# High-Resolution Sequence Stratigraphy of Paleogene, Nontropical Mixed Carbonate/Siliciclastic Shelf Sediments, North Carolina Coastal Plain, U. S. A.

by

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**(ABSTRACT)**

The sequence stratigraphic development of the subsurface Paleogene, Albemarle Basin, North Carolina, was defined using well cuttings and wireline logs tied into largely published biostratigraphic and available seismic data. Facies include: silty and shelly sands and shell beds (estuarine/lagoon/protected inner shelf facies); clean quartz sands and sandy mollusk-fragment grainstones (shoreface/shallow shelf); phosphatic hardgrounds (current and wave-swept shoreface and shallow shelf); bryozoan and echinoderm grainstones/packstones (storm reworked middle shelf); and fine skeletal wackestones and planktonic marls (slightly storm-winnowed to sub-wave base, deeper shelf). Paleogene deposition on this high-energy, open-shelf was characterized by a distinctive shelf profile of inner shelf and inner shelf break, deep shelf and continental shelf/slope break. The successive positions of terminal supersequence inner-shelf-breaks

parallel the modern day continental margin and its onshore arches. Thickness trends were strongly controlled by more rapid subsidence within the Albemarle Basin.

The Paleocene supersequence is dominated by deep shelf marl and developed following flooding after the latest Cretaceous low-stand. Major shallowing occurred at the end of the Early Paleocene and near the end of the Late Paleocene. The Eocene supersequence developed following lowstand deposition (evident on seismic) just off the terminal Paleocene depositional shelf break. With flooding, a major transgressive sediment body developed (Pamlico spur), that formed a 50 km wide by 50 m high promontory at the inner shelf break, followed by HST progradation of quartzose and bryozoan-echinoderm open shelf carbonates that filled in the laterally adjacent shelf topography. This was followed by ancestral Gulf Stream incision of the southeast-trending, shallow shelf to the south, and deep shelf further northeast. Late Eocene-Oligocene deposition was initiated with localized lowstand sedimentation off the earlier terminal inner shelf break, followed by thin regional marl deposition and widespread highstand inner shelf, quartz sands and quartzose carbonates. Localized Late Oligocene lowstand deposition occurred along the earlier Oligocene terminal inner shelf break, followed by widespread deposition of quartzose facies over the shallow shelf. Oligocene units on the deep shelf were modified by highstand Gulf Stream scour.

## ACKNOWLEDGMENTS

This project would not have been possible without the help of friends, colleagues, and family. I thank Fred Read for exposing me to the carbonate realm, both in the field and classroom, and for treating me as a friend and peer, with valuable suggestions and hours of engaging conversation. Members of the graduate committee, Richard Bambach, Thomas Burbey, Kenneth Eriksson, Matthias Imhof, and Daniel Textoris, are also thanked for their valuable input and instruction. Discussion with new and old friends who have called the Carbonate Lab home, particularly Aus Al-Tawil, Taury Smith, Amy Khetani, and Thomas Wynn, have helped improve my understanding of geology and made my time at Virginia Tech enjoyable. Also, I am fortunate to have met so many new friends while in the department, who have stimulated many scientific and social discussions. The office staff has been invaluable to everyday life, and is thanked for their kind assistance. Students helping to prepare the thousands of thin-sections needed for this study, Chris Chitty, Chad Haiar, Karen Michelson, and Miles Gentry provided great assistance and companionship during long hours in the Carbonate Lab. Richard Laws and Tim Bralower provided nannofossil age picks from critical stratigraphic intervals. This work has benefited greatly from grants from the American Association of Petroleum Geologists, the Department of Geological Sciences at Virginia Tech, the Geological Society of America, the North Carolina Geological Survey, and the Society of Professional Well Log Analysts. Special thanks for the ever-helpful personnel at the North Carolina Geologic Survey for providing access to data and materials. Quarry operators, Orrin Pilkey, and the personnel at the U.S. Geological Survey are thanked for allowing access to outcrops, dredge samples, cores, and seismic data. I thank my parents

for unending encouragement and support and, most importantly, Ginger for companionship, support, and patience during the long 2½ years we were separated while I completed this degree. I thank you all for your help and value each of you as friends.

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# CHAPTER 1: INTRODUCTION

This dissertation presents results from a largely subsurface study, based largely on cuttings from exploratory oil and gas wells of the 0 to 500 m thick Paleogene mixed carbonate-siliciclastic sequences from the North Carolina coastal plain. The relatively thin outcrops and shallow cores were used to better define sediment types, geometries, and gamma-ray response.

Chapter 2 describes how lithofacies can be accurately defined using thin sections of plastic impregnated cuttings from over 1500 sample intervals from the wells. It then describes and evaluates the techniques used to define sequence stratigraphy from well cuttings. The advantages and shortcomings of the procedure are evaluated.

Chapter 3 presents the high-resolution sequence stratigraphy of Paleogene units across the North Carolina coastal plain and continental shelf. The study describes four supersequences and at least 20 sequences from onshore well cuttings and regional onshore and offshore seismic data. Sequences were mapped on the basis of regionally-correlatable deepening, followed by shallowing of sedimentary facies. Sequences consist of quartz sand-dominated lowstands, overlain by transgressive shelf skeletal limestones, and capped by upward-shallowing highstand marls and wackestone/mudstones to skeletal limestones that commonly become more quartzose upward. Cross sections generated were incorporated into a regional depositional model. The subsurface and regional seismic data then were used to develop a revised sequence stratigraphic model for nontropical, mixed carbonate-siliciclastic shelf units.

This is the first attempt at a comprehensive, but preliminary lithology-based sequence stratigraphic framework for the basin. This study provides a detailed cuttings-based framework that will be tested by future deep coring planned for the basin.

## CHAPTER 2: LITHOFACIES AND HIGH RESOLUTION SEQUENCE STRATIGRAPHY OF MIXED CARBONATE-SILICICLASTIC SUCCESSIONS FROM WELL-CUTTINGS, PALEOGENE, N. C.


### ABSTRACT

Well-cuttings provide an abundant, yet underused source of subsurface information in shallow carbonate- and mixed carbonate-siliciclastic Cenozoic basins, which generally have been understudied, because of sparsity of outcrop and core data. In this study, plastic-impregnated thin sections of well-cuttings from the early Cenozoic nontropical, mixed carbonate-siliciclastic succession of the North Carolina coastal plain were used to document the facies developed, and then in conjunction with biostratigraphic data, wireline logs, and seismic profiles, were used to provide a regional lithofacies-based depositional sequence stratigraphy. Although downhole mixing, which inhibits stratigraphic resolution, and the time required to process the cuttings are problems, the cuttings can be used to provide a readily-accessible, low cost means of generating lithology-based sequence stratigraphic frameworks for shallow (less than 1 km) sedimentary basins in the subsurface.


### INTRODUCTION

Most Tertiary sedimentary basins in the world have been drilled in search of water, oil/gas, base metals, or phosphate, leaving a legacy of well-cuttings and wireline logs from the exploration wells. This paper demonstrates that these well-cuttings from exploratory oil/gas and water wells, when plastic-impregnated, thin-sectioned, and used in conjunction with wireline logs, can be used to generate high resolution sequence stratigraphies in shallow (less than 1 km) basins, although their value probably decreases with increasing depth, due to greater downhole mixing. Well-cuttings and wireline logs have been used in Tertiary siliciclastic successions to generate high-resolution sequence stratigraphies (cf. Van Wagoner et al., 1990), but most carbonate or mixed carbonate-siliciclastic basin fills have poorly documented regional stratigraphic frameworks, because the wireline logs do not provide definitive lithologic information in these systems. Thin-sectioned, plastic-impregnated well-cuttings are necessary to analyze these carbonate-rich basin fills, because drilling mud coats and impregnates the permeable and weakly-consolidated cuttings, inhibiting the recognition of rock-types under the binocular microscope. The thin section analysis overcomes this problem and allows the various microfacies to be accurately determined, and percent of each microfacies within the cuttings interval to be estimated. This data then can used to define vertical facies successions, and map depositional sequences, as demonstrated here on the Early Tertiary mixed-carbonate-siliciclastic sediments, Albemarle Basin, eastern North Carolina.

## GEOLOGIC SETTING

The Paleogene (Paleocene, Eocene, and Oligocene) section in the Albemarle Basin of the North Carolina coastal plain (Figs. 1 to 3) overlies 0 to 12 km of early

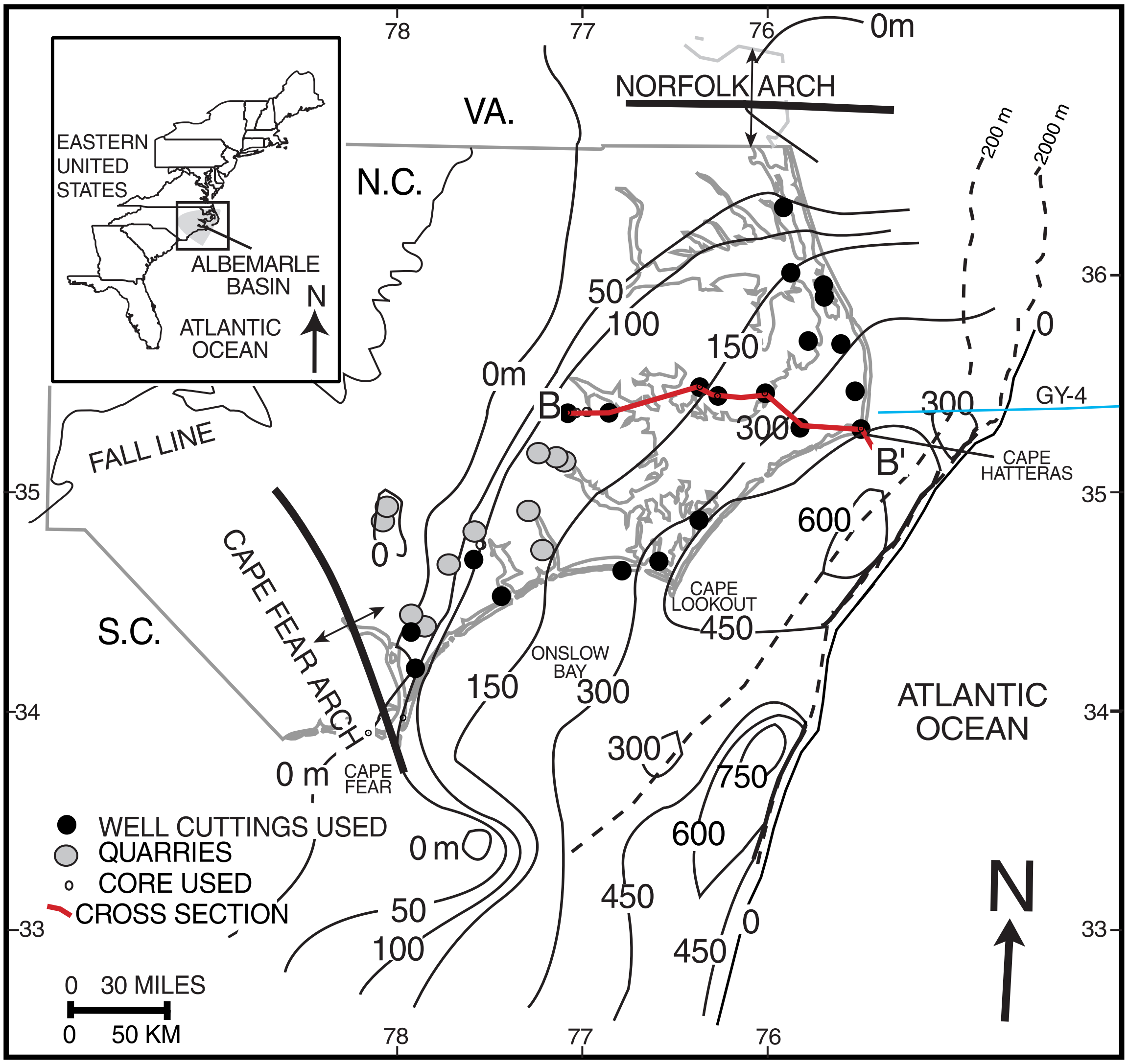


Figure 1. Study area, showing location of outcrops, cores, wells, and wells analyzed with cuttings. Albemarle Basin is shaded, and major structural features are marked. Isopachs give the approximate thickness (in meters) of the Paleogene sections (Modified from Popenoe, 1985 and Brown et al., 1972).

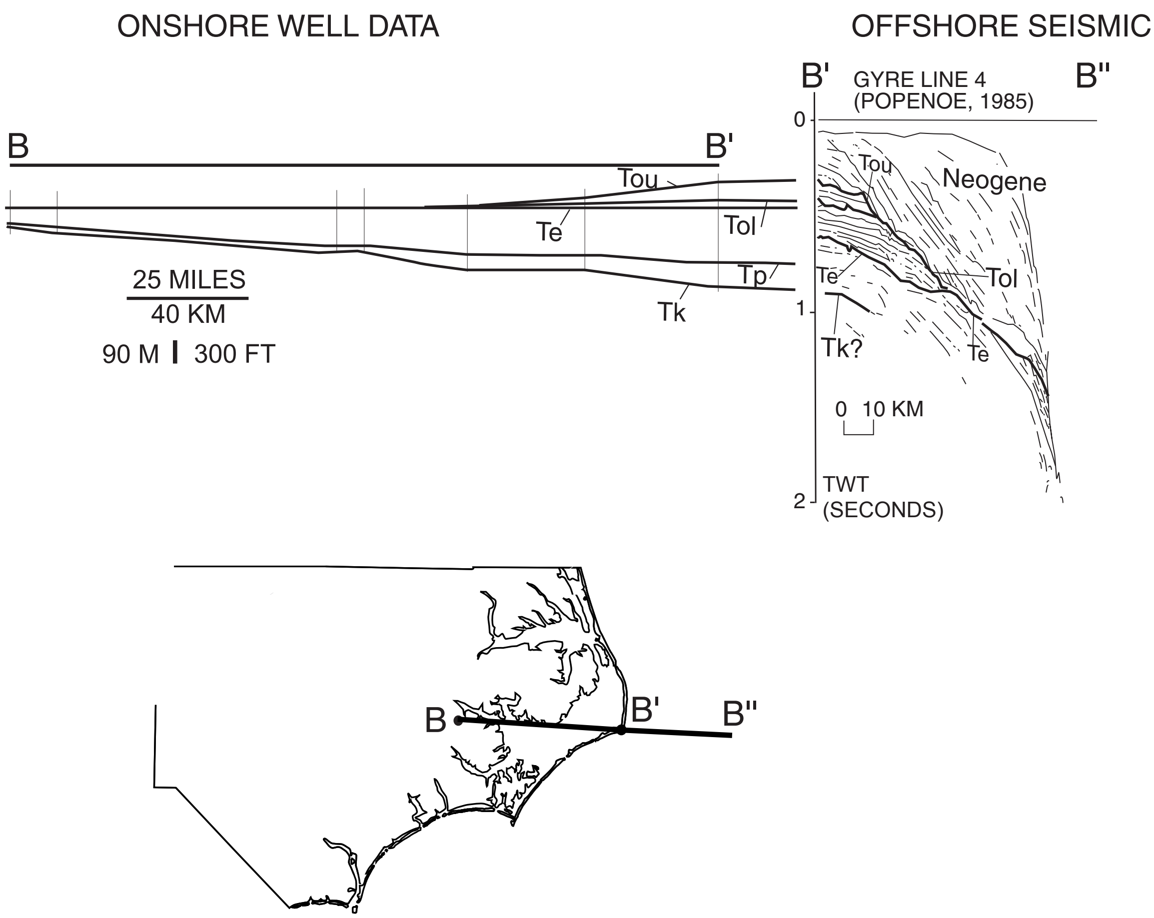


Figure 2A. Simplified, supersequence-scale cross-section (vertical scale in depth) based on the well cuttings analysis in this paper (left hand side of cross section). Right hand side of the cross-section is a two-way travel time seismic profile from the continental shelf (modified from Popenoe, 1985).  Cross-section extends onshoreand to Cape Hatteras, where seismic line extends across shelf.
TK marks the top-Cretaceous; Tp marks top-Paleocene;, Te marks the top-Middle Eocene; Tol marks the top-Lower Oligocene; Tou marks the top-Upper Oligocene.

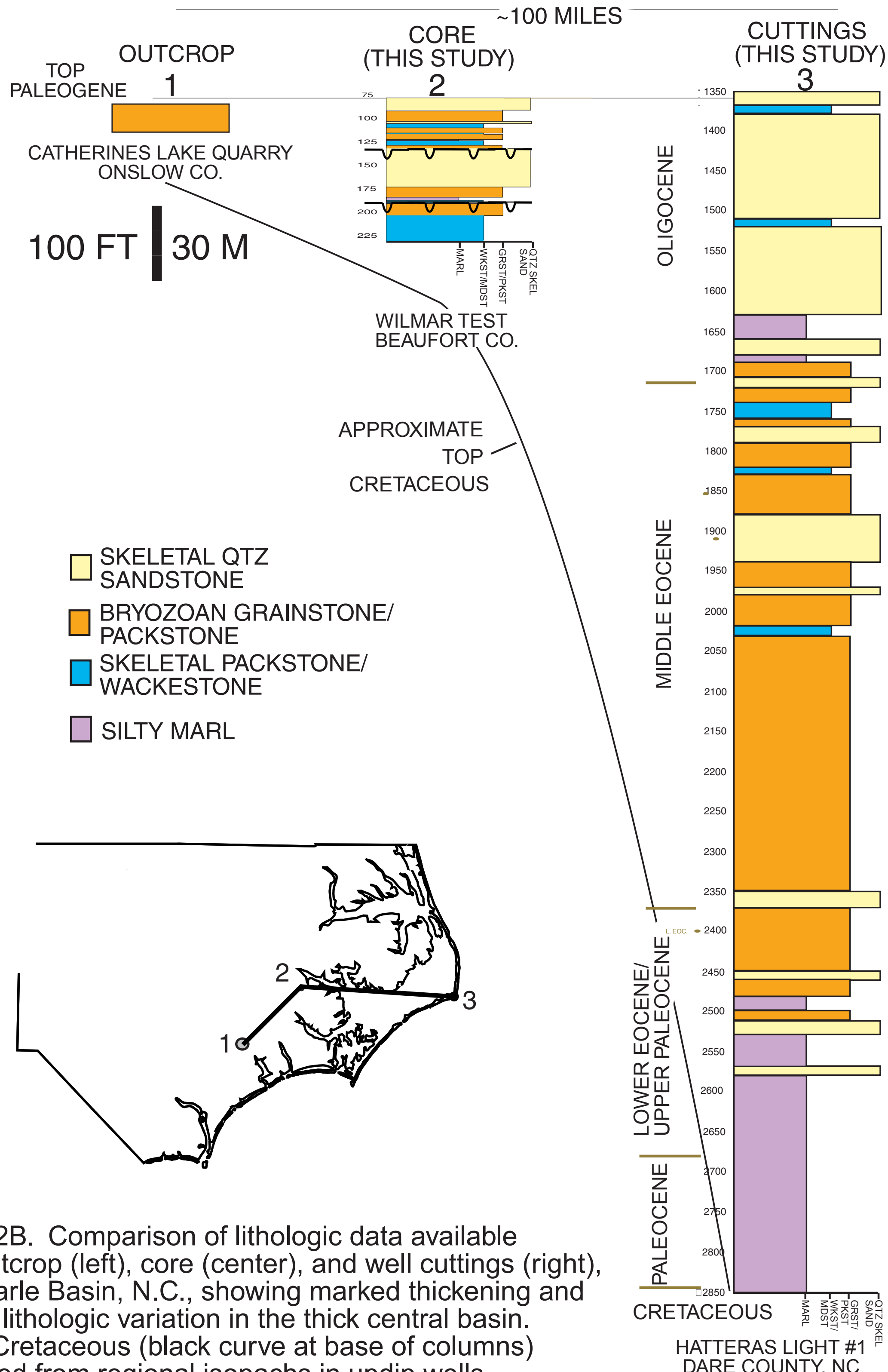


Figure 2B. Comparison of lithologic data available from outcrop (left), core (center), and well cuttings (right), Albemarle Basin, N.C., showing marked thickening and greater lithologic variation in the thick central basin. Top of Cretaceous (black curve at base of columns) estimated from regional isopachs in updip wells. Inset shows well locations.

Mesozoic siliciclastic rift sediments and middle to late Mesozoic shelf siliciclastics and carbonates (Klitgord et al., 1988). Paleogene sediment thickness ranges from 0 m to 500 m across the basin, with greatest thicknesses slightly seaward of the modern Outer Banks (Fig. 1). The Albemarle Basin is bounded to the north and south by the Norfolk and Cape Fear arches, respectively (Fig. 1). Isolated outliers near the present fall line mark the updip erosional limit of Paleogene sediments, which also have been truncated downdip against the modern continental slope (Figs. 1, 2A; Popenoe, 1985). Sediments were deposited on a slowly subsiding passive margin (1.5-4 cm/ky; Steckler and Watts, 1978), that underwent episodic uplift along the arches during the Late Cretaceous and Tertiary (Bonini and Woollard, 1960; Harris, 1975; Harris and Laws, 1994).

Paleogene units of the North Carolina shelf were deposited between 30 and 36 degrees north latitude and were strongly influenced by the ancestral Gulf Stream (Popenoe, 1985; Scotese and Mc Kerrow, 1992; Smith et al., 1994). They lack tropical carbonate indicators, such as peritidal laminites, oolites, and reefal boundstones (cf. Sarg, 1988; Schlager, 1992), but have some features in common with middle to high latitude, nontropical Cenozoic carbonates from the southern Australian margin (cf. Boreen and James, 1993; James et al., 1994), whose facies are dominated by bryozoans, echinoderms, and foraminifera, admixed with siliciclastic detritus.

Regional Stratigraphy.- Most of the Paleogene stratigraphic framework of the North Carolina coastal plain has been based on updip outcrops and quarry exposures (cf. Baum et al., 1978; Ward et al., 1978; Hazel et al., 1984; Zullo and Harris, 1987; Fig. 3). Most quarry exposures are thin (less than 10 m) and widely separated and can only be tied

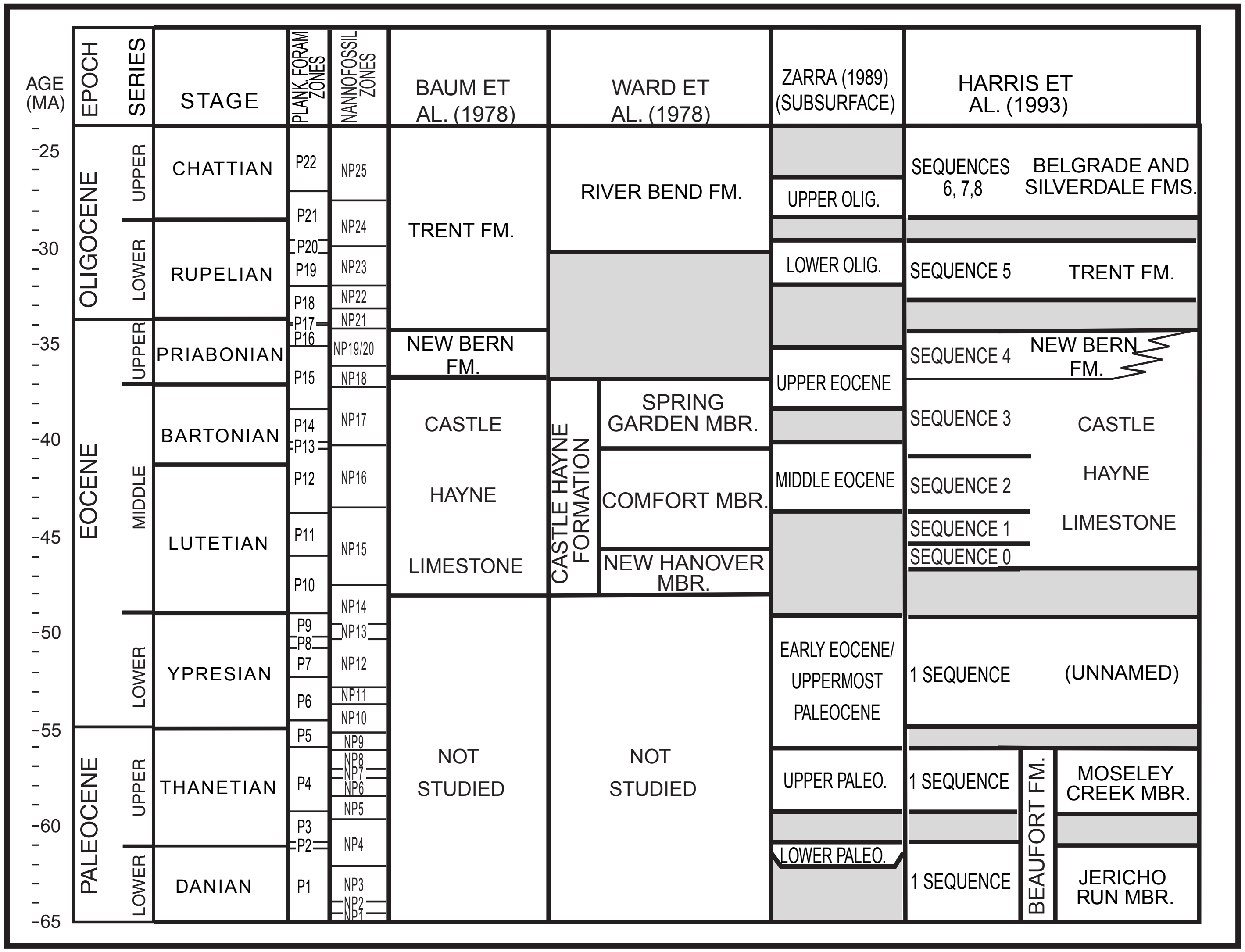


Figure 3. Various regional stratigraphic nomenclature for the Paleogene beneath the North Carolina coastal plain. Biostratigraphic zonations and radiometric time scale are from Berggren et al. (1995).

together by biostratigraphic correlation. The thicker subsurface sections (up to 500 m) in the basin have been correlated largely on the basis of microfossil zonations and logged only in terms of gross lithology in exploratory wells (cf. Brown et al., 1972; Jones, 1983; Zarra, 1989; Harris et al., 1993; Harris et al., 1997; Fig. 2B). Regional high-resolution mapping of depositional sequences in the deeper basin has not been conducted prior to this study, apparently because the available data sets are mainly well-cuttings, and only short cores penetrate the updip portions of the basin.

## METHODS

Twenty-four wells with cuttings at 3 to 5 m, and less commonly, 10 m sample intervals were selected from over 100 wells through the Paleogene, and were used to define lithologic successions in the basin (Fig. 1). Variable cementation and high porosity of the cuttings, many of which are impregnated with "drilling slurry" and are easily disaggregated, inhibited lithologic identification by standard binocular analysis. Instead, cuttings were sieved (0.7 mm mesh), split, dried (24 hours), plastic-impregnated, thin-sectioned, and stained with Dickson's (1965) solution. The cuttings were examined using a petrographic microscope and grouped into microfacies, (using Dunham, 1962), and the percent of each rock type was counted for each thin-sectioned sample interval. Fifteen hundred thin sections were studied, noting the microfacies, biota, cement type, and diagenetic features. The lithologies in the cuttings were grouped into 7 lithofacies: (1) terrigenous silt and sand, (2) quartz sand and skeletal quartz sand (lacking siliciclastic silt), (3) mollusk grainstone/packstone (variably sandy), (4) phosphatic hardground and phosphatic sandstone, (5) bryozoan-echinoderm-foram packstone/grainstone, (6) foram-bryozoan skeletal wackestone, and (7) silty carbonate mudstone (marl) (Figs. 4A, B). The relative abundance of each lithofacies was plotted against depth in the well, then exported to a graphics program for corrections to vertical scaling to account for any non-standard spacing of sample-intervals. To simplify lithologic correlation between wells, each sample interval was classified according to the dominant lithology, and this facies was then used for mapping lithologic units between well sites. Well-to-well correlations in the subsurface were constrained by existing biostratigraphic data, wireline log correlations, and seismic data (Brown et al., 1972; Zarra, 1989).

## AGE CONTROL

Much of the existing age control for the Paleogene of the Albemarle Basin was from studies done in the late 1960s and early 1970s, and was based on ostracodes and foraminifera, and differ slightly from those done later (cf. Brown et al., 1972; Zarra, 1989; Harris, pers. comm., 1997). Few age diagnostic faunas have been reported from the thick Albemarle Basin sections (commonly fewer than 5 age picks for a single well with 300 m of Paleogene section; Zarra, 1989). The Paleogene has been subdivided previously into seven biostratigraphic stages (Brown et al., 1972; Zarra, 1989; Fig. 3). Wells were correlated using the age picks. Published age-picks were honored in the cross sections, unless additional age data, clear lithostratigraphic data, or seismic data suggested otherwise (cf. absence of Lower Paleocene in Esso #2; Appendix D). Additional calcareous nannofossil picks from the cuttings were used to constrain ages, but vertical mixing of these fine components in the wells limits their use (Laws, Bralower, pers. comm., 1999). This is because only tops of zones (first occurrence in the well or last appearance datums) can be used in the wells, and actual ages commonly were younger than the sample depth based on pre-existing microfossil data. Dissolution of age-diagnostic faunas from the Paleocene interval also limited resolution of early Paleogene sequences (Laws, pers. comm., 1999). Microfossils, such as foraminifera, may be less susceptible to downhole mixing than nannofossils, which may occur in mud coating and impregnating the cutting, and which are difficult to wash free without disaggregating the cutting.

## LITHOFACIES FROM CUTTINGS

Lithofacies in the outcrops and well-cuttings are summarized in Table 1 and Figures 4 and 5, and associated hand-held spectral gamma-ray responses are presented in Figure 6A. Small-scale sedimentary geometries, sedimentary structures, and hand-held gamma-ray response are based on outcrop exposures. Well-cuttings data are the only information on the thick subsurface succession downdip from the arches.

Muddy Quartz Sands/Silts (Back-Barrier Bay/Moderate Energy Inner Shelf).- Core and outcrop data suggest that two spatially separate facies may be included in this group, that are not easily distinguished in cuttings. These poorly-consolidated units are dark yellowish-brown, silts and fine to very fine quartz sands, with terrigenous clay matrix and rare, very fine glauconite (Fig. 4; Table 1). Units are 3 to 15 m thick, and may be associated with cleaner, and slightly coarser quartz sandstones. Rare lignite locally is

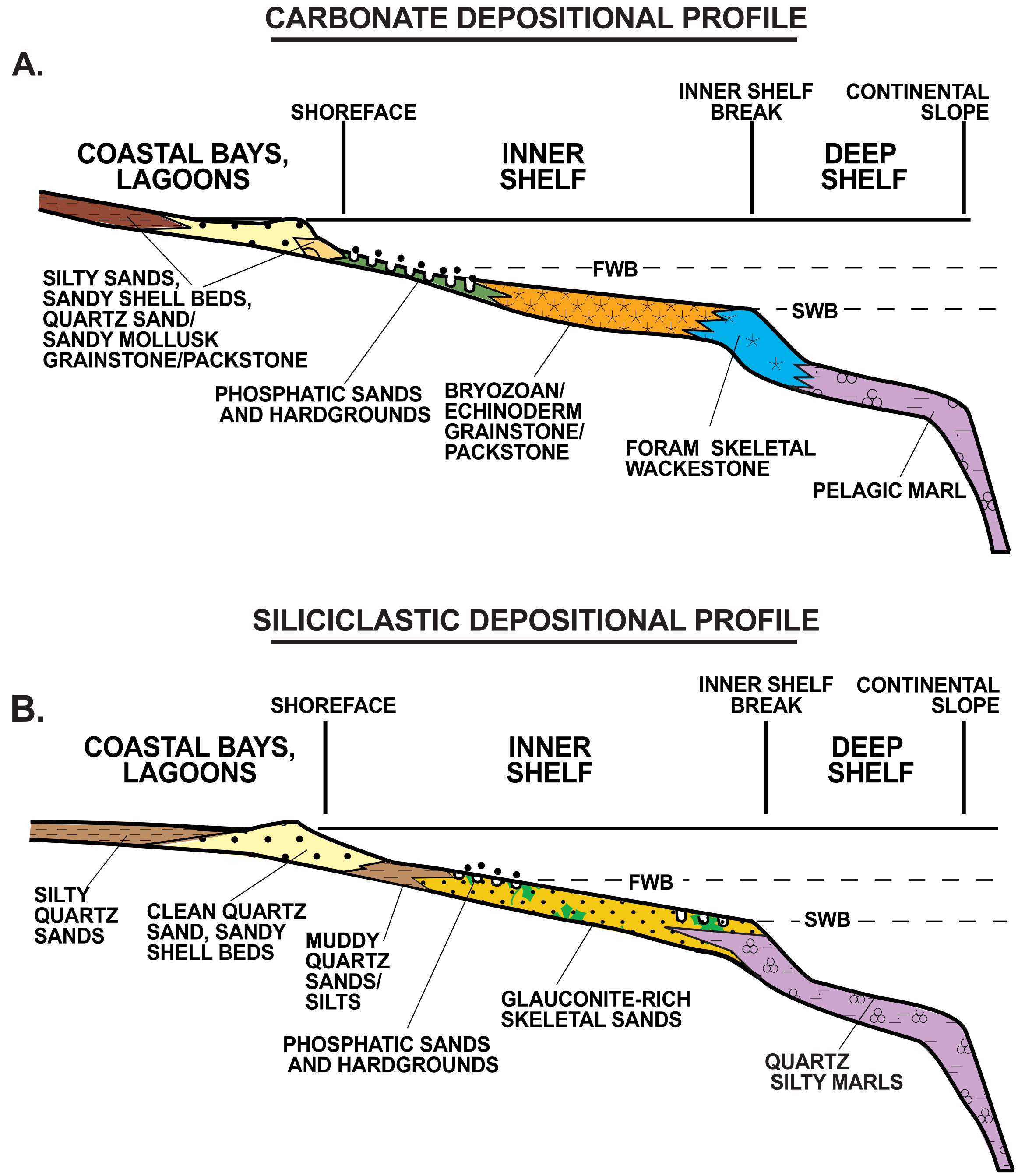


Figure 4. (A) Generalized carbonate facies distribution across the Paleogene shelf and, (B) generalized siliciclastic facies distributions across the Paleogene shelf. Both have a distinctive depositional profile with a low-relief shoreface, passing out onto a wave-swept region on the inner shelf, passing out into a sediment accreting region on the slightly deeper inner shelf (10 m to 50 m plus), an inner shelf break sloping gently (~1 degree) to a Gulf Stream-influenced deep shelf at depths greater than 100 m deep, which terminates against the continental slope.

Table 1. Mixed carbonate-siliciclastic facies.

| Facies | Quartz sands/skeletal fragment quartz sands; (barrier/ shoreface) | Fine to medium, muddy quartz sand and silt; (back-barrier bay and moderate energy inner shelf) | Sandy whole mollusk packstone/ grainstone (shell beds); (bay and shallow inner shelf) | Sandy mollusk-fragment grainstone/ packstone; (bay/shore-face/shallow inner shelf) | Phosphatic sands and hardgrounds; (shallow inner shelf) | Bryozoan-echinoderm-grainstones/ packstones; (storm-influenced deep inner shelf) | Glauconitic sands; (deep inner shelf) | Fine wackestones/ mudstones; (deep shelf below storm wave base) | Marls and sandy marls; (deep, low energy shelf below storm wave base) |
|---|---|---|---|---|---|---|---|---|---|
| **Stratigraphic occurrence and thickness** | Occur with shell beds, especially in Upper Eocene and Oligocene; 0.5 to 10m thick, but rarely greater than 1 m in outcrop | Not present in outcrop; associated with sands in subsurface; 3 to 15m thick; common in Upper Eocene and Oligocene strata in northeast | Sheets, lenses, and small banks associated with quartz sands and skeletal quartz sands; 0.25 to 3m thick; more common in Oligocene strata | Interlayered with shell beds and quartz sands; common in Oligocene interval; form stacked units; 1 to 5 m thick | Phosphatic hardgrounds form regional planar surfaces; may be overlain by phosphatic sands up to 0.5m thick, except in Upper Oligocene phosphorite accumulations of northern basin | Dominant Middle Eocene facies; 2 to 15m thick; less common in Upper Paleocene and Oligocene | Associated with planktic marls; more abundant in northern Albemarle Embayment (3-10m thick) | Thin (3-5m) units in outcrop and wells; commonly associated with marls | Thick sections (50m) in Paleocene; In Eocene/Oligocene, relatively thin (2-10m) in subsurface ; thin to 3 m in outcrop over the arches |
| **Color** | Light gray | Dark yellowish to brown | Light gray to light yellowish gray | Light gray to light yellowish gray | Yellowish brown to grayish black | White to very light gray | Dark green | Light gray to light olive gray | Light olive gray |
| **Bedding and sedimentary structures** | Massive to crudely bedded | Massive in core | Massive/ bioturbated | Massive, heavily burrowed; laterally discontinuous in outcrop | Regional planar to irregular surfaces, with borings; common lags | Some meter-scale sand waves in outcrop, commonly large-scale cross-bedded | Not present in outcrop | Massive/ bioturbated | Massive, or thin-bedded to laminated in outcrop |
| **Constituents:** | Highly-fragmented angular to rounded skeletal material and abundant rounded medium to coarse quartz sand (Fig. 5B) | Common subrounded fine sand to silt, and clay matrix; common fine skeletal fragments (Fig. 5A) | Abundant leached whole mollusks and variable amounts of very fine to fine quartz sand and silt; lime mud matrix sparse to abundant (Fig. 5C) | Abundant leached, variably fragmented mollusks and abundant rounded medium to coarse sand; minor lime mud (Fig. 5D) | Minor skeletal material, commonly phosphatized and common rounded medium to coarse sand (Fig. 5E) | Medium sand-gravel; bryozoans, echinoderms, clams, and forams; variable fine angular to subrounded medium sand; sparse to abundant lime mud matrix (Fig. 5F) | Minor planktic and benthic forams; medium to very coarse sand sized, spherical to ovoid glauconite pellets and rounded very fine to medium quartz sand; siliceous silt/clay present in stringers or as ovoid fecal pellets (Fig. 5G) | Fine sand to gravel sized benthic skeletal debris; variable planktic biotas and very fine to fine subangular quartz sand in argillaceous lime mud matrix | Planktic tests and spicules variable amounts of angular quartz silt to very fine sand in a matrix of silt to clay-sized carbonate and terrigenous silt/clay; finely disseminated phosphate and oxides; (Fig. 5H) |
| **Biota** | Clams, oysters, barnacles; minor echinoderms | Gastropods, bivalves, and echinoderms common; Diatoms, planktic and benthic forams in marine shelf facies | Abundant clams and oysters; some gastropods | Clams, oysters, some barnacles; minor echinoderms | Boring mollusks, encrusting organisms common (benthic foraminifera, thick-walled bryozoans) | Abundant bryozoa, echinoderms, brachiopods, moderate benthic and planktic forams; minor red algae, crab fragments, and ostracodes | Planktic and benthic foraminifera, minor sponge spicules, and pycnodontid oysters | Delicate bryozoans, echinoderms, and benthic forams; some planktic forams | Common planktic foraminifera, sponge spicules, radiolaria, calcareous nannoplankton, minor benthic foraminifera |
| **Glauconite** | Minor, very fine to fine sand size | Minor, very fine sand size | Minor, very fine to fine sand size | Minor, fine to medium sand size | Common, medium to coarse sand size | Variable, fine to medium sand size | Very abundant, medium to very coarse sand size | Variable, very fine to fine sand size | Abundant, very fine to fine sand size |

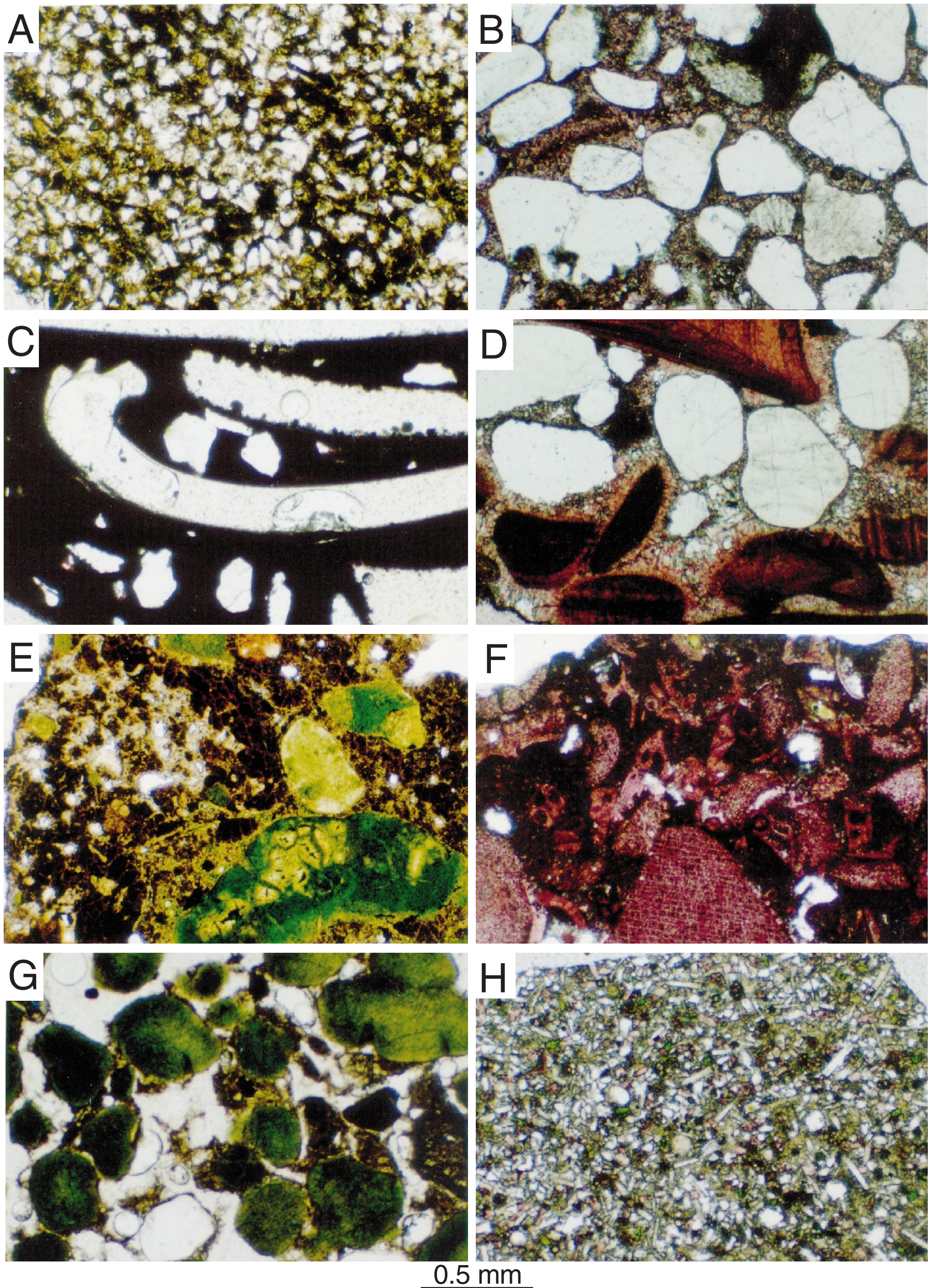


Figure 5. Photomicrographs of facies in well-cuttings. (A). Poorly-consolidated, silty quartz sand, (B) Mud-lean, calcite-cemented quartz sandstone, (C), Phosphatic hardground, with abundant glauconite, (D) Poorly-consolidated glauconitic sand, (E) Mud-rich, whole mollusk packstone from shell bed, (F) Quartz sandy mollusk-fragment grainstone, with heavily-abraded shell fragments, (G) Echinoderm-bryozoan packstone, (H) Silty marl, with abundant planktic foraminifera, sponge spicules, and fine glauconite.

associated with this facies. One facies contains unabraded oysters, turritellid gastropods, bivalves, and diatoms. The other is common in the northern study area and in the Upper Eocene through Oligocene sections, and contains few macrofossils, but abundant diatoms and rare benthic foraminifera (Figs. 4, 5A; cf. Poag, 1989). Gamma-ray response of the silty quartz sands is generally high due to clays and organic material, but may vary because of common downhole caving, as indicated by caliper log kicks.

Abundant siliciclastics and organic material, low faunal diversity, and low carbonate content suggest this facies was deposited nearshore, in moderately low-energy settings. Units with scattered oysters, clams and snails could be a low-energy back-barrier to shallow inner shelf facies (cf. MacGregor, 1983; Webb, 1995; Clarke et al., 1996). In contrast, organic-rich silty units with foraminifera and diatoms suggest deposition on a slightly reduced marine delta front or low-energy shelf (Poag, 1989). Thick accumulations of silty facies in the northern study area indicate the presence of major siliciclastic source input from north of the study area, during Upper Eocene through Oligocene time.

<u>Quartz Sands/Skeletal Fragment Quartz Sands (Barrier/Shoreface)</u>.- Sandy units (1 to 15 m thick) occur in outcrops of Upper Eocene to Oligocene age; but well-cuttings from the deeper basin indicate sands are relatively thin in the Paleocene to Middle Eocene units. These facies are light gray to light yellowish-gray, medium to coarse, quartz sands and skeletal quartz sands that grade in outcrop laterally and vertically into leached, sandy mollusk grainstone/packstone (Figs. 4, 5b; Table 1). They contain highly fragmented and abraded bivalves (oysters and leached clams), common barnacle and echinoderm

fragments, and minor epibionts (encrusting bryozoans, sponges, and flattened benthic foraminifera). Skeletal sands have extensive moldic porosity and are patchily cemented by calcite, making them susceptible to downhole collapse (marked by caliper kicks on logs). Sands have low to intermediate gamma-ray response, due to moderate percentages of fine phosphate and feldspar (Fig.6A).

These facies formed in open marine, high-energy beach, shoreface, and shallow inner shelf settings, indicated by highly abraded skeletal grains, rounded quartz sands, and moderately diverse biotas. Lateral pinch-outs of facies may be due to channels, bars, and storm washovers (cf. Baum, 1981; Griffin, 1982; Moslow and Heron, 1986; Riggs et al., 1995;). Quartz-poor units may have formed by hydrodynamic sorting of quartz and shell fragments within a barrier/shoreface complex, or they could have formed on the shallow inner shelf, some distance from the quartzose shoreface. Greater abundance of this facies in the Oligocene resulted from the establishment of large siliciclastic delta systems onshore.

<u>Sandy, Whole Mollusk Packstone/Grainstone (Back-Barrier Bay/ Shallow Inner Shelf)</u>.- These units are abundant in the Oligocene, range from 3 to 5 m thick, and are interbedded with quartz sand and skeletal-fragment sand. Silicified erosional outliers of sandy shell beds (Eocene?) occur in updip areas. Units are light gray, massive, whole-mollusk packstone/grainstone (shell beds), with variable amounts of interstitial lime mud, sandy lime mud, and quartz sand (Fig. 4; Table 1). Leached bivalves and turritellid gastropods, and calcitic oysters (locally in mounds) are the dominant biota (Fig. 5c) (Baum, 1977, Griffin, 1982; Zullo and Harris, 1987; Rossbach and Carter, 1991). Most shells are

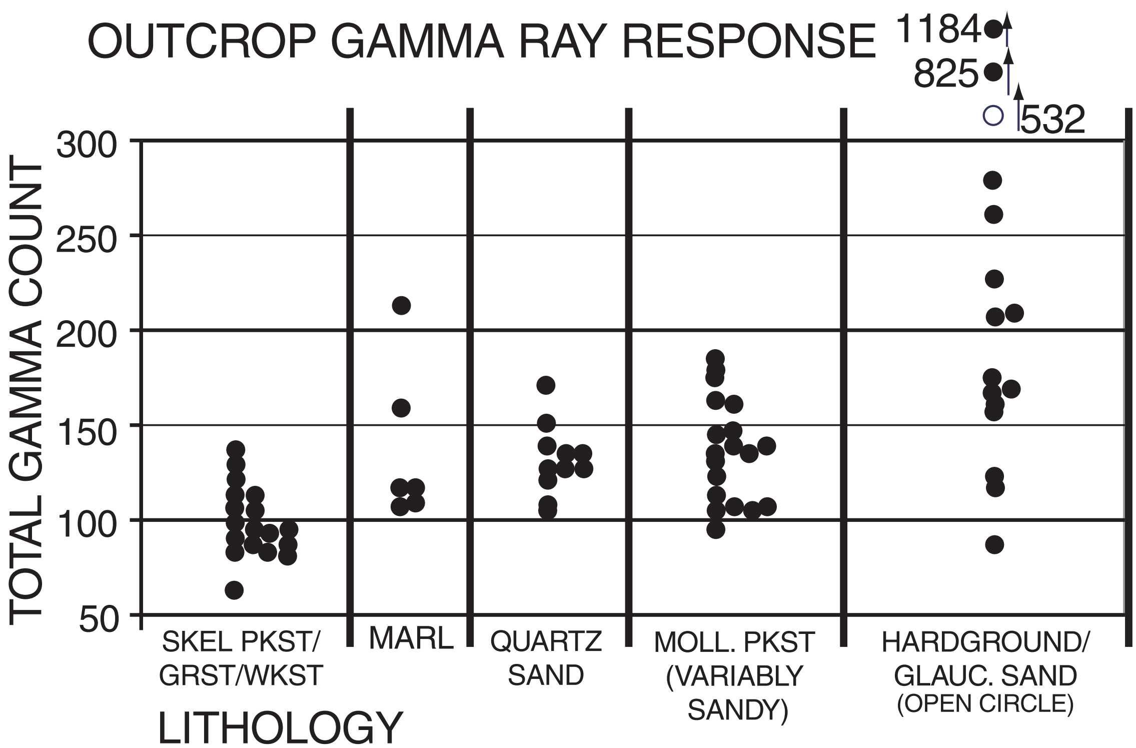


Figure 6A. Hand-held spectral gamma-ray scintillometer measurements of lithologies in outcrop. Overlap of signatures makes differentiation of siliciclastic and carbonate units difficult on wireline logs. Highly variable response of phosphatic and glauconitic units results from variable thickness in outcrop.

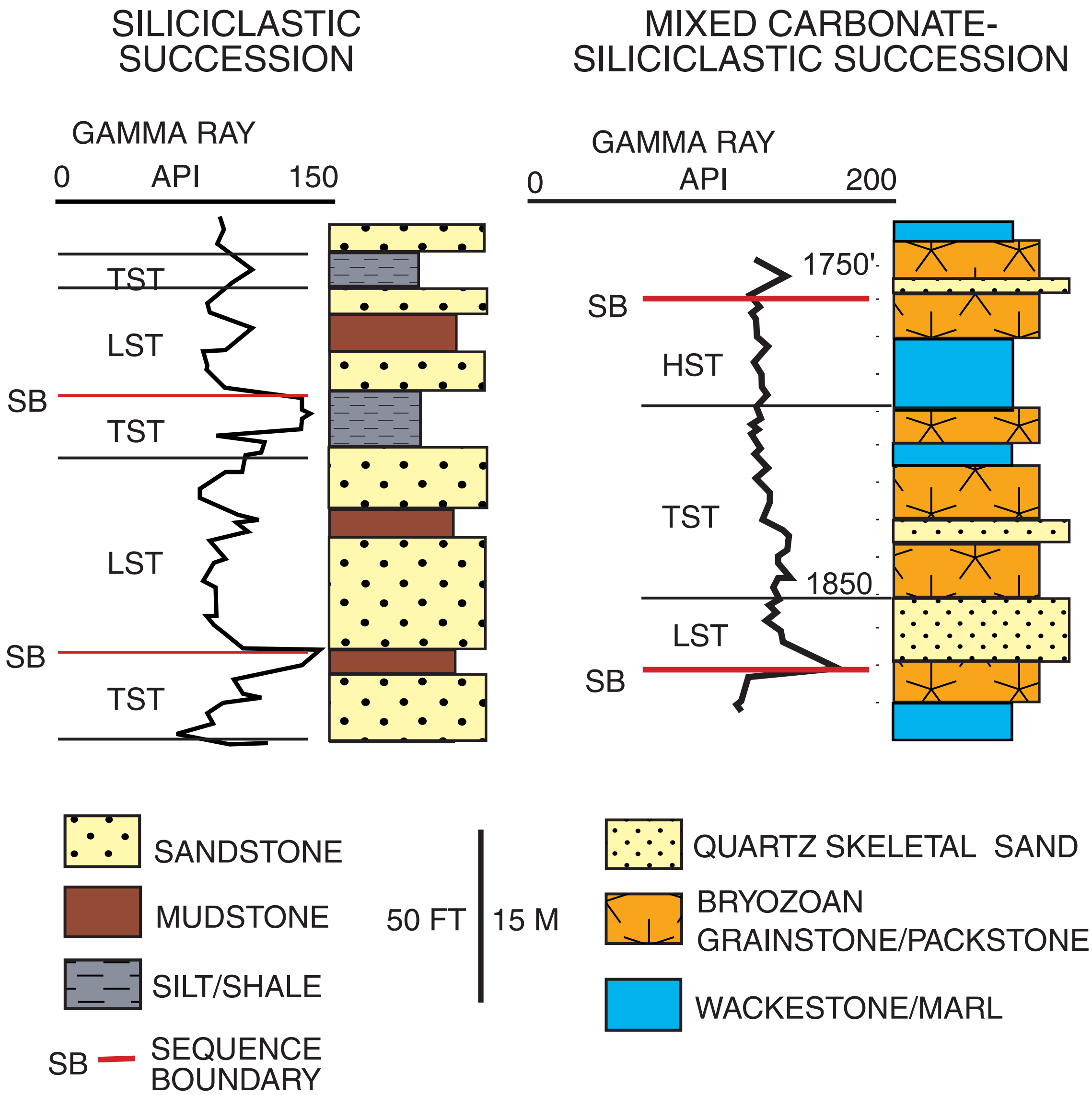


Figure 6B. Comparison of wireline responses in siliciclastic (Exxon #2 well, Sego Canyon, Utah, left, from Van Wagoner et al., 1992) and mixed carbonate-siliciclastic successions (Mobil #2 well, Dare Co., N.C., right, this study), showing that depositional sequences and systems tracts can easily be differentiated using wireline logs in siliciclastic units, but cannot be reliably located in mixed systems. Variable cementation and gamma ray response in the mixed carbonate-siliciclastic successions causes inconsistent wireline log responses, making well-cuttings necessary to identify subsurface lithologies.

gravel-sized and whole, and many are extensively bored. A rare, but distinct variant of this facies in the Lower River Bend Formation is a gastropod packstone, composed of turritellid snails in a gray lime mud matrix (Rossbach and Carter, 1991; Fig. 3). Spectral gamma-ray response from the shell beds generally is low to intermediate (Fig. 6A).

