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Late Eocene–Early Oligocene paleofloristic patterns in southern Mississippi and Alabama, US Gulf Coast

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Abstract

Climate, vegetation and sediment supply are fundamental controls on the palynofloras of depositional sequences. In ancient depositional environments, the diversity and abundance of palynomorphs being transported into, and preserved in the basin of deposition are dependent on these factors as well as burial conditions. Preserved palynomorph assemblages can be used to recognize past floral patterns and climates, and such a model is used here to interpret the Late Eocene Shubuta Member of the Yazoo Formation and Early Oligocene Vicksburg Group in southern Mississippi and southwestern Alabama. Two hundred and sixty spore and pollen taxa have been identified in the strata. Eleven groups representing about 50% of the taxa have been recognized on the basis of abundance, occurrence in most samples and ecological significance. The groups are spores, bisaccate pollen, *Sequoiapollenites–Cupressacites*, *Momipites*, *Carya*, *Quercoidites*, *Fraxinoipollenites*, *Cupuliferoidaepollenites*, *Cupuliferoipollenites*, *Cyrillaceaepollenites*, and *Siltaria*. Statistical analysis on presence–absence data produced five significant cluster groups which were dominated by species of the eleven groups, as well as by *Ulmipollenites thompsonianus* and *Salixipollenites parvus*. These cluster groups show some ecological significance because they appear to represent upland, swamp and marsh taxa. The prominence of *Quercoidites*, *Sequoiapollenites*, *Cupressacites* and *Cyrillaceiopollenites* in the rich palynomorph assemblage, which contains some tropical to subtropical elements, suggests a warm temperate paleoclimate during the Late Paleogene in the eastern Gulf Coast. Although *Momipites* was generally more abundant in the Eocene and *Quercoidites* increased during the Oligocene, there was no significant paleofloristic change across the Eocene–Oligocene boundary.

1. Introduction

The Late Eocene–Early Oligocene stratigraphic interval has received a lot of attention because of an abrupt cooling of the paleoclimate during the Oligocene as documented by microfaunas from deep sea cores (Shackleton and Kennett, 1975; Wei, 1991). Plant megafossils and microfossils have also indicated that the paleoclimate cooled in the Gulf Coast and western North America toward the end of the Eocene, or beginning of the Oligocene (Wolfe, 1971, 1992, 1994; Elsik, 1974; Frederiksen, 1988), resulting in changes in vegetation patterns. In general, palynological studies of many Phanerozoic strata are increasingly being used to study paleoclimatic and paleofloristic changes as well as paleophytogeography (Askin, 1994; Srivastava, 1994). This study documents diverse, abundant and well preserved palynomorphs in five sections of Late Paleogene strata in southern Mississippi and southwestern Alabama (Fig. 1). They have been used to interpret the

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Fig. 1. Map showing locations of the five measured sections. *1* = St. Stephens Quarry, Washington County; *2* = Milepost 54 on US Route 84, east of Whatley, Clarke County; *3* = Type Red Bluff locality, Wayne County; *4* = Road cut east of Waynesboro, US Route 54; *5* = Mississippi Valley Portland Cement Quarry, Warren County.

paleofloristic pattern and paleoecology, and to make paleoclimatic inferences during the Late Paleogene in the study area.

Two of the five localities were sampled from the latest Eocene Shubuta Clay of the Yazoo Formation (Jackson Group) and the Early Oligocene Red Bluff Clay of the Vicksburg Group. The other three localities comprise formations of the Vicksburg Group; of these, the St. Stephens Quarry in southwestern Alabama is the most complete, and additional samples from the overlying Chickasawhay Limestone at this locality were analyzed. The Vicksburg and Jackson groups comprise strata of nearshore to shallow marine origin that were deposited during the Tejas 4.1 and 4.2 depositional sequences (Tew and Mancini, 1992). Deposition of the sequences was controlled by sea-level fluctuations, sediment supply and carbonate productivity. The recovered palynomorphs include non-marine (spores, pollen, fungal remains) and marine taxa (dinoflagellate cysts, acritarchs, microforaminiferal wall linings). Two hundred and sixty pollen and spore taxa, 212 of which are listed in Oboh and Reeves Morris (1994), were identified in the samples. Eleven groups of palynomorphs were recognized on the basis of abundance, occurrence in many samples and ecological significance, while statistical analysis of presence–absence data in three sections provided additional ecological information.

2. Materials and methods

This study is based on 60 samples from the Shubuta Clay of the Yazoo Formation, the seven units of the Vicksburg Group, and the Chickasawhay Limestone (see Fig. 2 for stratigraphic positions). The samples were prepared at the US Geological Survey (Reston, VA) using standard palynological techniques, including mild oxidation in nitric acid, and heavy liquid separation in zinc chloride. The residues were sieved through 10 μm nylon meshes before permanent slides were made. Illustrations of some of the identified spores and pollen, and count data for most of the taxa can be found in Oboh and Reeves Morris (1994). Microscope slides are currently in the care of the first author. The slides will eventually be reposited at the US Geological Survey (Reston, VA), and the Geological Museum of the University of California at Riverside.

Average linkage cluster analysis, using Euclidean distance (SYSTAT 5) on presence–absence palynomorph data, was used to interpret three measured sections that were > 15 m thick. We used presence–absence data instead of abundance data in order to reduce the effect of dominant taxa in the analysis. Dominant palynomorphs, such as *Sequoiapollenites* and *Quercoidites*, would probably have obscured the importance of less dominant forms in the five possible ecological associations that are common to all three measured sections.

