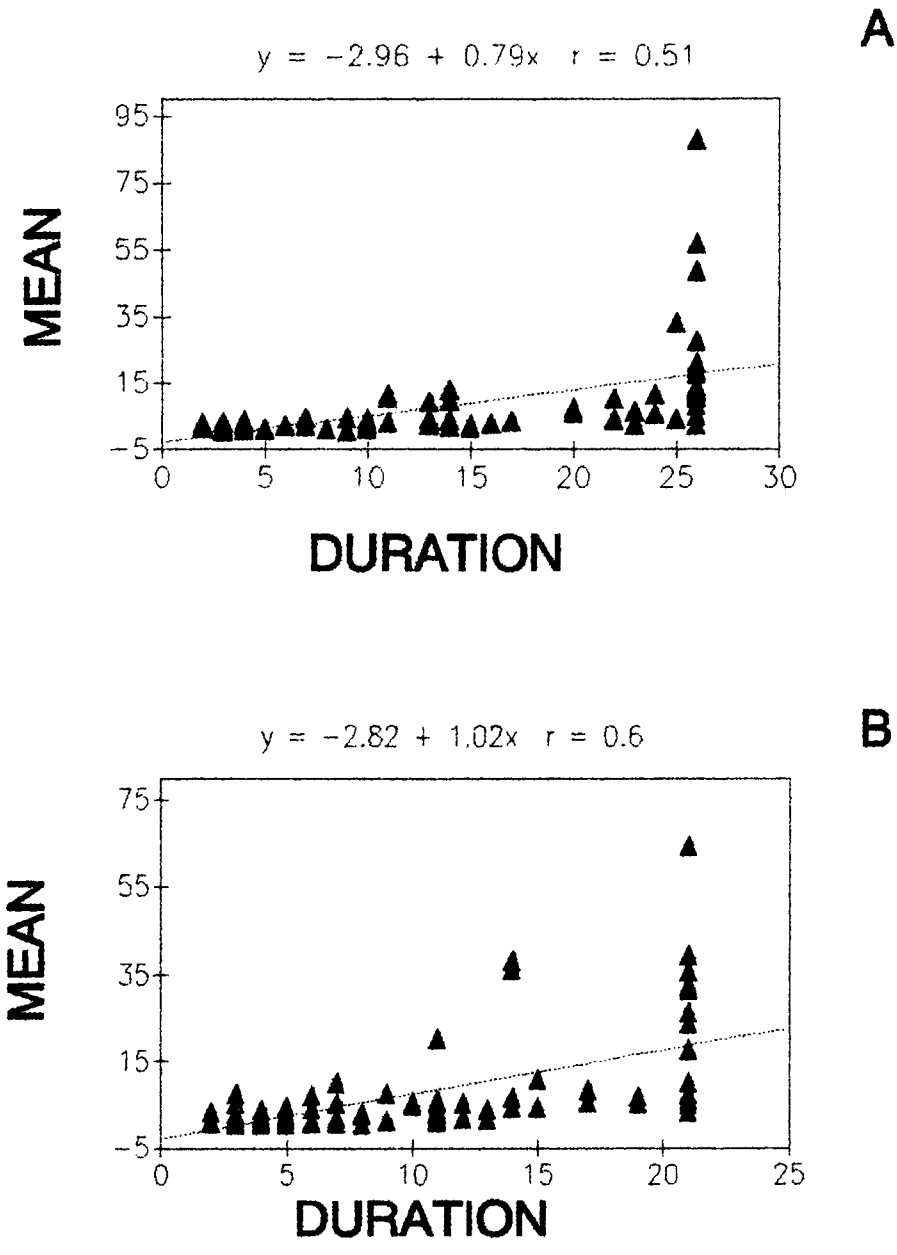


Figure 62. Plot of mean versus duration of Sepugla River data. A. No gaps in duration allowed. B. Gaps of 2 or less in duration allowed.

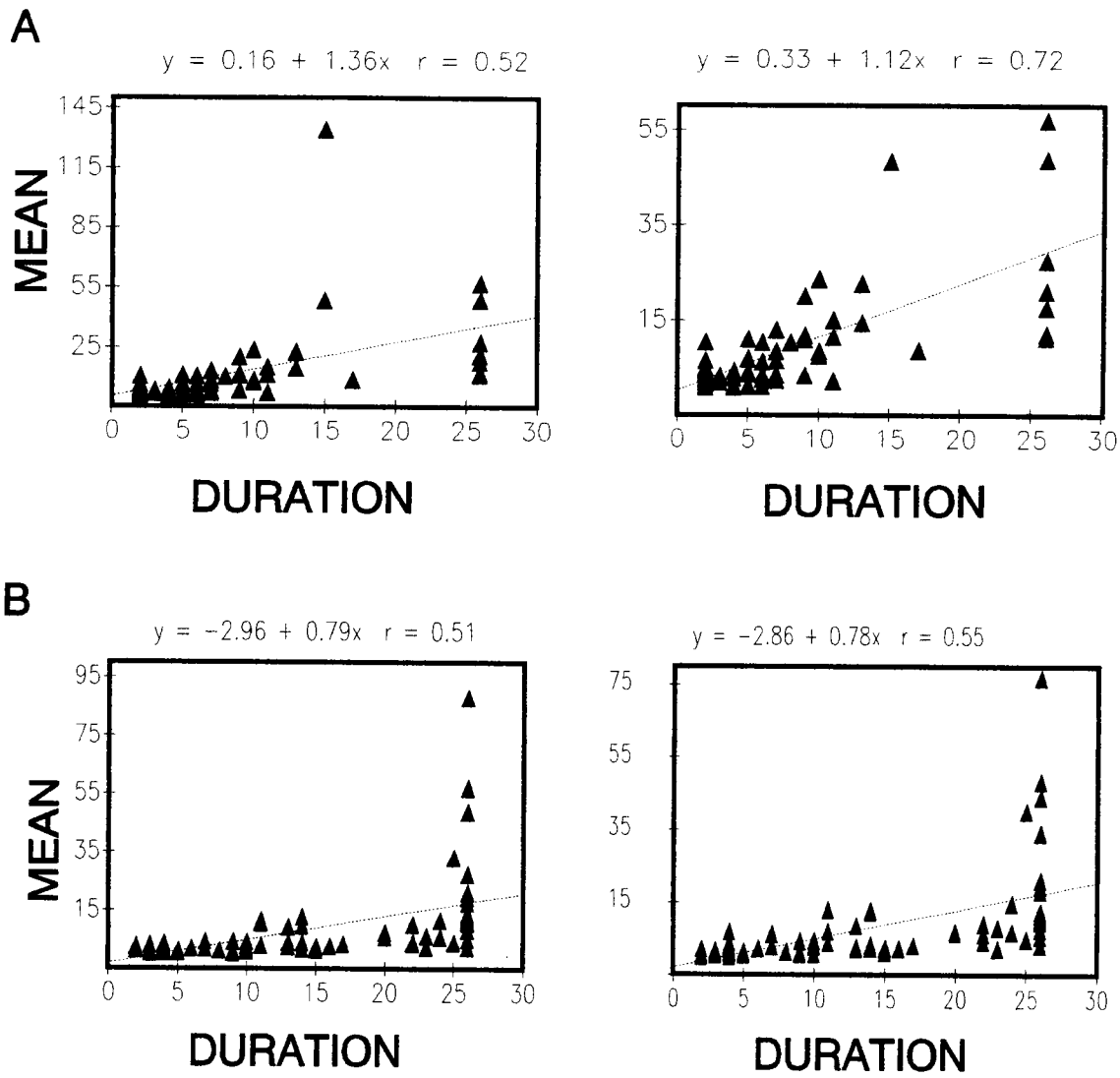


Figure 63. Mean versus duration for GGS-3535 data. A. No gaps in sample run allowed. B. Gaps of 2 samples or less allowed. The right hand plot in each case is all the data the left hand with outliers removed.

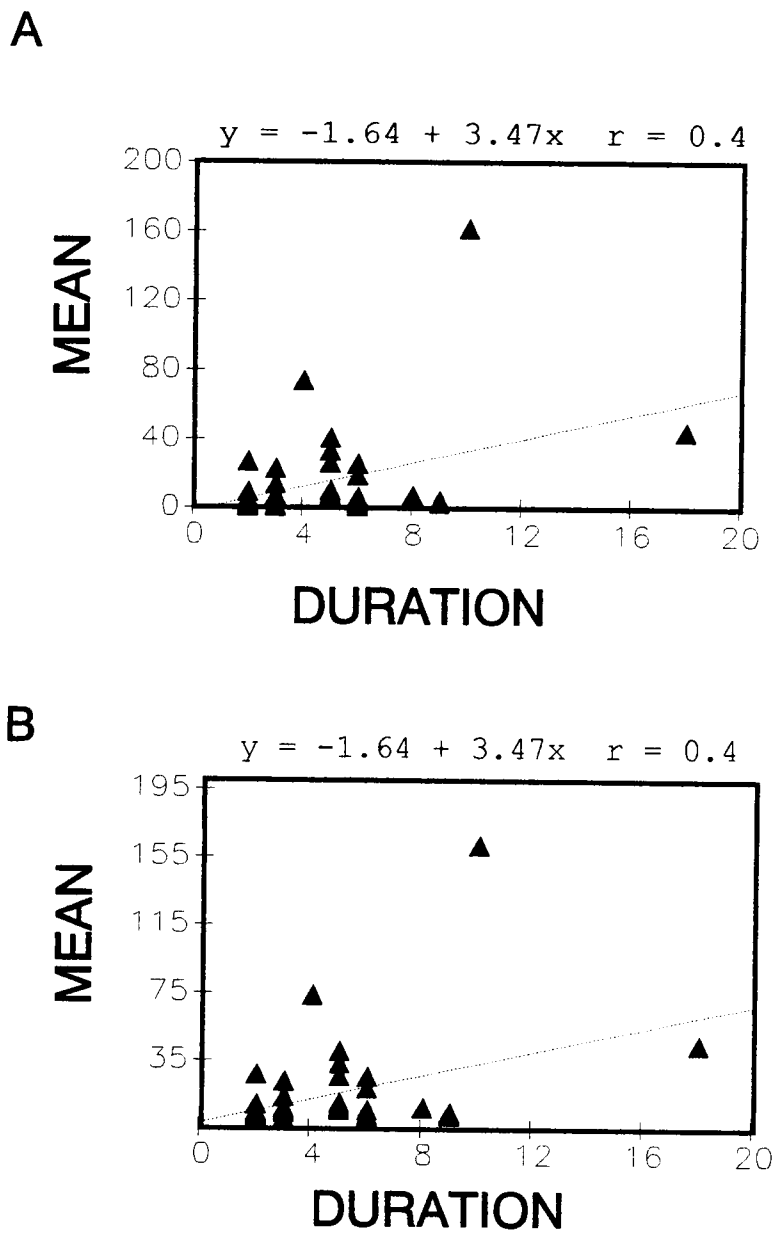


Figure 64. Plot of mean versus duration of the Brooksville data. A. No gaps in duration allowed. B. Gaps of 2 or less in duration allowed.

which have very high populations and short durations. These species often are those with first or last occurrence at or near the E/O boundary in that section. In this case the shortness of the run may well be a result of external events and not of population dynamics (*i.e.* species extinction will terminate a large as well as small populations). The correlation between mean and duration is also lowered by the range of population means found in species which range throughout the section studied (41 samples at Red Bluff, 22 at Sepugla River, 26 in GGS-3535, and 25 at Brooksville). Longer sampling runs might well increase the correlation as the duration of species with higher mean abundance increases. The pattern of increasing mean abunadnace and durtion is fairly robust. With species which deviate from the overall trend tending to be those which have long duration and low abundance. Species with low abundances but large geographic ranges have been noted in modern faunas (Rabinowitz et al. 1986).

If species abundance is some proxy for patch size then this analysis show the potential for recognizing population patches in the fossil record. In addition the recognition of this pattern has implications for study of species extinction and the recognition of species ranges and optimal conditions. Populations in marginal environments tend to have smaller patch size and short durations. Consequently analysis of the population structure of a species over its paleogeographic range may provide insight in to preferred environmental conditions and evolutionary processes.

Prediction three: If metapopulations are recognizable in the fossil record and assuming relative environmental stability, The longer the time interval between two samples the less similar they should be in composition. The longer the amount of time between any two samples the more population that will have migrated away from the sampling point thus lowering similarity.

This prediction was tested in two ways: First, the overall similarity of successive samples with the lowest sample in each section was plotted. In expected pattern in this test is

a high degree of similarity in the lower samples and decreasing similarity up section (Figure 65). In the GGS-3535 core this test gave the best results (Figure 66). In this section the predicted pattern was seen in the lower portion of the section with the lowest sample being most similar to the bottom and slowly decreasing similarity in the Eocene portion of the section. However, at the E/0 boundary the similarity abruptly drops to near 0 for seven samples and then increases to a point which would be similar to that expected if the original trend had been maintained. This rapid change corresponds in a general way to the presence of increased clastic content in the core and possibly to a change in the benthic environment, followed by a return to conditions similar to those seen the lower core. In addition, all but two samples in this interval have lower than average abundance and numbers of species, and poor recovery of specimens. Thus, both environmental and diagenetic changes may have affected the similarity with the bottom sample. The results from the other sections are not clear. However, as seen in the microhabitat analysis above these sections probably had larger changes in environmental conditions than at GGS-3535.

The second test of this prediction was conducted by examining species similarity between samples rather than overall sample similarity. In this case the abundance of each species was compared to its abundance in the lowest sample. If metapopulations are observable in the fossil record and a species is relatively evenly distributed in a patch then the basal sample can be used as a predictor of abundance. While the population patch remains on the sampling point the abundance of that species should remain relatively constant. As the patch moves off the sampling point the abundance will drop to zero. Thus the predicted values for each sample will be the same as the observed in the lowest sample. Negative deviation from the predicted value indicates movement of the patch from the sampling point.

Results: In the case the data from GGS-3535 show the predicted trend (Figure 67). Species which have high abundances (large patch size) deviate little from the predicted abundance in the lower samples and only slowly in upper samples. Those species which are

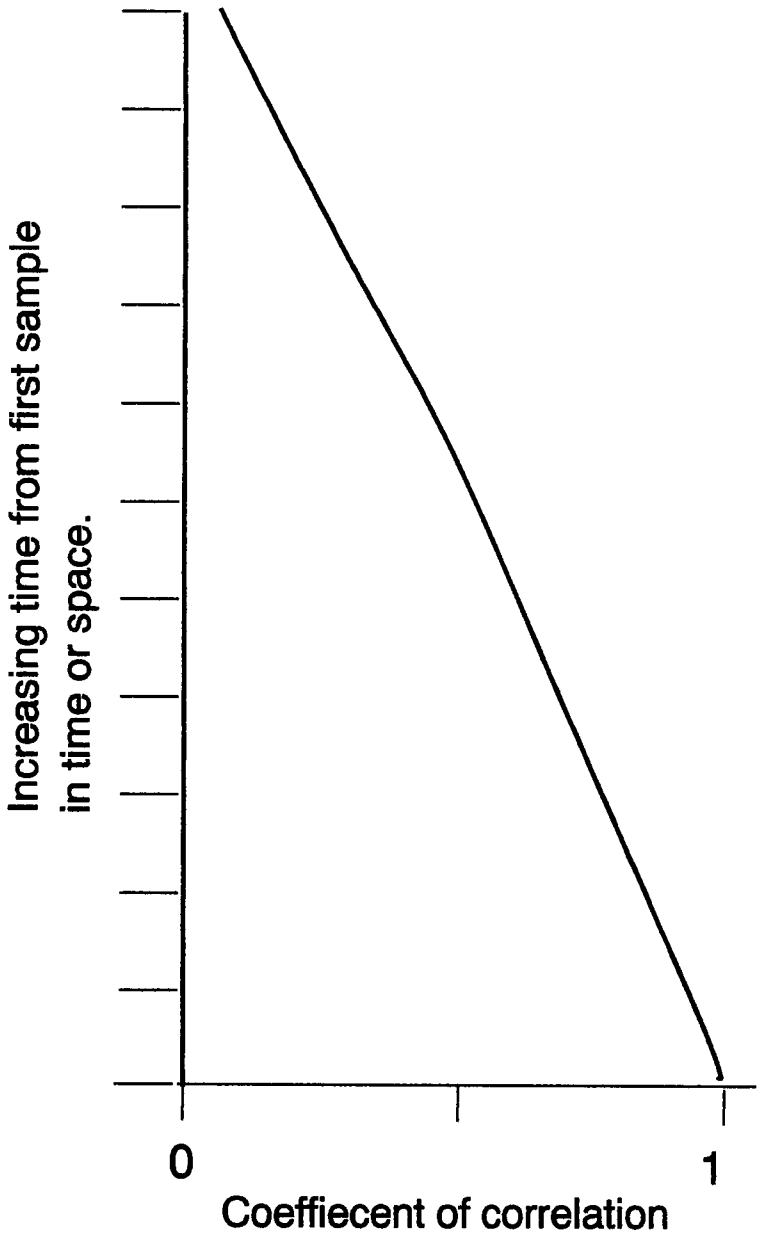


Figure 65. Expected coefficient of correlation between earliest sample and samples at increasing distance away. The distance may be in stratigraphic distance or time. The decreasing coefficient of correlation is expected due to changes in minor species composition with increasing distance from the base sample.

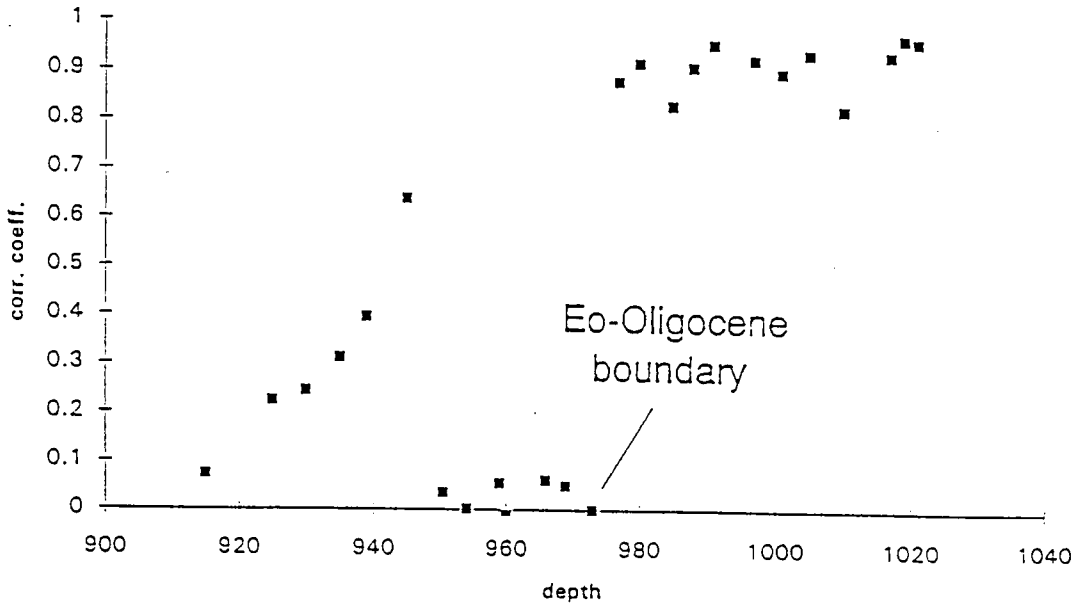
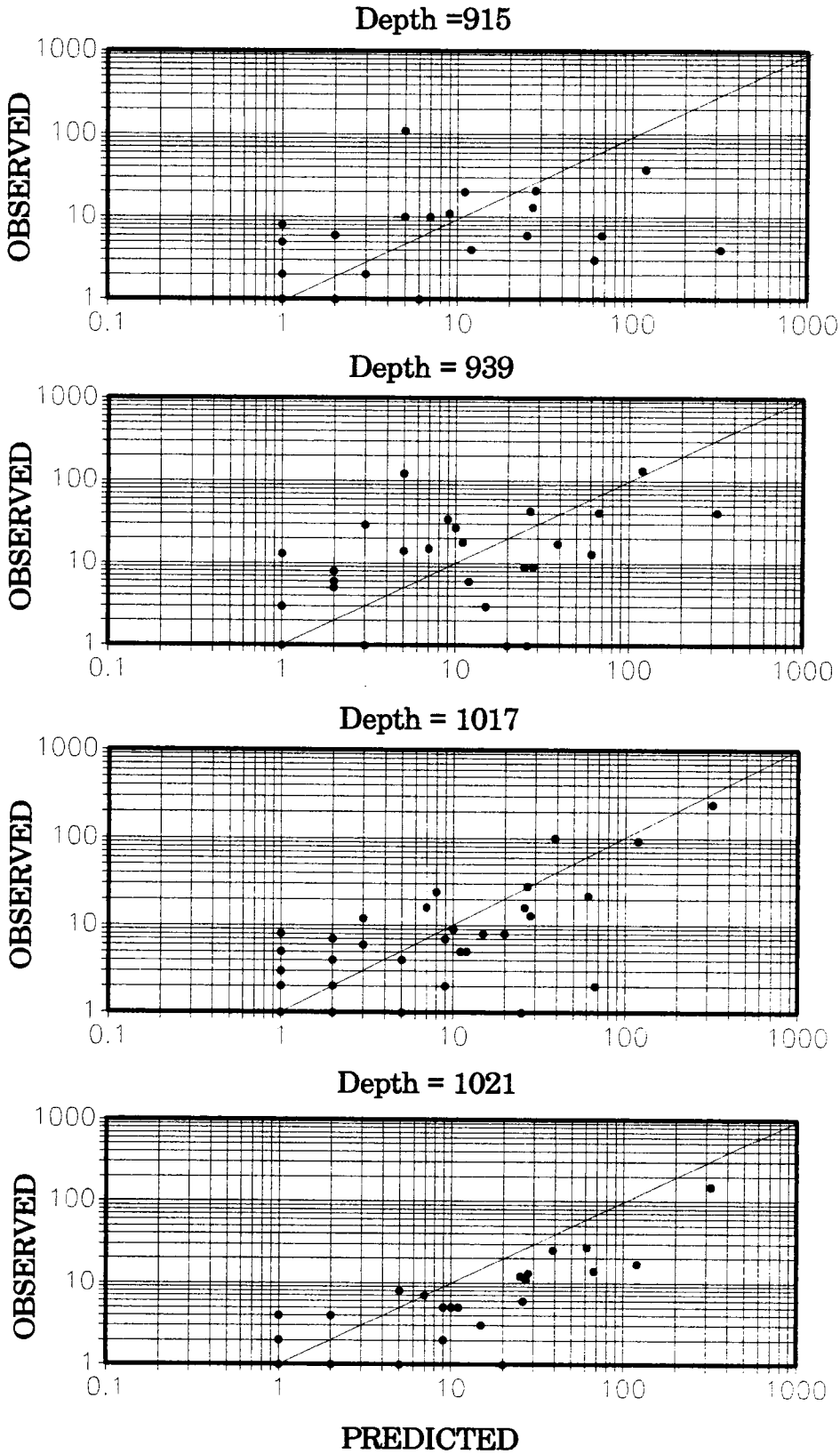


Figure 66. Correlation between lowest and sucessive samples in GGS-3535. The predicted pattern is interrupted near the E/O boundary in an interval of differing lithology.

Figure 67. Observed versus predicted abundance in samples of GGS-3535. In each the observed value is that seen in sample S1032. The diagonal line has a slope of 1 representing observed and predicted being equal. Values plotting above the line indicate greater observed than predicted values, those below the line the reverse. In general the most abundant species show the least deviation from the predicted pattern with rare species often going to zero or being added.


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Depth = 1021
OBSERVED
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PREDICTED

predicted to have small patches (low abundance) rapidly drop below the predicted value and often disappear from the data set. Some low abundance species do reappear in the data up section however, species this is to be expected if the environment is not under going directional change. In addition, species which first appear in the section above the lowermost sample (i.e. those plotting to the right above the predicted line) tend to be less abundant and would be expected to have small more isolated patches.

Testing the application of abundance change to paleoecological tolerances:

The use of population patch analysis also has the potential to be extended to determining paleoecolgic preferences. This is important in the study of organisms which have no living close relatives or are suspected of having major shifts in ecological tolerance. Below one possible case of this type of analysis is examined.

It has been suggested that species of the Genus *Cassidulina* prferentially living in fine grained soft bottom environments (Murray, 1973). Therefore they should be more abundant in areas with high mud content and less abundant in areas which contain more sand and silt sized sediment(Murray, 1973; Breen, 1987). Using this as a model a predicted pattern of occurrence would be larger patches (longer duration) and higher average abundance in mud dominated sections. This, in essence, is a test of ecological preference in the fossil record. This presumed preference was used to explain a west to east increase in *Cassidulina* seen in the Oligocene Marianna Formation by Breen (1987). The pattern of occurrence in the sections studied in this report is in Table 5.2. In this study most of the substrates were dominated by mud and silt sized material with major difference being the amount of carbonate material and macrofossils present. *Cassidulina* as can be seen from Table 5.2 exhibits very distinctive patterns of duration. The longest durations and highest average abundances of Cassidulina are in the more fossil rich Red Bluff Formation and the carbonates. *Cassidulina* is not present in the fine muds of the Eocene at Red Bluff where it would be expected if occurrence was a

function of sediement grain size alone. Therefore it would appear that the actual pattern of ecological preference is for carbonate content and lowered sedimentation rate, not grain size as suggested by Breen (1987). The modern preference of *Cassidulina* for mud dominated environments may reflect a shift in ecologic tolerance or other environmental factors.

Chapter 6 DISCUSSION

Faunal change

The main goal of this study was to examine the change in benthic foraminifera across the Eocene-Oligocene boundary in the eastern Gulf Coast Region. This time interval is a period of change in the global flora and fauna associated with climatic change driven in part by the isolation of Antarctica (Breggren and Prothero, 1992). Previous studies have indicated a significant change in the benthic foraminiferal assemblage associated with this boundary in the Gulf Coast (Bandy, 1949; Gaskell, 1991; Huddlestun, 1965; 1993).

The range of paleoenvironmental settings examined in this study and the development of a qualitative model of stratigraphic development allowed for analysis of local as well as regional trends. In general, the amount of faunal change seen in this study was lower than that in previous reports. Several reasons account for this difference. First much of the previous work has been concentrated in the clastic units in the western part of the region. These units, while having generally better fossil preservation, exhibit greater lithologic changes between the uppermost Eocene and lowermost Oligocene units than is seen in the carbonates. Thus, even though the overall paleoecologic setting did not change parameters such as sediment grain size, sedimentation rate and perhaps oxygen content of the sediment did change, triggering faunal shifts not seen elsewhere. Another difference between the clastic and carbonate units is the potential for down slope transport of shallow water species by gravity flows. Smith and Zumwalt (1984) documented the presence of such features in the upper Yazoo and similar features occur in the Red Bluff formation. Thus, some of the faunal change may be attributed to contamination. A second cause may be artifacts due to use of compilation data in which a form considered a single species in this study is listed under several names in the literature. Finally combining data to Formation-level time frames results in the summing of faunal change over longer periods of time than examined in this study.

Change in the benthic foraminiferal fauna in this study is highly dependent on paleoecologic setting. Each of the sections studied exhibits a differing degree of change with the highest rates occurring at Red Bluff and Brooksville. At Red Bluff changes in the composition of the fauna can largely be attributed to a loss of infaunal species and an increase in epifaunal species both as a proportion of the assemblage and in diversity. The loss of infaunal taxa is seen most dramatically in the extinction of *Bulimina jacksonensis* and the decline of species of *Uvigerina*. Thirteen of the nineteen species which first appear in the Oligocene at Red Bluff are epifaunal. Increased abundance in epifaunal species in also very clear in this section. Of those showing increased abundance, by far the most abundant are *Cibicides pippeni, C. pseudoungerianus* and *Hanzawaia danvillensis*, all of which are epifaunal taxa.

The highest rate of species last occurrence and lowest rate of first occurrence is at Brooksville. Here much of the faunal change is in the loss of large benthic species. Many of these species were symbiont bearing and thus sensitive to change in environmental setting. This section, in contrast to the others, underwent a shoaling in the earliest Oligocene. The loss of large benthic taxa and declines in the abundance of other species reflects the change to shallow water conditions.

Sepugla River and GGS-3535 record much lower rate of species turnover. The large changes in microhabitat seen at Red Bluff are not present in these sections. In addition, both the regional model of stratigraphic development and sediments in these sections do not indicate major changes either in water depth or paleoecologic setting for either of these sections. The major difference between the Eocene and Oligocene is a lower sedimentation rate which may not have lasted long, particulary in core GGS-3535. Thus, the relatively constant environment throughout the time interval studied is translated into a decreased rate of faunal turnover.

Many of the changes in the fauna are seen as increases or decreases in the abundance of species. This is particularly clear at Sepugla River and GGS-3535 where the amount of change in species composition is low. In each of these section the Eocene fauna can be

distinguished from the Oligocene on the basis of the relative abundance of a few species. At Sepugla, River the Eocene is characterized by high abundance of *Cassidulina* and the Oligocene by high abundance of *Angulogerina bryamensis*. While the pattern of changing dominace is clear each taxa has a unique pattern of occurrence. *C. Armosa* and *C. alabamensis* decline steadly through the uppermost Eocene samples and *A. byramensis* increases in abundance very rapidly in abundance in the lower Oligocene. At GGS-3535, this pattern of changing compositon is reflected in the decrease in the abundance of *Cibicides* and increases in the abundance of *Discorbis*. Note that both of these genera are epifaunal so the change is not in habitat distribution.

This shifting faunal composition without loss or gain of large numbers of species is reflected in the generally poor results from multivariate analysis of the data. Cluster analysis failed to group the samples according to stratigraphic position. Principal components analysis resulted in grouping of the samples by stratigraphic position but the separation was fairly weak. This gradational change in assemblage also affected the results of multivariate analysis for species associations. Principal components Analysis of the data for species associations both in individual sections and in the entire data set did not yield meaningful results. In part this lack of association may be due to the highly variable numbers of dominance of many species. In addition the pressence of many rare taxa added variance.

When compared to reported extinctions of other taxa in the Gulf Coast Region, during the time interval studied, the benthic foraminifera show a lower less sharp and more localized pattern of faunal change. This pattern raises several interesting points.

First, the first the faunal change seen in this study is much less sharp than that reported for both planktonic foraminifera and for sporomorphs. Two factors could account for this. First, presence of a condensed section straddling the E/O boundary could have resulted in compression of the faunal changes in these groups giving a distorted picture of the actual changes. Second and more interesting is the possibility of a delayed response of the benthic

foraminiferal assemblage to the climatic changes compared to that of the terrestrial and surface waters. This pattern of lag in benthic response has been suggested for the deep ocean, but not previously for the shelf regions (Corliss, 1979). A delayed response of the benthic assemblage can also explain some of the differences in faunal change between section. The shallow waters of the Florida platform would be the first to react to climatic change. This section contains the largest rate of last occurrence. In addition the loss of the large symbiont-bearing species would be expected during a rapid cooling of the climate.

Second, the lack of congruence of rate of benthic foraminiferal change across the E/O boundary in the sections studied even accounting for differences in assemblage composition (*i.e.* many taxa which either have a last or first occurrence in one section are found in others) raises the possibility of multiple causal events for the faunal changes. The Red Bluff, Sepugla River and GGS-3535 sections are all in shelf settings but the clastic dominated Red Bluff has the highest rate of faunal change. This section shows the greatest change in microhabitat distribution reflecting a difference bottom oxygen conditions not seen at the other two sections. On the other hand the highest rate of faunal change was seen at Brooksville where there is no change in microhabitat distribution. However, this section would have been the most affected by climate change. In addition there is some evidence that the Florida platform underwent a shoaling during this time period due to the *in situ* production of carbonate sediments. Either of the above would have had a great impact on this section but lesser or no impact on the benthic foraminiferal fauna of the other areas. Thus, it is possible and even likely that the changes in benthic foraminiferal faunas associated with the E/O boundary in the study are due to the confluence of several events and not a single forcing mechanism. Sea level rise and migration of the oxygen minimum zone on to the continental shelf for the changes seen at Red Bluff and climate or facies changes at Brooksville. In the sections located out of the clastic facies and in deeper water, the low rate of faunal change can be explained by their relative isolation from the

events described above. Whether this has implication for models of extinction in other taxa is not clear. Changes in composition have not been analyzed at the same level of detail.

The changes in the benthic foraminferal assemblage seen in this study are lower than previously reported and vary according to the paleoenvironmental setting. Indicating that the causes of faunal change were mostly in response to local or regional events.

Analysis of Abundance Variation in the Fossil Record

The extraction of meaningful patterns from abundance variation in the fossil record has important implications for the study of evolution and extinction. This type of analysis would begin to bridge the gap between studies conduction on ecologic and geologic time scales, in many cases a gap of tens to hundreds of thousands of years. Providing methods of testing models of evolution and extinction which require time frames longer than possible from studies of living organisms but on a shorter time scale than seen in most paleontologic studies.