Shell beds containing abundant oysters and which interfinger with quartz sands could have formed in very shallow, restricted, brackish to marine back-barrier bays, or in shallow open shelf settings; other units with greater molluscan diversity may have been deposited on the shallow inner shelf (Griffin, 1982; Rossbach and Carter, 1991; Clarke et al., 1996). Differentiation of back-barrier bay and shoreface facies in thin sections from well-cuttings is difficult, because faunal diversity cannot be assessed from fragments of shell molds in the small cuttings. The muddy gastropod packstones may have formed in sheltered lagoons or, in depressions or areas sheltered from wave-sweeping on the shallow shelf, perhaps behind headlands or offshore promontories.

<u>Sandy, Mollusk-Fragment Grainstone/Packstone (Bay/Shoreface/Shallow Inner Shelf)</u>.- Mud-lean, sandy-mollusk fragment grainstone/packstone, with abundant medium to coarse quartz sand is abundant in Upper Eocene to Oligocene units, occurring in 1 to 5 m thick units, interbedded with quartz sandy facies (Fig. 4; Table 1). The biota includes scattered large (up to 10 cm) leached clams, barnacles, echinoderms, and benthic foraminifera (Fig. 5D; Thayer and Textoris, 1972; Baum, 1977; Griffin, 1982; Zullo and Harris, 1987; Rossbach and Carter, 1991). These units have low to intermediate gamma-ray responses, reflecting moderate percentages of fine detrital phosphate in sands (Fig.

6A). They are cemented by extensive inter- and intragranular coarse equant to bladed low magnesium calcite cement.

This facies formed in nearshore, moderate- to high-energy environments, as indicated by abundant quartz sand, scarce mud, and open-marine biota. Extensive bioturbation by bivalves could have destroyed any layering. These facies resemble late Pleistocene to early Holocene palimpsest shallow inner shelf facies from the southern and eastern Australian and North Carolina margins (Stetson, 1938; Emery, 1965; Milliman et al., 1968; Boreen et al., 1993; Boreen and James, 1993; James et al., 1994; Marshall et al., 1998).

<u>Phosphatic Sands and Hardgrounds (Shallow Inner Shelf)</u>.- These include yellowish-brown to grayish-black phosphatized hardgrounds and medium- to coarse-grained, rounded phosphate-glauconite quartz sands, along with boring mollusks and robust, encrusting organisms (Table 1). The hardgrounds are highly bored, undulatory, irregular to planar surfaces, and are up to 20 cm thick (Fig. 5E). Coarse sand to pebble lags of phosphatic overly well-developed hardgrounds. Sediments beneath the hardgrounds commonly are dolomitized or silicified. The thicker hardgrounds and phosphate lags commonly are regionally traceable as positive responses on gamma-ray logs, reflecting uranium and glauconite enrichment. Outcrop gamma-ray measurements show such that thin hardgrounds (less than 10 cm) are beyond the resolution of the logging tool, so values vary greatly (Fig. 6A).

Some phosphatized surfaces have been interpreted as exposure surfaces that formed in supratidal to intertidal settings, because of the association with microkarstic fabrics (Cunliffe, 1968; Moran, 1989), and depleted carbon-oxygen isotopic compositions (Baum and Vail, 1988). Although modern intertidal phosphorites have been reported, these uncommon deposits are associated with sea bird nesting habitats (cf. Baker et al., 1998). Most of the hardgrounds and phosphate lags formed in nondepositional, subtidal shelf areas swept by currents and swell-waves. Such non-depositional zones are common on modern nontropical shelves subjected to sweeping by open ocean swell-waves, which reworks relict shelf sediments and inhibits sediment accumulation (cf. Emery, 1965; Milliman et al., 1968; Collins, 1988; Boreen et al., 1993; Boreen and James, 1993; James et al., 1994). Other well-developed, hardgrounds and lags may have formed from sweeping by contour currents and associated upwelling gyres on the deep shelf and upper slope (Prokopovich, 1955; Riggs, 1984). Quartz sands associated with hardgrounds and lags were transported seaward from coastal areas by storms. Wave-reworking rounded coarser grains and transported fines seaward. Such high-energy conditions on modern shelves inhibit colonization by most carbonate-producing organisms; instead, soft macro-algae are common inhabitants (Boreen et al., 1993). The hardgrounds and lags formed time-transgressive surfaces and veneers, which migrated across the shelf in response to changing sea-level.

Bryozoan/Echinoderm Grainstones/Packstones (Deep Inner Shelf).- These occur in units of interfingering and interlayered grainstone and packstone from 2 to 15 m thick and may have meter-scale cross-bedded dune-forms, oriented seaward (mostly to the northeast) in outcrops along the southern portion of the basin (Fig. 7). This facies makes up most of the Comfort Member of the Castle Hayne Limestone in outcrop (Fig. 3)

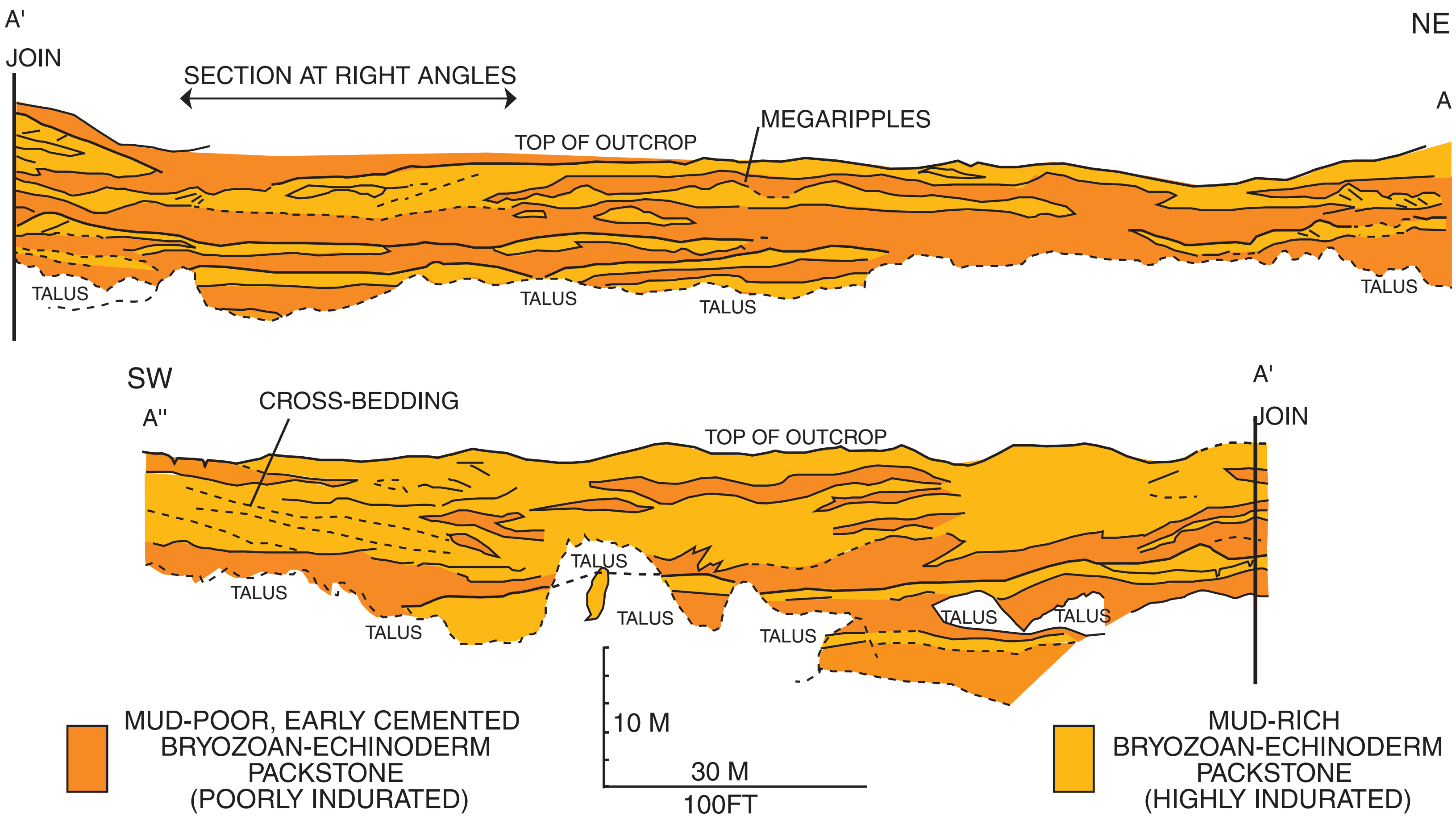


Figure 7. Outcrop photomosaic of quarry wall, showing interlayering of indurated, mud-rich and mud-poor, weakly indurated marine-cemented bryozoan-echinoderm grainstone/packstone units. Outcrop has northeast-oriented, meter-scale, cross-beds and megaripples (Catherines Lake Quarry, Onslow Co., N.C.).

(Ward et al., 1978). Sediments are white to very light gray skeletal grainstone and packstone with minor fine- to medium-grained, angular quartz sand, variable amounts of glauconite, and common interstitial lime mud in the packstones (Fig. 5F). They contain diverse biotas, including (in decreasing order): bryozoans, echinoderms, benthic and planktic forams, pectens, brachiopods, crustaceans, red algae, and solitary corals (cf. Canu and Bassler, 1920; Cheetham, 1961; Baum, 1977; Kier, 1980; Jones, 1983; Hazel et al., 1984; Zullo, 1984; Worsley and Laws, 1986; Zullo and Harris, 1987). Most skeletal material is coarse-sand to gravel-size, both whole and fragmented, and generally lacks evidence of extensive abrasion and reworking, although some grains are slightly abraded and rounded. These sediments have much primary intergranular and secondary moldic intragranular porosity. Primary porosity in the packstones is partly occluded by infiltrated lime mud, which rests directly on the grains and predates any cement. Cements are common in the grainstones and include rare turbid bladed calcite cement, and clear, equant and syntaxial calcite cement. All these facies have a low spectral gamma-ray response, except where glauconitic.

These facies resemble modern and Tertiary carbonates from the nontropical southern Australian and New Zealand shelves (Nelson, 1988; James and Bone, 1991; Boreen and James, 1993; Clarke et al., 1996; James, 1997). Cross-bedding, hardgrounds, and faunal assemblages in these facies have been cited by earlier workers as evidence of shallow, subtidal deposition (Cunliffe, 1968; Upchurch, 1973). However, most workers now consider that such facies formed on the middle shelf, roughly 30-100 meters water depth, as supported by foraminiferal assemblages from updip outliers (Fallaw, 1962;

Baum, 1977; Otte, 1981; Powell, 1981). These generally low-energy, deep inner shelf environments were episodically winnowed by storm-wave sweeping (Fig. 4). Deep shelf contour currents also may have reworked and winnowed the skeletal carbonates. Storm-ebb currents reworked shelf sediments into seaward dipping, cross-bedded dunes and carried fine quartz sand onto the deep shelf, where it was admixed with the carbonate sediment (cf. James et al., 1984; Boreen et al., 1993; Heinrich et al., 1995; Anastas et al., 1998). Analogous reworking occurs on modern nontropical shelves which are storm-wave influenced to 100 m and sometimes as deep as 250 m (Boreen et al., 1993; James et al., 1994; Collins et al., 1997; Anastas et al., 1998; Marshall et al., 1998). During prevailing quiet-water periods, fine carbonate mud infiltrated and was burrow-mixed into some of the skeletal units. The relatively diverse biotas indicate open marine shelf conditions, in which substrates were mobile only during major storms. The faunal assemblages (especially large benthic foraminifera such as lepidocyclinids and heterosteginids, and common aragonitic bryozoans) suggest subtropical to warm temperate settings, in which cool winter temperatures were ameliorated by the warm Gulf Stream (Baum, 1977; Otte, 1981; Powell, 1981; Moran, 1989). Similar warmer shelf temperatures characterize the modern Carolina margin and the western Australian margin (Gorsline, 1963; Menzies et al., 1966; Collins, 1988; James et al., 1999). The bladed marine cements in some units probably were deposited following deepening and stabilization of the sediment substrate, or following initial shallow burial by an overlying thin sediment cover. There does not appear to have been any cementation directly at the sediment-water interface, because cements mainly post-date infiltrated marine muds.

Such limited marine cementation is typical of temperate/nontropical shelves (Alexandersson, 1978; Nelson et al., 1988; Heinrich et al., 1995).

Glauconitic Sands (Shallow to Deep Inner Shelf).- These occur as rare thin veneers in outcrop, but are present as 2 to 10 m thick beds in the basin. Sands are especially common in the Paleocene and Upper Eocene. They are dark green, very fine- to very coarse-grained, poorly-consolidated silty "green sands," of very fine- to medium-grained quartz sand, glauconite, planktic and benthic foraminifera, spicules, and pycnodontid bivalves (Fig. 5G; Table 1). Poorly developed cements are fine equant ferroan calcite, rare silica, dolomite, and phosphorite.

Glauconitic sands developed in low-energy conditions with low sedimentation rates. Dominance of planktic biota and presence of interstitial mud suggest deep inner shelf deposition, but thick Paleocene deposits also appear to have formed in shallow inner shelf, distal deltaic settings. Glauconitic sands are present on modern temperate shelves in water depths from 70 to 3000 m in Western Australia and eastern North America (Gorsline, 1963; James et al., 1999;), but have been reported to form in water as shallow as 20 m (Cloud, 1955). Relatively reducing environments with abundant phyllosilicate clays and organic matter, characteristic of distal deltas, favor glauconite formation (Cloud, 1955), as do cool, normal salinity marine waters with elevated levels of dissolved silica (Harder, 1980). The increase in glauconite in the Paleogene sediments north of Cape Hatteras probably is due to distal deltaic influx of siliciclastics onto the shelf. Increased siliciclastics, plus decreased water temperatures in this area, related to seaward avulsion of the warm Gulf Stream, prevented widespread carbonate production, because biotas were unable to colonize the deep shelf (Fig. 6A).

Fine Wackestones/Mudstones (Deep Shelf).- These units are 2 to 10 m thick and are regionally correlatable. They are light gray-olive gray, thick bedded to massive skeletal wackestone and lesser packstone, with minor silt- to very fine quartz sand, very fine to medium rounded glauconitic sand and glauconitic skeletal grains (Fig. 4; Table 1). Biota include delicate (fan-shaped) and lunulitiform bryozoa, echinoderms, benthic forams, brachiopods, and planktic forams (cf. Canu and Bassler, 1920; Cheetham, 1961; Baum, 1977; Kier, 1980; Jones, 1983; Hazel et al., 1984; Zullo, 1984; Worsley and Laws, 1986; Zullo and Harris, 1987). The fine wackestone/packstone has low gamma-ray response, which locally may be elevated by abundant glauconite (Fig. 6A). The wackestone lithology resembles the matrix of some of the bryozoan-echinoderm packstones. Thus, small cuttings from the matrix of these packstones could have been misidentified as wackestone in this group.

Fine wackestone formed in low-energy, deeper shelf settings largely below storm/swell wave base, based on abundant lime mud, terrigenous clays, delicate benthic skeletons, and abundant planktic foraminifera. Facies were pervasively bioturbated to form the mottled to massive fabrics evident in outcrop and shallow core. Regionally-correlatable wackestone units suggest that large areas of the shelf were below storm wave base at the time of deposition, whereas isolated wackestone units could have formed in local areas protected from storm reworking, perhaps in intrashelf lows or adjacent to the flanks of the embayment.

Argillaceous, Variably Sandy Carbonate Mudstone (Marls And Sandy Marls; Deep Shelf to Slope).- In outcrop, marl units rarely exceed 3 m, but thicken to over 30 m in the basin. Cuttings indicate that hick marls are common in the Paleocene section, but Eocene and Oligocene marls are relatively thin (2 to 10 m thick). The marls range from laminated to burrow-homogenized units of light olive gray quartz silty to very fine quartz sandy marls with abundant very fine glauconite, planktic forams, sponge spicules, calcareous nannoplankton, and rare radiolaria and benthic forams (Fig. 5H; Table 1). Marls are variably cemented by microspheroidal chalcedony, fine-equant, ferroan calcite, and very fine ferroan dolomite rhombs. Gamma-ray responses are low, and poorly-consolidated marls show as caliper kicks on wireline logs, due to borehole erosion (Fig 6A).

Marls were deposited below storm wave-base in low-energy settings, on the deep shelf, where fines winnowed from the shelf, along with planktic debris accumulated (Fig. 4) (cf. James et al., 1994; James, 1997; Marshall et al., 1998). Abundant siliceous sponge spicules and radiolaria in the sediments caused secondary silicification and occlusion of pore-space. Intense bioturbation generally homogenized these units, except possibly where low oxygen levels in the deep waters precluded burrowing. Ferroan dolomite probably formed shortly after deposition, in slightly reducing conditions with elevated alkalinity (cf. Baker and Kastner, 1981; Middelburg et al., 1991).

## DEPOSITIONAL SEQUENCES FROM THE CUTTINGS DATA

Overlap in gamma-ray response between the various lithofacies prevented recognition of lithologic units in the Paleogene by wireline logs alone, unlike distinctive log signatures in siliciclastic sequences (Fig. 6B). Instead, trends in the cuttings (marked by upsection changes in percent of the various facies) were used to recognize depositional sequences and systems tracts (Fig. 8). Stratigraphic columns generated using cuttings from updip wells were compared with available nearby shallow cores, which suggest that third-order sequence-scale events are easily resolved using the cuttings (Fig. 9).

<u>Sequence Boundaries (SB).-</u> These were arbitrarily placed below intervals containing the maximum percent of the shallowest-water facies in that portion of the well (typically quartz sand/mollusk-dominated facies) in the cuttings, and above sections with relatively high percentages of slightly deeper marine facies (typically bryozoan-echinoderm grainstone/packstone, or wackestone/mudstone and marl) (Fig. 8).

<u>Lowstand Systems Tracts (LST).-</u> Lowstands appear to be expressed in the cuttings as zones with high percentages of quartz sands and quartz skeletal sands; their tops are placed beneath units showing dramatic increases in middle to deep shelf skeletal carbonate facies. In units dominated by quartz sandy facies, such as the Upper Oligocene, the LST was difficult to differentiate (Fig. 10).

<u>Transgressive Systems Tracts (TST).-</u> These were defined on the basis of sections with upward decrease in percentage of relatively shallow water facies, such as quartz sand/mollusk-dominated facies or bryozoan-echinoderm grainstone/packstone, coupled with an increase in percent of deeper water wackestone/mudstone/marl (Fig 8). Transgressive deposits are best developed in the thicker (20-30 m) sequences.

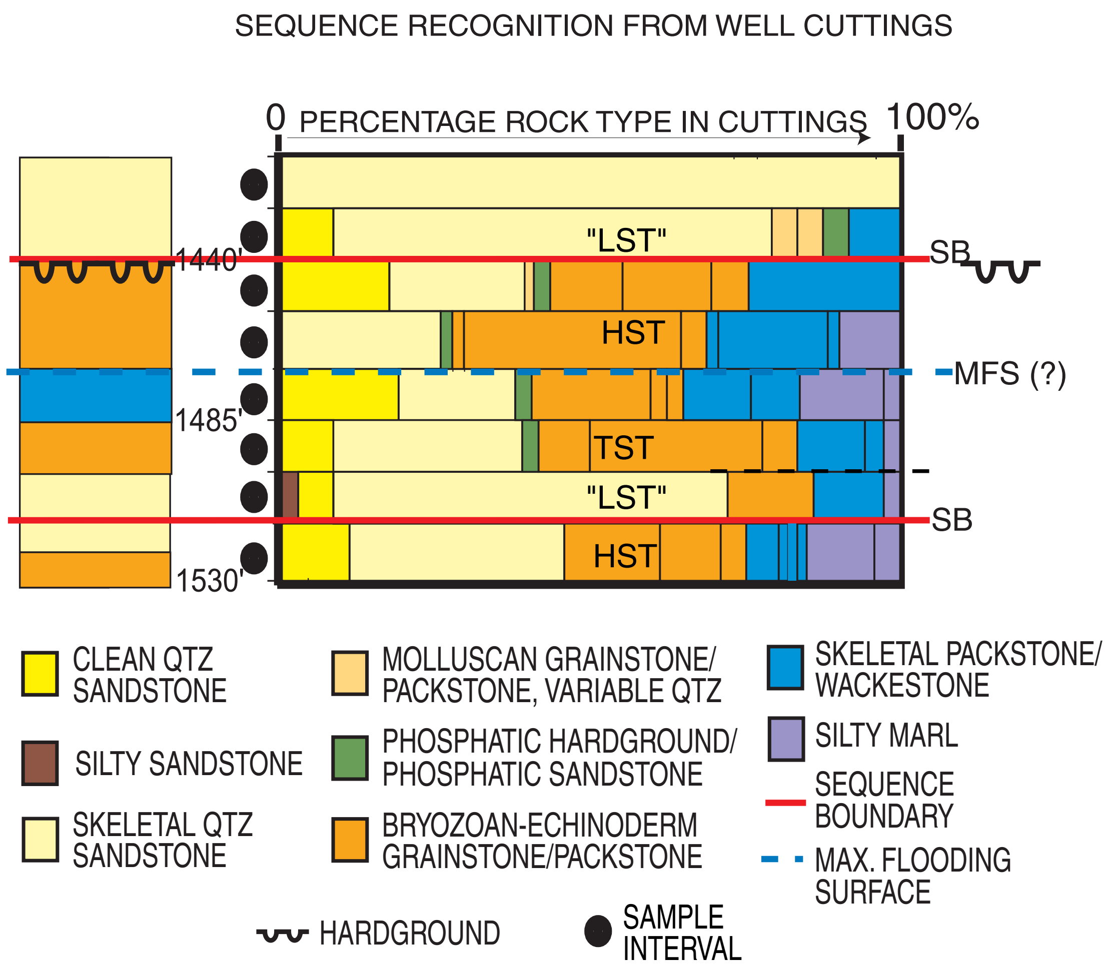


Figure 8. Example of raw data (right) and interpreted data (left) from analysis of thin-sectioned well-cuttings, through a single depositional sequence in an approximately 100 ft interval from Baylands #1 well (depths shown alongside column). High percentages of quartz sand occur in lowstand, TST shows upsection decrease in shallow shelf facies, and HST shows upsection increase in shallow shelf facies. MFS arbitrarily placed beneath interval with minimum quartz-mollusk facies, but it also could be placed beneath the underlying interval with the maximum abundance of deep water facies fragments in cuttings (not used, because less reliable as indicators of water depth).

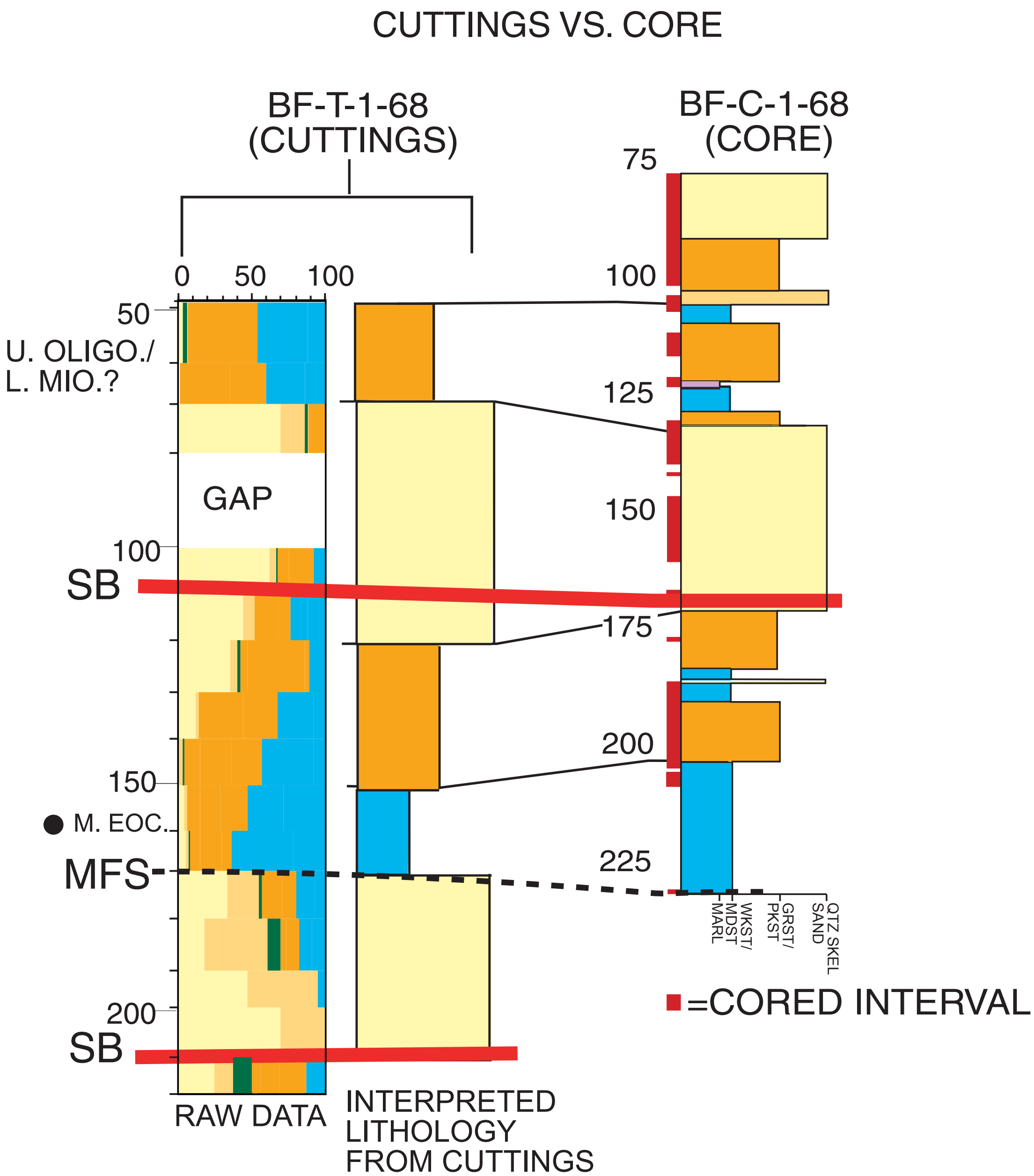


Figure 9. Comparison of lithologic variations between a well analyzed using cuttings (left) and a nearby core (right; 6.5 miles apart). Sequence-scale lithologic variations can be correlated between the wells, as supported by biostratigraphic recognition of major Middle Eocene MFS muddy carbonates in both wells (Bralower, pers. comm.). Units are comparable in thickness, suggesting that downhole mixing has not destroyed the signal in the cuttings, at least to depths of slightly over 200 ft, the limit of the core control.

Maximum Flooding Surfaces (MFS).- Where possible, the maximum flooding surfaces were placed at the base of the interval with the highest percentage of deep shelf facies, above upward decreasing (percentages moving to the left), and below upward-increasing shallow-water facies (Fig. 8).  Skeletal wackestones and marls were most commonly associated with maximum flooding, but skeletal grainstone/packstone units commonly overlie maximum flooding surfaces updip.  In some sequences, the cuttings data suggested more than one maximum flooding event.  This could be due to overestimation of the amount of wackestone/mudstone in the interval, resulting from counting of cuttings fragments of matrix from shallower water facies, or due to mixing of cuttings, or could reflect more than one maximum flood, related to superimposed, higher frequency relative sea-level changes.  Consequently, the MFS is the most difficult and perhaps the least reliable boundary picked using the cuttings.

Highstand Systems Tracts (HST).- These were defined on the basis of upward increase in percent of cuttings of relatively shallow water facies, coupled with a decrease in deeper water facies (for example, bryozoan-echinoderm grainstone/packstone facies that decrease upward, as quartz/mollusk-dominated facies become more abundant).

Sequence Stratigraphic Position of Hardgrounds.- Phosphatized hardgrounds are commonly developed on quartz-mollusk grainstones/packstones and shell beds, echinoderm-bryozoan grainstone/packstones (Fig. 8), and on skeletal wackestone/mudstone facies.

Hardgrounds tend to mark sequence boundaries in outcrops of the coastal plain (Zullo and Harris, 1987).  This is supported by 47% of the identified hardgrounds in the wells occurring at sequence boundaries in this study.  However, 24% of the hardgrounds underlie transgressive surfaces; and 18% occur at the maximum flooding surface.  Only a few occur in either the HST or LST.  Lower Paleocene and Lower Eocene hardgrounds appear to be less continuous than those of other ages in the succession, which form regionally-correlatable surfaces.

## SEQUENCE STRATIGRAPHY AND LONG-TERM TRENDS FROM WELL-CUTTINGS

On the basis of the well-cuttings data, a single supersequence set composed of five supersequences can be recognized in the Paleogene of North Carolina, as well as at least 20 component sequences that can be mapped regionally.  Many of the sequences may match with the global eustatic cycles of by Haq et al. (1987) and Harris and Laws (1997), but additional biostratigraphic data from deep subsurface cores would be required to determine if these events match the published sea-level cycles.

Paleocene sequences have thin lowstand quartz sands, but are dominated by highstand marls.  Eocene sequences are dominated by transgressive and highstand bryozoan-echinoderm skeletal grainstone/packstone units, with variably thick lowstand to early transgressive quartz sands at the bases of the sequences.  Oligocene sequences are composed of dominantly thick quartz sand/mollusk units, with thin, discontinuous mollusk grainstone/packstone and skeletal wackestone/mudstone facies (Figs. 10, 11).

Variation in sequence makeup appears to have resulted from changes in relative sea-level, climate, siliciclastic influx, and submarine current activity.  The long-term

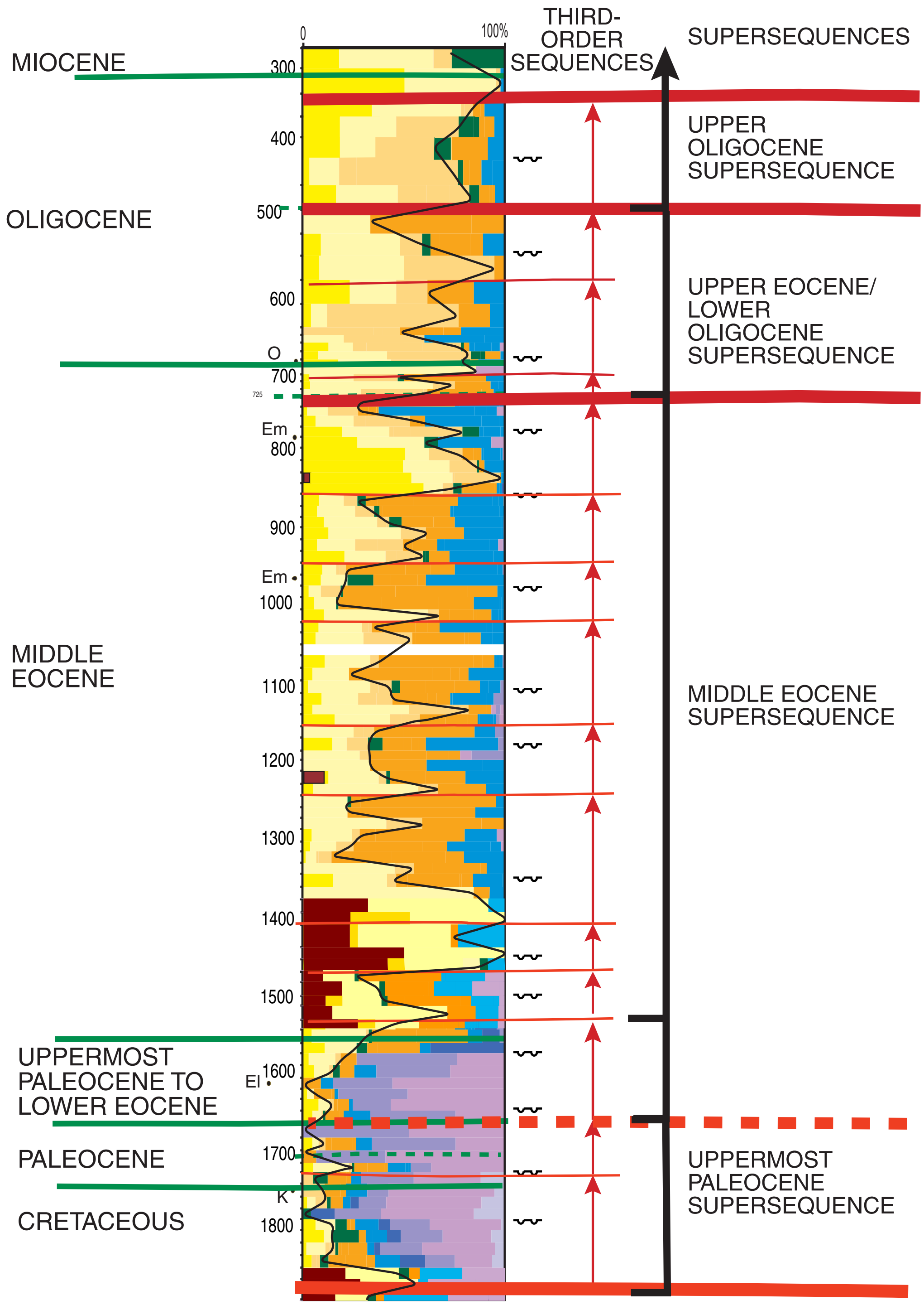


Figure 10. Sequence boundary picks (red lines) from the Baylands #1 well, N.C., showing how third-order sequences and supersequences are manifested in the cuttings data. Percentage of shallow shelf facies (sand and quartz-mollusk-rich facies) marked by black curve. Well thickness in feet. Supersequence boundaries picked in conjunction with offshore seismic data. Lithofacies coded as in Figure 7A. Horizontal lines on left of well are geologic age boundaries.

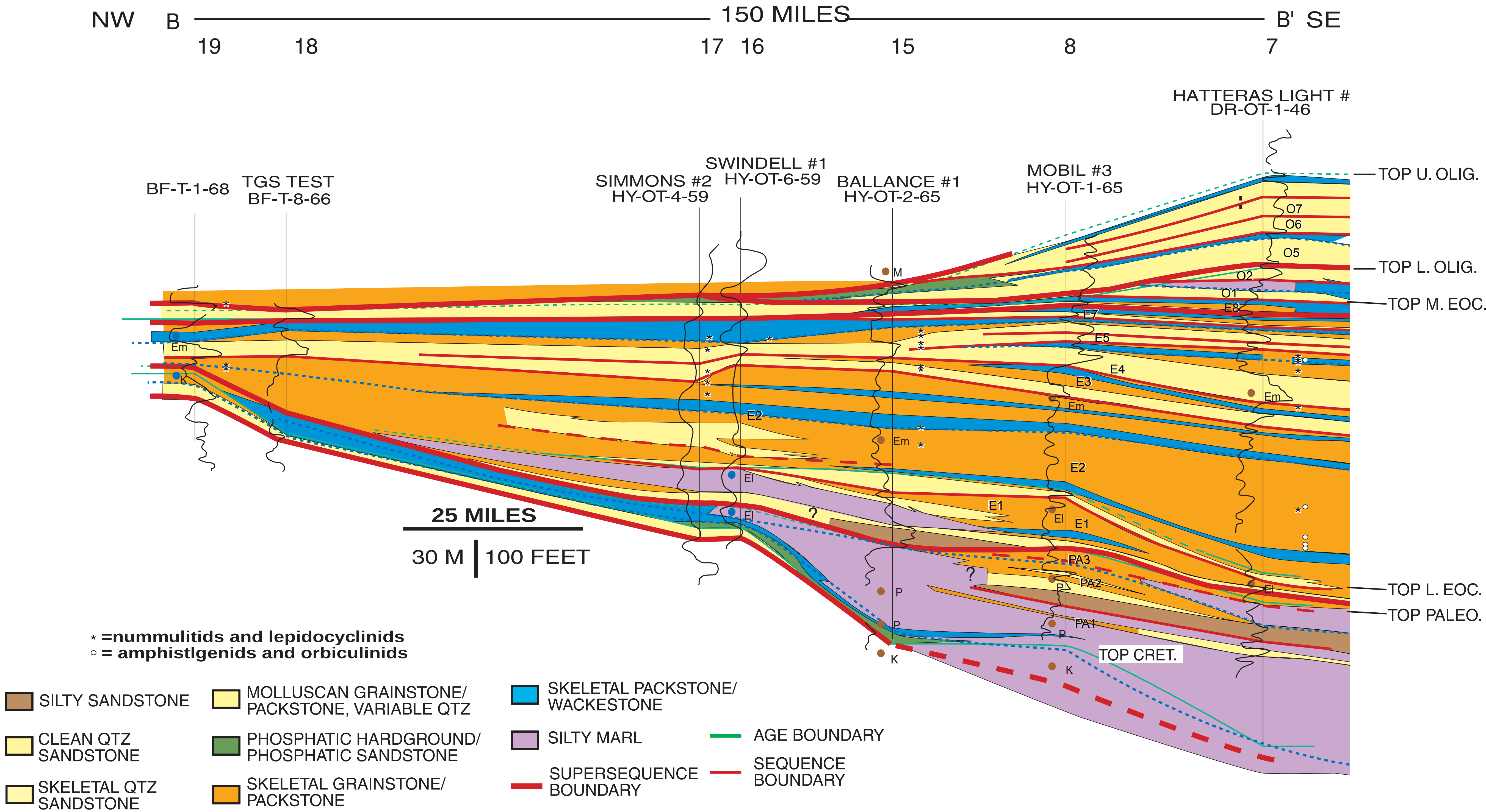


Figure 11. Dip cross-section B-B' generated from well cuttings and constrained by biostratigraphic data. Vertical "wiggle-traces" based on abundance of shallow shelf facies, increasing to the right. The landward and seaward migration of nearshore facies define 5 supersequences (thick red lines), each of which contains several third-order depositional sequences (marked by fine red lines). Cross-section location is shown on Figure 1.

shallowing-upward trend from Paleocene marls to Oligocene quartz sandy units corresponds to the global greenhouse/icehouse transition (cf. Prothero, 1994). The Paleocene to Middle Eocene sequences were formed under greenhouse conditions, with reduced global ocean circulation (cf. Zachos et al., 1993; Berggren et al., 1998). The lack of extensive continental ice sheets resulted in overall high sea-levels, and relatively small superimposed third-order sea-level fluctuations (cf. Haq et al., 1987). Following Cretaceous flooding, these relatively stable sea-levels probably favored development of uniformly thick marls on the shelf, with only a few shallowing events (Fig. 11). Thick, regionally extensive bryozoan-echinoderm-rich carbonates in the Eocene formed on warm, wave-swept open marine shelves, with moderate contour current activity and minor siliciclastic influx (cf. Pinet et al., 1981; Boersma et al., 1987). Quartz-rich Upper Eocene and Oligocene sequences formed in response to gradually falling long-term sea-levels, with superimposed large sea-level fluctuations and cooler, more arid climates (associated with global icehouse conditions). The cooler climates favored increased siliciclastic influx because of decreased sediment trapping by dense vegetation under warmer, more humid greenhouse conditions (cf. Prothero, 1994; Fig. 11), while the increased sea-level changes caused widespread progradation of siliciclastics across the shelf. Parasequence-scale shallowing events appear to occur in deep basin well-cuttings, but these cannot be correlated between wells.

Regional condensed surfaces during ice-house times may reflect greater Gulf Stream current activity and generation of gyres with upward-ascending water masses on the wave-swept middle shelf. Repeated development of upwelling gyres at various positions on the shelf resulted in regional, planar, phosphatized surfaces during extended shelf flooding. Rises and falls of relative sea-level caused the wave-swept, nondepositional surface to migrate across the shelf to form time-transgressive, regional hardground surfaces. Increases in contour current activity enhanced sediment starvation on the middle shelf, by trapping siliciclastics nearshore and preventing carbonate producers from inhabiting the wave- and current-swept shelf.

## LIMITATIONS ON THE CUTTINGS DATA

Downhole Mixing.- Mixing of cuttings from different layers in the well occurs during drilling, as the cuttings are carried from the drill bit up to the surface. Mixing becomes more pronounced as well depths increase. In addition, because the cuttings take a finite time to travel to the surface with the circulating drilling fluid, for example, 30 minutes from a 2000 m well, a lag interval (on the order of 3 m) results in most wells (Low, 1951). The likelihood of mixing increases with depth, however the shallow depths of Paleogene basins make mixing less of a problem.

The degree of downhole mixing was assessed by comparing a short (30 to 40 m) cores, collected less than 5 km from the most updip well analyzed with cuttings (cf. Fig. 9). The core was logged, sampled, and Thin-sectioned at regular intervals (3 to 5 m or less, when possible) for comparison with the data generated from well-cuttings. Although subsurface depths to the top of the Paleogene vary by as much as 20 m between the well and core localities, two bryozoan-echinoderm skeletal grainstone/packstone units, interbedded with mud-rich skeletal carbonates and thin marls recognized in the core correspond with high percentages of similar facies in the well-cuttings. One thick quartz sand and mollusk-dominated unit was encountered in both wells, with consistent thickness. Several smaller scale lithologic variations were evident in the cores, which were suggested by, but not initially interpreted from, the cuttings data (cf. thin quartz sand/mollusk-rich interval just above 200 ft depth in the core, versus minor increase in quartz sandy units at 120 ft depth in cuttings; Fig. 9). A hardground observed in core corresponded with a gamma-ray kick in the well and a single hardground fragment in the well-cuttings thin section, but because these surfaces are thin (less than 6 cm), they often are not well-expressed in either well-cuttings or on wireline logs.

Sequence stratigraphic comparison of the two wells further suggests that downhole mixing is minimal. Skeletal wackestones at the base of the core equate with the MFS interpreted from the cuttings (Fig. 9). Thin quartz sandy mollusk packstones, overlying a thin hardground at 187 ft in the core, represent a higher frequency parasequence not resolved by the well-cuttings. This sandy unit could be correlated between the two cored wells, with noticeable thickening downdip. The thick quartz sand and mollusk-dominated units between 75 and 100 ft in the cuttings well represent the late HST and the LST of the next sequence. However, no clearly defined sequence boundary was observed in cuttings or core. A well-developed hardground surface on top of the quartz-mollusk unit is the transgressive surface, which is overlain by open shelf skeletal carbonates of the TST. The variable core recovery in the less consolidated, quartz sand- and mud-dominated units made the evaluation of mixing in these intervals difficult to assess.

Sample Spacing.- Cuttings typically are sampled at regular intervals during drilling. Because of the lag time the cuttings take to reach the surface, a small vertical correction generally is needed to match the wireline log to the cuttings log (Low, 1951). The degree of shifts in the wireline logs and the cuttings log can be checked by examining wells with high gamma-ray responses, then comparing the location of these gamma-ray 'kicks' to the lithology inferred from the cuttings (e.g. phosphate horizons, shales, silty sands).

Sample Resolution.- Wells with 3 to 5 m sample spacing are optimal for definition of sequences and facies in the wells. It was difficult to recognize 3$^{rd}$ order sequences in wells with 10 m of greater sample intervals, because these are approaching the thickness (10 to 50 m) of the sequences. With the larger sample intervals, only supersequence scale features (30 to 100 m) could be recognized. Thin units were extrapolated through these large-sample interval wells from adjacent wells with closer (3 to 5 m) sample spacing, where an increase in a specific lithology was evident.

Time Requirements.- In shallow, Paleozoic/Mesozoic basins that typically have highly-indurated units, high quality, high resolution sequence stratigraphic lithologic data can be generated quickly, using binocular microscopy of etched/stained cuttings (cf. Al-Tawil, 1998; Wynn and Read, 1999). However, in Tertiary basins with variably consolidated units, this study shows that thin sections of cuttings are necessary. This is because drilling mud and ground-up rock coats and impregnates the porous cuttings, which, because they are commonly weakly indurated, cannot be easily washed or acid etched. Thin sections from approximately one hundred sample intervals of a 500 m well can be prepared and examined at less than 1/100 the cost of drilling a continuous core. Detailed analysis of large numbers of thin sections is time-consuming, but study of cuttings from several wells can provide the resolution needed to identify regional facies distributions, depositional sequences, confining units, and potential reservoirs in understudied areas.

Interbedding Versus Mixing.- The observed trends in the lithologic columns (plotted in percent rock type in cuttings) from a well can be interpreted as either: (1) little mixing during drilling, or (2) a model in which there is considerable mixing (Fig. 12).

In the limited mixing model, the observed trends could be due to lithologies being interbedded at a scale beyond the resolution of the well-cuttings. In this case, lithologic trends record high-frequency interlayering of facies within sequences, as might be expected where parasequences are developed as in outcrops of nontropical carbonates from southern Australia (cf. Boreen and James, 1995).

In the mixing model, upward changes in percentage of cuttings could result from drilling through relatively thick units of two or more lithologies. As the cuttings move up the well, the different lithologies become mixed to varying degrees. The first appearance of a lithology in the cuttings sample marks the depth where the lithology was first intersected, when corrected for drilling lag time. The abundance of these cuttings types increases as the unit is penetrated. The cuttings type then will decrease as a new unit is entered, and the new lithology is mixed with the previous lithologies (Fig. 12).

The well-cuttings data indicate that both mixing models occur, but they are difficult to differentiate without nearby core control. Thus, the resolution of the cuttings in this study is limited to third-order, sequence scale (20 to 30 m thick) changes in lithology.

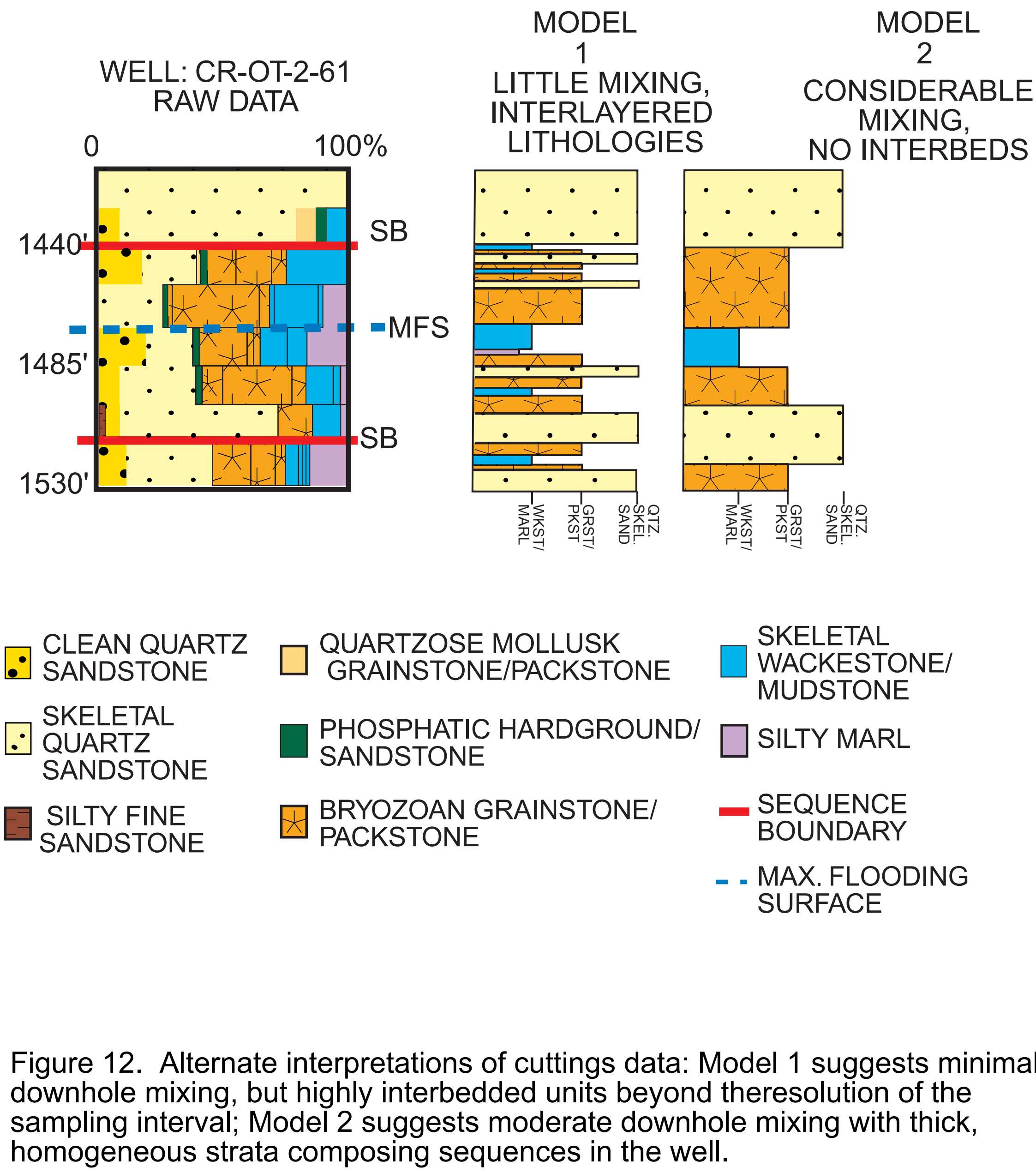


Figure 12. Alternate interpretations of cuttings data: Model 1 suggests minimal downhole mixing, but highly interbedded units beyond theresolution of the sampling interval; Model 2 suggests moderate downhole mixing with thick, homogeneous strata composing sequences in the well.

## CONCLUSIONS

1. In Cenozoic mixed carbonate-siliciclastic basins, it is not possible to differentiate the various facies developed using wireline logs from exploratory wells alone, because the various facies do not have a unique wireline log response. However, thin-sectioned well-cuttings can be used to define the facies types, and to generate a high-resolution, facies-based sequence stratigraphy. However, thin sections of cuttings need to be plastic-impregnated, because variably cemented and permeable rock types are coated and impregnated by drilling muds, preventing the recognition of the various facie types under the binocular microscope.
2. The vertical stacking of facies types in the well was defined by assuming that the dominant cuttings type in the interval was the dominant subsurface rock type. Lithofacies then were grouped into shallow, middle, and deep shelf facies associations, in order to simplify construction of stratigraphic columns.
3. Depositional sequences and component systems tracts were differentiated using the thin-sectioned well-cuttings. Sequence boundaries were placed at the base of quartz sandy, shallow shelf facies, and LSTs were dominated by quartz-rich shallow shelf facies. The TSTs were defined by up-section decrease in shallow water facies in the cuttings, and increase in muddy middle to deep shelf skeletal carbonates. The maximum flooding surfaces typically were placed at the base of the most open marine facies in the interval. HSTs were defined by up-section increase in shallow shelf facies, culminating in quartz-rich facies of the overlying LST.

4. Integration of lithologic data from well-cuttings with biostratigraphic data, seismic data, wireline logs, and any available core potentially can provide a low-cost means of mapping lithofacies and sequences on a basinal scale. A more detailed basin history can be generated using cuttings, which are an under-utilized dataset.

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# CHAPTER 3: CUTTINGS BASED SUBSURFACE SEQUENCE STRATIGRAPHY OF A PALEOGENE, MIXED CARBONATE/SILICICLASTIC CONTINENTAL SHELF, NORTH CAROLINA, U. S. A.


## ABSTRACT

The sequence stratigraphy of the Paleogene in the subsurface of the Albemarle Basin, North Carolina, was defined using 1500 thin-sectioned well-cuttings, along with wireline logs, tied into largely published biostratigraphic and available seismic data. Facies include: silty and shelly sand and shell bed (bay and low energy middle shelf facies); clean quartz sand and sandy mollusk-fragment grainstone (shoreface/shallow inner shelf); phosphatic hardground (current and wave-swept shoreface and shallow shelf); bryozoan and echinoderm grainstone/packstone (storm-reworked middle shelf); and skeletal wackestone and planktonic marl (storm-influenced to sub-wave base, deeper shelf). This Paleogene high energy, open-shelf was characterized by a distinctive shelf profile of shoreface to inner shelf, inner shelf break, deep shelf, and continental shelf/slope break. The successive positions of terminal supersequence inner-shelf-breaks parallel the modern continental margin geometry. Thickness trends were strongly controlled by more rapid subsidence within the Albemarle Basin.