3. Result

Three criteria were used to identify eleven groups of palynomorphs which represent about 50% of the 260 taxa: relative frequencies > 2%, occurrence in most samples, and ecological significance. These groups are (1) spores, (2) bisaccates, (3)

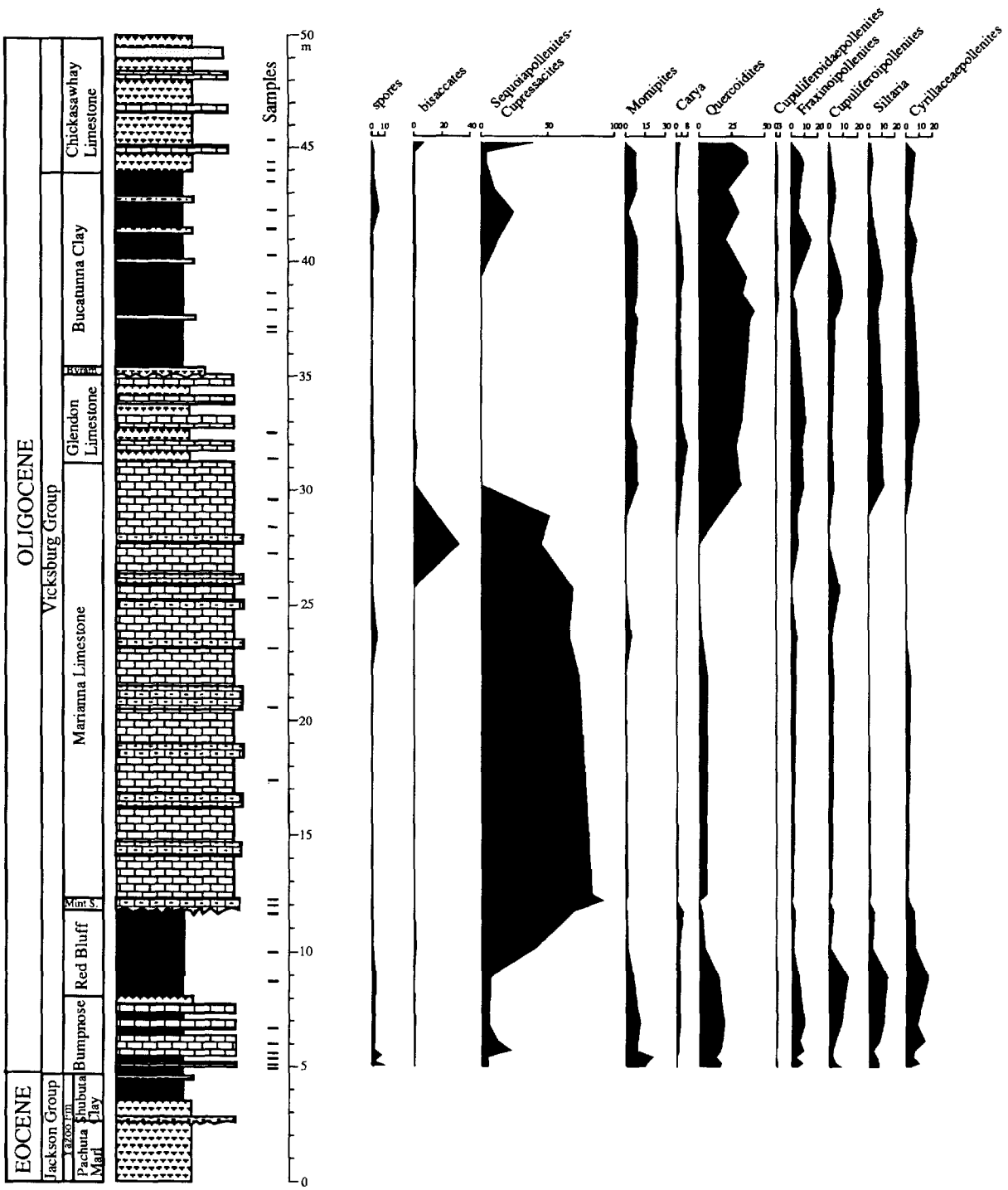

Fig. 2. Relative frequencies (%) of 11 groups of palynomorphs identified in this study, for Locality 1 at the St. Stephens Quarry.

Sequoiapollenites–Cupressacites, (4) *Momipites*, (5) *Carya*, (6) *Quercoidites*, (7) *Fraxinoipollenites*, (8) *Cupuliferoidaepollenites*, (9) *Cupuliferoipollenites*, (10) *Cyrillaceaepollenites*, and (11) *Siltaria* (see Figs. 2–6). We used these groups to identify any relationship between the distribution of the palynomorph taxa in the strata and the Late Paleogene stratigraphy in the study area.