The discontinuous or patchy distribution modern species including benthic foraminifera indicates that, if assuming a relatively continuous fossil record, abundance variation of fossil species should give some insight into the population dynamics of fossil species, paleoecologic preferences and how these affected evolution and extinction patterns. The major obstacle to the use of abundance variation analysis is the development of the fossil record and the effects of sampling error on recognition of true variation as oppose to artifacts. The question is then "are variations in abundance observed in the fossil record meaningful?" The transition from living population to fossil assemblage is complex with factors acting to both remove data and time average the remaining information compressing or smearing events. Thus it is unreasonable to expect to be able to read population dynamics directly from the fossil record. However, it is possible that the broad outlines of biologicaly meaningful pattarns maybe observable.

The model for recording discontinuously distributed species in the fossil record described in this study indicates that some patterns are preserved at least for benthic foraminifera.

Organisms which have differing population densities and population patch sizes will leave very different fossil records. The series of predictions of population duration versus mean abundance, gap length and duration, sample similarity, and species abundance similarity all showed patterns similar to that expected if discontinuous population patches are recorded in the fossil record. However, it shoould be noted that many of the same patterns could result from sampling errors. These results indicate this model has potential use in interpreting the fossil record.

Future work

This study has revealed several areas were studies are needed and lines of research. Future studies to clarify the patterns observed in this study are needed in three main areas. First, there is a need for reexamination and revision of the benthic foraminiferal taxonomy in the Eocene and Oligocene of the Gulf Coastal region. Much of the taxonomy is outdated and many of the taxa have either been split into a wide range of species of doubtful validity or, on the genus level recent revisions require the reassignment. Dependence on outdated taxonomy makes comparison to other regions difficult and casts doubt on studies based on complied faunal lists. Second, the nature of the Upper Eocene and Lower Oligocene carbonates in peninsular Florida and southern Georgia need to be examined in detail to gain a clearer picture of the exact location of the Eocene-Oligocene boundary, changes in depositional environments, and improve the correlation of this region with the rest of the Gulf Coast. A third area which needs more study is the timing and rate of change in other fossil groups relative to the patterns seen in this study. Finally, continued study of the rate and timing of benthic foraminiferal change in the upper Eocene and lower Oligocene is needed.

This study has pointed out to me several avenues of potential future research. First the application of benthic foraminiferal microhabitat analysis to other periods of faunal change. Second, the use of gradient analysis to examine the rate and timing of faunal changes. Third,

further work is needed to refine and test models using abundance variation in the fossil record to analyze evolutionary and paleoecologic trends in the fossil record.

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APPENDIX 1

SYSTEMATIC PALEONTOLOGY

The genus level and above classification in this section follows that of Loeblich and Tappen (1988). For each species a short synomny is given to aid in identification of the species. In this report no new species are named. Forms not assignable to known species are either listed as spp or have been given number designation if the form is consistently recognizable. In the latter case these may be formally named in the future. Some taxa have been reassigned to different genera either on the basis of suppression of genera or published reassignments.

For all taxa a brief description of their occurrence is given complete data on occurrence is given on distribution charts in appendix 2.

Kingdom PROTISTA

Subkingdom PROTOZOA

Phylum SARCOMASTIGOPHORA
Honiberg & Balamuth, 1963

Subphlylum SARCODINA
Schmarda, 1871

Superclass RHIZOPODA
von Siebold, 1848

Class GRANULORETICULOSA
de Saedelter, 1934

Order FORAMINIFERIDA
Zborzewski, 1834

Suborder TEXTULARIINA
Delage & Heround, 1869

Superfamily SPIROPLECTAMMINACE
Cushman, 1927

Family SPIROPLECTAMMINIDAE
Cushman, 1927

Genus SPIROPLECTAMMINA
Cushman, 1927

Spiroplectammina curta

Spiroplectoides curta Cushman, 1927, Contr. Cushman Lab. Foram. Res., v. 9, p. 11, pl. 1, fig. 24a-b.

Diagonsis: This species is here reassigned to the genus *Spiroplectammina* on the basis of a perforate wall and stratigraphic position. *Spiroplectoides* is considered invalid by Loeblich and Tappen (1988).

Occurrence: Present only at Red Bluff throughout, ranging from 0-159 specimens per sample.

Spiroplectammina mississippiensis Cushman

Textularia mississippiensis, Cushman, 1922, U.S. Geol. Sur., Prof. Paper 129-E, p. 90, pl. 14, fig. 4.

Spiroplectammmina mississippiensis Stuckey, 1946, Jour. Paleo., v. 20., p. 163, pl. 29, figs. 6, 11, (?)7.

Spiroplectammina mississippiensis Bandy, 1949, Bull. Amer. Paleo, v. 32, no.121, p. 34, pl. 4, fig. 10a-b.

Occurrence This species occurs in moderate abundances (0-64) throughout at Red Bluff, and low abundance at Sepugla River. This species shows a reversal of pattern being more abundant in Oligocene at Red Bluff and the Eocene at Sepugla River.

Spiroplectammina alabamensis Cushman

Textularia alabamensis Cushman, 1923, U. S. Geol. Sur. Prof. Paper 133, p. 17, pl. 1, fig. 4.

Spiroplectoammina alabamensis Stuckey, 1946, Jour. Paleont. v. 20, p. 164, pl. 29, figs. 4, 5.

Spiroplectammina alabamensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 34-35, pl. 4, fig. 5a-b.

Occurrence: This species is present at Red Bluff and Sepugla River. At Red Bluff it is common in the Oligocene and rare in the Eocene, with the reverse pattern observed in the Sepugla River section.

Spiroplectammina gracilenta Bandy

Spiroplectammina gracilenta Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 33, pl. 4, fig. 7a-b.

Occurrence: This species occured only at Red Bluff in 8 samples with a maximum abundance of 4.

Spiroplectammina pesudoelongata Bandy

Spiroplectammina pseudoelongata Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 34, pl. 4, fig. 9a-b.

Occurrence: *S. pseudoelongata* is present in very low abundances (0-5) at Red Bluff.

Superfamily VERNEUILINACEA
Cushman, 1911

Family VIERNEUILINIDAE
Cushman, 1911

Subfamily VERNEUILININAE
Cushman, 1911

Genus GAUDRYINA
d'Orbigny, 1839

Gaudryina jacksonensis Cushman

Gaudryina jacksonensis Cushman, 1926, Contr. Cushman Lab. Foram. Res., v. 2, p. 33, pl. 5, fig. 1.

Gaudryina jacksonensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 29, pl. 3, fig. 10a-b.

Guadryina jacksonensis Jones, 1983, North Carolina Geol, Sur. Pub. 8, p. 22, pl. 1, figs. 24, 25.

Occurrence: This species is only present in a single sample (RB-10) at Red Bluff.

Gaudryina stavensis Bandy

Gaudryina stavensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 29-30, pl. 3, fig. 8a-b.

Occurrence: Present in a single sample at Sepugla River and scattered samples at Red Bluff.

Gaudryina spp.

Remarks: Specimens of *Gaudryina* not identifiable to the species level are included in this catagory.

Occurrence: Presnt only at Red Bluff in samples SR-22 and RB-6.

Superfamily ATAXOPHRAGMIACEA
Schwager, 1877

Family GLOBOTEXTULARIIDAE
Cushman, 1927

Subfamily LIEBUSELLINAE
Saidova, 1981

Genus LIEBUSELLA
Cushman, 1933

Liebusella byramensis turgida Cushman

Clavulina byramensis turgida Cushamn, 1923, U.S. Geol Sur., Prof. Pap. 133, p. 22, pl. 2, figs. 4,5.

Liebusella byramensis turgida Cushaman, 1946, Cushman, Lab. Foram. Res., Special Publ. 16, p. 5,pl. 1, figs. 8-10.

Leibusella byramensis turgida Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 130, pl. 3, fig. 12a-b.

Occurrence: *L. byramensis trugida* is found at Sepugla River and Red Bluff and Brooksville in a few scattered samples in each section.

Superfamiliy TEXTULARIACEA
Ehrenberg, 1838

Family TEXTULARIIDAE
Ehrenberg, 1838

Subfamily TEXTULARIINA
Ehrenberg, 1838

Genus TEXTULARIA
Defrance, 1824

Textularia adalta Cushman

Textularia adalta Cushman, 1926, Contr. Cushman Lab. Foram. Res., v. 2, p. 29, pl. 4, fig. 2a-b.

Textularia adalta Poag, 1966, Micropaleontology, v. 12, no. 4, p. 400, pl. 1, figs. 1-3.

Textularia adalta Jones, 1983, North Carolina Geol, Sur. Pub. 8, p. 22, pl. 1, fig. 11.

Occurrence: Single sample (B24) at Brooksville. .

Textularia distincta Cushman

Spiroplectammina mississippiensis distincta Cushman, 1946, Cushman Lab. Foram. Res., Special Pub. 16, p. 3, pl. 1, figs.1-2

Textularia distincta Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 37, pl. 4, fig. 16a-b.

Occurrence: *T. distincta* is present in the Red Bluff and Sepugla River. At Red Bluff it occurrs in 5 samples scattered throughout the section. At Sepugla River it is present in moderate abundances in the Eocene and a single sample in the Oligocene.

Textularia dibollensis humblei Cushman and Applin

Textularia dibollensis humblei Cushman and Applin, 1926, Amer. Ass. Petro. Geol. Bull. v. 10, p. 165, pl. 6, figs. 12-14.

Textularia dibollensis humblei Bandy, 1949, Bull. Amer.Paleo., v. 32, no 131, p. 36, pl. 4, g. 17a-b.

Textularia dibollensis Puri, 1953, Florida Geol. Sur. Bull. 36, p. 80.

Occurrence: This species is present at Red Bluff and Sepugla River. In both sections it occurs in low abundances and scattered samples.

Textularia hannai Davis

Textularia hannai Davis, 1941, Jour. Paleo., v. 15, p. 149, pl. 24, figs. 11-13, 19.

Textularia hannai Cushman & Herrick, 1945, Contr. Cushman Lab. Foram. Res. v. 21, p. 57, pl. 9, fig. 5.

Textularia hannai Bandy, 1949, Bull. Amer. Paleo, v. 32, no. 131, p. 38, pl. 5, fig. 1a-b.

Occurrence: This species occurs only at Red Bluff in a few samples scattered throughout the section.

Textularia ocalana Cushman

Textularia ocalana Cushman 1926, Contr. Cushman Lab. Foram. Res., v. 2, p . 30, pl. 4, g. 3a-b.

Textularia ocalana Puri, 1957. Florida Geol. Sur. Bull. 38, p. 100, pl. 1, fig. 3a-b.

Occurrence: *T. ocalana* was found only in the Brooksville where it is present in low abundances (0-5) scattered thoughout the section.

Textularia ouachitaensis Howe and Wallace

Textularia ouachitaensis Howe and Wallace, 1932, Louisiana Dept. Cons. Geol. Bull., no. p. 20, l. 1, fig. 1a-b.

Textularia ouachitaensis Bergquist, 1942, Mississippi State Sur. Bull., 49 (Fossils), p. 16, . 1,figs. 11a-b.

Occurrence: This species is present in low abundances in the Red Bluff and Sepugla Rivers in low abundances with no pattern of abundance.

Textularia spp.

Remarks: All nondifferentiated specimens of *Textularia* are included in this category.

Occurrence: Present in a single sample (RB-19) at Red Bluff and in scattered samples throughout Sepugla River and GGS-3535.

Genus TEXTULARINELLA
Saidova, 1975

Textulariella barretti Jones and Parker

Textularia barretti Jones and Parker, 1863, Report British Assoc. New Castle Meeting, p. 80, 105.

Textulariella barretti Cushman, 1937, Cushman Lab. Foram. Res. Special Pub. 8, p. 66, pl. 7, figs. 5-8.

Textulariella barretti Puri, 1957, Florida Geolo. Sur., Bull. 38, p. 105, pl. 2, fig. 6a-b.

Occurrence: Brooksville single Oligocene sample (B25).

Family PSEUDOGAUDRYINIDAE
Loeblich and Tappen, 1985

Family PSEUDOGAUDRYININAE
Loeblich and Tappan, 1985

Genus PSEUDOCLAVULINA
Cushman, 1936

Pseudoclavulina cocoaensis Cushman

Pseudoclavulina cocoaensis Cushman, 1936, Cushman Lab. Foram. Res., Spec. Publ. 6, p. 18, pl. 3, fig. 6a-b.

Pseudoclavulina cocoaensis Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 31-32, pl. fig. 3a-b.

Occurrence: Red Bluff single sample (RB-20)

Family VALVULAMMINIDAE
Loeblich and Tappen, 1986

Genus DISCORINOPSIS
Cole, 1941

Discorinopsis gunteri Cole

Discorinopsis gunteri Cole, 1941, Florida Geol. Sur. Bull. 19, p. 36, pl. 1, figs. 7-9

Discorinopsis gunteri Puri, 1957, Florida Geol. Sur. Bull. 38, p. 123. pl. 12, fig. 5a-c.

Occurrence: Present at Brooksville in 4 samples.

Suborder SPIRILLININA
Hoheneggen and Pilller, 1975

Family SPILLINIDAE
Reuss and Fritsch, 1861

Ganus SPIRILLINA
Ehrenberg, 1843

Spirillina vicksburgensis Cushman

Spirillina vicksburgensis Cushman, 1935 Contr. Cushman Lab. Foram. Res. v. 11, p. 34, . 5, fig. 6.

Spirillina vicksburgensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 17, pl. 1, fig. -c.

Occurrence: Present in the Oligocene at Red Bluff and Sepugla River. Moderate abundances (0-27).

Suborder MILIOLINA
Delange & Herouard, 1896

Superfamily MILIOLACEA
Ehrenberg, 1839

Family SPIROLOCULINIDAE
Wiesner, 1920

Genus SPIROLOCULINA
d' Orbigny, 1826

Spiroloculina bidentata Hadley

Spiroloculina bidentata Hadley, 1935, Bull. Amer. Paleo., v. 22, no. 74, p. 5, pl. 1, fig. 4.

Spiroloculina bidentata Puri, 1957. Florida Geol. Sur.Bull. 38, p. 108, pl. 3, fig. 8a-c.

Occurrence: Brooksville rare in 3 samples.

Spiroloculina lisbonensis Bandy

Spiroloculina lisbonensis Bandy, 1949, Bull. Amer.Paleo., v. 32, no 131, p. 18, pl. 1, fig. -c.

Occurrence: Present in low abundances (0-17) at Red Bluff.

Spiroloculina newberryensis Puri

Spiroloculina newberryensis Puri, 1957. Florida Geol. Sur. Bull. 38, p. 109, pl. 3, figs. 1,

Occurrence: Present at Brooksville in 3 samples.

Family HAVERINIDAE
Schwager, 1876

Subfamily SIPHONAPERTINAE
Saidova, 1971

Genus MASSILINA
Schlumberger, 1893

Massilina cookei Cushman

Massilina cookei Cushman, 1935, U. S. Geol. Sur. Prof. Pap. 181, p. 13, pl. 3, fig. 17,
Massilina cookei Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 24, pl. 3, fig. 1a-c.

Occurrence: Red Bluff only rare in Eocene and Oligocene.

Massilina decorata Cushman

Massilina decorata Cushman, 1922, U.S. Geol. Sur. Prof. Pap. 129-F, p. 143, pl. 34, fig. 7.
Massilina decorata Bandy, 1949, Bull. Amer. Paleo, v. 32, no. 131, p. 54, pl. 2, fig. 7a-b.

Occurrence: Present only in at Red Bluff. Moderate abundances in Eocene and rare in Oligocne.

Massilina yazooensis Bandy

Massilina yazooensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 25, pl. 3, fig. 2a-c.

Occurrence: Low abundances in the lower part of the section and Oligocene at Red Bluff.

Massilina spp;

Remarks: Specimens of the genus Massilina not assignable to any species.

Occurrence: Rare in the Oligocene of at Red Bluff only.

Genus QUNIQUELOCULINA
d' Orbigny, 1826

Quinqueloculina constans Bandy

Quinqueloculina constans Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 18, pl. 1, fig. 4a-c.

Occurrence: Red Bluff only, 1-3 specimens in 4 samples.

Quinqueloculina harrisi Howe and Roberts

Quinqueloculina harrisi Howe and Roberts, 1939, Louisiana Dept. Cons. Geol. Bull. 14, p. 35, pl. 2, figs. 13-15.

Quinqueloculina harrisi Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 19, pl. 1, fig. 5a-c.

Occurrence: Red Bluff in a single sample RB-19.

Quinqueloculina hermosa Cole

Quinqueloculina hermosa Cole, 1927, Bull. Amer. Paleo., v. 14, no. 51, p. 13, pl. 2, figs. 28, 29.

Quinqueloculina hermosa Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 19-20, pl. 1, fig. 7a-c.

Occurrence: Single specimen in a single sample (RB-19) at Red Bluff.

Quinqueloculina mauricensis apertaexpansa Bandy

Quinqueloculina mauricensis apertaexpansa Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 20, pl. 1, fig. 9a-c.

Occurrence: Present at Red Bluff, in 4 Oligocene and 2 Eocene samples abundance 2-11 specimens.

Quinqueloculina mauricensis lisbonensis Cushman and Todd

Quinqueloculina mauricensis lisbonensis Cushnam and Todd, 1945, Contr. Cushman Lab. Foram. Res., v. 21, p. 12, pl. 3, figs. 7-8.

Quinqueloculina mauricensis lisbonensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 20, pl. 1, fig. 1a-c.

Occurrence: Present only at Red Bluff in 5 Oligocene samples abundance range for 1-74.

Quinquelculina newberryensis Puri

Quinqueloculina newberryensis Puri, 1957. Florida Geol. Sur. Bull. 38, p. 107, pl. 3, fig. 6a-b.

Occurrence: This species is present at Brooksville, where it is a major component of the fauna in the upper part of the section comprising up to 90 % of the assemblage.

Quinqueloculina stavensis Bandy

Quinqueloculina stavensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 21, pl. 1, fig. 2a-c.

Occurrence: Present in a single sample (RB-19) at Red Bluff.

Quinqueloculina substriata Bandy

Quinqueloculina substriata Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 21, pl. 1, fig. 3a-c.

Occurrence: Present in 4 samples at Red Bluff. Abundance 1-24 specimens per sample.

Quinqueloculina yeguaensis Weinzierl and Applin

Quinqueloculina yeguaensis Weinizierl and Applin, 1929, Jour. Paleo., v. 3, p. 393, pl. 44, fig. 4.

Quinqueloculina yeguaensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 22, pl. 2, figs. 4a-c, 5a-c.

Occurrence: Red Bluff only, rare in the lower part of the section and in moderate abundance in the upper. Abundance range from 1-32.

Subfamily MILIOLINELLINAE
Vella, 1957

Genus PYRGO
Defrance, 1824

Prygo inornata d'Orbigny

Pyrgo cf. P. inornata Puri, 1957, Fla. Geol. Sur. Bull. 38, p. 110.

Occurrence: This species was found only at Brooksville as a minor part of the assemblage in the upper portion of the section and in a single sample at Red Bluff.

Genus TRILOCULINA
d'Orbigny, 1826

Triloculina subrotunda Bandy

Triloculina subrotunda Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 23, pl. 1 fig. 10a-c.

Occurrence: Red Bluff in low abundance. Shows a similar pattern of distribution as species of *Quinqueloculina*.

Triloculina subtumidfrons Bandy

Triloculina subtumidfrons Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 23-24, pl. 2 fig. 10a-c.

Occurrence: Present in a single sample (RB-17) at Red Bluff.

Triloculina spp. A few specimens which can not be assigned to the above species are included here.

Occurrence: Present in a few samples at Red Bluff.

Family MILIOLIDAE
Ehrenberg, 1839

Subfamily MILIOLINAE
Ehrenberg, 1839

Genus MILIOLA
Lamarck, 1804

Miliola jacksonensis Cushman

Miliola jacksonensis Cushman, 1933, Contr. Cushman Lab. Foram. Res., v. 9, p. 2, pl. 1, figs. 2-3.

Miliola jacksonensis Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 22, pl. 2, fig. 6a-c.

Occurrence: Present at Red Bluff in 2 Oligocene and 1 Eocene samples.

Miliola saxorum Lamarck

Miliolites saxorum Lamarck, 1804, Annales du Meseum, v. 5, p. 17, p. 2a-b.

Quinqueloculina saxorum d'Orbigny, 1826, Annales Sci. Nat., v. 7, p. 301, pl. 16, figs. 10-14.

Miliola saxorum Puri, 1957, Florida Geol. Sur. Bull 38, p. 107-108, pl. 3, fig. 10a-c.

Occurrence: This species comprises a minor but consistent portion of the assemblage at Brooksville and in a single Oligocene sample at Red Bluff.

Miliola spp.: A few specimens at Red Bluff not identifiable to the species level are included here.

Family SORITIDAE
Ehrenberg, 1839

Subfamily ARCHAIASINAE
Cushman, 1927

Genus ARCHAIAS
Montfort, 1808

Archaias withlacochensis Puri

Archaias withlacochensis Puri, 1957, Florida Geol. Sur. Bull. 38, p. 142-143, pl. 3, fig. 11a-b.

Occurrence: Present at Brooksville in a single sample (B3-B).

Superfamily CORNUSPIRACEA
Schultze, 1854

Family CORNUSPIRIDAE
Schultze, 1854

Subfamily CORNUSPIRINAE
Schultze, 1854

Genus CORNUSPIRA
Schultze, 1854

Cornuspira lisbonensis Bandy

Cornuspira lisbonensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 18. pl. 1, fig. 3a-c.

Occurrence: Present in a single sample (RB-19) at Red Bluff.

Subfamily SIGMOILOPSINAE
Vella, 1957

Genus ARTICULINA
d'Orbigny, 1826

Articulina advena Cushman

Vertebralina advena Cushman, 1922, U.S. Geol Sur., Prof. Paper 129-E, p. 102, pl. 25, figs. 5-6.

Articulina advena Puri, 1953, Florida Geol. Sur. Bull. 36, p. 91, pl. 6, figs. 1-2.

Occurrence: *A. advena* is present at Red Bluff in the Oligocene frequently occurs with *Quinquoculina*.

Articulina byramensis Cushman

Articulina byramensis Cushman, 1922, U. S. Geol. Sur. Prof. Paper 129, p. 103, pl. 27, figs. 5-6.

Occurrence: Present in a single Eocene sample and 4 Oligocene samples at Red Bluff.

Articulina terquemi Cushman

Articulina terquemi Cushman, 1935, Contr, Cushman Lab. Foram. Res., v. 9, p. 3, pl. 1, fig. 7.

Articulina terquemi Cushamn, 1935, U.S. Geol. Sur. Prof. Paper, 181, p. 14, pl. 4, figs. 2a-a & 3a-b.

Articulina terquemi Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 25-26, pl. 1 fig. 6a-b.

Occurrence: Occurs in 3 Oligocene samples at Red Bluff. All samples containing this species also contain *A. byramensis* and/or *Quinqueloculina*.

Articulina zuberensis Puri

Articulina zuberensis Puri, 1957. Florida Geol. Sur. Bull. 38, p. 109, pl. 3, fig. 7.

Occurrence: Present in 4 samples in the lower part at Brooksville.

Articulina spp.: A few unidentifiable specimens from Red Bluff.

Suborder LAGENINA
Delage & Herouard, 1896

Superfamily NODOSARIACA
Ehrenberg, 1838

Family NODOSARIIDAE
Ehrenberg, 1838

Genus DENTALINA
Risso, 1826

Dentalina cf. communis d'Orbigny

Dentalina communis d'Orbigny, 1826, Ann. Sci. Nat. v. 7, p. 254, No. 35.

Dentalina cummunis Puri, 1953, Florida Geol. Sur. Bull. 36, p. 99, pl. 23, fig. 4.

Occurrence: Present in scattered Eocene samples at Red Bluff in low abundance (1-4) and a single sample at GGS-3535.

Dentalina cooperensis Cushman

Dentalinoides cooperensis Cushman, 1933, Contr. Cushman Lab. Foram. Res., v. 9, p. 8, pl. 1, fig. 17.

Dentalina cooperensis Puri, 1957, Florida Geol. Sur. Bull. 38, p. 112-113, pl. 4, fig. 4.

Occurrence: Present in a single sample at Red Bluff.

Dentalina cocoaensis crucifera Bandy

Dentalina cocoaensis crucifera Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 51-52, pl. 7, fig. 2a-b

Dentalina cocoaensis curcifera Oman, 1965, Unpubl. Disst. Florida State Univ., p. 44, pl. 1, fig. 7a-b.

Occurrence: Present in 2 Eocene samples at Red Bluff and a single Eocene sample at GGS-3535.

Dentalina cucarensis Cole

Dentalina cucarensis Cole, 1927, Bull. Amer. Paleo., v. 14, no. 51, p. 14, pl. 3, fig. 14.

Dentalina cucarensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 52, pl. 7, fig. 3a-b.

Occurrence: Present in a single Eocene sample (SR-2) at Red Bluff.

Dentalina indifferens Reuss

Dentalina indifferens Reuss, 1863, K. Acad. Wiss., Math. Naturw. CL. Sitzber., Bd. 48, Abt. 1, p. 44, pl. 2, figs. 15-16.

Dentalina indifferens Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131,p. 52-53, pl. 7, fig. 6a-b.

Occurrence: Present in 1 Eocene and 4 Oligocene samples at Red Bluff and a single sample at Sepugla River.

Dentalina jacksonensis Cushman and Applin

Dentalina jacksonensis Cushman and Applin, 1926, Bull. Amer. Assoc. Petr. Geol., v. 10, p. 170, pl. 7, figs. 14-16.

Dentalina jacksonensis Jones, 1983, North Carolina Geol, Sur. Pub. 8, p. 26, pl. 2, figs. 9-10.

Occurrence: Rare, present in 7 Eocene samples at Red Bluff and 2 Eocene samples in GGS-3535.

Dentalina vertebralis albatrossi Cushman

Nodosaria vertebralis albatrossi Cushman, 1923, U.S. Nat. Mus. Bull. 104, pt. 4, p. 87, pl. 15, fig. 1.

Dentalina vertebralis albatrossi Jones, 1983, North Carolina Geol, Sur. Pub. 8, p. 26, pl. 2, fig. 14.

Occurrence: Rare, occurs in 2 Eocene samples at Red Bluff.

Dentalina spp.: Specimens not assignable to the species level are included in this group.

Genus NODOSARIA
Lamarck, 1812

Nodosaria longiscata d'Orbigny

Nodsaria longiscata d'Orbigny, 1846 Foraminiferis fossiles du Basin Tertiaire de Vienne, p. 32, pl. 1, figs 10-12.

Nodosaria cf. longiscata Bandy, 1949, Bull. Amer. Paleo. v.32, no. 131, p. 55, pl. 7, fig. 10.

Nodosaria longiscata Jones, 1983, North Carolina Geol, Sur. Pub. 8, p. 30, pl. 2, fig. 13.

Occurrence: Present in low abundance's in scattered Eocene samples at Red Bluff and 2 samples at Sepugla River.

Subfamily PLECTOFRONDICULARIINAE
Cushman, 1927

Genus LANKSTERINA
Loeblich and Tappan, 1961

Lanksterina nuda Howe and Roberts

Polymorphina advena nuda Howe and Roberts, 1939, *in* Howe, 1939, Louisiana Dept. Cons. Geol. Bull. 14, p. 56, pl. 7, fig. 4.

Polymorphina nuda Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 65-66, pl. 9, fig. 8a-b.

Lanksterina nuda Jones, 1983, North Carolina Geol, Sur. Pub. 8, p. 29, pl. 2, fig. 26.

Remarks: Present at Red Bluff and Sepugla River. In no sample does it have an abundance greater than 2.

Genus PLECTOFRONDICULARIA
Liebus, 1903

Plectofrondicularia? inglisiana Puri

Plectofrondicularia? inglisiana Puri, 1957. Florida Geol. Sur. Bull. 38, p. 118, pl. 3, fig. 14a-b.

Occurrence: Occurs in moderate abundance in Oligocene samples at Brooksville.

Family VAGINULINIDAE
Reuss, 1860

Subfamily LENTICULININAE
Chapman, Parr and Collins, 1934

Genus SARACENARIA
Defrance, 1824

Saracenaria bottcheri Reuss

Sacacenaria bottcheri Reuss, 1863, K. Akad. Wiss.,Math. Naturw. Cl., Sitzber., Wein, Osterreich, Bd. 48, Abt. 1, p. 49, pl. 3, figs. 38-42.

Saracenaria bottcheri Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 39, pl. 5, fig. 5a-b & 6a-b.

Occurrence: Rare, Present in scattered samples at Red Bluff.

Saracenaria moresiana Howe and Wallace

Saracenaria moresiana Howe and Wallace, 1932, Louisiana Dept. Cons. Geol. Bull., no. 2, p. 42, pl. 62, fig. 3.

Saracenaria moresiana Jones, 1983, North Carolina Geol, Sur. Pub. 8, p. 32, pl. 4, fig. 1.

Occurrence: Present in low (1-5) abundance at Red Bluff. Although this species is not present continuously it is rarely absent for more than 2 samples.

Saracenaria ornatula regia Bandy

Saracenaria ornatula regia Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 40-41, pl. 5, fig. 9a-b.

Occurrence: This species is only present in a single sample at GGS-3535.

Saracenaria spp.: Specimens not classifiable to the species level were included in this category, mostly due to poor preservation.

Genus DIMORHPINA
d'Orbingy, 1826

Dimorphina danvillensis Howe and Wallace

Dimorphina danvillensis Howe and Wallace, 1932, Louisiana Dept. Cons., Geol. Bull. 2, p. 44 pl. 8, fig. 1a-b.

Occurrence: Present in 3 Eocene samples at Red Bluff and a single Oligocene sample at Sepugla River.

Genus LENTICULINA
Lamark, 1804

Lenticulina alatolimbatus Gumbel

Robolina alato-limbatus Gumbel, 1868, K. Akad. Wiss., Muchen, cl. 2, abb., v. 10, p. 641, pl. 2, fig. 70a-b.

Robulus alato-limbatus Berquist, 1942, Mississippi State Geol. Sur. Bull. 49(Fossils), p. 26, pl. 3, fig. 7.

Lenticulina alatolimbatus Jones, 1983, North Carolina Geol, Sur. Pub. 8, p. 29, pl. 3, fig. 3.

Occurrence: Present in low abundance (0-7) in the Eocene and Oligocene at Red Bluff.

Lenticulina carolinianus Cushman

Robulus carolinianus Cushman, 1933, Contr. Cushman Lab. Foram. Res., v. 9, p. 4, pl. 1, fig. 9.

Robulus carolinianus Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 58, pl. 8, fig. 2a-b.

Occurrence: Rare, present in 3 samples (RB-9-RB-11) at Red Bluff.

Lenticulina convergens Bornemann

Cristellaria convergens Bornemann, 1855, Zeitschrift Deutsch. Geol. Gesell., v. 7, p. 327, pl. 13, fig. 16.

Lenticulilna convergens Cushman, 1935, U.S. Geol Sur., Prof. Pap. 181, p. 67, pl. 6, fig. 4a-b.

Robulus convergens Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 68-58, pl. 8, fig. 3a-b.

Lenticulina convergens Jones, 1983, North Carolina Geol. Sur. Pub. 8, p. 29, pl. 3, fig. 5.

Occurrence: Present at low numbers in scattered samples at Red Bluff and a single sample at the bottom of GGS-3535.

Lenticulina euglypheus Bandy

Robulus euglypheus Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 59, pl. 8, fig. 7a-b.

Remarks: The well developed keel described by Bandy (1949) is not always present.

Occurrence: *L. euglypheus* is present at Red Bluff, Sepugla River, and GGS-3535 . At Red Bluff it is present in scattered samples in low to moderate abundances. In the other 2 sections it is very rare.

Lenticulina inusitatus Cushman

Robulus inusitatus Cushman, 1946, Cushman Lab. Foram. Res. Spec. Pub., 16, p. 7, pl. 2, figs. 1-7.

Robulus inusitatus Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 60-61, pl. 8, fig. 6a-b.

Occurrence: Rare, present in 3 samples at Red Bluff and a single sample in GGS-3535.

Lenticulina jugosus Cushman and Thomas

Robulus jugosus Cushman and Thomas, 1930, Jour. Paleont., v. 4, p. 36, pl 3, fig. 4a-b.

Lenticulina jugosus Jones, 1983, North Carolina Geol, Sur. Pub. 8, p. 29, pl. 3, fig. 8.

Remarks: Jones (1983) noted a range of ornamentation on the sutures of this species.

Occurrence: Rare, present in scattered samples throughout Red Bluff and 2 samples in GGS-3535.

Lenticulina pseudovortex Cole

Robulus pseudovortex Cole, 1927, Bull Amer. Paleo., v. 14, no. 51, p. 19, pl. 1, fig. 12.