The Paleocene supersequence is dominated by deep shelf marl and developed following flooding after the latest Cretaceous low-stand. Two major shallowing events occurred at the end of the Early Paleocene and near the end of the Late Paleocene. The Eocene supersequence developed following lowstand deposition (evident on shelf

seismic profiles) just off the terminal Paleocene depositional inner shelf break. With Eocene flooding, a major transgressive sediment body developed (Pamlico Spur), that formed a 50 km wide by 50 m high promontory at the inner shelf break, followed by HST progradation of quartzose and bryozoan-echinoderm open shelf carbonates that filled in the adjacent shelf topography. This was followed by ancestral Gulf Stream incision of the southeast-trending, shallow shelf to the south and the deep shelf to the northeast. Late Eocene-Oligocene deposition was initiated with localized lowstand sedimentation off the earlier terminal inner shelf break, followed by thin regional marl deposition and widespread deposition of highstand inner shelf, quartz sands and quartzose carbonates. Localized Late Oligocene lowstand deposition occurred along the earlier Oligocene terminal inner shelf break, followed by widespread deposition of quartzose facies over the shallow shelf. Oligocene units on the deep shelf were modified by highstand Gulf Stream scour.

## INTRODUCTION

In North Carolina, there is little information concerning the detailed facies successions from the thick Paleogene successions in the Albemarle Basin, which has been drilled for oil and gas, but not cored at depth. In this study, early Tertiary units from the North Carolina coastal plain were studied on a basinwide scale, with emphasis on the thick (up to 500 m), less studied subsurface. Cuttings from wells drilled across the coastal plain were used as the primary dataset, because no other lithologic information was available from the deep basin. Lithologic data from the cuttings were used to define the facies present, and to generate a sequence stratigraphic framework for the Paleogene units beneath the coastal plain. From the regional facies stacking patterns and distribution, a better understanding of controls on deposition and evolution of this nontropical shelf was obtained, which could not have been done using the thin, updip outcrops of earlier investigations. The cuttings-based stratigraphy was tied into the available onshore and offshore seismic to provide a more complete picture of the Atlantic margin evolution in the region. The North Carolina Paleogene provides important information on the development of a mixed carbonate-siliciclastic open shelf in a non-tropical, swell wave- and boundary current-influenced setting, during transition from early Tertiary greenhouse to ice-house conditions.

## BACKGROUND

The Paleogene section developed on 0 to 12 km of Mesozoic sediments, composed of rifted siliciclastics overlain by largely marine shelf carbonates and siliciclastics (Klitgord et al., 1988). North Carolina Paleogene strata form a seaward-thickening wedge, with erosional remnants near the present fall line, which thickens to 500 m along the basin axis beneath the present continental shelf (Fig. 1). Paleogene sediments are erosionally terminated at or beneath the modern continental shelf (Popenoe, 1985). Thick packages of Paleogene deep water sediment, with a major component of resedimented shelf material, form a basin-fan complex at the foot of the continental slope (Poag, 1992).

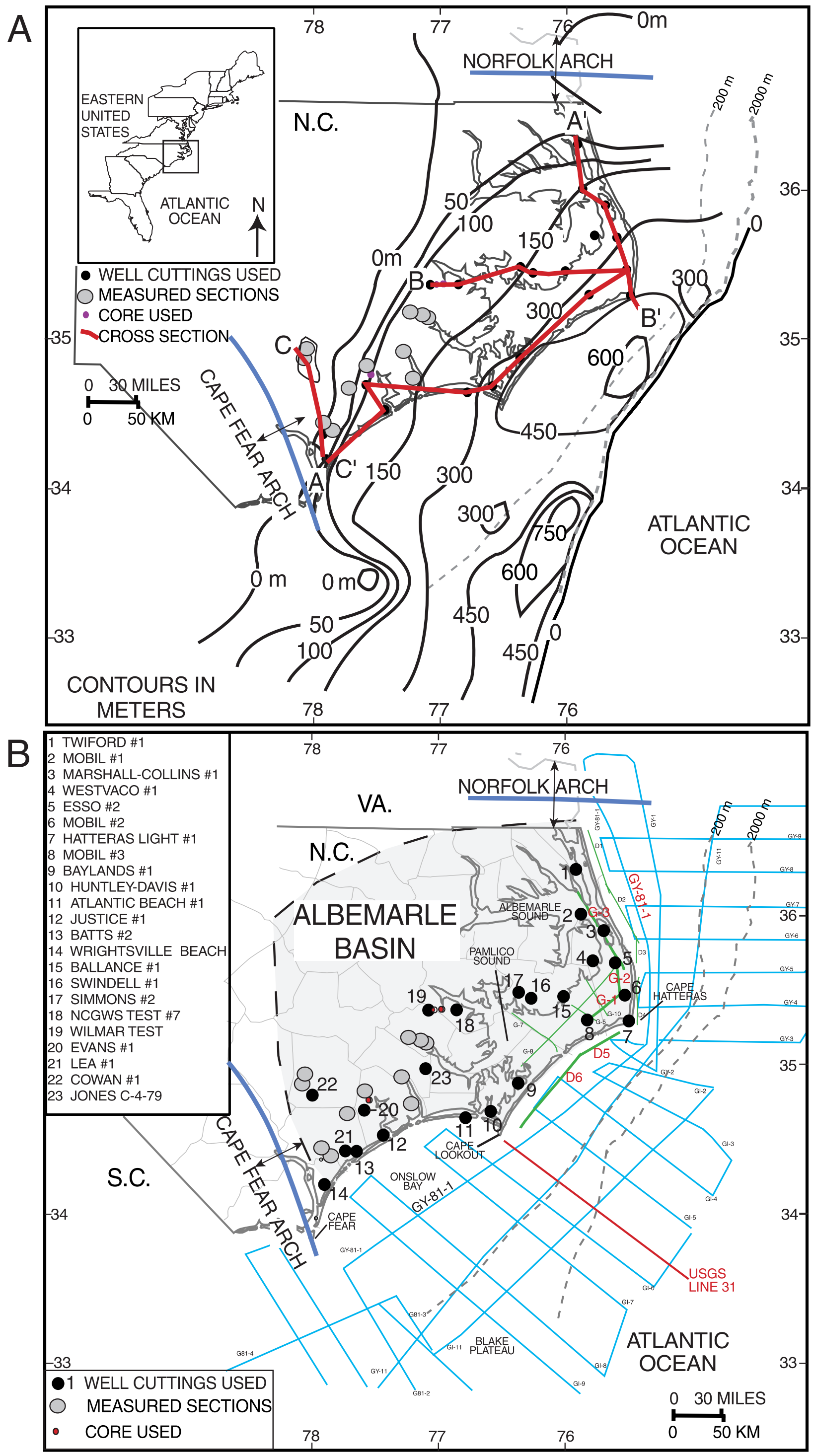


Figure 1. (A) Regional location of Albemarle Basin, eastern U.S.A. (inset map) study area, detailed map shows major structural features and isopachs (in meters) of Paleogene (Modified from Popenoe, 1985; Brown et al., 1972). Detailed sequence stratigraphic cross-sections A-A' and B-B' are shown with bold line. (B) Location map of Albemarle Basin (updip limit dashed line) showing wells, outcrops, and seismic data used in the study. Wells are identified by numbers on inset.

Structural Setting

The Albemarle Basin is located on the eastern U.S. continental margin and is bounded on the south by the Cape Fear Arch and on the north by the Norfolk Arch (Fig. 1A). Arches may have formed in response to greater thermal isostatic rebound from Jurassic rifting and were subsequently sites of lower sedimentation (cf. Hansen et al., 1993). The arches also may be subsurface expressions of updip extensions of ocean transform fault/fracture zones (Sykes, 1978), which caused apparent uplift along these zones throughout the Mesozoic and Cenozoic (Bonini and Woollard, 1960; Harris, 1975; Harris and Laws, 1994A). Crustal compression of areas of pre-existing crustal weakness was the most likely mechanism for Cenozoic tectonic activity (cf. Gardner, 1989; Prowell, 1989). Resultant orthogonal sets of en-echelon, “wrench-style” dip-slip faults have been recognized as foci for displacement across the southeastern U. S. (cf. Brown et al., 1972). Cenozoic subsidence was driven largely by sediment loading, thus the passive margin had low average subsidence rates of 1.5-4 cm/ky during the Paleogene (Steckler and Watts, 1978). Local accommodation space in the late Paleogene also could have been generated by marine incision from contour currents and gyres, which scoured large areas of the continental shelf (Snyder, 1982; Popenoe, 1985).

Palegeographic Setting

During the Paleogene, the North Carolina shelf lay between 30 and 36 degrees north latitude (Scotese and McKerrow, 1990; Smith et al., 1994) and was open to the Atlantic Ocean as an open shelf or distally steepened ramp (cf. Ginsburg and James, 1974; Read, 1985). Partially restricted embayments may have existed intermittently.

The shelf drops off rapidly (15-20 degree slope) onto the Hatteras abyssal plain, with much of the slope being an erosional surface. The shelf lay within the transition zone between tropical and temperate climate belts throughout much of the Cenozoic. This resulted in mixing of warm (Gulf Stream) and cool (Labrador) marine current systems along the North Carolina shelf. During high sea-level stages, warm, subtropical waters from the north-flowing ancestral Gulf Stream moved along the shelf and allowed warmer water faunas to inhabit the shelf. To the south, the South Carolina shelf had high percentages of subtropical faunas and low amounts of siliciclastic material (Powell, 1981). To the north in Virginia, biotas are cooler water "foramol" assemblages (Lees and Fuller, 1972; Mixon et al., 1989), and sediments are dominantly siliciclastic.

Stratigraphic Setting

Many previous stratigraphic studies of the North Carolina Paleogene concentrated on offshore seismic data (Fig. 1B), and the thin outcrop exposures along the axis of the Cape Fear Arch and updip outliers (Fig. 2) (Thayer and Textoris, 1972; Baum et al., 1978; Ward et al., 1978; Otte, 1981; Popenoe, 1985; Zullo and Harris, 1987). Subsurface studies have largely concentrated on biostratigraphic dating of the units and recognition of large-scale depositional units (Brown et al., 1972; Zarra, 1989; Harris et al., 1993; Harris and Laws, 1997). In outcrop, the Paleogene units generally unconformably overlie Upper Cretaceous sediments. In most places, this contact consists of thick phosphatized hardgrounds and conglomerates (New Hanover Member of Ward et al., 1978) on the Cretaceous (Upper Maastrichtian) Pee Dee Limestone that is overlain by Middle Eocene sediments (Fig. 2). The Paleogene succession is relatively conformable in the deep

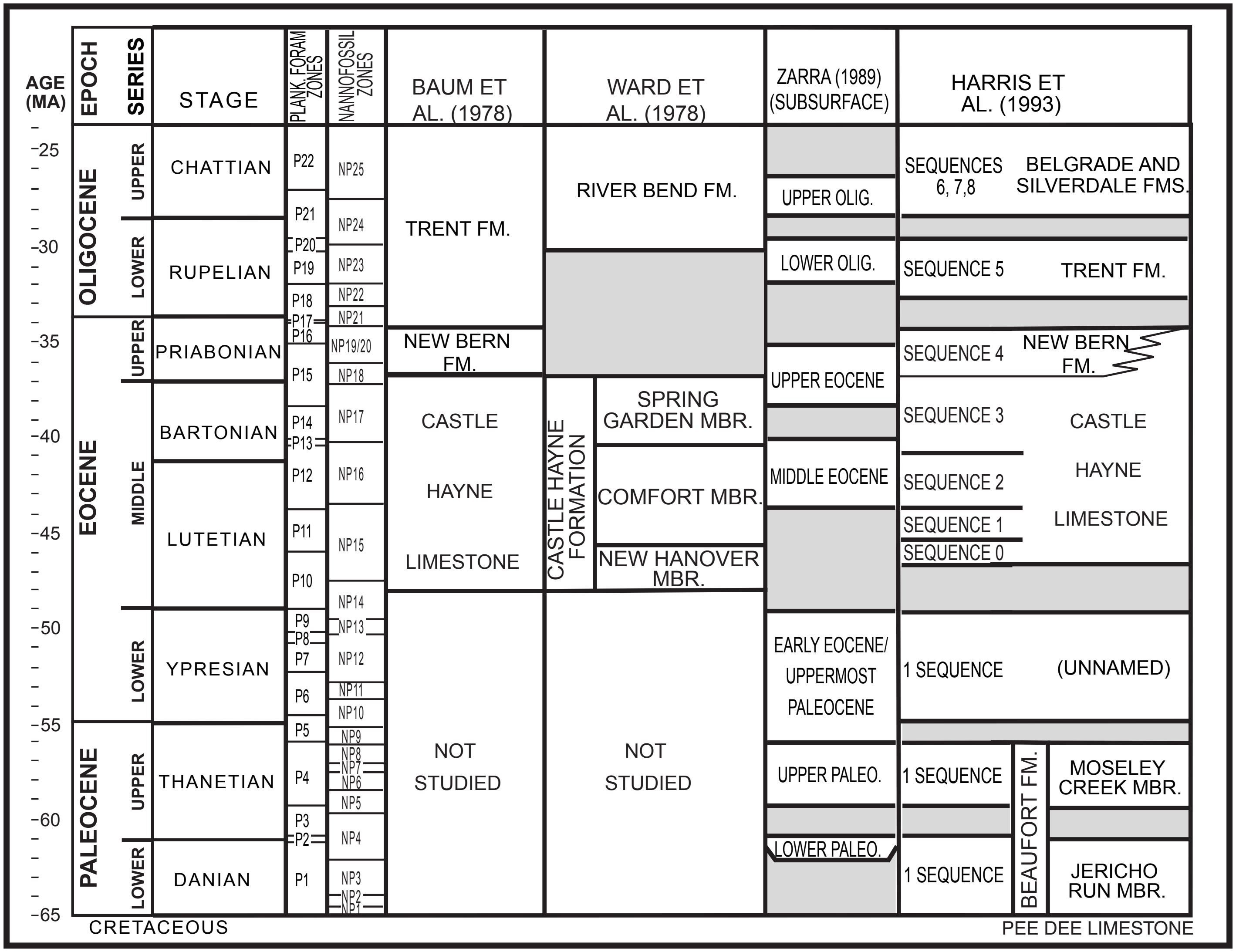


Figure 2. Various regional stratigraphic nomenclature for the Paleogene beneath the North Carolina coastal plain. Biostratigraphic zonations and radiometric time scale are from Berggren et al. (1995).

subsurface, but lack of core material prevents confirmation of contact relationships. The Paleogene is unconformably overlain by Miocene or younger units in outcrop, but may be conformable with the Miocene in the deep basin (cf. Baum, 1981; Zullo and Harris, 1987).

<u>Paleocene</u>.- Paleocene sediments range from 3 m to 100 m in thickness across the Albemarle Basin, with northward-thickening occurring in the east-central coastal plain (Fig. 3A) (Spangler, 1950; Brown et al., 1972; Zarra, 1989; Harris and Laws, 1994B). Updip, the units are glauconitic quartz sand, sandy molluscan packstone, and siliceous mudstone. Downdip, the units consist of marls with thin quartz-glauconitic sandy interbeds.

<u>Eocene</u>.- Lower Eocene sediments are confined to the subsurface in the Albemarle Basin and range from 0 m to 20 m thick, but generally are 10-15 m thick across the central basin area (Brown et al., 1972; Zarra, 1989).

Middle Eocene strata range from less than 1 m to 15 m updip, but thicken to 150 m in the basin (Fig. 3B; Miller, 1912; Baum et al., 1978; Ward et al., 1978). The Middle Eocene strata contain abundant bryozoan-echinoderm skeletal grainstone/packstone units. In outcrop, they have been subdivided into several members, based on lithologic and biostratigraphic data (Fig. 2).

Upper Eocene strata range from 0 m to 10 m thick in outcrop, but have poor biostratigraphic control. They consist of sandy molluscan packstone/grainstone and quartz skeletal sand, which fine downdip into basinal wackestones (Baum, 1977; Zarra, 1989).

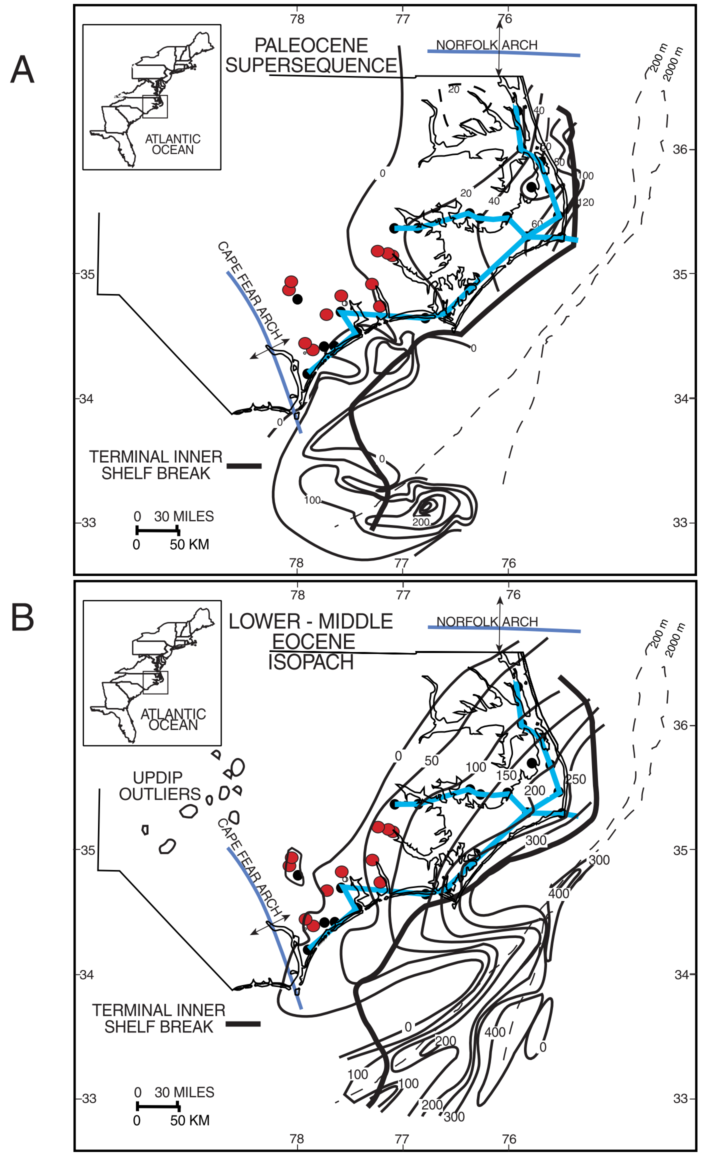


Figure 3. Isopach maps (in meters) showing sediment thicknesses of the four main supersequences in the Albemarle Basin. Seismically defined terminal inner shelf breaks, marked with bold red line, trend north-south in the northern basin, then trends southwest, before bending southeast around the Cape Fear Arch. Offshore isopachs were modified from Popenoe (1985), and onshore data was modified from Brown et al. (1972) and Harris and Laws (1997). (A) Paleocene supersequence isopach map, showing gradual eastward thickening in north, a major erosional, non-depositional area to the south, bordered further south by an east to west-trending lobe. (Offshore contour interval is 50 m.) (B) Lower to Middle Eocene supersequence isopach map, showing southeasterly thickening in north and southwest-to northeast-trending belt of marine erosional incision, and non-deposition. (Contour interval is 50 m.)

C

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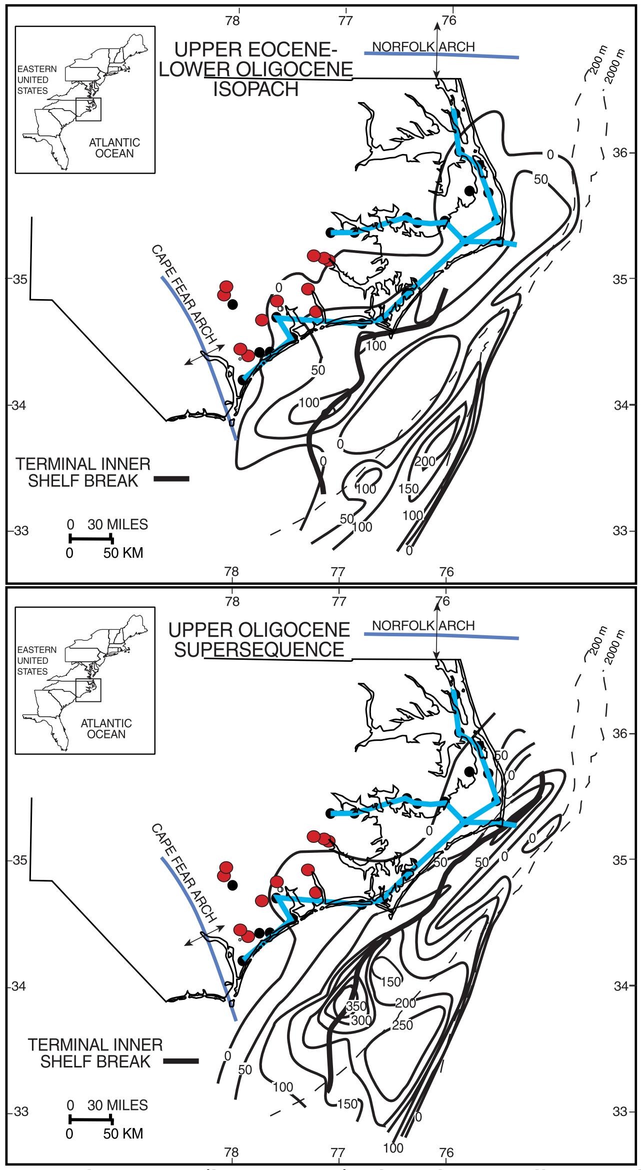



Figure 3. contd. Isopach maps (in meters) showing sediment thicknesses of the four main supersequences in the Albemarle Basin (Contour interval is 50 m). Seismically defined terminal inner shelf breaks, marked with bold red line, trend north-south in the northern basin, then trends southwest, before bending southeast around the Cape Fear Arch. Offshore isopachs were modified from Popenoe (1985), and onshore data was modified from Brown et al. (1972) and Harris and Laws (1997). (C) Upper Eocene to Lower Oligocene supersequence isopach map, showing southeasterly thickening onshore, local sediment lobes (in part lowstand deposits) near terminal inner shelf break, north-northeast-trending belt of marine erosion/nondeposition, and strike-parallel sediment lobe of the deep shelf. (D) Upper Oligocene supersequence isopach map, showing gradual eastward thickening onshore to offshore, with major sediment lobes (in part lowstand deposits) near the terminal inner shelf break; strike-parallel marine erosional incision/nondeposition to seaward, and large elongate, lobate sediment body on deep shelf.

Oligocene.- Oligocene strata range from 0 m to over 100 m thick, with major thickening into the basin center (Figs. 3C, D). Outcropping units are dominated by variably muddy, sandy mollusk packstone (Brown et al., 1972; Baum et al., 1978; Ward et al., 1978). Lower Oligocene units generally have higher percentages of quartz sand, relative to the more muddy Upper Oligocene units.

Duration.- Harris and Laws (1997) summarized the existing biostratigraphic control and recognize Paleogene planktic foraminiferal zones P1, P4, P5-9, P12-1313, P15-16, P19/20, and P22 from outcropping units and well-cuttings (Fig 2) (Blow, 1969; Berggren et al., 1972). These zones represent a total of 29 million years of the 41 million year duration of the Paleogene (Berggren et al., 1995), however, additional zones may be present, but lack age-diagnostic fossils.

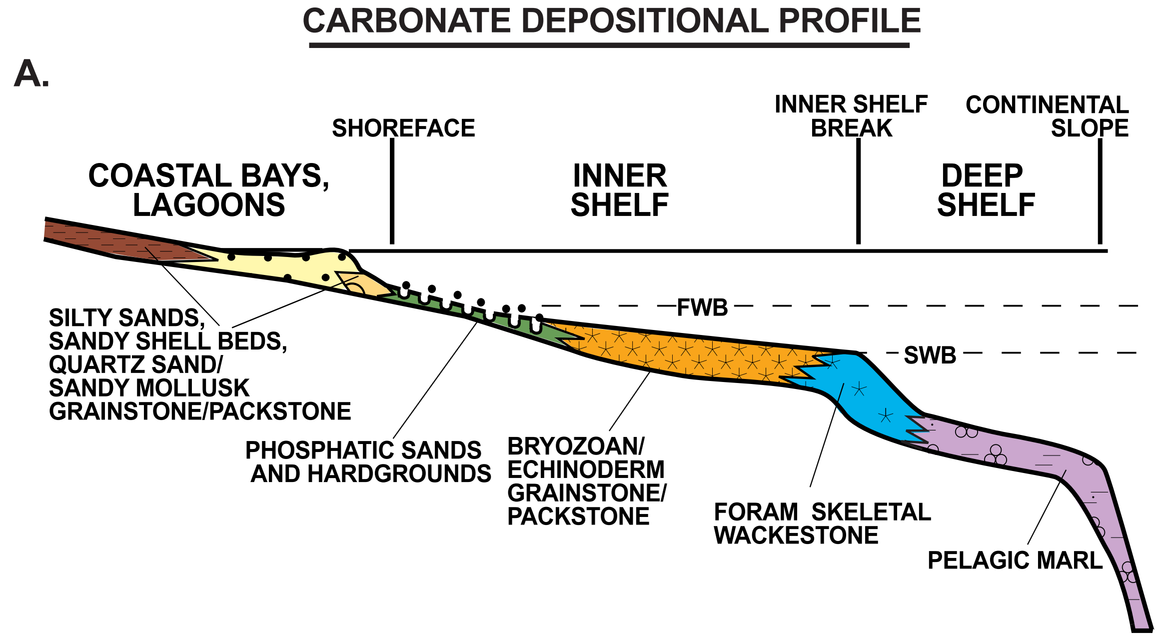
## METHODS

Outcrop Data.- Outcrops studied by previous authors were examined as analogs of the subsurface (Appendix A). They were measured bed-by-bed to document vertical lithologic variations, and some quarry walls were mapped with photomosaics to document lateral facies changes and geometries. Gamma-ray signatures of the facies in quarry walls were measured with a hand-held spectral gamma-ray scintillometer to characterize responses on wireline logs.

Subsurface Data.- Well-cuttings from 24 wells were used to define lithologic succession In the basin (Fig. 1B, Appendix B). Variable cementation of the Tertiary cuttings and impregnation by drilling mud prevented simple binocular examination of the well-cuttings. Instead, cuttings were sieved (0.7 mm mesh), split, dried (24 hours), plastic-impregnated, thin-sectioned, stained with Dickson's (1965) solution, examined under a petrographic microscope. The lithologies present in the cuttings were tabulated for each bagged (3 to 5 m and, in some wells, 10 m) sample interval. Approximately 1600 thin sections were point counted. Besides lithology, biota, zoned cements, and other diagenetic features also were noted in the thin sections. The relative abundance of each rock type for every sample interval was tabulated, using 9 lithofacies. The data generated (Appendix C) were plotted as a graphic log showing the relative abundance of each lithofacies versus depth in the well, then exported to a graphics program for corrections to vertical scaling to account for any variably spaced sample-intervals. Subsurface well-to-well correlations were constrained by existing biostratigraphic data, wireline logs and seismic data (Brown et al., 1972; Zarra, 1989) (Appendices D, E). To simplify facies correlation between wells, the dominant lithofacies making up each sample interval was assumed to be the dominant rock type in the interval. Thin, variably-consolidated quartz sands were identified both on the dominance of cuttings fragments of quartz sandstone and caliper kicks indicating the presence of poorly consolidated sand.

## LITHOFACIES

The major lithofacies and their inferred depositional settings are described in Chapter 2, and summarized in Table 1 and Figures 4 and 5. <u>Shallow inner shelf facies</u> include quartz sand and silty quartz sand, mollusk shell beds and mollusk-fragment sand, phosphatic sandstone and hardgrounds, <u>deeper inner shelf facies</u> are mainly echinoderm-



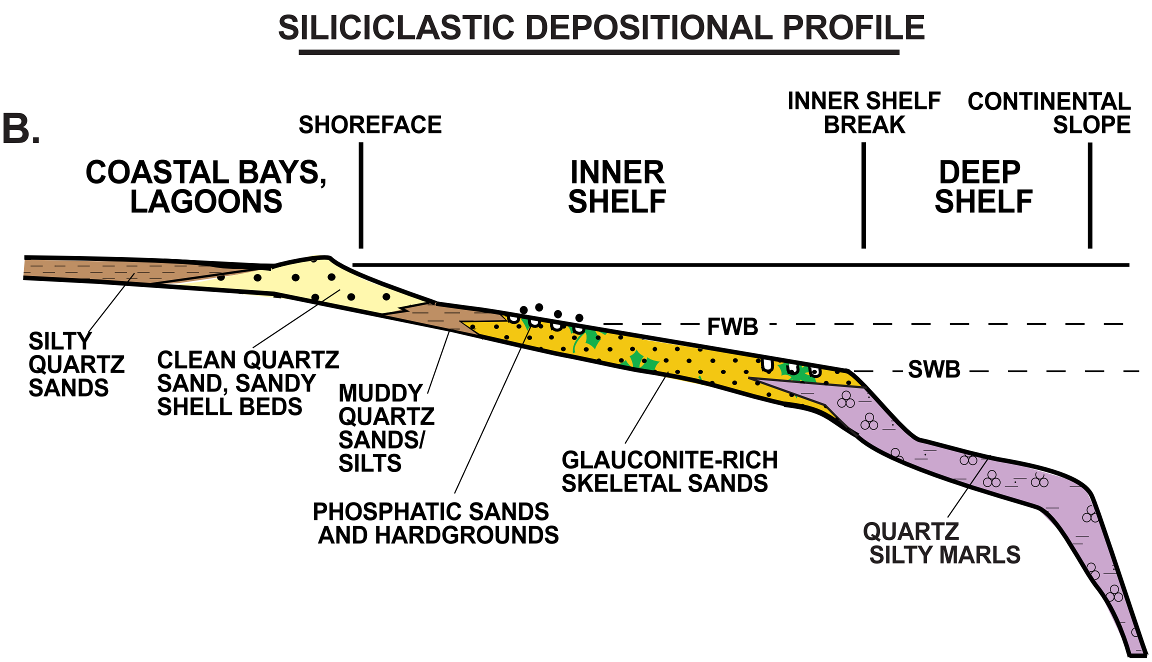




Figure 4. (A) Generalized carbonate facies distribution across the Paleogene shelf and, (B) generalized siliciclastic facies distributions across the Paleogene shelf. Both have a distinctive depositional profile with a low-relief shoreface, passing out onto a wave-swept region on the inner shelf, passing out into a sediment accreting region on the slightly deeper inner shelf (10 m to 50 m plus), an inner shelf break sloping gently (~1 degree) to a Gulf Stream-influenced deep shelf at depths greater than 100 m deep, which terminates against the continental slope.

Table 1. Summary of mixed carbonate-siliciclastic facies.

| Facies | Quartz sands/skeletal fragment quartz sands; (barrier/ shoreface) | Fine to medium, muddy quartz sand and silt; (back-barrier bay and moderate energy inner shelf) | Sandy whole mollusk packstone/ grainstone (shell beds); (bay and shallow inner shelf) | Sandy mollusk-fragment grainstone/ packstone; (bay/shore-face/shallow inner shelf) | Phosphatic sands and hardgrounds; (shallow inner shelf) | Bryozoan-echinoderm-grainstones/ packstones; (storm-influenced deep inner shelf) | Glauconitic sands; (deep inner shelf) | Fine wackestones/ mudstones; (deep shelf below storm wave base) | Marls and sandy marls; (deep, low energy shelf below storm wave base) |
|---|---|---|---|---|---|---|---|---|---|
| **Stratigraphic occurrence and thickness** | Occur with shell beds, especially in Upper Eocene and Oligocene; 0.5 to 10m thick, but rarely greater than 1 m in outcrop | Not present in outcrop; associated with sands in subsurface; 3 to 15m thick; common in Upper Eocene and Oligocene strata in northeast | Sheets, lenses, and small banks associated with quartz sands and skeletal quartz sands; 0.25 to 3m thick; more common in Oligocene strata | Interlayered with shell beds and quartz sands; common in Oligocene interval; form stacked units; 1 to 5 m thick | Phosphatic hardgrounds form regional planar surfaces; may be overlain by phosphatic sands up to 0.5m thick, except in Upper Oligocene phosphorite accumulations of northern basin | Dominant Middle Eocene facies; 2 to 15m thick; less common in Upper Paleocene and Oligocene | Associated with planktic marls; more abundant in northern Albemarle Embayment (3-10m thick) | Thin (3-5m) units in outcrop and wells; commonly associated with marls | Thick sections (50m) in Paleocene; In Eocene/Oligocene, relatively thin (2-10m) in subsurface ; thin to 3 m in outcrop over the arches |
| **Color** | Light gray | Dark yellowish to brown | Light gray to light yellowish gray | Light gray to light yellowish gray | Yellowish brown to grayish black | White to very light gray | Dark green | Light gray to light olive gray | Light olive gray |
| **Bedding and sedimentary structures** | Massive to crudely bedded | Massive in core | Massive/ bioturbated | Massive, heavily burrowed; laterally discontinuous in outcrop | Regional planar to irregular surfaces, with borings; common lags | Some meter-scale sand waves in outcrop, commonly large-scale cross-bedded | Not present in outcrop | Massive/ bioturbated | Massive, or thin-bedded to laminated in outcrop |
| **Constituents:** | Highly-fragmented angular to rounded skeletal material and abundant rounded medium to coarse quartz sand (Fig. 5B) | Common subrounded fine sand to silt, and clay matrix; common fine skeletal fragments (Fig. 5A) | Abundant leached whole mollusks and variable amounts of very fine to fine quartz sand and silt; lime mud matrix sparse to abundant (Fig. 5C) | Abundant leached, variably fragmented mollusks and abundant rounded medium to coarse sand; minor lime mud (Fig. 5D) | Minor skeletal material, commonly phosphatized and common rounded medium to coarse sand (Fig. 5E) | Medium sand-gravel; bryozoans, echinoderms, clams, and forams; variable fine angular to subrounded medium sand; sparse to abundant lime mud matrix (Fig. 5F) | Minor planktic and benthic forams; medium to very coarse sand sized, spherical to ovoid glauconite pellets and rounded very fine to medium quartz sand; siliceous silt/clay present in stringers or as ovoid fecal pellets (Fig. 5G) | Fine sand to gravel sized benthic skeletal debris; variable planktic biotas and very fine to fine subangular quartz sand in argillaceous lime mud matrix | Planktic tests and spicules variable amounts of angular quartz silt to very fine sand in a matrix of silt to clay-sized carbonate and terrigenous silt/clay; finely disseminated phosphate and oxides; (Fig. 5H) |
| **Biota** | Clams, oysters, barnacles; minor echinoderms | Gastropods, bivalves, and echinoderms common; Diatoms, planktic and benthic forams in marine shelf facies | Abundant clams and oysters; some gastropods | Clams, oysters, some barnacles; minor echinoderms | Boring mollusks, encrusting organisms common (benthic foraminifera, thick-walled bryozoans) | Abundant bryozoa, echinoderms, brachiopods, moderate benthic and planktic forams; minor red algae, crab fragments, and ostracodes | Planktic and benthic foraminifera, minor sponge spicules, and pycnodontid oysters | Delicate bryozoans, echinoderms, and benthic forams; some planktic forams | Common planktic foraminifera, sponge spicules, radiolaria, calcareous nannoplankton, minor benthic foraminifera |
| **Glauconite** | Minor, very fine to fine sand size | Minor, very fine sand size | Minor, very fine to fine sand size | Minor, fine to medium sand size | Common, medium to coarse sand size | Variable, fine to medium sand size | Very abundant, medium to very coarse sand size | Variable, very fine to fine sand size | Abundant, very fine to fine sand size |

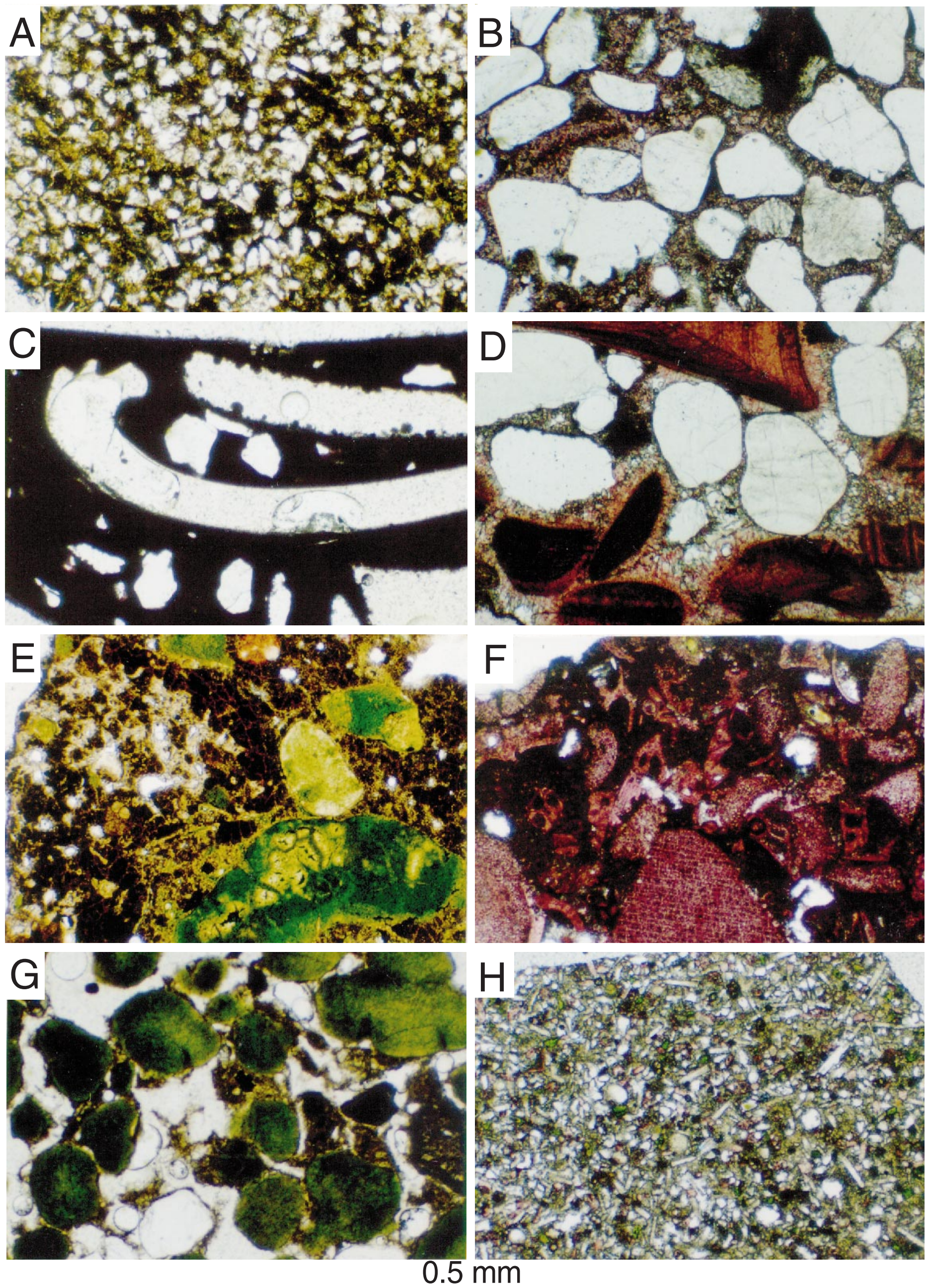



Figure 5. Photomicrographs of facies from thin-sectioned, plastic-impregnated in well cuttings. (Scale bar at base of plate) (A). Silty quartz sand, with interstitial clay and fine skeletal fragments, (B) Clean quartz sandstone cemented by calcite, (C) Muddy, sandy whole mollusk packstone, (D) Quartz sandy mollusk fragment grainstone, with abraded and rounded shell fragments and quartz sand, cemented by fine equant calcite, (E), Phosphatic hardground with abundant glauconite, scattered quartz sand, and skeletal fragments, (F) Echinoderm-bryozoan packstone with abundant foraminifera and abundant lime mud matrix, (G) Glauconitic, quartz sand, with some terrigenous silts (dark), (H) Silty marl, with abundant planktic foraminifera and sponge spicules.

bryozoan grainstone/packstone, and the deep shelf facies are fine skeletal wackestone/packstone and silty carbonate muds or marls.

Shallow Inner Shelf Facies: These facies typically have abundant quartz sand and whole and fragmented mollusks. They include coarse-grained, well- rounded quartz sands and mollusk-fragment quartz sands (Table 1; Fig. 5B) and finer grained muddy quartz sand/silts (Table 1; Fig. 5A), and sandy shell beds and sandy mollusk-fragment grainstone/packstone (Table 1; Fig. 5C).

Quartz sands and quartz skeletal-fragment sands were formed in coastal barriers, shoreface and shallow inner-shelf settings, subjected to continuous wave-reworking. Shell beds and mollusk-fragment grainstone/packstone may have formed on the shoreface or shallow shelf, where local grass or macroalgal cover allowed deposition of fine matrix, or they could have formed in protected bays or back-barrier lagoons. Fine muddy quartz sands and silts could be prodelta or protected, low energy inner shelf facies, given their diverse skeletal makeup and abundant fines; others could be back-barrier, low-energy lagoonal facies. Phosphatic sands/hardgrounds formed on the wave-swept inner shelf (Fig. 5E).

Deeper Inner Shelf Facies

Lime mud-lean to mud-rich bryozoan-echinoderm grainstone/packstone (Table 1; Fig. 5F) formed across much of the deeper inner shelf. These strata were subjected to episodic storm- and swell-wave reworking, which winnowed fines and formed cross-bedded units in which bladed marine cements were deposited. More mud-rich units appear to have formed in lower energy perhaps slightly deeper water conditions.

Deep Shelf to Slope Facies

These include glauconitic sands (Table 1; Fig. 5G) and skeletal wackestone/mudstone and silty carbonate muds (ranging from quartz silty spiculite to sandy/silty argillaceous marls) (Table 1; Fig. 5H). These facies formed in deeper water during high sea level stages on the deep inner shelf and inner shelf break below the depths of wave reworking, and extended out as a blanket onto the deep shelf. Glauconitic sands formed on the shallow to deep shelf offshore from areas of siliciclastic influx. Deep shelf facies likely were subjected to periodic reworking and incision by ancestral Gulf Stream currents, which moved landward onto the deeply submerged inner shelf during highstands and seaward onto the deep shelf and slope during lowstands (cf. Fig. 3C).

## SEQUENCE STRATIGRAPHY

Biostratigraphic Control

Published and unpublished age picks based on cuttings in the wells are shown alongside the lithologic columns and are summarized in Appendix F. The limited biostratigraphic control thus makes the sequence correlations subject to change as better biostratigraphic control becomes available. Biostratigraphic control for the exploratory wells, based on the from well-cuttings is from Brown et al. (1972) and Zarra (1989), except when otherwise noted. Only the tops of ranges could be used, because well-cuttings were the only data set available for age control. Age control was used to subdivide the Paleogene into seven time divisions (Lower and Upper Paleocene, Lower, Middle, and Upper Eocene, and Lower and Upper Oligocene), with greater weighting placed on the more recent planktic foraminifera-based picks of Zarra (1989). However, Lower versus Upper Paleocene, Upper Eocene, and Lower versus Upper Oligocene, were differentiated in only five wells by Zarra (1989). Time horizons were drawn from available age picks, to control the sequence stratigraphic correlations between wells. Time slices constructed using the age control were used to constrain sequence correlation between wells. Wells lacking sufficient age control or having larger than normal (3 to 5 m) sample spacing were correlated only after regional lithologic trends were defined. Published age picks were honored in the cross sections, except where additional evidence (regional correlation, seismic data, or additional age control) suggested age picks were in error largely due to downhole mixing of cuttings. Attempts were made to use calcareous nannofossils to better constrain ages in the cuttings from the deeper basin, but were of limited success due to considerable vertical mixing of these extremely fine components during drilling (Laws, pers. comm., 1999). Global planktonic foraminiferal zones of Blow (1969) and Berggren et al. (1972) and calcareous nannofossil zones of Martini (1971) were used to compare sequences from North Carolina with the global cycle chart of Haq et al. (1988).

Well to Seismic Ties and Seismically Defined Shelf Profiles

Cuttings-based lithologic data and biostratigraphic age picks were plotted onto interval transit time logs (inverse of sonic velocity) from 5 wells and then onto regional seismic lines (Fig. 6). These picks (and significant reflectors) then were mapped on the onshore seismic lines (provided by the North Carolina Geologic Survey). In areas

MARSHALL COLLINS #1 (DR-OT-3-65)

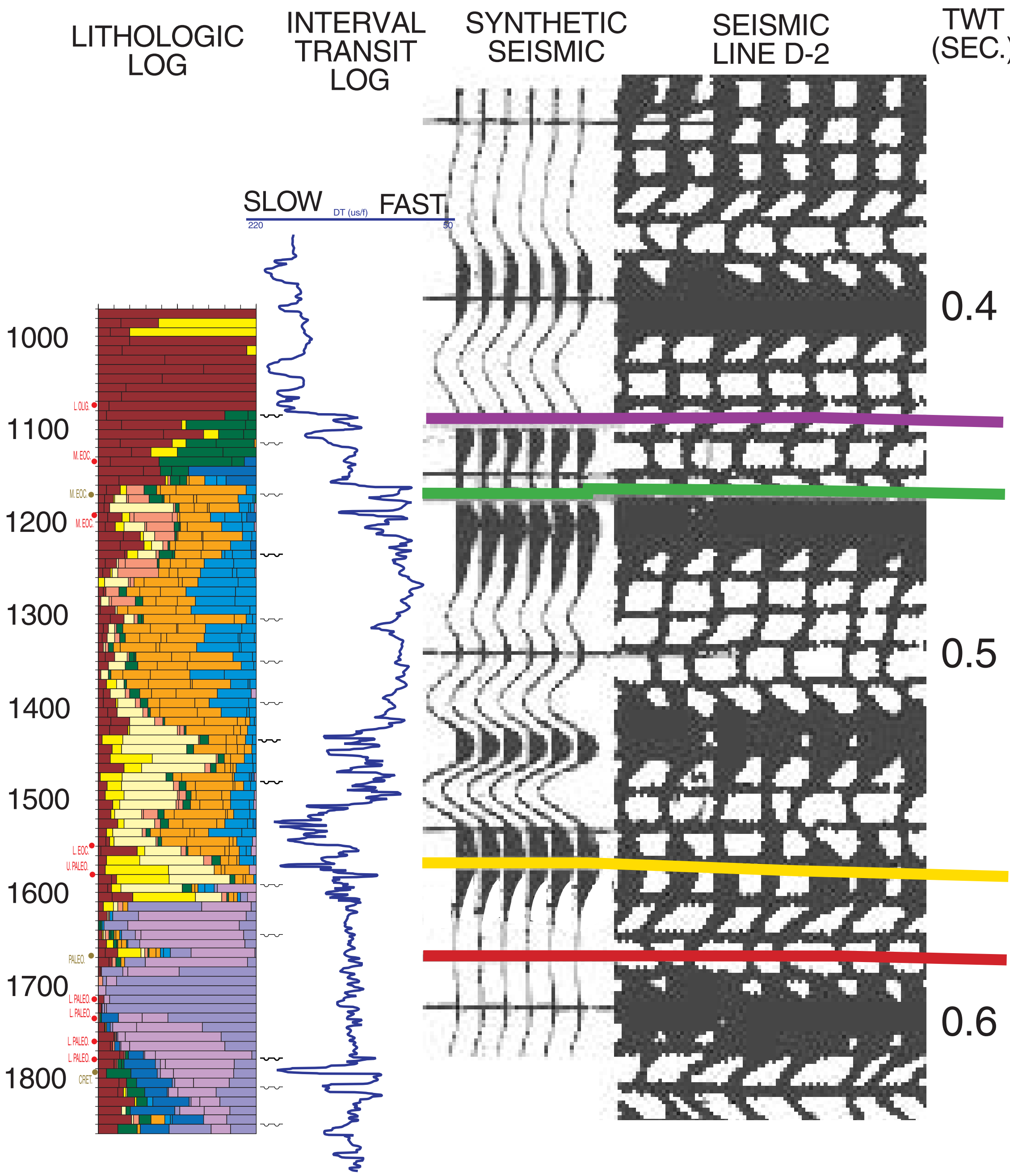



Figure 6. Comparison of well-cuttings data and sonic log with synthetic seismic from the Marshall-Collins #1 well and offshore 2-D data (left to right, respectively). Biostratigraphic picks were used to match lithologic units with seismic responses on synthetic seismic seismic profiles from the same wells. Seismic horizons then were mapped between wells. Wireline logs,synthetic seismic, and seismic data are courtesy of the North Carolina Geologic Survey.

showing clinoforming, seismic reflectors were used to correlate stratal surfaces between wells at a higher resolution than obtainable from the biostratigraphy (Appendix D), to provide control for construction of lithologic cross-sections from the cuttings. Seismic reflectors were projected onto offshore lines (USGS Lines 29 and 31 and lines presented by Popenoe, 1985) (Fig. 6; Appendices G, H, and I). The seismic data (Popenoe, 1985) suggests that the Paleogene continental shelf had a distinctive profile, characterized by a flat-topped inner shelf, which on high resolution seismic profiles locally shows low-relief (10-20 m), shoreface-related clinoforms that prograde seaward (Snyder et al., 1994). The inner shelf terminates at the inner shelf break, which slopes gently (less than one degree) to paleowater depths of 50 to 200 m, estimated from seismic profiles (cf. Popenoe, 1985). Units along the inner shelf break commonly occur as low angle clinoforms. The inner shelf break passes seaward into the deep shelf of the ancestral northern Blake Plateau. This region shows seaward thickening deep water sediment sheets, broad strike-parallel sediment lobes, and broad, elongate erosional/nondepositional regions seaward scoured by the ancestral Gulf Stream. Sediments are flat-lying to gently clinoformed. The deep shelf terminates against the continental slope, which is depositional in some areas and erosionally truncated in others.

The position of terminal inner shelf breaks for each supersequence on the offshore seismic lines were obtained from data published by Popenoe (1985). These helped to locate supersequence lowstand wedges on the shelf. Finally, generalized facies maps were constructed for each supersequence, showing the geographic position of the terminal shelf break, possible lowstand wedges, distribution of dominant facies, and sites of marine erosion. The thicknesses and geometries of the units offshore are from the maps of Popenoe (1985).

Sequences

Sequence stratigraphic terminology used in this paper has been adapted from Vail et al. (1977) and Van Wagoner et al. (1990). The Paleogene succession defines a supersequence set composed of several supersequences. These supersequences each contain several third-order (0.5 to 5 my duration) depositional sequences (Fig. 7A) that can easily be recognized in well-cuttings, but are difficult to differentiate on wireline logs from mixed carbonate-siliciclastic units (Fig. 7B). Higher frequency parasequences may be present, but cannot confidently be correlated between wells with the cuttings data. Distributions of Paleogene sediments are shown in Figures 8, 9, and 10.

Sequence Boundaries.- On the cuttings logs, these were recognized by upward-shallowing of shelf carbonate facies into skeletal quartz sands, the sequence boundary (SB) being placed at the base of the interval showing a major increase in shallower water lithofacies in (Fig. 7A). The percentage of quartz sand generally increases gradually upward to the sequence boundary, then increases dramatically just above the boundary. In downdip wells lacking sandy intervals, sequence boundaries were placed near the top of upward-shallowing trends expressed by increasing percentages of bryozoan-echinoderm units, versus deep shelf facies. Phosphatic hardgrounds commonly occur at many sequence boundaries, but because they occur in other parts of sequences, they cannot be used on their own to define sequence boundaries.

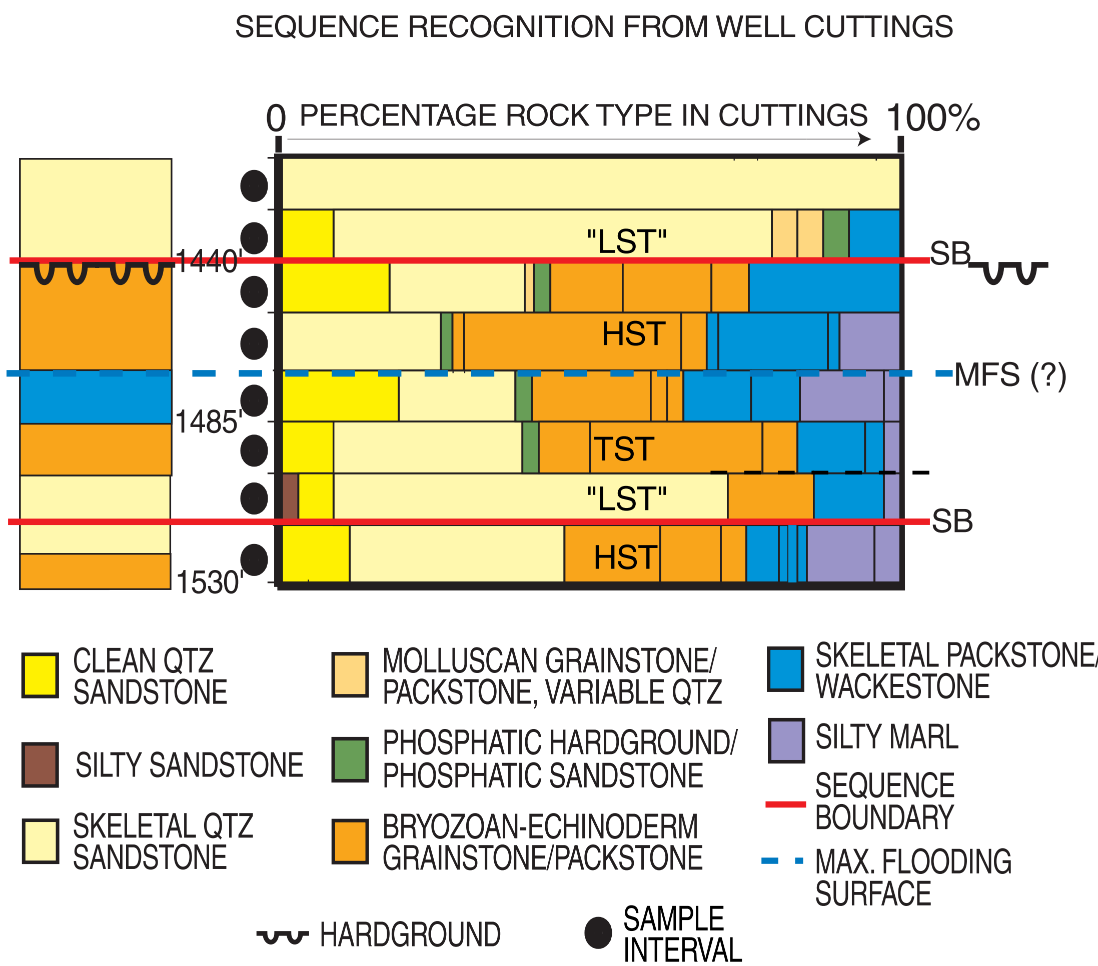



Figure 7A. Example of raw data (right) and interpreted data (left) from analysis of thin-sectioned well-cuttings, through a single depositional sequence in an approximately 100 ft interval from Baylands #1 well (depths shown alongside column). High percentages of quartz sand occur in lowstand, TST shows upsection decrease in shallow shelf facies, and HST shows upsection increase in shallow shelf facies. MFS arbitrarily placed beneath interval with minimum quartz-mollusk facies, but it also could be placed beneath the underlying interval with the maximum abundance of deep water facies fragments in cuttings (not used, because less reliable as indicators of water depth).