The Eocene–Oligocene boundary at the top of the Shubuta (Figs. 3, 4) is marked by a slight increase in *Momipites* and *Quercoidites* whereas *Sequoiapollenites* decreases in abundance. In southwest Alabama and southeast Mississippi, *Sequoiapollenites–Cupressacites* and *Quercoidites* are the most important components in the Vicksburg units, the former being more prominent in transgressive and highstand deposits of Mint Spring Marl, Marianna Limestone and Glendon Limestone (see Figs. 2, 5, 7). The Marianna and Glendon limestones do not contain diverse palynomorphs, but show an increase in the number of marine palynomorphs. The floristic pattern in the Mint Spring and Glendon in southwest Mississippi, where the Marianna Limestone has been replaced laterally by the Mint Spring, is different from that in the eastern part of the study area: the *Sequoiapollenites–Cupressacites* group is a minor element whereas spores (Fig. 6) are more prominent in the assemblage. The Byram palynofloras are similar to those of the Bucatunna and Chickasawhay in southwest Alabama. In the Vicksburg Group, increases up to the order of 7–30% were recorded for *Siltaria*, *Quercoidites* and *Cyrillaceaepollenites* over their abundances in the Shubuta Clay. With the exception of a slight increase in the Red Bluff (as noted above), *Momipites* is generally more abundant in the Shubuta Clay (Jackson Group) than younger Vicksburg formations.

Presence–absence data from three measured sections were analyzed by average linkage cluster analysis in order to identify any possible ecological groups in the samples. Out of the 260 taxa, five cluster groups containing 18 taxa (or approximately 7%), which are listed in Oboh and Reeves Morris (1994), are common to all three sections (Figs. 7–9). Group A comprises *Sequoiapollenites lapillipites* and *Sequoiapollenites* sp. 1; group B is composed of *Carya simplex*, *Siltaria* sp. cf. *S. scabriextima*, *Quercoidites microhenrici*, *Momipites coryloides*, and *Ulmipollenites thompsonianus*; group C comprises *Laevigatosporites haardtii*, *Cupuliferoidaepollenites* sp. cf. *C. selectus*, *C. liblarensis*, *Cupressacites hiatipites*, *Cupressacites* sp. 1, *Quercoidites inamoenus*, *Cyrillaceaepollenites megaexactus*, and *Momipites microfoveolatus*; group D is composed of *Salixipollenites parvus*, and *Cicatricosisporites dorogensis*; and group E contains *Fraxinoipollenites* spp.

4. Discussion

The pollen genera used to identify the eleven groups (based on abundance and occurrence in many samples) are present in the five significant cluster groups (based on presence–absence). The additional pollen species in the clusters are *Ulmipollenites thompsonianus* and *Salixipollenites parvus*, while the spores are predominantly *Cicatricosisporites dorogensis* and *Laevigatosporites haardtii*. The 18 taxa contain anemophilous, zoophilous and hydrophilous elements, the anemophilous types being dominant.

The presence of common elements in the two analytical approaches reveal that *Sequoiapollenites–Cupressacites* and *Quercoidites* are definitely important elements in the palynomorph assemblage. The coniferous pollen *Sequoiapollenites* is dominant (albeit in low numbers) in samples from the transgressive and highstand systems of the Marianna and Glendon Limestones in southeast Mississippi and southwest Alabama where other taxa are relatively few, probably as a result of diagenetic alteration (Oboh and Reeves Morris, in press). It is also dominant in the more palyniferous Mint Spring Marl in the area. The significance of *Sequoiapollenites* in these samples is purely ecological because it is not an important element in southwest Mississippi, where spores, bisaccates and other gymnosperms are more important. The genus probably experienced abundant production on adjacent land areas and was easily dispersed into the nearshore (Mint Spring) and offshore environments (Marianna and Glendon) where it was preserved.