Robulus pseudovortex Cushman, and McMasters, 1936, Jour. Paleo., v. 10, p. 510, pl. 74, fig. 12a-b.

Occurrence: Present in moderate abundances in the Eocene and rare in the Oligocene at Red Bluff. At Sepugla River rare in the Oligocene and absent in the Eocene, rare (3 samples) in GGS-3535.

Lenticulina rectidorsatus Bandy

Robulus rectidorsatus Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 62, pl. 8, fig. 5a-b.

Occurrence: Present in a single sample (SP-23) at Sepugla River.

Lenticulina vicksburgensis Cushman

Cristellaria vicksburgensis Cushman, 1922, U. S. Geol. Prof. Paper 129, p. 130, pl. 31, figs. 6-7.

Robulus vicksburgensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 63, pl. 8, fig. 11a-b.

Occurrence: Rare, Present only at Red Bluff in 2 samples in the Eocene, and 4 samples in the Oligocene.

Lenticulina westermanni Pijpers

Cristellaria westermanni Pijpers, 1933, Geology and Paleontology of Bonaire (Dutch West Indies), Geog. Geol. Med., Physiogr. Geol. Recks, no. 8, p. 61, tfs. 39-40.

Robulus westermanni Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 64, pl. 9, fig. 1a-b.

Occurrence: Rare: Present in only 2 samples at Red Bluff.

Lenticulina sp. 1

Diagnosis: Similar to *L. jugosus* but, lacks raised sutures and smooth surface.

Occurrence: Present in 3 samples at Sepugla River and in low abundance scattered throughout Red Bluff.

Lenticulina sp. 2

Diagnosis: Small test with gobular initial chambers. This form strongly resumes *Robulus deformis* of Galloway, and Morrey (1929). However the specimens in the collection and in the figures of Gollaway and Morrey (1929) are not sufficient for confident identification.

Occurrence: Rare, present in scattered samples in at Red Bluff and a single sample in GGS-3535.

Subfamily MARGINULININAE
Wedekind, 1937

Genus ASTACOLUS
de Montfort, 1808

Astacolus danvillensis Howe and Wallace

Astacolus danvillensis Howe and Wallace, 1932, Louisiana Dept. Cons. Geol. Bull., no. 2, p. 36, pl. 3, fig. 1.

Astacolus danvillensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 41, pl. 5, fig. 11a-b.

Occurrence: Rare: Present in a single sample at Red Bluff.

Astacolus sublituus Nuttall

Cristellaria sublituus Nuttall, 1932, Jour. Paleo., v. 6, p. 11, pl. 1, figs. 13, 14.

Astacolus sublituus Bandy, 1949, Bull. Amer. Paleo., v. 32, no.131, p. 42, pl. 5, fig. 13a-b.

Occurrence: Present in the uppermost Eocene and a few Oligocene samples at Red Bluff, and in single samples at Sepugla River, and GGS-3535.

Astocolus spp.: Specimens not identifiable to the species level were placed in this category.

Occurrence: Rare present in two samples at Red Bluff (RB-19 & Rb-9)

Genus MARGINULINA
d' Orbigny, 1826

Marginulina cocoaensis Cushman

Marginulina cocoaensis Cushman, 1925, Contr, Cushman Lab. Foram. Res., v. 1, pt. 3 p. 67, pl. 10, figs. 9, 10.

Marginulina cocoaensis Bandy, 1949, Bull. Amer. Paleo, v. 32, no.131,p. 45, pl. 6, fig. 1a-b.

Occurrence: Present in low abundances in the Eocene at Red Bluff

Marginulina hantkeni Bandy

Marginulina hantkeni Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 46-47, pl. 6, fig. 9a-b.

Occurrence: Present in a single sample (RB-10) at Red Bluff.

Marginulina stavensis Bandy

Marginulina stavensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 48, pl. 6, fig. 8a-b.

Occurrence: Present in a single sample (SR-23) at Red Bluff.

Marginulina spp. Specimens not identifiable to the species level are included in this category.

Occurrence: Present in a few samples at Red Bluff and Sepugla River.

Subfamily VAGINULININAE
Reuss, 1860

Genus FLABELLINELLA
Schubert, 1900

Flabellinella lanceolata Bandy

Flabellinella lanceolata Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 44, pl. 5, fig. 16a-b.

Occurrence: Present only in a single sample at Red Bluff.

Family GLANDULINIDAE
Reuss, 1860

Subfamily GLANDULINIAE
Reuss, 1860

Genus GLANDULINA
d'Orbigny, 1839

Glandulina occidentalis Cushman

Nodosaria (Glandulina) laevigata occidentalis Cushman, 1923, U. S. Nat. Mus., Bull. 104, pt. 4, p. 64, pl. 12, fig. 8.

Glandulina laevigata occidentalis Toulmin, 1941, Jour. Paleont., v. 15, p. 595, pl. 80, figs. 12-13.

Glandulina occidentalis Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 49-50, pl. 6, fig. 14a-b.

Occurrence: Rare, present in a single sample at Red Bluff.

Glandulina spp.

Specimens scattered throughout the Red Bluff section which could not be assigned to a species.

Family LAGENIDAE
Reuss, 1862

Genus LAGENA
Walker, and Jacob, 1798

Lagena acuticosta Reuss

Lagena acuticosta Reuss, 1861, Akad. Wiss. Wein, Sitz.,v. 44, p. 305, pl. 1, fig. 4.

Lagena acuticosta Puri, 1957, Florida Geol. Sur. Bull.38, p. 115, pl. 4, fig. 9a-b.

Occurrence: Single sample at Brooksville.

Lagena gracilicosta Reuss

Lagena gracilicosta Reuss, 1862, K. Akad. Wiss. Math.Naturw. cl. Sitz. Wein, Bd. 46, Abt. 1, p. 327, pl. 3, figs. 42, 43.

Lagena gracilicosta Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 56, pl. 7, fig. 11a-b.

Occurrence: Low abundance in samples scattered throughout Red Bluff.

Lagena hexagona Williamson

Lagena hexagona Williamson Siddall, 1879, Catalogue of Rec. Foram., p. 6.
Lagena hexagona Cushman, 1922, U. S. Geol. Survey, Prof. Paper 129, p. 129, pl. 29, fig. 12.
Lagena hexogona Oman, 1965, Unpub. Diss. Florida State Univ. p. 45, pl. 1, fig. 13.

Occurrence: This distinctive species is rare in the Red Bluff and Sepugla Rivers never being present in more than 2 specimens per sample.

Lagena humifera Bandy

Lagena humifera Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 56-57, pl. 7, fig. 17.

Occurrence: Present in low abundances (0-8) throughout Red Bluff and Sepugla River.

Lagena laevis Montagu

Vericulum laeve Montagu, 1803, Testacea Britannica, p. 524.
Lagena laevis Cushman, 1935, U.S. Geol Sur., Prof. Pap. 181, p. 22, pl. 19, figs. 3, 4.
Lagena laevis Puri, 1957, Florida Geol. Sur. Bull. 38, p. 115, pl. 4, fig. 8a-b.

Occurrence: Present in 2 samples at Brooksville.

Lagena ouachitaensis alabamensis Bandy

Lagena ouachitaensis alabamensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 57, pl. 7, fig. 12a-b.

Occurrence: Rare, present in scattered samples of the Eocene at Red Bluff.

Lagena wallacei Bandy

Lagena wallacei Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 57, pl. 7, fig. 19.
Lagena wallacei Jones, 1983, North Carolina Geol, Sur. Pub. 8, p. 29, pl. 2, fig. 25.

Occurrence: *L. wallacei* is present in low abundance in the Eocene and in moderate abundance in the lowermost Oligocene at Red Bluff.

Lagena spp A few specimens at Red Bluff and Sepugla River not identifiable to the species level.

Occurrence: Rare present in scatttered samples throughout Red Bluff and Sepugla River.

Family ELLIPOSOLAGENIDAE
A.Silvestri, 1923

Subfamily OOLININAE
Loeblich and Tappen, 1961

Genus OOLINA
d'Orbigny, 1839

Oolina spherica Bandy

Oolina spherica Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 50, pl. 7, fig. 20.

Occurrence: Rare, present at Sepugla River in a few scattered samples.

Subfamily ELLIPSOLAGENINAE
A. Silvestri, 1923

Genus FISSURINA
Reuss, 1850

Fissurina crassicarnata Bandy

Fissurina crassicarnata Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 64-65, pl. 9, fig. 6a-b.

Occurrence: Present at Sepugla River and Red Bluff. Rare at Sepugla River and in the Eocene of Red Bluff. In the moderate abundance in the Oligocene at Red Bluff.

Fissurina mauricensis Howe and Roberta

Ellipsolagena(?) mauricensis Howe and Roberts, 1939, Lousiana Dept. Cons. Geol. Bull., 14, p. 72, pl. 9, Figs. 12-13.

Fussurina mauricensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 65, pl. 9, fig. 11a-b.

Fissurina mauricensis Oman, 1965, Unpub. Diss. Florida State Univ., p. 49, pl. 3, fig. 6a-b.

Occurrence: *F. mauricensis* shows a similar pattern of abundance to *F. crassicarata* with somewhat higher presence in the Eocene at Red Bluff.

Fissurina spp.:

Tests not identifiable to the species level were placed in this category.

Occurrence Counting this group the genus *Fissurina* is present in low to moderate abundance in the three deeper water sections.

Suborder GLOBIGERINA
Delage and Herouard, 1896

Superfamily HETEROHELICACEA
Cushman, 1927

Family HETEROHELICIDAE
Cushman, 1927

Subfamily HETEROHELICINAE
Cushman, 1927

Genus BIFARINA
Parker and Jones, 1872

Bifarina vicksburgensis Cushman

Bolivina vicksburgensis Cushman, 1922, U.S. Geol Sur., Prof. Pap. 129-F, p. 126, pl. 29, fig. 2.

Bifarina vicksburgensis Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 131-132, pl. 25, fig. 11a-b.

Occurrence: This species is present in three Eocene samples and in low abundance in the Oligocene at Red Bluff.

Bifarina spp.:

Specimens not idenifiable to the species level.

Occurrence: Present in the Sepugla River in a single Oligocene sample.

Family NONIONIDAE
Schultze, 1854

Genus NONION
de Montfort, 1808

Nonion advena Cushman

Nonionina advena Cushman 1922, U.S. Geol. Sur. Prof. Pap. 129-F, p. 139, pl. 32, fig. 8.

Nonion advenum Puri, 1957, Florida Geol. Sur. Bull. 38, p. 132-133, pl. 9, fig. 4a-c.

Nonion advena Oman, 1965, Unpub. Diss. Florida State Univ., p. 66, pl. 9, fig. 10a-b.

Occurrence: Present in the Oligocene at Red Bluff and in low abundance at Sepugla River, GGS-3535 and Brooksville, with a peak of in the Upper Eocene at Brooksville.

Nonion inexcavatus Cushman and Applin

Nonion advena inexcavatus Cushman and Applin, 1926, Bull. Amer. Assoc. Pet. Geol., v. 10, p. 182, pl. 10, figs. 18, 19.

Nonion inexcavatum Ellisor, 1933, Bull. Amer. Assoc. Pet. Geol., v. 17, no. 11, p. pl. 2, fig. 7.

Nonion inexcavatus Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 72-73, pl. 10, fig. 9a-b.

Occurrence: Restricted to the Oligocene at Red Bluff, but occurs throughout Sepugla River.

Nonion mauricensis Howe and Ellis

Nonion mauricensis Howe and Ellis, 1939, in Howe 1939 Louisiana Dept. Cons., Geol. Bull. 14, p. 57, pl.8, fig. 1, 2.

Nonion mauricensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 72, pl. 10, fig. 12a-b.

Occurrence: Present in a single sample (RB-20) at Red Bluff.

Nonion nicobarensis Cushman

Nonionina umbilicata Brady, 1884 Rep. Vog. Challenger, Zoology, v. 9, p. 726, pl. 109, figs, 8,9.

Nonion nicobarensis Cushmanm 1936, Contr. Cushman Lab. Foram. Res., v. 12, p. 67, pl. 12, fig. 9a-b.

Nonion nicobarensis Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 73-74, pl. 10, fig, 13a-b.

Occurrence: Red Bluff common in Oligocene, rare in Eocene. Uncommon throughout Sepugla River and GGS-3535.

Nonion planatum Cushman and Thomas

Nonion planatum Cushman and Thomas, 1930, Jour. Paleont., v. 4, p. 37, pl. 3, fig. 5a-b.

Nonion planatum Puri, 1957, Florida Geol. Sur. Bull. 38, p. 133, pl. 8, fig. 13a-b.

Occurrence: Present only at Brooksville in 4 Eocene samples.

Nonion spp.

This grouping includes all specimens that where not placed in a known or new species due mostly to poor preservation.

Genus NONIONELLA
Cushman 1926

Nonionella jacksonensis Cushman

Nonionella jacksonensis Cushman, 1933, Contr. Cushman Lab. Foram. Res., v. 9, p. 10, pl. 1 fig. 23a-c.

Nonionella jacksonensis Jones, 1983, North Carolina Geol, Sur. Pub. 8, p. 31, pl. 15, figs. 1-2.

Occurrence: At Red Bluff *N. jacksonensis* low abundance in the Eocene and moderate abundance in the Oligocene. At Sepugla River and GGS-3535 this species is present in low abundances throughout.

Nonionella spp.:

Remarks: Listing of poorly preserved forms not indentifiable to the especies level. However, this group may not be taxonomically pure in that some of the specimens may belong to the genus *Florilus* and where included into this category before the division of the genus was noted.

Occurrence: Scattered samples at Red Bluff, Sepugla River and GGS-3535.

Genus FLORILUS
Cushman, 1931

Florilus spissa Cushman

Nonionella hantkeni spissa Cushman, 1931, Contr. Cushman Lab. Foram. Res., v. 7, p. 58, pl. 7, fig. 13.

Nonionella spissa Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 78, pl. 11, figs. 2a-c, 4a-c.

Florilus spissa Jones, 1983, North Carolina Geol, Sur. Pub. 8, p. 27, pl. 14, figs. 20-21.

Occurrence: Low to moderate abundance (0-12 specimens per sample) throughout Red Bluff, Sepugla River and GGS-3535. Generally somewhat more common in the Oligocene.

Subfamily PULLENIINAE
Schwager, 1877

Genus PULLENIA
Parker and Jones, 1862

Pullenia quinqueloba aplata Bandy

Pullenia quinqueloba aplata Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 79, pl. 12, fig. 5a-b.

Occurrence: Present at low abundance throughout Red Bluff, and Sepugla River. Maximum abundance is 7 in any sample.

Superfamily CHILOSTOMELLACEA
Brady, 1881

Family ALABAMINIDAE
Hofker, 1951

Genus ALABAMINA
Toulmin, 1941

Alabamina obtusa Burrows and Holland

Pulvinulina exigua obtusa Burrows and Holland, 1897, Geologists Assoc. London, Proc., v. 15, pt. 1, p. 49, pl. 2, fig. 25

Alabamina obtusa Puri, 1957, Florida Geol. Sur. Bull. 38, p. 128, pl. 10, fig. 9a-b.

Occurrence: Rare, present in 4 samples at Brooksville.

Alabamina spp.:

Remarks: Several specimens which appear to belong the genus *Alabmaina* are included in this category. Species level identification was not attempted.

Occurrence: Only present at Red Bluff.

Family GAVELINELLIDAE
Hofker, 1956

Subfamily GAVELINELLINAE
Hofker, 1956

Genus GYROIDINA
d'Orbigny, 1826

Gryoidina crystalriverensis Puri

Gryoidina crystalriverensis Puri, 1957, Florida Geol. Sur. Bull. 38, p. 124-125, pl. 9, figs. 10-11.

Occurrence: Common at Brooksville where t is a conspicuous part of the assemblage in many samples.

Gryoidina nassauensis Cole

Gryoidina nassauensis Cole, 1944, FLorid Geol. Sur. Bull. 26, p. 53-54, pl. 2 fig. 12.

Gryoidina nassauensis Puri, 1957, Florida Geol. Sur. Bull. 38, p. 125, pl. 12, fig. 6a-c.

Occurrence: Present in 4 samples at Brooksville.

Gyroidina obesa Bandy

Gyroidina obesa Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 90, pl. 14, fig. 4a-c.

Occurrence: Uncommon, Present in low abundance in the Oligocene at Red Bluff and scattered throughout Sepugla River and GGS-3535.

Gryoidina ocamerata Cushman and Hanna

Gyroidina soldani octacamerata Cushman and Hanna, 1927, Calif. Acad. Sci., Proc., ser. 4, v. 16, p. 223, pl. 14, figs.16-18.

Valvulineria ocatacmerata Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 84, pl. 13, fig. 1a-c.

Occurrence: Low to moderate abundances in the Red Bluff, Sepugla River, and GGS-3535 sections. In the latter two this species is present in higher abundances in the Oligocene. No trend was observed at Red Bluff.

Family POLYMORPHINIDAE
d'Orgibny, 1839

Subfamily POLYMORPHININAE
d'Orbigny, 1839

Genus GLOBULINA
d'Orbigny, 1839

Globulina gibba d'Orbigny

Globulina gibba d'Orbigny, 1826, Ann. Sci Nat., v. 7, p. 266, Modele No. 63.

Globulina gibba Puri, 1957, Florida Geol. Sur. Bull. 38, p. 116, pl. 5, fig. 6.

Globulina gibba Jones, 1983, North Carolina Geol, Sur. Pub. 8, p. 27-28, pl. 4, figs. 4, 8.

Occurrence: Rare: Present in the scattered samples in all 4 sections, with no pattern of Occurrence.

Globulina tuberculata d'Orbigny

Globulina tuberculata d'Orbigny, 1846, Foraminiferes fossiles du basin Tertiare de Vienne, p. 230, pl. 13, figs. 21-22.

Raphulina tuberculata Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 70-71, pl. 10, fig. 6a-b.

Occurrence: Rare: Present in 5 samples at Red Bluff.

Genus GUTTULINA
d'Orbigny, 1839

Guttulina byramensis Cushman

Guttulina byramensis Cushman, 1922, U. S. Geol. Sur. Prof. Pap. 129-E, p. 94, pl. 17, fig. 2.

Guttulina byramensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 68, pl. 9, fig. 14a-b.

Occurrence: Rare: Present in low abundance in scattered samples at Red Bluff and Sepugla River.

Guttulina communis d'Orbigny

Polymorphina [Guttulina] communis d'Orbigny, 1826, Ann. Sci. Nat., ser. 1, v. 7, p. 266, pl. 12, figs. 1-4.

Guttulina communis Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 68, pl. 9, fig. 12a-b.

Guttalina communis Jones, 1983, North Carolina Geol, Sur. Pub. 8, p. 28, pl. 4, fig. 5.

Occurrence: Rare: Present in 2 samples at Sepugla River.

Guttulina consobrina Fornasini

Polymorphina sororia consobrina Fornasini, 1900-1902, Mem. R. Accad. Sei. 1st. Bolonga, ser. 5, v. 18, p. 69, fig. 21.

Globulina consobrina Cushman and Ozawa, 1930, U. S. Nat. Mus., Proc.v. 77, art. 6, p. 85, pl. 21, figs. 6a-c.

Guttulina consobrina Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 69, pl. 10, fig. 7a-c.

Occurrence: Rare: Present in a few Oligocene samples of Red Bluff and Sepugla River.

Guttulina hantkeni Cushman and Ozawa

Polymorhina acuta Hantken, 1895, Magy. Kir. Foldt. int.Evkonge, v. 4, p. 51, pl. 8, fig. 4.

Guttulina hantkeni Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 69, pl. 10, fig. 1a-b.

Guttalina hantkeni Oman, 1965, Unpub. Diss. Florida State Univ., p. 48, pl. 2, fig. 9a-c.

Occurrence: Rare: Present in scattered samples at Red Bluff, maximum abundance 2.

Guttulina irregularis d'Orbigny

Guttulina irregularis d'Orbigny, 1846, Foram Foss. Veinne. p. 226. pl. 13, figs. 9, 10.

Guttulina irregularis Puri, 1957. Florida Geol. Sur. Bull. 38, p. 116, pl. 5, fig. 10a-c.

Occurrence: Low to moderate abundance at Brooksville.

Guttulina spicaeformis Roemer

Polymorphina spicaeformis Roemer, 1838, Neus Jarrb., p. 386, pl. 3, fig. 31.
Guttulina spcaeformis Puri, 1957. Florida Geol. Sur. Bull. 38, p. 116, pl. 5, fig. 6.

Occurrence: Rare: Present in 4 samples at Brooksville.

Guttalina spp.:

Specimens not assignable to the species level were placed in this category.

Occurrence: Present in low abundances scattered throughout Red Bluff and Sepugla River, and in the Oligocene of GGS-3535.

Genus SIGMOMORPHINA
Cushman and Ozawa, 1928

Sigmomorphina jacksonensis Cushman

Polymorphina jacksonensis Cushman, 1926, Contr. Cushman Lab. Foram. Res., v. 2, p. 36, pl. 5, fig. 5a-b.
Sigmomorphina jacksonensis Puri, 1957. Florida Geol. Sur. Bull. 38, p. 117, pl. 5, fig. 5.

Occurrence: Extremely rare, present in a single sample at Sepugla River.

Suborder ROTALIINA
Delage and Herouard, 1896

Superfamily BOLIVINACEA
Glaessner, 1937

Family BOLIVINIDAE
Glaessner, 1937

Genus BOLIVINA
d'Orbigny, 1839

Bolivina dalli Cushman

Biafarina dalli Cushman, 1926, Contr. Cushman Lab. Foram. Res., vol. 2, p. 31, pl. 4, fig. 5.
Bolivina dalli Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 125-126, pl. 24, fig. 6a-b.

Occurrence: Abundant in the Eocene of Red Bluff. Rare in the Oligocene of Red Bluff and Sepugla River.

Bolivina jacksonesis Cushman and Applin

Bolivina jacksonensis Cushman and Applin, 1926, Bull. Amer. Pet. Geol., v. 10, p. 167, pl. 7, figs. 3-4.

Bolivina jacksonensis Cushman, 1937, U. S. Geol. Sur. Prof. 181, p. 37, pl. 14, figs. 11-13.

Occurrence: Present in 4 samples at Brooksville.

Bolivina mississippiensis Cushman

Bolivina mississippiensis Cushman, 1922, U. S. Geol. Sur. Prof. Paper 129-E, p. 92, pl. 15, fig. 5.

Bolivina mississippiensis Cushman and Todd, 1945, Contr. Cushman Lab. Foram. Res., vol. 22, p. 92, pl. 15, fig. 30.

Bolivina mississippiensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 127-128, pl. 25, fig. 4a-b.

Occurrence: Rare, present in a few samples at Red Bluff and Sepugla River.

Bolivina sp. 1

Occurrence: Present at Red Bluff, Sepugla River and GGS-3535.

Bolivina sp. 2 (aplanta)

Bolivina spp.:

Specimens not identifiable to the species level are included in this category.

Occurrence: Present in moderate to high abundance throughout GGS-3535.

Genus BRIZALINA
O.G. Costa, 1856

Brizalina alazanensis Cushaman

Bolivina alazanensis Cushman, 1926, Contr. Cushman Lab. Foram. Res. v. 1, pt. 4, p. 82, pl. 12, fig. 1.

Bolivina alzanensis Cushman, 1937, Cushman Lab. Foram. Res. Spec. Publ. 9, p. 63, pl. 8, figs. 6-7.

Occurrence: Common at Red Bluff and present in the Oligocene of Sepugla River.

Brizalina huneri Howe

Bolivina huneri Howe, 1939, Louisiana Dept. Cons. Geol Bull., 14, p. 66, pl. 9, figs. 3 & 4.
Bolivina huneri Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 127, pl. 25, fig. 1a-b.
Brizalina huneri Oman, 1965, Unpub. Diss. Florida State Univ., p. 51, pl. 3, fig. 10

Occurrence: Common, present in moderate abundance in the GGS-3535 section and low to moderate abundance in at Red Bluff.

Brizalina retifera Bandy

Bolivina retifera Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 128-129, pl. 24, fig. 10a-b.

Occurrence Rare: present in very low abundaces in the Red Bluff, Sepugla River and GGS-3535 sections.

Brizalina salebrosa Bandy

Bolivina salebrosa Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 129, pl. 25, fig. 6a-b.

Occurrence: Common to abundant. Moderate to high abundance throughout Red Bluff and GGS-3535. low abundance in the Eocene and in high abundance in the Oligocene at Sepugla River.

Brizalina striatellata Bandy

Bolivina jacksonensis striatellata Cushman and Applin, 1926,Bull. Amer. Pet. Geol., v. 10, p. 167, pl. 7, figs. 5-6.
Bolivina striatellata Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 129-130, pl. 24, figs 8a-b, 9a-b.
Brizalina striatellata Jones, 1983, North Carolina Geol, Sur. Pub. 8, p. 24, pl. 4, fig. 19.

Occurrence: Moderate to high abundances throughout Red Bluff. At GGS-3535 the abundance drops across the boundary, and at Sepugla River increases across the E/O boundary.

Superfamily LOXOSTOMACEA
Loeblich and Tappen, 1962

Family LOXOSTOMATIDAE
Loeblich and Tappen, 1962

Genus LOXOSTOMUM
Ehrenberg, 1854

Loxostomum baculum Bandy

Loxostomum baculum Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 131, pl. 25, fig. 8a-b.

Occurrence: Present throughout Red Bluff, and low abundance in the Oligocene of Sepugla River.

Loxostomum serrula Bandy

Loxostomum serrula Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 131, pl. 25, fig. 8a-b.

Remarks: Many of the specimens which might have been included in this species by other workers have been placed in *Loxostomum sp. 1* due to consistent differences between the specimens in this study and descriptions of previous workers.

Occurrence: Present in low to moderate abundance in a few samples at Red Bluff.

Loxostomum sp. 1

Remarks: This species is much more ovate in cross section than *L. serrula* without overlapping chambers. Aperture is terminal. May be same as *Bolivina graclis* (Cushman and Applin AAPG, vol. 10)

Occurrence: Present only at Red Bluff in low to moderate abundance in the Eocene and low abundance in the Oligocene.

Family BOLIVINELLIDAE
Hayward, 1980

Genus BOLIVINELLA
Cushman, 1927

Bolivinella rugosa Howe

Bolivinella rugosa Howe, 1928, Journ. Paleont., v. 2, p. 174 (list).
Bolivinella rugosa Howe, 1930, Journ. Paleont., v. 4, p. 267, pl. 21, fig. 4a-b.
Bolivinella rugosa Poag, 1966, Micropaleontology, v. 12, no. 4, p. 403, pl. 2, figs. 29-30.

[illegible]e: This species is present at Sepugla River, and GGS-3535 in low abundance [illegible]ughout.

Superfamily CASSIDULINACEA
d'Orbigny, 1839

Family CASSIDULINIDAE
d'Orbigny, 1839

Subfamily CASSIDULINIAE
d'Orbigny, 1839

Genus CASSIDULINA
d'Orbigny, 1826

Cassidulina alabamensis Bandy

Cassidulina alabamensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 139, pl. 26, fig. 11a-b.

Occurrence: Moderate abundance in Eocene of GGS-3535 absent from Oligocene. Very abundant in the Eocene and uncommon in the Oligocene at Sepugla River.

Cassidulina armosa Bandy

Cassidulina armosa Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 139, pl. 26, fig. 12a-b.

Cassidulina armosa Jones, 1983, North Carolina Geol, Sur. Pub. 8, p. 24, pl. 14, figs. 13-14.

Occurrence: Abundance patterns at Sepugla River and GGS-3535 similar to *C. alabamensis*, but more abundant in the Oligocene. Abundant in the Oligocene nearly absent in the Eocene at Red Bluff.

Cassidulina braziliensis Howe and Wallace

Cassidulinoides braziliensis Howe and Wallace, 1932, Louisiana Dept. Cons., Geol. Bull. 2, p. 72, pl. 5, fig. 6a-b.

Occurrence: Present in moderate abundances in the lowermost portion of Red Bluff. Present in very low abundances in scattered samples in the rest of Red Bluff, Sepugla River and GGS-3535.

Cassidulina cf. moodyensis Cushman and Todd

Cassidulina moodyensis Cushman and Todd, 1945, Contr. Cushman Lab. Foram. Res., v. 21, p. 102, pl. 16, figs. 9, 10.

Occurrence: Present in very low abundance in scattered samples at Brooksville.

Genus GLOBOCASSIDULINA
Voloshinova, 1960

Globocassidulina subglobosa Brady

Cassidulina subglobosa Brady, 1881, Quart. Jour. Micr. Soc. v. 21, p. 60

Cassidulina subglobosa Brady, 1884, Rep. Voy. *Challenger* Zool., v. 9, p. 430, pl. 54, fig. 17a-c.

Globocassidulina subglobosa Oman, 1965, Diss. p. 87, pl. 9, fig. 8a-b.

Globocassidulina subglobosa Jones, 1983, North Carolina Geol, Sur. Pub. 8, p. 27, pl. 14, fig. 12.

Occurrence: Present in the Red Bluff, Sepugla River and GGS-3535 sections. At Red Bluff and GGS-3535 it is present throughout the section in moderate abundance and low abundance in the Oligocene of Sepugla River.

Family BULIMINIDAE
Jones, 1875

Genus BULIMINA
d' Orbigny, 1826

Bulimina jacksonensis Cushman

Bulimina jacksonensis Cushman, 1925, Contr. Cushman Lab. Foram. Res., v. 1, p. 6, pl. 1, figs. 6, 7.

Bulimina jacksonensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 134, pl. 26, fig. 5a-b.

Occurrence: This important species is present in Red Bluff, Sepugla River, GGS-3535 sections. At Red Bluff the extinction of *B. jacksonensis* near the E/O boundary marks the major change of benthic foraminiferal assemblage. *B. jacksonensis* is rare in the other 2 sections and is generally confined to the Eocene.

Bulimina trigona Terquem

Bulimina trigona Terquem, 1882, Soc. Geol. France, Mem., ser. 3, v. 2, p. 110, pl. 11, figs. 28, 29.

Bulimina trigona Cushman and Todd, 1945, Contr. Cushman Lab. Foram. Res., v. 21, p. 17, pl. 4, fig. 6.

Bulimina trigona Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 136, pl. 25, figs. 17a-b, 18a-b.

Occurrence: Present in a single sample at Sepugla River.

Family BULIMINELLIDAE
Hofker, 1951

Genus BULIMINELLA
Cushman, 1911

Buliminella biformata Bandy

Buliminella biformata Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 138, pl. 26, fig. 2a-b.

Occurrence: Present low abundance in scattered Eocene and the lowest Oligocene samples at Red Bluff.

Buliminella elgantissima d'Orbigny

Buliminella elgantissima Howe and Wallace, 1932, Louisiana Dept. Cons., Geol. Bull. 2, p. 102, pl. 11, fig. 3.

Buliminella elgantissima Poag, 1966, Micropaleontology, v. 12, no. 4, p. 410, pl. 5, figs. 33-35.

Buliminella elgantissima Jones, 1983, North Carolina Geol, Sur. Pub. 8, p. 24, pl. 4, fig. 18.

Occurrence: Rare to moderate abundances in the Red Bluff, Sepugla River, and GGS-3535 sections. Most consistent presence is in the GGS-3535 sections where it is a minor part of the assemblage throughout the section.

Buliminella longicamerata Bandy

Buliminella longicamerata Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 138, pl. 26, fig. 8a-c.

Occurrence: Rare, present only at Red Bluff. No pattern of distributions was observed.

Buliminella pulchra Terquem

Bulimina pulchra Terquem, 1882, Soc. Geol. France, Mem., ser. 3, v. 2, p. 114, pl. 12, figs. 8-12.

Buliminella pulchra Cushman and Parker, 1937, Contr. Cushman Lab. Foram. Res., v. 13, p. 69, pl. 10, figs. 1-2.

Buliminella pulchra Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 138-139, pl. 26, fig. 6a-b.

Occurrence: Present in moderate abundance throughout Red Bluff and GGS-3535 and a single sample at Sepugla River.

Buliminella spp.: A few speciemens not identifiable to the species level are included here.

Occurrence: Present in a single sample (RB-4) at Red BLuff.

Family SIPHOGENERINOIDIDAE
Saidova, 1981

Subfamily TUBULOGENERININAE
Saidova, 1981

Geinus BITUBULOGENERINA
Howe, 1934

Bitubulogenerina howei Cushman

Bitubulogenerina sp. Howe, 1934, Jour. Paleo, v. 8, pl. 51, g. 4.
Bitubulogenerina howei Cushman, 1935 Contr. Cushman Lab. Foram. Res. v. 11, pt. 1, p. 20, pl. 3, figs. 10-12.
Bitubulogenerina howei Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 132, pl. 25, fig. 12a-b.

Occurrence: This distinctive species is present in low abundance in the Oligocene at Red Bluff, Sepugla River, and GGS-3535.