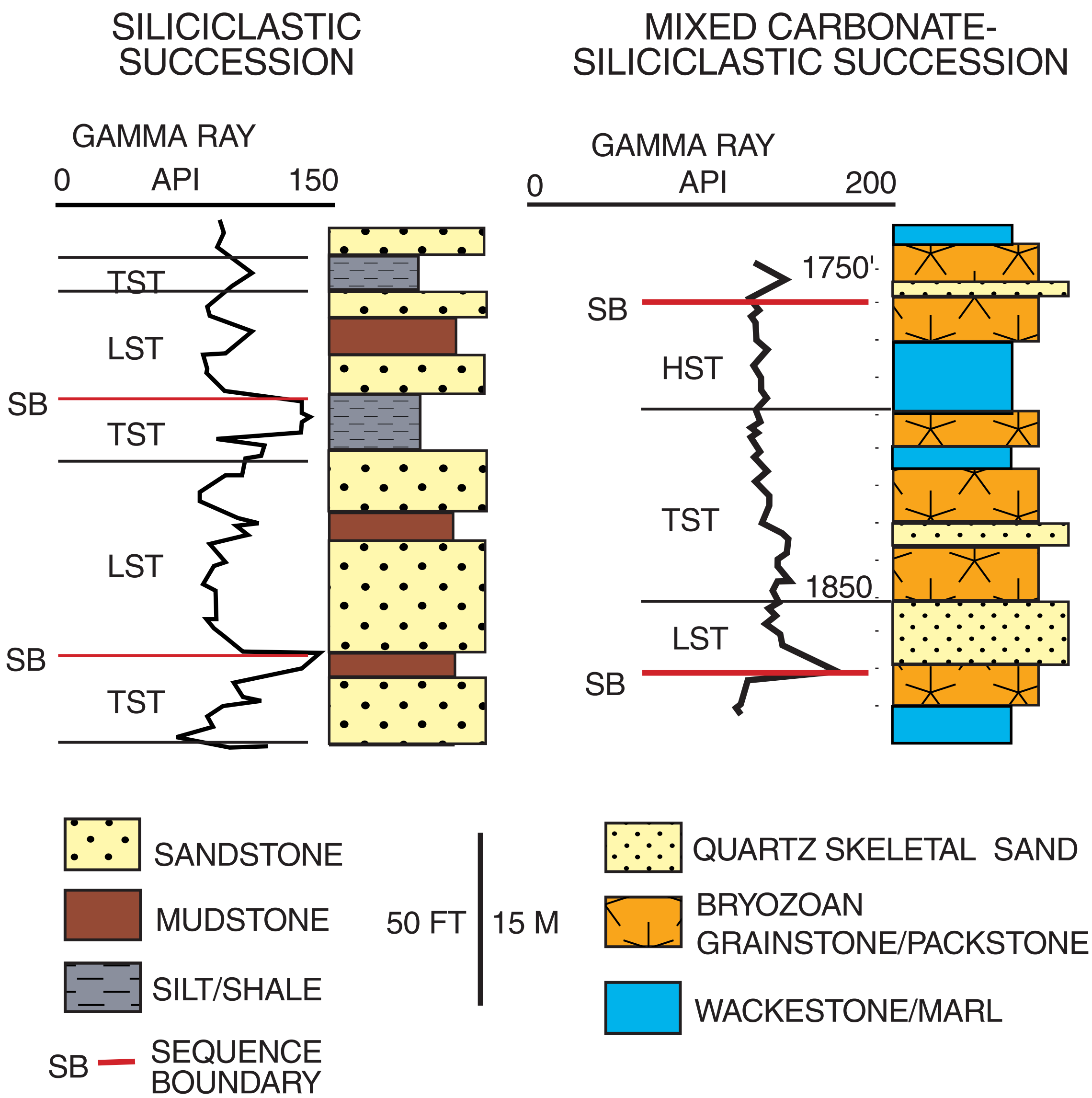



Figure 7B. Comparison of wireline responses in siliciclastic (Exxon #2 well, Sego Canyon, Utah, left, from Van Wagoner et al., 1992) and mixed carbonate-siliciclastic successions (Mobil #2 well, Dare Co., N.C., right, this study), showing that depositional sequences and systems tracts can easily be differentiated using wireline logs in siliciclastic units, but cannot be reliably located in mixed systems. Variable cementation and gamma ray response in the mixed carbonate-siliciclastic successions causes inconsistent wireline log responses, making well-cuttings necessary to identify subsurface lithologies.

Transgressive Systems Tract (TST).- The TST is marked by upward increase in proportion of deeper shelf skeletal carbonates (bryozoan-echinoderm units or skeletal wackestone/marl), overlying lowstand quartz sandy facies (Fig. 7A). The accompanying upsection decrease in abundance of shallow water facies reflects landward migration of facies during transgression. Transgressive deposits commonly are separated from lowstand deposits by thin, phosphatized, hardground surfaces. TSTs could not be differentiated from HSTs in sequences less than 10 m thick, because maximum flooding surfaces generally could not be identified based on the cuttings data.

Maximum Flooding Surface (MFS).- Maximum flooding surfaces were placed at the base of the interval characterized by the highest percentage of the deepest water facies. Skeletal wackestones and silty marls commonly overlie the MFS, but skeletal carbonates overlie updip flooding surfaces on more quartzose facies (Figs 7A, 8A).

Highstand Systems Tract (HST).- The Highstand Systems Tracts were recognized by up-section increase in shallow water facies, at the expense of deeper water units. They could only be recognized where an MFS could be defined; otherwise, the TST and HST were not subdivided.

Supersequence Set

The Paleogene strata of the North Carolina coastal plain comprise one supersequence set of latest Cretaceous through Lower Oligocene sediments (Tejas A of Haq et al., 1988). In addition, the Upper Oligocene sediments form the basal part of a second supersequence set, largely of Neogene age, that extends to the present (Tejas B of Haq et al., 1988). The Paleogene supersequence set lowstand is marked by latest

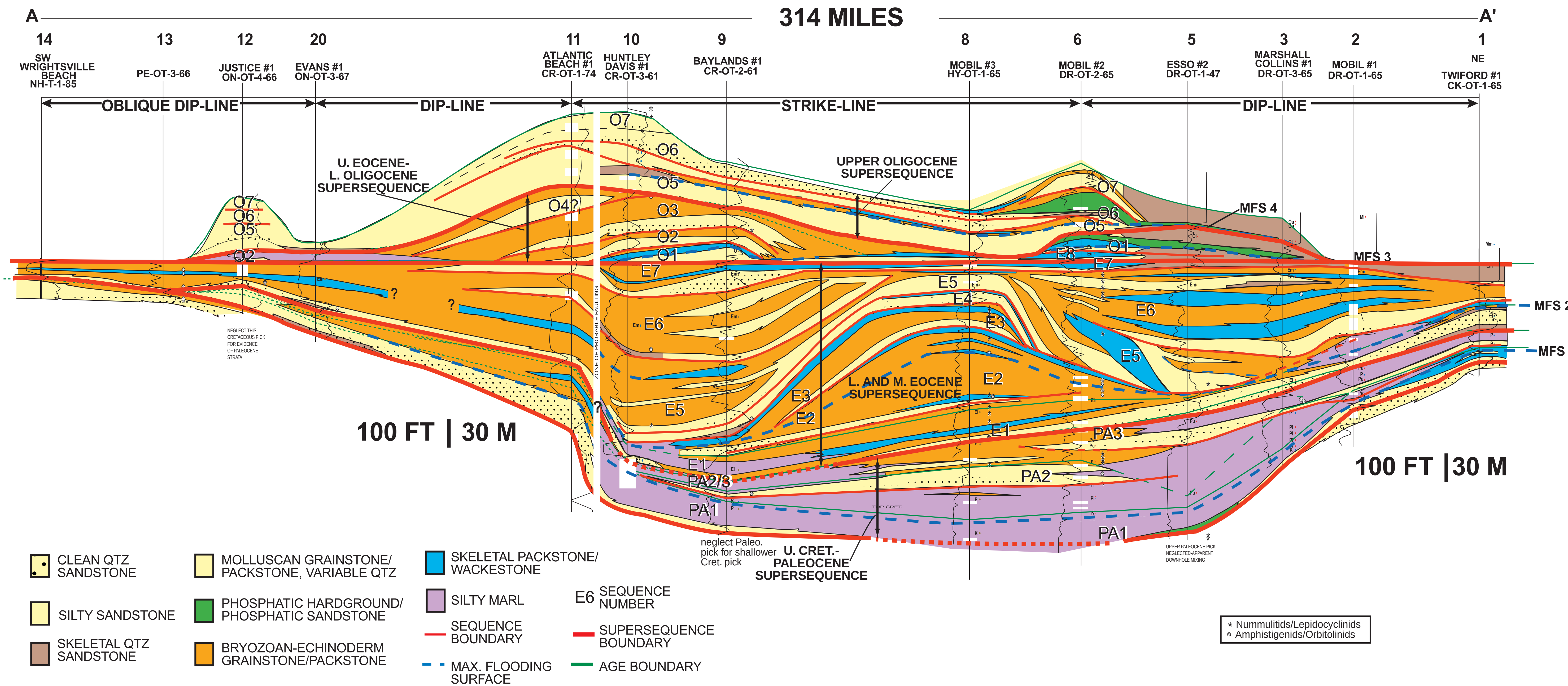



Figure 8 (A). Interpretive "strike" cross-section, Albemarle Basin, showing inferred dominant lithologic units, supersequence and sequence boundaries, and supersequence maximum flooding surfaces, based on the cuttings data. Interpretation constrained by regional biostratigraphic age control and seismic data. Wavy, black curves for each well shows the relative percentage of shallow shelf facies. Location of cross section is shown in Figure 1.

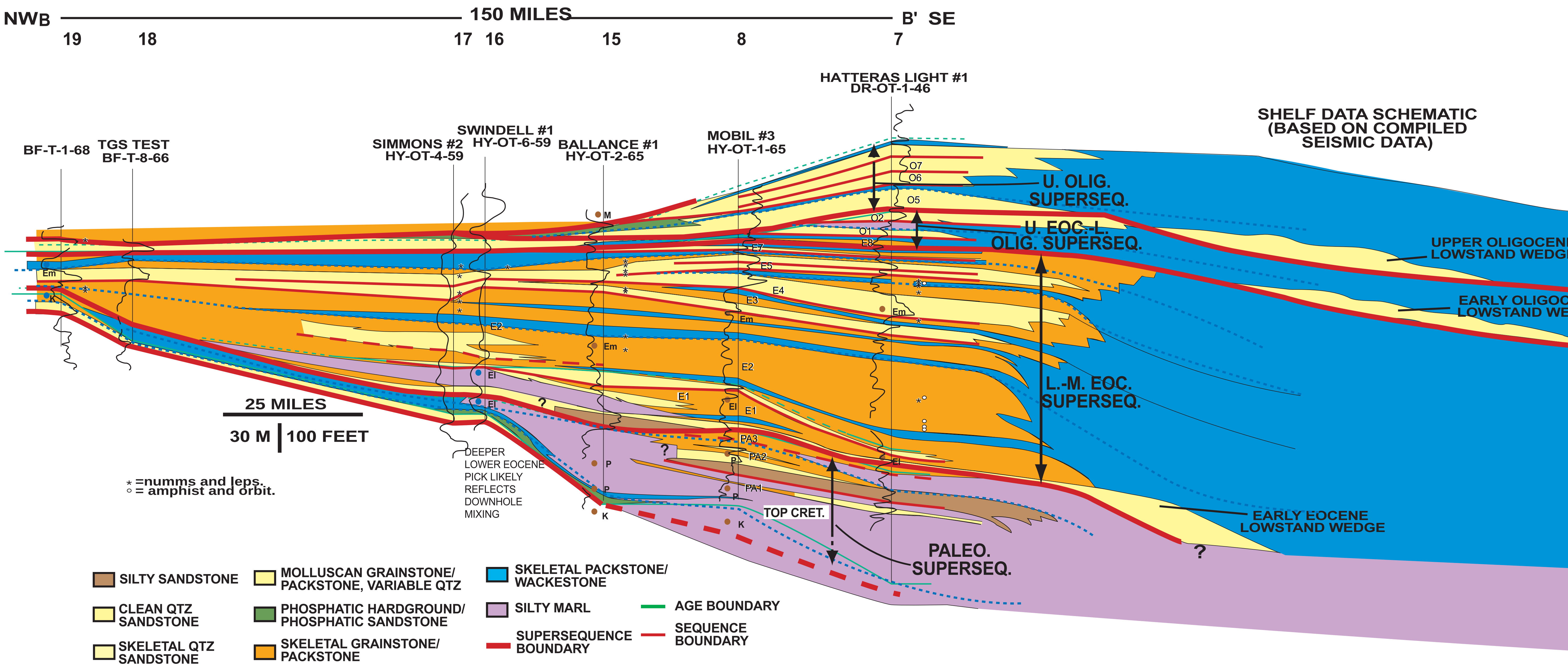



Figure 8 (B). Interpretive dip cross-section, Albemarle Basin and offshore shelf, showing inferred dominant lithologic units, supersequence and sequence boundaries, and supersequence maximum flooding surfaces, based on the cuttings data. Interpretation constrained by regional biostratigraphic age control and seismic data. Wavy, black curves for each well shows the relative percentage of shallow shelf facies. Schematic offshore projection is based on lowstand wedges and terminal shelf edges identified from shelf seismic data (Popenoe, 1985; Hutchinson et al., 1992). Location of cross section is shown in Figure 1.

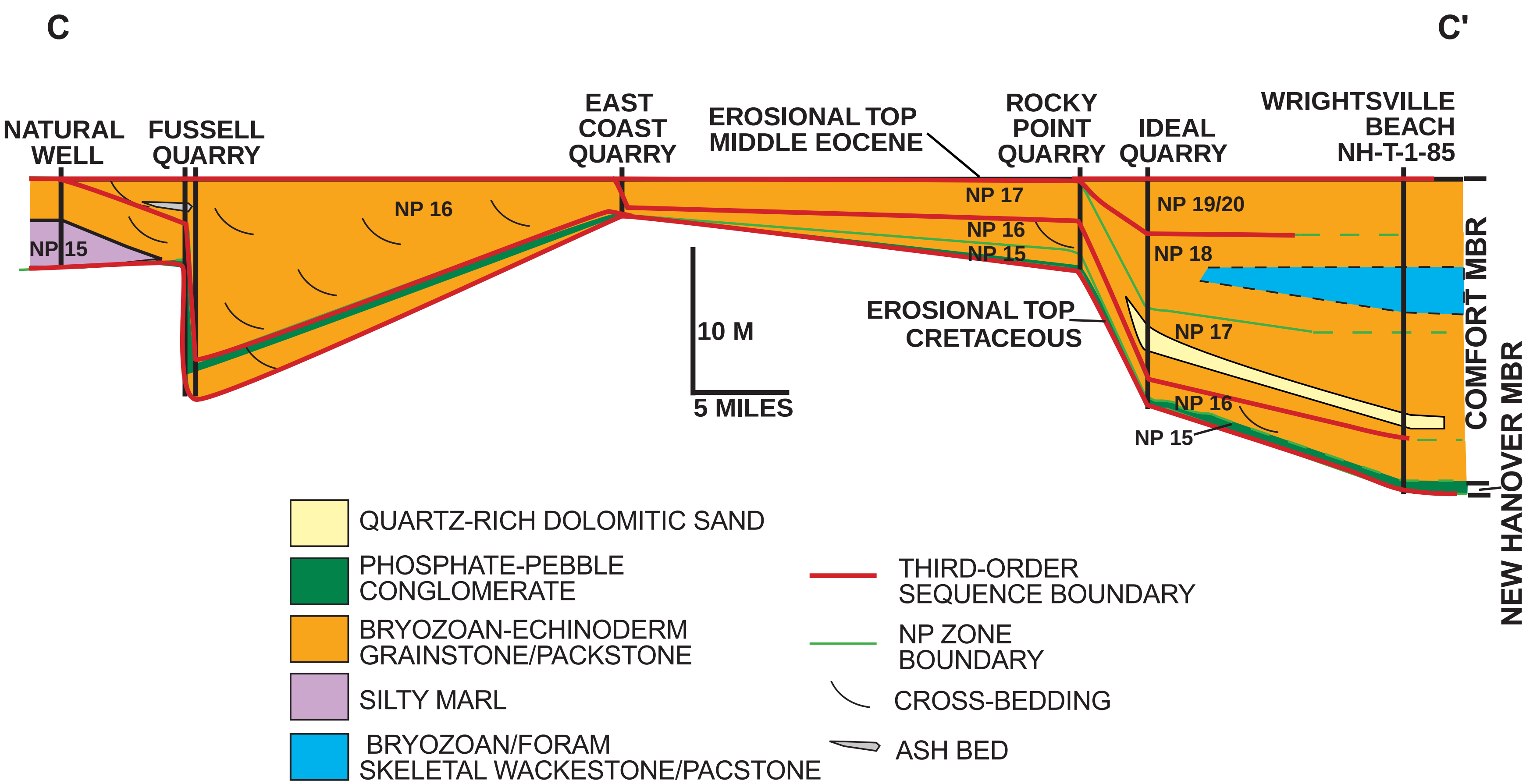



Figure 8 (C). Highly thinned, updip dip cross-section, showing general lithofacies trends and sequence stratigraphy of the Middle Eocene Castle Hayne Formation (limestone) on the Cape Fear arch. Lithologic data and age picks are from Worsley and Laws, (1986) and Zullo and Harris (1987). Location of cross section is shown in Figure 1.

Cretaceous quartz-rich sediments along the updip basin margin, which pinch-out downdip into marls (Figs. 8A, B).

Thick phosphatized hardgrounds occur on the transgressive surface in several wells in the northern part of the basin (Figs. 8A, B). The transgressive sediments are dominated by variably silty marls (50 to 150 m thick), which onlap Upper Cretaceous sediments and become more widespread in the updip part of the basin in the Upper Paleocene. Maximum flooding occurred in either the Upper Paleocene or the Lower to early Middle Eocene, based on widespread updip marl/wackestone in the cuttings (Figs. 8A, B).

The supersequence set highstand includes Lower to Middle Eocene bryozoan-echinoderm grainstone/packstone middle shelf facies, which grade upward into Upper Eocene to Lower Oligocene quartz sandy, shallow shelf facies (20 to 100 m thick; Figs. 8A, B). The supersequence set boundary corresponds with the base of regional, thick (10 to 30 m) quartz sandy units at the Lower-Upper Oligocene boundary.

An Upper Oligocene lowstand wedge marks the base of the overlying, largely Neogene supersequence set. The TST contains marine shelf quartz sandy units of Upper Oligocene age, which thicken and thin markedly along strike (Fig. 8A).

Supersequences

Four supersequences are recognized in the North Carolina Paleogene; each contains an upward deepening to shallowing succession of third-order depositional sequences. Beneath the present coastal plain, the Paleocene supersequence is dominated by deep-shelf marls, the Lower to Middle Eocene supersequence has extensive middle to deep shelf bryozoan carbonate facies, and the Upper Eocene to Oligocene supersequences are composed largely of shallow shelf, mollusk-rich, siliciclastic-dominated facies.

Paleocene Supersequence

Age Control.- Uppermost Cretaceous (Upper Maastrichtian) fossils occur in quartz sandy facies in the northern updip Twiford #1 and Mobil #1 wells (Appendix F). A Cretaceous pick in the Justice #1 well was neglected, because Harris and Laws (1997) have documented Paleocene strata from this interval, based on both lithologic and biostratigraphic evidence. Downdip, the top of the Cretaceous appears to be within a marl sequence, as shown by Upper Maastrichtian biostratigraphic picks in the Mobil #2 and Mobil #3 wells. These picks indicate the downdip Cretaceous-Tertiary boundary occurs within the marl. Well-dated Paleocene sections occur in the Twiford #1, Mobil #1, Marshall Collins #1 and Mobil #2 wells. In the Esso #2 well, Zarra (1989) has an Upper Paleocene age pick low in the marly Paleocene section (Fig. 8A). This pick may be related to downhole mixing of the planktic foraminifera from higher in the Paleocene section. If it is not related to mixing and is real, then it implies that the Upper Paleocene is incised 200 ft into the Lower Paleocene section in this well. The top Paleocene appears to correlate with a regional quartz sandy facies within the Mobil #1, Marshall Collins #1, Esso #2, and Mobil #3 wells.

Systems Tracts.- The Paleocene supersequence in the north has an erosional feather-edge updip, and forms a seaward thickening wedge over 150 m thick beneath Cape Hatteras (Fig. 3A). In the central area, the Paleocene thickens locally to 150 m at the terminal inner shelf break, while in the south, the Paleocene forms an east-west trending sediment lobe that is thickest (300 m) just seaward of the terminal inner shelf edge (Fig. 3A). The central and southern “thicks” are separated by a north-east trending erosional/non-depositional re-entrant.

Offshore data shows low angle, parallel reflectors that clinoform and downlap (up to 100 m relief; $0.5^0$ slope) to seaward onto the top-Cretaceous reflector (Figs. 9A, B, D), whereas onshore data has relatively flat-lying, parallel reflectors (Fig. 9C).

The updip Paleocene supersequence has quartz sands, with variable molluscan skeletal material, and glauconitic sands, while downdip it has thick successions of marl and silty spiculitic marl (Fig. 10A). The well data indicates that the Paleocene supersequence contains three subseismic sequences (PA1, PA2, and PA3), that grade upward from marl into skeletal carbonates and quartz skeletal sands. (Figs. 8A, B). The supersequence LST consists of uppermost Cretaceous quartz sands that make up the bulk of Sequence PA1 updip. These sands grade downdip into phosphatized hardgrounds (in Ballance #1) and thin into marls in the basin center (Fig. 8B). The supersequence transgressive surface (cf. Swindell #1) is a hardground that overlies quartz sands updip, but dies out downdip into marl-dominated successions. The TST is highly condensed updip, occurring as glauconitic and phosphatic sands and wackestones/mudstones of Sequences PA2 and lower PA3 (Figs. 8A, B). Downdip, the TST is dominated by marl, with localized sands and bryozoan limestone of the antecedent Pamlico Spur. Offshore, the supersequence TST appears to be subseismic, evidenced by low angle clinoform reflectors along the Paleocene terminal shelf edge that downlap directly onto the top-Cretaceous unconformity (Fig. 9A). The supersequence MFS is placed at the base of the

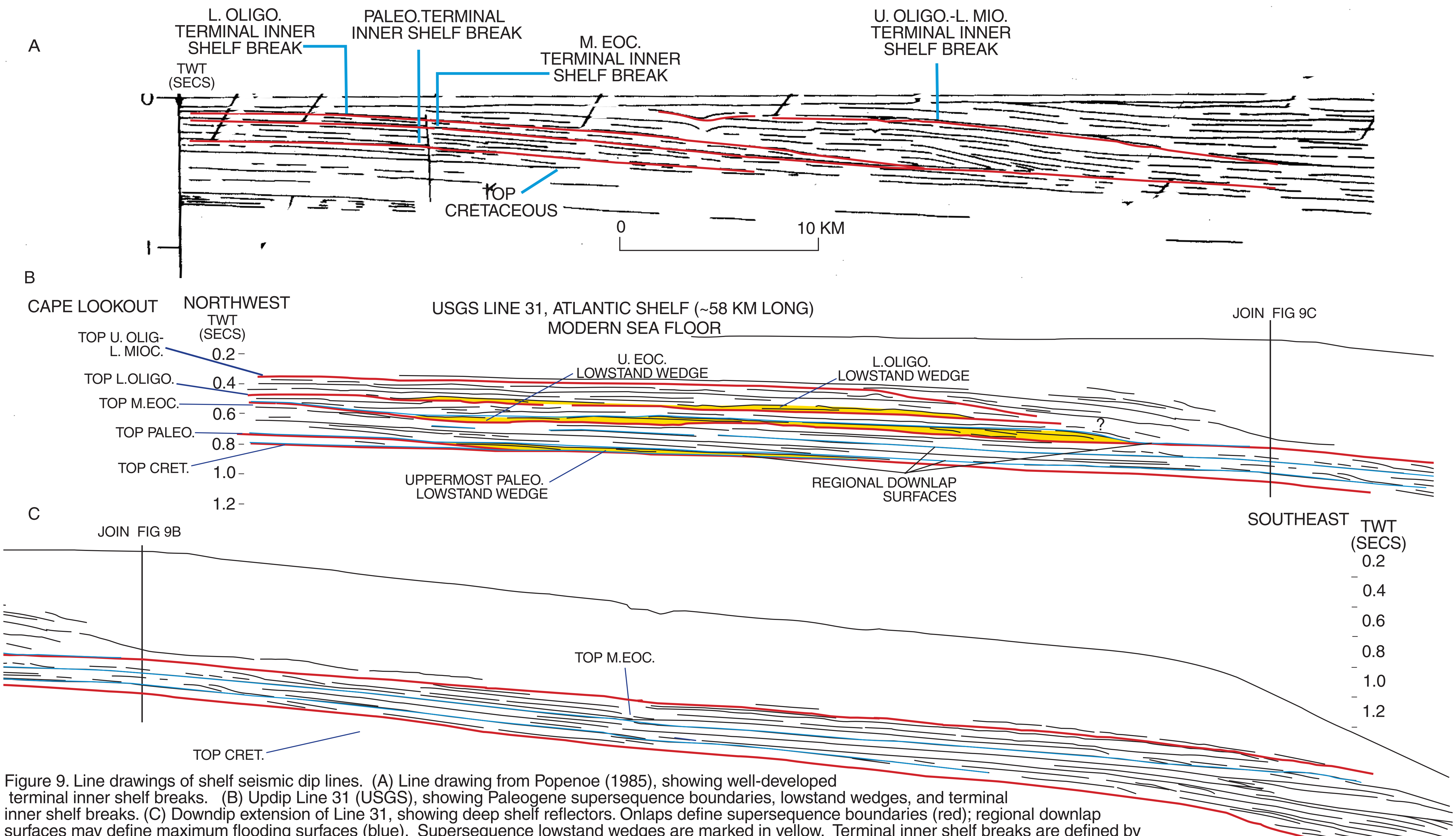
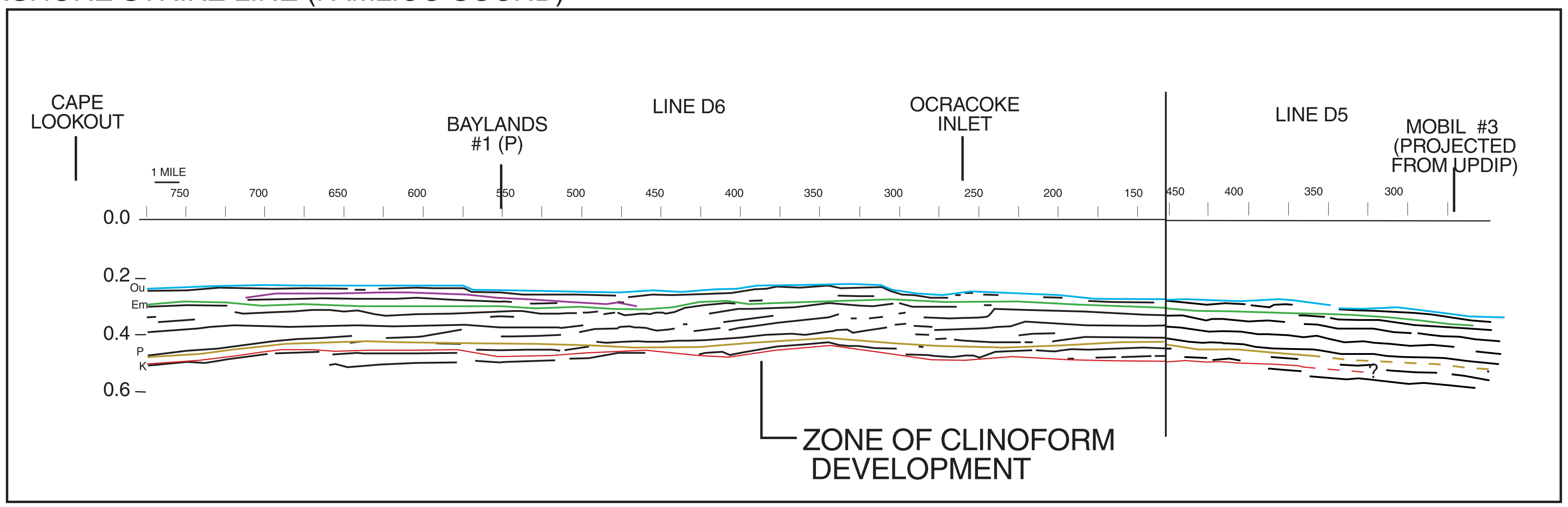


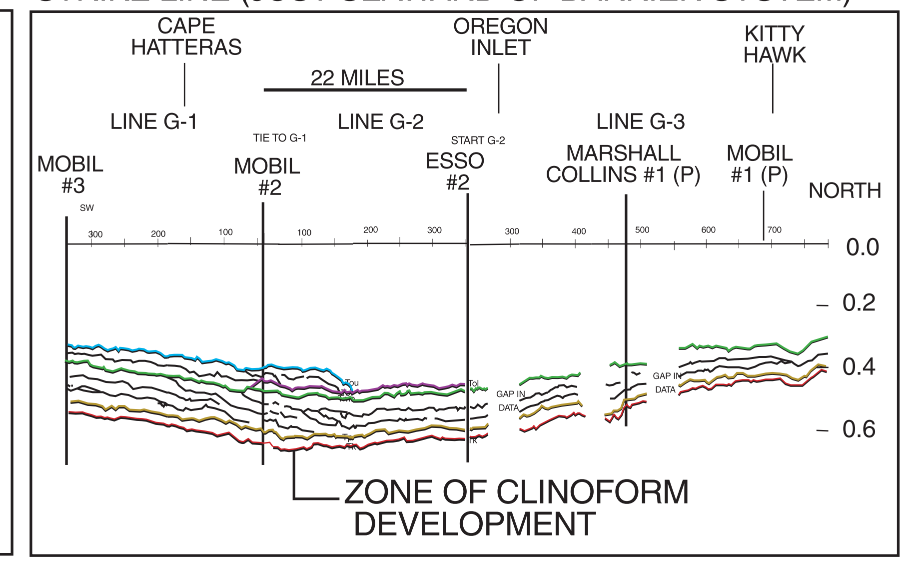

Figure 9. Line drawings of shelf seismic dip lines. (A) Line drawing from Popenoe (1985), showing well-developed terminal inner shelf breaks. (B) Updip Line 31 (USGS), showing Paleogene supersequence boundaries, lowstand wedges, and terminal inner shelf breaks. (C) Downdip extension of Line 31, showing deep shelf reflectors. Onlaps define supersequence boundaries (red); regional downlap surfaces may define maximum flooding surfaces (blue). Supersequence lowstand wedges are marked in yellow. Terminal inner shelf breaks are defined by seaward rollover of inner shelf reflectors.

D

ONSHORE STRIKE LINE (PAMLICO SOUND)

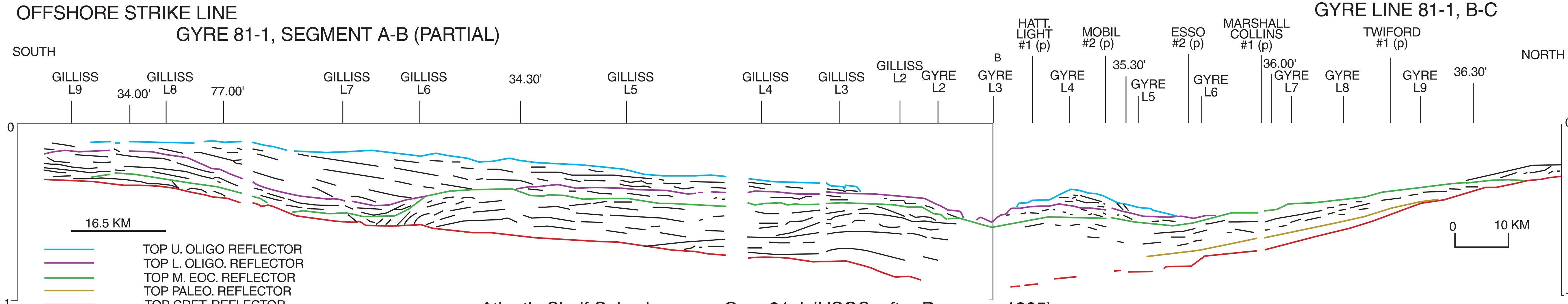



STRIKE LINE (JUST SEAWARD OF BARRIER SYSTEM)




E

OFFSHORE STRIKE LINE




Atlantic Shelf Seismic survey Gyre 81-1 (USGS; after Popenoe, 1985)

Figure 9 (D). Strike seismic lines from the onshore (Cities Service, Citgo, courtesy N.C. Geol. Survey), and (E) offshore shelf (USGS, Popenoe, 1985), showing locally developed clinoforms and seismic-scale erosion and lobe-like geometries of units on the shelf (from Popenoe, 1985). Location of lines is shown on Figure 1.

regional marl and wackestone/mudstone (of Sequence PA2/3) (Fig. 8A) that covers the shelf updip, and extends to the 0 m (erosional) isopach (Fig. 8B).

The supersequence HST, which is made up of the upper part of Sequence PA3, consists of marls grading upward into coarse, skeletal carbonates and quartz skeletal sands. Quartz skeletal sands and echinoderm-bryozoan grainstones/packstones occur at the top of the supersequence on the dip section (Fig. 8B). This upward-shallowing succession may correspond with gently downlapping clinoforms on shelf seismic just seaward to the modern coastline (roughly 5 km southeast of Cape Lookout) (Figs. 9A, B). The terminal highstand shelf edge can be recognized by a change in slope on the top of the Paleocene on shelf seismic, which signifies the updip depositional shelf break. Where mappable, the terminal Paleocene shelf break roughly parallels the modern coastline 20 to 30 km further offshore, except on the southeastern shelf, where it bends significantly seaward (up to 100 km) of the coastline (Fig. 10A). The top-Paleocene reflector appears to be a regional skeletal carbonate, which is overlain by quartz sandy facies in well-cuttings. This lithologic break marks the top-Paleocene supersequence boundary in the onshore basin updip.

## Lower To Middle Eocene Supersequence

The Lower to Middle Eocene supersequence may be composed of two supersequences: a thin (40 m) Lower Eocene supersequence and a thick (150 m) Middle Eocene supersequence. The two units cannot be easily differentiated on the shelf seismic data, and only one lowstand wedge is evident (Fig. 9B) (Popenoe, 1985). However, they can be differentiated in the well data.

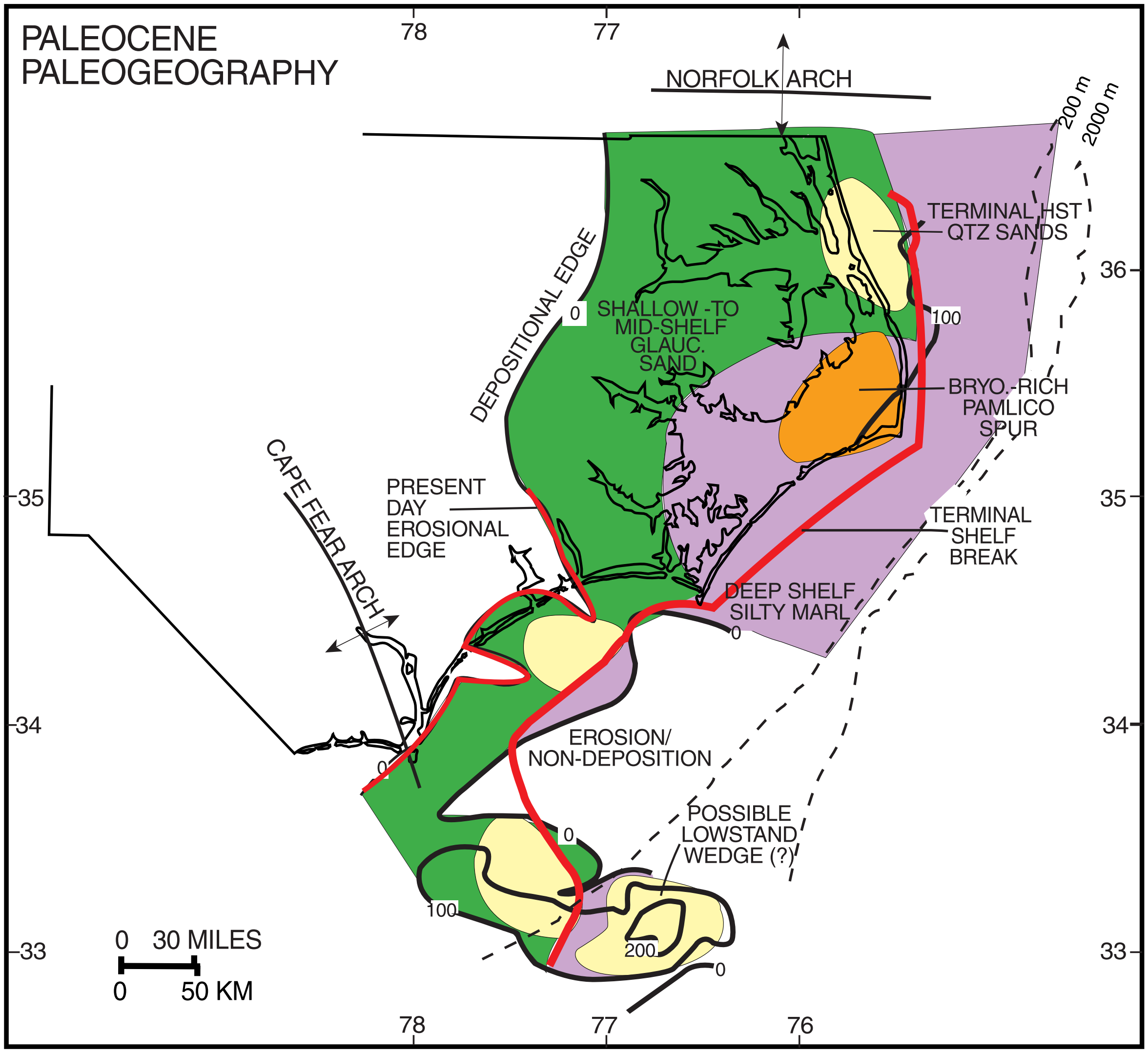



Figure 10 (A). Interpretive Paleocene paleogeography and dominant facies. Glauconitic sands are widespread on the shallow shelf, and curve seaward over the Cape Fear Arch. Local quartz sandy lobes are near the terminal shelf break, with marl to seaward in the tectonically-depressed basin center. In the Upper Paleocene, the Pamlico sediment spur was initiated beneath Cape Hatteras. Current-sweeping of the deep shelf appears to have inhibited deposition or eroded Paleocene silty marls on some of the southern deep shelf. Isopachs in meters.

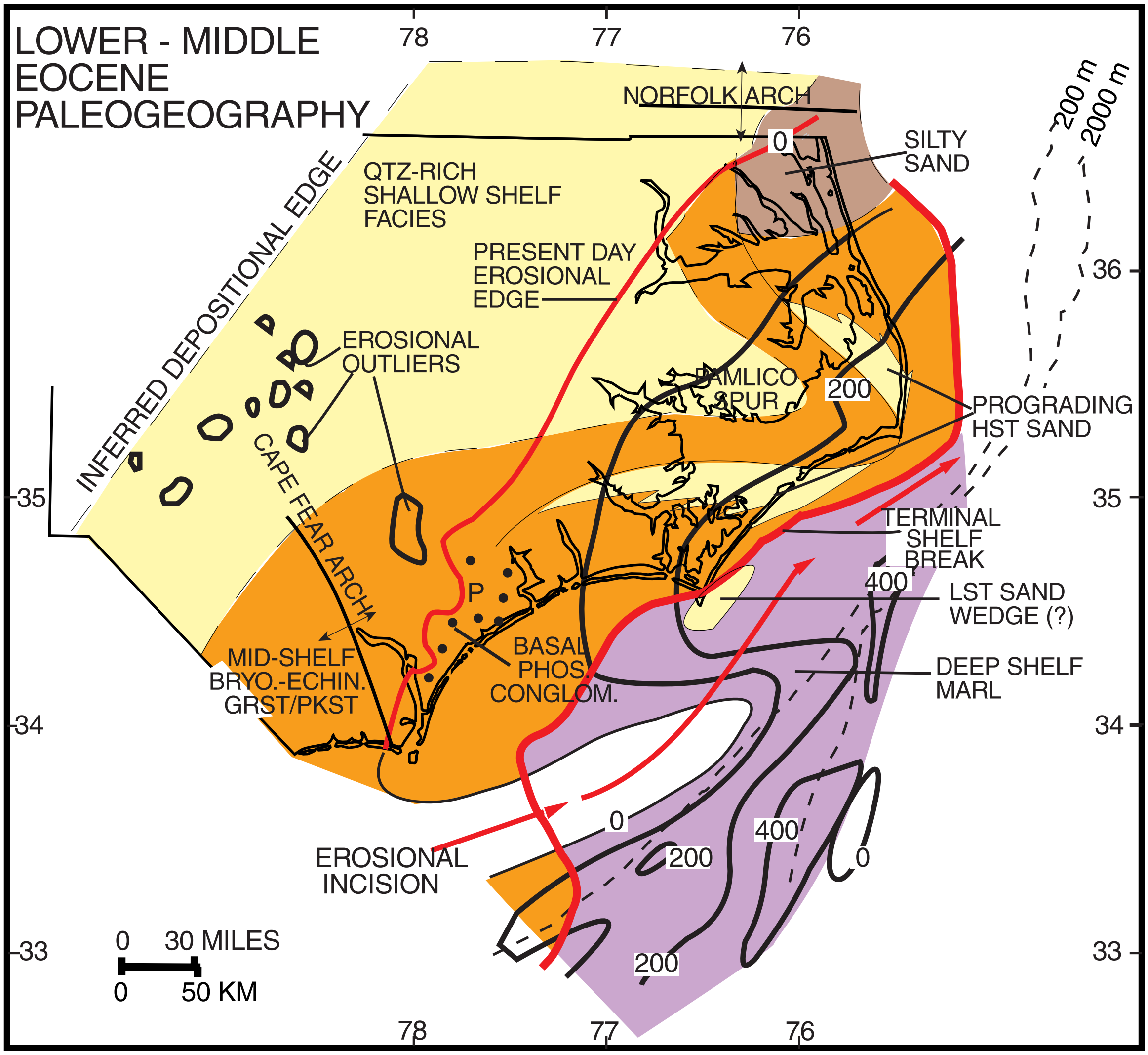



Figure 10 (B). Interpretive Lower to Middle Eocene paleogeography and dominant facies. The shallow shelf is the site of updip quartz-rich facies (largely eroded) and widespread bryozoal carbonate deposition. The Pamlico spur is marked by a local promontory, apparently flanked by prograding, clinoformed quartz and bryozoal units. Marl blankets formed across the deep shelf, and underwent extensive syn- and post-depositional (?) incision by the ancestral Gulf Stream currents (marked by red arrow), especially on the southern part of the shelf, where the Eocene marls are absent from the northeast-trending belt. Terminal inner shelf break grossly parallels modern coastline, but appears to be deflected seaward adjacent to the Cape Fear Arch. Isopachs in meters.

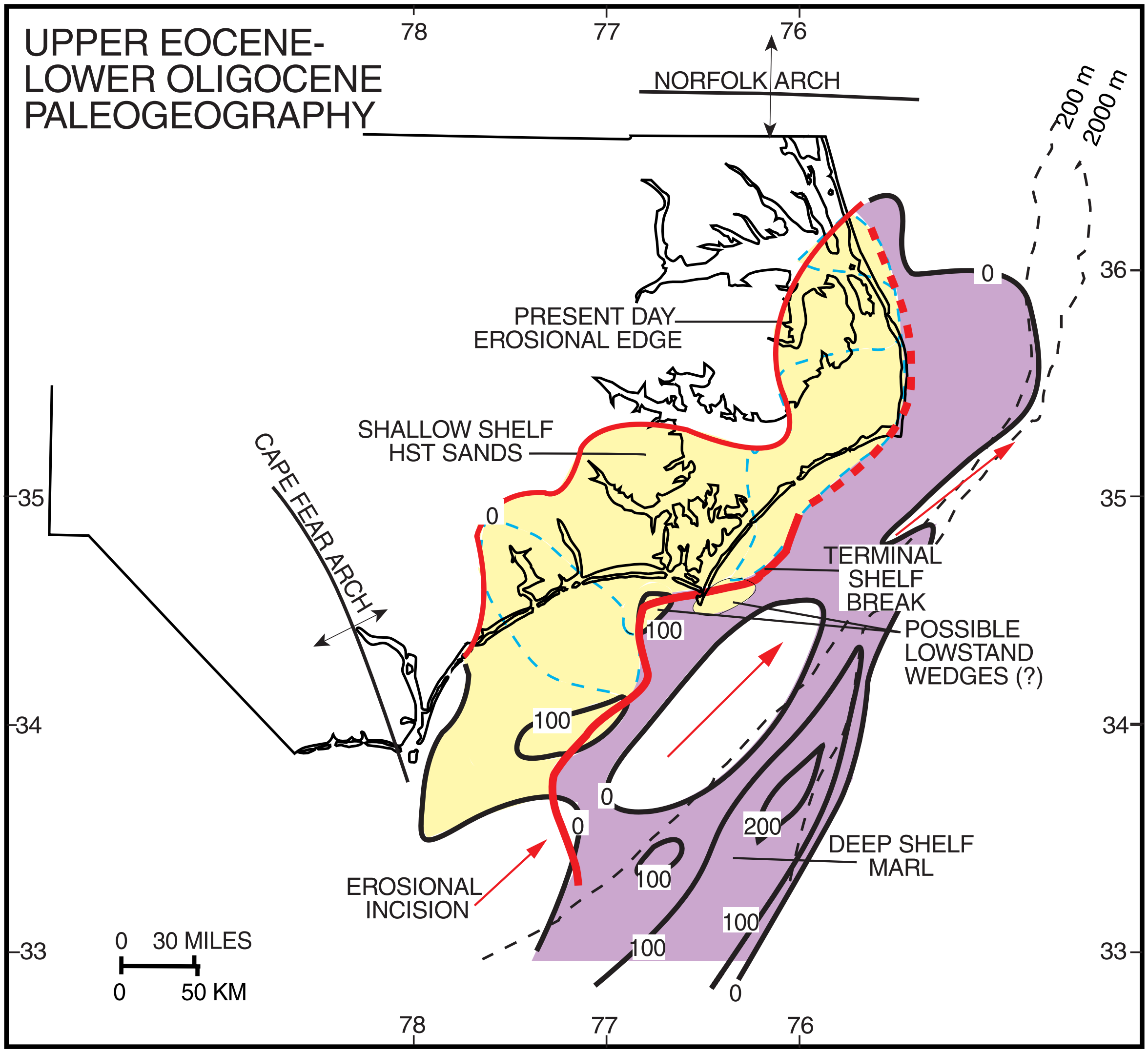



Figure 10 (C). Interpretive Upper Eocene to Lower Oligocene paleogeography and dominant facies. Extensive quartz sands and quartz-mollusk sands, and bryozoal carbonates formed on the shallow shelf updip, and built seaward to the terminal shelf break. The dashed blue lines on the shelf show the landward limit of incursions of deeper shelf, muddy carbonates into the shelf succession. Extensive post-depositional incision/erosion on the deep shelf by the ancestral Gulf Stream is marked by red arrows. Isopachs in meters.

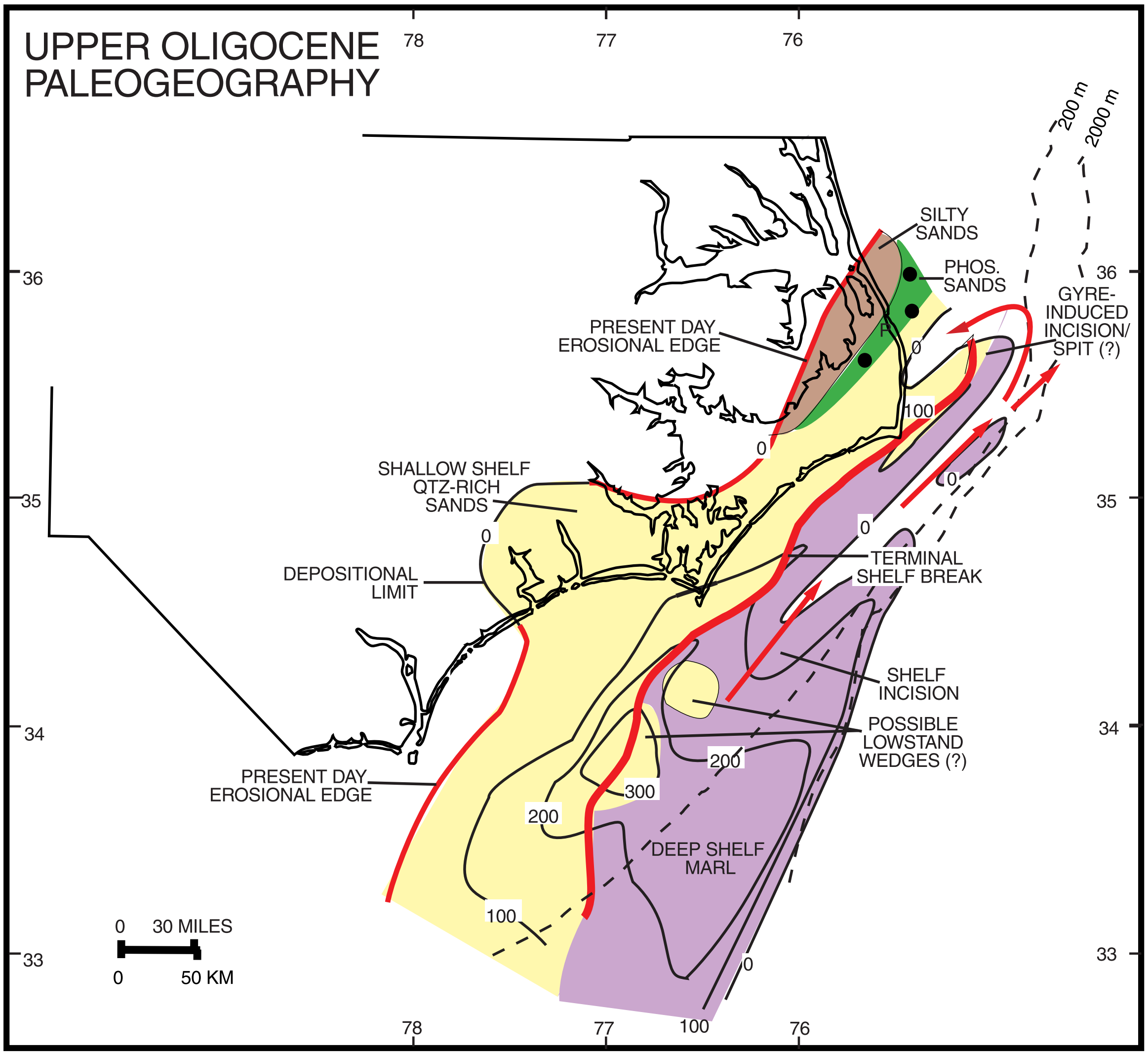



Figure 10 (D). Interpretive Upper Oligocene paleogeography and dominant facies. Shelf dominated by quartz-rich, shallow shelf deposition updip, forming thick HST/LST lobes adjacent to the terminal inner shelf break. Phosphatic sands in the north may mark the position where the ancestral Gulf Stream was deflected off the shelf near Cape Hatteras, which might have generated gyres and local upwelling. Extensive non-deposition or post-depositional incision/erosion by the ancestral Gulf Stream (red arrows) removed sediment from the deep shelf in the north. Isopachs in meters.