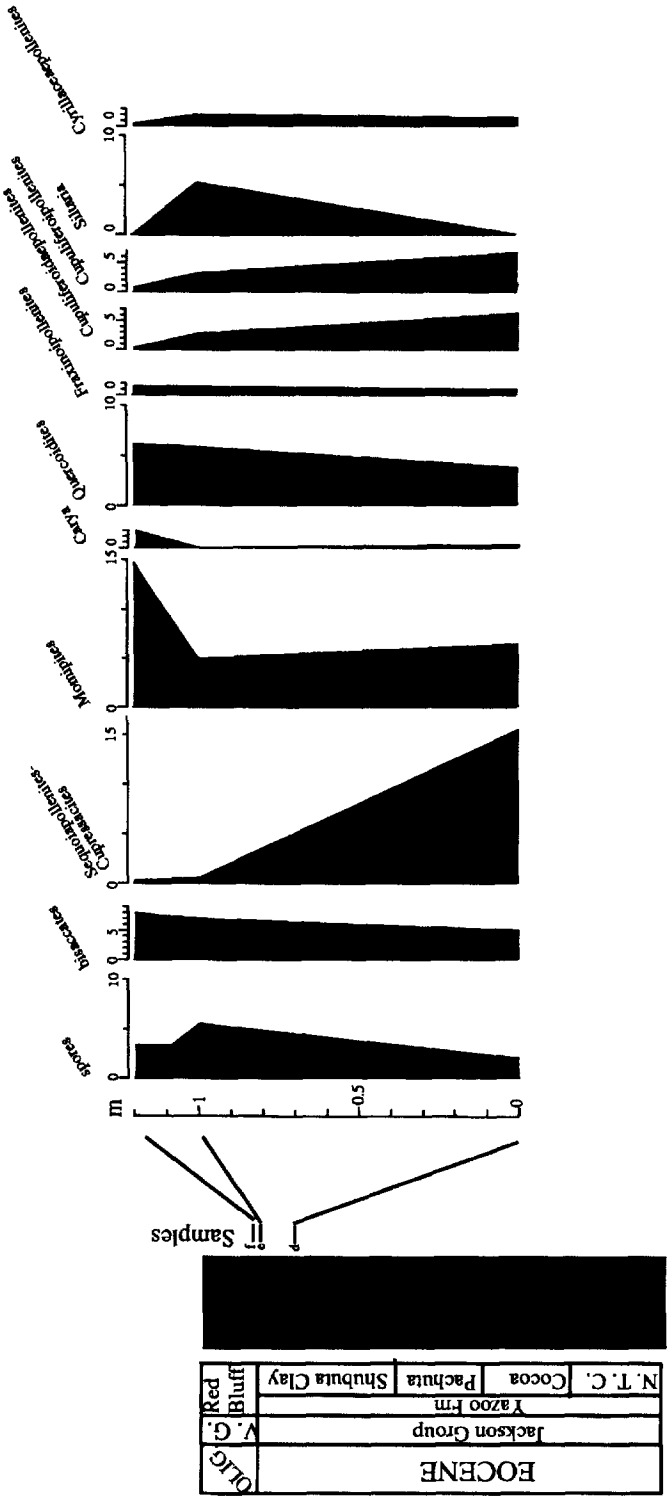

Fig. 3. Relative frequencies (%) of 11 groups of palynomorphs identified in this study, for Locality 2 at Milepost 54 on US Route 84, Clarke County, Alabama.

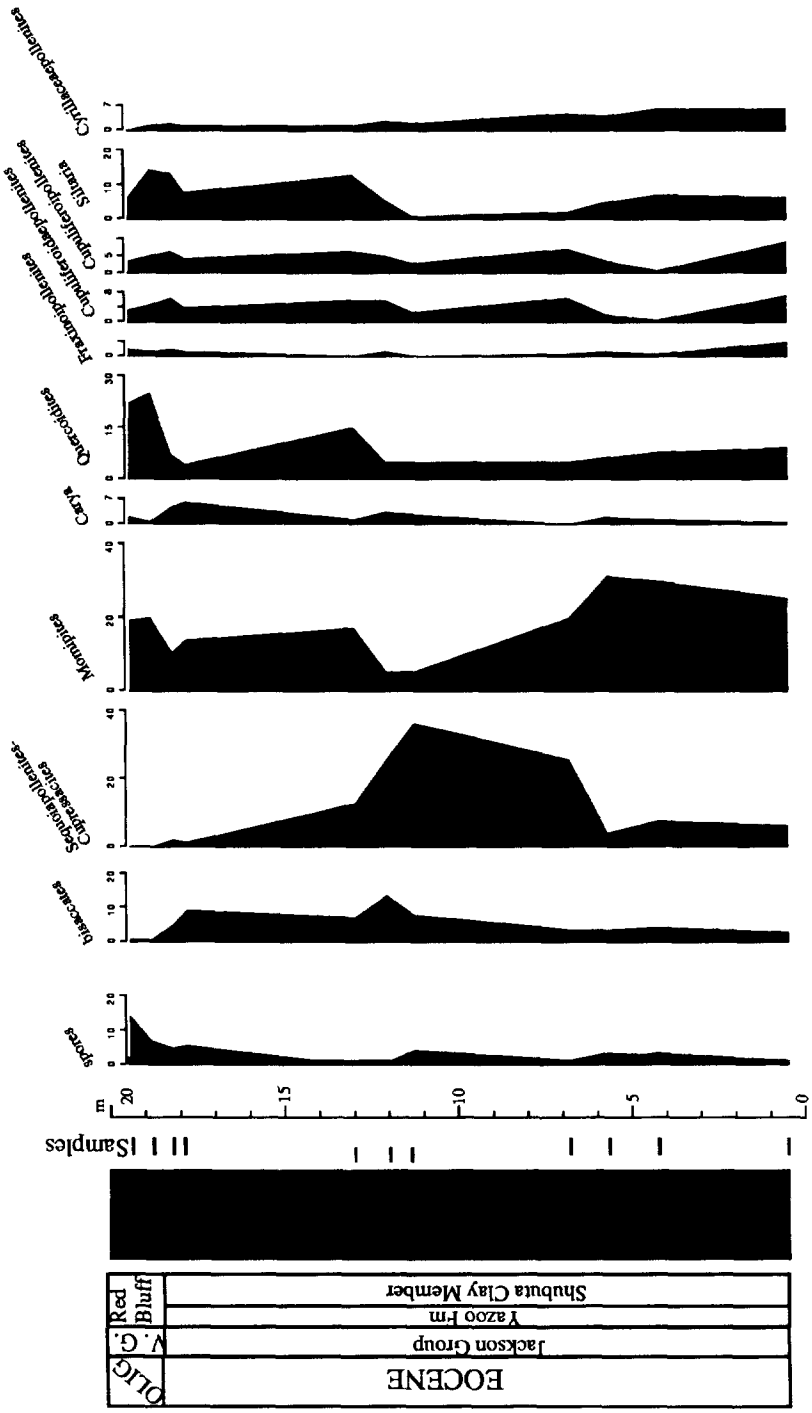

Fig. 4. Relative frequencies (%) of 11 groups of palynomorphs identified in this study, for Locality 3 at the Type Red Bluff Section.