Family UVIGERINIDAE
Haeckel, 1894

Subfamily Uvigerininae
Haeckal, 1894

Genus UVIGERINA
d'Orbigny, 1826

Remarks: The genus Uvigerina has been split into a wide variety of species. In many cases these species are based on dubious and/ or redundant forms. The approach taken in this study has been to reduce the number of species recognized to 3 basic types: Those with well developed costa(*U. jacksonensis*), Those with spines covering the last formed or more chambers (*U. gardnerea)* and, Those forms which are unornamented by either costa or spines (*U. glabrans*). Future work is needed on this genus to better define both morphometric and temporal species ranges and boundaries.

Uvigerina gardnerae Cushman

Uvigerina gardnerae Cushman, 1926, *in* Cushman and Applin. Bull. Amer. Assoc. Petro. Geol., v. 10, p. 177, pl. 8, fig. 19.
Uvigerina gardnerae Cushman, 1946, Cushman Lab. Foram. Res. Spec. Publ. 16, p. 29, pl. 6, figs. 3-5.
Uvigerina gardnerea Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 141-142, pl. 27, fig. 2.

Occurrence: Present in the Red Bluff and Sepugla River in low to moderate abundances throughout.

Uvigerina glabrans Cushman

Uvigerina glabrans Cushman, 1933, Contr. Cushman Lab. Foram. Res., v. 9, p. 13, pl. 1, fig. 28.

Uvigerina glabrans Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 142, pl. 27, fig. 3.

Uvigerina glabrans Puri, 1957, Florida Geol. Sur. Bull. 38, p. 120, pl. 8, fig. 5-6.

Occurrence: Rare at Sepugla River, uncommon at Red Bluff present in scattered samples with no pattern of occurrence.

Uvigerina jacksonensis Cushman

Uvigerina jacksonensis Cushman, Contr. Cushman Lab. Foram. Res., v. 1, p. 67, pl. 10, fig. 13.

Uvigerina jacksonensis Howe and Wallace, 1932, Louisiana Dept. Con. Geol. Bul. 2, p. 65, pl. 12, figs. 7, 8.

Uvigerina jacksonensis Puri, 1957, Florida Geol. Sur. Bull. 38, p. 120.

Occurrence: Abundant in the Eocene at Red Bluff up to 20 % of the fauna, lower abundance in the Oligocene. Lower abundance but similar pattern at GGS-3535. More abundant in the Oligocene at Sepugla River.

Family REUSSELLIDAE
Cushman, 1933

Genus REUSSELLA
Galloway, 1933

Reussella eocena Cushman

Reussella eocena Cushman, 1933, Contr. Cushman Lab. Foram. Res. v. 9, p. 13, pl. 1, fig. 25.

Remarks: The diagnosis of this species is not entirely clear thus it may be more common than thought. See discussion of *R. sculptilis* below.

Occurrence: Common to abundant at Brooksville. This species occurs in lower and middle parts of this section and in lower abundances or is absent in he rest of the section.

Reussella moodyensis Bandy

Reussella moodyensis Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 133, pl. 25, fig. 13a-b.

Occurrence: Common to rare at Red Bluff, Sepugla River and GGS-3535 in each case the highest abundance is near the base of the sampled section

Reussella sculptilis Cushman

Vernevilina sculptilis Cushman, 1926, Contr. Cushman Lab. Foram. Res., v. 2, p. 34, pl. 5, fig. 3.

Reussella sculptilis Cushman, 1935, U.S. Geol Sur., Prof. Pap. 181, p. 38-39, pl. 15, fig. 6-7.

Reussella sculptilis Puri, 1957, Florida State Geol. Sur., Bull. 38, p. 120, pl. 9, fig. 1, 3.

Remarks: Puri's (1957) diagnosis of *R. sculptilis* seems to be a combination of Cushman's *R. eocena* and *R. sculptilis*. Therefore the exact description of this species is unclear.

Occurrence: Present in low to moderate abundances in all sections. Generally more abundant in the Oligocene restricted to Oligocene at Red Bluff.

Reussella spp.: All specimens assignable to the genus Reussella but not to one of the 3 above species are included in this group. This is nearly always a result of poor preservation obscuring the fine details.

Occurrence: Low to moderate abundance throughout GGS-3535 and in scattered samples iat Sepugla River.

Superfamily FURSENKOINACEA
Loblich and Tappan, 1961

Family FURSENKOINIDAE
Loeblich and Tappen, 1961

Genus Fursenkoina
Loeblich and Tappan, 1961

Fursenkoina dibollensis Cushman and Applin

Virgulina dibollensis Cushman and Applin, 1926, Bull. Amer. Assoc Pet. Geol., v. 10, p. 168, pl. 7, fig. 7.

Virgulina dibollensis Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 136-137, pl. 26, fig. 9a-b.

Remarks: Following Jones 1983 and Poag (1966) many species originally assigned to *Virgulina* have been transferred to *Fusenkoina* when the former genus was suppressed..

Occurrence: Rare (maximum abundance of 4) at Red Bluff and Sepugla River.

Fursenkoina spp.:

Specimens not identifiable to the species level are in this category.

Occurrence: Low abundance in scattered Oligocene samples of Red Bluff and GGS-3535.

Superfamily PLEUROSTOMELLACEA

Reuss, 1860

Family PLEUROSTOMELLIDAE
Reuss, 1860

Subfamily STILOSTOMELLIDAE
Finlay, 1947

Genus NODOGENERIA
Cushman, 1927

Nodogeneria annulospinosa Bandy
Nodosarella annulospinosa Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 146, pl. 27, fig. 14a-b.

Occurrence: Moderate abundance in the Eocene at Red Bluff

Nodogeneria cocoaensis Cushman
Nodosarella cocoaensis Cushman, 1925, Contr. Cushman Lab. Foram. Res., v. 1, p. 66, pl. 10, figs. 5-6.
Dentalina cocoaensis Cushman, 1927, Journ. Paleo. v. 1, p. 153, pl. 24, fig. 24.
Ellipsonodosaria cocoaensis Cushman, 1939, Contr. Cushman Lab. Foram. Res., v. 15, p. 68, pl. 11, figs. 27, 33.
Nodosarella cocoaensis Oman, 1965, Unpub. Diss. Florida State Univ., p. 63, pl. 9, fig. 5.

Occurrence: Rare, only at Red Bluff in 2 Eocene samples.

Nodogeneria spp.:
Specimens not identifiable to the species level are included in this group.

Occurrence: Rare in 2 Eocene samples at Red Bluff and 1 Eocene sample in GGS-3535.

Subfamily ANGULOGERININAE
Galloway, 1933

Genus ANGULOGERINA
Cushman, 1927

Angulogerina byramensis Cushman
Uvergina byramensis Cushman, 1922, U.S. Geol Sur., Prof. Pap. 129, p. 95, pl. 18, fig. 5.
Angulogerina byramensis Ellisor, 1933, Amer. Assoc. Pet. Geol., Bull., v. 17, p. , pl. 3, fig. 16.
Angulogerina byramensis Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 144, pl. 27, fig. 9a-b.

Occurrence: Present at Red Bluff, and Sepugla River in low to moderate abundances in the Eocene with increasing abundance in the Oligocene. At GGS-3535 it is rare with no apparent pattern of abundance.

Angulogerina danvillensis Howe and Wallace

Angulogerina danvillensis Howe and Wallace, 1932, Louisiana Dept. Cons., Geol. Bull. no. 2, p. 56, pl. 12, fig. 2.

Angulogerina danvillensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 144-145, pl. 27, fig. 10a-b.

Occurrence: Distibution similar to *A. byramensis* except it is more abundant particulary at Red Bluff. In addition, it is more abundant in the Eocene at this section than the Oligocene.

Angulogerina vicksburgensis Cushman

Angulogerina vicksburgensis Cushman, 1935, Contr. Cushman Lab. Foram. Res., vol. 11, p. 33, pl. 5, figs. 3 & 4.

Angulogerina vicksburgensis Cushman, 1945, Contr. Cushman Lab. Foram. Res., vol. 21, p. 67, pl. 10, fig. 27.

Angulogerina vicksburgensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 145, pl. 27, fig. 12a-b.

Occurrence: This species shows a pattern of lower abundance similar to that of *A. byramensis*, although it is more abundant at GGS-3535

Genus TRIFARINA
Cushman, 1923

Trifarina spp.: No specimens identifiable to a particular species of this genus were encountered..

Occurrence: Low to moderate abundances in the Eocene at Sepugla River. Rare in the Oligocene at Sepugla River Bluff and GGS-3535.

Family CIBICIDIDAE
Cushman, 1927

Subfamily HANZAWAIAE
Cushman, 1929

Genus CIBICIDES
Montfort, 1808

Cibicides cocoaensis Cushman

Eponides cocoaensis Cushamn, 1927, Contr. Cushman Lab. Foram. Res., v. 4, p. 73, pl. 10, fig. 2

Cibicides cocoaensis Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 103, pl. 18, fig. 4a-c.

Occurrence: Low to moderate abundances throughout GGS-3535 and Sepugla River. Rare in the lower part at Red Bluff.

Cibicides cooperensis Cushman

Cibicides cooperensis Cushman, 1933, Contr. Cushman Lab. Foram. Res., v. 9, p. 20,pl. 2, fig. 11a-c.

Occurrence: Rare, present in 3 Oligocene samples at Brooksville.

Cibicides lobatulus Puri

Cibicides lobatulus Puri, 1953, Florida Geol. Sur. Bull. 336, p. 139.

Cibicdes lobatulus Schnitker, 1970, North Carolina Dept. Cons. Devel. Spec. Pub. 3, p. 48-49, pl. 3, fig. 4a-b.

Occurrence: Present in low abundances throughout Sepugla River. Rare in the Oligocene of Red Bluff and GGS-3535.

Cibicides lobatus d'Orbigny

Truncatulata lobata d'Orbigny, 1839, in Barker, Webb, and Berthelot, Hist. Nat. Iles Canaries, v. 2, pt. 2, " Foraminiferes"," p. 134, pl. 2, figs. 22-24.

Cibicides lobatus Cushman, 1935, U.S. Geol Sur., Prof. Pap. 181, p. 52, pl. 22, fig. 4.

Cibicides lobatus Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 105, pl. 19, fig. 3a-c.

Occurrence: Present at Red Bluff, Sepugla River, and GGS-3535. At Red Bluff *C. lobatus* is present in low abundances throughout the section. At Sepugla River and GGS-3535 it is present throughout the section, with higher abundance in the Oligocene.

Cibicides mississippiensis Cushman

Anomalina mississippiensis Cushman, 1922, U.S. Geol Sur., Prof. Pap. 129, p. 99, pl. 21, fig. 6-8.

Cibicides mississippiensis Cushman, 1935, U.S. Geol Sur., Prof. Pap. 181, p. 54, pl. 22, fig. 3a-c.

Occurrence: Present only at Brooksville where it is common in the lower part of the section.

Cibcides pippeni Cushman and Garrett

Cibcides pippeni Cushman and Garrett, 1938, Contr. Cushamn Lab. Foram. Res., v. 14, p. 64, pl. 11, fig. 2.

Cibicides pippeni Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 106-107, pl. 19, figs. 4a-b, 5a-b.

Occurrence: Common to very abundant at Sepugla River and GGS-3535. In these sections C. pippeni while present throughout the section is more abundant in the Oligocene. At Red Bluff this species is rare or not present in the Eocene and moderate to common in the Oligocene.

Cibicides pseudoungerianus Cushman

Truncatulina pseudoungeriana Cushman, 1922, U.S. Geol Sur., Prof. Pap. 129-E, p. 97, pl. 20, fig. 9.

Cibicides pseudoungeriana Cushman, 1931, U. S. Nat Mus., Bull. 104, pt. 8, p. 123, pl. 22, figs. 3-7.

Cibicides pseudoungerianus Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 109-110, pl. 20, fig. 3a-c.

Occurrence: This species is present all sections. At Brooksville and GGS-3535 it is more abundant in the Eocene than the Oligocene. In the other 2 sections it is more abundant in the Oligocene. This species frequently makes up the bulk of the assemblage in the Brooksville and Sepugla Rivers.

Cibicides vicksburgensis Cushman

Rotalia vicksburgensis Cushman, 1922, U.S. Geol Sur., Prof. Pap. 129-F, p. 139, pl. 35, figs. 3, 4.

Cibicides vicksburgensis Cushman and Todd, 1946, Contr. Cushman Lab. Foram. Res., v. 22, p. 102, figs. 30-32.

Cibicides vicksburgensis Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 111-112, pl. 20, fig. 6a-c.

Occurrence: Rare, present in scattered samples throughout Red Bluff and Sepugla River.

Cibicides yazooensis Cushman

Cibicides yazooensis Cushman, 1931, Contr. Cushman Lab. Foram. Res., v. 7, p. 59, pl. 7, fig. 12a-c.

Cibicides yazooensis Cushman, 1935, U.S. Geol Sur., Prof. Pap. 181, p. 53, pl. 23, fig. 2a-c.

Occurrence: Rare, present only in 2 samples at Brooksville.

Cibicides sp. 1

Diagnosis: Resembles *C. cookei* of Cushman and Garrett (1938) but is smaller and has fewer chambers in the final whorl.

Occurrence: Present in low abundances in the Oligocene at Red Bluff only.

Cibicides sp. 3

Diagnosis: Resembles *C. pseudoungerianus* with a more flattened shape.

Occurrence: Rare-abundant, this form is rare at GGS-3535 and in the Eocene of Sepugla River and Red Bluff. In the Oligocene of the last 2 sections it is common to abundant.

Cibicides sp. 4

Diagnosis: This form strongly resembles *Cibicides pippeni*, having a high spire and clearly defined umbilical boss.

Occurrence : Only at GGS-3535 rare to moderate abundance throughout the section.

Cibicides spp.

Forms identifiable to the genus level were placed in this category. In general this includes those specimens which are poorly preserved.

Occurrence: Moderate to high abundance throughout GGS-3535 and in 2 Oligocene samples at Sepugla River.

Genus Hanzawaia
Asano, 1944

Hanzawaia danvillensis Howe and Wallace

Cibicides danvillensis Howe and Wallace, Louisiana Dept. Cons., Geol. Bull. 2, p. 77, pl. 14, fig. 5.

Cibicides danvillensis Cushman and Herrick, 1945, Contr. Cushman Lab. Foram. Res., v. 21, p. 72, pl. 11, fig. 4.

Cibicidina danvillensis Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 92, pl. 14, fig. 7a-c.

Occurrence: This is common species is present in high abundance in the Oligocene of Red Bluff, decreasing abundances from the Eocene to Oligocene at Sepugla River and in consistent numbers at GGS-3535.

Hanzawaia mississippiensis Cushman

Anomalina mississippiensis Cushman, 1922, U.S. Geol Sur., Prof. Pap. 129-E, p. 98, pl. 21, figs. 6-8.

Cibicidina mississippiensis Oman, 1965, Unpub. Diss. Florida State Univ., p. 63, pl. 8, fig. 8a-c.

Cibicidina mississippiensis Poag, 1966, Micropaleont. v. 12, p. 432-434, pl 9, fig. 26-28.

Occurrence: Rare in GGS-3535, common at Sepugla River, and Abundant at Red Bluff.

Hanzawaia walli Bandy

Cibicidina walli Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 95, pl. 15, fig. 5a-c.

Remarks: The type specimen for this species is missing, and the original description is not clear (Bandy, 1949). Thus, the presence of this species in the data is considered questionable and those specimens identified as *C. walli* may belong in other species.

Occurrence: Rare, *C. walli* occurs in the Red Bluff and questionably in the GGS-3535 sections.

Hanzawaia sp. 1

Diagnosis Similar to *H. mauricensis* but is more compressed.

Occurrence: Common, this form occurs throughout the Red Bluff, Sepugla River and GGS-3535 sections.

Hanzawaia sp. 2

Diagnosis: Small test with depressed sutures, umbilical boss which overlaps the terminal chamber. 3 to 4 chambers visible.

Occurrence: Common-Abundant, this form is present in the same sections as *H. sp. 1* however, while in higher abundances in some samples its occur is more spotty.

Hanzawaia sp. 3

Diagnosis: Similar to *H. sp. 2* but larger with a lobate margin.

Occurrence: Rare, present in very low abundances in scattered samples in the Red Bluff and GGS-3535 sections.

Hanzawaia sp. 4

Diagnosis: Moderate sized test dorally flattened with depressed sutures and sharp margin. This form resembles *H. danvillensis* but is larger (1-2mm dia.) and flattened.

Occurrence: Rare, a few scattered Occurrences in the GGS-3535 section.

Hanzawaia spp.:
Specimens not identifable to the species level are in this group.

Occurrence: Scattered specimens at Sepugla River and GGS-3535.

Superfamily DISCOBACEA
Ehrenberg, 1838

Family BAGGINIDAE
Cushman, 1927

Subfamily BAGGININAE
Cushamn, 1927

Genus CANCRIS
de Montfort, 1808

Cancris claibornesis Howe

Cancris claibornensis Howe, 1939, Louisiana Dept. Cons., Bull. 14, p. 78, pl. 10, figs. 20-21.

Cancris claibornensis Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 81, pl. 12, fig. 2a-c.

Cancris claibornensis Oman, 1965, Unpub. Diss. Florida State

Occurrence: Rare, present in the Oligocene of Red Bluff and Sepugla River and 3 samples of the Eocene at GGS-3535.

Cancris cocoaensis Cushman

Cancris brongniartii Cushman, 1935, U.S. Geol Sur., Prof. Pap. 181, p. 48, pl. 20. fig. 1.

Cancris cocoaensis Cushman and Todd, 1942, Contr. Cushman Lab. Foram. Res., v. 18, p. 90, pl. 23, figs. 3-4.

Cancris cocoaensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131,p. 81, pl. 12, fig. 7a-c.

Occurrence: Rare, present only in 2 samples at Sepugla River and 2 samples at Red Bluff.

Cancris spp.:

Remarks: Includes forms not identifiable to the above species of *Cancris* and those whose preservation prevented species level identification.

Occurrence: Present in low abunadnce throughout Sepugla River and GGS-3535.

Family EPONIDIDAE
Hofker, 1951

Subfamily EPONIDINAE
Hofker, 1951

Genus EPONIDES
de Montfort, 1808

Eponides ellisorae Garratt

Eponides ellisorae Garratt, 1939, Jour. Paleo., vol. 13, p. 579, pl. 66, figs. 6-8.

Eponides ellisorae Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 86, pl. 13, fig. 7a-b.

Occurrence: Rare, present only in scattered samples at Red Bluff. No pattern of occurrence was seen.

Eponides jacksonensis Cushman and Applin

Pulvinulina jacksonensis Cushman and Applin, 1926, Amer. Assoc. Pet. Geol. Bull, v. 10, p. 181, pl. 9, figs. 24, 25.

Eponides jacksonensis Cushman, 1935, U. S. Geol. Sur. Prof. Paper 181, p. 46, pl. 9, figs. 4-8.

Eponides jacksonensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 87, pl. 14, fig. 1a-c.

Occurrence: Present in a single sample in the GGS-3535 section, in the other sections its abundance varies widely. At Brooksville dominate in some samples absent in others. In the Red Bluff and Sepugla Rivers it is present in scattered samples throughout the sections.

Eponides lotus(?) Schwager

Pulvinulina lotus Schwager, 1883, Palaeont. v. 30, p. 132, pl. 28, fig. 9a-c.

Eponides lotus Cushman and Ponton, 1932, Contr. Cushman Lab. Foram. Res., v. 8, p. 71, pl. 9, fig. 8a-c.

Eponides lotus Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 88, pl. 14, fig. 3a-c.

Remarks: The specimens assigned to this species in this study are uniformly smaller than the published descriptions.

Occurrence: At Red Bluff it can comprise the majority of the assemblage in some samples but shows no pattern of changing abundance. In the Sepugla River it is very abundant in the Oligocene and nearly absent in the Eocene. *E. lotus* is very rare at GGS-3535.

Eponides ocalana Cushman

Eponides ocalana Cushman, 1933, Contr. Cushman Lab. Foram. Res., v. 9, p. 17, pl. 2, fig. 7a-c.

Eponides ocalana Puri, 1957, Florida Geol. Sur. Bull. 38, p. 126.

Occurrence: Common to abundant in the lower part of Brooksville.

Eponides spp.:

Poorly preserved specimens not identifiable to the species level are included in this group.

Occurrence: Scattered sample at Red Bluff, Sepugla River and GGS-3535.

Genus VERNONINA
Puri, 1957

Vernonina tuberculata Puri

Vernonina tuberculata Puri, 1957, Florida Geol. Sur. Bull. 38, p. 124, pl. 10, figs. 5-7

Occurrence: Rare, present only in 3 samples of the Brooksville section.

Genus VALVULINERIA
Cushman, 1926

Valvulineria texana Cushman and Ellisor

Valvulineria texana Cushman and Ellisor, 1931, Contr. Cushman Lab. Foram. Res., v. 7, p. 56, pl. 7, fig. 9.
Valvulineria texana Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 84, pl. 13, fig. 5a-c.
Valvulineria texana Oman, 1965, Unpub. Diss. Florida State Univ., p. 54, pl. 4, figs. 5a-c.

Occurrence: Rare, at Sepugla River and GGS-3535, more abundant in the Oligocene. In at Red Bluff this species is present in moderate abundances and shows no trend in Occurrence.

Valvulineria spp.:

This category includes forms which were not identifiable the above 2 species and which did not fit other described species.

Occurrence: This form shows a distribution similar to that of *V. texana*.

Family MISSISSIPPINIDAE
Saidova, 1981

Subfamily STOMATORBININAE
Saidova, 1981

Genus STOMATORBINA
Dorreen, 1948

Stomatorbina spp.:

Occurrence: Only at Brooksville in a few scatterd samples..

Subfamily MISSISSIPPININAE
Saidova, 1981

Genus MISSISSIPPINA
Howwe, 1930

Mississippina monsouri Howe

Mississippina monsouri Howe, 1930, Jour. Paleont., v. 4, p. 330, pl. 27, fig. 4a-c.
Mississippina monsouri Puri, 1957, Florida Geol. Sur. Bull. 38, p.p. 123, pl. 12, fig. 5a-c.

Occurrence: Rare, present in very low abundances at Brooksville.

Family DISCORBIDAE

Ehrenberg, 1838

Genus DISCORBIS
Lamarck, 1804

Discorbis alveatus

Discorbis alveatus Cushman, 1933, Contr. Cushman Lab. Foram. Res. v. 9, p. 16.

Occurrence: Present at Red Bluff, Sepugla River, and GGS-3535 rare in the Eocene and common to abundant in the Oligocene.

Discorbis bulla Cushman

Discorbis bulla Cushman, 1933, Contr. Cushman Lab. Foram. Res., v. 9, p. 16, pl. 2, fig. 6a-c.

Discorbis bulla Puri, 1957, Florida Geol. Sur. Bull. 38, p. 122, pl. 10, fig. 8a-c.

Occurrence: Present at Brooksville common in some samples.

Discorbis cocoaensis Cushman and Garrett

Discorbis subaraucana Cushman, 1935, U.S. Geol Sur., Prof. Pap. 181, p. 43, pl. 18, fig. 1a-c.

Discorbis cocoaensis Cushman and Garrett, 1938, Contr. Cushman Lab. Foram. Res. v. 14, p. 63, pl. 11, fig. 1.

Discorbis cocoaensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 98, pl. 16, fig. 3a-c.

Occurrence: Present only at Red Bluff where it occurs in low to moderate (1-30) abundances throughout.

Discorbis globulospinosa Cushman,

Discorbis globulo-spinosa Cushman, 1933, Contr. Cushman Lab. Foram. Res., v. 9, p. 14, pl. 2, fig. 1a-c.

Discorbis globulo-spinosa Cushman, 1935, U.S. Geol Sur., Prof. Pap. 181, p. , pl. 16, fig. 14a-c.

Occurrence: This small distinctive species is present at Red Bluff, Sepugla River, and GGS-3535. In at Red Bluff it is rare and scattered. At Sepugla River this species has a low abundance in the Eocene and is rare in the Oligocene and at GGS-3535 the reverse pattern.

Discorbis hemisphaericus Cushman

Discorbis hemisphaericus Cushman, 1931, Contr. Cushman Lab. Foram. Res., 7, p. 59, pl. 7, fig. 14.

Discorbis hemisphearicus Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 96-97, pl. 16, fig. 2a-c.

Occurrence: *D. hemisphearicus* is restricted to the Oligocene at Red Bluff and occurs in greater abundances in the Oligocene of the other 2 section

Discorbis sp. 1 (bulla)

Remarks: Specimens which resemble *D. bulla* but for which positive identification was not possible are placed in this category.

Occurrence: Present in a few scattered samples at Red Bluff and GGS-3535.

Discorbis spp.:
Specimens which could not be identified to species level are included in this group.

Occurrence: Scattered Eocene samples at Red Bludff. Common to very abundant in GGS-3535.

Genus TROCHULINA
d'Orbigny, 1839

Trochulina packardi Bandy
Rotorbinella packardi Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 90-91, pl. 15, fig. 1a-c.

Remarks: This species has been placed in the genus *Trochulina* since Loeblich and Tappen (1988) considered them to be synonymous.

Occurrence: *T. packardi* is present in scattered samples at Red Bluff in the Eocene.

Superfamily DISCORBINELLACEA
Sigal, 1952

Family PARRELLOIDIDAE
Hofker, 1956

Genus CIBICIDOIDES
Thalmann, 1939

Cibicidoides bilateralis Cushman
Anomalina bilateralis Cushman, 1927, U.S. Geol Sur., Prof. Pap. 129-E, p. 97, pl. 21, figs. 1, 2.
Anomalina bilateralis Bandy, 1949, Bull. Amer. Paleo.,v. 32, no. 131, p. 100-101, pl. 17, fig. 7a-c.

Occurrence: This species is present in the upper and lower part of Red Bluff. Low abundance in the Eocene and moderate abundance in the Oligocene at Sepugla River. Moderate abundance in Eocene and rare in the Oligocene at GGS-3535.

Family DISCORBINELLINAE
Sigal, 1952

Genus DISCOBITURA
Bandy, 1949

Discorbitura dignata Bandy

Discorbitura dignata Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 100, pl. 17, fig. 3a-c.

Discorbitura dignata Poag, 1966, Micropaleontology, v. 12, no. 4, p. 410, pl. 4, figs. 33-35.

Occurrence: Rare at GGS-3535, rare in the Eocene and low abundances in the Oligocene at Red Bluff and Sepugla River.

Superfamily DISCORBINELLACEA
Sigal, 1952

Family PSEUDOPARRELLIDAE
Voloshinova, 1952

Subfamily PSEUDOPARRELLINAE
Volshinova, 1952

Genus PSEUDOPARRELLA
Cushman and ten Dan, 1948

Pseudoparrella danvillensis Howe and Wallace

Puluinvlinella danvillensis Howe and Wallace, 1932, Louisiana Dept. Conser. Geol. Bull. 2, p. 71-72, pl. 13, fig. 7a-c.

Occurrence: This species is very abundant at Red Bluff particularly in the Eocene with abundances ranging up to 250 specimens per sample. In the GGS-3535 section it occurs in low abundance throughout the section and rare at Sepugla River.

Superfamily SIPHONINACAE
Cushman, 1927

Family SIPHONINIDAE
Cushman, 1927

Genus SIPHONINA
Reuss, 1850

Siphonina advena Cushman

Siponina advena Cushman, 1922, U.S. Geol Sur., Prof. Pap. 129-E, p. 98, pl. 22, figs. 1-2.

Siphonina cf. advena Poag, 1966, Micropalont. v. 12, p. 412, pl. 5, figs.19-21.

Occurrence: Common to abundant at Red Bluff with slightly higher abundances in the Eocene. At Sepugla River this species is common throughout. Present in rare scattered samples at GGS-3535.

Siphonina danvillensis Howe and Wallace

Siphonina danvillensis Howe and Wallace, 1932, Louisiana Dept. Cons. Geol. Bull. 2, p. 70, pl. 13, fig. 7.

Siphonina danvillensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no 131, p. 115-116, pl. 21, fig. 8a-c.

Occurrence: Low to moderate abundances at Red Bluff and Sepugla River.

Siphonina jacksonensis Cushman and Applin

Siphonina jacksonensis Cushman and Applin, 1926, Amer. Assoc. Pet. Geol., Bull., v. 10, p. 180, pl. 9, figs. 20-23.

Siphonina jacksonensis Puri, 1957, Florida Geol. Sur. Bull. 38, p. 129, pl. 9, fig. 6a-b.

Occurrence: Present in low abundances at Brooksville.

Siphonina spp. :

Remarks: Includes specimens which could not be identified to the species level due to preservation or breakage.

Occurrence: Low to moderate abundance throughout GGS-3535 and 4 samples at Sepugla River.

Superfamily PLANORBULINACEA
Schwanger, 1877

Family PLANULINIDAE
Bermudez, 1952

Genus PLANULINA
d'Orbigny, 1826

Planulina cocoaensis Cushman

Planulina cocoaensis Cushman, 1928, Contr. Cushman Lab. Foram. Res., v. 4, p. 76, pl. 10, fig. 1.

Planulina cocaensis Puri, 1957, Florida Geol. Sur. Bull. 38, P. 129, pl. 12, fig. 1a-c.

Occurrence: Present in all sections low abundances (maximum 6) in scattered samples.

Planulina cooperensis Cushman

Planulina cocoaensis cooperensis Cushman, 1933, Contr. Cushman Lab. Foram. Res., v. 9, p. 20, pl. 2, fig. 12a-c.

Planulina cooperensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 113, pl. 21, fig. 1a-c.

Occurrence: Present only in the Eocene at Red Bluff low abundance.

Planulina kendrickensis Puri

Planulina kendrickensis Puri, 1957. Florida Geol. Sur. Bull. 38, p. 129, pl. 12, fig. 2a-b.

Occurrence: This small distinctive species is found at Sepugla River, GGS 3535 and the Brooksville. Although very distinctive in shape it is rare in all 3 sections and shows no particular pattern of abundance.

Planulina subinflata Bandy

Planulina subinflata Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 113-114, pl. 18, fig. 1a-c.

Occurrence: Present in low abundances in the Eocene at Brooksville and Sepugla River.

Planulina venezuelana Nuttall

Planulina venezuelana Nuttall, 1935, Jour. Paleo., v. 9, p. 130, pl. 15, figs. 22-24.

Planulina venezuelana Bandy, 1949, Bull. Amer. Paleo.v. 32, no. 131, p. 114, pl. 21, fig. 3a-c.

Occurrence *P. venezuelana* occurs in moderate abundances (0-13) in the Eocene at Red Bluff and rarely in the Oligocene. At Sepugla river *P. venezuelana* occurs in 3 samples in the Eocene.

Planulina spp.

Specimens not identifiable to species level due to poor preservation.

Occurrence: Rare scattered samples in Sepugla River and GGS-3535.

Family PLANORBULINIDAE
Schwager, 1877

Subfamily PLANORBULININAE
Schwager, 1877

Genus PLANORBULINA
d'Orbigny, 1826

Planorbulina cf mediteranensis d'Orbigny

Planorbulina mediterranensis d'Orbigny 1826, Ann. Sci. Nat., v. 7, p. 280, pl. 14, figs. 4-6.

Planorbulina mediterranensis Bandy, 1949, Bull. Amer. Paleo., v. 32, no. 131, p. 116, pl. 21, fig. 2a-c.

Remarks: The identification of this species is tentative at best. The condition and presence of a single specimen made positive identification impossible.

Occurrence: A single sample (SP-20) in the Oligocene at Sepugla River.

Planorbulina spp.:

Specimens not identifiable to the species level.

Occurrence: One specimen in each the Red Bluff and GGS-3535 sections both occur in the Oligocene.

Superfamily ORBITOIDACEA
Schwager, 1876

Family LINDERINIDAE
Loeblich and Tappen, 1984

Genus LINDERINA
Schlumberger, 1893

Linderina spp.

Occurrence: Brooksville, rare in a single sample.

Superfamily ROTALIACEA
Ehrenberg, 1839

Family ROTALIIDAE
Ehrenberg, 1839

Subfamily ROTALIINAE
Ehrenberg, 1839

Genus CAMAGUEYIA
Cole and Bermudez, 1944

Camagueyia perplexa Cole and Bermudez

Camagueyia perplexa Cole and Bermudez, 1944, Bull. Amer. Paleo., v. 28, no. 113, p. 5, pl. 1, figs. 2,3.

Camagueyia perplexa Puri, 1957. Florida Geol. Sur. Bull. 38, p. 122, pl. 10, figs. 1-4.

Occurrence: low abundance in the Oligocene at Brooksville.

Genus Rotalia
Lamarack, 1804

Rotalia cushmani Applin and Jordan

Rotalia cushmani Applin and Jordan, 1945, Jour. Paleont., v. 19, p. 143-144.

Rotalia cushmani Puri, 1957. Florida Geol. Sur. Bull. 38, p. 122, pl. 11, fig. 1a-c.

Occurrence: Present only in the Brooksville section. Occurs in low abundances in scattered samples.