Age Control.- Diagnostic Lower Eocene microfossils occur in or just above post-Paleocene quartz sandy facies in the Twiford #1, Marshall Collins #1, Hatteras Light #1, and Huntley-Davis #1 wells (Appendix F). Middle Eocene picks occur in basal and top Eocene siliciclastic-dominated parts of sections in the Twiford #1 well. In the Mobil #3, Ballance #1, Hatteras Light #1, Baylands #1, Huntley-Davis #1, and Evans #1 wells, Middle Eocene picks occur in the middle to upper parts of the Eocene section. Middle Eocene age picks occur in the uppermost parts of the Eocene interval in the Marshall Collins #1, Esso #2, and Mobil #2 wells.

Systems Tracts.- The Eocene supersequences are the most extensive Paleogene units on the North Carolina coastal plain. Their erosional edge extends updip from the Cape Fear Arch in the south to beyond the northern tip of the modern North Carolina Outer Banks (Fig. 10B). In the north, the Eocene supersequences are 0 to 15 m thick updip, thickening gradually to the south to 250 m beneath the present coastline. In the region of Cape Hatteras, seismic data define a major sediment lobe within the Lower to Middle Eocene interval that clinoforms to the north, south, and east (Fig. 8A). On the southern shelf, the Lower to Middle Eocene succession has been eroded in a southwest to northeast trending, 50 km-wide erosional band, as well as from a smaller erosional channel further to the southeast (Popenoe, 1985). The isopachs in the south area parallel these erosional features (Fig. 3B).

At the inner shelf break, the seismic shows low angle clinoforms (up to 150 m relief; $0.5^{o}$ slope) that downlap onto the top-Paleocene reflector (Fig. 9A). On the present-day deep shelf, Eocene seismic reflectors have wavy, irregular signatures.

Onshore, the Lower to Middle Eocene supersequences grade from thin marls into thick skeletal carbonates, then into a mix of quartz skeletal sands and skeletal carbonates. These sediments make up at least 7 sequences (E1 through E7) within the Lower to Middle Eocene supersequence.

Lower Eocene Supersequence.- The supersequence LST is expressed on offshore seismic data as a wedge seaward of the terminal Paleocene shelf break (Figs. 9A, B). It onlaps the top-Paleocene supersequence boundary roughly 15 km east of Cape Lookout, but appears to be absent updip.

Onshore, the Lower Eocene supersequence is Sequence E1 (Fig. 8A, B). The TST is a thin (3-5 m), basinwide quartz sand, grading up into quartz skeletal sand. The Lower Eocene supersequence MFS is placed at the base of regional marls, which extend up to 100 miles updip of the modern shoreline. The Lower Eocene supersequence HST is an upward-shallowing succession of wackestone/mudstone or marl, that grade up into bryozoan skeletal limestone (Fig. 8B). Offshore, the TST is not resolvable, as the base-Eocene supersequence boundary is a regional downlap surface, which defines the MFS (Fig. 9B). Downdip, a progradational sediment unit with gently clinoformed reflectors downlaps onto the Paleocene. This unit may be the Lower Eocene HST, and is likely composed of deeper water facies (Fig. 9A). The terminal Lower Eocene inner shelf break is not evident on seismic.

Middle Eocene Supersequence.- The basal Middle Eocene supersequence boundary appears to be a Type II boundary, based on the absence of a lowstand wedge seaward of the terminal inner shelf break. The Middle Eocene supersequence TST consists of most of Sequence E2 (Figs. 8A, B), which is developed as a large sediment spur of bryozoan-echinoderm grainstone/packstone (100 m thick by 50 km wide) beneath the Cape Hatteras region. The spur is informally named the Pamlico Spur. Away from the spur, the TST is highly condensed. However, the offshore seismic data suggests that deep water TST deposits gradually thicken toward the continental shelf edge (Fig. 9B). The Middle Eocene supersequence MFS is placed at the base of a regional wackestone/mudstone, within the upper part of Sequence E2 in the Pamlico Spur (Fig. 8A). This surface appears to be a regional downlap surface on the onshore seismic data (Fig. 9D). Updip, the supersequence MFS may have been eroded or may be a condensed zone.

The supersequence HST has well-developed, upward-shallowing sequences (E3 to E7) composed of quartz sand, grading upward into skeletal carbonates, that prograde out from the Pamlico Spur, but become more layercake to the north and south away from the spur (Figs. 8A, B). Updip, sequences are highly-condensed, and often lack basal quartz sandy lowstand facies (Fig. 8C). Offshore, the Middle Eocene supersequence HST has clinoformed reflectors near the inner shelf break. The terminal inner shelf break of the Middle Eocene supersequence lies roughly 30 km offshore from (and parallel with) the modern coastline, except near Cape Lookout, where it is beneath the modern barrier system (Fig. 3B). In the south, the terminal shelf break extends southward up to 60 km offshore, flanking the axis of the Cape Fear Arch. Presumably, the Middle Eocene seaward of the terminal inner shelf break is deeper water marl that thickens gradually toward the continental shelf edge, where it has not been modified by erosion (Fig. 10B).

Upper Eocene To Lower Oligocene Supersequence

Age Control.- Brown et al. (1972) did not recognize Upper Eocene sediments on the U.S. Atlantic margin. However, Upper Eocene biotas were recognized in the Mobil #2 well by Zarra (1989) (Appendix F). Age picks were from deep shelf glauconitic sands and marls, which only could be correlated to adjacent wells in the onshore depocenter (Fig. 8A). Oligocene age picks were not differentiated into Upper and Lower divisions by Brown et al. (1972), but Zarra (1989) identified Lower Oligocene faunas in silty, phosphate-rich sediments in the Marshall Collins #1, Esso #2, and Mobil #2 wells. Harts (1992) recognized Lower Oligocene foraminifera in marls updip, near the Evans #1 well.

Systems Tracts.- The Upper Eocene to Lower Oligocene supersequence is 0 to 15 m thick updip and is developed onshore north and west of Cape Lookout (Fig. 3C). The sediment thickens southeastward from 0 to 50 m throughout much of the onshore depocenter, but thins to less than 10 m between Cape Hatteras and Cape Lookout. Two thick localized sediment lobes are developed just seaward of the underlying Lower to Middle Eocene terminal inner shelf break (Fig. 10C). The supersequence is thin to absent in a broad northeast-trending belt on the deep shelf, but thickens into elongate lobes (50 to 200 m thick) near the modern continental shelf edge (Fig. 3C).

Onshore seismic reflectors are flat-lying and parallel, with evidence of minor northward progradation in the northern part of the basin (Fig. 9D). Offshore, near the terminal Lower Oligocene inner shelf break, the shelf units have clinoforms (up to 250 m relief; $1^{o}$ slope) (Figs. 9A, B). Seaward of the inner shelf break, low angle clinoforms in deeper water facies prograde along strike to the northeast, roughly parallel to a major southwest- to northeast-trending erosional fairway beneath the modern outer shelf (Fig. 9E). The 200 m thick lobes on the outer shelf are mounded to clinoformed. Wavy, irregular reflectors occur at the top of the supersequence on the middle to deep shelf.

The Upper Eocene-Lower Oligocene supersequence, which consists of at least 3 higher frequency sequences in the well data, is dominated by quartzose skeletal sands, interlayered with wackestones/mudstones. The seismically defined supersequence LST forms a thin (35 m), elongate wedge, extending 3 km in front of the Middle Eocene inner shelf break, but is not penetrated by any wells. Upper Eocene LST to TST reflectors onlap the top-Middle Eocene sequence boundary updip and gently downlap onto the deep shelf (Fig. 9B).

The subseismic Upper Eocene to Lower Oligocene TST is thin (15 m), patchy mollusk-rich quartz sands, which fine upward into marls and skeletal wackestones (Sequence E8). The supersequence MFS is at the base of thin (5 m), regional marls (Trent marl) and phosphatic sands/hardgrounds (Sequence O1) (Figs. 8, 9). Offshore, the MFS is a regional downlap surface onto the top-Middle Eocene (?) supersequence boundary (Fig. 9B).

The supersequence HST has locally developed quartz sandy facies, with minor interlayered mollusk-rich carbonates (Sequences O2, O3, O4?). Onshore, highstand sediments form two or more sediment lobes that thin and pinch out laterally (Fig. 10C). Near the terminal, inner shelf break, the HST has low angle, progradational clinoforms that build seaward (and slightly northeastward) (Figs. 9A, B). These clinoformed reflectors steepen at the inner shelf break, and downlap the basal, supersequence boundary. The top Lower Oligocene seismic reflector onshore is a phosphatic hardground, overlain by quartz-skeletal sand. The terminal Lower Oligocene inner shelf break is irregular and trends broadly to the southwest, but with a series of south-trending and east-trending segments (Fig. 3C). Supersequence HST reflectors have been truncated by subsequent shore-parallel, erosional incision over much of the shelf.

Upper Oligocene Supersequence

Age Control.- Upper Oligocene foraminifera were encountered in shallow shelf, quartz sandy facies from the Marshall Collins #1 and Mobil #2 wells (Zarra, 1989). Although age control is sparse, thick (up to 60 m) quartz sandy facies that overlie sequences containing Lower Oligocene marls are interpreted to be Upper Oligocene to Lower Miocene in age.

Systems Tracts.- The Upper Oligocene supersequence is composed of Upper Oligocene to Lower Miocene strata. The Lower Miocene units were not analyzed in well-cuttings onshore, but they are included in the offshore isopach maps and seismic line drawings offshore (Popenoe, 1985). The Upper Oligocene units range from 0 to 50 m thick updip in the southern part of the onshore basin, thickening gradually to 40 to 50 m in the onshore part of the basin (Fig. 3D). The Upper Oligocene thickens downdip from present-day river systems (especially near the White Oak and New Rivers) into a series of elongate to lobate clinoformed wedges roughly 50 km across, and 50 to 350 m thick just off the underlying terminal inner shelf break (200-300 m relief; 0.5-1$^{o}$ slope) (Fig. 10D). The thickest lobe is south of Cape Lookout and east of Cape Fear. The supersequence thins progressively to zero along a southwest- to northeast-trending zone on the outer shelf.  It thickens to 250 m in an elongated sediment lobe along the outer shelf. Sediments are eroded seaward of the modern continental slope (Fig. 10D).

The Upper Oligocene portion of the supersequence is almost entirely quartz sand and quartz skeletal (mollusk) sand, which make up 3 or more sequences (O5, 6, 7) in the wells (Fig. 8A).  The seismically defined supersequence LST onlaps the terminal Lower Oligocene shelf break, and clinoforms and downlaps onto the deep shelf.  They occur as a thin, strike-parallel lowstand wedge 10 km east of Cape Lookout, and larger and thicker, more lobate wedges along strike to the southeast (Fig. 3D).

Onshore, the supersequence TST consists of quartz skeletal sands (10 to 15 m thick) (Sequence O4) (Figs. 8A, b).  The Upper Oligocene supersequence MFS probably is at the base of an open shelf skeletal grainstone/packstone of Sequence O5, which overlie transgressive quartz-skeletal-fragment sands.  Just offshore, the MFS is a regional downlap surface on the Upper Oligocene lowstand wedge; further seaward, where this unit is absent, the MFS downlaps on the top-Lower Oligocene and top-Middle Eocene.

The Upper Oligocene supersequence HST analyzed in well data is dominated by quartz skeletal sands, coarsening-upward into quartz sands (Sequences O5, O6, O7). Offshore, seismic reflectors in the HST are relatively flat-lying over the deep shelf, with gentle clinoforming directed northward within elongate sediment lobes, and directed seaward near the continental shelf edge (Popenoe, 1985).  The Upper Oligocene terminal inner shelf break extends south-southwest and HST units are gently clinoformed to seaward from just offshore at Cape Hatteras to Cape Lookout, where it turns toward the south seaward of Onslow Bay (Fig. 10D). Post-Oligocene marine erosional incision has strongly influenced the distribution of highstand sediments.

Third-Order Sequences

The third-order sequences recognized vary from less than 5 m updip to 10 to 40 m thick downdip (Figs. 8A, B, C). In the wells, third-order sequence boundaries were arbitrarily placed beneath regional, shallow water quartz-rich facies, where they overlie deeper water skeletal carbonate facies (e.g. bryozoan packstone or wackestone/mudstone). Many of the sequence boundaries are marked by phosphatic hardgrounds, especially in highly-thinned updip areas (Fig. 8C; Zullo and Harris, 1987; Baum and Vail, 1988; Harris et al, 1993).

Shelf lowstand units could not be differentiated from early transgressive units, thus these have been grouped into lowstand units. These lowstand units commonly occur as regional, 3-10 m thick quartz sand-rich facies in the onshore basin depocenter. These units generally are absent in updip parts of the basin and along structural arches (cf. Zullo and Harris, 1987).

Third-order TSTs can only be differentiated in sequences with three or more lithofacies. Third-order TSTs commonly are open shelf skeletal carbonate facies that overlie lowstand quartz-rich units, and are overlain by highstand deeper water wackestone/mudstone or marl facies (Figs. 7A, B). Updip, the transgressive surface coincides with the underlying sequence boundary (Zullo and Harris, 1987; cf. Kidwell, 1997).

Third-order maximum flooding surfaces generally were placed at the base of regional deep shelf bryozoan-benthic foraminiferal wackestone/packstone or marl units. Phosphatic hardgrounds are associated with some maximum flooding surfaces. In Lower Paleocene and Upper Oligocene sequences containing only a single lithofacies, the MFS could not be distinguished. In sequences with two or more facies, the MFS was placed beneath the most open marine unit.

Third-order highstand units consist of deeper water wackestone/mudstone or marl, commonly overlain by bryozoan-echinoderm skeletal grainstone/packstone, that become more quartzose upsection towards the sequence boundary. Most HSTs are 5 to 10 m thick, and are overlain by quartz-rich units.

<u>Characteristics of Paleocene Third-Order Sequences</u>.- Paleocene sequences range from 0 to 40 m thick, thinning updip. Sequences have deeper water facies off the arches and off the Pamlico Spur, as well as deepening to seaward (Figs. 8A, B). They generally are marl-dominated and have thin (a few meters) lowstand/early TSTs of quartz sandy facies localized within the onshore basin depocenter. Sequence TSTs cannot be differentiated from HSTs, because maximum flooding surfaces cannot be recognized in the marl-dominated sections in cuttings. Near the Pamlico sediment spur, third-order HST sediments are dominantly bryozoan-echinoderm grainstone/packstone (Fig. 8A).

<u>Characteristics of Eocene Third-Order Sequences</u>.- These sequences are generally 10 to 20 m thick over much of the region, thickening to 40 m in the onshore depocenter (e.g. Sequence E2, Mobil #3 well; Figs. 8A, B, C). Harris et al (1993) recognized 5 sequences updip in outcrop, while we recognize 8 sequences in wells from the basin. The updip

sequences are highly condensed, and incomplete (Fig. 8C), much like the updip Miocene sequences from Maryland (Kidwell, 1997). In the basin, LSTs form 10 to 20 m thick, quartz sand-dominated units. The Lower Eocene LST units are thin (5 m) regional features, but Middle Eocene LSTs are thicker (15 m) and are limited to the central part of the onshore basin, especially near the Pamlico spur (Fig. 8B). Lower to Middle Eocene third-order sequence TSTs are 3 to 10 m thick bryozoan-echinoderm grainstone/packstone units, that overlie LST/early TST sands, and are overlain by deeper water units. Maximum flooding surfaces are at the bases of regional wackestones/mudstones and, less commonly, marls. HSTs are 3 to 10 meters thick and consist of muddy packstone/wackestone, grading up into bryozoan-echinoderm grainstone/packstone.

Characteristics of.-Upper Eocene to Lower Oligocene Third-Order Sequences.- These sequences range from 5 to 20 m thick and are best-developed beneath the Cape Hatteras area and northeast beneath Cape Lookout. Quartz sandy units dominate sequences in the southern half of the basin, and silty sands are more common in the north (Figs. 8A, B). Thin (3-5 m) quartz sandy units are common in lowstand/early transgressive deposits. TSTs are poorly-developed and are difficult to recognize, but may be quartz skeletal sand units. Where present, maximum flooding surfaces underlie thin (3-5 m) wackestone/mudstone/marl units, especially in the southern basin. HSTs have thin wackestone/mudstone units, coarsening upward into quartz skeletal fragment sand and sandy mollusk packstone. Phosphatic sands occur in HST strata in the north (upper part of Sequence O1, Mobil #2; Fig. 8A).

Characteristics of Upper Oligocene Third-Order Sequences.- Biostratigraphic control is weak for Upper Oligocene sequences. Seismic data and cuttings data suggest extensive erosion of Upper Oligocene sediments by Miocene and post-Miocene shelf incision. The Upper Oligocene sequences 0 to 20 m thick are quartz sand-rich, becoming more silty (and less consolidated) in the north. Third-order LSTs are quartz sands and quartz-skeletal-fragment sands. Transgressive deposits also appear to be quartz sand-dominated, but have greater amounts of molluscan skeletal material. Maximum flooding surfaces are poorly expressed in well-cuttings, but correspond with the bases of thin (few meters) echinoderm/bryozoan limestones onshore in the south. Thin phosphatized hardgrounds and phosphatic sands are associated with the MFSs, especially in the north (Fig. 8A). Third-order HSTs are thin skeletal carbonates, grading up into quartz skeletal-fragment sands, and in the north, phosphatic sands (Mobil #2 well; Fig. 8A). Thick phosphatic units and regional phosphatic hardgrounds also are associated with Upper Oligocene third-order sequence boundaries.

Recognition and Sequence Stratigraphic Significance of Hardgrounds in the Paleogene Sequences.- Phosphatized hardground surfaces are common in the Paleogene units. Hardgrounds in the wells are represented in the cuttings as multiple angular fragments of phosphate (non-bone), phosphatized grains, or phosphate-cemented lithic fragments and often show as positive gamma-ray responses on the wireline logs. Medium to coarse oolitic phosphate, glauconite and quartz sands, variably cemented by calcite, dolomite, and silica, are associated with hardgrounds in cuttings. Hardground fragments generally span only one or two sample intervals (3-10 m). Paleogene hardgrounds range from local to regionally correlatable horizons.

Hardgrounds are poorly developed in Lower Paleocene, Uppermost Paleocene/Lower Eocene, and Lower Oligocene sequences, where they commonly form isolated surfaces (limited to one well). Upper Paleocene, Middle Eocene, and Oligocene hardgrounds form more regionally correlatable surfaces. Latest Cretaceous to Lower Paleocene and Middle Eocene hardgrounds are concentrated on flanks of areas with positive shelf relief, such as the Pamlico spur (Fig. 8A).

Hardground surfaces are most commonly associated with sequence boundaries (47%), as suggested by Zullo and Harris (1987) from outcrop data. In the wells, hardgrounds appear to underlie quartz sands and many are regionally mappable. Sequence-bounding hardgrounds are common in Upper Paleocene, Middle Eocene, and Upper Oligocene sequences. Few hardgrounds are located within LSTs, but they are well developed as the transgressive surface at the top of the third-order regional LST, where they form regional surfaces beneath bryozoan-echinoderm grainstone/packstone in Upper Paleocene and Middle Eocene sequences. Some hardgrounds correspond with recognizable third-order maximum flooding surfaces. Other hardgrounds occur between the LST and the overlying HST, and appear to form a condensed surface that includes the entire TST and MFS (e.g. Sequence O1, Esso #2). Few hardgrounds were recognized from early to middle HST units.

## CONTROLS ON SEQUENCE DEVELOPMENT

### Duration of Sequences

The Paleogene is from 65 to 23.8 m.a., but biostratigraphic data indicate only 29 million years of deposition occurred on the North Carolina coastal plain (Berggren et al., 1995; Harris and Laws, 1997; GSA, 1999). Harris and Laws (1997) recognized 16 Paleogene sequences in North Carolina, based on biostratigraphy, suggesting an average duration of 1.75 m.a. per sequence. However, their study did not include offshore seismic data, in which three supersequence lowstands were recognized. Each supersequence LST may represent as much time as a third-order sequence updip. The 18 sequences recognized onshore from the thick Albemarle Basin sections in this study, plus the additional time represented by the supersequence lowstands, based on the duration of missing NP zones from the lowstand intervals, approximately 4.25 m.a. (Berggren et al., 1995) suggest an average sequence duration on the shelf of roughly 1.6 million years. The sequences thus are third-order (between 0.5 and 5 million years; Weber et al., 1995) events.

### Tectonic Control

Paleogene subsidence rates of approximately 1 cm/k.y. calculated from geohistory plots (Fig. 11) from the deepest onshore wells are similar to those calculated from sediment backstripping offshore New Jersey and Georgia wells, which are consistent with passive margin (Steckler and Watts, 1982; Heller et al., 1982). Subsidence rates on the arches were considerably less. Instead, the arches were sites of Cenozoic faulting, relative uplift, and pulses of increased sedimentation, which could be associated with

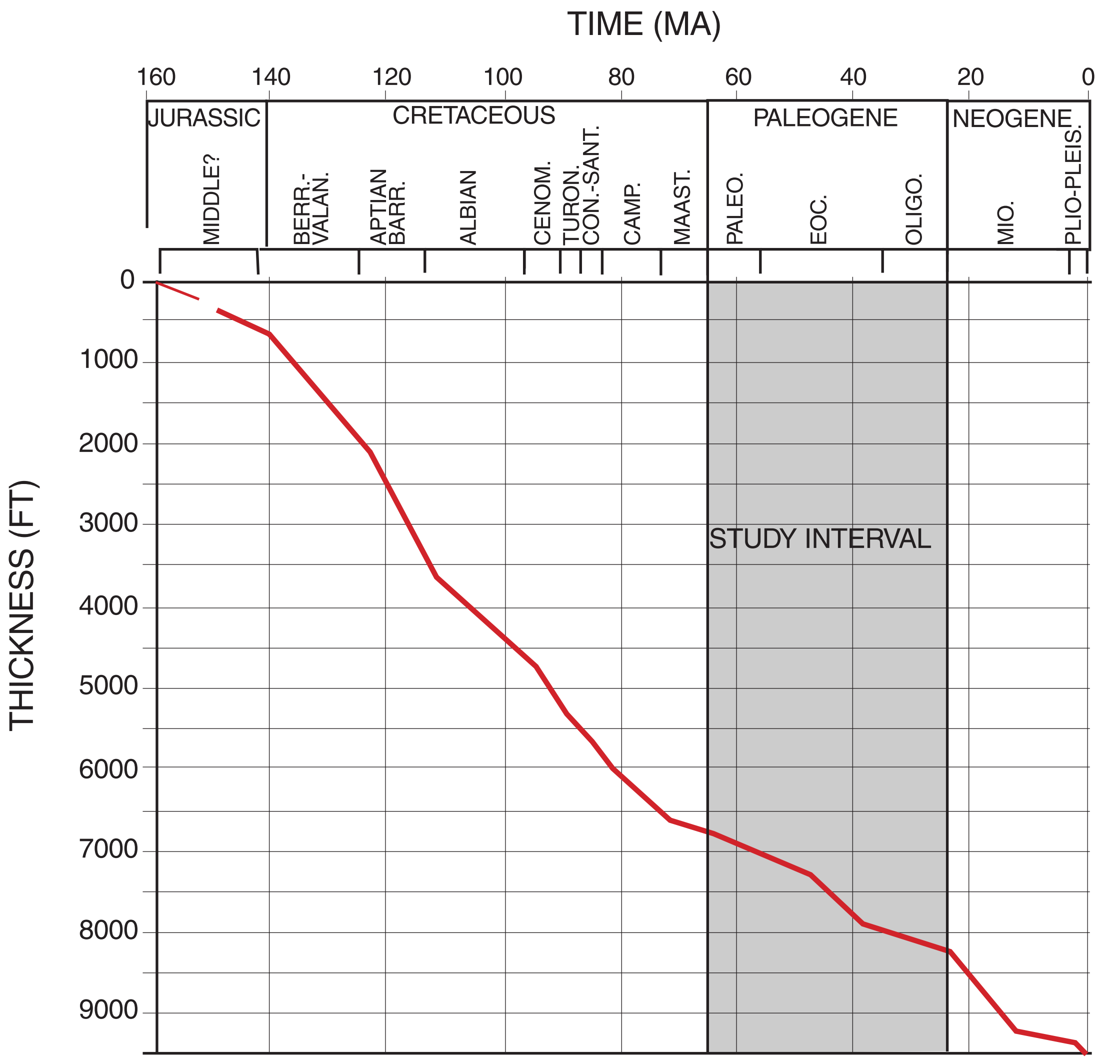



Figure 11. Sediment accumulation plot, in thickness (not decompacted) versus time, for the middle Mesozoic through Cenozoic of the North Carolina coastal plain. Sediment thicknesses are from the Hatteras Light #1 well (Brown et al., 1972). Reduced accumulation in the Paleogene, relative to middle Mesozoic and Neogene values, suggests minimal tectonic influence on central basin formation during the Paleogene.

antecedent crustal weakness related to rift basins or terrane boundaries (Reinhardt et al., 1984; Prowell, 1989).

Faulting.- Isolated, high-angle reverse faults have been recognized near the fall line from Georgia to Virginia (Bramlett et al., 1982; Brown et al, 1982; Reinhardt et al., 1984; Prowell, 1989; Berquist and Bailey, 1998). Most faults show northeast-southwest compression, with subvertical (less than 10 m displacement) dip-slip offset. Faults offset Paleocene and Eocene strata in Georgia, South Carolina, and North Carolina (Christopher et al., 1980; Gohn et al., 1981; Brown et al, 1982). A zone of rapid sediment thinning south of Cape Lookout (Fig. 8A; near Neuse Fault of Baum, 1977) corresponds to a zone of numerous, small-offset faults suggested on seismic data.

Igneous Activity.- Intrusive rocks dated at 42-47 Ma from the Appalachian Valley and Ridge have a general northeast-southwest trend, along with contemporaneous ash beds from the coastal plain, may have formed from reactivation of existing Jurassic zones of structural weakness (Fullagar and Bottino, 1969; Ressetar and Martin, 1980; Nusbaum et al., 1988; Harris and Fullagar, 1989; Southworth et al., 1993). The intrusions probably were associated with localized uplift in western Virginia, but did not influence sedimentation on the North Carolina coastal plain (Ressetar and Martin, 1980). Reorganization of lithospheric plate stress fields in the Eocene (Clague and Jarrard, 1973) could have caused onset of Eocene magmatism (Ressetar and Martin, 1980; Southworth et al., 1993). Mid-Atlantic meteor impact events also reconfigured Eocene crustal stress fields (cf. Poag, 1997).

Relative Uplift.- Paleogene uplift rates are difficult to constrain, because most uplift has been inferred from variations in sediment thickness. Episodic uplift occurred along the Cape Fear and Norfolk arches throughout the Mesozoic and Cenozoic, based on regional sediment isopachs and terrace mapping (Brown et al., 1972; Owens and Gohn, 1985; Soller, 1988; Bonini and Woollard, 1960). Relatively thin sedimentary cover suggests that the Cape Fear Arch/Carolina Platform was a subtle positive area throughout the Paleogene (Fig. 8C). Norfolk Arch uplift was active in the Paleocene, Lower Eocene, and Oligocene (Powars et al., 1987). However, much of the uplift of the arches has occurred since the Miocene (Winker and Howard, 1977; Ager et al, 1981; Gardner, 1989; Prowell and Obermeier, 1991).

In the Salisbury embayment north of the study area, increased siliciclastic sedimentation has been linked to increased tectonism in the Appalachian hinterland (Gibson, 1970; Pazzaglia, 1993). The ensuing sediment loading of the continental shelf and slope could have promoted additional regional uplift via flexural upwarping and isostatic rebound from erosion (Pazzaglia and Gardner, 1994; Pazzaglia and Brandon, 1996). The localization of Paleogene siliciclastics to the southern part of the Albemarle Basin seaward of the modern Cape Fear and White Oak Rivers suggests possible uplift of the Cape Fear Arch and hinterland of the central North Carolina Piedmont. Seaward displacement of Paleocene sediments along the Cape Fear and Norfolk arches indicate shelf promontories caused by relative uplift. Eocene sediments also are thinned near the arches, but lithologic similarities with deeper basin sediments suggest thinning my be related to post-Eocene erosion (Fig. 8A). Isolation of Upper Eocene and Oligocene sediments to the central part of the basin suggests renewed uplift along the arches. However, late Paleogene sediment distribution also may relate to siliciclastic point sources from river systems during lower sea-levels (Figs. 10C, D). There is no evidence of large-scale siliciclastic sedimentation pulses along the Atlantic margin in the Paleogene, suggesting that the region was a low-relief, stable margin, and that much of the modern Appalachian Mountain topographic relief relates to uplift in the Miocene, when widespread, thick siliciclastic sediments accumulated along the U. S. Atlantic shelf and rise (cf. Poag, 1992; Pazzaglia and Brandon, 1996).

<u>Eustatic Control</u>

<u>Paleogene Supersequence Set.-</u> The North Carolina Paleogene supersequence set (latest Cretaceous lowstand to the top of the Lower Oligocene) corresponds to the Tejas A (TA) supercycle set of the Haq et al. (1988) (Fig. 12). Relative sea-level rose rapidly to between 75 m and 150 m above modern sea-level during the early Paleogene supercycle set, then gradually fell to slightly above modern levels in the late Paleogene (Haq et al., 1988; Kominz et al., 1998).

<u>Paleocene Supersequence.-</u> The Paleocene supersequence extends from the latest Cretaceous to the latest Paleocene and appears to correspond to the TA1 supercycle, plus the lower part of the TA2 supercycle (Haq et al., 1988).

Sequences PA1 and PA2 (Plankton Zones P1, P2, and P4; Zarra, 1989), may be equivalent to global supercycle TA1, and the boundary between PA1 and PA2 may correlate with the Haq et al (1988) curve lowstand at the base of TA1.4 (Fig. 12). The uppermost Paleocene sequence PA3 (Plankton Zone P4; Zarra, 1989) probably

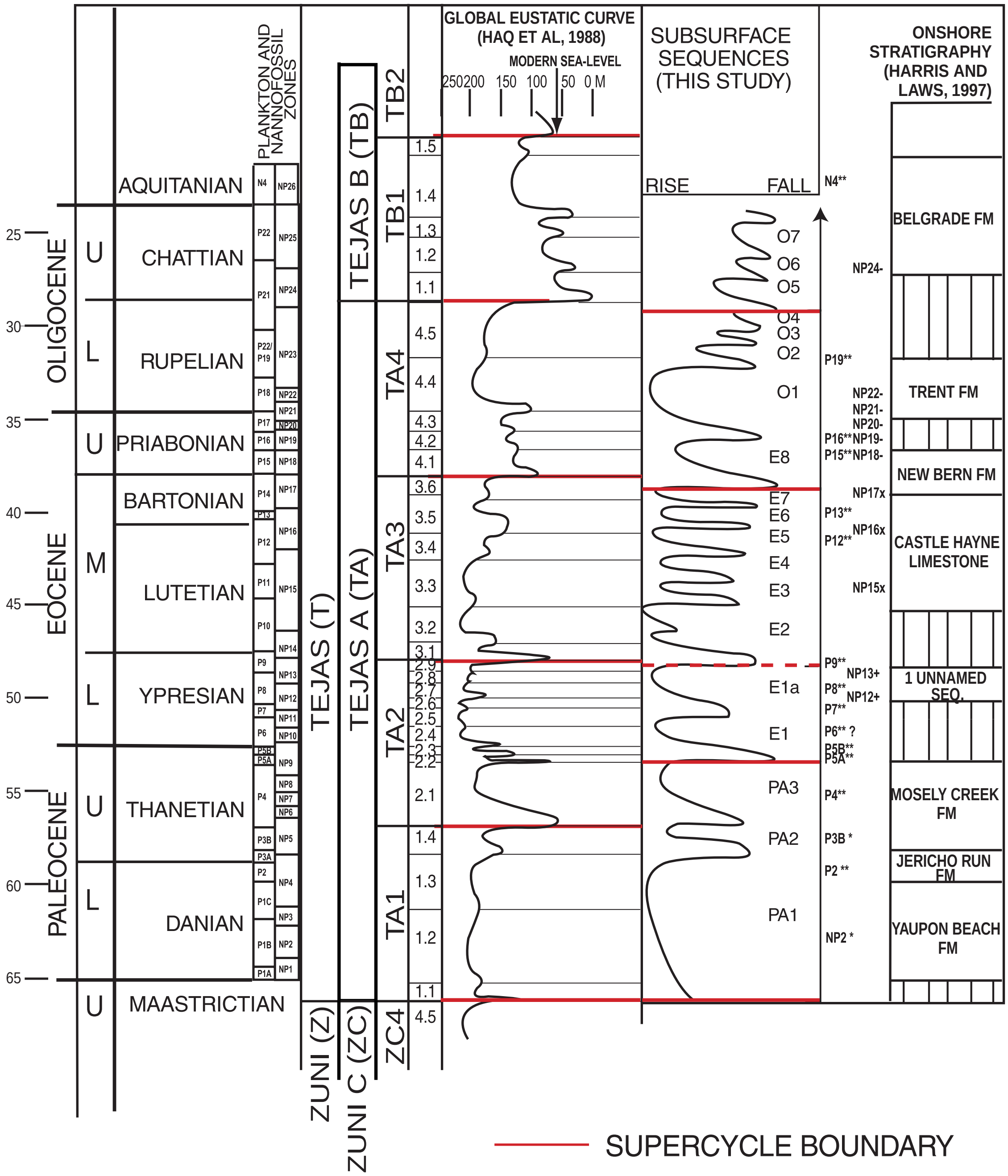



Figure. 12. Comparison of the Paleogene global eustatic curve of Haq et al. (1988) with the Paleogene eustatic curve from the Albemarle Basin, N.C. (this study). Flood amplitudes from the Albemarle Basin are schematic, and are based on changes in the location of shallow shelf deposits (constrained by biostratigraphic picks-right of the curve). Age-equivalent formations from the updip basin (Harris and Laws, 1997) are shown to the right of the eustatic curve. Supercycles correlate well with the global eustatic curve, but third-order scale events from North Carolina often lack sufficient age control to confidently correlate with global events.

corresponds to global cycle TA2.1. The top-Paleocene supersequence lowstand probably corresponds with the global cycle lowstand at the base of TA2.2, between uppermost Paleocene Plankton Zone P4 and Lower Eocene Nannofossil Zone NP12 (Zarra, 1989; Bralower, pers. comm.).

Paleocene sea-level was up to 100 m above modern sea-level, resulting in widespread marl deposition throughout most of the Paleocene, with superimposed smaller fluctuations (less than 20 m) (Haq et al., 1988). Significant fall at the supersequence boundary could have exceeded 100 m, as suggested by the terminal Paleocene lowstand wedge seaward of the modern shoreline (Fig. 10A).

Lower through Middle Eocene Supersequence.- This supersequence in North Carolina extends from the base of the Lower Eocene to the top of the Middle Eocene and may be composed of two smaller supersequences, one Lower Eocene and one Middle Eocene (Fig. 8b). Lower Eocene supersequence E1A (pre Zone NP12-13; Bralower, pers. comm.) may correspond to the middle of the TA2 supercycle (Lower Eocene), which likely is equivalent to the unnamed subsurface sequence (Zone P8) mapped by Zarra (1989), and probably correlates with cycles 2.7 to 2.9 on the Haq et al. (1988) chart. The supersequence lowstand at the base of Sequence E2 (Zone P9) is probably equivalent to the TA3 supercycle (Haq et al., 1988) (Fig. 12). Based on the presence of middle Zone NP15 biota in updip marls (Worsley and Laws, 1986), the Middle Eocene supersequence MFS could correlate with the maximum flood of global cycle TA3.2 or TA3.3. Harris et al. (1997) did not recognize units from the Middle Eocene Castle Hayne Limestone older than the middle of NP15 Zone (cycle TA3.3) in outcrop. However, it is possible that a lower Zone NP15 age occurs in the deeper basin in the upper part of Sequence E2. The MFS of the Middle Eocene supersequence in seismic data appears to be the Sequence E2 downlap surface extending from the Pamlico Spur (Fig. 9D). The top-Middle Eocene supersequence boundary is picked at the top of the Middle Eocene, because the top sequence has an NP17 age (Harris et al., 1993), and appears to correlate with a regional onlap surface on seismic (Fig. 9B). Because only Middle Eocene sequences E2 and E7 are dated, while the 4 additional Middle Eocene sequences (E3-E6) have poor age constraints, we cannot directly correlate the sequences with the 6 Middle Eocene third-order cycles on the Haq et al. (1988) curve.

Lower to Middle Eocene sea-levels were between 50 m and 150 m above modern levels throughout deposition of the supersequence, with a fall to roughly 20 m above modern sea-level at the end of the Lower Eocene (Haq et al., 1988; Kominz et al., 1998). Large third-order sea-level falls are suggested by global eustatic curves, and these are superimposed on a long-term Eocene fall, causing seaward progradation of Middle Eocene highstand sequences (Fig. 8B) (Haq et al., 1988).

<u>Upper Eocene through Lower Oligocene Supersequence.-</u> Upper Eocene strata have been identified in only two wells from the deep subsurface (Mobil #2 and Esso #2; Zarra, 1989, and Laws, pers. comm., respectively), thus Oligocene strata unconformably overlie Middle Eocene units across much of the onshore basin. Offshore, there is an undated lowstand wedge in this position. The Upper Eocene supersequence is poorly dated in North Carolina, but occurs between Middle Eocene Zone NP16 (Worsley and Laws, 1986) and Upper Eocene Zone P15/17 (Zarra, 1989). Thus the basal boundary to Upper

Eocene Sequence E8 probably correlates with the major sea-level fall at the base of the Upper Eocene TA4 supercycle lowstand (Haq et al., 1988) (Fig. 12). Harris and Laws (1997) recognized two Upper Eocene sequences updip, but only one thin sequence (Zone P15-P16; Zarra, 1989) can be recognized in the subsurface; it may correspond to the sea-level rise and fall associated with cycle set TA4.1-4.3 of Haq et al. (1988). The MFS for the Upper Eocene to Lower Oligocene supersequence in outcrop and updip wells occurs in Lower Oligocene Zone NP21-22 (P19-20) (Worsley and Turco, 1979; Parker, 1992). In the subsurface, this MFS occurs in Sequence O1, and a local downlap surface is associated with the age-equivalent Trent Formation deep shelf marl (Zullo and Harris, 1987; Parker, 1992). This flood is the TA4.4 cycle of the Haq et al. (1988) eustatic curve. Three, and perhaps four, Lower Oligocene sequences in the onshore subsurface (Fig. 8A) and the offshore south of the study area (Snyder et al., 1994), although only two global eustatic cycles are shown on the Haq et al. (1988) chart.

Sea-level dropped 30 m below present level at the end of the Middle Eocene (Haq et al., 1988; Kominz et al., 1998). The large flooding event in the Upper Eocene to Lower Oligocene may have been over 100 m (Haq et al., 1988). However, average sea-level probably varied between 20 and 50 m above modern sea-level.

<u>Upper Oligocene Supersequence.-</u> The basal Upper Oligocene supersequence boundary lies between Zone P19-20 and Zone NP 24, which likely is the medial Oligocene (base-Tejas B) lowstand (Zarra, 1989; Parker, 1992) (Fig. 12), and may be equivalent to an undated lowstand wedge onlapping the top Lower Oligocene supersequence boundary on seismic data. This major medial Oligocene global sea-level fall was about 150 m, falling

to 50 m below modern sea-level. The Upper Oligocene supersequence in North Carolina is grossly equivalent to the TB 1.1-1.3 cycle set of the global eustatic curve (Haq et al., 1988), with the upper sequence boundary at the top of the Oligocene succession, although the supersequence may encompass the Upper Oligocene/Lower Miocene TB1 global supercycle. At least three sequences exist in the Upper Oligocene of North Carolina, most of which cannot be regionally correlated, because of lithologic similarities (all quartz sandy). Lack of precise age control on these Upper Oligocene sequences of the onshore subsurface and the Upper Oligocene to Lower Miocene seismically-defined sequences to the south (Snyder, 1982) prevents any correlation with the Haq et al. (1988) third-order cycles. Following the major 150 m medial Oligocene fall, third-order Upper Oligocene sea-level changes of about 40 m are suggested by global eustatic curves (Fig. 12) (Haq et al., 1988; Kominz et al., 1998).

Climate Control

Early Paleocene climate was wet temperate, gradually warming due to global greenhouse conditions, from the latest Cretaceous glaciation of Antarctica (Barrera, 1990). High sea-levels and reduced benthic productivity, due to cooler temperatures or lower oxygen levels associated with the stratified Paleocene oceans, favored deposition of silty marls in the Lower Paleocene. As the climate warmed in Upper Paleocene, terrestrial climates in the region became more warm, moist subtropical (Nystrom et al., 1991). The resultant forest cover probably caused slow deposition of fine siliciclastics on the shelf, which promoted glauconite formation (Fig. 10A) (cf. Cloud, 1955).

The greater amounts of skeletal carbonate, including large benthic foraminifera in Upper Paleocene deep shelf facies reflect warmer water on the shelf, and possibly thermohaline and more oxygenated ocean circulation. Initiation of bryozoan-echinoderm-rich shelf deposition appears begun in the Upper Paleocene. The Paleocene/Eocene boundary saw a widespread global extinction, synchronous with the basal Eocene lowstand wedge, in both the marine and terrestrial realms and coinciding with a major negative $^{13C}$ isotope shift, suggesting a rapid, short-lived (2 m.y.) warming event and turnover from thermohaline to stenohaline ocean circulation (Berggren et al., 1998).

Isotopic, faunal, and floral data indicate that the Cenozoic thermal maximum occurred in the Eocene (Prothero, 1994; Berggren et al, 1998). Eocene shelf waters in the region were marginally subtropical and well oxygenated, favoring development of bryozoal facies with scattered large benthic foraminifera (nummulitids and discocyclinids) and buildup of the Pamlico Spur and the associated shelf (Fig. 10B). Onset of global cooling and aridification in the late Middle Eocene increased fluvial siliciclastic input (cf. Cecil, 1990) and disappearance of warmer water shelf biotas. This cooling trend was briefly interrupted by the latest Middle Eocene Kirthar Restoration, which marks the Cenozoic thermal maximum in the southern oceans (McGowran et al., 1997) and corresponds with a rapid sea-level rise, and the brief recurrence of warmer water benthic foraminifera in North Carolina (Fig. 8B). Increasingly arid, cooler climates in the Upper Eocene and Oligocene caused changeover to cooler water, mollusk-dominated assemblages (Emery, 1965; Milliman et al, 1968; Swift et al., 1970; Lees and Buller, 1972; Blackwelder et al, 1982) across the North Carolina shelf.

Isotopic data and Antarctic dropstones indicate that a major global cooling in the Upper Eocene caused transition from greenhouse to icehouse climates and onset of Antarctic continental glaciation (Denison et al., 1993; Prothero, 1994; Zachos et al., 1994). The increased aridity and cooling decreased terrestrial forest cover from the Upper Eocene to the Oligocene, causing increased siliciclastic sedimentation on the Atlantic shelf and basin floor fan complex, especially near fluvial systems (Figs., 8A, 10C, D) (Poag, 1992). The well-developed lowstand deposits just off the terminal inner shelf breaks in North Carolina reflect this high siliciclastic influx during cool Oligocene lowstands.

## SUPERSEQUENCE DEVELOPMENT

The North Carolina Paleogene margin's destructive shelf profile, with a high-relief inner shelf break and deep shelf terminating at the continental slope, is the product of the large sea-level rise following latest Cretaceous lowstand incision, which submerged the previously gently seaward sloping, broadly concave up, Mesozoic shelf. This Mesozoic shelf formed by drowning of the high-relief, Lower Cretaceous-Jurassic flat-topped shallow water tropical rimmed carbonate platform, and subsequent Upper Cretaceous progradation of deep water siliciclastics out onto the margin (Meyer, 1989).

Latest Cretaceous to Paleocene sea-level rise caused widespread flooding of the gradually seaward-deepening Upper Cretaceous surface and large-scale backstepping of the shallow shelf to many miles landward of the present shoreline in the Albemarle Basin. During supersequence highstands, the shallow shelf built out to a position seaward of the present shoreline, but well updip from the continental shelf-slope break. Repeated drowning and emergence during each Paleogene supercycle brought the terminal inner shelf break near, or slightly seaward of, the position of the previous terminal inner shelf break.

Paleocene Supersequence

Global cooling in the latest Cretaceous caused a major sea-level fall and lowstand (cf. Keller and Stinnesbeck, 1996) to form the Paleogene supersequence set boundary in North Carolina. As climate warmed and sea level rose, thin, onlapping sands, widespread deep water marl deposition, and updip silty glauconite-rich facies were deposited from latest Cretaceous through Paleocene in the tectonically subsiding Albemarle Basin (Fig. 10A). Terrigenous deposition occurred throughout much of the Lower Paleocene over the positive Cape Fear Arch.

At the end of the Lower Paleocene, minor sea-level fall caused quartz sand deposition within the axis of the central basin depocenter. This formed a subtle constructional high that became the site of shallower-water, skeletal carbonate deposition (Fig. 8A, 10A), as warm temperate waters flooded the basin in the Upper Paleocene; this favored deposition of glauconite-rich sediment updip and continued marl deposition downdip. Further south toward the Cape Fear Arch, warmer water, bryozoal shelf carbonates were deposited on earlier quartz sands (Figs. 8A, 10A). The precursor to the Pamlico Spur may have been initiated by sand and bryozoal limestone deposition that resulted from interaction of the Ancestral Gulf Stream (which became active on the shelf during the early Upper Paleocene; Huddleston, 1993; Pinet and Popenoe, 1985) with a bend in the continental margin near Cape Hatteras. Upper Paleocene third-order sea-level falls of 30 m or so lowered sea-level sufficiently to expose the deep inner shelf to storm wave (rather than shoreface) reworking in the Albemarle Basin, remobilizing updip siliciclastic sediments and causing thin, widespread shelf sand deposition. The major latest Paleocene sea-level fall resulted in progradation of the inner shelf break roughly 9 miles (14 km) seaward of the position of the uppermost Cretaceous terminal inner shelf break (Fig. 10A).

Eocene Supersequence

Early Eocene sea-level rise of up to 100 m, coupled with the low subsidence rates and warm subtropical conditions allowed widespread deposition of Lower Eocene inner shelf (sub-fair-weather wave-base) bryozoal carbonate units across the flooded shelf (Figs. 8A, 10B). The ancestral Gulf Stream moved back onto the shelf during the highstand, erosionally incising Lower Eocene units over the southeast-trending southern shelf (Popenoe, 1985). Latest Lower Eocene global ocean cooling and falling sea-level (McGowran et al., 1997) caused thin quartz sand deposition over the Pamlico Spur (Fig. 8A). Renewed warming and sea-level rise in the early Middle Eocene caused shelf flooding, and subtropical bryozoal carbonate deposition, while the Ancestral Gulf Stream left winnowed lags of phosphatic conglomerates (New Hanover Member) across the Cape Fear area (Fig. 10B). This Eocene flooding allowed thick skeletal carbonates with large benthic foraminifera to form the Pamlico Spur beneath Cape Hatteras, while elsewhere, condensed shallow to deep inner shelf facies accumulated (Fig. 8A). During the Middle Eocene supersequence highstand, structural highs were flooded and bryozoal shelf carbonates were deposited. Downdip, HST skeletal carbonates and third-order lowstand quartz sand units filled the remaining accommodation space on the flanks of the Pamlico Spur, smoothing the shelf topography by the end Middle Eocene (Figs. 8A, 10B). The latest Middle Eocene thermal maximum (Kirthar Restoration, McGowran et al., 1997) resulted in abrupt sea-level rise and widespread, but thin deposition of subtropical bryozoal carbonates with large benthic foraminifera (Figs. 8A, B). Eocene sea-level rise allowed the Ancestral Gulf Stream to flow in a northeastward path through the Suwanee Straits of northern Florida (Huddleston, 1993), erosionally incising and remobilizing Eocene lobes on the deep shelf, North Carolina (Fig. 10B) (Popenoe, 1985). The terminal Middle Eocene inner shelf break prograded 8 miles (13 km) seaward of the position of the uppermost Paleocene terminal inner shelf break across much of the shelf.

Upper Eocene through Lower Oligocene Supersequence

Global cooling at the Middle/Upper Eocene boundary caused sea-level fall and deposition of broad, presumably siliciclastic lowstand lobes at the terminal inner shelf break downdip from rivers. Lowered sea-level caused the Ancestral Gulf Stream to migrate south to the Florida Straits (Huddleston, 1993), probably resulting in a decrease in deep shelf incision, but increased incision along the continental slope. Subsequent warming and sea-level rise led to regional, thin Upper Eocene temperate shallow mollusk-rich sands updip, and muddy carbonates downdip during highstands (Figs. 8A, 10C). The Lower Oligocene glacial maximum lowered sea-level significantly, resulting in quartz sand deposition across the shelf. Return to warmer climates caused an abrupt, 75 to 100 m Lower Oligocene sea-level rise, allowing widespread temperate shelf mollusk and bryozoal carbonate deposition in the onshore basin and ancestral Gulf Stream incision on the deep shelf (Figs. 8A, 10C) (Popenoe et al, 1987). Gradually cooling climates and falling sea-level through the Lower Oligocene increased siliciclastic deposition on the Lower Oligocene shelf. Highstand Gulf Stream currents incised a swath across the deep shelf, reworked hemipelagic sediments into broad lobes, and could have spalled gyres onto the shelf north of Cape Hatteras that localized upwelling and phosphate accumulation (cf. Riggs, 1984) (Figs. 8A, 10C). The terminal Lower Oligocene inner shelf break prograded roughly 8 miles (13 km) seaward of the previous Middle Eocene supersequence terminal shelf break position.

Upper Oligocene Supersequence

Major global cooling and sea-level fall of over 100 m in the medial Oligocene caused deposition of lowstand siliciclastic (?) sediment lobes seaward of the Lower Oligocene terminal inner shelf break. The Suwanee Straits closed to Ancestral Gulf Stream flow, which migrated to the Florida Straits for the remainder of the Oligocene through Lower Miocene (Huddleston, 1993). Transgressive quartz sandy units were deposited over much of the cool, temperate water shelf (Fig. 10D). Small-scale sea-level rises and falls generated interbedded quartz sands and cool water, mollusk-dominated skeletal carbonates across the southern shelf, while in the northern basin, prograding distal deltaic silty sands, with localized gyre-induced phosphorites, were deposited (Figs. 8A, 10D). Limited accommodation space on the shallow shelf, lowered sea-levels, and greater siliciclastic sedimentation resulted in steep, well-developed clinoform development on the updip shelf during the HST; downdip, continued deep shelf contour current activity eroded sediments along a southwest- to northeast-trending swath. Sedimentation probably continued into the Lower Miocene, when a major sea-level fall formed the upper supersequence boundary. The terminal inner shelf break (Lower Miocene) prograded approximately 5 miles (7 km) seaward of the top-Lower Oligocene terminal shelf break location.

Comparison of Paleogene Shelves, Northwest Atlantic Margin

New Jersey Margin.- The early Paleocene-Eocene marl-dominated shelf off New Jersey resembled the North Carolina shelf. It was a wave-swept, temperate margin with a shallow inner shelf break and a deep shelf break, terminating at the continental slope (Steckler et al, 1998; Poag, 1992). Paleogene shallow shelf skeletal carbonates are scarce off New Jersey, because waters were cooler than those on the North Carolina shelf, and there was greater siliciclastic influx (Poag, 1992). In the early Paleogene of the New Jersey shelf, low sedimentation rates resulted in much unfilled accommodation. However, during late Paleogene to early Neogene eustatic lowering, this space was filled by prograding siliciclastics and the shelf was flattened.

As climate cooled in the Upper Eocene, the previous warm temperate, deep shelf silty marls and glauconitic silts gave way to quartz silty sands with sparse admixed carbonate skeletal material. This resulted in similar (but slightly more siliciclastic-dominated) overall lithologic successions compared to North Carolina (cf. Miller et al., 1997). Boundary current incision has been recognized on the deep shelf, but erosion affected smaller areas and was of shorter duration than on the Carolina shelf (Miller et al., 1996, 1997).

Florida Margin.- Low accommodation and high carbonate sediment production rates resulted in aggraded rimmed shelf development during the early Paleogene (Randazzo, 1997; Cunningham et al., 1998). There was widespread deposition of early Paleogene tropical to subtropical peritidal carbonates (cf. algal laminites, evaporites, caliche horizons, and sea-grass bank deposits), stacked into high frequency sequences (Jee, 1993). These differ greatly from the updip thin, shelly and siliciclastic-dominated shallow shelf sequences in North Carolina.

Late Eocene to Oligocene cooling on the Floridan peninsula resulted in subtropical to warm temperate, mixed carbonate-siliciclastic deposition across the shelf, and reduced sediment production rates. Available accommodation space was not filled, which led to deeper water, shallow- to mid-shelf-dominated, carbonate-ramp deposition across much of the Florida shelf. The resultant Paleogene upward-deepening trend contrasts greatly with upward-shallowing trends observed on cooler water carbonate shelves to the north.

Ancestral Gulf Stream currents played a major role in sediment dispersion throughout the Paleogene, by separating siliciclastic material in the north from peritidal carbonates of the southern peninsula (Huddleston, 1993; Hine, 1997). Eustatic fluctuations changed the position and intensity of the current flow across the Suwannee Straits, with major flow through the straits in the mid-to-late Paleocene, Lower-Middle

Eocene, and Lower Oligocene, followed by final closing of the straits by Upper Oligocene sea-level fall (Popenoe et al., 1987; Huddleston, 1993).