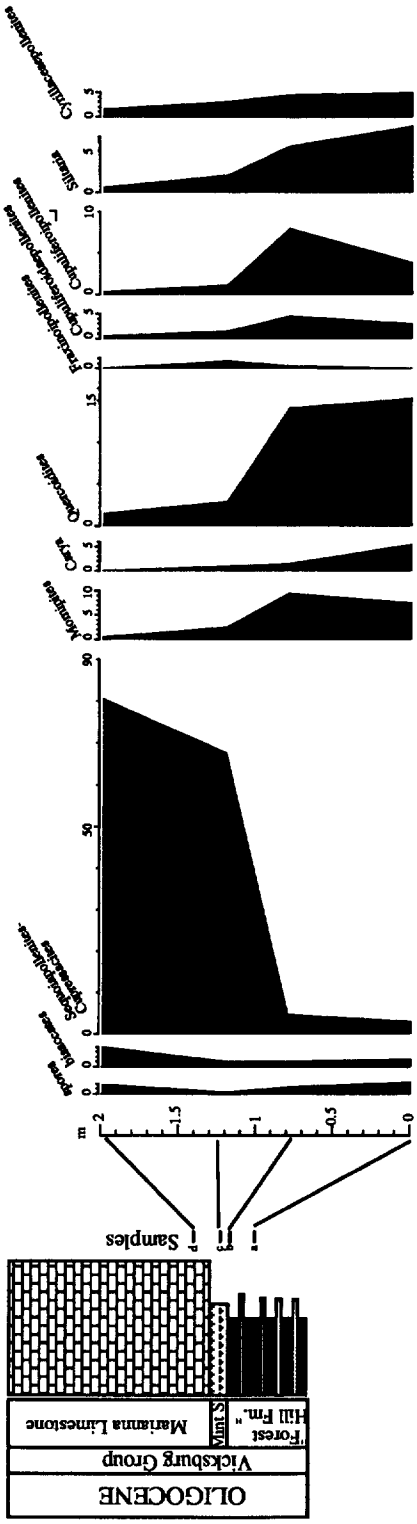

Fig. 5. Relative frequencies (%) of 11 groups of palynomorphs identified in this study, for Locality 4 east of Waynesboro, Mississippi.