Rotalia similis Bandy

Rotalia similis Bandy, 1949, Bull. Amer. Paleo. v. 32, no. 131, p. 90, pl. 14, fig. 4a-c.

Occurrence: Present in low to moderate abundances at Red Bluff, Sepugla River and GGS-3535. Rare at Red Bluff occurring only in the Oligocene. At Sepugla River and GGS-3535 this species is present in moderate abundances throughout the sections.

Rotalia sp. 1

Diagnosis: Similar to R. similis but with an inflated central portion.

Occurrence: Only present at the Sepugla River.

Rotalia sp. 2

Diagnosis: Large flat form resembling to some extent *R. cushmanni* but larger.

Occurrence: Present only in the Sepugla River.

Family VICTORIELLIDAE
Chapman and Crespin, 1930

Subfamily RUPERTININAE
Loeblich and Tappen, 1961

Genus RUPERTINA
Loeblich and Tappen, 1961

Rupertina floridana Cushman

Rupertia floridana Cushman, 1933, Contr. Cushman Lab. Foram. Res. v. 9, p. 21, pl. 2, figs. 13, 14.

Rupertia floridana Puri,Puri, 1957. Florida Geol. Sur. Bull. 38, p. 99, pl. 8, figs. 7-8; pl. 12, fig. 8.

Occurrence: Present as single specimens in four samples at Brooksville.

Superfamily ACERVULINACEA
Schultze, 1854

Family ACERVULINIDAE
Schultze, 1854

Genus SPHAEROGYPSINA
Galloway, 1933

Sphaerogypsina globulus Reuss

Ceripra globulus Reuss, 1847, Haidlinger's Naturwiss. Abh. v. 2, p. 33, pl. 5, fig. 7.

Sphearogypsina globulus Bandy, 1949, Bull. Amer. Paleo. 32, no. 131, p. 116-117, pl. 21, fig. 5.

Occurrence: Common at Brooksville, rare occurring in scattered samples in Red Bluff, Sepugla River and GGS-3535.

Superfamily ASTERIGERINACEA
d'Orbigny, 1839

Family EPISTOMARIIDAE
Hofker, 1954

Subfamily EPISTOMARIINAE
Hofker, 1954

Genus EPISTOMARIA
Galloway, 1933

Epistomaria semimarginata d'Orbigny

Rotalia (Turbinulina) semimarginata d'Orbigny, 1826, Annales Sci. Nat., v. 7, p. 110, (276) mod. no. 53.

Epistomaria semimarginata Puri, 1957, Florida Geol. Sur. Bull. 38, p. 128, pl. 12, fig. 3a-c.

Occurrence: Rare, present only in a single sample from Brooksville.

Family ALFREDINIDAE
S. N. Singh and Kalia, 1972

Genus EPISTOMAROIDES
Uchio, 1952

Epistomaroides sp.:

Occurrence: Rare, present in a single sample at Brooksville.

Family AMPHISTEGINIDAE
Cushman, 1927

Genus AMPHISTEGINA
d'Orbigny, 1826

Amphistegina pinarensis Applin and Jordan

Amphistegina pinarensis Applina and Jorban, 1945, Jour. Paleont., v. 19, p. 145, pl. 18, fig. 8.

Occurrence: Present in moderate abundance in the lower portion at Brooksville.

Family LEPIDOCYCLINIDAE
Scheffen, 1932

Subfamily LEPIDOCYCLININAW
Schefen, 1932

Genus LEPIDOCYCLINA
Gumbel, 1870

Lepidocyclina chaperi Lemoine and Douville

Lepidocyclina chaperi Lemoine and R. Douville, 1904, Soc. Geol. France Mem., v. 12, p. 14-15, pl. 2, fig. 5.

Lepidocyclina chaperi Cole, 1952, U.S. Geol Sur., Prof. Pap. 244, p. 23-27, pl. 8, figs. 5-8, pl. 9, figs. 3-19, pl. 10, figs. 1-10, pl. 11, fig. 1-8, pl. 12, figs. 1-15, pl. 20, figs. 8-10, pl. 23, figs. 8, 11, 12.

Occurrence: Brooksville, rare, only in a few (3) samples.

Lepidocyclina ocalana Cushman

Lepidocyclina ocalana Cushman, 1919, U.S. Geol Sur., Prof. Pap. 125, p. 71-72, pl. 28, figs. 3, 4, pl. 29, figs. 1-3.

Lepidocyclina ocalana Puri, 1957, Florida Geol. Sur. Bull. 38, p. 137, pl. 14, figs. 1, 9, 11, pl. 15, figs. 2, 7.

Occurrence: Rare, only recorded from 3 samples at Brooksville.

Superfamily NUMMULITACEA
de Blianville, 1827

Family NUMMULITIDAE
de Blainville, 1827

Genus HETEROSTERGINA
d'Orbigny, 1826

Heterostegina ocalana Cushman

Heterostegina ocalana Cushman, 1921, U.S. Geol Sur., Prof. Pap. 128-E, p. 130-131, pl. 21, figs. 15-18.

Heterostegina ocalana Puri, 1957, Florida Geol. Sur. Bull. 38, p. 136, pl. 6, figs. 10, 11, pl. 7, fig. 16.

Occurrence: Brooksville, rare, 3 samples in low abundance.

Genus NUMMULITES
Lamarck, 1801

Nummulites vanderstocki Rutten and Vermut

Nummulites vanderstocki Rutten and Vermut, 1932, Proc. Konik. Akad. Amsterdam, v. 35, p. 240, pl. 1, fig. 8, pl. 2, figs. 6, 12.

Nummulites vanderstocki Puri, 1957, Florida Geol. Sur. Bull. 38, p. 133-134, pl. 6, fig. 1, pl. 7, figs. 12-15.

Occurrence: Present only in the Brooksville section where it is abundant in lower portion of the section and rare in the upper.

Genus Operculinoides
Hanzawa, 1935

Operculinoides moodybranchensis Gravell and Hanna

Camerina moodybranchensis Gravell and Hanna, 1935, Jour. Paleo., v. 9, p. 332-333, pl. 29, figs. 15, 22-24.

Operculinoides moodybranchensis Cole, 1952, U.S. Geol Sur., Prof. Pap. 244, p. 10, pl. 1, figs. 10-19.

Occurrence: Rare present at Brooksville in only 3 samples in the lower section.

Operculinoides ocalanus Cushman

Operculina ocalana Cushman, 1921, U.S. Geol Sur., Prof. Pap. 128-E, p. 129, pl. 19, figs. 4-5.

Operculinoides ocalanus Barker, 1939, U. S. Nat. Mus. Proc.. v. 86, no. 3052, p. 316-317, pl.12, fig. 5, pl. 15, fig. 5.

Operculinoides ocalanus Puri, 1957, Florida Geol. Sur. Bull. 38, p. 134, pl. 6, fig. 12.

Occurrence: Common to abundant in the lower portion of the Brooksville section. Absent from the Oligocene.

Operculinoides willcoxi Heilprin

Nummulites willcoxi Heilprin, 1882, Acad. Nat. Sci. Philadelphia Proc., v. 34, p. 191, figs. 1-2.

Operculinoides willcoxi Cole, 1952, U.S. Geol Sur., Prof. Pap. 244, p. 9, pl. 1, figs. 1-9, 20, 21, pl. 3, fig. 8.

Operculinoides willcoxi Puri, 1957, Florida Geol. Sur. Bull. 38, p. 135-136, pl. 6, figs. 4, 6, pl. 7, figs. 1-3, 6.

Occurrence: Present in high abundance in some samples of the lower part of the Eocene at Brooksville.

Operculinoides spp.

Remarks: Specimens not identifiable to the species level are included in this group.

Occurrence: Present only at Brooksville in a single sample.

Family ASTROCYCLINA
Gumbel, 1870

Genus ASTROCYCLINA
Gumbel, 1870

Astrocyclina spp.:

Occurrence: Present in a single sample at Sepugla River.

Genus PSEUDOPHRAGMINA
Douville, 1923

Pseudophragmina spp.:

Occurrence: Present only in a single sample at Brooksville.

Unknown sp. A:

Diagnosis: This species has the general form of *Eponides*, but has straight sutures, a flat umbilical side. Six to eight chambers in final whorl.

Cuurrence: Present in large numbers in the Eocene of Red Bluff, and scattered samples at Sepugla River and GGS-3535.

APPENDIX 2 DATA TABLES

REDBLUFF SECTION
SPECIES LIST

1) *Spiroplectammina curta*
2) *Spiroplectammina mississippiensis*
3) *Spiroplectammina alabamensis*
4) *Spiroplectammina pseudoelongata*
5) *Spiroplectammina gracilenta*
6) *Spiroplectammina spp.*
7) *Gaudyrina jacksonensis*
8) *Gaudyrina stavensis*
9) *Gaudyrina spp.*
10) *Liebosella bryamensis turgida*
11) *Textularia dibollensis*
12) *Textularia distincta*
13) *Textularia hannai*
14) *Textularia ouachitaensis*
15) *Textularia spp*
16) *Pseudoclavulina cocoaensis*
17) *Spirillina vicksburgensis*
18) *Spiroloculina lisbonensis*
19) *Massilina cookei*
20) *Massilina decorata*
21) *Massilina yazooensis*
22) *Massilina spp.*
23) *Quinqueloculina constans*
24) *Quinqueloculina mauricensis apertaexpansa*
25) *Quinqueloculina mauricensis*
26) *Quinqueloculina harrisi*
27) *Quinqueloculina hermosa*
28) *Quinqueloculina stavensis*
29) *Quinqueloculina substriata*
30) *Quinqueloculina yeguaensis*
31) *Quinqueloculina spp*
32) *Prygo sp. aff. inornata*
33) *Triloculina subrotunda*
34) *Triloculina subtumidifrons*
35) *Triloculina spp.*
36) *Miliola jacksonensis*
37) *Miliola saxamorum*
38) *. Comuspira lisbonensis*
39) *Articulina bryamensis*
40) *Articulina terquemi*
41) *Articulina spp*
42). *Articulina advena*
43) *Dentalina cf. communis*
44) *Dentalina cucarensis*
45) *Dentalina cocoaensis*
46) *Dentalina cooperensis*
47) *Dentalina indifferens*
48) *Dentalina jacksonensis*
49) *Dentalina vertebralis albatrossi*
50) *Dentalina spp.*
51) *Nodosaria longiscata*
52) *Lanksterina nuda*
53) *Saracenaria bottcheri*
54) *Saracenaria moresiana*
55) *Saracenaria spp.*
56) *Dimorphina danvillensis*
57) *Lenticulina alatolimbatus*
58) *Lenticulina carolinianus*
59) *Lenticulina convergens*
60) *Lenticulina euglypheus*
61) *Lenticulina inusitatus*
62) *Lenticulina jugosus*
63) *Lenticulina pseudovortex*
64) *Lenticulina vicksburgensis*
65) *Lenticulina westermanni*
66) *Lenticulina sp. 1*
67) *Lenticulina sp. 2*
68) *Astacolus sublituus*
69) *Astocolus danvillensis*
70) *Astocolus spp.*
71) *Marginulina cocaensis*
72) *Marginulina hantkeni*
73) *Marginulina stavensis*
74) *Marginulina spp.*
75) *Flabellinella c. f. lanceolata*
76) *Glandulina occidentalis*
77) *Glandulina spp.*
78) *Lagena humifera*
79) *Lagena hexagona*
80) *Lagena gracilcosta*
81) *Lagena ouachitaensis alabamensis*
82) *Lagena wallacei*
83) *Lagena spp.*
84) *Fissurina crassicarnata*
85) *Fissurina mauricensis*
86) *Bifarina vicksburgensis*
87) *Nonion advena*
88) *Nonion inexcavatus*
89) *Nonion mauricensis*
90) *Nonion nicobarensis*
91) *Nonion spp.*
92) *Nonionella jacksonensis*
93) *Florilus spissa*
94) *Pullenia quinqueloba aplata*
95) *Alabamina spp.*
96) *Gyroidina obesa*
97) *Globulina gibba*
98) *Globulina tuberculata*
99) *Guttalina bryamensis*
100) *Guttalina consobrina*

101) *Guttalina hantkeni*
102) *Guttalina spp.*
103) *Brizalina alazanensis*
104) *Bolivina dalli*
105) *Brizalina huneri*
106) *Bolivina mississippiensis*
107) *Brizalina retifera*
108) *Brizalina salebrosa*
109) *Brizalina striatellata*
110) *Bolivina sp. 1*
111) *Bolivina sp. 2 (Aplanata)*
112) *Cassidulina armosa*
113) *Cassidulina braziliensis*
114) *Globocassidulina subglobosa*
115) *Bulimina jacksonensis*
116) *Buliminella biformata*
117) *Buliminella elgantissima*
118) *Buliminella longicamerata*
119) *Buliminella pulchra*
120) *Buliminella spp.*
121) *Bitubulogenerina howei*
122) *Loxostomum baculum*
123) *Loxostomum serrula*
124) *Loxostomum sp. 1*
125) *Bolivinella rugosa*
126) *Uvigerina gardnerae*
127) *Uvigerina glabrans*
128) *Uvigerina jacksonensis*
129) *Reussella moodyensis*
130) *Reussella sculptilis*
131) *Fursenkoina dibollensis*
132) *Fursenkoina spp.*
133) *Nodogeneria annulospinosa*
134) *Nodogeneria cocoaensis*
135) *Nodogeneria spp.*
136) *Angulogerina bryamensis*
137) *Angulogerina danvillensis*
138) *Angulogerina vicksburgensis*
139) *Trifarina spp.*
140) *Cibicides cocoaensis*
141) *Cibicides lobatulus*
142) *Cibicides lobatus*
143) *Cibicides pippeni*
144) *Cibicides pseudoungerianus*
145) *Cibicides vicksburgensis*
146) *Cibicides sp. 1*
147) *Cibicides sp. 3*
148) *Hanzawaia danvillensis*
149) *Hanzawaia vicksburgensis*
150) *Hanzawaia walli*
151) *Hanzawaia sp. 1*
152) *Hanzawaia sp. 2*
153) *Hanzawaia sp. 3*
154) *Cancris claibornensis*
155) *Cancris cocoaensis*
156) *Cancris spp.*
157) *Eponides ellisorae*
158) *Eponides jacksonensis*
159) *Eponides lotus(?)*
160) *Eponides spp.*
161) *Gyroidina octocamerata*
162) *Valvulineria texana*
163) *Valvulineria spp.*
164) *Discorbis alveatus*
165) *Discorbis cocoaensis*
166) *Discorbis globulospinosa*
167) *Discorbis hemisphaericus*
168) *Discorbis sp. cf. bulla*
169) *Discorbis spp.*
170) *Trochulina packardi*
171) *Cibicidoides bilateralis*
172) *Discorbitura dignata*
173) *Pseudoparrella danvillensis*
174) *Siphonina advena*
175) *Siphonina danvillensis*
176) *Planulina cocoaensis*
177) *Planulina cooperensis*
178) *Planulina venezulana*
179) *Planulina subinflata*
180) *Planulina spp.*
181) *Planuorbulina spp.*
182) *Rotalia similas*
183) *Sphaerogypsina globulus*
184) *Unknown sp. A*

		SPECIES																								
	SAMPLE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
OLIGOCENE	RB-21	4	39	3	1	0	0	0	0	0	0	0	0	0	1	0	0	4	0	0	0	0	0	0	0	0
	RB-20	5	51	33	3	0	0	0	0	0	1	0	4	0	12	0	1	12	13	0	0	0	0	0	0	14
	RB-19B	0	64	78	5	1	0	0	0	0	5	4	7	0	38	4	0	0	0	0	1	0	1	1	0	74
	RB-18	6	27	13	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	4
	RB-17	2	31	21	0	0	0	0	0	0	0	0	0	0	0	0	0	7	3	0	1	0	3	0	0	0
	RB-16	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	RB-15	0	25	25	9	0	0	0	0	0	0	2	2	0	23	0	0	5	0	0	0	0	0	0	8	42
	RB-14	0	29	14	1	0	0	0	0	0	0	0	0	0	0	0	0	4	17	0	0	0	0	0	15	0
	SR-9	2	22	17	3	0	0	0	1	0	1	0	0	0	0	0	0	1	3	1	0	1	0	3	11	0
	SR-8	26	20	10	0	2	0	0	0	0	0	2	2	7	0	0	0	0	3	0	2	2	0	0	7	6
	SR-5	94	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	SR-4	159	7	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	SR-3	45	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
	SR-2	12	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
EOCENE	SR-1	61	7	8	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	SR-11	23	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR-12	33	15	2	0	0	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR-13	39	0	3	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR-14	13	0	6	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR-15	30	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR-16	19	12	0	0	0	3	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR-17	25	0	3	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR-18	18	0	7	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-1	66	0	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR-20	47	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-2	6	2	5	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

		SPECIES																								
	SAMPLE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
EOCENE	SR-22	41	0	6	0	0	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR-23	63	1	7	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-3	37	5	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR-25	60	4	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR-27	81	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-4	105	4	4	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-5	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-6	60	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-7	11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-8	79	25	5	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-9	85	13	8	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
	RB-10	9	31	9	17	0	0	44	0	0	0	2	7	0	6	0	0	0	0	0	10	3	0	0	0	0
	RB-11	4	10	3	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	1	3	1	0	1	2	0
	RB-12	1	0	0	2	0	0	0	0	0	0	0	1	8	0	0	0	0	0	1	6	1	0	0	0	0
	RB-13	6	23	2	0	4	0	0	6	0	0	0	0	0	1	0	0	0	0	0	3	0	0	0	3	0

		SPECIES																								
	SAMPLE	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
OLIGOCENE	RB-21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-20	0	0	0	3	8	11	0	2	0	0	0	0	0	5	15	0	25	0	0	0	0	0	0	0	0
	RB-19B	10	1	7	24	32	0	0	20	0	0	7	0	3	0	0	0	15	0	0	0	0	4	0	0	0
	RB-18	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
	RB-17	0	0	0	15	3	0	0	1	15	0	0	0	0	0	1	0	13	0	0	0	0	1	0	0	0
	RB-16	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-15	0	0	0	0	9	0	0	6	0	2	0	0	0	16	0	0	10	0	0	0	0	0	0	0	0
	RB-14	0	0	0	1	7	0	5	0	0	0	0	4	0	13	0	3	11	0	2	0	0	0	0	0	1
	SR-9	0	0	0	5	5	0	0	3	0	0	3	0	0	0	0	0	3	0	0	0	0	0	0	0	0
	SR-8	0	0	0	0	7	0	0	1	0	0	0	0	0	1	0	0	8	0	0	0	0	0	0	0	0
	SR-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR-3	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
EOCENE	SR-1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	SR-13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	SR-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	SR-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	1	0	0
	SR-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	SR-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	SR-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

		SPECIES																								
	SAMPLE	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
EOCENE	SR-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0
	SR-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	RB-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
	SR-25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2
	SR-27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	RB-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	RB-5	0	0	0	0	2	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	RB-6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-8	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-9	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	4	0
	RB-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	3	3	1	23	3	0
	RB-11	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-12	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	RB-13	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	3	0	2	0	5	1	0	2

		SPECIES																							
	SAMPLE	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
OLIGOCENE	RB-21	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0
	RB-20	0	1	0	0	0	0	0	0	0	0	0	0	0	3	0	1	4	0	0	0	0	0	0	0	0
	RB-19B	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	.0	0	1	1	0	0	0	0	0
	RB-18	0	2	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
	RB-17	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	1	0
	RB-16	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0
	RB-15	0	1	0	1	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0
	RB-14	0	1	0	0	0	0	0	0	2	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0
	SR-9	0	0	0	0	0	0	4	0	0	1	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0
	SR-8	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	SR-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	SR-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR-3	0	0	0	1	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR-2	0	0	0	2	0	0	0	0	0	1	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0
EOCENE	SR-1	0	1	0	1	0	0	8	0	0	13	0	0	5	0	0	1	3	0	0	0	0	0	0	0	0
	SR-11	0	0	0	0	0	0	3	0	0	2	0	0	12	0	0	0	0	4	0	0	0	0	0	0	0
	SR-12	0	0	1	2	0	0	9	0	1	1	0	6	5	0	0	1	0	3	0	0	0	0	0	1	0
	SR-13	2	1	0	1	0	0	6	0	0	0	0	2	3	0	0	2	0	3	0	0	0	0	0	1	0
	SR-14	0	0	0	1	0	0	1	0	0	0	0	0	4	0	0	1	0	1	0	0	0	0	0	0	0
	SR-15	0	0	0	0	2	0	6	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
	SR-16	0	0	0	0	0	0	3	0	0	0	0	0	6	0	0	2	0	2	0	0	0	0	0	1	0
	SR-17	1	0	0	3	0	0	1	0	0	4	0	0	4	0	0	1	1	1	0	0	0	0	0	0	0
	SR-18	2	0	0	2	0	0	1	0	1	0	0	0	2	0	0	2	3	1	0	0	0	0	0	0	0
	RB-1	0	0	0	2	0	0	1	0	0	0	0	0	3	0	0	1	1	1	0	0	0	0	0	0	0
	SR-20	0	0	0	1	0	0	0	0	0	0	0	0	5	0	0	0	0	2	0	0	0	0	0	0	0
	RB-2	0	0	0	4	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0

		SPECIES																								
	SAMPLE	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
EOCENE	SR-22	1	0	0	3	0	0	3	0	1	0	0	0	8	0	0	0	4	0	0	0	0	0	0	0	1
	SR-23	0	0	0	1	0	0	3	0	0	0	0	0	4	0	0	3	0	0	0	0	2	0	1	1	0
	RB-3	0	0	0	0	0	0	3	0	0	0	0	0	4	0	0	0	3	0	0	0	0	0	0	0	0
	SR-25	0	0	0	1	0	0	4	0	0	0	0	0	4	0	0	2	0	0	0	0	0	0	0	1	0
	SR-27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
	RB-4	2	0	0	2	0	0	1	0	0	1	0	0	5	0	0	0	0	0	0	0	1	0	0	0	0
	RB-5	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0
	RB-6	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	6	0	0	0	0	0	0	2	0
	RB-7	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0
	RB-8	0	0	0	4	0	2	1	0	0	0	0	0	6	0	0	0	0	1	0	0	0	0	0	2	0
	RB-9	0	0	4	7	0	1	7	1	8	0	1	0	12	0	0	5	0	1	0	1	3	0	0	0	0
	RB-10	3	0	0	2	1	0	4	2	0	14	2	0	18	6	0	5	4	2	0	0	13	1	0	0	0
	RB-11	4	0	0	0	0	2	5	1	0	0	0	4	4	1	0	0	1	0	0	0	0	0	0	2	0
	RB-12	0	1	0	0	0	0	1	0	0	0	4	1	6	0	2	2	1	0	0	0	1	0	0	0	0
	RB-13	0	0	1	0	0	1	4	0	0	0	1	0	9	0	0	0	0	0	0	0	0	0	0	0	0

		SPECIES																								
	SAMPLE	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
OLIGOCENE	RB-21	0	0	0	1	0	0	0	0	0	2	0	0	6	0	48	0	13	0	0	0	1	4	1	3	0
	RB-20	0	0	0	0	0	0	0	0	5	0	6	0	0	1	7	7	14	11	0	0	1	0	0	10	0
	RB-19B	0	0	0	0	0	0	0	3	0	2	0	2	4	0	0	0	13	6	0	0	0	1	0	1	0
	RB-18	0	0	3	0	1	0	0	0	2	20	9	0	13	0	14	2	16	3	0	0	0	0	4	4	5
	RB-17	0	0	0	0	1	0	0	0	11	3	2	0	0	0	13	5	15	9	1	0	0	0	0	3	3
	RB-16	0	0	0	0	0	0	0	0	1	0	5	0	0	0	10	0	4	0	0	0	0	0	0	0	0
	RB-15	0	0	1	0	0	0	0	0	3	0	1	0	1	0	5	0	1	8	0	0	0	1	0	2	1
	RB-14	0	0	2	0	0	0	0	1	17	1	2	0	0	0	4	3	29	11	0	0	3	0	0	4	0
	SR-9	0	0	1	0	0	0	0	0	0	0	1	6	0	0	9	1	6	1	0	0	3	1	0	3	0
	SR-8	0	1	0	0	0	0	0	0	1	1	0	10	1	0	12	3	13	7	1	0	2	0	0	1	0
	SR-5	0	0	0	0	0	0	0	0	0	1	1	5	5	0	7	0	3	6	0	3	0	0	0	1	0
	SR-4	0	0	0	0	0	0	0	0	0	1	1	8	9	0	51	5	7	10	0	0	2	1	0	2	0
	SR-3	0	0	0	1	0	1	0	0	0	1	2	15	0	0	0	0	11	0	0	0	0	0	0	2	0
	SR-2	0	0	0	0	0	0	27	0	0	0	1	0	2	0	0	0	0	3	3	0	0	0	0	0	0
EOCENE	SR-1	0	0	0	0	2	1	2	1	0	2	2	1	5	0	0	0	9	1	1	0	0	4	2	2	0
	SR-11	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	3	10	0	0	0	0	0	0	0	0
	SR-12	1	0	1	0	0	0	0	0	1	3	0	0	0	0	0	5	6	0	4	0	0	0	0	0	0
	SR-13	0	0	1	0	4	0	0	0	2	2	0	0	0	0	0	0	6	2	0	0	0	1	0	0	0
	SR-14	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
	SR-15	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
	SR-16	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	5	0	3	0	0	0	0	0	0
	SR-17	0	0	3	0	0	0	2	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	1	0
	SR-18	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0
	RB-1	0	0	1	0	0	0	5	0	0	2	0	0	0	0	1	0	4	0	0	0	0	0	0	0	0
	SR-20	0	0	3	0	0	0	0	2	0	0	0	0	0	0	0	1	13	0	0	0	0	0	0	0	0
	RB-2	0	0	0	0	2	3	4	0	0	0	0	0	0	0	1	1	21	0	0	0	0	0	0	0	0

		SPECIES																								
	SAMPLE	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
EOCENE	SR-22	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0
	SR-23	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-3	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR-25	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
	SR-27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	1	1	0	0
	RB-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-6	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
	RB-7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RB-8	0	0	0	0	0	2	0	0	0	2	2	0	0	0	0	0	10	0	0	0	0	0	0	0	0
	RB-9	0	0	0	0	2	2	0	1	3	3	0	0	0	0	0	0	16	0	4	0	0	0	0	2	0
	RB-10	0	7	2	0	0	0	0	0	0	0	0	0	0	0	0	0	8	6	5	0	0	0	0	3	0
	RB-11	0	0	0	0	0	0	0	0	2	8	1	0	0	0	0	0	9	5	5	0	0	2	0	0	0
	RB-12	0	0	1	1	0	0	2	0	0	0	3	0	0	0	0	0	4	4	5	0	0	1	0	0	0
	RB-13	0	3	8	1	1	0	1	2	0	8	0	0	0	0	0	0	18	0	7	0	0	1	0	5	0

		SPECIES																								
	SAMPLE	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125
OLIGOCENE	RB-21	0	0	32	0	0	0	11	76	39	3	14	136	4	0	0	0	1	0	1	0	5	43	0	9	8
	RB-20	0	0	20	0	0	0	9	44	26	0	7	186	0	5	0	0	1	0	8	0	3	29	0	4	12
	RB-19B	1	0	9	0	15	0	0	54	5	0	0	217	0	14	0	0	1	1	2	0	1	2	0	0	6
	RB-18	0	0	15	0	9	0	25	84	40	3	4	354	0	4	3	0	2	5	6	0	2	17	0	0	18
	RB-17	0	0	34	2	5	0	0	77	32	1	4	301	0	1	0	0	0	5	21	0	5	18	0	1	29
	RB-16	0	0	12	0	2	0	0	4	6	0	0	17	0	2	0	0	0	0	0	0	0	7	0	1	2
	RB-15	0	4	10	0	1	0	0	13	2	0	5	31	0	0	0	0	0	0	3	0	4	11	0	0	8
	RB-14	2	3	27	9	6	0	0	101	77	2	18	426	0	4	0	0	4	0	20	0	4	20	0	1	56
	SR-9	0	0	8	0	0	0	3	26	15	0	0	7	0	8	0	0	0	0	3	0	1	7	0	2	4
	SR-8	1	1	20	1	5	0	0	47	36	0	2	7	2	0	0	0	0	1	2	0	0	5	0	0	0
	SR-5	1	0	9	1	6	0	0	25	33	1	7	22	0	2	2	0	0	0	0	0	0	7	0	0	0
	SR-4	0	0	6	11	16	0	0	40	62	0	2	34	0	4	0	0	2	0	1	0	0	5	0	1	1
	SR-3	0	0	11	0	3	0	0	19	27	0	0	15	0	1	11	0	1	0	4	0	0	6	0	0	0
	SR-2	0	0	23	0	3	0	18	0	0	46	0	0	0	4	46	0	0	0	0	0	0	23	1	6	4
EOCENE	SR-1	0	0	15	23	0	0	2	66	38	0	0	4	0	3	57	0	1	0	0	0	0	12	0	0	0
	SR-11	0	1	16	45	11	2	0	2	0	0	0	0	0	2	148	4	0	0	3	0	0	3	0	10	0
	SR-12	0	0	6	23	0	0	0	53	8	5	4	0	0	9	96	0	0	3	0	0	0	9	0	23	0
	SR-13	0	0	0	39	2	0	0	41	7	5	0	0	1	9	198	1	0	1	4	0	0	11	0	48	0
	SR-14	0	0	0	14	0	0	0	10	7	2	0	0	0	0	45	0	0	0	4	0	0	1	0	5	0
	SR-15	0	0	0	15	1	0	0	0	1	0	0	0	0	0	55	0	0	0	6	0	0	1	0	1	0
	SR-16	0	0	0	9	0	0	0	16	1	3	0	0	0	7	143	0	0	2	1	0	0	6	0	1	0
	SR-17	0	0	6	149	4	0	0	30	7	0	0	0	0	0	55	2	0	0	0	0	0	2	0	67	0
	SR-18	0	0	0	10	1	0	0	8	0	0	3	0	0	4	151	0	0	2	0	0	0	4	0	10	0
	RB-1	0	0	0	30	2	0	0	13	15	0	0	0	0	2	81	0	0	4	5	0	0	4	7	3	0
	SR-20	0	2	0	25	0	0	0	20	7	0	0	0	0	1	145	0	0	4	0	0	0	9	0	32	0
	RB-2	1	0	0	15	0	0	0	13	0	0	0	0	0	6	113	0	0	0	13	0	0	9	0	14	0

		SPECIES																								
	SAMPLE	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125
EOCENE	SR-22	0	0	26	112	3	0	0	18	17	24	0	0	0	17	86	3	0	4	0	0	0	3	0	3	0
	SR-23	0	0	9	168	0	0	0	14	4	6	0	0	0	1	63	2	0	0	14	0	0	6	0	6	0
	RB-3	0	0	0	26	2	0	0	30	0	9	0	0	0	1	169	0	0	0	25	0	0	0	0	20	0
	SR-25	0	0	2	45	5	0	0	98	1	5	0	0	0	7	206	0	0	0	11	0	0	1	0	33	0
	SR-27	0	0	8	57	0	0	0	24	2	0	0	0	0	1	139	0	0	0	0	0	0	1	0	16	0
	RB-4	0	0	6	89	2	0	2	10	10	16	5	0	0	2	79	0	0	0	2	3	0	16	0	9	0
	RB-5	0	1	8	26	0	0	0	1	5	3	0	0	0	0	10	0	0	0	1	0	0	2	0	5	0
	RB-6	0	0	11	57	0	0	0	17	11	25	2	0	0	3	62	0	0	0	2	0	0	1	0	4	0
	RB-7	0	0	3	21	0	0	0	4	1	9	0	0	0	5	25	1	0	0	5	0	0	3	0	3	0
	RB-8	1	2	3	44	6	0	0	18	31	34	2	0	12	4	49	0	0	2	17	0	0	4	1	2	0
	RB-9	0	0	17	54	5	0	0	168	7	38	0	0	0	21	40	11	0	4	37	0	0	62	0	12	0
	RB-10	0	1	30	10	0	0	16	3	38	7	0	0	5	4	41	1	0	17	6	0	0	21	0	1	0
	RB-11	0	0	10	0	0	0	2	4	9	1	1	0	10	13	16	0	0	0	1	0	0	16	0	4	0
	RB-12	0	1	0	3	0	0	4	3	2	0	0	0	13	7	8	0	2	0	3	0	0	8	3	0	0
	RB-13	0	3	3	4	4	0	0	16	8	0	13	0	40	16	0	0	0	6	16	0	0	28	31	4	0