## RESERVOIR/AQUIFER AND SOURCE POTENTIAL OF THE SUBTROPICAL TO TEMPERATE MIXED SILICICLASTIC/CARBONATE SHELF, N.C.

The North Carolina Paleogene shelf has a different distribution of potential reservoir/aquifer facies than on the standard tropical sequence model. Leached molluscan lagoonal/inner shelf units typically have moldic porosity, but because molds are enclosed in low permeability, muddy matrix and have low to moderate connectivity, these facies could require extensive fracturing or later vuggy leaching to develop high permeability. Fine siliciclastic estuarine to distal deltaic units likely have poor reservoir properties, but may be potential source beds, as they contain terrestrial organics. Barrier sands are uncemented to moderately cemented and have high between-grain porosity; they form excellent (but highly localized) potential reservoir facies, and probably have strike and sheet sand geometries. Quartz-skeletal fragment sand and mollusk-fragment sand and grainstone have variable moldic intraparticle- (leached aragonitic mollusk grains) and moderate to high interparticle porosity, due to some occlusion by periodic meteoric cementation. Well-cemented inner to middle shelf hardgrounds form seals within the succession, with micrite, dolomite, and phosphorite plugging porosity. In the wells, dead hydrocarbons locally are associated with the hardgrounds, occurring between secondary dolomite crystals. Echinoderm/bryozoan grainstone/packstone facies have variable porosity, with highest porosity values and permeability in the meter-scale, mud-lean, early marine cemented units, whereas interbedded, mud-prone bryozoal units lack marine cement, but tend to be tight and indurated by micritic cementation of the matrix. Deep shelf mud-rich pelagic carbonates are little indurated and have low between-grain porosity and variable (generally low) permeability, depending on the degree of early cementation, versus burial compaction. These are unlikely source beds, because of boundary current circulation of oxygenated waters on the shelf during highstands.

## A MIXED CARBONATE/SILICICLASTIC RAMP SEQUENCE STRATIGRAPHIC MODEL FOR SWELL-WAVE-DOMINATED MARGINS

Sequence stratigraphic models for carbonate ramps typically are based on tropical examples (cf. Sarg, 1988; Hanford and Loucks, 1993). However, mixed carbonate-siliciclastic, nontropical ramps from swell-wave and boundary current-dominated passive margins differ significantly from existing sequence stratigraphic models. However, they have much in common with swell-wave-dominated, temperate open shelves (Collins, 1988, Collins et al., 1997; James et al., 1999). Peritidal carbonate facies and common high-frequency sequence (parasequence)-capping exposure surfaces are rarely developed on these nontropical settings. Instead, lagoonal, back-barrier bay, or shallow shelf shelly-quartz sandy facies and shell beds, along with siliciclastic barrier sands are the most updip facies. Skeletal banks and local reefs, which form fringing and barrier shoreface complexes on many tropical ramps (Read, 1985), are absent from nontropical systems. Instead, lower shoreface and shallow-shelf facies are mollusk-fragment sands, passing seaward into hardground and wave abrasion surfaces, and then into storm- and swell-

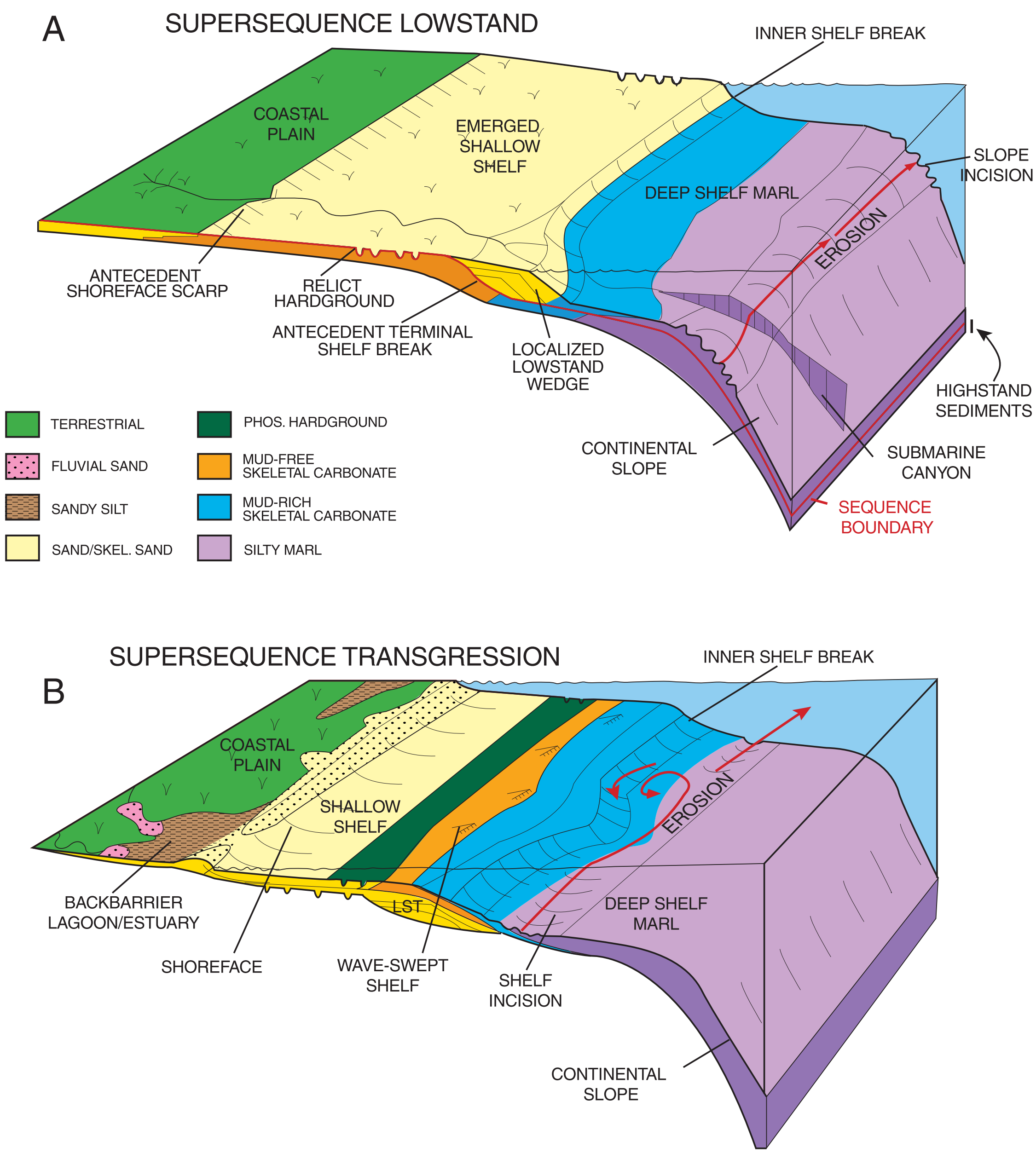



Figure 13. Revised sequence stratigraphic model for nontropical mixed carbonate/siliciclastic shelves, (A) Supersequence lowstand; shelf is emergent, and there is local deposition of lowstand wedges adjacent to lowstand fluvial point sources. Ancestral Gulf Stream moves to the continental margin, eroding the upper slope.
(B) Supersequence transgression; previously emergent shelf becomes gradually flooded, hardgrounds may develop on the sequence boundary (also marks transgressive surface), and units show progressive backstepping of quartz sands, molluscan carbonates, and bryozoal facies. Siliciclastic material is limited largely to updip barrier/lagoon/bay complexes. Deeper water facies extend as tongues onto the shallow shelf during supersequence maximum floods and superimposed, higher frequency floods. The Ancestral Gulf Stream moves onto the deep shelf, incision and remolding units. Hardgrounds may develop on the wave-swept, shallow shelf at the maximum flood.

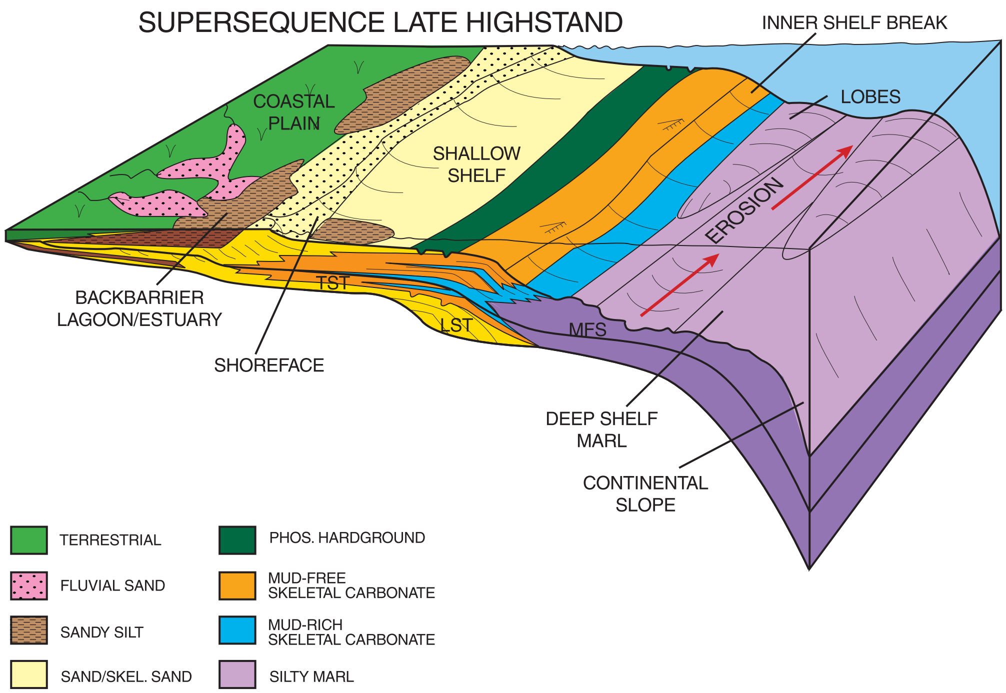



Figure 13 contd. Revised sequence stratigraphic model for nontropical mixed carbonate/siliciclastic shelves, (C) Supersequence highstand; coastal and shoreface mollusk-quartz-rich units aggrade and may prograde as low relief (10-20 m) clinoforms; wave-swept shallow shelf zone migrates gradually seaward as bryozoan limestones of inner shelf prograde seawards onto deep shelf wackestone/mudstone and marls. Ancestral Gulf Stream migrates seawards across deep shelf remolding and eroding marls.

wave influenced (mud-lean to mud-rich), bryozoan-echinoderm grainstone/packstone facies (summarized in Figs. 13A, B, C). The zone of wave-sweeping on much of the inner shelf on these nontropical shelves, results in hardground development at sequence boundaries, on top of the LST at the transgressive surface, and at the MFS beneath deeper water facies.

Extensive wave-sweeping on nontropical shelves moves fines onto and seaward of the low-angle slope at the inner shelf-break, causing it to prograde as low angle clinoforms downlapping onto the deep shelf (water depths of 50 to 200 m).

Nontropical shelves subjected to boundary currents are susceptible to erosional truncation of the continental slope during lowstands, when currents flowing along the shelf margin erode and redeposit sediment onto the abyssal plain. During highstands, large volumes of sediment also may be eroded and redeposited as large, low-relief, mounded lobes along boundary currents in broad strike-parallel swaths on the deep shelf (Fig. 13C). Such erosion is rarely documented or discussed in the standard tropical carbonate models. Contour currents also may be responsible for buildup of sediment spurs on the inner to middle shelf on nontropical ramps, as expressed by the Pamlico Spur, through spalling of gyres as the current is deflected around promontories along the continental margin (Fig. 10B).

On the seismic scale, nontropical mixed carbonate/siliciclastic shelf morphology also differs greatly from tropical ramps. On nontropical ramps, parallel reflectors characterize coastal and lagoonal facies. Low-relief, (less than 10 m) low-angle shoreface clinoforms extending onto the shallow inner shelf reflect the high wave energy offshore. The wave-swept inner shelf has relatively flat-lying reflectors that terminate at the inner shelf break, which is characterized by moderate relief (50 to 100 m), low-angle clinoforms sloping at less than one degree onto the inner shelf (Fig. 13). In contrast, models for tropical, distally steepened ramp models show only minor relief from the shoal complex onto the deep shelf (Read, 1985). This break in slope at the seaward margin of the inner shelf probably corresponds with the depth of storm-wave sweeping and dips at less than two degrees, which is compatible with the angle of repose for muddy carbonate slopes (Schlager, 1992). Deep shelf marls have parallel to very low angle clinoformed units associated with sediment lobes deposited by boundary current reworking of hemipelagic sediments.

## CONCLUSIONS

1. Data from well-cuttings, wireline logs, published biostratigraphic and seismic data, supplemented by outcrops and shallow cores, were used to construct a regional sequence stratigraphic framework for the 0-500 m thick Paleogene succession of the Albemarle Basin, North Carolina. Facies recognized include: terrigenous silt and sand, clean quartz sand and skeletal quartz sand, glauconitic sands, whole mollusk packstone/grainstone, sandy fragmented mollusk grainstone/packstone, phosphatic hardgrounds and sands, bryozoan-rich packstone/grainstone, foraminiferal skeletal wackestone, and marl.
2. The Paleocene supersequence is dominated by updip glauconitic sands and downdip marls and records two major sea-level cycles. The two Lower to Middle Eocene

supersequences recognized in the wells are composed of middle to deep bryozoal skeletal carbonates. The Pamlico sediment spur beneath present-day Cape Hatteras formed during Eocene transgression, which was followed by extensive progradation of carbonate and siliciclastic shelf sediments. Upper Eocene through Oligocene quartz sand- and sandy molluscan sediments formed in response to global cooling and related sea-level fall. North Carolina Paleogene sequences correspond well with the global eustatic curve, with minor discrepancies perhaps related to superimposed higher frequency events.

3. Basin subsidence controlled thicknesses in the onshore basin and affected sedimentation near structural highs and along the axis of the Neuse Fault. Eustatic variations were the dominant control on sequence and facies development, with climate strongly influencing the type of sediment deposited.
4. Latest Cretaceous to early Paleocene units were deposited under warm temperate conditions. Subtropical conditions existed from the Upper Paleocene through Middle Eocene, with widespread deposition of bryozoal shelf carbonates. Upper Eocene cooling caused turnover to temperate conditions on the shelf through the Oligocene, and deposition of sandy molluscan shelf facies. The position of the ancestral Gulf Stream influenced sediment thicknesses on the deep shelf during highstands, and scoured the upper continental slope during lowstands.
5. Mixed carbonate/siliciclastic, open shelves or distally steepened ramps differ from tropical carbonate ramp models due to the presence of quartz sand and sandy mollusk facies inshore, broad, wave-swept hardground surfaces on the shallow inner shelf, and

widespread deposition of bryozoan-echinoderm grainstone/packstone to depths of 30 to 100 m over the inner shelf. Muddy carbonates and marls characterize deposition on the inner shelf only during highstands, while marl deposition is widespread on the deep shelf throughout most of the sequence development, with erosion and reworking of sediment bodies by the deep shelf boundary currents. Potential reservoir facies reflect these distributions, modified by diagenesis.

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# APPENDIX A: LOCATIONS OF OUTCROPS

Craven County

Martin-Marietta Clarks Quarry:  South side of SR 1005, roughly 0.75 mile east of Clarks, NC

Martin-Marietta New Bern Quarry:  1 km east of the intersection of SR 55W and Route 1402 in New Bern, NC (now flooded)

Reedy Creek Quarry:  1801 Simmons Street, New Bern, NC

Duplin County

Fussell Lime Pit:  1.1 km west of the intersection of US 117 and SR 1148, on the south side of SR 1148

Wells Marl Pit:  1.5 miles northeast of Rose Hill, on right side of SR 1911
Natural Well

Riverside Marl pit:  Roughly 1 mile east of NC 50 at Maready, NC on SR 1818, at end of drive on south side of the road

Jones County

Foy Marl pit: north of NC 58, 3 miles west of Trenton, NC (now flooded)

New Hanover County

Martin-Marietta Ideal Quarry:  3.2 km east of the intersection of US 117 and SR 1002, on the north side of SR 1002

Onslow County

Martin-Marietta Catherines Lake Quarry:  1 mile SE of US258, on south side of SR 1223, roughly 3 miles south of Richlands, NC

Martin-Marietta Belgrade Quarry:  East of the White Oak River, Just east of US 17 at Belgrade, NC

Silverdale Marl Pit:  100 m south of Silverdale, NC on east side of SR 1434

Pender County

Martin-Marietta Rocky Point Quarry:  2 km southeast of Rocky Point, NC on the east side of Interstate 40

East Coast Limestone Quarry:  4 km northwest of Maple Hill, NC on the north side of SR 53 (now flooded)

Wake County

Zebulon area: Roughly 4 miles south of Zebulon in field on SR 96

APPENDIX B: WELL LOCATIONS

OT denotes oil test, T denotes water test, C denotes core, and the final two digits denote the year drilled on NCGS code.

| County | NCGS well code | Well name | lat. | long. |
|---|---|---|---|---|
| **Beaufort** | BF-C-1-68 | TGS Test | 35.375 | -76.975 |
| | BF-C-4-68 | TGS Test | 35.358 | -76.925 |
| | BF-C-2-68 | TGS Test | 35.372 | -77.079 |
| | BF-T-1-68 | N/A | 35.375 | -77.092 |
| | BF-T-8-66 | TGS Test | 35.379 | -76.768 |
| **Carteret** | CR-OT-1-74 | Atlantic Beach #1 | 34.719 | -76.687 |
| | CR-OT-3-61 | Huntley Davis #1 | 34.731 | -76.575 |
| **Currituck** | CK-OT-1-65 | Twifford #1 | 36.303 | -75.925 |
| **Dare** | DR-OT-1-46 | Hatteras Light #1 | 35.250 | -75.529 |
| | DR-OT-1-47 | Esso #2 | 35.703 | -75.598 |
| | DR-OT-1-65 | Mobil #1 | 35.999 | -75.867 |
| | DR-OT-2-65 | Mobil #2 | 35.439 | -75.576 |
| | DR-OT-2-71 | Westvaco #1 | 35.863 | -75.851 |
| | DR-OT-3-65 | Marshall Collins #1 | 35.883 | -75.671 |
| **Hyde** | HY-OT-4-59 | Simmons #2 | 35.486 | -76.319 |
| | HY-OT-6-59 | Swindell #1 | 35.458 | -76.252 |
| | HY-OT-1-65 | Mobil #3 | 35.305 | -75.945 |
| | HY-OT-2-65 | Ballance #2 | 35.456 | -76.031 |
| **Jones** | JO-C-4-79 | N/A | 34.969 | -77.144 |
| **New Hanover** | NH-T-1-85 | Wrightsville Beach | 34.221 | -77.825 |
| **Onslow** | ON-OT-3-67 | Evans #1 | 34.692 | -77.508 |
| | ON-OT-4-66 | Justice #1 | 34.550 | -77.375 |
| | ON-C-1-94 | N/A | 34.696 | -77.465 |
| **Pender** | PE-OT-1-66 | Cowan #1 | 34.675 | -77.708 |
| | PE-OT-3-66 | Batts #2 | 34.433 | -77.564 |
| | PE-OT-5-66 | Lea #1 | 34.376 | -77.733 |

BF-T-8-66/TGS TEST

| start (Feet) | finish | **N=** | shale | siltysand | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 130 | 140 | 24 | | 2 | 1 | 1 | | | 1 | 3 | 16 | | | | | | | | | | | | | | | |
| 140 | 150 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 150 | 160 | 74 | | 0 | 30 | 27 | | 1 | 1 | 7 | 4 | 2 | 1 | | | | | | 1 | | | | | | | |
| 160 | 170 | 38 | | | 7 | 19 | | 11 | | 1 | | | | | | | | | | | | | | | | |
| 170 | 180 | 93 | | | 5 | 21 | | 7 | 1 | 1 | | | 15 | | 2 | | 22 | | 19 | | | | | | | |
| 180 | 190 | 54 | | | 2 | 1 | | 4 | 2 | | | | 16 | | 2 | | 18 | | 9 | | | | | | | |
| 190 | 200 | 46 | | | 1 | 4 | | 7 | 9 | | | | 6 | | 1 | | 12 | | 4 | | | 2 | | | | |
| 200 | 210 | 54 | | | 1 | 2 | | 1 | 14 | | | 3 | 20 | | 1 | | 7 | | 5 | | | | | | | |
| 210 | 220 | 66 | | | 2 | 3 | | 3 | 19 | | | 2 | 18 | | 2 | | 15 | | 2 | | | | | | | |
| 220 | 230 | 64 | | 2 | 5 | 20 | | 3 | 8 | | 1 | | 12 | | 1 | | 8 | | 4 | | | | | | | |
| 230 | 240 | 95 | | | 4 | 32 | | 18 | 9 | 3 | 1 | 1 | 13 | | 1 | | 10 | | 3 | | | | | | | |
| 240 | 250 | 71 | | | 11 | 29 | | 19 | 3 | | | 1 | 3 | | 4 | | 1 | | | | | | | | | |
| 250 | 260 | 77 | | | 2 | 20 | | 35 | 7 | | | | 3 | | 1 | | 9 | | | | | | | | | |
| 260 | 270 | 84 | | | 1 | 13 | | 10 | 2 | | 2 | | 33 | | | | 16 | | 7 | | | | | | | |
| 270 | 280 | 69 | | | | 7 | | 6 | 6 | 1 | | 1 | 34 | | 3 | | 7 | | 1 | | | 3 | | | | |
| 280 | 290 | 65 | | | 1 | 6 | | 6 | 3 | | | 3 | 36 | | 3 | | 6 | | 1 | | | | | | | |
| 290 | 300 | 66 | | | | 8 | | 2 | 6 | | | 10 | 29 | | 7 | | 3 | | 1 | | | | | | | |
| 300 | 310 | 63 | | | 1 | 4 | | 3 | 8 | 1 | | 9 | 21 | 4 | 10 | | 1 | | 1 | | | | | | | |
| 310 | 320 | 61 | | 0 | | 7 | 0 | 2 | 2 | 4 | | 3 | 22 | 2 | 7 | | 9 | | 2 | | | | | | 1 | |
| 320 | 330 | 87 | | | 2 | 9 | | 6 | | 1 | | 13 | 41 | | 5 | | 6 | 1 | 2 | | | | | | 1 | |
| 330 | 340 | 67 | | | | 3 | | 1 | 3 | 3 | | 5 | 26 | | 3 | | 10 | | 3 | | | | | | 10 | |
| 340 | 350 | 50 | | | | 1 | | 1 | 1 | 7 | | 1 | 30 | | 1 | | 3 | | 1 | | | | | | 4 | |
| 350 | 360 | 67 | | | 1 | 3 | | | 2 | 6 | | 5 | 31 | | 4 | | 7 | | 6 | | | | | | 2 | |
| 360 | 370 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 370 | 380 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 380 | 390 | 67 | | | 1 | | | 2 | 2 | 12 | | 23 | 22 | | 3 | | 2 | | | | | | | | | |
| 390 | 400 | 55 | | | 3 | 3 | | 1 | | 22 | | 11 | 10 | | 1 | | | | | | | | | | 4 | |
| 400 | 410 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 410 | 420 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 420 | 430 | 77 | | | 12 | 2 | | | 1 | 9 | 17 | 2 | 5 | | | | 3 | | | | 12 | | | 5 | 9 | |
| 430 | 440 | 70 | | 5 | | 1 | | 3 | | 4 | 3 | | | | | | | | 2 | | 30 | | 11 | 4 | 7 | |
| 440 | 450 | 28 | | 2 | | | | | 1 | 2 | | 1 | | | | | | | 1 | | 15 | | 3 | 3 | | |
| 450 | 460 | 74 | | | 3 | 4 | | 2 | 3 | 8 | 2 | | 5 | | | | 4 | | 2 | | 28 | | 6 | 2 | 5 | |
| 460 | 470 | 47 | | | 4 | 5 | | 3 | 6 | 7 | | | 7 | | | | | | 2 | | 1 | | 3 | 2 | 7 | |
| 470 | 480 | 65 | | | 4 | 2 | | 3 | 6 | 3 | 3 | | 6 | 1 | 1 | | 5 | | 4 | | 5 | | 5 | | 17 | |
| 480 | 490 | 41 | | | 2 | 5 | | | 4 | 3 | | 2 | 10 | | 1 | | 3 | 1 | 3 | | 1 | | 2 | | 4 | |
| 490 | 500 | ### | | | 1 | 3 | | 1 | 2 | 4 | | | 26 | 1 | 1 | | 4 | | 3 | | | | | 1 | 2 | |
| 500 | 510 | 59 | | | 1 | | | 1 | | | | | 27 | | 1 | | | | 2 | | 19 | | 2 | 2 | 4 | |

BF-T-8-66/TGS TEST

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 510 | 520 | 44 | | | 2 | | | | 2 | 6 | | 1 | 23 | | 1 | | | | | | 4 | | | | 5 | |
| 520 | 530 | 40 | | | 1 | | | 1 | 2 | 10 | | 1 | 14 | | | | | 3 | | | 3 | | 1 | 1 | 3 | |
| 530 | 540 | 55 | | | 7 | 13 | | 1 | | 10 | | | 15 | | | | 2 | | | | 1 | | | 1 | 5 | |
| 540 | 550 | 79 | | | 9 | 18 | | | 2 | 10 | | | 17 | | 1 | | 2 | | 1 | | 3 | | 6 | | 10 | |

BF-T-1-68 (NEAR CHOCOWINNITY)

| start | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 30 | 18 | | 3 | | 4 | | 3 | | 2 | | | 1 | | 1 | | 2 | | 2 | | | | | | | 0 |
| 30 | 40 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 40 | 50 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 51 | 61 | 35 | | | | | | | 1 | 1 | | 1 | 4 | 1 | 11 | | 12 | | 4 | | | | | | | |
| 61 | 69 | 37 | | | | 1 | | | 1 | | | 3 | 8 | | 9 | | 10 | 3 | 2 | | | | | | | |
| 69 | 79 | 124 | | | 4 | 33 | | 31 | 13 | 1 | | 6 | 28 | | 3 | | 5 | | | | | | | | | |
| 79 | 89 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 89 | 101 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 101 | 110 | 74 | | | 13 | 33 | | 1 | 2 | 1 | | 6 | 7 | 1 | 4 | | 4 | | 2 | | | | | | | |
| 110 | 121 | 25 | | | 2 | 9 | | 2 | | | | 4 | 2 | | | | 3 | | 2 | | | | 1 | | | |
| 121 | 131 | 45 | | | | 16 | | 2 | | 1 | | 2 | 18 | | 1 | | 3 | | 2 | | | | | | | |
| 131 | 141 | 52 | | | | 6 | | | 1 | | | 5 | 11 | | 12 | | 13 | | 4 | | | | | | | |
| 141 | 151 | 79 | | | | 1 | | | 1 | 1 | | 9 | 17 | | 16 | | 28 | | 6 | | | | | | | |
| 151 | 160 | 49 | | | | 1 | | 1 | 1 | | | 4 | 7 | | 9 | | 12 | | 14 | | | | | | | |
| 160 | 169 | 61 | | | | 3 | | | 1 | 1 | | 4 | 9 | | 4 | | 26 | | 13 | | | | | | | |
| 169 | 179 | 77 | | | 3 | 23 | | 3 | 13 | 2 | | | 10 | 0 | 8 | 0 | 10 | | 5 | | | | | | | |
| 179 | 189 | 23 | | | 2 | 2 | | 2 | 8 | 2 | | 1 | 2 | | | | 2 | | 2 | | | | | | | |
| 189 | 199 | 19 | | | 7 | 2 | | | 9 | | | | | | | | | | 1 | | | | | | | |
| 199 | 209 | 13 | | | 9 | | | | 4 | | | | | | | | | | | | | | | | | |
| 209 | 219 | 16 | | | 4 | | | | 2 | 2 | | 1 | 1 | 1 | 3 | | 2 | | | | | | | | | |
| 219 | 229 | 35 | | | | 3 | | 4 | 11 | 1 | | | 11 | 3 | 1 | | 1 | | | | | | | | | |
| 229 | 239 | 36 | | | 1 | 3 | | 1 | 2 | 4 | | | 19 | | 4 | | 2 | | | | | | | | | |
| 239 | 249 | 34 | | | | 8 | | 1 | 2 | 16 | | 1 | 1 | 1 | 2 | | | | 1 | | | | 1 | | | |
| 249 | 259 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 259 | 269 | 56 | | | 5 | 12 | | | 2 | 7 | | 3 | 9 | | 4 | | 13 | 1 | | | | | | | | |
| 269 | 279 | 50 | | | 2 | 17 | | 1 | 2 | 6 | | 6 | 7 | | 6 | | 3 | | | | | | | | | |
| 279 | 289 | 32 | | | 5 | 13 | | 2 | 1 | | | 4 | 3 | | 3 | | 1 | | | | | | | | | |
| 289 | 299 | 40 | | | 6 | 20 | | | 2 | 2 | | 3 | 1 | 1 | 4 | | 1 | | | | | | | | | |
| 299 | 309 | 22 | | | 6 | 8 | | 2 | 1 | | | | 2 | | 2 | | 1 | | | | | | | | | |
| 309 | 319 | 42 | | | 40 | | | | | | | | | | | | 2 | | | | | | | | | |
| 319 | 329 | 25 | | | 4 | 7 | | 3 | 1 | 3 | | | 2 | | 3 | | 1 | 1 | | | | | | | | |
| 329 | 339 | 10 | | | 7 | 1 | | | 1 | 1 | | | | | | | | | | | | | | | | |
| 339 | 349 | 87 | | | 1 | 19 | | 10 | 4 | 2 | | 3 | 10 | | 11 | | 22 | | 5 | | | | | | | |
| 349 | 359 | 85 | | | 4 | 23 | | 6 | | | | 6 | 12 | | 15 | | 10 | | 9 | | | | | | | |
| 359 | 369 | 68 | | | 1 | 17 | | | 1 | | | 4 | 22 | | 10 | | 11 | | 1 | | | | | 1 | | |
| 369 | 379 | 52 | | | 1 | 15 | | 3 | | 3 | | 4 | 9 | | 10 | | 5 | | 2 | | | | | | | |

BF-T-1-68 (NEAR CHOCOWINNITY)

| start | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 379 | 389 | 69 | | | 2 | 38 | | 6 | 9 | 1 | | | 7 | | 1 | | 4 | | 1 | | | | | | | |
| 389 | 399 | 66 | | | 1 | 31 | | 8 | 4 | 2 | | 2 | 4 | | 6 | | 7 | | 1 | | | | | | | |
| 399 | 409 | 93 | | | 6 | 28 | | 21 | 8 | 2 | | | 11 | | 8 | | 7 | | 2 | | | | | | | |
| 409 | 419 | 55 | | 2 | 3 | 14 | | 17 | 3 | 2 | 1 | 2 | 2 | | 6 | | 3 | | | | | | | | | |
| 419 | 429 | 42 | | 1 | 3 | 10 | | 2 | 3 | 1 | | 2 | 2 | | 8 | | 7 | | 3 | | | | | | | |
| 429 | 439 | 37 | | 6 | 4 | 9 | | 3 | 3 | 3 | | 1 | 5 | | 1 | | 1 | | 1 | | | | | | | |
| 439 | 449 | 36 | | 8 | 4 | 5 | | 3 | 2 | 2 | | | 3 | | 5 | | 1 | | 3 | | | | | | | |
| 449 | 459 | 30 | | 2 | 25 | | | | | | | 2 | | | | | | | 1 | | | | | | | |
| 459 | 469 | 13 | | 2 | 2 | 3 | | | 2 | 1 | | | | | 1 | | 2 | | | | | | | | | |
| 469 | 479 | 19 | | | 3 | 2 | | 5 | | 1 | | 1 | 2 | | 1 | | 3 | | 1 | | | | | | | |
| 479 | 489 | 37 | | 2 | 4 | 10 | | 5 | 1 | 2 | | 1 | 5 | | | | 3 | | 4 | | | | | | | |
| 489 | 499 | 15 | | | 11 | | | 2 | | 2 | | | | | | | | | | | | | | | | |
| 499 | 509 | 10 | | 2 | 5 | | | 1 | | | | | | | | | | | 2 | | | | | | | |

CR-OT-2-61/BAYLANDS #1

| start (Feet) | finish | **N=** | shale | SILTY SAND | SAN DST | SKEL .SS | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 280 | 310 | 34 | | 2 | 4 | 16 | 3 | | | 9 | | | | | | | | | | | | | | | | |
| 310 | 340 | 44 | | | 22 | 20 | 1 | | | | | | | | | | | | 1 | | | | | | | |
| 340 | 370 | 50 | | | 17 | 22 | 1 | | 2 | | | 2 | | | 1 | | 5 | | | | | | | | | |
| 370 | 400 | 34 | | 2 | 11 | 11 | 3 | 1 | | 1 | | 1 | | | 3 | | 1 | | | | | | | | | |
| 400 | 430 | 39 | | | 7 | 11 | | 1 | 11 | 3 | 1 | 1 | | | 2 | | | 2 | | | | | | | | |
| 430 | 460 | 34 | | | 1 | 5 | | 3 | 17 | 1 | | | | 1 | 2 | | 2 | 2 | | | | | | | | |
| 460 | 490 | 62 | | | 10 | 19 | 9 | 7 | 6 | 3 | | 3 | | 1 | 1 | | 3 | | | | | | | | | |
| 490 | 520 | 6 | | | | 2 | | | | | | 3 | | | 1 | | | | | | | | | | | |
| 520 | 550 | 46 | | | 4 | 18 | | 5 | | 2 | | 2 | 7 | | 3 | 1 | 4 | | | | | | | | | |
| 550 | 580 | 38 | | | 3 | 16 | 16 | | 1 | | | 2 | | | | | | | | | | | | | | |
| 580 | 610 | 13 | | | 3 | 3 | 2 | | | | | 3 | | | | | 2 | | | | | | | | | |
| 610 | 640 | 26 | | | 1 | 2 | 17 | | | | | | | | 4 | | 2 | | | | | | | | | |
| 640 | 650 | 23 | | | | | 8 | 1 | 2 | | | 4 | 1 | | 2 | | 3 | | 2 | | | | | | | |
| 650 | 660 | 10 | | | | 2 | 3 | | 1 | | | | | | | | 3 | | 1 | | | | | | | |
| 660 | 670 | 73 | | | 9 | 9 | 5 | 20 | 14 | | 1 | 1 | | | 1 | 2 | 6 | | 3 | | | 2 | | | | |
| 670 | 680 | 41 | | | 3 | 14 | | 15 | 2 | 2 | 1 | 2 | | | 1 | | 1 | | | | | | | | | |
| 680 | 690 | 69 | | | 12 | 18 | 14 | 9 | 1 | | 3 | 3 | | | | | 2 | 1 | 6 | | | | | | | |
| 690 | 700 | 7 | | | | 6 | | | | | | | | | | | | | | | | 1 | | | | |
| 700 | 710 | 32 | | | 1 | 7 | | 7 | | 1 | | 12 | | | 1 | 1 | 2 | | | | | | | | | |
| 710 | 720 | 28 | | | 1 | 17 | | 3 | | | | 5 | | | | | | 1 | 1 | | | | | | | |
| 720 | 730 | 52 | | | | 15 | | 16 | 1 | | | 14 | 3 | | | | 3 | | | | | | | | | |
| 730 | 740 | 40 | | | 1 | 7 | | 2 | 1 | | | 9 | 10 | | | 1 | 8 | 1 | | | | | | | | |
| 740 | 750 | 99 | | | 2 | 10 | | 12 | 3 | | | 5 | 4 | 1 | | 4 | 43 | 6 | 5 | | | 4 | | | | |
| 750 | 765 | 68 | | | 4 | 13 | 4 | 8 | 7 | | | 5 | 0 | | | | 19 | 6 | 2 | | | | | | | |
| 765 | 780 | 47 | | | 9 | 11 | 1 | 4 | 12 | 4 | | | | | | 1 | 4 | | 1 | | | | | | | |
| 780 | 795 | 15 | | | 4 | 5 | | | | | 1 | | | | | | 4 | | | | | 1 | | | | |
| 795 | 810 | 85 | | | 43 | 10 | 12 | | 2 | | | 5 | | 1 | 2 | 1 | 5 | | 2 | 1 | | 1 | | | | |
| 810 | 825 | 87 | | | 43 | 20 | 5 | 7 | | 1 | | 2 | | | | | 9 | | | | | | | | | |
| 825 | 840 | 112 | 4 | | 56 | 23 | 1 | 21 | 4 | | | | 1 | | | 2 | | | | | | | | | | |
| 840 | 855 | 74 | | | 44 | 7 | | 4 | | 2 | 1 | 1 | 11 | | 1 | 1 | 1 | | | | 1 | | | | | |
| 855 | 870 | 116 | | | 9 | 14 | | 6 | 2 | 5 | | 7 | 20 | | 26 | | 20 | 3 | 3 | | | | 1 | | | |
| 870 | 885 | 74 | | | 5 | 14 | | 7 | | | 2 | 1 | 17 | | 8 | 1 | 17 | 2 | | | | | | | | |
| 885 | 900 | 68 | | | 7 | 18 | | 3 | 1 | 4 | | 1 | 10 | | 7 | | 14 | | 2 | 1 | | | | | | |
| 900 | 915 | 0 | | | 8 | 23 | | 8 | | | | | 7 | | 5 | | 12 | | 1 | | | | | | | |
| 915 | 930 | 89 | | | 6 | 17 | | 10 | 11 | | | 4 | | | 11 | 3 | 20 | | 4 | | | 2 | 1 | | | |
| 930 | 945 | 69 | | | 14 | 14 | | 4 | 9 | 1 | 1 | | | | 7 | | 15 | | 1 | 3 | | | | | | |
| 945 | 960 | 105 | | | 10 | 7 | | 2 | 3 | | | 31 | 13 | | 13 | | 22 | | 3 | | | | 1 | | | |

CR-OT-2-61/BAYLANDS #1

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 960 | 975 | 23 | | 1 | 1 | 3 | | | | 3 | | 2 | | 3 | 1 | | 8 | | 1 | | | | | | | |
| 975 | 990 | 81 | | | 2 | 5 | | 5 | 3 | 1 | | 21 | 29 | | 12 | | 3 | | | | | | | | | |
| 990 | 1005 | 98 | | | 5 | 11 | | | | 1 | | 21 | 28 | | 17 | | 12 | | 1 | 2 | | | | | | |
| 1005 | 1020 | 58 | | | 6 | 30 | | 3 | | | | 3 | 7 | 1 | 4 | 2 | | 1 | 1 | | | | | | | |
| 1020 | 1035 | 65 | | | 5 | 14 | | 2 | 1 | | | 4 | 10 | 4 | 4 | | 15 | 2 | 4 | | | | | | | |
| 1035 | 1050 | 50 | | | 3 | 12 | | 10 | 2 | | | 1 | 12 | 1 | 3 | | 3 | | 3 | | | | | | | |
| 1050 | 1065 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1065 | 1080 | 96 | | | 10 | 22 | | 1 | 3 | | | 45 | 4 | | 6 | 1 | 1 | | 2 | | | | 1 | | | |
| 1080 | 1095 | 22 | | | 1 | 4 | | | | | | 9 | 2 | 1 | 1 | | 3 | 1 | | | | | | | | |
| 1095 | 1110 | 48 | | | 1 | 15 | | 2 | 3 | 2 | | 6 | 7 | | 6 | | 2 | | 3 | | | | 1 | | | |
| 1110 | 1125 | 88 | | | 8 | 16 | | 8 | 7 | | | 15 | 4 | | 6 | 1 | 15 | | 3 | | | | 5 | | | |
| 1125 | 1140 | 44 | | 11 | 2 | 10 | | 11 | 2 | | | 4 | | | 1 | | | | | | | 1 | 1 | | 1 | |
| 1140 | 1155 | 109 | | 5 | 12 | 30 | | 6 | 10 | | | 14 | 12 | | 5 | 1 | 7 | 1 | 1 | | | | 2 | | 3 | |
| 1155 | 1170 | 20 | | | 0 | 5 | | 1 | 1 | | | 3 | 7 | | | | 2 | | | | | | 1 | | | |
| 1170 | 1185 | 28 | | | 4 | 2 | | 3 | | 2 | | 3 | 1 | 1 | 1 | | 10 | | | | | | 1 | | | |
| 1185 | 1200 | 18 | | | | 5 | | 1 | | | | 5 | 1 | 1 | 1 | | | | | | | 1 | 3 | | | |
| 1200 | 1215 | 18 | | 3 | | 3 | | | | | | | 5 | | | | 5 | 2 | | | | | | | | |
| 1215 | 1230 | 56 | | 6 | 1 | 14 | | | 2 | 1 | | 10 | 11 | | | | 11 | | | | | | | | | |
| 1230 | 1245 | 21 | | | 1 | 11 | | 1 | 1 | | | 5 | | | | | 2 | | | | | | | | | |
| 1245 | 1260 | 46 | | | | 10 | | | | 1 | | 2 | 31 | | | | 2 | | | | | | | | | |
| 1260 | 1275 | 55 | | | | 12 | | | | | | 4 | 31 | | | | 8 | | | | | | | | | |
| 1275 | 1290 | 17 | | | | 7 | | 3 | | | | | 5 | | 2 | | | | | | | | | | | |
| 1290 | 1305 | 25 | | | 1 | 5 | | 1 | | | | 2 | 11 | | | 1 | 3 | | | | | 1 | | | | |
| 1305 | 1320 | 56 | | | 2 | 7 | | 5 | | | | 2 | 17 | | 7 | | 12 | | 3 | | | 1 | | | | |
| 1320 | 1335 | 78 | | | 1 | 4 | | 1 | 5 | | | 23 | 18 | 3 | 7 | 0 | 16 | | | | | | | | | |
| 1335 | 1350 | 33 | | | | 15 | | 1 | 2 | | | 3 | 8 | | 1 | | 3 | | | | | | | | | |
| 1350 | 1365 | 89 | | 6 | 13 | 18 | | 3 | 1 | | | 5 | 23 | 1 | 5 | | 10 | 3 | 1 | | | | | | | |
| 1365 | 1380 | 13 | | | | 11 | | | | | | | 1 | | | | 1 | | | | | | | | | |
| 1380 | 1395 | 25 | | 8 | | 15 | | | | | | | | | | | | 2 | | | | | | | | |
| 1395 | 1410 | 17 | | 4 | 5 | 8 | | | | | | | | | | | | | | | | | | | | |
| 1410 | 1425 | 26 | | 6 | 1 | 12 | | | | | | | | | 1 | | 5 | 1 | | | | | | | | |
| 1425 | 1440 | 15 | | 7 | | 7 | | | | | | | | | | | | | | | | | | | | |
| 1440 | 1455 | 24 | | 10 | 2 | 7 | | 1 | 1 | 1 | | | | | | | 2 | | | | | | | | | |
| 1455 | 1470 | 69 | | 10 | 5 | 10 | | | 1 | 2 | | 8 | 10 | | 4 | | 17 | | | | | | | | | |
| 1470 | 1485 | 51 | | 5 | | 8 | | | | 1 | | 1 | 18 | | 2 | 1 | 9 | 1 | | | | | 5 | | | |
| 1485 | 1500 | 37 | | 7 | 0 | 7 | | | | 1 | | 7 | 1 | | 1 | | 4 | 3 | | | | | 5 | | 1 | |
| 1500 | 1515 | 36 | | 4 | 3 | 7 | | | | 1 | | 3 | 10 | | 2 | | 4 | 1 | | | | | 1 | | | |
| 1515 | 1530 | 36 | | 5 | 0 | 20 | | | | | | 5 | | | | | | 4 | | | | | 1 | | | |

CR-OT-2-61/BAYLANDS #1

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1530 | 1545 | 72 | | 25 | 8 | 20 | | | | | | 11 | 7 | | 3 | | 4 | 1 | 1 | 1 | 8 | | 3 | | | |
| 1545 | 1560 | 71 | | 5 | 3 | 14 | | 1 | | 1 | | 16 | 14 | | 4 | | 5 | | | | 6 | | 2 | | | |
| 1560 | 1575 | 19 | | 6 | 0 | 6 | | | | 1 | | 1 | 4 | | | | | 1 | | | 7 | | | | | |
| 1575 | 1590 | 38 | | 3 | 0 | 3 | | 1 | | | | 2 | 1 | | | | | | | | | | 19 | | 9 | |
| 1590 | 1605 | 55 | | 4 | 0 | 3 | | | 1 | 2 | | 4 | | | | | 2 | 4 | | | | | 20 | | 15 | |
| 1605 | 1620 | 34 | | | | | | | | | | 3 | | | | | 2 | | | | | | 10 | | 19 | |
| 1620 | 1635 | 58 | | 1 | 1 | 1 | | | | | | 5 | | | 1 | | 1 | | | | | | 20 | | 28 | |
| 1635 | 1650 | 53 | | 3 | 1 | 3 | | 1 | | | | 1 | 3 | | | 1 | | | | | | | 10 | | 30 | |
| 1650 | 1665 | 90 | | 1 | 4 | 3 | | | 1 | 1 | | 6 | 2 | | | | 11 | 1 | | | | | 38 | | 22 | |
| 1665 | 1680 | 40 | | | | | | | | | | | | | | | | | | | | | 21 | | 19 | |
| 1680 | 1695 | 65 | | | 3 | 2 | | 2 | | | | 2 | 7 | | 1 | | 5 | | | | | | 27 | | 16 | |
| 1695 | 1710 | 32 | | | | | | | | | | | 2 | | | | | | | | | | 11 | | 19 | |
| 1710 | 1725 | 79 | | | 4 | 14 | | 1 | | 1 | | 5 | 7 | 1 | | | 7 | 1 | 1 | | | | 8 | | 29 | |
| 1725 | 1740 | 42 | | | | | | 2 | | 3 | | | 4 | 1 | | | | | 2 | | | | 11 | | 14 | 5 |
| 1740 | 1755 | 38 | | | | | | 4 | | | | 3 | 1 | | | | 4 | | | | | | 4 | | 20 | 2 |
| 1755 | 1770 | 51 | | | 1 | 2 | | 3 | | 1 | | 3 | | | | | 2 | | | | 2 | | 7 | | 24 | 6 |
| 1770 | 1785 | 26 | | | | | | | | 1 | | | | | | | | | | | 3 | | 6 | | 12 | 4 |
| 1785 | 1800 | 51 | | | 3 | 5 | | | | 3 | | 1 | | | 1 | | 5 | 1 | | | 3 | | 10 | | 18 | 1 |
| 1800 | 1815 | 29 | | | 3 | 1 | | | | 4 | | | | | 1 | | 1 | 2 | | | 2 | | 6 | | 7 | 2 |
| 1815 | 1830 | 63 | | | 1 | 6 | | 1 | 2 | 1 | | 1 | | 2 | 6 | | 1 | 1 | | | 2 | | 13 | | 23 | 3 |
| 1830 | 1845 | 48 | | | 2 | | | 1 | 1 | 2 | | 4 | 5 | | 2 | | 6 | | | | 6 | | 7 | | 9 | 3 |
| 1845 | 1860 | 19 | | 4 | | 5 | | | | 1 | | | 1 | | | | | | | | 4 | | | | 4 | |
| 1860 | 1875 | 21 | | 6 | | 5 | | 1 | | | | | | | | | | | | | 1 | | 5 | | 3 | |
| 1875 | 1890 | 25 | | 4 | | 4 | | | | 1 | | | 1 | | | | 1 | | | | 7 | | 5 | | 2 | |

CR-OT-3-61/HUNTLEY-DAVIS #1

| start (Feet) | finish | **N=** | SHALE | SILTSTONE | SANDST | SKEL.SS | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 235 | 250 | | | 2 | | 2 | 27 | | 4 | 1 | | | | | | | 15 | 14 | | | | | | | | |
| 250 | 265 | | 0 | | | 4 | 5 | 13 | 25 | | | 1 | | | | | 1 | | | | | | | | | |
| 265 | 280 | | | | 3 | 11 | 5 | 17 | 45 | | | 1 | 3 | | 3 | | | | | | | | | | | |
| 280 | 295 | | | | 5 | 33 | 6 | 27 | 21 | 2 | | 4 | | | 1 | | | | | | | | | | | |
| 295 | 310 | | | | 10 | 15 | 1 | 9 | 12 | | | 1 | | | | | | | | | | | | | | |
| 310 | 325 | | | | 7 | 16 | 9 | 6 | 17 | 3 | | 6 | | | 3 | | | | 1 | | | | | | | |
| 325 | 340 | | | | 5 | 28 | 8 | 16 | 10 | | | 3 | | | 2 | | | | | | | | | | | |
| 340 | 365 | | | | 19 | 17 | 8 | 4 | 4 | | | 6 | | | 3 | 1 | 1 | | | | | | | | | |
| 365 | 380 | | | | 10 | 24 | 10 | 7 | | 1 | | 3 | | | 1 | | | | | | | | | | | |
| 380 | 395 | | | | | 15 | 16 | 5 | 17 | | | | | | | | 13 | | 5 | | | | | | | |
| 395 | 410 | | | | 7 | 21 | 8 | 9 | 5 | | | 3 | | | | | | | | | | | | | | |
| 410 | 425 | | | | 4 | 20 | 8 | 3 | 5 | 1 | | 2 | | | 3 | | | | | | | 1 | | | | |
| 425 | 440 | | | | 2 | 18 | 11 | 2 | 3 | 3 | | 1 | | | 2 | | | 8 | 1 | | | | | | | |
| 440 | 465 | | | | 8 | 22 | 6 | 3 | 2 | 1 | | 4 | | | | | 2 | | | | | | | | | |
| 465 | 480 | | | 50 | | | 3 | | | | | | | | | | | | | | | | | | | |
| 480 | 495 | | | 38 | 1 | | 3 | | | 1 | 3 | 1 | | | | | | | | | | | | | | |
| 495 | 510 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 510 | 525 | | | 3 | 13 | 12 | 12 | | 2 | 5 | | 6 | | | 1 | | 1 | | | | | | | | | |
| 525 | 540 | | | | 5 | 12 | 11 | 2 | 26 | 1 | | | | | 1 | | 4 | 1 | 4 | | | | | | | |
| 540 | 555 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 555 | 570 | | | | 4 | 16 | 5 | 2 | 8 | 2 | | 1 | | | 1 | | 12 | | 5 | | | | | | | |
| 570 | 585 | | | | 2 | 6 | 2 | 1 | 2 | | | 11 | | | 2 | | | | 4 | | | | | | | |
| 585 | 600 | | | | 4 | 3 | 13 | 2 | | | | 18 | | | | | | | | | | | | | | |
| 600 | 615 | | | | 10 | 16 | | 3 | 1 | | | 30 | | | | | 5 | | 5 | | | | | | | |
| 615 | 630 | | | | 4 | 17 | 6 | 1 | 2 | 3 | 19 | | | | 1 | | 9 | | 3 | | | | | | | |
| 630 | 645 | | | 2 | 3 | 13 | 2 | | 10 | 1 | | 26 | | | | | 7 | | 8 | | | | | | | |
| 645 | 660 | | | 1 | 20 | 5 | | 1 | 1 | 1 | | 18 | | | | | | | 1 | | | | | | | |
| 660 | 675 | | | | 37 | 42 | 3 | 2 | 5 | 3 | | 19 | | | | | 2 | | 1 | 1 | | 1 | | | | |
| 675 | 690 | | | 1 | 21 | 20 | | | | 3 | | 1 | | | | | 3 | | 1 | | | | | | | |
| 690 | 705 | | | 1 | 2 | 18 | | | 5 | 1 | | 9 | 16 | 5 | 4 | | 5 | | 0 | | | | | | | |
| 705 | 720 | | | | 5 | 34 | | 14 | 7 | 1 | | | 13 | 3 | 1 | | 10 | | | | | | | | | |
| 720 | 740 | | | 10 | 5 | 31 | | 10 | 5 | 1 | | 3 | 2 | | 5 | | 3 | | | | | | | | | |
| 740 | 755 | | | 2 | 3 | 2 | | 4 | 14 | 7 | | | | | 5 | | 1 | 1 | | | | | | | | |
| 755 | 770 | | | | | | | | 5 | | | 4 | 25 | | 11 | | 6 | | | | | | | | | |
| 770 | 785 | | | | | 5 | | 2 | 1 | 2 | | 3 | 20 | 2 | 4 | | 14 | | | | | | | | | |
| 785 | 800 | | | | 4 | 15 | | 2 | | 1 | | 5 | | | 20 | | 10 | | 1 | | | | | | | |