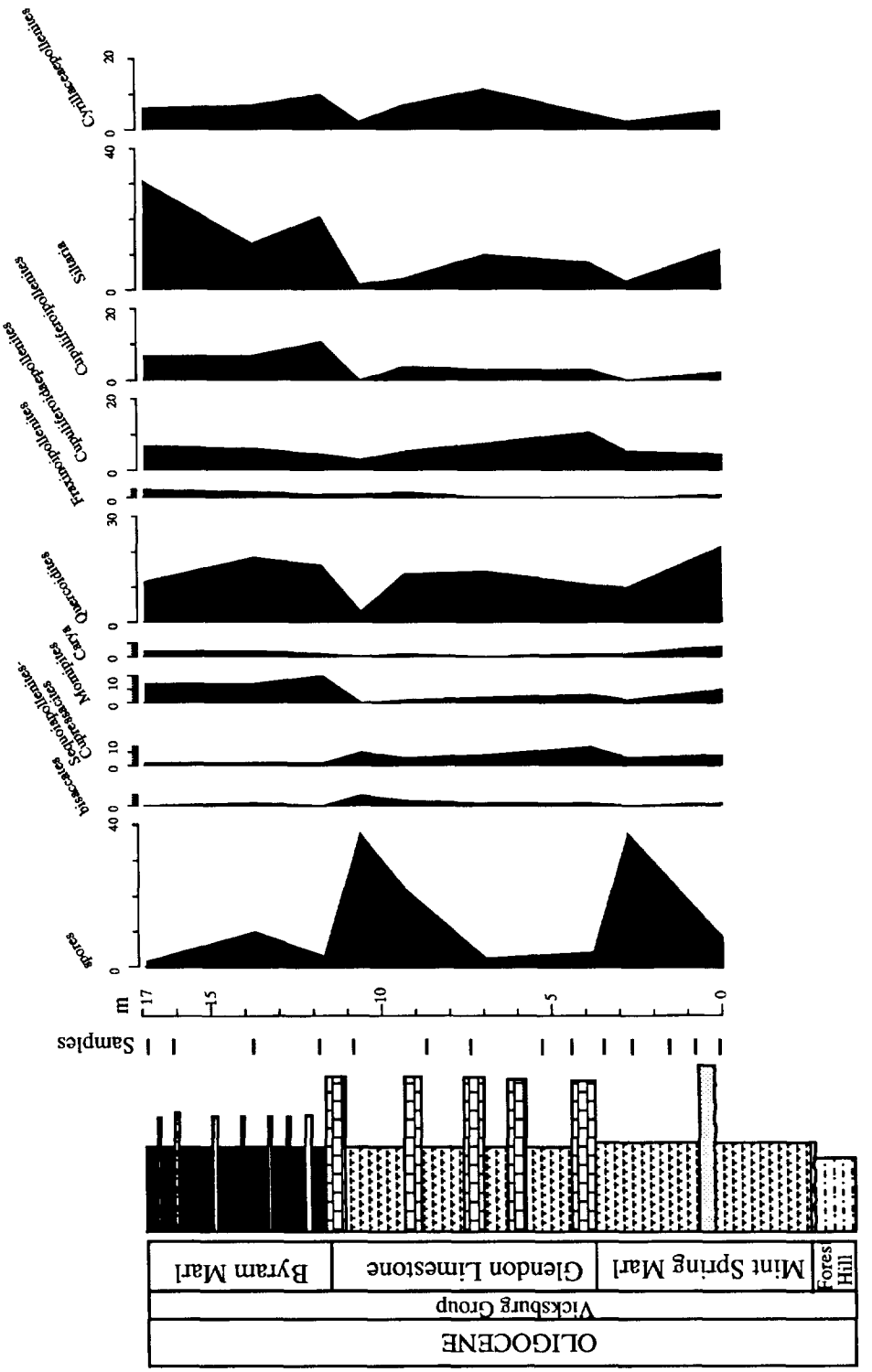

Fig. 6. Relative frequencies (%) of 11 groups of palynomorphs identified in this study, for Locality 5 at the Mississippi Valley Portland Cement Quarry.

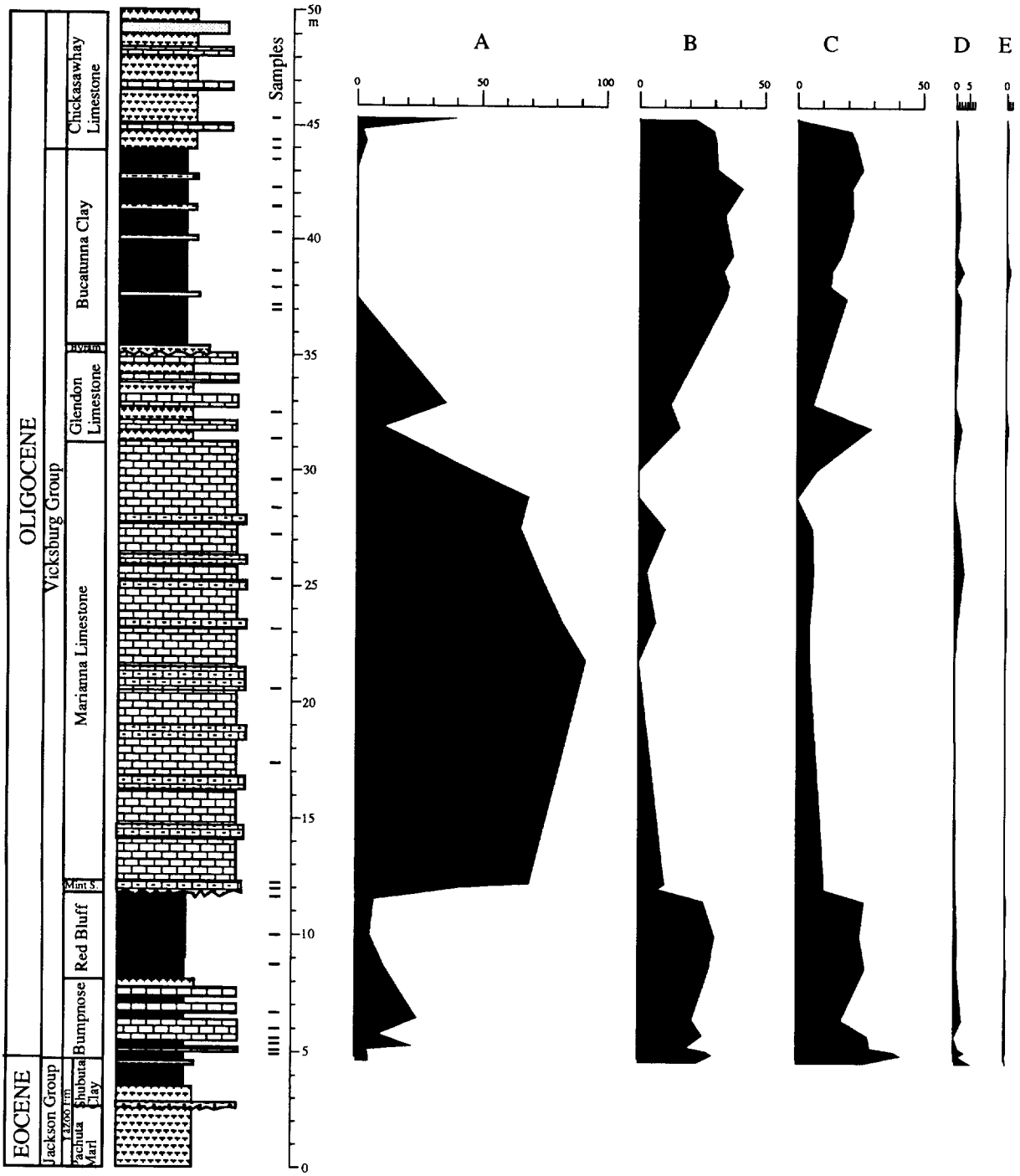

Fig. 7. The five significant clusters expressed as percentages in Locality 1.
Cluster A = *Sequoiapollenites lapillipites*, and *S.* sp. 1.
Cluster B = *Carya simplex*, *Siltaria* cf. *S. scabriextima*, *Quercoidites microhenricii*, *Momipites coryloides*, and *Ulmipollenites thompsonianus*.
Cluster C = *Laevigatosporites haardtii*, *Cupuliferoidaepollenites* cf. *C. selectus*, *Cupuliferoidaepollenites liblarensis*, *Cupressacites hiatipites*, *Cupressacites* sp. 1, *Quercoidites inamoenus*, and *Cyrillaceaepollenites megaexactus*.
Cluster D = *Salixipollenites parvus*, and *Cicatricosisporites dorogensis*.
Cluster E = *Fraxinoipollenites* spp.