		SPECIES																								
	SAMPLE	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
OLIGOCENE	RB-21	2	1	26	0	6	4	0	0	0	0	23	9	1	0	0	0	7	155	42	0	0	6	94	16	0
	RB-20	3	1	39	1	24	3	0	0	0	0	57	20	11	0	8	5	25	304	96	0	0	20	73	120	0
	RB-19B	4	0	21	10	18	5	0	0	0	0	69	21	11	0	2	0	15	279	42	3	6	0	79	114	0
	RB-18	0	1	26	6	24	4	0	0	0	0	74	2	9	0	1	1	21	191	57	0	0	8	131	52	0
	RB-17	1	3	27	9	35	3	0	0	0	0	62	14	8	0	0	0	6	205	8	2	2	3	135	13	0
	RB-16	0	0	6	0	0	2	0	0	0	0	2	5	2	0	0	0	0	46	0	0	0	0	13	2	0
	RB-15	0	0	6	3	4	1	0	0	0	0	12	17	4	0	0	0	4	107	10	7	0	0	36	30	2
	RB-14	2	6	25	8	52	4	0	0	0	0	54	26	5	0	0	0	12	303	5	0	0	2	173	30	2
	SR-9	1	0	21	1	12	3	0	0	0	0	12	4	2	0	3	0	4	77	23	0	0	3	47	29	3
	SR-8	0	0	31	0	0	2	0	0	0	0	14	26	2	1	1	0	0	94	28	0	0	0	43	21	0
	SR-5	0	0	7	2	0	2	0	0	0	0	0	10	1	1	0	0	0	32	6	0	1	0	17	1	0
	SR-4	0	0	27	0	0	1	0	0	0	0	5	21	0	2	0	0	0	9	32	0	0	0	0	0	0
	SR-3	0	0	60	0	0	0	0	0	0	0	0	7	1	0	0	0	0	5	1	0	0	0	13	2	0
	SR-2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	16	2	0	0	45	11	0	0	0	10
EOCENE	SR-1	5	0	175	5	0	2	0	0	0	0	6	31	0	0	0	0	4	37	0	0	0	0	68	13	0
	SR-11	5	0	160	0	0	0	0	23	0	9	5	48	0	0	0	0	4	0	0	0	0	0	15	39	0
	SR-12	11	0	86	1	0	0	0	4	0	0	10	25	0	0	0	0	12	0	0	0	0	0	12	13	0
	SR-13	8	1	204	0	0	0	0	7	0	0	12	30	2	0	0	0	3	0	0	0	0	0	24	36	0
	SR-14	7	2	69	0	0	0	0	5	0	0	8	16	0	0	0	0	3	0	0	0	0	0	5	12	0
	SR-15	7	0	63	0	0	1	0	4	0	0	0	3	0	0	0	0	0	0	0	0	0	0	4	33	0
	SR-16	16	0	148	1	0	0	0	5	0	0	8	30	0	0	0	0	3	0	0	0	0	0	5	37	0
	SR-17	1	0	73	0	0	0	0	6	0	2	0	5	0	0	0	0	0	0	0	0	0	2	2	40	0
	SR-18	8	0	128	0	0	0	1	7	0	0	2	8	0	0	1	0	0	0	4	0	0	1	0	18	0
	RB-1	11	3	169	0	0	0	0	8	0	0	6	83	0	0	0	0	0	0	0	0	0	0	13	32	0
	SR-20	6	0	123	0	0	0	0	5	0	0	0	15	0	0	0	0	0	0	1	0	0	0	7	20	0
	RB-2	3	0	93	0	0	0	0	2	2	0	5	7	0	0	0	0	3	1	0	1	0	0	0	22	0

		SPECIES																								
	SAMPLE	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
EOCENE	SR-22	30	0	135	2	0	2	1	8	0	0	75	94	0	0	0	0	10	0	2	0	0	0	6	32	0
	SR-23	11	0	123	0	0	0	0	8	0	0	0	18	0	0	0	0	3	0	0	0	0	2	0	0	0
	RB-3	7	0	107	0	0	0	0	10	0	0	0	11	0	0	0	0	0	2	0	0	0	0	2	2	0
	SR-25	2	0	158	0	0	1	0	7	0	0	14	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	SR-27	4	1	191	0	0	0	0	0	0	0	10	27	0	0	0	0	0	0	0	0	0	0	1	2	0
	RB-4	17	4	100	1	0	0	0	11	0	0	2	35	0	1	0	0	0	0	0	0	0	0	6	1	0
	RB-5	3	0	40	1	0	0	0	3	0	0	0	2	0	0	0	0	1	3	0	0	0	0	4	2	0
	RB-6	6	0	58	0	0	0	1	4	0	0	0	26	0	0	0	0	3	3	0	0	0	1	0	0	0
	RB-7	3	2	28	0	0	0	0	3	0	0	0	10	0	0	0	0	1	0	0	0	0	0	0	0	0
	RB-8	21	0	33	0	0	6	0	9	0	0	1	21	0	0	1	0	3	0	0	0	0	0	29	30	0
	RB-9	20	3	222	6	0	1	0	3	0	0	1	262	1	0	3	0	39	0	0	0	0	0	15	6	0
	RB-10	25	1	221	22	0	6	0	8	12	0	3	51	0	0	7	0	16	0	0	0	0	0	28	3	20
	RB-11	16	2	59	31	0	2	0	0	0	0	0	35	0	0	1	0	0	4	0	0	0	0	15	0	0
	RB-12	13	0	26	19	0	1	0	0	0	0	0	11	0	0	0	0	2	0	1	0	0	0	1	3	0
	RB-13	5	1	51	63	0	3	0	0	0	0	0	85	0	0	0	0	2	2	0	0	0	1	23	1	0

		SPECIES																								
	SAMPLE	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175
OLIGOCENE	RB-21	6	6	0	0	0	0	0	3	114	0	19	1	11	16	1	0	4	1	0	0	16	4	7	39	3
	RB-20	7	14	0	0	0	0	0	5	166	0	35	7	25	68	2	3	11	15	0	0	55	10	20	84	4
	RB-19B	3	0	0	15	5	0	4	4	52	0	24	0	12	65	11	0	0	11	8	0	64	14	0	97	14
	RB-18	11	3	0	1	0	3	2	3	81	2	0	6	8	58	6	3	6	11	0	0	8	11	45	23	0
	RB-17	13	1	0	0	0	5	0	3	27	0	3	5	11	68	24	0	7	9	0	0	56	1	12	16	0
	RB-16	0	0	0	0	0	0	0	0	17	0	8	0	0	6	0	0	0	0	0	0	0	0	4	8	0
	RB-15	3	5	0	0	0	3	0	4	13	0	4	2	1	25	0	0	9	0	0	0	18	2	4	42	4
	RB-14	9	11	0	0	0	2	0	1	90	1	2	2	11	102	1	0	8	0	6	0	16	8	15	32	4
	SR-9	1	2	0	0	0	0	4	12	15	3	20	1	2	26	1	1	2	2	0	0	14	1	6	82	8
	SR-8	2	0	2	0	0	1	2	0	24	0	22	2	0	11	5	5	3	0	0	0	7	0	18	34	0
	SR-5	5	0	2	0	0	0	0	0	21	41	2	4	2	6	3	0	0	0	0	0	0	0	57	14	0
	SR-4	0	0	0	0	0	0	0	0	13	14	5	11	2	12	1	2	0	2	0	0	2	0	125	9	0
	SR-3	3	3	0	0	0	0	0	0	3	0	13	3	2	4	8	1	0	0	0	0	3	0	54	18	0
	SR-2	2	0	0	0	0	0	0	8	51	0	0	0	0	0	39	15	0	0	0	0	39	0	95	0	0
EOCENE	SR-1	14	2	0	0	0	0	0	0	0	0	20	4	4	3	63	2	0	2	0	3	21	0	72	67	10
	SR-11	0	0	0	0	0	0	0	49	0	1	2	0	5	0	46	0	0	0	0	7	4	0	0	46	18
	SR-12	14	0	0	0	0	0	0	1	53	0	0	1	21	0	11	0	0	0	2	13	3	0	223	102	1
	SR-13	13	0	0	0	0	0	0	7	66	0	3	0	54	0	2	0	0	0	0	2	0	0	222	49	4
	SR-14	7	0	0	0	0	0	0	4	23	0	0	0	35	0	1	0	0	0	0	3	0	0	113	34	3
	SR-15	0	0	0	0	0	0	0	0	7	0	0	0	4	0	19	0	0	0	0	3	0	0	86	12	8
	SR-16	12	0	0	0	0	0	0	3	31	0	0	0	34	0	1	0	0	0	0	9	0	0	158	38	3
	SR-17	0	0	0	0	0	0	0	2	0	0	0	0	16	0	6	0	0	0	1	0	0	0	66	3	1
	SR-18	2	0	0	0	0	0	0	0	17	7	0	0	8	0	5	0	0	0	0	6	0	0	52	16	0
	RB-1	9	0	0	0	0	0	0	5	39	0	0	0	59	0	12	0	0	0	0	3	0	0	254	48	0
	SR-20	0	0	0	0	0	0	0	5	46	0	0	2	2	0	11	0	0	0	0	7	0	0	202	26	3
	RB-2	0	0	4	0	0	0	0	11	48	10	13	0	0	0	21	0	0	0	0	0	0	0	0	2	4

		SPECIES																								
	SAMPLE	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175
EOCENE	SR-22	0	0	0	0	0	0	0	1	131	0	5	5	5	0	0	0	0	0	0	0	0	0	89	25	0
	SR-23	16	0	0	0	0	0	0	0	50	0	0	5	3	0	63	0	0	0	0	0	0	0	157	3	0
	RB-3	5	0	0	0	0	0	0	0	56	0	5	9	13	0	8	0	0	0	0	0	0	0	63	24	0
	SR-25	6	0	0	0	0	0	0	0	58	0	0	3	14	0	24	0	0	0	0	3	0	0	124	29	4
	SR-27	5	0	5	0	0	0	0	0	7	0	0	0	2	0	0	0	0	0	0	0	0	0	24	2	0
	RB-4	28	0	0	0	0	0	0	0	87	0	0	9	8	0	30	0	0	0	1	0	4	0	200	7	0
	RB-5	6	0	0	0	0	0	0	0	34	0	0	1	1	3	8	0	0	0	0	0	0	0	43	0	0
	RB-6	1	0	0	0	0	0	0	0	82	0	0	5	2	1	11	0	0	0	0	0	0	0	92	7	0
	RB-7	2	0	0	0	0	0	0	0	29	0	1	2	4	0	15	0	0	0	0	0	0	0	32	3	0
	RB-8	41	0	0	0	0	0	0	3	555	0	0	22	14	1	1	0	0	0	0	0	9	0	422	52	0
	RB-9	7	0	0	0	15	0	0	3	12	0	0	30	29	0	0	0	0	0	6	10	29	0	26	79	0
	RB-10	9	19	0	0	0	0	19	8	11	0	0	9	8	0	0	0	0	0	0	44	35	0	20	159	10
	RB-11	5	2	0	0	0	0	0	0	27	11	0	16	22	2	0	1	0	0	0	4	7	0	61	87	0
	RB-12	1	0	0	0	0	0	0	3	1	0	1	4	14	0	0	0	0	0	0	2	22	0	24	42	0
	RB-13	12	0	0	0	0	0	0	6	65	0	3	17	44	3	0	1	0	0	0	11	29	0	166	192	4

		SPECIES										
	SAMPLE	176	177	178	179	180	181	182	183	184	TOTAL NUMBER OFSPECIMENS	NUMBER OF SPECIES
OLIGOCENE	RB-21	0	0	0	0	0	0	0	0	0	1161	60
	RB-20	0	0	0	0	0	1	8	0	0	1993	72
	RB-19B	0	0	0	3	0	0	0	0	0	1876	72
	RB-18	0	0	0	0	0	0	0	0	0	1650	78
	RB-17	0	0	0	0	0	0	2	3	0	1525	78
	RB-16	0	0	0	0	0	0	0	0	0	209	30
	RB-15	0	0	0	4	0	0	0	0	1	692	84
	RB-14	0	0	0	0	0	0	1	6	0	2027	84
	SR-9	1	0	0	0	0	0	0	0	0	659	71
	SR-8	0	0	1	1	0	0	1	1	0	697	74
	SR-5	0	0	1	0	0	0	0	0	0	485	47
	SR-4	0	0	0	0	0	0	0	0	3	748	56
	SR-3	0	0	0	0	0	0	0	0	6	400	48
	SR-2	3	0	0	0	0	0	0	0	13	594	63
EOCENE	SR-1	3	0	3	0	0	0	0	0	19	1026	74
	SR-11	0	6	6	0	0	0	0	0	12	853	47
	SR-12	0	1	8	0	0	0	0	0	32	1005	61
	SR-13	0	0	11	0	0	0	0	0	19	1230	59
	SR-14	0	0	8	0	0	0	0	0	13	496	40
	SR-15	0	0	4	0	0	0	0	0	3	390	35
	SR-16	0	0	7	0	5	0	0	0	21	829	50
	SR-17	0	17	9	0	0	0	0	0	7	641	46
	SR-18	0	0	10	0	0	0	0	0	13	558	47
	RB-1	3	0	2	0	0	0	0	0	59	1082	46
	SR-20	0	11	5	0	0	0	0	0	8	827	48
	RB-2	13	0	2	1	0	0	0	0	0	506	57

		SPECIES										
	SAMPLE	176	177	178	179	180	181	182	183	184	TOTAL NUMBER OFSPECIMENS	NUMBER OF SPECIES
EOCENE	SR-22	0	1	8	0	0	0	0	0	12	1080	62
	SR-23	0	0	7	0	0	0	0	0	0	853	40
	RB-3	0	0	9	2	0	0	0	0	0	677	35
	SR-25	0	0	13	0	0	0	0	0	4	970	42
	SR-27	0	0	0	0	0	0	0	0	2	618	30
	RB-4	0	0	0	0	0	0	0	0	5	945	50
	RB-5	0	1	0	0	0	0	0	0	1	241	35
	RB-6	0	0	0	0	0	0	0	0	4	581	39
	RB-7	0	0	2	0	0	0	0	0	2	237	32
	RB-8	0	0	5	0	0	0	0	0	46	1701	55
	RB-9	0	18	2	0	0	0	0	0	11	1541	84
	RB-10	1	1	0	5	0	0	0	0	9	1272	88
	RB-11	1	4	0	0	0	0	0	0	11	605	77
	RB-12	3	0	0	1	0	0	0	0	3	318	69
	RB-13	4	0	0	0	1	0	0	0	6	1128	86

SEPUGLA RIVER SECTION
SPECIES LIST

1) *Spiroplectamimna alabamensis*
2) *Spiroplectammina mississippiensis*
3) *Spiroplectammina spp.*
4) *Liebusella bryamensis trugida*
5) *Gaudryina stavensis*
6) *Textularia distincta*
7) *Textularia dibollensis*
8) *Textularia ouachitaensis*
9) *Textularia spp.*
10) *Spirilllina vicksburgensis*
11) *Quinqueloculina spp.*
12) *Dentalina indifferens*
13) *Nodosaria longiscata*
14) *Lanksterina nuda*
15) *Dimorphina danvillensis*
16) *Lenticulina euglypheus*
17) *Lenticulina pseudovortex*
18) *Lenticulina rectidorsatus*
19) *Lenticulina sp. 1*
20) *Lenticulina spp.*
21) *Astoculus sublituus*
22) *Marginulina spp.*
23) *Lagena humifera*
24) *Lagena hexagona*
25) *Lagena spp.*
26) *Oolina sphearica*
27) *Fissurina crassicarnata*
28) *Fissurina mauricensis*
29) *Fissurina spp.*
30) *Nonion advena*
31) *Nonion inexcavatus*
32) *Nonion nicobarensis*
33) *Nonion spp.*
34) *Nonionella jacksonensis*
35) *Florulis spissa*
36) *Pullina quinquoloba aplanta*
37) *Gyroidina obesa*
38) *Globulina gibba*
39) *Guttalina bryamensis*
40) *Guttalina consorbina?*
41) *Guttalina communis*
42) *Guttalina spp.*
43) *Sigmophina jacksonensis*
44) *Bolivina mississippiensis*
45) *Bolivina sp. 1*
46) *Bolivina alazanensis*
47) *Brizalina dalli*
48) *Brizalina hunneri*
49) *Brizalina slabrosa*
50) *Brizalina retifera*
51) *Brizalina striatellata*
52) *Cassidulina alabamensis*
53) *Cassidulina armosa*
54) *Cassidulina brazilensis*
55) *Cassidulina spp.*
56) *Globocassidulina subglobosa*
57) *Bulimina jacksonensis*
58) *Bulimina trigona*
59) *Buliminella elgantissima*
60) *Buliminella pulchra*
61) *Bitubulogenerina howei*
62) *Loxostomum baculum*
63) *Uvigerina gardnerae*
64) *Uvigerina glabrans*
65) *Uvigerina jacksonensis*
66) *Reussella moodyensis*
67) *Reussella sculptilis*
68) *Reussella spp.*
69) *Fursenkoina dibollensis*
70) *Angulogerina bryamensis*
71) *Angulogerina danvillensis*
72) *Angulogerina vicksburgensis*
73) *Trifarina spp.*
74) *Cibicides cocoaensis*
75) *Cibicides lobatus*
76) *Cibicides lobatulus*
77) *Cibicides pippeni*
78) *Cibicides pseudoungeriansis*
79) *Cibicides vicksburgensis*
80) *Cibicides sp. 3*
81) *Cibicides spp.*
82) *Hanzawaia danvillensis*
83) *Hanzawaia mississippiensis*
84) *Hanzawaia sp. 1*
85) *Hanzawaia sp. 2*
86) *Cancris claibornesis*
87) *Cancris cocoaensis*
88) *Cancris spp.*
89) *Eponides jacksonensis*
90) *Eponides lotus*
91) *Eponides spp.*
92) *Gyroidina octocamerata*
93) *Valvulineria texana*
94) *Valvulineria spp.*
95) *Discorbis alveatus*
96) *Discorbis globulospinosa*
97) *Discorbis hemisphaericus*
98) *Cibicidoides bilateralis*
99) *Discorbitura diganata*
100) *Pseudoparrella danvillensis*
101) *Siphonina advena*

102) *Siphonina danvillensis*
103) *Siphonina spp.*
104) *Planulina cocoaensis*
105) *Planulina kendrickensis*
106) *Planulina subinflata*
107) *Planulina venzuelana*
108) *Planulina spp.*
109) *Planuorbulina cf. mediteranensis*
110) *Rotalia similas*
111) *Rotalia sp. 2*
112) *Rotalia spp.*
113) *Sphaerogypsina globulus*
114) *Astrogerina spp.*
115) *Unknowns sp. A*

		SPECIES																					
	SAMPLE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
OLIGOCENE	SP-23	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	2	1	0	2	0	0
	SP-22	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SP-21	0	0	0	0	0	0	0	10	0	5	0	0	0	0	0	0	2	0	0	1	0	0
	SP-20	2	1	0	1	6	0	1	0	1	0	0	0	0	1	0	0	1	0	0	1	0	0
	SP-19	3	4	0	0	0	0	0	4	0	0	0	0	0	1	0	0	3	0	0	0	0	0
	SP-18	0	0	0	0	0	0	0	6	10	0	0	0	0	2	0	2	0	0	1	1	0	0
	SP-17	2	0	0	0	0	0	0	1	0	17	0	0	0	1	0	0	0	0	1	1	0	0
	SP-16	0	0	0	0	0	5	0	7	0	24	0	1	0	0	0	1	0	0	0	2	0	0
	SP-15	0	0	1	0	0	0	0	0	3	0	1	0	0	0	1	1	1	0	0	4	0	2
	SP-14	0	0	1	0	0	0	0	2	0	0	1	0	2	0	0	0	0	0	0	0	0	0
	SP-13	7	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	2	0	0
EOCENE	SP-12	41	9	0	0	0	1	0	4	8	0	0	0	0	0	0	2	0	0	0	0	0	3
	SP11	1	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SP-10	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	SP-8	4	0	3	0	0	8	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	SP-7	1	4	0	0	0	19	0	8	2	0	0	0	0	1	0	0	0	0	0	2	0	0
	SP-6	0	0	3	0	0	28	1	13	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	SP-5	0	11	1	0	0	8	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SP-4	4	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SP-3	0	8	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	SP-2	2	5	0	0	0	0	0	0	2	0	0	0	1	0	0	0	3	0	1	3	1	0

		SPECIES																					
	SAMPLE	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
OLIGOCENE	SP-23	0	0	0	0	0	1	0	0	0	0	1	5	2	0	0	3	0	0	0	1	0	3
	SP-22	0	0	0	0	0	0	2	0	0	0	1	2	0	0	0	0	1	0	0	0	0	0
	SP-21	3	1	0	0	0	0	0	0	0	0	1	9	4	0	0	1	0	0	0	2	0	0
	SP-20	3	0	1	0	0	0	1	0	0	0	0	0	6	0	0	4	1	0	1	0	0	2
	SP-19	2	0	0	0	1	0	0	7	4	0	0	0	1	0	2	3	0	0	0	1	0	0
	SP-18	4	2	0	0	1	0	0	1	0	13	0	0	0	0	0	2	2	0	0	0	0	0
	SP-17	0	0	0	0	0	0	0	0	2	4	0	0	0	1	4	5	0	0	0	1	0	0
	SP-16	0	0	0	0	1	1	0	0	0	5	2	2	10	0	13	3	0	2	1	1	0	0
	SP-15	0	0	0	0	0	0	0	0	1	12	0	0	0	0	4	0	0	0	0	0	0	0
	SP-14	0	0	0	0	0	0	0	0	0	0	0	4	2	0	0	0	0	2	0	0	0	0
	SP-13	3	0	0	0	1	0	0	0	0	9	0	0	4	0	0	0	3	0	0	0	0	0
EOCENE	SP-12	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	7	0	0	0	0	0
	SP11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0
	SP-10	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0
	SP-8	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
	SP-7	0	1	1	1	0	0	0	1	0	7	0	0	6	0	2	1	0	0	0	0	1	0
	SP-6	0	0	0	0	0	0	0	1	0	3	0	1	3	0	5	0	0	0	0	1	0	0
	SP-5	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	0	0	0	0	0
	SP-4	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	0	0	3	0	0
	SP-3	2	1	0	0	0	0	0	0	0	0	0	0	5	0	0	0	3	0	0	3	0	0
	SP-2	1	4	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	1	0	0

		SPECIES																						
	SAMPLE	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66
OLIGOCENE	SP-23	3	1	7	0	77	0	18	13	2	0	0	4	0	0	0	0	0	0	4	0	13	0
	SP-22	0	1	2	0	42	0	13	15	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	SP-21	0	0	14	0	62	0	19	0	10	3	0	17	0	0	0	0	1	1	2	0	14	0
	SP-20	0	0	0	1	39	5	5	27	1	0	1	0	0	0	0	0	3	0	0	0	2	4
	SP-19	0	1	0	4	48	0	25	8	8	0	0	9	0	0	0	0	2	3	1	0	0	0
	SP-18	0	3	0	13	41	1	0	6	7	0	3	1	0	0	0	0	5	4	0	0	15	3
	SP-17	0	0	0	0	31	1	26	0	0	0	0	6	0	0	0	0	0	2	0	1	11	0
	SP-16	0	3	0	0	22	3	4	4	7	0	0	0	0	0	0	0	0	0	3	2	14	0
	SP-15	0	2	0	0	36	7	22	7	7	0	0	0	0	0	0	0	2	2	4	0	14	0
	SP-14	0	0	0	0	14	2	7	0	2	0	0	0	0	0	0	0	0	0	0	0	6	0
	SP-13	3	3	1	3	53	6	16	12	0	0	0	0	0	1	1	0	3	0	1	0	17	0
EOCENE	SP-12	0	0	0	0	3	0	1	57	22	0	1	0	0	0	0	0	3	0	0	0	0	2
	SP11	9	0	0	0	0	0	0	54	9	0	0	0	0	0	0	0	0	0	0	0	1	0
	SP-10	0	0	0	3	9	0	2	68	29	0	0	0	0	0	0	0	0	0	0	0	1	9
	SP-8	1	0	0	0	4	0	6	158	12	0	0	0	0	0	0	0	0	0	0	0	4	3
	SP-7	0	0	0	0	6	0	0	154	45	0	0	0	0	0	0	0	0	0	0	0	4	5
	SP-6	0	0	0	0	4	0	0	168	29	0	0	0	0	0	3	0	0	0	0	0	3	6
	SP-5	0	0	0	0	0	0	0	172	35	0	0	0	1	0	0	0	0	0	1	0	7	7
	SP-4	0	0	0	0	3	0	1	161	22	0	0	0	0	0	0	0	0	0	0	0	0	9
	SP-3	0	0	0	1	0	0	0	134	60	0	0	0	0	0	0	0	0	0	0	1	2	3
	SP-2	0	0	0	0	8	0	3	135	65	0	0	0	0	0	0	1	0	0	0	0	1	15

		SPECIES																					
	SAMPLE	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88
OLIGOCENE	SP-23	0	1	0	75	0	5	0	7	24	0	285	4	0	63	0	13	4	0	0	0	0	4
	SP-22	0	1	0	74	0	1	0	13	9	0	280	22	0	40	0	7	15	0	0	0	0	0
	SP-21	0	3	0	67	4	2	0	11	19	0	257	35	0	31	0	14	12	0	0	0	3	5
	SP-20	0	4	0	52	4	4	0	11	23	0	232	13	5	218	0	34	15	1	0	0	0	7
	SP-19	5	2	0	47	6	9	0	1	16	16	234	26	2	27	0	8	41	0	0	0	0	0
	SP-18	6	0	1	124	8	19	0	5	29	9	301	65	4	61	6	49	54	5	52	1	0	0
	SP-17	0	0	0	22	3	4	0	1	6	0	114	28	3	10	1	19	15	0	0	0	0	0
	SP-16	1	0	0	41	9	5	0	3	11	6	105	37	0	4	0	5	33	1	2	0	0	6
	SP-15	0	0	0	129	15	6	1	2	8	4	261	33	11	18	0	19	48	2	3	0	0	0
	SP-14	0	0	0	37	3	1	0	0	4	3	132	25	0	8	0	15	12	1	0	0	0	0
	SP-13	0	0	0	118	11	9	0	4	12	1	231	25	0	19	0	34	25	6	25	0	0	0
EOCENE	SP-12	6	0	0	3	11	0	15	18	4	0	155	0	0	2	0	54	49	3	3	0	0	0
	SP11	8	0	0	3	3	0	2	16	4	2	45	50	0	1	0	23	30	0	0	0	0	0
	SP-10	7	0	0	11	0	1	3	28	1	0	50	36	0	5	0	32	28	1	3	0	0	0
	SP-8	32	0	0	8	4	1	3	5	8	3	58	77	2	0	0	34	53	0	0	0	0	2
	SP-7	41	0	0	6	10	0	13	9	6	0	177	82	1	0	0	36	65	0	0	0	0	0
	SP-6	47	3	0	0	4	0	6	4	2	6	63	87	1	0	0	52	53	0	25	0	2	0
	SP-5	25	0	0	1	7	0	1	2	9	0	113	9	0	1	0	84	54	0	12	0	0	0
	SP-4	11	0	0	9	0	0	4	3	3	0	134	10	0	0	0	107	39	1	5	0	0	0
	SP-3	15	0	0	2	0	0	0	14	9	0	123	18	0	1	0	69	29	0	0	0	0	0
	SP-2	12	0	0	3	1	0	2	4	9	0	244	4	0	0	0	116	16	0	5	0	0	0

		SPECIES																					
	SAMPLE	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110
OLIGOCENE	SP-23	2	94	1	2	0	9	6	0	0	27	14	0	24	0	0	0	0	0	0	0	0	18
	SP-22	0	40	0	3	0	5	6	0	0	16	7	0	19	0	0	0	0	0	0	0	0	5
	SP-21	5	54	6	6	1	11	8	0	1	6	4	0	32	0	0	0	0	1	0	0	1	0
	SP-20	3	17	0	25	0	5	15	0	0	5	7	0	45	2	0	0	0	0	0	0	0	0
	SP-19	0	40	0	0	3	22	11	0	21	0	8	0	41	0	0	0	0	1	0	0	0	20
	SP-18	14	59	2	11	1	7	4	1	17	18	14	0	45	0	0	4	0	6	0	0	0	27
	SP-17	3	95	0	4	3	7	3	0	3	3	1	6	9	0	0	0	0	1	0	0	0	0
	SP-16	14	31	0	6	0	8	9	0	7	15	3	0	52	0	0	0	0	3	0	0	0	4
	SP-15	5	53	0	5	2	11	2	1	10	5	3	1	34	0	0	0	0	1	0	1	0	5
	SP-14	0	9	0	0	1	3	4	0	5	0	0	0	9	0	0	0	0	0	0	0	0	0
	SP-13	1	42	0	4	1	2	3	1	6	14	3	0	30	0	1	0	0	0	0	1	0	13
EOCENE	SP-12	6	1	4	0	0	0	1	3	0	10	2	0	41	0	2	0	0	0	0	0	0	9
	SP11	6	0	0	0	0	0	2	3	0	0	0	0	20	0	0	0	0	0	0	0	0	5
	SP-10	3	1	0	1	0	2	2	10	0	4	0	0	13	0	0	0	3	1	0	0	0	0
	SP-8	0	0	0	1	0	0	2	6	0	0	0	0	24	0	0	1	1	0	0	0	0	7
	SP-7	0	0	0	0	0	0	19	17	4	0	2	0	26	0	0	4	0	0	0	0	0	5
	SP-6	0	0	0	0	0	0	0	5	1	2	3	0	38	2	2	5	1	0	0	0	0	3
	SP-5	0	0	0	1	0	0	2	10	0	4	5	0	15	1	1	1	0	0	0	0	0	4
	SP-4	2	0	0	0	0	0	2	15	0	3	0	0	17	0	0	0	0	0	0	0	0	6
	SP-3	2	0	0	0	0	0	3	2	0	0	4	0	9	0	0	0	0	0	0	0	0	14
	SP-2	2	0	0	1	0	2	5	16	0	0	7	0	12	0	0	0	0	0	0	1	0	10

		SPECIES						
	SAMPLE	111	112	113	114	115	TOTAL NUMBER OF SPECIMENS	NUMBER OF SPECIES
OLIGOCENE	SP-23	9	0	0	0	0	858	43
	SP-22	1	0	0	0	1	647	32
	SP-21	0	13	0	0	0	794	48
	SP-20	29	40	0	0	9	947	53
	SP-19	2	0	0	0	4	758	48
	SP-18	1	0	1	0	9	1189	61
	SP-17	0	0	0	0	3	485	44
	SP-16	0	0	1	0	0	565	53
	SP-15	0	0	0	0	14	847	52
	SP-14	0	0	0	0	3	320	30
	SP-13	0	0	0	0	6	802	50
EOCENE	SP-12	10	0	0	0	0	581	41
	SP11	0	1	0	0	0	309	26
	SP-10	1	7	0	1	0	385	38
	SP-8	1	0	0	0	0	550	38
	SP-7	0	0	0	0	0	795	34
	SP-6	15	0	0	0	0	705	42
	SP-5	16	6	0	0	0	636	37
	SP-4	2	0	0	0	0	583	28
	SP-3	10	0	0	0	0	553	30
	SP-2	2	2	0	0	0	732	42

GGS-3535 CORE
SPECIES LIST

1) *Textularia spp.*
2) *Spirillina spp.*
3) *Quinqueloculina spp.*
4) *Dentalina cocoaensis*
5) *Dentalina cf .communis*
6) *Dentalina jacksonensis*
7) *Dentalina spp.*
8) *Saracenaria ornatula riga*
9) *Saracenaria spp.*
10) *Lenticulina convergans*
11) *Lenticulina euglypughus*
12) *Lenticulina jugosus*
13) *Lenticulina insitatus*
14) *Lenticulina pseudovortex*
15) *Lenticulina sp. 2*
16) *Lenticulina spp.*
17) *Astoculus sublituus*
18) *Marginulina spp.*
19) *Fussurina spp.*
20) *Bifarina spp.*
21) *Nonion advena*
22) *Nonion nicobarensis*
23) *Nonion spp.*
24) *Nonionella jacksonensis*
25) *Nonionella spp.*
26) *Florilus spissa*
27) *Gyroidina obesa*
28) *Globulina gibba*
29) *Guttalina spp.*
30) *Brizalina hunneri*
31) *Brazilina salabrosa*
32) Brizalina striatellata
33) *Brizalina retifera*
34) *Bolivina sp. 1*
35) *Bolivina sp. 3*
36) *Bolivina spp.*
37) *Cassidulina alabamensis*
38) *Cassidulina armosa*
39) *Cassidulina brazilensis*
40) *Cassidulina spp.*
41) *Globocassidulina subglobosa*
42) *Bulimina jacksonensis*
43) *Buliminella elgantism*
44) *Buliminella pulchra*
45) *Buliminella spp.*
46) *Bitubulogenerina howei*
47) *Loxostomum spp.*
48) *Bolivinella rugosa*
49) *Uvigerina jacksonensis*
50) *Uvigerina spp.*
51) *Reussella moodyensis*
52) *Reussella sculptilis*
53) *Reussella spp.*
54) *Fursenkoina spp.*
55) *Nodogeneria spp.*
56) *Angulogerina bryamensis*
57) *Angulogerina danvillensis*
58) *Angulogerina vicksburgensis*
59) *Angulogerina spp.*
60) *Trifarina spp.*
61) *Cibicides cocoaensis*
62) *Cibicides lobatulus*
63) *Cibicides lobatus*
64) *Cibicides pippeni*
65) *Cibicides pseudoungerianus*
66) *Cibicides sp. 3*
67) *Cibicides sp. 4*
68) *Cibicides spp.*
69) *Hanzawaia danvillensis*
70) *Hanzawaia mississippiensis*
71) *Hanzawaia walli(?)*
72) *Hanzawaia sp. 1*
73) *Hanzawaia sp. 2*
74) *Hanzawaia sp. 3*
75) *Hanzawaia sp. 4*
76) *Hanzawaia spp.*
77) *Canceris claibornensis*
78) *Canceris spp.*
79) *Eponides jacksonensis*
80) *Eponides lotus*
81) *Eponides spp.*
82) *Gyroidina octocamerata*
83) *Valvulineria texana*
84) *Valvulineria spp.*
85) *Discorbis alveatus*
86) *Discorbis globulo-spinosa*
87) *Discorbis hemisphaericus*
88) *Discorbis sp. 1 (c.f. bulla)*
89) *Discorbis spp.*
90) *Cibicidoides bilateralis*
91) *Discorbitura dignata*
92) Pseudoparrella danvillensis
93) *Siphonina advena*
94) *Siphonina spp.*
95) *Planulina cocoaensis*
96) *Planulina kendrickensis*
97) *Planulina spp.*
98) *Planorbulina spp.*
99) *Rotalia simalis*
100) *Rotalia spp.*
101) *Sphaerogypsina spp.*