CR-OT-3-61/HUNTLEY-DAVIS #1

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 800 | 815 | | | | 2 | 9 | | | | 1 | | 7 | 4 | 1 | 31 | | 12 | | 3 | | | | | | | |
| 815 | 830 | | | | | 5 | | 1 | | | 2 | 20 | 3 | | 11 | | 5 | | 2 | | | | | | | |
| 830 | 845 | | | 4 | 1 | 4 | | 2 | 1 | | | 14 | 1 | | 15 | | 4 | | | | | | | | | |
| 845 | 860 | | | | 1 | 7 | | 2 | 7 | 1 | | 30 | | | 24 | | 7 | | | | | 1 | | | | |
| 860 | 875 | | | | 3 | 14 | | 1 | | | | 4 | 3 | 3 | 11 | | 16 | | | | | 3 | | | | |
| 875 | 890 | | | | 2 | 14 | | 2 | 3 | | | 23 | 11 | | 28 | | 18 | | | | | | | | | |
| 890 | 905 | | | 18 | 4 | | | 6 | 5 | 1 | | 11 | 5 | | 5 | 1 | 18 | | | | | | | | | |
| 905 | 920 | | | 15 | | | | 1 | 2 | | | 10 | 21 | | 8 | | 13 | | 2 | | | | | | | |
| 920 | 935 | | | 4 | | | | | | | | 4 | 14 | | 5 | | 6 | | | | | | | | | |
| 935 | 950 | | | | 2 | 9 | | | | | | 17 | 15 | | 17 | | 5 | | | | | | | | | |
| 950 | 965 | | | | | 5 | | | | | | 51 | 23 | | 13 | | 2 | 6 | 1 | | | | | | | |
| 965 | 980 | | | | | 6 | | 1 | | 3 | | 27 | 25 | | 10 | | | 2 | | | | | | | | |
| 980 | 995 | | | | | | | 1 | | 2 | | 41 | 9 | | 1 | | 3 | | | | | | | | | |
| 995 | 1010 | | | | | 1 | | | | | | 19 | 23 | | 2 | | 2 | 4 | | | | | | | | |
| 1010 | 1025 | | | | | 1 | | | | | | 11 | 8 | | 3 | | | | | | | | | | | |
| 1025 | 1040 | | | | 1 | 4 | | | | | | 20 | 9 | | 2 | | | | | | | | | | | |
| 1040 | 1055 | | | | 1 | 7 | | 2 | 1 | | | 22 | 15 | | 7 | | 4 | 4 | | | | | | | | |
| 1055 | 1070 | | | | | 2 | | | | | | 25 | 25 | | | | | | | | | | | | | |
| 1070 | 1085 | | | | | 19 | | | | | | 8 | 17 | | 1 | | | 3 | 9 | | | | | | | |
| 1085 | 1100 | | | | 7 | 17 | | | 1 | | | 25 | 8 | | 3 | | 6 | 1 | | | | | | | | |
| 1100 | 1115 | | | 37 | 2 | | | | | 3 | | 4 | 12 | | 2 | | 1 | 1 | | | | 2 | | | | |
| 1115 | 1130 | | | 20 | 2 | | | | | 1 | | 18 | 16 | | 3 | | 1 | 6 | | | | | | | | |
| 1130 | 1145 | | | 25 | 1 | 0 | | | | | | 27 | 30 | | 2 | | 4 | 2 | | | | | | | | |
| 1145 | 1160 | | | 16 | 0 | 2 | | | | | | 23 | 21 | | | | | 10 | 3 | | | | | | | |
| 1160 | 1175 | | | 5 | | 7 | | | | 1 | | 20 | 27 | | 6 | | | 2 | | | | | | | | |
| 1175 | 1190 | | | | 1 | 19 | | | | | | 33 | 35 | | | | 2 | 18 | | | | | | | | |
| 1190 | 1205 | | | | 2 | 11 | | | | | | 15 | 41 | | | | 3 | 12 | | | | | | | | |
| 1205 | 1220 | | | | | 15 | | | | | | 22 | 15 | | 1 | | | 2 | | | | | | | | |
| 1220 | 1235 | | | | 3 | 18 | | | 1 | 8 | | 16 | 25 | | | | | 15 | 10 | | | | | | | |
| 1235 | 1250 | | | | 5 | 21 | | 3 | 4 | | | 3 | 30 | 24 | 2 | 0 | 1 | 2 | 3 | | | | | | | |
| 1250 | 1265 | | | 5 | | 7 | | 1 | 3 | 3 | | 7 | 20 | | 9 | | 4 | 2 | | | 2 | | | | | |
| 1265 | 1280 | | | | 6 | 12 | | 8 | 3 | 1 | | 10 | 8 | 2 | 16 | | 9 | 2 | | | | | | | | |
| 1280 | 1295 | | | | 1 | 40 | | | | | | 12 | 35 | | 1 | | 2 | 7 | | | | | | | | |
| 1295 | 1310 | | | | | 10 | | | | | | 5 | 20 | | | | 2 | | | | | | | | | |
| 1310 | 1325 | | | | | 32 | | | | 2 | | 15 | 25 | | 5 | | 2 | 10 | | | | | | | | |
| 1325 | 1340 | | | | | 28 | | | | | | 11 | 45 | | 1 | | 6 | 10 | | | | | | | | |
| 1340 | 1355 | | | | | 32 | | | | | | 5 | 48 | | 1 | | 1 | 3 | | | | | | | | |

CR-OT-3-61/HUNTLEY-DAVIS #1

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1355 | 1370 | | | | | 33 | | | | | | 3 | 25 | | | | | 9 | | | | | | | | |
| 1370 | 1385 | | | 26 | | 40 | | | | 1 | | 3 | 20 | | | | 8 | | | | | | | | | |
| 1385 | 1400 | | | | | 28 | | | | 2 | | | 20 | | | | 4 | | | | | | 16 | | 5 | |
| 1400 | 1415 | | | 17 | | 20 | | | | 1 | | 3 | 25 | | 1 | | 4 | | | | | | 9 | | | |
| 1415 | 1430 | | | | | | | | | | | | | | | | | | | | | | | | 23 | |
| 1430 | 1445 | | | | | | | | | 2 | | | | | | | | | | | 10 | | 4 | | 60 | 21 |
| 1445 | 1460 | | | | | | | | | 1 | | | | | | | | | | | 4 | | 2 | | 16 | |
| 1460 | 1475 | | | | 30 | | | | | | | | | | | | | | | | | | | | | |
| 1705 | 1720 | | | | 38 | | | | | | | | | | | | | | | | | | | | | |

CR-OT-1-74/ATLANTC BEACH#1

| start (Feet) | finish | **N=** | clayey sand | siltstone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 90 | 120 | 11 | | 8 | 0 | 1 | | | | 1 | 1 | | | | | | | | | | | | | | | |
| 120 | 150 | 66 | | 8 | 0 | 8 | 32 | | 2 | 1 | 2 | | | | 2 | | 11 | | | | | | | | | |
| 150 | 161 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 161 | 192 | 36 | | | 6 | 21 | 6 | | | | | 3 | | | | | | | | | | | | | | |
| 192 | 223 | 26 | | | 8 | 9 | 2 | | | 3 | | 1 | | | 1 | | | | 1 | | | | | 1 | | |
| 223 | 255 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 255 | 285 | 66 | | | 2 | 20 | 27 | | | 4 | | 12 | | | | | 1 | | | | | | | | | |
| 285 | 316 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 316 | 348 | 52 | | | 6 | 8 | 22 | | 1 | 2 | | 5 | | | 5 | | 2 | | 1 | | | | | | | |
| 348 | 379 | 95 | | | 5 | 18 | 12 | 8 | 13 | 2 | | 1 | 10 | | | | 18 | 3 | 4 | | | 1 | | | | |
| 379 | 411 | 53 | | | 4 | 23 | | 7 | 5 | 1 | 1 | 3 | 2 | | | | 6 | | | | | 1 | | | | |
| 411 | 442 | 42 | | | 3 | 16 | | 9 | 2 | 1 | 1 | 3 | 3 | | | | 3 | | 1 | | | | | | | |
| 442 | 475 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 475 | 507 | 83 | | | | 31 | | 3 | 4 | | | 22 | 6 | | 15 | | | 2 | | | | | | | | |
| 507 | 537 | 84 | | | | 31 | 1 | 6 | 3 | 1 | | 9 | 10 | | 23 | | | | | | | | | | | |
| 537 | 561 | 69 | | | | 28 | | 1 | 1 | | | 11 | 9 | | 18 | | 1 | | | | | | | | | |
| 561 | 598 | 61 | | | 2 | 12 | | 1 | 4 | | | 16 | 10 | | 13 | | 3 | | | | | | | | | |
| 598 | 630 | 102 | | | 3 | 44 | | 13 | 7 | 1 | | 6 | 23 | | 3 | | 2 | | | | | | | | | |
| 630 | 661 | 105 | | | 4 | 47 | | 8 | 5 | 1 | | 7 | 23 | | 1 | | 9 | | | | | | | | | |
| 661 | 692 | 66 | | | 1 | 11 | | | | | | 12 | 34 | | 7 | | 1 | | | | | | | | | |
| 692 | 724 | 96 | | | | 44 | | | | | | 12 | 21 | 1 | 16 | | 1 | | 1 | | | | | | | |
| 724 | 754 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 754 | 785 | 94 | | | 1 | 30 | | 6 | 1 | 1 | | 16 | 28 | | 8 | | 3 | | | | | | | | | |
| 785 | 816 | 47 | | | | 2 | | | | 3 | | 22 | 17 | | 3 | | | | | | | | | | | |
| 816 | 848 | 83 | | | | 5 | | | 1 | | | 27 | 43 | | 2 | | 2 | 3 | | | | | | | | |
| 848 | 879 | 86 | | | | 3 | | | | 1 | 0 | 21 | 60 | | | | | 1 | | | | | | | | |
| 879 | 910 | 86 | | | | 2 | | | | | | 8 | 76 | | | | | | | | | | | | | |
| 910 | 941 | 111 | | | | 6 | | | | | | 16 | 86 | | | | | 3 | | | | | | | | |
| 941 | 973 | 41 | | 4 | | 11 | | 3 | | 4 | | 2 | 12 | | | | 3 | 2 | | | | | | | | |
| 973 | 1004 | 73 | | | | 5 | | | | 1 | | 7 | 57 | | | | 1 | 2 | | | | | | | | |
| 1004 | 1034 | 115 | | | | 4 | | | | | | 30 | 66 | | 2 | | 2 | 11 | | | | | | | | |
| 1034 | 1065 | 119 | | | | 5 | | | | | | 20 | 89 | | | | 4 | 1 | | | | | | | | |
| 1065 | 1096 | 78 | | | | 17 | | | 0 | 23 | | 6 | 30 | | | | | 2 | | | | | | | | |
| 1096 | 1127 | 20 | | | 7 | 8 | | 3 | | 2 | | | | | | | | | | | | | | | | |
| 1127 | 1158 | 27 | | | 15 | 4 | | | 2 | 3 | | | | | 2 | | | | | | | 1 | | | | |
| 1158 | 1190 | 38 | | | 24 | 7 | | | 1 | 2 | | | | | | | 3 | | | 1 | | | | | | |

CR-OT-1-74/ATLANTC BEACH#1

| start (Feet) | finish | **N=** | clayey sand | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1190 | 1221 | 85 | 19 | | 18 | 11 | | | | 15 | | 5 | | | | | 3 | | 14 | | | | | | | |
| 1221 | 1255 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1255 | 1283 | 38 | | | 3 | 20 | | 3 | | | | 2 | | | | | 10 | | | | | | | | | |
| 1283 | 1314 | 52 | 2 | | 21 | 20 | | 3 | | 2 | | 4 | | | | | | | | | | | | | | |
| 1314 | 1346 | 52 | 26 | | 7 | 10 | | | 1 | 1 | | | | | 2 | 1 | 4 | | | | | | | | | |
| 1346 | 1376 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1376 | 1409 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1409 | 1440 | 44 | 41 | 2 | | 1 | | | | | | | | | | | | | | | | | | | | |
| 1440 | 1470 | 2 | 1 | | | | | | | | | 1 | | | | | | | | | | | | | | |
| 1470 | 1501 | 17 | 17 | | | | | | | | | | | | | | | | | | | | | | | |

CK-OT-1-65/TWIFORD #1

| start | finish | N= | shale | siltysand | dolostone | sand stone | skel. Sand | barn. Grst | sand moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. Wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc Sand | lime mud | plank sandy marl | spic pkst | plank. Silty marl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 700 | 710 | 21 | | 20 | | | | | | | 1 | | | | | | | | | | | | | | | |
| 710 | 720 | 16 | | 16 | | | | | | | | | | | | | | | | | | | | | | |
| 720 | 730 | 17 | | 17 | | | | | | | | | | | | | | | | | | | | | | |
| 730 | 740 | 19 | | 19 | | | | | | | | | | | | | | | | | | | | | | |
| 740 | 750 | 18 | | 18 | | | | | | | | | | | | | | | | | | | | | | |
| 750 | 760 | 18 | | 18 | | 0 | | | | | | | | | | | | | | | | | | | | |
| 760 | 770 | 20 | | 20 | | | | | | | | | | | | | | | | | | | | | | |
| 770 | 780 | 17 | | 17 | | | | | | | | | | | | | | | | | | | | | | |
| 780 | 790 | 18 | 3 | 14 | | | 1 | | | | | | | | | | | | | | | | | | | |
| 790 | 800 | 17 | 3 | 12 | | | 2 | | | | | | | | | | | | | | | | | | | |
| 800 | 810 | 20 | | 20 | | | | | | | | | | | | | | | | | | | | | | |
| 810 | 820 | 17 | | 17 | | | | | | | | | | | | | | | | | | | | | | |
| 820 | 830 | 77 | 4 | 29 | | 1 | 7 | | 6 | 13 | | | 5 | | | 4 | | 8 | | | | | | | | |
| 830 | 840 | 30 | | 3 | | | 5 | | 4 | 4 | | | 2 | 5 | | 2 | | 3 | | 2 | | | | | | |
| 840 | 850 | 76 | | 3 | | | 4 | | 2 | 11 | | | 7 | 20 | 1 | 16 | | 11 | | 1 | | | | | | |
| 850 | 860 | 67 | | 1 | | 1 | 19 | | 3 | 9 | | | 11 | 7 | | 4 | | 8 | | 4 | | | | | | |
| 860 | 870 | 71 | 1 | 3 | | 11 | 22 | | 3 | 3 | | | 3 | 10 | | 2 | | 9 | | 4 | | | | | | |
| 870 | 880 | 39 | | 7 | | 4 | 7 | | 3 | 2 | | | | 8 | | 2 | | 4 | | 2 | | | | | | |
| 880 | 890 | 80 | 4 | 7 | | 16 | 18 | | 3 | 4 | 3 | | 4 | 14 | | 1 | | 3 | | 3 | | | | | | |
| 890 | 900 | 69 | 2 | 12 | | 13 | 10 | | 3 | 4 | | | 2 | | | 1 | | 8 | | 14 | | | | | | |
| 900 | 910 | 67 | | 11 | | 7 | 8 | | 13 | 1 | 5 | | 5 | 7 | | | | 4 | | 6 | | | | | | |
| 910 | 920 | 33 | | 18 | | 0 | 7 | | 1 | | 1 | | 2 | | | 2 | | 1 | | | | | | | | 1 |
| 920 | 930 | 31 | | 8 | | 2 | 7 | | 4 | 1 | | | 2 | 2 | | 2 | | 1 | | 2 | | | | | | |
| 930 | 940 | 67 | | 10 | | 13 | 2 | | 4 | | | | | | | 1 | | 1 | | 3 | | | | | | |
| 940 | 950 | 75 | 6 | 21 | | 21 | 9 | | 1 | 1 | 3 | | 2 | 4 | | 3 | | 1 | | 3 | | | | | | |
| 950 | 960 | 49 | 4 | 12 | | 22 | 8 | | | | 2 | | | 1 | | | | | | | | | | | | |
| 960 | 970 | 34 | | 12 | | 12 | 6 | | | 3 | | | | 1 | | | | | | | | | | | | |
| 970 | 980 | 31 | 4 | 16 | | 8 | | | | | | | | 2 | | | | | | 1 | | | | | | |
| 980 | 990 | 78 | 7 | 22 | | 23 | 5 | | | 4 | | | 1 | 1 | | | | 1 | | 1 | | | | 13 | | |
| 990 | 1000 | 93 | 6 | 5 | | 14 | 1 | | | | | | 1 | | | | | | | | | | | 23 | | 33 |
| 1000 | 1010 | 80 | 8 | 2 | | 8 | 7 | | | | 2 | | 1 | | | 2 | | 4 | | 4 | | 3 | | 14 | | 24 |
| 1010 | 1020 | 102 | 2 | 5 | | 6 | 2 | | | | 1 | | | | | 1 | | | | | | 3 | 1 | 55 | | 21 |
| 1020 | 1030 | 80 | 8 | | | 5 | 2 | | | 2 | 6 | | | | | | | | | 2 | | 4 | | 23 | | 21 |
| 1030 | 1040 | 40 | 2 | 7 | | 4 | | | | 1 | 3 | 1 | 1 | | | | | 1 | | | | 12 | | 3 | | 5 |
| 1040 | 1050 | 34 | | 3 | | 1 | | | | 1 | 3 | | 1 | | | 1 | | 1 | | | | 19 | | 2 | | |
| 1050 | 1060 | 52 | 4 | 9 | | 2 | | | | | 6 | | | | | 1 | | | | | | 26 | | 1 | | 3 |
| 1060 | 1070 | 64 | | 5 | | 3 | | | | 28 | | | 1 | | | | | 1 | | | | 10 | | 4 | | 12 |

CK-OT-1-65/TWIFORD #1

| start | finish | N= | shale | Silt stone | dolos tone | sand stone | skel. Sand | barn. Grst | sand moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. Wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc Sand | lime mud | plank sandy marl | spic pkst | plank. Silty marl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1070 | 1080 | 65 | | 4 | | 6 | | | | | 25 | | | | 1 | | | | | | | 25 | | 2 | | 2 |
| 1080 | 1090 | 37 | | 4 | | 8 | 5 | | | 14 | | | | | | | | | | | | 5 | | 1 | | |
| 1090 | 1100 | 62 | | 3 | | 21 | 17 | | 2 | 3 | 7 | | | | | | | | | | | 5 | | 1 | | 3 |
| 1100 | 1110 | 52 | | 5 | | 12 | 11 | | 4 | 1 | 8 | | | | | 2 | | | | 1 | | 5 | | 1 | | 2 |
| 1110 | 1120 | 53 | | 3 | | 18 | 11 | | | 1 | 5 | | | | | 1 | | 1 | | 2 | | 4 | | 1 | | 6 |
| 1120 | 1130 | 41 | 1 | 3 | | 6 | 4 | | | 2 | | | | | | | | | | 2 | | 21 | | 1 | | 1 |
| 1130 | 1140 | 65 | | 6 | | 2 | | | | | 2 | | | | | | | | | | | 53 | | | | 2 |
| 1140 | 1150 | 76 | 6 | 15 | | 3 | 0 | | | | | | | | | | | | | | | 46 | | 1 | | 5 |

DR-OT-1-46/HATTERAS LIGHT #1

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1250 | 1260 | 51 | | | | 6 | 16 | 9 | 15 | | 1 | | | | | | 2 | | 2 | | | | | | | |
| 1260 | 1270 | 44 | | | | 5 | 16 | 12 | 9 | | | | | | | | | | 2 | | | | | | | |
| 1270 | 1280 | 52 | | | | 14 | 8 | 7 | 8 | | | 1 | | | | | 1 | | 13 | | | | | | | |
| 1280 | 1290 | 47 | | | | 6 | 5 | 4 | 12 | | | | | | 1 | | 5 | | 14 | | | | | | | |
| 1290 | 1300 | 45 | | | | 6 | 8 | 3 | 9 | | 1 | | 2 | | 3 | | 4 | | 9 | | | | | | | |
| 1300 | 1310 | 40 | | | 2 | 7 | 5 | 3 | 11 | | | 1 | | | 2 | | 3 | | 6 | | | | | | | |
| 1310 | 1320 | 23 | | | 1 | 3 | 5 | | 4 | | | 2 | | | 4 | | 3 | | 1 | | | | | | | |
| 1320 | 1330 | 26 | | | 4 | 3 | 2 | 2 | 3 | | | 4 | | | 2 | | 2 | | 4 | | | | | | | |
| 1330 | 1340 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1340 | 1350 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1350 | 1360 | 62 | | | 2 | 5 | 16 | 3 | 14 | 3 | | 2 | | | 1 | | 13 | | 3 | | | | | | | |
| 1360 | 1370 | 39 | | | 1 | 1 | 18 | 3 | 10 | 1 | 1 | | | | 1 | | 3 | | | | | | | | | |
| 1370 | 1380 | 40 | | | 4 | | 8 | | 7 | 1 | | | | | | | 4 | | 16 | | | | | | | |
| 1380 | 1390 | 47 | | | 1 | | 27 | 2 | 9 | 4 | | | 1 | | | | 1 | | 2 | | | | | | | |
| 1390 | 1400 | 43 | | | 1 | 13 | 13 | 1 | 11 | | | | | | 1 | | 2 | | 1 | | | | | | | |
| 1400 | 1410 | 53 | | | 3 | 3 | 27 | 10 | 3 | 1 | | | | | | | 4 | | 2 | | | | | | | |
| 1410 | 1420 | 51 | | | 2 | 11 | 23 | 7 | 3 | | | 1 | | | | | | | 4 | | | | | | | |
| 1420 | 1430 | 56 | | | 7 | 19 | 7 | 7 | 3 | 3 | 1 | | | | | | 3 | | 6 | | | | | | | |
| 1430 | 1440 | 28 | | | 2 | 10 | 4 | 3 | | 2 | | | | | | | 1 | | 6 | | | | | | | |
| 1440 | 1450 | 61 | | | 7 | 12 | 4 | 10 | 9 | 2 | | | | | 1 | | | | 14 | | | 2 | | | | |
| 1450 | 1460 | 64 | | | 8 | 19 | 7 | 15 | 5 | 4 | | | | | | | 3 | | 3 | | | | | | | |
| 1460 | 1470 | 51 | | | 8 | 12 | 7 | 9 | 5 | 2 | | | | | 1 | | 3 | | 4 | | | | | | | |
| 1470 | 1480 | 30 | | | 4 | 4 | 4 | 3 | 5 | | | 1 | | | 1 | | 5 | | 3 | | | | | | | |
| 1480 | 1490 | 48 | | | 3 | 4 | 16 | | 9 | 2 | | | | | | | 6 | | 8 | | | | | | | |
| 1490 | 1500 | 45 | | | 4 | 4 | 11 | 5 | 6 | | | | | | | | 9 | | 6 | | | | | | | |
| 1500 | 1510 | 61 | | | 1 | 6 | 21 | 12 | 15 | 3 | | | | | | | 1 | | 2 | | | | | | | |
| 1510 | 1520 | 33 | | | 1 | 7 | 6 | | 4 | | | | | | | | 4 | | 8 | | | 3 | | | | |
| 1520 | 1530 | 43 | | | 1 | 8 | 7 | 4 | 7 | | | 2 | | | | | 8 | | 5 | | | 1 | | | | |
| 1530 | 1540 | 62 | | | 1 | 12 | 15 | 5 | 6 | 4 | | | | | | | 8 | | 7 | | | 4 | | | | |
| 1540 | 1550 | 51 | | | | 18 | 4 | 3 | 7 | | | 1 | | | 1 | | 10 | | 6 | | | 1 | | | | |
| 1550 | 1560 | 44 | | | 2 | 15 | 7 | 2 | 1 | 5 | | 2 | | | | | 7 | | 3 | | | | | | | |
| 1560 | 1570 | 56 | | | 4 | 15 | 10 | 3 | 4 | 4 | | 1 | | | | | 10 | | 4 | | | 1 | | | | |
| 1570 | 1580 | 42 | | | 3 | 10 | 7 | 3 | 1 | 3 | 1 | | | | | | 10 | | 4 | | | | | | | |
| 1580 | 1590 | 39 | | | | 15 | 9 | 5 | 1 | | | | | | | | 7 | | 2 | | | | | | | |
| 1590 | 1600 | 29 | | 1 | | 1 | 7 | 2 | 2 | 6 | | 3 | | | | | 6 | | 1 | | | | | | | |
| 1600 | 1610 | 16 | | | 1 | 7 | 3 | | 1 | | | | | | | | 1 | | 3 | | | | | | | |

DR-OT-1-46/HATTERAS LIGHT #1

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1610 | 1620 | 34 | | | 4 | 11 | 5 | 4 | 3 | | 2 | | | | | | 3 | | 2 | | | | | | | |
| 1620 | 1630 | 41 | | | 1 | 9 | 3 | 6 | 8 | 5 | 3 | | | | | | 5 | | 1 | | | | | | | |
| 1630 | 1640 | 27 | | | | 3 | 4 | 4 | | | 3 | | | | | | 5 | | 3 | | | | 4 | | 1 | |
| 1640 | 1650 | 27 | | | 2 | 2 | 4 | 2 | 2 | 1 | | | | | | | 1 | | 3 | | | | 6 | | 4 | |
| 1650 | 1660 | 48 | | | | 5 | 3 | 3 | | 2 | 1 | | | | | | 5 | | 2 | | | | 11 | | 14 | 2 |
| 1660 | 1670 | 38 | | 1 | 2 | 1 | 2 | 4 | 3 | 3 | 1 | 1 | | | 2 | | 4 | | 2 | | 4 | | 1 | | 5 | 2 |
| 1670 | 1680 | 0 | | | 3 | 3 | 6 | 4 | 8 | 8 | | 2 | | | 1 | | | | | | 15 | | 4 | | 5 | 1 |
| 1680 | 1690 | 76 | | | 2 | 3 | 2 | 1 | 6 | 12 | 1 | 6 | | | | | 3 | | 1 | | 24 | | 2 | | 13 | |
| 1690 | 1700 | 57 | | 2 | 0 | 2 | 3 | 1 | 2 | 13 | | 10 | | | | | 1 | 2 | | | 12 | | 2 | | 7 | |
| 1700 | 1710 | 45 | | | | 2 | 1 | | 2 | 18 | | 8 | | | | | 2 | | | | 10 | | 2 | | | |
| 1710 | 1720 | 63 | | 14 | 2 | 0 | 1 | | 2 | 9 | 2 | 13 | | | | | | | 4 | | 9 | | 3 | | 4 | |
| 1720 | 1730 | 51 | | 3 | | 0 | 1 | | 1 | 8 | 1 | 15 | 1 | | | | 1 | | 1 | | 9 | 4 | 2 | | 4 | |
| 1730 | 1740 | 51 | 1 | 5 | | 0 | 2 | 1 | 1 | 10 | | 7 | 4 | | | | 5 | 2 | | | 13 | | | | | |
| 1740 | 1750 | 51 | | | | 1 | 4 | 3 | 3 | 6 | 1 | | 1 | | 1 | | | 2 | 4 | | 22 | | | | 3 | |
| 1750 | 1760 | 31 | | | | 3 | | 1 | | 2 | 1 | 5 | | | | | | 1 | | | 11 | | 2 | | 5 | |
| 1760 | 1770 | 37 | | | | 2 | 3 | | 5 | 10 | 1 | 3 | 1 | | 1 | | 1 | | 2 | | 7 | | | | 1 | |
| 1770 | 1780 | 29 | | | 2 | 10 | 2 | | 1 | 1 | 1 | 2 | 1 | | 1 | | 2 | | | | 5 | | 1 | | | |
| 1780 | 1790 | 53 | | | 2 | 2 | | 3 | 25 | | | 3 | | | 2 | | 10 | | 4 | | 2 | | | | | |
| 1790 | 1800 | 60 | | | | | | | 13 | | | | 22 | | 10 | | 12 | | 3 | | | | | | | |
| 1800 | 1810 | 53 | | | | 1 | | | 19 | 1 | | | 18 | | 2 | | 6 | 1 | 5 | | | | | | | |
| 1810 | 1820 | 63 | | | 1 | | | | | | | 4 | 28 | | 13 | | 11 | 2 | 3 | | | 1 | | | | |
| 1820 | 1830 | 57 | | | | | | | 3 | | | 7 | 13 | | 10 | | 19 | 1 | 4 | | | | | | | |
| 1830 | 1840 | 69 | | | | | | | 1 | | | 8 | 32 | | 8 | | 18 | | 2 | | | | | | | |
| 1840 | 1850 | 40 | | | | | | 1 | 7 | | | 5 | 15 | | 3 | | 6 | 2 | 1 | | | | | | | |
| 1850 | 1860 | 35 | | | | | | | 2 | | 1 | 2 | 16 | | 6 | | 6 | | 1 | | 1 | | | | | |
| 1860 | 1870 | 43 | | | | 3 | | 2 | 4 | | | 4 | 19 | | 5 | | 5 | | 1 | | | | | | | |
| 1870 | 1880 | 58 | | | | 15 | | 13 | 4 | | | 5 | 12 | | 5 | | 2 | | 1 | | | 1 | | | | |
| 1880 | 1890 | 75 | | | 8 | 31 | | 6 | 1 | | | 5 | 13 | | 6 | 0 | 1 | | 4 | | | | | | | |
| 1890 | 1900 | 35 | | | 1 | 13 | | 4 | 3 | 2 | | | 11 | | | | | | 1 | | | | | | | |
| 1900 | 1910 | 64 | | | 12 | 31 | | 5 | 1 | | | 2 | 9 | | 2 | | 1 | | 1 | | | | | | | |
| 1910 | 1920 | 33 | | 14 | 2 | 10 | | 2 | 1 | | | | 1 | | | | 1 | | 2 | | | | | | | |
| 1920 | 1930 | 40 | | | 8 | 25 | | | 3 | | | | 2 | | | | | | 2 | | | | | | | |
| 1930 | 1940 | 8 | | | | 8 | | | | | | | | | | | | | | | | | | | | |
| 1940 | 1950 | 39 | | | 1 | 4 | | 8 | 6 | | | 1 | 6 | | 1 | | 9 | | 3 | | | | | | | |
| 1950 | 1960 | 38 | | | 2 | 8 | | 1 | 3 | | | | 9 | | | | 7 | | 8 | | | | | | | |
| 1960 | 1970 | 38 | | 3 | | 2 | | 1 | 5 | | | 1 | 6 | | 2 | | 9 | | 9 | | | | | | | |
| 1970 | 1980 | 24 | | | 1 | 8 | | 2 | 5 | | | 1 | 2 | | | | 4 | | 1 | | | | | | | |

DR-OT-1-46/HATTERAS LIGHT #1

| start (Feet) | finish | N= | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|1980|1990|26||||6||2|3|||2|6|0|2||2||3||||||||
|1990|2000|24||||4|||3|||2|5||1||9||||||||||
|2000|2010|56|||2|6|||2|||9|12||15||8||2||||||||
|2010|2020|35||||10||3||||3|10||2||4||3||||||||
|2020|2030|45||||2||1||||4|14||3||17||4||||||||
|2030|2040|46|||1|8||2|3|||5|12||1||7||5|||2|||||
|2040|2050|65|||1|10||4|1|||3|27||3||13||3||||||||
|2050|2060|34||||5||2|2|1||6|10||1||5||2||||||||
|2060|2070|32||||3|1|||||5|15||||8||||||||||
|2070|2080|44|||1|1|1|||||3|19||4||9||6||||||||
|2080|2090|54||||2|||2|||7|20||5||16||2||||||||
|2090|2100|50||1||4|||1|||6|27||1||10||||||||||
|2100|2110|71||||7||||1||19|26||3||13||2||||||||
|2110|2120|84||||8|3|||||24|32||||15||2||||||||
|2120|2130|54||||2||1||||9|31||||8||3||||||||
|2130|2140|58||||1|||1|||7|30||1||17||1||||||||
|2140|2150|42||||7||||||3|20||4||6||2||||||||
|2150|2160|74||||8||1|3|||13|22||9||14|1|3||||||||
|2160|2170|65|||1|2||1|1|1||6|29||7||9|4|3||||||1||
|2170|2180|73||||4|||1|||16|22||8||21||1||||||||
|2180|2190|47||||7|1|3|4|1||10|15|0|1||2||3||||||||
|2190|2200|54||1||6|1||8|||10|16||3||5||4||||||||
|2200|2210|38||||3|||5|||5|12||3||8||2||||||||
|2210|2220|60||||5||2|2|||18|22||3||4||4||||||||
|2220|2230|55||||1||1|1|||7|38||2||5||||||||||
|2230|2240|41||||1||||||8|30||||2||||||||||
|2240|2250|68||||6|||1|2||14|37||1||3||2|||2|||||
|2250|2260|68||2|0|0||||||13|38||2||12|||||1|||||
|2260|2270|61||||||1||||17|36||1||5|||||1|||||
|2270|2280|57||||||||||20|25||1||9||1|||1|||||
|2280|2290|49||||||||1||24|21||3||||||||||||
|2290|2300|58||||||||||33|20||2|||2|1||||||||
|2300|2310|55||||||||||31|21||3||||||||||||
|2310|2320|62||||||||||52|7||||2||1||||||||
|2320|2330|56||||2|||2|||36|12||1||1|||||2|||||
|2330|2340|54||||3||3|2|2||21|20||1||2||||||||||
|2340|2350|32||||||2|5|1||11|9||2||2||||||||||

DR-OT-1-46/HATTERAS LIGHT #1

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2350 | 2360 | 33 | | | | 4 | | | 4 | 4 | | 10 | 6 | | 2 | | 2 | | 1 | | | | | | | |
| 2360 | 2370 | 42 | | | | 8 | | 1 | 2 | 3 | | 14 | 14 | | | | | | | | | | | | | |
| 2370 | 2380 | 47 | | | | 4 | | | 4 | | | 8 | 22 | | 2 | | 7 | | | | | | | | | |
| 2380 | 2390 | 43 | | | | 9 | | | 2 | | | 14 | 16 | | | | 2 | | | | | | | | | |
| 2390 | 2400 | 36 | | | | 10 | | 1 | 1 | 1 | | 8 | 13 | | 1 | | 1 | | | | | | | | | |
| 2400 | 2410 | 37 | | | 1 | 2 | | 1 | 4 | | | 12 | 13 | | | | 4 | | | | | | | | | |
| 2410 | 2420 | 43 | | | 2 | 7 | | 6 | 6 | 1 | | 13 | 8 | | | | | | | | | | | | | |
| 2420 | 2430 | 40 | | | 12 | | | | 2 | | | 17 | 6 | | 2 | | | | | | | 1 | | | | |
| 2430 | 2440 | 40 | | | 1 | 6 | | 1 | | 1 | | 16 | 13 | | 1 | | | | 1 | | | | | | | |
| 2440 | 2450 | 25 | | | 1 | 2 | | | | | | 13 | 5 | | | | | | | | | 1 | 3 | | | |
| 2450 | 2460 | 52 | | | 2 | 17 | | 1 | 2 | | | 11 | 11 | | | | | 2 | | | | | 6 | | | |
| 2460 | 2470 | 32 | | | 5 | 5 | | | | | | 3 | 4 | | | | | | 1 | | | | 14 | | | |
| 2470 | 2480 | 45 | | 5 | 0 | 4 | | | | | | 4 | 12 | | | | 1 | 1 | | | | | 18 | | | |
| 2480 | 2490 | 49 | | | 5 | 8 | | 1 | 1 | 2 | | 3 | 3 | | | | | | | | | | 26 | | | |
| 2490 | 2500 | 49 | | | 4 | 10 | | 2 | | | | 4 | 3 | | | | 1 | | | | | | 25 | | | |
| 2500 | 2510 | 41 | | | 4 | 7 | | 3 | | | | 5 | 4 | | | | | | | | | | 18 | | | |
| 2510 | 2520 | 52 | | 16 | 0 | 13 | | | | | | 4 | 11 | | 2 | | | | | | | 1 | 5 | | | |
| 2520 | 2530 | 50 | | 35 | 0 | 10 | | | | | | 2 | 3 | | | | | | | | | 3 | 17 | | | |
| 2530 | 2540 | 72 | | 20 | 0 | | | | | | | 3 | 1 | | | | 1 | | | | | | 47 | | | |
| 2540 | 2550 | 76 | | 19 | 0 | 15 | | | | | 1 | 1 | | | | | | | | | | | 40 | | | |
| 2550 | 2560 | 61 | | | 0 | 5 | | | | | | 1 | | | | | | | | | | | 52 | 3 | | |
| 2560 | 2570 | 40 | | | | | | 6 | 1 | | | 1 | | | | | 4 | | 1 | | | | 26 | | 1 | |
| 2570 | 2580 | 14 | | | | 3 | | 5 | | | | | | | | | 1 | | | | | | 5 | | | |
| 2580 | 2590 | 28 | | 2 | 0 | 6 | | 2 | | 1 | | 1 | | | | | 1 | | | | | | 15 | | | |
| 2590 | 2600 | 62 | | | 1 | | | | 1 | | | | 1 | | | | | | | | | | 59 | | | |
| 2600 | 2610 | 46 | | | 8 | 6 | | | | | | 1 | | | | | | | | | | | 30 | | 1 | |
| 2610 | 2620 | 40 | | | | 4 | | 1 | 1 | | | | | | | | | | | | | | 33 | | 1 | |
| 2620 | 2630 | 71 | | | | 1 | | | 3 | | | | | | 1 | | 4 | | | | | | 54 | | 8 | |
| 2630 | 2640 | 64 | | | | | | 1 | 2 | | | 3 | | | | | | | | | | | 45 | | 13 | |
| 2640 | 2650 | 62 | | | | | | | | | | 1 | | | | | | | | | | | 52 | | 9 | |
| 2650 | 2660 | 63 | | | | | | | | | | 1 | | | | | | | | | | | 55 | | 7 | |
| 2660 | 2670 | 59 | | | | | | | | | | | | | | | | | | | | | 52 | | 7 | |
| 2670 | 2680 | 71 | | | | | | 1 | | | | | | | | | | | | | 1 | | 63 | | 6 | |
| 2680 | 2690 | 46 | | | | | | | | 1 | | 1 | 1 | | | | | | | | | | 34 | | 9 | |
| 2690 | 2700 | 46 | | | | | | 1 | | | | | | | | | | | | | | | 37 | | 8 | |
| 2700 | 2710 | 45 | | | | | | 1 | | | | | | | | | | | | | | | 36 | | 8 | |
| 2710 | 2720 | 47 | | | | | | 1 | | 1 | | | | | | | | | | | | | 34 | | 11 | |

DR-OT-1-46/HATTERAS LIGHT #1

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2720 | 2730 | 68 | | | | | | | | | | 1 | | | | | | | | | | | 51 | | 16 | |
| 2730 | 2740 | 58 | | | | | | | | | | | | | | | | | | | | | 44 | | 14 | |
| 2740 | 2750 | 30 | | | | | | | | | | | | | | | | | | | | | 24 | | 6 | |
| 2750 | 2760 | 44 | | | | | | | | | | | | | | | | | | | | | 29 | | 15 | |
| 2760 | 2770 | 66 | | | | | | | | | | | | | | | | | | | | | 47 | | 19 | |
| 2770 | 2780 | 30 | | | | | | | | | | | | | | | | | | | | | 20 | | 10 | |
| 2780 | 2790 | 41 | | | | | | | | | | | | | | | | | | | | | 26 | | 15 | |
| 2790 | 2800 | 16 | | | | | | | | | | | | | | | | | | | | | 9 | | 7 | |
| 2800 | 2810 | 35 | | | | | | | | | | | | | | | | | | | | | 16 | | 19 | |
| 2810 | 2820 | 18 | | | | | | | | | | | | | | | | | | | | | 5 | | 13 | |
| 2820 | 2830 | 21 | | | | | | | | | | | | | | | | | | | | | 4 | 1 | 16 | |
| 2830 | 2840 | 51 | | | | | | | | | | | | | | | | | | | | | 10 | | 41 | |
| 2840 | 2850 | 49 | | | | | | | | | | | | | | | | | | | | | 2 | | 27 | 20 |
| 2850 | 2860 | 66 | | | | | | | | | | | | | | | | | | | | | 3 | 7 | 30 | 26 |
| 2860 | 2870 | 36 | | | | | | | | | | | | | | | | | | | | | 4 | 6 | 20 | 6 |
| 2870 | 2880 | 61 | | | | 1 | | 1 | | | | | | | | | | | | | | | 3 | | 35 | 21 |
| 2880 | 2890 | 48 | | | | | | | | | | | | | | | | | | | | | 6 | 2 | 30 | 10 |
| 2890 | 2900 | 46 | | | | | | | | | | | | | | | | | | | | | 6 | | 32 | 8 |

DR-OT-1-47/ESSO #2

| start (Feet) | finish | **N=** | shale | SILTY SAND | SAN DST | SKEL .SS | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1100 | 1110 | 7 | | 7 | | | | | | | | | | | | | | | | | | | | | | |
| 1110 | 1120 | 14 | | 14 | | | | | | | | | | | | | | | | | | | | | | |
| 1120 | 1130 | 18 | | 18 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 1130 | 1140 | 32 | | 32 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 1140 | 1150 | 13 | | 13 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 1150 | 1160 | 17 | | 17 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 1160 | 1170 | 21 | | 21 | | | | | | | | | | | | | | | | | | | | | | |
| 1170 | 1180 | 22 | | 22 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 1180 | 1190 | 12 | | 9 | 0 | 3 | | | | | | | | | | | | | | | | | | | | |
| 1190 | 1200 | 6 | | 6 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 1200 | 1210 | 13 | | 13 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 1210 | 1220 | 9 | | 8 | 0 | 1 | | | | | | | | | | | | | | | | | | | | |
| 1220 | 1230 | 9 | | 9 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 1230 | 1240 | 7 | | 7 | | | | | | | | | | | | | | | | | | | | | | |
| 1240 | 1250 | 9 | | 9 | | | | | | | | | | | | | | | | | | | | | | |
| 1250 | 1260 | 10 | 3 | 7 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 1260 | 1270 | 25 | 6 | 19 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 1270 | 1280 | 22 | 1 | 10 | 0 | | | | | | 11 | | | | | | | | | | | | | | | |
| 1280 | 1290 | 16 | 1 | 12 | 0 | | | | | | 3 | | | | | | | | | | | | | | | |
| 1290 | 1300 | 21 | | 11 | 0 | | | | | 1 | 9 | | | | | | | | | | | | | | | |
| 1300 | 1310 | 17 | | 12 | 0 | | | | | 1 | 4 | | | | | | | | | | | | | | | |
| 1310 | 1320 | 19 | | 10 | 0 | | | | | 1 | 8 | | | | | | | | | | | | | | | |
| 1320 | 1330 | 11 | | 7 | 0 | | | | | | 4 | | | | | | | | | | | | | | | |
| 1330 | 1340 | ### | 3 | 9 | 0 | | | | | 2 | 6 | | | | | | | | | | | | | | | |
| 1340 | 1350 | 10 | | 5 | 0 | | | | | 4 | | | | | | | 1 | | | | | | | | | |
| 1350 | 1360 | 14 | | 6 | 0 | | | | | 4 | 4 | | | | | | | | | | | | | | | |
| 1360 | 1370 | 52 | | 45 | 0 | | | | | 2 | 1 | | 1 | | | | | | 3 | | | | | | | |
| 1370 | 1380 | 50 | 2 | 40 | 0 | | | | | 2 | | | | | | | 1 | | | | 5 | | | | | |
| 1380 | 1390 | 33 | | 23 | 0 | | | | | | 2 | | 9 | | | | 1 | | | | | | | | | |
| 1390 | 1400 | 19 | 3 | 13 | 0 | | | | | | | | 3 | | | | | | | | | | | | | |
| 1400 | 1410 | 26 | | 25 | 0 | 1 | | | | 1 | 1 | | | | | | | | | | | | | | | |
| 1410 | 1420 | 22 | 2 | 19 | 0 | | | | | | | | | | | | | | 1 | | | | | | | |
| 1420 | 1430 | 53 | | 2 | | | | | | | | 14 | | | 31 | | 5 | | 1 | | | | | | | |
| 1430 | 1440 | 52 | 2 | 2 | 0 | | | 2 | 1 | 3 | | 20 | | | 20 | | 2 | | | | | | | | | |
| 1440 | 1450 | 47 | | 1 | 1 | 2 | | 1 | | | | 6 | | | 16 | | 15 | | 3 | | | 2 | | | | |
| 1450 | 1460 | 44 | | 1 | 2 | 2 | | | 2 | | | 4 | 7 | | 12 | | 12 | 1 | 1 | | | | | | | |
| 1460 | 1470 | 37 | | 2 | 10 | 7 | | | | | | 5 | | | 10 | | 2 | | | | | 1 | | | | |

DR-OT-1-47/ESSO #2

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1470 | 1480 | 19 | | 1 | | 6 | | 3 | | | | 2 | | | 6 | | 1 | | | | | | | | | |
| 1480 | 1490 | 26 | | 2 | 1 | | | 2 | 1 | | | 1 | | 1 | 14 | | 2 | 1 | 1 | | | | | | | |
| 1490 | 1500 | 26 | | | | 4 | | 5 | 2 | | | 2 | | 1 | 7 | | 3 | | 2 | | | | | | | |
| 1500 | 1510 | 32 | | | 1 | 2 | | | | | 1 | | | | 6 | | 5 | | 5 | | | 12 | | | | |
| 1510 | 1520 | 63 | | 3 | 0 | | | 2 | 4 | | | 3 | 21 | | 6 | | 16 | | 7 | | | 1 | | | | |
| 1520 | 1530 | 16 | | | | | | | | | | | 2 | | 3 | | 9 | | 2 | | | | | | | |
| 1530 | 1540 | 29 | | 1 | | 3 | | | 1 | | | 3 | 8 | | 2 | | 8 | | 3 | | | | | | | |
| 1540 | 1550 | 16 | | | | | | | | | | 2 | 4 | 1 | 0 | | 8 | | 1 | | | | | | | |
| 1550 | 1560 | 44 | | 5 | 0 | 6 | | 6 | | | | 5 | 2 | | 7 | | 11 | | 1 | | | 1 | | | | |
| 1560 | 1570 | 17 | | 4 | 0 | 3 | | | | | | | 1 | | 5 | | 2 | | 2 | | | | | | | |
| 1570 | 1580 | 24 | | 10 | 0 | 0 | | | 1 | | | 1 | 4 | | 7 | | 1 | | | | | | | | | |
| 1580 | 1590 | 25 | | 4 | 0 | 2 | | 1 | 1 | 1 | | 2 | 2 | | 8 | | 3 | | 1 | | | | | | | |
| 1590 | 1600 | 14 | | | | 2 | | | 2 | | | 1 | 1 | | 7 | | | | | | | | | 1 | | |
| 1600 | 1610 | 11 | | | 1 | 1 | | | 1 | | | | 3 | 1 | 3 | | | | 1 | | | | | | | |
| 1610 | 1620 | 27 | | 11 | 0 | 0 | | | | 1 | | 1 | 2 | 6 | 2 | | 1 | 2 | 1 | | | | | | | |
| 1620 | 1630 | 11 | | 2 | | | | | | | | | | | 2 | | 7 | | | | | | | | | |
| 1630 | 1640 | 30 | | 5 | 0 | 2 | | | 1 | | | 1 | | | 1 | 1 | 9 | | 10 | | | | | | | |
| 1640 | 1650 | 35 | | 3 | 0 | | | | 2 | 1 | | | | | 3 | 1 | 22 | | 3 | | | | | | | |
| 1650 | 1660 | 30 | 1 | 2 | | 1 | | | 1 | | | 1 | | | 2 | | 13 | 1 | | | 7 | 1 | | | | |
| 1660 | 1670 | 72 | | 3 | 0 | 9 | | | | | | 4 | 52 | | 3 | | 1 | | | | | | | | | |
| 1670 | 1680 | 21 | | 2 | 2 | 5 | | | 1 | | | 2 | 8 | | 1 | | | | | | | | | | | |
| 1680 | 1690 | 35 | | 2 | 1 | 7 | | | 1 | | 1 | 7 | 11 | | 3 | | | | 2 | | | | | | | |
| 1690 | 1700 | 40 | | | 1 | 13 | | | | | | 2 | 17 | | 5 | | 1 | 1 | | | | | | | | |
| 1700 | 1710 | 65 | | 7 | 3 | 0 | | | | | | 30 | 12 | | 4 | | 9 | | | | | | | | | |
| 1710 | 1720 | 28 | | | | 3 | | | | | | 8 | 9 | | 2 | 1 | 4 | | 1 | | | | | | | |
| 1720 | 1730 | 27 | | | 3 | 10 | | 1 | | | | 4 | 3 | | | | 4 | | 2 | | | | | | | |
| 1730 | 1740 | 18 | | | | 6 | | 7 | | | | 1 | | | | 1 | 2 | 1 | | | | | | | | |
| 1740 | 1750 | 34 | | | 3 | 14 | | | | | | 1 | 2 | | 3 | 3 | 7 | | 1 | | | | | | | |
| 1750 | 1760 | 34 | | | 1 | 9 | | 2 | | | | 14 | 5 | | 1 | | 1 | | 1 | | | | | | | |
| 1760 | 1770 | 34 | | 4 | 0 | 7 | | 3 | | 2 | | 11 | 3 | 1 | | | 2 | | 1 | | | | | | | |
| 1770 | 1780 | 12 | | 1 | 1 | 5 | | | | | | 3 | 1 | | 1 | | | | | | | | | | | |
| 1780 | 1790 | 47 | | 2 | 4 | 16 | | 2 | 2 | 2 | | 13 | | | 1 | 4 | | | 1 | | | | | | | |
| 1790 | 1800 | 30 | | 2 | 1 | 8 | | 5 | 1 | | | 9 | 1 | | 3 | | | | | | | | | | | |
| 1800 | 1810 | ### | | 2 | 1 | 24 | | | 2 | | | 14 | | | 1 | 2 | | | | | | | | | | |
| 1810 | 1820 | 16 | | | 1 | 11 | | | | | | 1 | 1 | | | | | | 1 | 1 | | | | | | |
| 1820 | 1830 | 44 | | 1 | 3 | 25 | | | 2 | | | 7 | | | 1 | | 4 | | 1 | | | | | | | |
| 1830 | 1840 | 24 | | | 3 | 16 | | | | | | 2 | | | 2 | 1 | | | | | | | | | | |
| 1840 | 1850 | 15 | | | | 13 | | | | 1 | | 1 | | | | | | | | | | | | | | |

DR-OT-1-47/ESSO #2

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1850 | 1860 | 31 | | 1 | 1 | 19 | | 1 | | 2 | | 2 | 2 | | 2 | | | | | | | | 1 | | | |
| 1860 | 1870 | 67 | | | 11 | 17 | | | | | | 2 | 31 | | 3 | | 3 | | | | | | | | | |
| 1870 | 1880 | 30 | | 1 | 12 | 10 | | 1 | 1 | | | 1 | | | 2 | | 1 | | 1 | | | | | | | |
| 1880 | 1890 | 21 | | | 2 | 15 | | | | | | | | | 2 | | | | 1 | | | 1 | | | | |
| 1890 | 1900 | 33 | | 1 | 0 | 28 | | | | | | 2 | | | 1 | | 1 | | | | | | | | | |
| 1900 | 1910 | 24 | | 9 | 0 | 11 | | 1 | 1 | | | | | | 2 | | | | | | | | | | | |
| 1910 | 1920 | 21 | | 7 | 0 | 11 | | | | | | 1 | | | 2 | | | | | | | | | | | |
| 1920 | 1930 | 25 | | 9 | 0 | 10 | | | | | 2 | | | | 1 | | 3 | | | | | | | | | |
| 1930 | 1940 | 12 | | 3 | 0 | 2 | | | | | | | | | | | | | | | | | 4 | | 3 | |
| 1940 | 1950 | 15 | | 3 | | 4 | | | | | | | | | | | | | | | | | 5 | | 3 | |
| 1950 | 1960 | 15 | | 2 | 1 | 1 | | | | | | 1 | | | | | 1 | | | | | | 9 | | | |
| 1960 | 1970 | 19 | | | 4 | | | 1 | | | | | 1 | | 1 | | | | | | | | 12 | | | |
| 1970 | 1980 | 19 | | 4 | 1 | 6 | | | 1 | | | 1 | 1 | | | | | | | | | | 5 | | | |
| 1980 | 1990 | 60 | | 3 | 12 | 21 | | | | | | 2 | | | | | 7 | | | | | | 14 | | 1 | |
| 1990 | 2000 | 11 | | 4 | 1 | 1 | | | | | | 2 | 1 | | 1 | | | | | | | | 1 | | | |
| 2000 | 2010 | 12 | | 5 | 1 | 0 | | 1 | | 1 | | 4 | 2 | | | | | | | | | | 1 | | | |
| 2010 | 2020 | 21 | | 2 | 5 | 3 | | 1 | | | | 3 | | | 1 | | 2 | | 1 | | | 1 | | 2 | | |
| 2020 | 2030 | 21 | | | | | | 1 | | | | | | | | | 1 | | | | | | 19 | | | |
| 2030 | 2040 | 34 | | 0 | | 3 | | 1 | | | | | | | | | 2 | | | | | | 10 | 1 | 17 | |
| 2040 | 2050 | 27 | | 3 | | 0 | | | | | | | | | | | | | | | | | 3 | | 21 | |
| 2050 | 2060 | 16 | | | | | | | | | | | | | | | | | | | | | | | 16 | |
| 2060 | 2070 | 10 | | | | | | | | | | | | | | | | | | | | | | 5 | 5 | |
| 2070 | 2080 | 30 | | | | | | | | | | | | | | | | | | | | | | | 30 | |
| 2080 | 2090 | 38 | | | | | | | | | | | | | | | | | | | | | 12 | 2 | 24 | |
| 2090 | 2100 | 20 | | | | | | | | | | | | | | | | | | | | | 12 | 2 | 6 | |
| 2100 | 2110 | 22 | | | | | | | | | | | | | | | | | | | | | 2 | 2 | 18 | |
| 2110 | 2120 | 31 | | | | | | | | | | | | | | | | | | | | | 4 | 1 | 26 | |
| 2120 | 2130 | 11 | | | | | | | | | | | | | | | | | | | | | 2 | | 9 | |
| 2130 | 2140 | 16 | | | | | | | | | | | | | | | | | | | | | | | | 16 |
| 2140 | 2150 | 11 | | | | | | | | 1 | | | | | | | | | | | | | | | 10 | |
| 2150 | 2160 | 20 | | | | | | | | | | | | | | | | | | | | | | | 10 | 10 |
| 2160 | 2170 | 7 | | | | | | | | | 1 | | | | | | | | | | | | | | 2 | 4 |
| 2170 | 2180 | 9 | | | | | | | | | | | | | | | | | | | | | | | 9 | |
| 2180 | 2190 | 9 | | | | | | | | | | | | | | | | | | | 4 | | | | 5 | |
| 2190 | 2200 | 8 | | | | | | | | | | | | | | | | | | | 2 | | | | 6 | |
| 2200 | 2210 | 10 | | | | | | | | | | | | | | | | | | | | | | | 7 | 3 |
| 2210 | 2220 | 11 | | | | | | | | | | | | | | | | | | | | | | | 11 | |
| 2220 | 2230 | 10 | | | | | | | | | | | | | | | | | | | | | | | 5 | 5 |