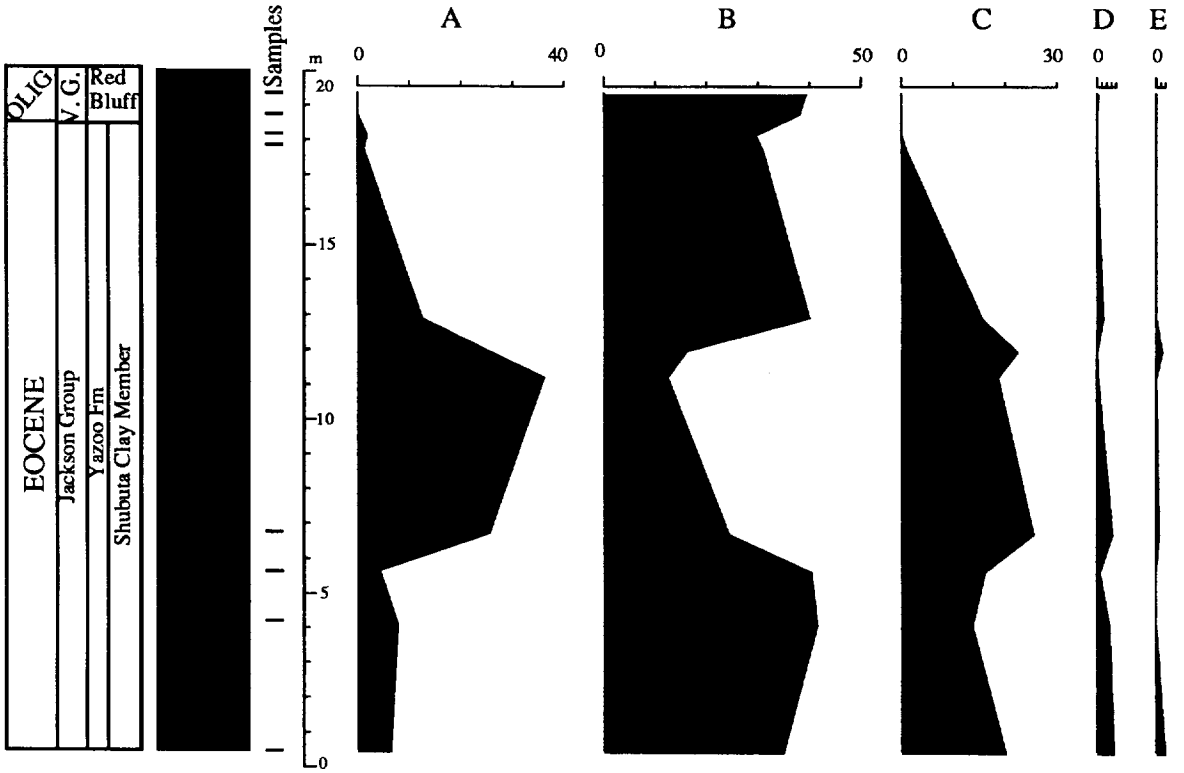

Fig. 8. The five significant clusters expressed as percentages in Locality 3. See Fig. 7 for the taxa in each cluster.

The five significant cluster groups, however, do show some ecological significance. Whereas group A with the two *Sequoiapollenites* species, may represent an upland assemblage, group B probably contains both dry land taxa (*Carya*, *Ulmipollenites*, *Quercoidites microhenrici*) and a swamp taxon (*Momipites coryloides*) (Judith Gennett, pers. commun., 1994). She also suggested that groups C and D contain predominantly freshwater and brackish swamp/marsh taxa. Group C is dominated by such swamp taxa as *Momipites microfoveolatus*, *Cupressacites* and *Cupuliferoidaepollenites*. Frederiksen (1981) suggested that *Salixipollenites* pollen probably was produced in marshes; this taxon and *Cicatricosisporites dorogensis* are the components of group D. The ecological significance of group E is not known. This group has only one taxon, *Fraxinoipollenites* spp., which is produced by several families (Frederiksen, 1980).

Our unpublished palynomorph data set indicates that many species were long-ranging, from the Eocene into the Oligocene. Elsik (1974) and Frederiksen (1980, 1988) have shown that most of the taxa occurring in our data, above the Eocene–Oligocene boundary, evolved before the deposition of the Shubuta Clay and ranged into the Oligocene. The boundary is marked only by a slight increase in *Momipites* (in the Red Bluff Clay) and *Quercoidites*, and is accompanied by a decrease in *Sequoiapollenites*. Generally, *Momipites* is more abundant in the Shubuta Clay than the Vicksburg units. We conclude, therefore, that in our study area the palynoflora at the Eocene–Oligocene boundary did not experience any abrupt floristic changes. The palynofloral patterns preserved in the strata were controlled by the vegetation on adjacent land areas, abundant production of certain species and easy dispersal into offshore environments.