102) *Unknown sp. A*

		SPECIES																						
	SAMPLE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
OLIGOCENE	S915	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	2	0	1
	S925	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3
	S930	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0
	S935	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
	S939	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	1
	S945	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	6	4	8	0
	S950.5	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	S954	2	1	4	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	3	0	2	4	2
	S959	0	0	9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	2	2
	S960	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
	S966	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	S969	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
	S973	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	S977	0	0	16	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0
EOCENE	S980	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
	S985	0	0	17	0	0	0	4	0	0	0	0	1	0	0	0	0	0	0	0	0	5	4	2	0
	S988	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	6	1	0	0
	S991	2	0	15	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	S997	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
	S1001	0	0	19	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	3	0	2	0
	S1005	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	2	3	1
	S1010	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1	0	0	0	0	3	2	0	0
	S1017	0	0	0	1	0	0	2	0	1	0	0	0	0	1	0	2	1	0	0	0	6	2	1	0
	S1019	1	0	4	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
	S1021	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	1	0	0
	S1032	0	0	0	0	0	0	9	4	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1

		SPECIES																							
	SAMPLE	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
OLIGOCENE	S915	0	0	1	0	0	0	21	0	0	1	4	20	0	3	0	6	6	0	1	2	0	1	0	6
	S925	0	2	0	0	2	0	56	1	0	0	7	23	0	19	0	5	12	0	0	7	0	0	0	10
	S930	0	1	0	0	0	0	24	5	0	1	8	38	0	11	2	8	3	0	0	1	0	0	0	8
	S935	0	2	0	0	0	0	2	2	0	0	7	15	0	8	1	11	1	0	0	0	0	0	0	4
	S939	1	6	0	0	0	27	9	17	0	0	9	18	0	13	0	9	8	0	3	1	0	0	0	7
	S945	0	9	0	0	0	0	19	13	4	0	0	12	6	8	0	11	6	0	0	0	6	0	0	0
	S950.5	0	0	0	0	0	0	4	0	0	0	3	14	0	2	0	2	2	0	0	0	3	0	0	7
	S954	5	0	0	0	1	4	74	11	0	0	0	15	0	0	1	18	38	4	7	13	0	0	0	42
	S959	0	1	0	0	2	0	65	5	0	2	8	26	0	4	0	10	27	0	3	10	0	0	0	34
	S960	0	0	0	0	0	0	6	0	0	4	0	0	0	0	0	5	2	0	0	0	3	0	0	5
	S966	0	7	2	0	0	0	58	13	0	4	0	30	0	1	1	0	18	0	6	6	1	0	0	0
	S969	2	0	0	0	0	0	19	7	0	0	4	8	0	0	0	4	12	0	5	1	0	0	0	6
	S973	0	0	0	0	0	3	21	7	0	0	3	13	0	0	0	9	2	0	2	2	0	0	0	8
	S977	0	0	4	0	1	19	55	51	4	0	3	18	0	24	0	13	4	0	4	1	0	0	0	1
EOCENE	S980	0	0	0	0	0	5	11	2	0	0	0	3	0	7	0	0	21	0	0	2	0	0	0	0
	S985	0	0	0	1	0	23	49	142	0	1	0	26	8	26	0	41	14	0	7	4	1	0	0	0
	S988	0	5	0	0	0	30	46	88	0	0	0	6	18	14	0	14	32	0	2	1	0	0	0	0
	S991	0	0	0	0	0	7	14	23	0	1	0	18	0	15	0	12	2	0	1	0	1	0	0	0
	S997	3	0	0	0	0	19	16	50	0	0	0	0	0	21	0	0	2	0	1	1	0	0	0	0
	S1001	2	0	1	0	0	43	36	63	0	0	0	10	16	34	0	24	35	2	3	2	0	0	0	0
	S1005	1	3	1	0	0	5	26	50	0	0	0	1	10	13	0	30	10	0	3	0	2	0	0	0
	S1010	6	5	0	0	0	3	28	106	0	0	0	5	43	30	1	4	27	0	4	2	0	0	1	0
	S1017	0	7	0	0	0	9	13	101	12	0	0	5	7	22	0	1	4	0	1	3	0	0	0	0
	S1019	0	0	0	0	0	0	3	9	0	0	0	1	1	2	0	8	3	0	1	0	0	0	0	0
	S1021	0	1	0	0	0	5	13	25	0	0	0	5	5	27	0	12	4	0	1	4	0	0	0	0
	S1032	1	2	6	1	0	10	28	39	3	0	0	11	9	61	0	25	2	0	1	1	0	0	0	0

		SPECIES																							
	SAMPLE	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
OLIGOCENE	S915	0	4	0	0	2	0	0	0	0	1	1	0	0	0	11	38	4	0	5	6	13	4	0	6
	S925	0	4	0	4	0	1	0	7	0	2	8	0	1	0	16	106	7	0	2	22	27	8	1	1
	S930	0	1	0	5	2	0	0	0	0	0	2	0	0	4	3	60	12	0	3	11	35	7	0	3
	S935	0	0	0	4	3	0	0	0	0	0	1	0	0	0	10	56	8	0	4	9	23	3	0	0
	S939	0	4	0	15	4	0	0	2	0	0	5	0	3	11	23	133	41	4	0	41	43	6	0	2
	S945	0	3	0	6	9	0	0	6	1	1	3	0	1	10	18	70	57	0	13	21	39	10	0	0
	S950.5	0	0	0	0	2	0	0	0	0	0	4	0	0	0	5	17	0	0	3	7	1	0	0	0
	S954	7	0	0	2	19	4	0	17	6	0	2	0	0	5	18	25	8	0	4	18	27	6	0	5
	S959	6	0	0	5	10	1	0	0	1	0	5	0	0	1	16	51	9	0	7	12	12	3	0	1
	S960	0	0	0	0	2	0	0	0	0	0	0	0	0	0	5	1	0	0	0	5	5	1	0	0
	S966	0	2	3	4	0	0	0	0	0	0	5	0	0	8	4	14	21	3	38	3	18	5	0	31
	S969	0	0	0	0	7	0	0	0	0	0	3	0	0	0	5	3	7	0	6	6	25	0	0	5
	S973	0	3	0	0	3	0	0	0	0	0	5	0	0	0	2	6	4	0	6	8	15	0	0	4
	S977	8	4	0	2	6	0	0	0	0	0	0	0	5	0	7	31	113	0	4	20	17	1	0	0
EOCENE	S980	0	0	0	0	9	0	0	0	0	0	0	0	2	0	1	64	100	0	12	1	5	2	0	0
	S985	10	6	0	43	29	1	1	0	0	0	2	0	7	0	2	74	183	0	3	98	39	2	0	4
	S988	20	2	5	38	17	0	0	1	0	0	0	0	3	0	3	148	216	0	11	13	31	2	0	5
	S991	4	1	0	3	3	0	0	1	0	0	0	0	0	0	0	21	124	0	3	19	15	0	0	2
	S997	3	0	1	16	3	0	0	0	0	0	0	0	6	0	0	35	118	0	0	1	11	0	0	4
	S1001	22	4	0	7	3	0	0	0	0	0	0	0	1	0	2	62	155	0	4	12	38	0	2	3
	S1005	14	4	0	27	3	0	0	0	0	0	2	0	3	0	0	71	138	0	3	25	8	0	0	3
	S1010	9	8	2	45	1	0	0	0	0	1	3	0	1	0	0	153	162	0	0	2	35	3	0	4
	S1017	24	3	8	37	0	0	0	0	0	1	2	0	8	0	0	93	243	0	0	2	28	5	0	0
	S1019	1	1	0	6	6	0	0	0	0	0	0	0	0	0	0	18	91	0	1	19	4	0	0	0
	S1021	0	1	0	15	0	0	0	0	0	0	0	0	3	0	0	17	149	0	2	14	11	0	1	0
	S1032	8	0	1	0	0	0	0	0	0	2	2	2	15	0	0	119	320	0	1	67	27	12	0	0

		SPECIES																							
	SAMPLE	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
OLIGOCENE	S915	2	0	0	11	0	0	0	0	2	4	0	3	10	21	3	1	109	0	0	10	0	0	0	0
	S925	0	0	0	11	0	0	0	0	0	8	2	4	62	7	2	1	91	5	0	15	1	0	0	0
	S930	0	0	0	25	0	0	0	0	0	6	0	0	20	17	0	0	70	3	0	8	0	0	0	1
	S935	1	1	0	23	0	0	0	0	0	6	0	0	7	2	3	4	39	5	0	0	1	1	0	2
	S939	0	2	0	34	0	1	0	0	0	1	0	0	15	15	0	1	122	1	3	14	0	1	1	2
	S945	0	0	1	33	0	0	0	0	0	13	3	0	11	5	13	0	51	0	2	6	0	7	0	0
	S950.5	0	0	0	4	0	0	0	0	0	0	0	0	7	0	3	0	58	1	0	4	0	0	0	1
	S954	0	0	0	13	0	0	0	4	5	0	3	1	170	22	13	0	128	6	0	22	0	0	0	10
	S959	0	0	0	29	0	0	0	0	2	2	0	5	47	23	4	1	187	1	0	11	0	2	0	4
	S960	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	32	0	0	2	0	0	0	0
	S966	10	1	0	8	0	0	0	0	0	0	0	2	24	0	20	0	82	1	0	10	0	1	0	0
	S969	0	0	0	9	0	0	0	1	0	0	0	0	19	13	0	0	55	2	0	3	0	1	0	3
	S973	0	0	0	13	0	0	0	0	0	0	1	0	7	13	6	2	91	0	0	10	0	2	0	0
	S977	3	0	0	12	0	0	2	1	0	0	0	0	9	0	0	0	13	0	0	3	0	16	2	1
EOCENE	S980	0	0	0	1	0	0	0	0	0	1	0	0	6	0	5	0	9	0	1	0	0	0	0	1
	S985	10	0	0	25	0	0	0	0	3	0	0	1	16	4	1	1	28	25	1	4	0	6	0	2
	S988	3	2	1	11	2	0	0	0	0	0	0	1	9	0	10	0	14	11	1	2	0	6	0	1
	S991	0	0	0	15	0	0	0	1	0	0	0	0	1	2	0	0	17	5	1	0	0	0	0	0
	S997	0	0	0	4	1	0	0	1	7	0	0	0	8	0	3	0	3	4	0	0	0	2	1	0
	S1001	4	0	0	9	0	0	0	0	0	0	0	2	6	2	3	0	21	16	0	3	3	4	0	0
	S1005	4	0	0	9	0	1	0	3	5	0	0	0	10	0	4	0	18	8	0	2	0	3	0	0
	S1010	0	3	0	3	0	0	0	1	1	0	2	0	16	0	5	0	8	7	3	3	0	13	0	0
	S1017	0	3	0	2	0	2	0	0	0	0	0	0	16	1	4	0	4	16	0	1	0	8	6	1
	S1019	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	10	3	0	0	0	2	1	0
	S1021	0	0	0	2	0	0	0	0	0	0	0	0	7	0	3	0	8	6	0	1	0	1	0	0
	S1032	0	0	0	9	0	0	0	0	1	0	0	0	7	0	0	0	5	26	0	5	5	20	3	0

	SAMPLE	SPECIES						TOTAL NUMBER OF SPECIMENS	NUMBER OF SPECIES
		97	98	99	100	101	102		
OLIGOCENE	S915	0	0	8	2	0	0	361	41
	S925	0	0	0	4	0	0	593	43
	S930	0	0	4	17	0	0	435	39
	S935	0	0	3	7	0	0	282	37
	S939	0	0	13	29	0	2	731	47
	S945	8	1	19	22	1	1	579	52
	S950.5	0	0	0	5	0	0	161	25
	S954	0	0	12	7	0	0	842	57
	S959	1	0	7	7	0	0	685	48
	S960	0	0	0	0	0	0	86	17
	S966	0	0	92	29	0	0	587	48
	S969	0	0	6	10	0	0	260	33
	S973	0	0	22	0	0	0	298	34
	S977	0	0	0	2	0	0	506	41
EOCENE	S980	1	0	3	6	0	0	290	30
	S985	0	0	0	17	0	0	1024	48
	S988	0	0	8	8	1	0	877	52
	S991	0	0	0	6	0	0	357	42
	S997	0	0	8	3	0	0	359	33
	S1001	0	0	3	15	0	0	703	47
	S1005	0	0	2	26	0	0	560	45
	S1010	0	0	3	5	1	3	780	52
	S1017	0	0	5	0	0	0	725	49
	S1019	0	0	0	0	0	0	201	28
	S1021	0	0	0	0	0	1	356	33
	S1032	2	0	1	3	0	0	879	49

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BROOKSVILLE SECTION
SPECIES LIST

1) *Cibicides pseudoungerianus*
2) *Amphistegina pinarensis*
3) *Anomalina spp.*
4) *Archaias withacoochensis*
5) *Articulina zuberensis*
6) *Bolivina jacksonensis*
7) *Camagueyia perplexa*
8) *Cassidulina cf. moodyensis*
9) *Cibicides cooperensis*
10) *Cibicides mississippiensis*
11) *Cibicides yazooensis*
12) *Alabamina obtusa*
13) *Cribrogloborotalia marielina*
14) *Dentalina spp.*
15) *Discorbis bulla*
16) *Discorbis gunteri*
17) *Discorbis spp.*
18) *Epistomaroides spp.*
19) *Epistomaria semimarginata*
20) *Eponides jacksonensis*
21) *Eponides ocalana*
22) *Plectofrondicularia ?inglisiana*
23) *Globorotalia cocoaensis*
24) *Globorotalia crystalriverensis*
25) *Globorotalia spp.*
26) *Globulina gibba*
27) *Guttalina irregularis*
28) *Guttalina spicaeformis*
29) *Gyroidina crystalriverensis*
30) *Gyroidina nassauensis*
31) *Heterostegina ocalana*
32) *Lagena acuticosta*
33) *Lagena laevis*
34) *Lepidocyclina ocalana*
35) *Leibusella bryamensis turgida*
36) *Linderina spp.*
37) *Miliola saxorum*
38) *Mississippiana monsouri*
39) *Neoclavulina spp.*
40) *Nonion advena*
41) *Lepiocyclina chaperi*
42) *Noionella spp.*
43) *Nonion planatum*
44) *Nummulites vanderstocki*
45) *Operculinoides moodyensis*
46) *Operculinoides ocalanus*
47) *Operculinoides spp.*
48) *Operculinoides willcoxi*
49) *Camagueyia perplexa*
50) *Planulina cocoaensis*
51) *Planulina kendrickensis*
52) *Planularia spp.*
53) *Pseudophragmina spp.*
54) *Pyrgo inornata*
55) *Quinqueloculina newberryensis*
56) *Reussella ecoena*
57) *Reussella sculptilis*
58) *Lenticulina spp.*
59) *Rotalia cushmani*
60) *Saracenaria spp.*
61) *Siphonina jacksonensis*
62) *Sphaerogypsina globula*
63) *Spiroloculina bidentata*
64) *Spiroloculina newberryensis*
65) *Stomatorbins spp.*
66) *Textularia adalta*
67) *Textulariella barretti*
68) *Textularia ocalana*
69) *Unidentified*
70) *Veronina tuberculata*

		SPECIES																							
	SAMPLE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
OLIGOCENE	B25	0	0	0	1	0	19	0	0	303	3	11	0	0	0	23	0	0	0	0	1	1	0	0	0
	B24	0	1	0	0	0	4	0	0	164	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	B21	0	0	0	0	0	9	0	0	257	5	0	0	0	0	18	0	0	0	0	0	1	0	0	0
	B17-T	0	0	0	0	1	0	0	0	47	2	5	0	0	0	1	0	1	0	0	3	0	0	2	0
	B17	0	0	0	0	0	7	0	1	75	10	9	0	0	0	0	0	0	0	0	0	7	0	2	0
	B15	0	0	0	0	0	0	0	0	57	1	1	0	0	0	0	0	0	0	0	1	0	0	4	0
	B14	0	0	0	0	1	3	0	0	244	6	0	0	0	0	46	0	0	0	1	2	0	0	1	0
EOCENE	B13-U	0	0	0	0	0	6	0	0	119	1	2	0	0	0	8	1	0	0	0	4	0	0	13	0
	B13-L	1	0	1	0	0	0	0	1	49	3	22	0	0	0	0	0	6	0	0	5	0	0	16	0
	B11	0	0	0	0	0	1	0	0	306	0	22	0	0	0	0	0	2	0	0	27	2	1	0	0
	B9	0	0	21	0	0	26	0	1	0	1	5	0	0	1	0	1	0	0	1	9	2	3	10	1
	B7	0	0	18	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	3	0	0	0	0
	B5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	8	0	0	2	0
	B3-7	0	0	3	0	0	4	0	1	2	0	4	0	0	0	0	0	1	0	0	0	0	0	1	4
	B3-6	0	0	1	0	1	4	1	0	44	0	2	0	0	0	0	0	4	0	0	3	0	0	0	0
	B3-5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3
	B3-4	0	0	2	0	0	1	0	0	33	0	1	0	0	0	0	0	4	0	0	2	0	0	0	0
	B3-3	0	0	4	0	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B3-2	0	0	1	0	0	5	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	3	4
	B3-1	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	15
	B3-B	0	0	3	0	1	2	0	1	4	0	0	1	1	0	0	0	0	1	0	4	2	0	8	0
	B1-T	0	0	0	0	0	14	1	2	39	0	0	0	0	0	0	0	1	0	0	0	11	0	8	0
	B1-2	0	0	3	0	0	4	0	0	5	0	0	0	1	0	0	0	0	0	0	7	1	0	2	0
	B1-1	0	0	6	0	0	13	0	0	46	0	3	0	2	0	0	0	0	0	0	1	0	0	0	0
	B1-B	0	0	0	0	0	1	1	0	33	0	4	0	1	0	0	0	0	0	0	4	0	1	0	0

		SPECIES																							
	SAMPLE	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
OLIGOCENE	B25	0	2	1	0	0	0	0	0	0	0	11	0	3	0	0	0	0	0	0	0	0	0	0	1
	B24	0	0	0	0	0	1	0	0	0	0	17	1	0	0	2	0	0	1	0	1	1	0	0	0
	B21	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
	B17-T	0	0	1	0	0	0	5	0	1	0	3	0	0	1	0	1	0	85	8	1	0	0	0	0
	B17	0	0	0	0	0	0	5	0	17	0	15	0	0	2	0	1	0	33	0	0	0	4	0	1
	B15	0	0	0	0	0	0	0	0	4	0	2	0	1	1	0	2	0	10	0	2	0	0	0	0
	B14	0	1	1	0	1	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0
EOCENE	B13-U	0	0	0	0	0	0	0	0	0	0	21	0	0	5	0	4	2	0	0	1	0	1	0	0
	B13-L	0	0	0	0	0	0	3	0	0	0	8	0	0	0	0	8	1	7	0	0	0	2	0	0
	B11	0	0	16	1	0	0	15	0	0	0	4	1	0	0	0	7	0	0	0	4	0	1	0	0
	B9	0	0	1	0	0	1	3	0	0	11	129	0	3	23	1	1	1	14	0	0	12	1	0	0
	B7	0	0	1	1	0	0	3	0	0	0	82	0	0	66	1	3	0	13	0	0	19	1	0	1
	B5	0	0	0	0	1	9	0	0	0	0	104	0	64	58	0	0	0	7	26	0	11	0	0	0
	B3-7	1	0	1	0	0	1	2	0	0	0	26	0	0	1	0	1	0	3	0	0	0	5	3	0
	B3-6	0	0	1	0	0	0	3	0	0	0	96	0	0	18	0	1	1	6	0	0	1	1	0	0
	B3-5	2	0	1	0	0	1	0	0	0	0	40	0	17	0	0	0	1	0	0	0	0	0	0	0
	B3-4	0	0	0	0	0	2	0	0	0	17	14	0	27	16	0	0	0	0	0	0	2	0	0	0
	B3-3	0	0	0	0	0	0	0	2	0	2	19	0	77	3	0	1	3	2	0	0	5	1	0	0
	B3-2	1	0	2	1	0	0	1	0	0	0	2	0	174	0	0	2	0	0	0	0	0	0	0	1
	B3-1	1	0	0	0	0	0	0	4	0	0	33	0	0	10	0	0	0	0	0	0	0	1	0	0
	B3-B	1	1	3	0	0	1	49	5	0	14	40	0	2	13	0	1	1	8	0	1	2	0	0	1
	B1-T	0	0	3	0	3	0	38	3	0	39	94	0	0	4	0	1	0	3	4	0	4	0	0	0
	B1-2	0	0	1	0	0	1	72	10	0	16	34	0	0	13	0	1	0	13	3	0	0	0	0	0
	B1-1	0	4	0	0	1	0	5	9	0	0	23	0	6	0	0	0	0	0	0	0	0	0	1	0
	B1-B	0	3	1	1	0	0	40	0	0	0	38	0	0	7	0	0	1	9	4	0	6	2	0	0

		SPECIES																					
	SAMPLE	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
OLIGOCENE	B25	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	B24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	B21	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B17-T	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	54	0	2	0
	B17	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B15	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
	B14	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1
EOCENE	B13-U	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	B13-L	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	1
	B11	0	0	2	0	3	0	0	8	0	0	0	0	0	0	0	1	0	0	0	0	0	1
	B9	0	0	10	0	0	5	0	0	0	1	0	0	0	1	0	0	0	0	0	0	2	0
	B7	0	0	3	0	0	0	5	0	0	0	0	0	65	0	0	0	0	9	0	0	4	0
	B5	0	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	5	0
	B3-7	0	4	1	0	0	0	7	0	1	0	0	1	4	0	0	0	0	1	0	0	2	1
	B3-6	0	0	1	0	0	0	1	0	0	0	0	5	1	0	0	0	0	10	0	0	1	1
	B3-5	1	0	1	0	0	0	0	0	0	0	0	24	58	0	0	0	0	0	0	0	4	0
	B3-4	0	3	1	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0
	B3-3	0	0	1	0	0	0	1	0	0	0	0	59	4	0	0	0	0	0	0	0	1	0
	B3-2	0	0	0	0	0	0	1	0	0	0	0	18	0	0	0	0	0	0	0	0	0	0
	B3-1	0	0	1	0	0	0	0	0	0	24	9	0	0	0	1	0	0	0	0	0	1	0
	B3-B	0	4	7	0	0	1	3	2	0	28	0	17	0	0	1	1	1	1	0	0	1	0
	B1-T	0	1	2	0	0	0	7	3	0	21	0	0	0	0	0	0	0	2	0	0	5	0
	B1-2	0	1	1	0	0	0	2	1	0	42	0	5	0	0	0	1	0	0	0	0	0	0
	B1-1	0	0	4	0	0	0	23	0	3	15	0	0	3	0	0	0	0	0	0	0	0	0
	B1-B	0	0	6	0	0	0	2	0	6	25	31	4	0	0	0	0	0	0	0	0	0	0

	SAMPLE	TOTAL NUMBER OF SPECIMENS	NUMBER OF SPECIES
OLIGOCENE	B25	388	15
	B24	198	12
	B21	296	8
	B17-T	230	21
	B17	192	17
	B15	90	14
	B14	316	19
EOCENE	B13-U	191	16
	B13-L	140	20
	B11	425	20
	B9	302	30
	B7	300	20
	B5	300	14
	B3-7	86	27
	B3-6	208	24
	B3-5	156	15
	B3-4	133	15
	B3-3	189	18
	B3-2	218	16
	B3-1	104	14
	B3-B	238	39
	B1-T	313	25
	B1-2	240	24
	B1-1	168	18
	B1-B	231	24

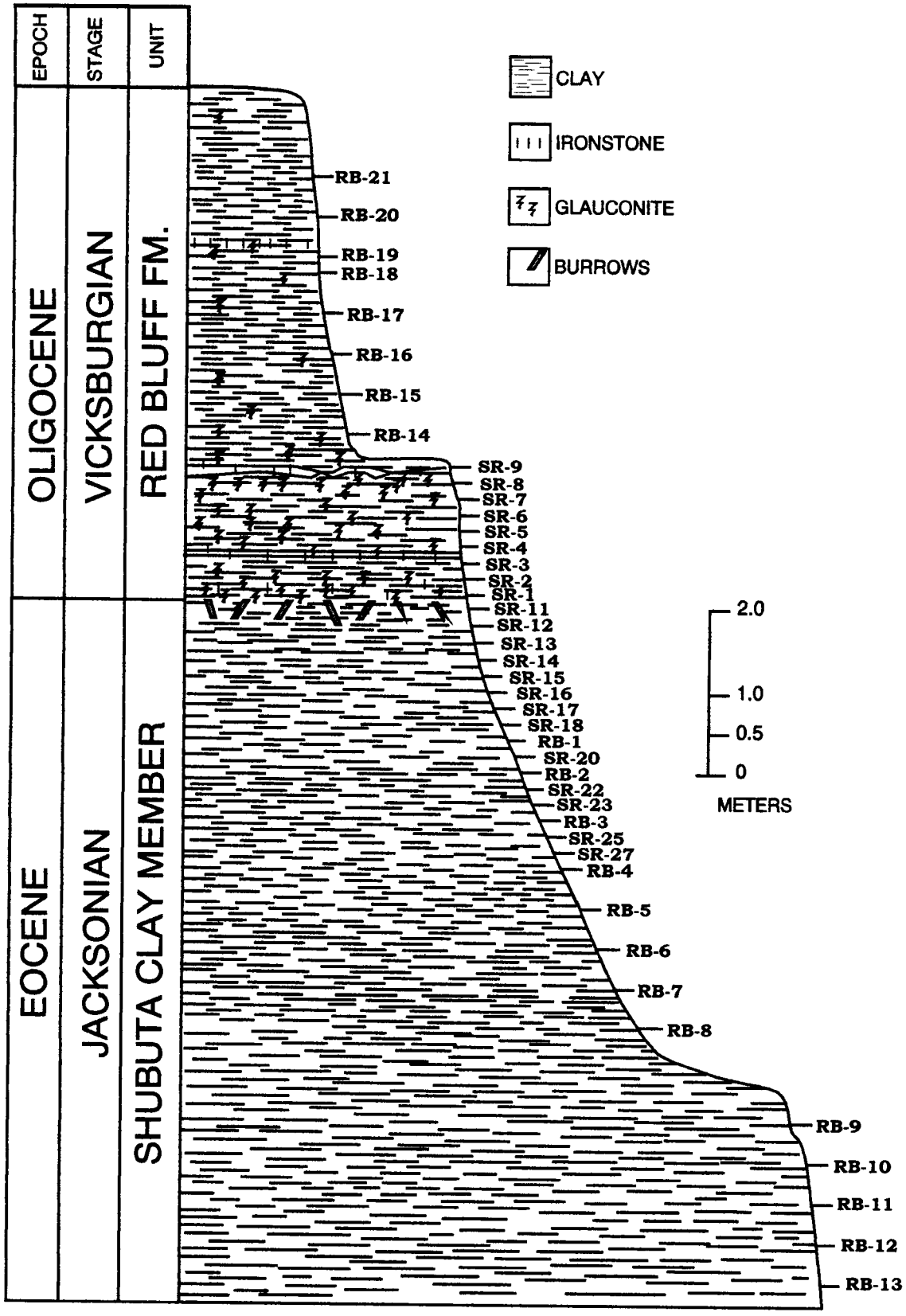
Appendix 3 SECTION DESCRIPTIONS

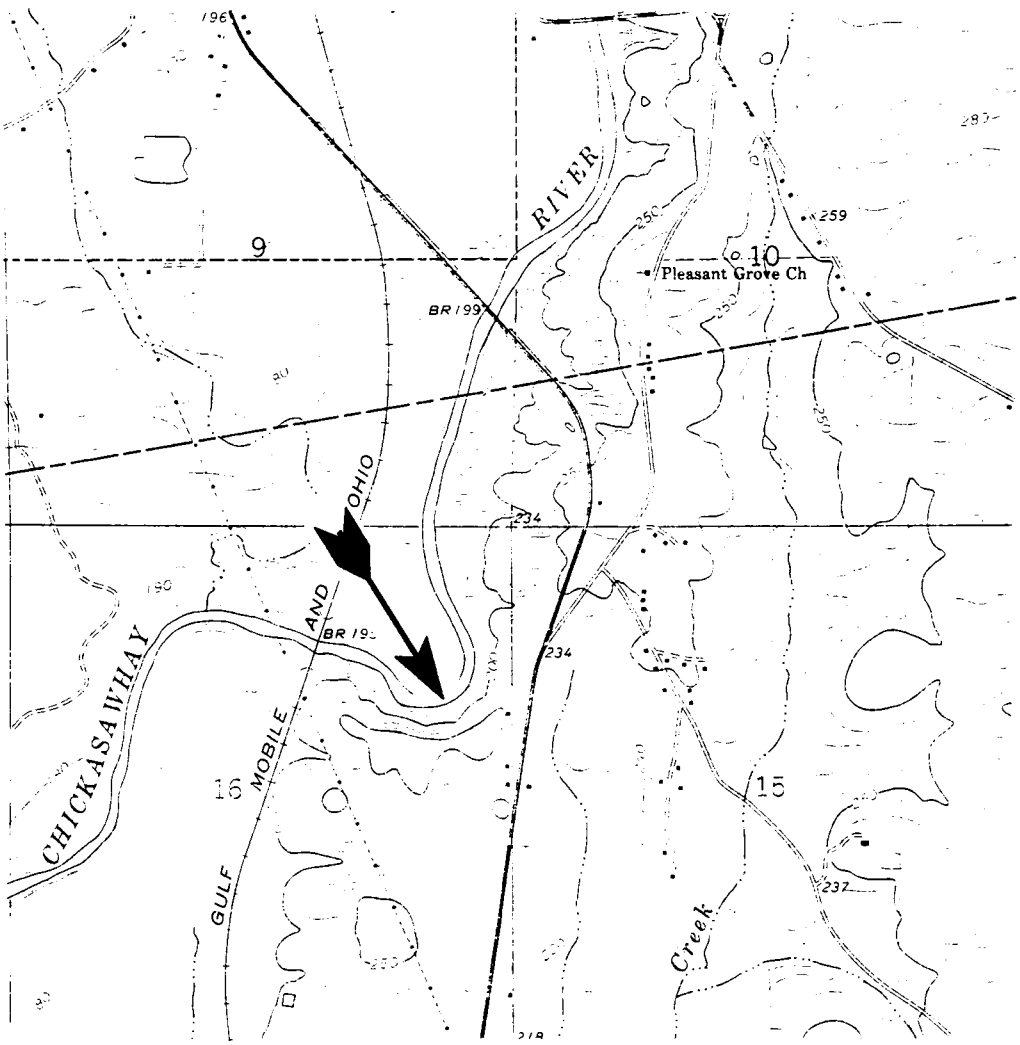
Red Bluff section

The Red Bluff type section is located in the NE 1/4, Sec. 16, T. 10 N., R. 7 W., Shubuta quadrangle, Wayne County, Mississippi. Latitude 31°50'12" North, Longitude 88°42'20" West. On the left bank of the Chickasawhay River approximately 2 miles south west of Shubuta, MS. In this section the upper Shubuta and the exposed Red Bluff Formation were sampled. This section was sampled twice. Samples with a SR prefix indicate the intial samples and those with RB prefix indicate the second sampling.