Climate plays an important role in the type of palynofloras present in sediments, occasionally resulting in major turnovers. Several paleontologic

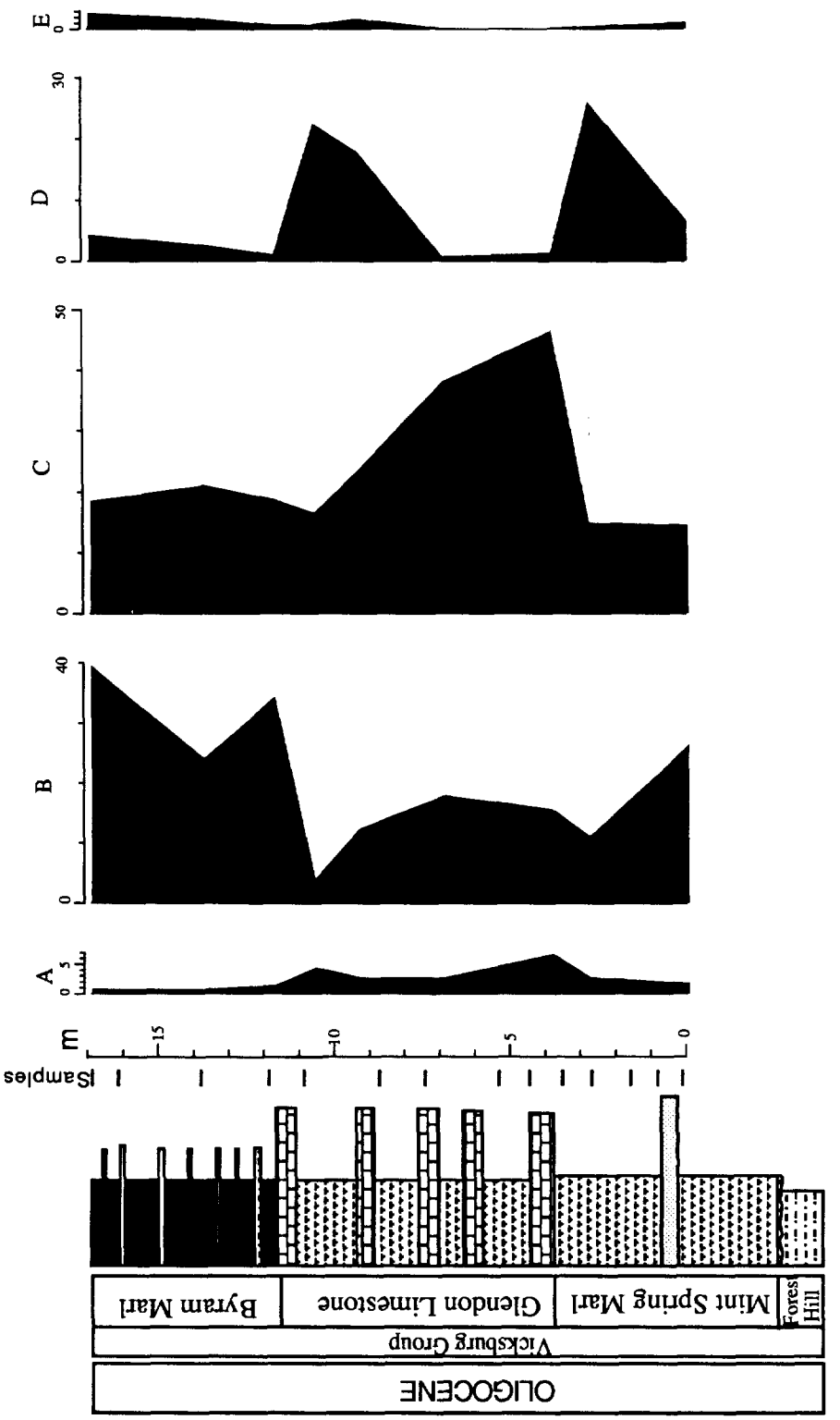

Fig. 9. The five significant clusters expressed as percentages in Locality 5. See Fig. 7 for the taxa in each cluster.

and geochemical studies (e.g. Wei, 1991) have demonstrated that the Early–Middle Oligocene was cooler than the Middle–Late Eocene in several parts of the world. The rise in dominance of *Quercoidites* over *Momipites* was used by Elsik (1974) and Frederiksen (1988) to suggest a cooling and drying trend that took place either at the beginning of the Oligocene, or toward the end of the Eocene in the Gulf Coast. The prominence of pollen related to *Quercus*, *Sequoia*, *Carya*, *Cyrilla*, *Taxodium*, *Ulmus*, and *Fraxinus* in this palynomorph assemblage is indicative of a warm temperate climate in the eastern Gulf during Vicksburgian time. This observation is supported by (1) the rarity of cool temperate to cold temperate palynomorphs related to *Picea*, *Abies*, *Tsuga*, *Betula*, among others, and (2) the presence of some tropical to subtropical palynomorphs such as *Psilatricolporites operculatus*, *Nyssapollenites pulvinus* and *Cicatricosisporites dorogensis* (Van der Hammen, 1954; Germeraad et al., 1968; Groot, 1991). The major floral turnover along the Gulf Coast occurred well before the deposition of the Vicksburg units during the Early Oligocene.

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