Measured section of Red Bluff locality

Bed	Lithology	Thickness (meters)
	Red Bluff Formation	
8.....	Clay, dark grey to orange, blocky, slightly to very glauconitic, sparse macrofossils.	2.6
7.....	Clay, orange indurated, glauconitic, fossiliferous.	0.2
6.....	Clay, dark grey, blocky, glauconite rich no macrofossils, abundant foraminifera.	1.0
5.....	Clay, dark grey to greenish grey, glauconite rich, intermittent indurated orange layer at top of bed, sparse macrofossils, abundant foraminifera.	0.40
4.....	Clay, orange, indurated with ironoxide, glauconite rich and fossiliferous, includingcoral, mollusk fragments and foraminifera	0.05
3.....	Clay, greenish-grey to dark grey, very glauconitic, nodules of ironoxide cemented clay, sparse macrofossils, coral and mollusk fragments.	0.2
	Shubuta Member	
2.....	Clay, dark grey, very glauconitic, burrowed, no macrofossils.	0.4
1.....	Clay, green to gray-green, blocky, sparse fossils, coral and mollusk fragments, and foraminifera	5.0+


EPOCH
STAGE
UNIT
OLIGOCENE
VICKSBURGIAN
RED BLUFF FM.
EOCENE
JACKSONIAN
SHUBUTA CLAY MEMBER
CLAY
IRONSTONE
GLAUCONITE
BURROWS
RB-21
RB-20
RB-19
RB-18
RB-17
RB-16
RB-15
RB-14
SR-9
SR-8
SR-7
SR-6
SR-5
SR-4
SR-3
SR-2
SR-1
SR-11
SR-12
SR-13
SR-14
SR-15
SR-16
SR-17
SR-18
RB-1
SR-20
RB-2
SR-22
SR-23
RB-3
SR-25
SR-27
RB-4
RB-5
RB-6
RB-7
RB-8
RB-9
RB-10
RB-11
RB-12
RB-13
2.0
1.0
0.5
0
METERS



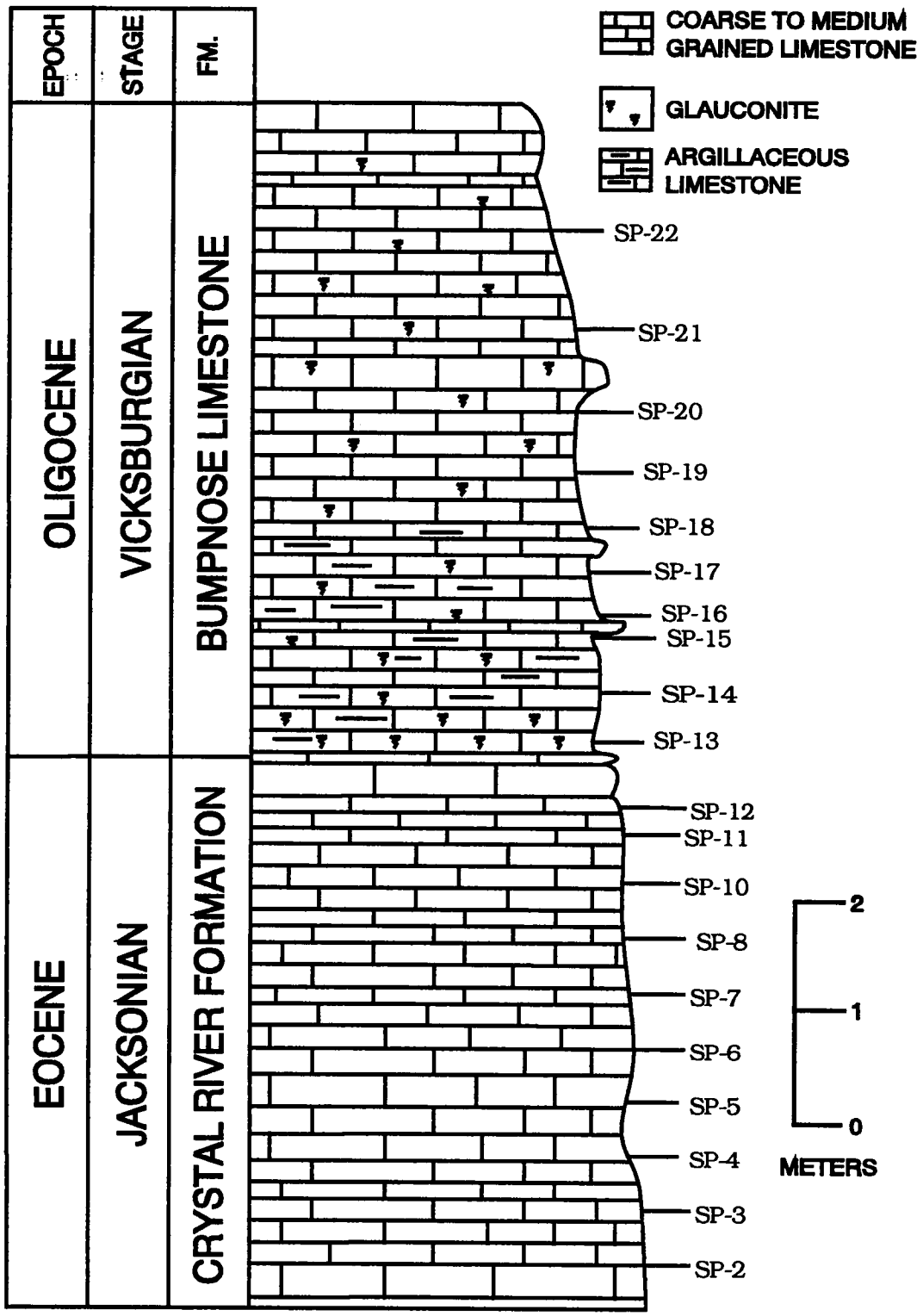
Location of Red Bluff section. Sampled section is located on Bluff at bend in River section 16 (See arrow on map).

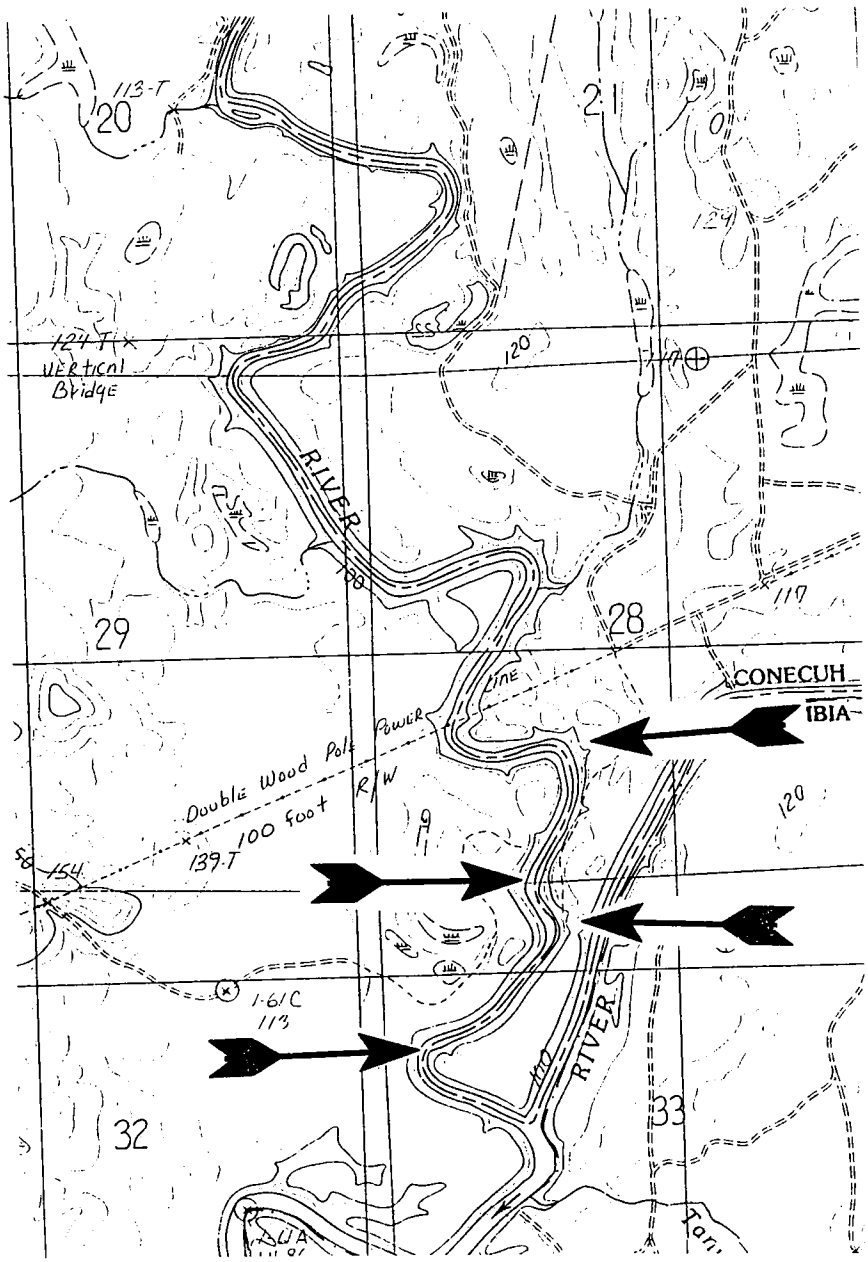
Sepugla River Section

The Sepulga River section is a composite of a series of cutbank sections located on the Sepugla River in south central Alabama. The cut banks are located in Sec. 28 & 33, T. 3 N., R. 13 E., Damascus quadrangle, Conecuh County, Alabama. Latitude 31°12' North, Longitude 86°50' West. The cut banks in this section correspond to those in Huddlestun (1965). Samples SP-2-SP-8 are from Huddlestuns section 21, SP-10-SP-12 from Huddlestun section 22, SP-13-SP-17 Huddlestun section 23 and SP-18-SP-24 from Huddlestun section 23. In this locality the entire Bumpnose limestone and upper 1/2 of the Crystal River Formations were collected. Due to the presence of a series of highly indurated to chert ledges in the upper Crystal River at this locality sample spacing is not entirely even. In this locality the Crystal River is composed of tan to white fossiliferous limestone. Containing abundant foraminifera, bryozoans, algae and common macrofossils. The Bumpnose Limestone, on the Sepulga River consists of glauconitic, argillaceous tan to buff colored limestone. Fossils in the Bumpnose in this locality include abundant smaller benthic foraminifera with common larger foraminifera, and bryozoans.

Sepugla River (Measured section)

Bed	Lithology	Thickness (meters)
	Bumpnose Limestone	
4.....	Limestone, white to tan; hard, variably glauconitic; Fossiliferous.	6.8
3.....	Limestone, white to tan, soft with hard ledges, glauconitic and argillaceous, fossiliferous.	1.2
	Crystal River Formation	
2.....	Limestone, white almost crystalline, fossiliferous; bryozoan, foraminifera and echinoids.	1.1
1.....	Limestone, white, hard to soft, contains some chert, fossiliferous including many foraminifera.	3+


EPOCH
STAGE
FM.
OLIGOCENE
VICKSBURGIAN
BUMPNOSE LIMESTONE
EOCENE
JACKSONIAN
CRYSTAL RIVER FORMATION
COARSE TO MEDIUM GRAINED LIMESTONE
GLAUCONITE
ARGILLACEOUS LIMESTONE
SP-22
SP-21
SP-20
SP-19
SP-18
SP-17
SP-16
SP-15
SP-14
SP-13
SP-12
SP-11
SP-10
SP-8
SP-7
SP-6
SP-5
SP-4
SP-3
SP-2
2
1
0
METERS



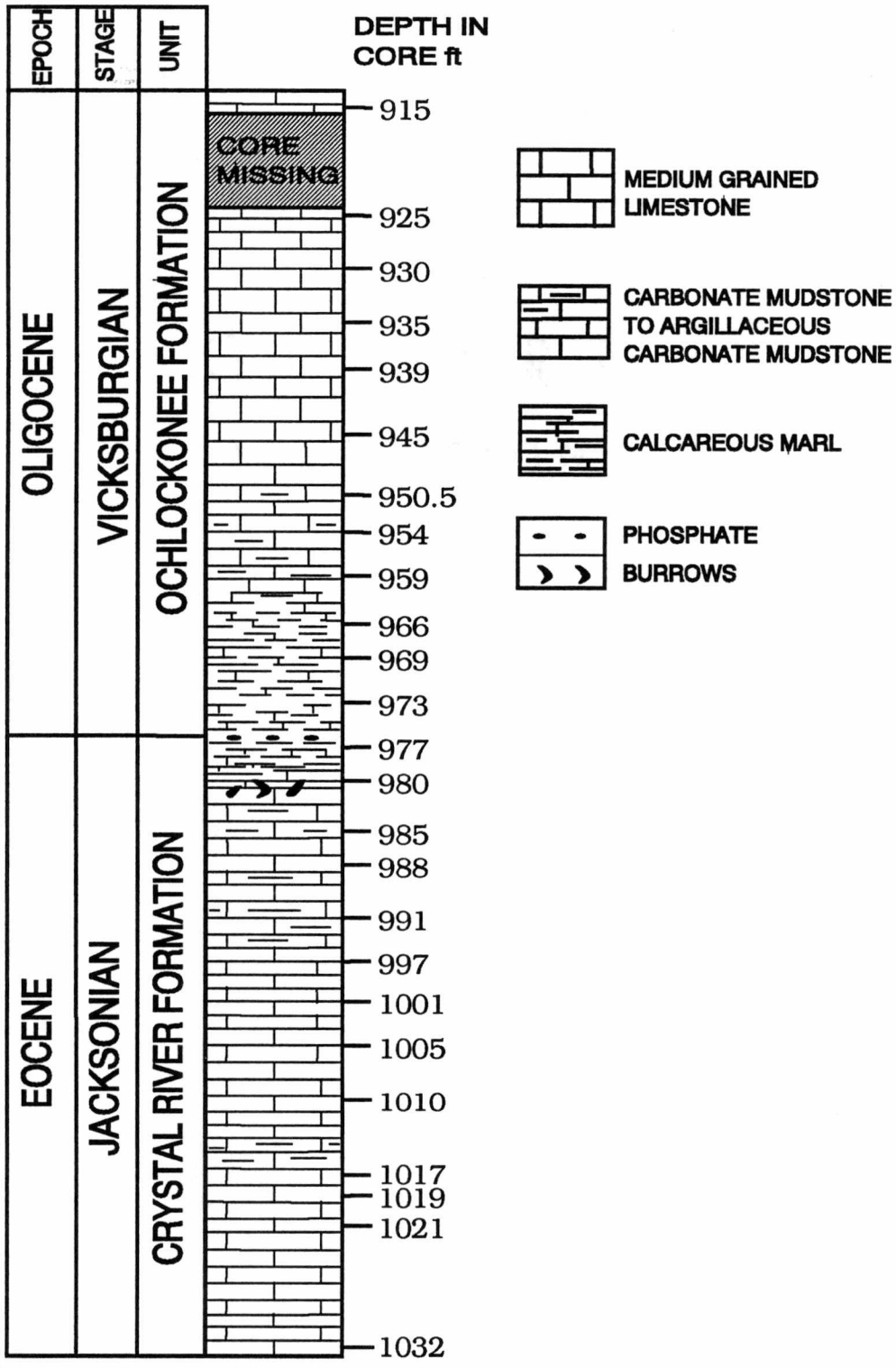
Location of Sepugla River section. Cut band sections are located on alternate sides of River in sections 28 and 33 (see arrows on map).

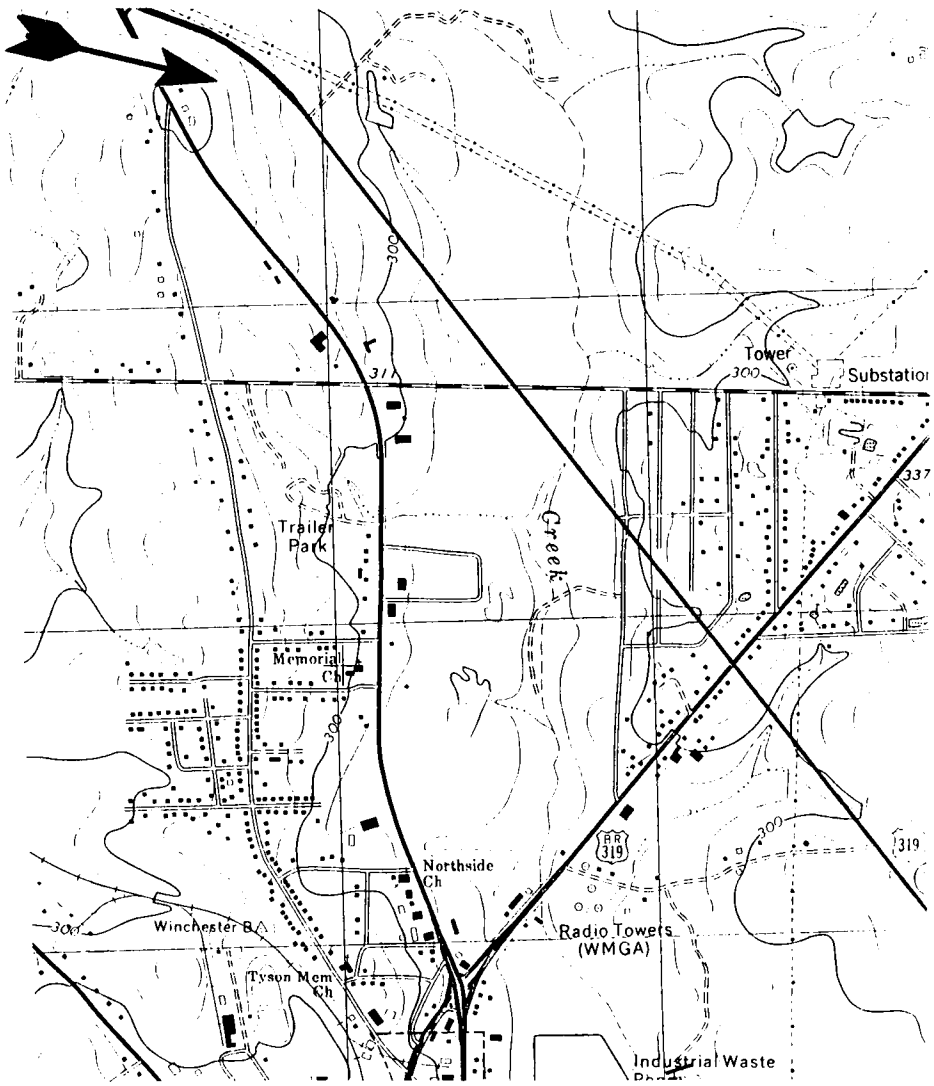
Core GGS-3535

The single core, Georgia Geologic Survey 3535 (GGS-3535), studied for this report was drilled by U. S. Gypsum approximately 3.1 miles northwest of Moultrie, Colquitt CO., Georgia. The core is housed at the Georgia Geological Survey, Atlanta Georgia. This core contains both the Crystal River and Ochlockonee Formation. Drilled within the deeper part of a depositional low termed the Gulf Trough (McFadden, et al., 1986; Gelbaum, 1978; Hetrick and Vorhis, 1963; Huddlestun, 1993) or the Swannee Strait (Jordan, 1954; Hull, 1962; Chen, 1965). The core contains 18 meters of Crystal River Formation and 60 meters of Ochlockonee Formation, of which 18.5 meters of the Eocene and 20 meters of the Oligocene were sampled. Both units consist of fine grained limestone with foraminifera, algae and some bryozoa present (Figure 7). The Eocene-Oligocene boundary in the core is marked by a thin layer of argillaceous limestone containing phosphatic material that maybe equivalent to the glauconitic horizons of the Bumpnose and Red Bluff Formations farther west.

Measured Section of the core GGS-3535

Bed	Lithology	Thickness (meters)
	Ockolucnee Formation	
4.....	Limestone, white, granular to chalky, brown, fine grained, argillaceous scattered glauconite, abundant foraminifera.	17.6
3.....	Limestone to marl, light brown to grey	3.0
	Crystal River Formation	
2.....	Limestone to marl, light brown to grey brown fine grained argillaceous, phosphate and burrows at top.	1.0
1.....	Limestone, white fine grained, scattered pyrite, no macrofossils, abundant foraminifera.	16.9


EPOCH
STAGE
UNIT
DEPTH IN CORE ft
OLIGOCENE
VICKSBURGIAN
OCHLOCKONEE FORMATION
EOCENE
JACKSONIAN
CRYSTAL RIVER FORMATION
CORE MISSING
915
925
930
935
939
945
950.5
954
959
966
969
973
977
980
985
988
991
997
1001
1005
1010
1017
1019
1021
1032
MEDIUM GRAINED LIMESTONE
CARBONATE MUDSTONE TO ARGILLACEOUS CARBONATE MUDSTONE
CALCAREOUS MARL
PHOSPHATE
BURROWS



Location of well from which GGS 3535 was taken (see arrow) (from Huddlsetun, 1993).

Brooksville section

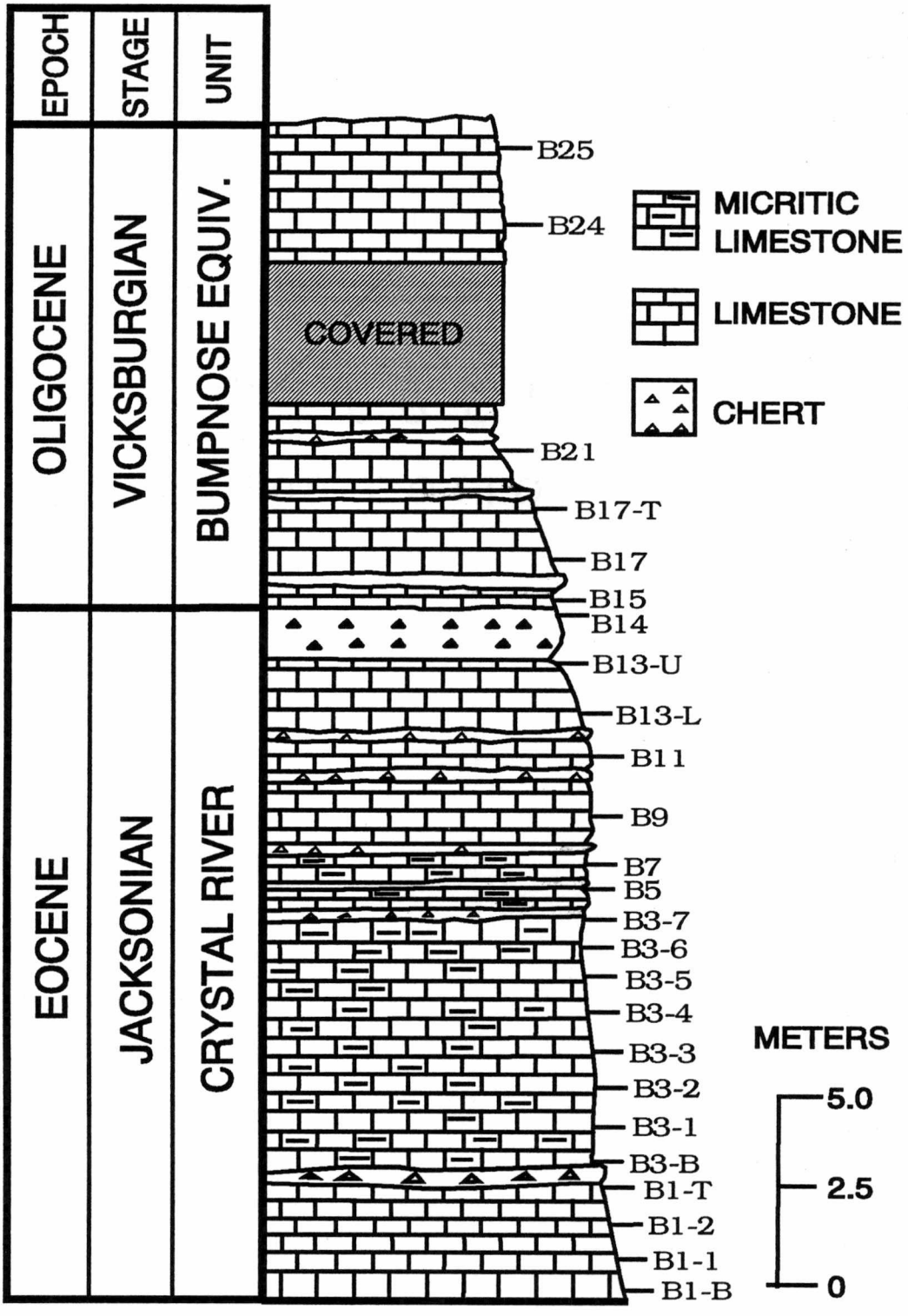
The Brooksville section is located in a quarry in NE 1/4 sec. 35 and NW 1/4 sec. 36, T. 20 S., R. 15 E., Nobleton quadrangle, Critus County, Florida. Latitude 28°42'30" North, Longitutde 82°22'30 West. The sample section is located in the southwest corner of the quarry. The base of the section is defined by the base of the quarry.

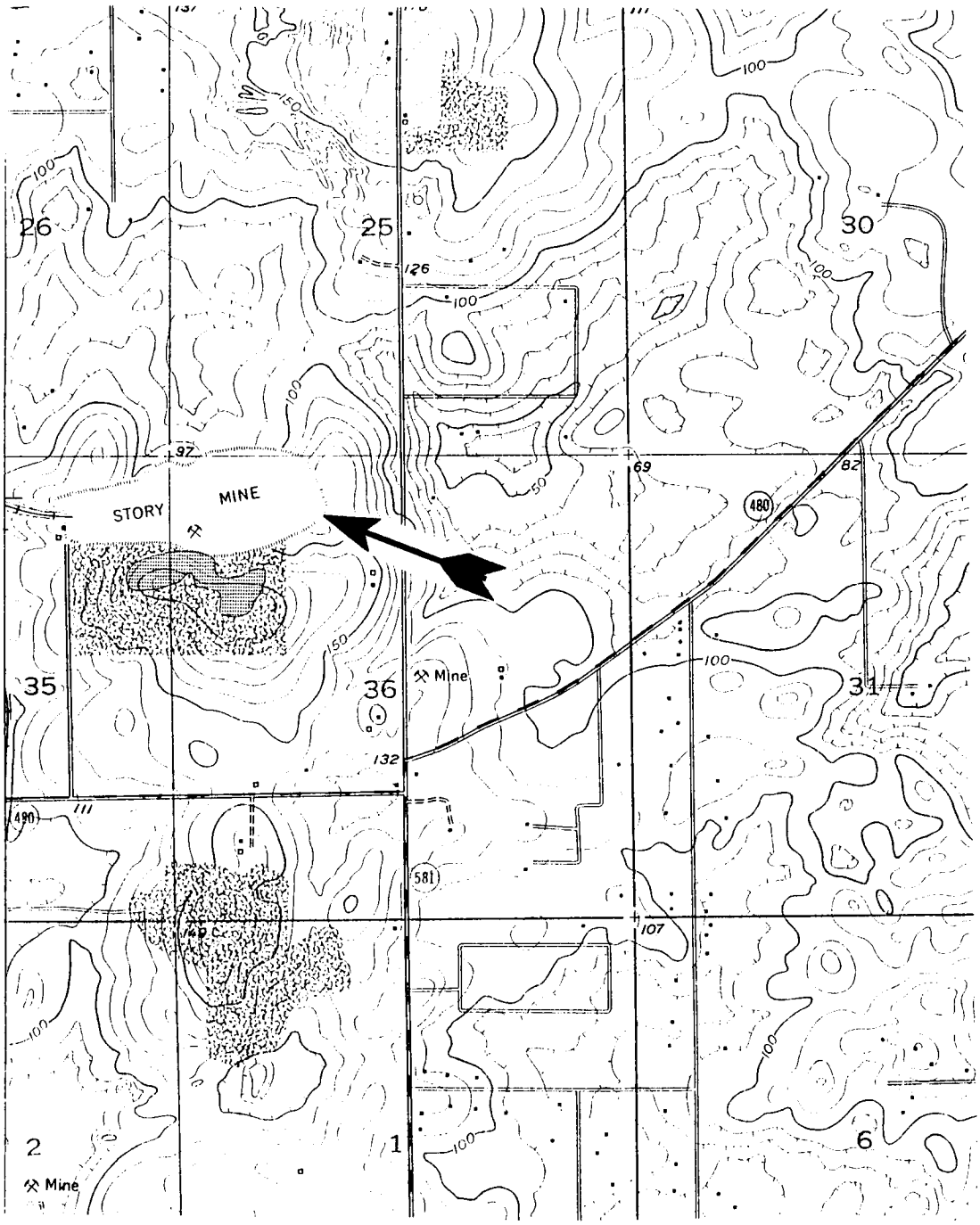
This section is composed of the upper Crystal River Formation and a Lower Oligocene unit. The Crystal River contains the index fossils *R. veroni* and the large benthic foraminifera *Lepidocylina* ocalana. Indicating that this section is similar in age to those described in northern Florida (Hoganson, 1972). The nature of the Eocene- Oligocene boundary in this section and the exact correlation of the presumed lower Oligocene unit(s) is not entirely clear. The Oligocene material is a chalky, occasionally chert rich, fossiliferous, white to tan limestone. Much of the appearance is similar to that of the Bumpnose Limestone, however a lack of glauconite and argillaceous material makes it distinct form the original description. This fact coupled with the presence of a large chert bed just below the presumed boundary and a lack of zonal microfossils renders judgment of the completeness of this section difficult. It may well be that in this section in contrast to the others in this study a significant unconformity exists at the Eocene-Oligocene boundary.

Measured section of Brooksville locality

Bed	Lithology	Thickness (meters)
	Bumpnose equilivents	
25.....	Limestone white, fine-grained, few fossils.	2.0
24.....	Limestone, white, fine grained, fossiliferous including coral and bryozoan.	2.0
23.....	Limestone tan, fossilferous with abundant mollusk molds.	0.75
22.....	Cherty limestone, tan,	0.25
21.....	Limestone, white, fossiliferous, internal mollusk molds abundant	0.7
20.....	Chert, beige, fine grained	0.12
19.....	Limestone, white, fine grained, soft.	0.25
18.....	Chert, white, fine grained, irregular and nodular.	0.25
17.....	Limestone, white soft, poorly fossiliferous.	2.0
16.....	Chert, white, coarse grained.	0.4
15.....	Limestone, white, soft, few fossils	0.5
14.....	Chert, tan, only partly continuos with large nodules and some carbonate sand between nodules.	1.4
13.....	Limestone, white, soft, sandy to nodular, fossil molds	2.0
12.....	Chert, tan, hard nonfossiliferous, irregular.	0.25
11.....	Limestone, white, soft, irregular nodular, no visible fossils.	0.55
10.....	Chert, hard, contains abundant fossil molds.	0.40
9.....	Limestone, fine sandy, cherty and nodular at bottom, fossiliferous, 1 cm clay layer at top.	1.5
8.....	Chert, hard, very fossiliferous	0.5
7.....	Limestone white soft, few macrofossils.	0.6
6.....	Cherty limestone, irregular, fossil molds	0.3
5.....	Limestone white, soft, few fossils	0.6

4.....	Limestone white, soft, few fossils	0.25
3.....	Limestone white fossiliferous fossils include *Perarchus?*. fragments.	1.0
2.....	Chert, fossiliferous continuos bed	0.10
1.....	Limestone, white, soft creamy, fossiliferous	2.7


EPOCH
STAGE
UNIT
OLIGOCENE
VICKSBURGIAN
BUMPNOSE EQUIV.
EOCENE
JACKSONIAN
CRYSTAL RIVER
COVERED
B25
B24
B21
B17-T
B17
B15
B14
B13-U
B13-L
B11
B9
B7
B5
B3-7
B3-6
B3-5
B3-4
B3-3
B3-2
B3-1
B3-B
B1-T
B1-2
B1-1
B1-B
MICRITIC LIMESTONE
LIMESTONE
CHERT
METERS
5.0
2.5
0



Location of Brooksville section. Sample section is located in southeast corner of the mine (see arrow). This section is no longer accessible for sampling.

VITA

Daniel Lee Frederick was born in Evansville Indian on October 12, 1960. He attended elementary school at Scott elementary school Evansville Indiana and graduated from Central High School in June 1979. The following September He entered Indiana University, Bloomington Indian and in May 1983 received the degree of Bachelor of Science in Geology. He entered North Illinois University in September 193 and receive a Master of Science degree in Geology August 1987. In September 1987 he entered The University of Tennessee, Knoxville and in December 1994 received a Doctor of Philosophy. in Geology.

He is currently employed as an Assistant Professor of Geology at Austin Peay State University , Clarksville Tennessee.