DR-OT-1-47/ESSO #2

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2230 | 2240 | 10 | | | | | | | | | | | | | | | | | | | 1 | | | | 5 | 4 |
| 2240 | 2250 | 46 | | | | | | | | 21 | | | | | 1 | | | | | | 7 | | 2 | | 15 | |
| 2250 | 2260 | 29 | | 1 | | | | | | 19 | | | | | | | | | | | 3 | | | | 3 | 3 |
| 2260 | 2270 | 43 | | 1 | | | | | | 10 | | | | | | | | | | | 20 | | | 0 | 1 | 11 |
| 2270 | 2280 | 12 | | | | 1 | | | | 1 | | | | | | | | | | | 6 | | | | | 4 |
| 2280 | 2290 | 15 | | | | | | | | | | | | | | | | | | | 11 | | | | 2 | 2 |
| 2290 | 2300 | 25 | | 3 | | 2 | | | | 3 | | | | | | | 1 | | | | 11 | | 1 | | 6 | |
| 2300 | 2310 | 14 | | | | 1 | | | | 2 | 7 | | | | | | | | | | 1 | | | | 2 | 1 |
| 2310 | 2320 | 23 | | | | | | | | 2 | 4 | | | | | | 1 | | | | 12 | | | | 1 | 3 |
| 2320 | 2330 | 32 | | 1 | | | | | | | 2 | | | | | | | | | | 20 | | | | | 9 |
| 2330 | 2340 | 27 | | 1 | | | | | | 2 | 1 | | | | | | 1 | | | | 16 | | | | | 6 |

DR-OT-1-65/MOBIL #1

| start (Feet) | finish | **N=** | shale | siltysand | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 680 | 690 | 13 | | 12 | 0 | 0 | | | | | | | | | | | | | | | | | | | | |
| 690 | 700 | 10 | | 10 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 700 | 710 | 11 | | 11 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 710 | 720 | 7 | | 7 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 720 | 730 | 8 | | 8 | | | | | | | | | | | | | | | | | | | | | | |
| 730 | 740 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 740 | 750 | 5 | | 5 | | | | | | | | | | | | | | | | | | | | | | |
| 750 | 760 | 6 | | 6 | | | | | | | | | | | | | | | | | | | | | | |
| 760 | 770 | 10 | | 8 | | | | | | 2 | | | | | | | | | | | | | | | | |
| 770 | 780 | 7 | | 7 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 780 | 790 | 7 | | 7 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 790 | 800 | 13 | | 12 | 0 | | | | | 1 | | | | | | | | | | | | | | | | |
| 800 | 810 | 7 | | 7 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 810 | 820 | 7 | | 7 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 820 | 830 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 830 | 840 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 840 | 850 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 850 | 860 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 860 | 870 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 870 | 880 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 880 | 890 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 890 | 900 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 900 | 910 | ### | | 3 | 0 | 3 | | | 1 | 1 | | 4 | 14 | | 11 | 1 | 32 | | 4 | 1 | | | | | | |
| 910 | 920 | 60 | | 6 | 0 | 5 | | | 4 | 4 | | 5 | 4 | | 11 | | 15 | | 5 | 1 | | | | | | |
| 920 | 930 | 51 | | 4 | 0 | 2 | | | 2 | 1 | | 4 | 9 | 1 | 9 | | 16 | | 3 | | | | | | | |
| 930 | 940 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 940 | 950 | 69 | | | | | | | 4 | 2 | | 5 | 15 | | 13 | | 21 | | 7 | | | 2 | | | | |
| 950 | 960 | 58 | | 1 | | | | | | | | 7 | 10 | | 10 | | 27 | | 3 | | | | | | | |
| 960 | 970 | 81 | | 5 | 0 | 7 | | | | 3 | | 4 | 20 | | 21 | | 19 | | 2 | | | | | | | |
| 970 | 980 | 59 | | | | 8 | | | 1 | 2 | 1 | 12 | 13 | | 14 | 1 | 6 | | 1 | | | | | | | |
| 980 | 990 | 56 | | 5 | | | | | 1 | 5 | 1 | 10 | 10 | | 15 | | 9 | | | | | | | | | |
| 990 | 1000 | 59 | | 3 | 2 | 8 | | | | | | 8 | 6 | 1 | 13 | 1 | 12 | 4 | | | | 1 | | | | |
| 1000 | 1010 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1010 | 1020 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1020 | 1030 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1030 | 1040 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1040 | 1050 | 65 | | 8 | 0 | 29 | | | 6 | 1 | | 3 | 12 | 2 | 2 | | 1 | | 1 | | | | | | | |

DR-OT-1-65/MOBIL #1

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1050 | 1060 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1060 | 1070 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1070 | 1080 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1080 | 1090 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1090 | 1100 | 9 | | | 5 | 2 | | | | | | 1 | | | | | | | 1 | | | | | | | |
| 1100 | 1110 | 115 | | 23 | 67 | 21 | | | | 1 | | | | | 3 | | | | | | | | | | | |
| 1110 | 1120 | 115 | | 4 | 9 | 4 | | | | | | | | | | | | | | | | | 50 | | 40 | 8 |
| 1120 | 1130 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1130 | 1140 | 40 | | 1 | 7 | 2 | | 1 | | | | 1 | | | | | 1 | | | | | | 11 | | 16 | |
| 1140 | 1150 | ### | | | | | | | | 4 | | 1 | 1 | | | | | | | | | | 43 | 1 | 47 | |
| 1150 | 1160 | 86 | | | | | | | | | | | | | | | | | | | | | 16 | | 61 | 9 |
| 1160 | 1170 | 114 | | | 2 | 3 | | | | 2 | | 2 | | 1 | | | | | | | | | 38 | 1 | 64 | 1 |
| 1170 | 1180 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1180 | 1190 | 10 | | | 1 | | | | | | | | | | | | | | | | | | 2 | | 7 | |
| 1190 | 1200 | 30 | | 1 | 6 | 1 | | | | 6 | | 1 | | 1 | | | | | | | | | 8 | | 6 | |
| 1200 | 1210 | 31 | | 2 | 4 | 1 | | | | | | | | | | | 2 | | | | | | 7 | | 13 | 2 |
| 1210 | 1220 | 12 | | 1 | 1 | 1 | | | 1 | | | 1 | | | | | | | | | | | 3 | | 4 | |
| 1220 | 1230 | 18 | | 1 | 2 | | | | | | | | | | | | | | | | 3 | | 4 | | 8 | |
| 1230 | 1240 | 55 | | 6 | 0 | | | | | 6 | | | | | | | | | | | 20 | | 9 | | 14 | |
| 1240 | 1250 | 58 | | 1 | 6 | 1 | | | | 10 | | | | | | | 1 | | | | 15 | | 10 | | 14 | |
| 1250 | 1260 | 17 | | | | | | | | 4 | | | | | | | | | | | 9 | | | | 4 | |
| 1260 | 1270 | 31 | | 3 | 0 | 1 | | | | 2 | | | | | 1 | | 1 | | | | 15 | | | | 8 | |
| 1270 | 1280 | 31 | | 3 | 0 | 1 | | | | 2 | | 1 | | 1 | 1 | | | | | | 10 | | 1 | | 8 | 3 |
| 1280 | 1290 | 26 | | 6 | 0 | 3 | | | | 8 | | | | | | | | | | | 3 | | | | 3 | 3 |
| 1290 | 1300 | 23 | | | 17 | | | | | 2 | | | | | | | | | | | | | | | 4 | |
| 1300 | 1310 | 44 | | | 25 | 1 | | | | 4 | | | | | | | | | | | 3 | | 3 | | 7 | 1 |
| 1310 | 1320 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1320 | 1330 | 38 | | | 28 | | | | | 2 | | | | | | | | | | | 1 | | | | 5 | 2 |
| 1330 | 1340 | 39 | | 1 | 8 | 0 | | | | | | | | | | | | | | | 7 | | 8 | | 14 | 1 |
| 1340 | 1350 | 29 | | 2 | 1 | 4 | | | | | | | | | | | | | | | | | 5 | | 12 | 7 |
| 1350 | 1360 | 20 | | 5 | 15 | | | | | | | | | | | | | | | | | | | | | |
| 1360 | 1370 | 19 | | | 10 | | | | | 3 | | | | | | | | | | | | | | | 4 | 2 |
| 1370 | 1380 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1380 | 1390 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1390 | 1400 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1400 | 1410 | 34 | | | 20 | | | | | 4 | | | | | | | | | | | 1 | | 2 | | 6 | 1 |
| 1410 | 1420 | 16 | | 2 | 9 | | | | | 2 | | | | | | | | | | | | | | | 5 | |
| 1420 | 1430 | 62 | | 5 | 2 | | | | | 6 | | | | | | | | | | | 13 | | 10 | 1 | 25 | |

DR-OT-1-65/MOBIL #1

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1430 | 1440 | 59 | | 7 | 1 | | | | | 2 | | | | | | | | | | | 18 | | 4 | | 24 | 3 |
| 1440 | 1450 | 41 | | 3 | 15 | | | | | | | | | | 1 | | | | | | 10 | | 3 | | 10 | 2 |
| 1450 | 1460 | 44 | | 4 | 12 | | | | 1 | 6 | | | | | | | | | | | 6 | | 4 | | 10 | 1 |
| 1460 | 1470 | 37 | | 2 | 5 | 0 | | | | 1 | | | | | | | | | | | 10 | | 1 | | 12 | 6 |
| 1470 | 1480 | 58 | | 3 | 1 | | | | 1 | 2 | | | | | | | | | | | 14 | | 8 | | 24 | 5 |
| 1480 | 1490 | 79 | | 6 | 2 | | | | | 4 | | | | | | | | | | | 19 | | 9 | | 33 | 6 |
| 1490 | 1500 | 48 | | 4 | 0 | 4 | | | | 1 | | 1 | | | | | | | | | 23 | | 2 | | 13 | |

DR-OT-2-65/MOBIL #2

| start (Feet) | finish | **N=** | shale | siltysand | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1200 | 1210 | 78 | 1 | 7 | 0 | 10 | 18 | 13 | 2 | 10 | 2 | 9 | | | | | 4 | | 2 | | | | | | | |
| 1210 | 1220 | 75 | 0 | 0 | 1 | 10 | 9 | | 3 | 11 | | 6 | 29 | | 2 | | | | 4 | | | | | | | |
| 1220 | 1230 | 53 | | 4 | 2 | 3 | 35 | | 1 | 5 | 1 | 1 | | | | | | | 1 | | | | | | | |
| 1230 | 1240 | 67 | | | 2 | 15 | 22 | 4 | | 7 | | 14 | | | | | | | 2 | | | 1 | | | | |
| 1240 | 1250 | 83 | 2 | 1 | 2 | 27 | 21 | 17 | 5 | | | 7 | | | | | 1 | | | | | | | | | |
| 1250 | 1260 | 78 | | | 2 | 43 | | | 3 | 1 | | 1 | 26 | | | | | | 1 | | | | 1 | | | |
| 1260 | 1270 | 77 | | | | 70 | | 1 | | 2 | | | | | | | 3 | | | | | 1 | | | | |
| 1270 | 1280 | 49 | | | | 5 | | | 6 | 5 | 1 | 16 | 8 | | 1 | | 7 | | | | | | | | | |
| 1280 | 1290 | 49 | | | | 5 | 17 | | | 9 | 2 | 14 | | | | | 2 | | | | | | | | | |
| 1290 | 1300 | 95 | | | | | 4 | | 7 | 81 | | 1 | | | | | 2 | | | | | | | | | |
| 1300 | 1310 | 79 | | | | | 1 | | | 7 | 68 | 1 | | | | | 2 | | | | | | | | | |
| 1310 | 1320 | 29 | | 2 | | 4 | | | | 3 | 15 | | | | | | 5 | | | | | | | | | |
| 1320 | 1330 | 50 | | | | 4 | | | 4 | 7 | 26 | 2 | | | 1 | | 6 | | | | | | | | | |
| 1330 | 1340 | 40 | | 3 | | | 2 | | | 4 | 29 | | | | | | 2 | | | | | | | | | |
| 1340 | 1350 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1350 | 1360 | 37 | | | | 20 | | | 3 | | 4 | | | | | | | | | | | | | | 10 | |
| 1360 | 1370 | 19 | | 11 | | 2 | 2 | | 1 | | 2 | | | | | | 1 | | | | | | | | | |
| 1370 | 1380 | 44 | | | | 3 | 4 | | | 6 | 20 | 8 | | | | | 3 | | | | | | | | | |
| 1380 | 1390 | 29 | | | | | 4 | | 4 | | 11 | 10 | | | | | | | | | | | | | | |
| 1390 | 1400 | 50 | | | | | 12 | | 3 | | | 3 | 13 | | 4 | | 11 | 2 | | | | 2 | | | | |
| 1400 | 1410 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1410 | 1420 | 51 | | 8 | 4 | 2 | 12 | | 2 | 8 | 7 | | | 1 | | | 5 | | | | | | | | 2 | |
| 1420 | 1430 | 30 | | 5 | 0 | | | | 8 | 15 | 1 | | | | | | | 1 | | | | | | | | |
| 1430 | 1440 | 23 | | 5 | 2 | 1 | 2 | | | 11 | | | | | | | | | | | | | 1 | | 4 | 1 |
| 1440 | 1450 | 45 | | 3 | 0 | | 6 | | | 2 | 11 | | | | | | | | 1 | | | | 10 | | 12 | |
| 1450 | 1460 | 47 | | | 1 | | | | 4 | 9 | 8 | | | | | | | 2 | | | 23 | | | | | |
| 1460 | 1470 | 52 | | | 1 | | 9 | | 2 | 3 | 6 | | | | | | | | | | | | 5 | | 26 | |
| 1470 | 1480 | 37 | | | 2 | | 1 | | | | | | | | 1 | | 3 | | | | | | 30 | | | |
| 1480 | 1490 | 76 | | | | | 47 | | 7 | 8 | | 1 | | | 2 | | 10 | | | | | | 1 | | | |
| 1490 | 1500 | 46 | | | | | 10 | | | 3 | | | | | | | | | | | | | 33 | | | |
| 1500 | 1510 | 21 | | | | | | | 1 | | | | | | | | | | | | | | 15 | | 5 | |
| 1510 | 1520 | 31 | | | 1 | | 5 | | | | 3 | | | | | | | | | | | | 16 | | 6 | |
| 1520 | 1530 | 10 | | | | | 4 | | | | | | | | | | | | | | | | | | 6 | |
| 1530 | 1540 | 11 | | | | | | | | | | | | | | | | | | | 3 | | 8 | | | |
| 1540 | 1550 | 24 | | | | | 3 | | | | | | | | | | | | 1 | | | | 2 | | 18 | |
| 1550 | 1560 | 20 | | | | | 2 | | 2 | | | | | | | | | | | | | | 2 | | 14 | |
| 1560 | 1570 | 87 | 27 | | | | | 3 | | | | 8 | 27 | 2 | 13 | | 6 | | 1 | | | | | | | |

DR-OT-2-65/MOBIL #2

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1570 | 1580 | 72 | | | | | 1 | | 1 | | | 13 | 17 | 1 | 22 | | 13 | 3 | 1 | | | | | | | |
| 1580 | 1590 | 63 | | 6 | | 8 | | 4 | 5 | | | 2 | 18 | | 1 | | 17 | 1 | 1 | | | | | | | |
| 1590 | 1600 | 79 | | 9 | 5 | 11 | | 5 | 4 | | | 12 | 9 | 1 | 10 | | 8 | | | | 2 | | | | 2 | |
| 1600 | 1610 | 89 | | | 8 | 14 | | 2 | 2 | | 3 | 12 | 13 | 1 | 15 | | 8 | | 1 | | | | 3 | | 7 | |
| 1610 | 1620 | 82 | | | 7 | 11 | 14 | | 5 | 9 | 4 | 6 | 10 | 0 | 7 | | 4 | 3 | 2 | | | | | | | |
| 1620 | 1630 | 26 | | | | 1 | | | 2 | 3 | 20 | | | | | | | | | | | | | | | |
| 1630 | 1640 | 58 | | | 3 | 8 | 12 | | 6 | 1 | 2 | 3 | | | 10 | | | 3 | 2 | | | | 3 | | 2 | 3 |
| 1640 | 1650 | 55 | | | | 8 | 4 | | 7 | 2 | 4 | 1 | 11 | | 4 | | 6 | 2 | 1 | 1 | | | | | | 4 |
| 1650 | 1660 | 87 | | | | 11 | | 3 | 9 | | | 14 | 28 | | 2 | | 17 | 3 | | | | | | | | |
| 1660 | 1670 | 62 | 7 | 3 | 1 | 4 | 4 | | 4 | 6 | | 8 | 11 | | 7 | | 5 | 1 | 1 | | | | | | | |
| 1670 | 1680 | 65 | 0 | 6 | 1 | | 10 | | 5 | 5 | 2 | 9 | 5 | 1 | 10 | | 7 | 3 | 1 | | | | | | | |
| 1680 | 1690 | 69 | 5 | | 3 | 2 | 2 | | 2 | 3 | 2 | 6 | 7 | 2 | 15 | | 7 | 5 | 6 | | | 2 | | | | |
| 1690 | 1700 | 48 | | | 1 | 3 | 1 | | 3 | 1 | | 4 | 8 | 4 | 10 | | 6 | 2 | 3 | | | 1 | | | 1 | |
| 1700 | 1710 | 42 | | | | 3 | | 5 | | | | 5 | 9 | 2 | 5 | | 5 | 1 | 7 | | | | | | | |
| 1710 | 1720 | 41 | | | | 3 | | | 3 | | | 6 | 10 | | 1 | | 15 | | 3 | | | | | | | |
| 1720 | 1730 | 36 | | | | 1 | | | 5 | | | 7 | 4 | 5 | 1 | | 9 | | 4 | | | | | | | |
| 1730 | 1740 | 48 | | | 1 | 2 | | | 5 | 1 | 1 | 4 | 10 | | 10 | | 10 | | 3 | | | | 1 | | | |
| 1740 | 1750 | 40 | | | | 2 | | | | | | 6 | 11 | | 2 | | 10 | | 9 | | | | | | | |
| 1750 | 1760 | 47 | | | | 3 | | | | | | 7 | 6 | 4 | 4 | | 19 | | 3 | | | | | | 1 | |
| 1760 | 1770 | 67 | | | | 3 | 5 | | 3 | 6 | 3 | 3 | 7 | 2 | 6 | | 18 | 5 | | | | 5 | | | | 1 |
| 1770 | 1780 | 45 | | | | 3 | | | 1 | 1 | | 7 | 11 | 3 | 1 | | 12 | | 6 | | | | | | | |
| 1780 | 1790 | 64 | | | | 5 | | | | | | 7 | 15 | | 2 | 1 | 27 | | 7 | | | | | | | |
| 1790 | 1800 | 53 | | | | | 2 | | 4 | | | 6 | 3 | 8 | 10 | 1 | 11 | | 2 | | | 6 | | | | |
| 1800 | 1810 | 56 | | | 1 | 11 | | | | | | 15 | 11 | 2 | 3 | | 10 | 2 | 1 | | | | | | | |
| 1810 | 1820 | 53 | | | | 3 | | 1 | | 1 | | 10 | 18 | | 2 | | 16 | | 2 | | | | | | | |
| 1820 | 1830 | 60 | | | | 13 | | | 1 | | | 10 | 15 | | 3 | | 14 | | 1 | | | 3 | | | | |
| 1830 | 1840 | 39 | | | | 18 | | | | | | 3 | 11 | | 2 | | 4 | | 1 | | | | | | | |
| 1840 | 1850 | 48 | | | | 16 | | | | | | 7 | 11 | | | | 13 | | 1 | | | | | | | |
| 1850 | 1860 | 20 | | | 1 | 11 | | | | | | 3 | | | | | 5 | | | | | | | | | |
| 1860 | 1870 | 84 | | | | 20 | | 6 | 10 | 1 | | 8 | 28 | | 3 | | 4 | 2 | 2 | | | | | | | |
| 1870 | 1880 | 25 | | 1 | 1 | 5 | | 1 | 1 | | | | 6 | | 1 | | 7 | 1 | 1 | | | | | | | |
| 1880 | 1890 | 30 | | | 1 | 2 | | | | | | 3 | 3 | | 1 | | 13 | | | | | | 1 | | 6 | |
| 1890 | 1900 | 86 | | 9 | 3 | 1 | 3 | | 8 | 30 | 23 | 1 | | | 1 | | 5 | | 2 | | | | | | | |
| 1900 | 1910 | 25 | 2 | | | 1 | | | 1 | | | 1 | 2 | | | | 17 | 1 | | | | | | | | |
| 1910 | 1920 | 31 | | | | 7 | | | 1 | | | 4 | 12 | 1 | 2 | | 4 | | | | | | | | | |
| 1920 | 1930 | 37 | | | | 14 | | | | | | 3 | 5 | 1 | 3 | | 11 | | | | | | | | | |
| 1930 | 1940 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1940 | 1950 | 75 | | | | 19 | | 1 | 7 | | | 9 | 21 | 3 | 4 | 5 | 5 | 1 | | | | | | | | |

DR-OT-2-65/MOBIL #2

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | 1960 | 64 | | | | 10 | | 3 | 9 | 1 | | 4 | 20 | 1 | 2 | | 11 | | 3 | | | | | | | |
| 1960 | 1970 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1970 | 1980 | 54 | | 2 | 0 | 7 | | | 2 | 1 | | 10 | 17 | | 1 | | 11 | 2 | 1 | | | | | | | |
| 1980 | 1990 | 49 | | | 3 | 17 | | | | | 2 | 12 | 7 | | 3 | | 5 | | | | | | | | | |
| 1990 | 2000 | 72 | | | 3 | 9 | | | 3 | | | 13 | 29 | 1 | 4 | | 5 | 5 | | | | | | | | |
| 2000 | 2010 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2010 | 2020 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2020 | 2030 | 26 | | | 4 | | | | 1 | | | 8 | 5 | 2 | 1 | | 5 | | | | | | | | | |
| 2030 | 2040 | 31 | | | 1 | 8 | | | 1 | 2 | | 7 | 5 | 1 | 1 | | 4 | | | | 1 | | | | | |
| 2040 | 2050 | 31 | | | 1 | 1 | | 1 | 2 | | | 1 | 13 | | 5 | | 6 | 1 | | | | | | | | |
| 2050 | 2060 | 54 | | | | 2 | | | | | 2 | 8 | 17 | 2 | 7 | | 11 | | 5 | | | | | | | |
| 2060 | 2070 | 73 | | | 2 | 13 | | 3 | | | | 12 | 11 | | 3 | | 16 | | 13 | | | | | | | |
| 2070 | 2080 | 48 | | | | 2 | | | | 2 | | 20 | 12 | | 1 | | 6 | | | 5 | | | | | | |
| 2080 | 2090 | 52 | | | | 10 | | | | 3 | | 26 | 7 | | 1 | | 4 | | 1 | | | | | | | |
| 2090 | 2100 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2100 | 2110 | 46 | | | 2 | 11 | 1 | 1 | 2 | 2 | | 14 | 4 | | 2 | | 6 | | 1 | | | | | | | |
| 2110 | 2120 | 59 | | | 4 | 10 | 1 | 1 | 1 | 2 | | 24 | 5 | | | 3 | 6 | | 2 | | | | | | | |
| 2120 | 2130 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2130 | 2140 | 43 | | 5 | 4 | 7 | | | 1 | | 1 | 13 | 7 | 1 | | | 4 | | | | | | | | | |
| 2140 | 2150 | 34 | | | | 4 | | | | | | 25 | 4 | | | | 1 | | | | | | | | | |
| 2150 | 2160 | 53 | | | | 7 | | | | | | 43 | | | 3 | | | | | | | | | | | |
| 2160 | 2170 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2170 | 2180 | 54 | | | 7 | 21 | | 1 | | 2 | 1 | 8 | 3 | | 3 | | 8 | | | | | | | | | |
| 2180 | 2190 | 44 | 1 | | 3 | 12 | 2 | | 2 | 3 | 2 | 4 | 6 | | | | 7 | 1 | | | | 1 | | | | |
| 2190 | 2200 | 69 | | | | 4 | | 1 | | | | 60 | | | 3 | 1 | | | | | | | | | | |
| 2200 | 2210 | 57 | | | 2 | 15 | 2 | | 1 | 2 | 1 | 6 | 8 | 3 | 6 | | 9 | | 2 | | | | | | | |
| 2210 | 2220 | 92 | | 3 | 2 | 5 | 4 | | 3 | | | 5 | 17 | 4 | 41 | | 8 | | | | | | | | | |
| 2220 | 2230 | 94 | | | 2 | 1 | 2 | | 1 | 3 | | 7 | 22 | | 45 | | 6 | 4 | | | | 1 | | | | |
| 2230 | 2240 | 94 | | 6 | | 12 | 5 | | 2 | 2 | | 13 | 16 | | 22 | | 10 | 5 | 1 | | | | | | | |
| 2240 | 2250 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2250 | 2260 | 50 | | 4 | 3 | 6 | 7 | | 3 | 1 | | 4 | 5 | | 5 | | | 2 | 9 | | | | 1 | | | |
| 2260 | 2270 | 42 | | | | 10 | 12 | | 1 | | | | | | 2 | | 4 | 1 | | 2 | | | 7 | | 3 | |
| 2270 | 2280 | 95 | | | | 5 | 3 | | 3 | 1 | 1 | 1 | | | 2 | | 2 | | 1 | | | | 62 | | 14 | |
| 2280 | 2290 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2290 | 2300 | 74 | | 13 | | 10 | 2 | | | | | | | | 3 | | 2 | | | | | | 37 | | 7 | |
| 2300 | 2310 | 72 | | 15 | 7 | 6 | 11 | | 6 | 2 | | 1 | 1 | | 2 | | 2 | | | 1 | | | 13 | | 5 | |
| 2310 | 2320 | 77 | | | | 2 | 10 | 2 | | | | 2 | | 1 | 2 | | | | 3 | | | | 40 | | 15 | |
| 2320 | 2330 | 35 | | | | | 2 | | | | | | | | | | | | 2 | 3 | | | 25 | | 3 | |

DR-OT-2-65/MOBIL #2

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2330 | 2340 | 16 | | 2 | 0 | | 2 | | | | | | | | 1 | | 1 | | | | | | 10 | | | |
| 2340 | 2350 | 42 | | 3 | 0 | 1 | 5 | | 2 | | | 1 | | | | | 1 | 2 | | | | | 23 | | 4 | |
| 2350 | 2360 | 63 | | | | | 5 | | 2 | | | | | | | | | | 1 | | | | 32 | | 23 | |
| 2360 | 2370 | 50 | | | | | 5 | | | | | | | | | | | | | | | | 4 | 6 | 29 | 6 |
| 2370 | 2380 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2380 | 2390 | 42 | | | | | 3 | | 2 | | | | | | | | | | | | | | 5 | | 21 | 11 |
| 2390 | 2400 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2400 | 2410 | 95 | | | 1 | | 11 | | 2 | | 1 | | | | | | | 1 | | | | | 5 | | 56 | 18 |
| 2410 | 2420 | 82 | | | | 1 | 6 | | 1 | | | 1 | 2 | | 3 | | 2 | | 1 | | | | 11 | | 40 | 14 |
| 2420 | 2430 | 114 | | | | | 7 | | | | | | | | | | 2 | | 1 | | | 4 | 6 | | 48 | 46 |
| 2430 | 2440 | 53 | | | | | 7 | | 3 | | | | | | | | | | 1 | | | 6 | 7 | | 18 | 11 |
| 2440 | 2450 | 83 | | | | 1 | 1 | | | | | | | | | | 1 | | | | | 2 | 10 | 6 | 50 | 12 |
| 2450 | 2460 | 29 | | | | | 2 | | | | | | | | | | | | | | | | 2 | | 8 | 17 |
| 2460 | 2470 | 28 | | | | | | | | | | | | | | | | | | | 3 | | 4 | 2 | 11 | 8 |
| 2470 | 2480 | 24 | | | | 1 | | | | 1 | | | | | | | | | | | | | | | 9 | 13 |
| 2480 | 2490 | 41 | | | | 1 | | 2 | | | | | | | | | 1 | | | | | | 3 | 2 | 30 | 2 |
| 2490 | 2500 | 29 | | | | | | | | | | | | | | | | | | | | | 4 | 1 | 24 | |
| 2500 | 2510 | 34 | | | | | | | | | | | | | | | | | | | 1 | | 2 | | 21 | 10 |
| 2510 | 2520 | 32 | | | | | | | | | | | | | | | | | | | | 1 | | | 12 | 19 |
| 2520 | 2530 | 28 | | | | | | | | | | | | | 1 | | | | | | | | | | 9 | 18 |
| 2530 | 2540 | 42 | | | | | | | | 3 | | | | | | | | | | | | | 2 | | 30 | 7 |
| 2540 | 2550 | 23 | | | | | | | | | | | | | | | | | | | | | | | 10 | 13 |
| 2550 | 2560 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2560 | 2570 | 25 | | | | | | | | | | | | | | | | | | | | | | | 23 | 2 |
| 2570 | 2580 | 31 | | | | | | | | | | | | | | | | | | | | | | | 26 | 5 |
| 2580 | 2590 | 31 | | | | | | | | | | | | | | | | | | | | | 1 | 1 | 4 | 25 |
| 2590 | 2600 | 14 | | | | | | | | | | | | | | | | | | | | | | | 2 | 12 |

DR-OT-3-65/MARSHALL-COLLINS #1

| start (Feet) | finish | **N=** | shale | siltstone | sandstone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 980 | 990 | 14 | | 14 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 990 | 1000 | 21 | 3 | 18 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 1000 | 1010 | 40 | 3 | 37 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 1010 | 1020 | 66 | 13 | 53 | | | | | | | | | | | | | | | | | | | | | | |
| 1020 | 1030 | 67 | 10 | 57 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 1030 | 1040 | 19 | 8 | 11 | | | | | | | | | | | | | | | | | | | | | | |
| 1040 | 1050 | 24 | 16 | 8 | | | | | | | | | | | | | | | | | | | | | | |
| 1050 | 1060 | 32 | 13 | 19 | | | | | | | | | | | | | | | | | | | | | | |
| 1060 | 1070 | 23 | 4 | 19 | | | | | | | | | | | | | | | | | | | | | | |
| 1070 | 1080 | 27 | 4 | 23 | | | | | | | | | | | | | | | | | | | | | | |
| 1080 | 1090 | 15 | 1 | 14 | | | | | | | | | | | | | | | | | | | | | | |
| 1090 | 1100 | 40 | 2 | 30 | | | | | | 6 | 2 | | | | | | | | | | | | | | | |
| 1100 | 1110 | 74 | 11 | 30 | 0 | | | | | 28 | 5 | | | | | | | | | | | | | | | |
| 1110 | 1120 | 63 | 26 | 22 | 0 | | | | | 10 | 5 | | | | | | | | | | | | | | | |
| 1120 | 1130 | 79 | 11 | 33 | 0 | | | | | 15 | 19 | | | 1 | | | | | | | | | | | | |
| 1130 | 1140 | 24 | 5 | 3 | 4 | | | | | 7 | 5 | | | | | | | | | | | | | | | |
| 1140 | 1150 | 13 | 1 | 4 | | | | | | 6 | 1 | | | | | | | | | | 1 | | | | | |
| 1150 | 1160 | 28 | 8 | 3 | | | | | | 2 | 3 | | | | | | | | | | 12 | | | | | |
| 1160 | 1170 | 68 | 9 | 21 | 0 | | | | 1 | 4 | 3 | | 1 | | 7 | | 5 | | 4 | | 13 | | | | | |
| 1170 | 1180 | 79 | 4 | 10 | 0 | | | | 9 | 6 | | 2 | 8 | | 35 | | 5 | | | | | | | | | |
| 1180 | 1190 | 106 | 4 | 6 | 1 | 8 | | 1 | 14 | 9 | 1 | 4 | 16 | 2 | 28 | | 10 | | 1 | | 1 | | | | | |
| 1190 | 1200 | 84 | 3 | 20 | | 21 | | | 1 | 2 | 0 | 8 | 7 | 1 | 16 | | 5 | 1 | 2 | | | 1 | | | | |
| 1200 | 1210 | 66 | 4 | 6 | 3 | | 2 | 16 | 2 | | 0 | 1 | | | 13 | | 6 | | 7 | 2 | 4 | | | | | |
| 1210 | 1220 | 92 | 4 | 6 | 5 | 12 | | 1 | 16 | 3 | 1 | 4 | | | 20 | | 12 | | 7 | | | 1 | | | | |
| 1220 | 1230 | 101 | 16 | 13 | 0 | 7 | | 0 | 13 | 1 | | 1 | 15 | 1 | 25 | | 6 | | 3 | | | | | | | |
| 1230 | 1240 | 86 | 12 | 17 | 0 | 6 | | | 3 | 1 | | 3 | 15 | | 15 | | 11 | | | | 3 | | | | | |
| 1240 | 1250 | 60 | 10 | 5 | 0 | 7 | | | 1 | 5 | 1 | | 10 | | 8 | 1 | 3 | | 7 | | 2 | | | | | |
| 1250 | 1260 | 70 | 3 | 5 | | 1 | | 3 | 14 | | 1 | 5 | 7 | | 8 | | 13 | | 10 | | | | | | | |
| 1260 | 1270 | 105 | 3 | 5 | 1 | 4 | | | 27 | | | 7 | | 6 | 15 | | 21 | 3 | 12 | | | 1 | | | | |
| 1270 | 1280 | 79 | | 8 | 0 | 9 | | 1 | 2 | | | 5 | 17 | 2 | 8 | | 20 | | 9 | | | | | | | |
| 1280 | 1290 | 61 | 2 | 1 | | | | | 5 | 3 | | | 5 | 8 | 10 | | 19 | | 8 | | | | | | | |
| 1290 | 1300 | 60 | 1 | | | 3 | | 1 | 9 | 3 | | 5 | 8 | | 7 | | 15 | | 8 | | | | | | | |
| 1300 | 1310 | 75 | 1 | 7 | | 1 | | | | | | 5 | 23 | | 7 | | 28 | | 3 | | | | | | | |
| 1310 | 1320 | 80 | 6 | 7 | | 5 | | | 2 | 2 | 1 | 26 | 20 | | 6 | | 3 | | 2 | | | | | | | |
| 1320 | 1330 | 97 | 3 | 3 | | 4 | | | 1 | 4 | | 17 | 16 | 1 | 17 | | 22 | | 9 | | | | | | | |

DR-OT-3-65/MARSHALL-COLLINS #1

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1330 | 1340 | 88 | 2 | 3 | | 4 | | | 3 | 3 | | 8 | 12 | 3 | 21 | | 19 | 1 | 8 | 1 | | | | | | |
| 1340 | 1350 | 93 | | 3 | | 1 | | | 2 | 3 | | 4 | 21 | 2 | 22 | | 25 | 1 | 9 | | | | | | | |
| 1350 | 1360 | 88 | 4 | 5 | | 7 | | | 1 | 3 | 1 | 20 | 10 | | 24 | | 11 | | 2 | | | | | | | |
| 1360 | 1370 | 64 | | 4 | | 7 | | | | 5 | | 8 | 12 | | 22 | | 5 | | 1 | | | | | | | |
| 1370 | 1380 | 64 | | 1 | | 3 | | | | 1 | | 5 | 11 | | 16 | | 14 | | 13 | | | | | | | |
| 1380 | 1390 | 79 | | 4 | 5 | 4 | | | | 1 | | 11 | 21 | 1 | 19 | | 9 | | 1 | 3 | | | | | | |
| 1390 | 1400 | 65 | 2 | 3 | | 6 | | | 2 | 4 | | 5 | 10 | | 17 | | 14 | | | | | 2 | | | | |
| 1400 | 1410 | 64 | 2 | 8 | 1 | 4 | | | 2 | 3 | | 5 | 14 | | 6 | | 16 | | 3 | | | | | | | |
| 1410 | 1420 | 67 | 4 | 4 | | 11 | | | 2 | 1 | | 4 | 16 | | 10 | | 11 | 1 | 3 | | | | | | | |
| 1420 | 1430 | 76 | 6 | 9 | | 12 | | | 4 | 1 | | 19 | 16 | 4 | 2 | | 2 | | 1 | | | | | | | |
| 1430 | 1440 | 70 | 5 | 8 | 1 | 21 | | 1 | 2 | 1 | | 21 | 3 | | 3 | | 4 | | | | | | | | | |
| 1440 | 1450 | 90 | | 2 | 12 | 43 | | 1 | | 5 | | 10 | 6 | | 5 | | 4 | | 2 | | | | | | | |
| 1450 | 1460 | 68 | | 6 | 4 | 28 | | | | 3 | | 14 | 5 | 3 | 3 | | 2 | | | | | | | | | |
| 1460 | 1470 | 79 | | 6 | 21 | 32 | | | 1 | 3 | | 3 | 7 | | | | 4 | | 2 | | | | | | | |
| 1470 | 1480 | 55 | | 9 | 6 | 22 | | | 2 | 2 | | 3 | 2 | 1 | 1 | | 6 | | 1 | | | | | | | |
| 1480 | 1490 | 93 | | 1 | 13 | 26 | | | | 4 | | 5 | 30 | | 1 | | 9 | | 1 | | 2 | | | | 1 | |
| 1490 | 1500 | 88 | | 5 | 8 | 29 | | 3 | | 4 | | 5 | 21 | 1 | 5 | | 4 | | 3 | | | | | | | |
| 1500 | 1510 | 92 | | 4 | 11 | 31 | | 1 | 4 | 3 | | 3 | 15 | | 5 | | 14 | | | | | | | | 1 | |
| 1510 | 1520 | 67 | | 6 | 3 | 24 | | 1 | 2 | 3 | | 4 | 10 | | 3 | | 8 | | 2 | | | | | | 1 | |
| 1520 | 1530 | 77 | | 6 | 2 | 13 | | 1 | 7 | 3 | | 5 | 25 | 1 | 3 | | 8 | | 3 | | | | | | | |
| 1530 | 1540 | 56 | | 7 | 2 | 11 | | | 2 | 3 | | 5 | 12 | | 3 | | 8 | | 2 | | 1 | | | | | |
| 1540 | 1550 | 76 | | 4 | 3 | 14 | | | 2 | 2 | | 5 | 14 | 2 | 7 | | 16 | | 7 | | | | | | | |
| 1550 | 1560 | 82 | 4 | 2 | 2 | 22 | | | 1 | 2 | | 13 | 22 | 2 | 2 | | 8 | | | | | | | | 2 | |
| 1560 | 1570 | 65 | 1 | 15 | 3 | 15 | | | 2 | 1 | | 5 | 10 | 2 | 4 | | 3 | | 2 | | | | | | 2 | |
| 1570 | 1580 | 57 | | 3 | 12 | 23 | | | 3 | 3 | | 3 | 3 | | 1 | | 5 | | 1 | | | | | | | |
| 1580 | 1590 | 45 | | 2 | 18 | 13 | | | | | | 2 | 1 | | 7 | | | | | | | | | | 2 | |
| 1590 | 1600 | 60 | 5 | 2 | 20 | 23 | | | | 2 | | 3 | 1 | | 3 | | | | 1 | | | | | | | |
| 1600 | 1610 | 49 | 3 | 6 | 3 | 14 | | | | 3 | | 1 | | 1 | | | 2 | | 3 | | | | 1 | | 12 | |
| 1610 | 1620 | 91 | 8 | 23 | 25 | 15 | | | 3 | 1 | | 3 | | | 2 | | | 2 | | | | | 4 | | 5 | |
| 1620 | 1630 | 32 | 1 | 2 | 0 | 1 | | | 1 | | | | | | 1 | | | | | | | | 15 | | 10 | 1 |
| 1630 | 1640 | 111 | | 6 | | 1 | | | 1 | | | | | | | | 2 | | | | | | 18 | | 76 | 7 |
| 1640 | 1650 | 85 | | | | | | | | 1 | 1 | | | | | | | | 1 | | | | 13 | | 60 | 9 |
| 1650 | 1660 | 89 | | 2 | 1 | 1 | | | 2 | 1 | 2 | 1 | | | 2 | | | | | 1 | | | 8 | 3 | 58 | 7 |
| 1660 | 1670 | 96 | | 9 | 0 | | | | | 2 | 1 | 2 | | | 3 | | | | 1 | | | | 7 | | 64 | 7 |
| 1670 | 1680 | 112 | 5 | 19 | 6 | 3 | | | 2 | 1 | | 5 | | | 3 | 2 | 5 | | | | | | 15 | | 45 | 1 |
| 1680 | 1690 | 91 | 6 | 2 | | | | | 2 | 3 | | | | | 2 | | | | | | | | 12 | | 59 | 5 |

DR-OT-3-65/MARSHALL-COLLINS #1

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1690 | 1700 | 149 | 2 | 1 | | | | | | | | | | | | | | | | | | | 20 | 5 | 48 | 73 |
| 1700 | 1710 | 112 | | | | | | | 3 | | | | | | | | | | | | | | 3 | | 7 | 99 |
| 1710 | 1720 | 42 | | | | | | | | | | | | | | | | | | | | | | | 2 | 40 |
| 1720 | 1730 | 110 | 4 | | | | | | | | | | | | | | | | | | | | | | 4 | 102 |
| 1730 | 1740 | 158 | 3 | | | | | | | 1 | | | | | | | | | | | | | 2 | | 2 | 150 |
| 1740 | 1750 | 111 | | | | | | | 1 | | 1 | | | | | | | | | | 12 | | | 17 | 18 | 62 |
| 1750 | 1760 | 132 | | 5 | | 1 | | | | | | | | | 1 | | | | | | 3 | | 2 | 20 | 55 | 45 |
| 1760 | 1770 | 154 | 15 | 1 | | | | | 1 | | | | | | 1 | | | | | | | | 1 | 7 | 94 | 34 |
| 1770 | 1780 | 156 | 12 | 2 | | | | 2 | | | | | | | | | | | | | 5 | | 1 | 9 | 94 | 31 |
| 1780 | 1790 | 105 | 14 | 3 | | | | | 1 | 2 | | | | | | | | | | | 10 | | 1 | 7 | 64 | 3 |
| 1790 | 1800 | 122 | 12 | 2 | | | | 1 | | 3 | 2 | | | | | | | | | | 24 | | 4 | 4 | 53 | 17 |
| 1800 | 1810 | 97 | 5 | | | | | | | 15 | | | | | | | | | | | 16 | | 2 | 8 | 37 | 14 |
| 1810 | 1820 | 124 | 16 | 6 | | | | | | 8 | | | | | | | | | | | 28 | | 2 | 15 | 28 | 21 |
| 1820 | 1830 | 137 | 17 | 5 | 2 | 1 | | | | 15 | | | | | | | | | | | 20 | | 1 | 8 | 33 | 35 |
| 1830 | 1840 | 104 | 24 | | 1 | | | | | 7 | | | | | | | 4 | | | | 24 | | 1 | 6 | 13 | 24 |
| 1840 | 1850 | 103 | 15 | | | 3 | | | | 3 | | | | | | | | | | | 29 | | 3 | 16 | 17 | 17 |
| 1850 | 1860 | 81 | 17 | | | 1 | | | 3 | 6 | | | | | 7 | | 3 | | 1 | | 16 | | | 0 | 12 | 15 |
| 1860 | 1870 | 49 | 6 | | | | | | | 6 | | | | | 1 | | | | | | 9 | | 13 | | 6 | 8 |

DR-OT-1-71/WESTVACO #1

| start (Feet) | finish | **N=** | shale | siltysand | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 910 | 930 | 46 | 3 | 43 | | | | | | | | | | | | | | | | | | | | | | |
| 930 | 950 | 38 | 3 | 33 | 2 | | | | | | | | | | | | | | | | | | | | | |
| 950 | 980 | 71 | 2 | 16 | 4 | | | | | 14 | 35 | | | | | | | | | | | | | | | |
| 980 | 1015 | 64 | 7 | 7 | 2 | | | | | 23 | 25 | | | | | | | | | | | | | | | |
| 1015 | 1045 | 60 | 5 | 24 | 0 | | | | | 10 | 21 | | | | | | | | | | | | | | | |
| 1045 | 1075 | 53 | 3 | 10 | 6 | | | | | 8 | 18 | | | | | | | | 4 | | | | | 4 | | |
| 1075 | 1105 | 68 | 5 | 30 | 0 | | | | | 7 | 15 | | | | | | 3 | | 5 | | | | | 3 | | |
| 1105 | 1140 | 90 | 21 | 28 | 1 | | 2 | | 2 | 5 | 3 | | | | 14 | | 11 | | 3 | | | | | | | |
| 1140 | 1170 | 104 | 3 | 6 | 6 | 20 | | 6 | 2 | 1 | 1 | 14 | 8 | | 18 | | 13 | | 6 | | | | | | | |
| 1170 | 1200 | 78 | 4 | 4 | 1 | 14 | 1 | 2 | | 1 | | 2 | 7 | | 20 | | 15 | | 7 | | | | | | | |
| 1200 | 1230 | 80 | 2 | 4 | 2 | 6 | | 1 | 2 | 1 | | 2 | 5 | 1 | 13 | | 24 | | 17 | | | | | | | |
| 1230 | 1260 | 78 | 3 | 6 | 1 | 9 | | 1 | | 1 | 1 | 2 | 9 | | 6 | | 18 | | 21 | | | | | | | |
| 1260 | 1290 | 63 | 10 | 17 | | 1 | | 1 | | 4 | | 6 | 3 | | 5 | | 3 | | 13 | | | | | | | |
| 1290 | 1320 | 81 | | 1 | 6 | 6 | | 3 | 5 | 2 | 2 | 6 | 3 | | 10 | | 19 | | 13 | | | 5 | | | | |
| 1320 | 1355 | 63 | 4 | 7 | 2 | 5 | | | 3 | 1 | 2 | 5 | 9 | | 5 | | 9 | | 7 | | 3 | 1 | | | | |
| 1355 | 1420 | 66 | 3 | 2 | 1 | 9 | | | 2 | 1 | 1 | 11 | 12 | | 3 | | 13 | | 4 | | | 4 | | | | |
| 1420 | 1450 | 45 | 2 | 1 | | 5 | | | 1 | | | 14 | 12 | | 3 | | 6 | | 1 | | | | | | | |
| 1450 | 1480 | 28 | | | | 5 | | | 3 | | | 7 | 2 | | 2 | | 7 | | 2 | | | | | | | |
| 1480 | 1510 | 48 | | 4 | 7 | 14 | | 1 | | 5 | 1 | 2 | | | 1 | | 12 | | | | 1 | | | | | |
| 1510 | 1540 | 54 | 5 | 6 | 8 | 10 | | 3 | | 2 | | 7 | 4 | | 4 | | 5 | | | | | | | | | |
| 1540 | 1570 | 42 | 3 | 10 | 2 | 12 | | | 3 | | | 6 | 1 | | | | 2 | | 3 | | | | | | | |
| 1570 | 1600 | 45 | 6 | 5 | 3 | 14 | | | 1 | 1 | | 2 | | | | | 3 | | 6 | | | | 3 | | 1 | |
| 1600 | 1630 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1630 | 1660 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1660 | 1680 | 64 | 3 | 2 | 9 | 10 | | 1 | 1 | | | 5 | 6 | | 1 | | 7 | | 5 | | | | 5 | | 9 | |
| 1680 | 1700 | 84 | | | 1 | 1 | | 1 | | | 1 | 1 | | | | | | | 2 | | | | 7 | | 28 | 42 |
| 1700 | 1730 | 73 | | | | | | | | | | | | | | | | | | | | | 5 | 2 | 26 | 40 |
| 1730 | 1760 | 90 | | | | | | | | 7 | | 1 | | | | | | | | | 23 | | 1 | 2 | 10 | 46 |
| 1760 | 1790 | 79 | | | | | | | | 4 | | | | | | | | | | | 21 | | | 7 | 19 | 28 |
| 1790 | 1820 | 73 | | | | | | | | 5 | | | | | | | | | | | 25 | | | 2 | 5 | 36 |
| 1820 | 1850 | 57 | | | | | | | | | | | | | | | | | | | 10 | | 24 | | 14 | 9 |
| 1850 | 1890 | 43 | | 4 | | | | | | 1 | | | | | | | | | | | 9 | | 17 | | 5 | 7 |
| 1890 | 1950 | 86 | | | | | | | | | | | | | | | | | | | | | 3 | 15 | 13 | 55 |
| 1950 | 1980 | 52 | | 2 | | | | | | 4 | | | | | | | | | | | 21 | | 14 | | | 11 |
| | | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2330 | 2360 | 49 | | | 4 | 7 | | 3 | 10 | | | | 12 | | 2 | | 6 | | | | 3 | | | | 2 | |

HAYNESVILLE CORE (VA)

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 180 | 195 | | | | | 1 | | | | | | | | | | | | | | | | | | | | |
| 195 | 200 | | | | | | | 1 | | | | | | | | | | | | | | | | | | |
| 200 | 204 | | | | | | | | | | | | 1 | | | | | | | | | | | | | |
| 204 | 239 | | | | | | | | | | | | 1 | | | | | | | | | | | | | |
| 239 | 260 | | | | | | | | | 1 | | | | | | | | | | | 6 | | | | | |
| 260 | 272 | | | | | 7 | | | | | | | | | | | | | | | 1 | | | | | |
| 272 | 282 | | | 4 | | | | | | | | | | | | | | | | | 1 | | | | | |
| 282 | 287 | | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| 287 | 289 | | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| 288.5 | 301 | | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| 300.5 | 310 | | | | | | | | | 1 | | | | | | | | | | | 7 | | | | | |
| 310 | 320 | | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| 320 | 324 | | | 2 | | | | | | | | | | | | | | | | | 2 | | | | | |
| 324 | 332 | | | 2 | | | | | | | | | | | | | | | | | 1 | | | | | |
| 332 | 340 | | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| 340 | 352 | | | | | | | | | 1 | | | | | | | | | | | 6 | | | | | |
| 352 | 374 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 374 | 384 | | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| 383.5 | 407 | | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| 407 | 417 | | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| 417 | 423 | | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| 423 | 427 | | | | | | | | | 1 | | | | | | | | 1 | | | | | | | | |
| 427 | 437 | | | | | | | | | | | | | | | | | 1 | | | | | | | | |
| 437 | 449 | | | | | | | | | | | | | | | | | | | | 1 | | | | | |
| 449 | 450 | | | | | | | | | | | | | | | | | | | | 1 | | | | | |

HY-OT-4-59/SIMMONS #2

| start | finish | N= | shale | siltstone | dolostone | sandstone | skel. Sand | barn. Grst | sand moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. Wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc Sand | lime mud | plank sandy marl | spic pkst | plank. Silty marl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 300 | 330 | 23 | | 3 | | 7 | 13 | | | | | | | | | | | | | | | | | | | |
| 330 | 360 | 24 | | 10 | | 0 | 7 | | | 2 | | 3 | | | | | | 2 | | | | | | | | |
| 360 | 390 | 33 | | 12 | | 4 | 11 | | 4 | | | | 2 | | | | | 1 | | 1 | | | | | | |
| 390 | 420 | 29 | | 25 | | 0 | | | | | | 4 | | | | | | | | | | | | | | |
| 420 | 450 | 26 | | 5 | 7 | | 4 | | | | | 10 | | | | | | | | | | | | | | |
| 450 | 480 | 54 | | 1 | 23 | 1 | 3 | | | | 11 | 15 | | | | | | | | | | | | | | |
| 480 | 510 | 34 | | 1 | | 1 | 11 | | 6 | 3 | 1 | 1 | | | | 1 | | 4 | | 5 | | | | | | |
| 510 | 540 | 36 | | | | | 2 | | | 4 | | | | | | 5 | | 17 | | 8 | | | | | | |
| 540 | 570 | 75 | | | | 1 | | | 3 | 13 | 2 | 2 | 3 | 3 | | 3 | | 20 | | 25 | | | | | | |
| 570 | 600 | 92 | | | | | 9 | | | 12 | | 1 | 2 | 12 | | 16 | | 19 | 2 | 19 | | | | | | |
| 600 | 630 | 72 | | | | | 16 | | 8 | 7 | 2 | | 2 | 9 | | 19 | | 8 | | 1 | | | | | | |
| 630 | 660 | 51 | | | | | 21 | | | 5 | | | 1 | 2 | | 11 | | 9 | | 2 | | | | | | |
| 660 | 690 | 80 | | | | 11 | 16 | | 6 | 3 | | | 2 | 5 | | 19 | | 13 | 1 | 4 | | | | | | |
| 690 | 720 | 69 | | 3 | | 0 | 8 | | 1 | 1 | 1 | | 4 | 15 | | 14 | | 16 | 1 | 5 | | | | | | |
| 720 | 750 | 96 | | | | 1 | 9 | | 2 | 1 | 2 | | 8 | 9 | | 17 | | 40 | | 7 | | | | | | |
| 750 | 780 | 77 | | 1 | | 1 | 7 | | 3 | 2 | 1 | | 27 | 9 | | 8 | | 4 | | 14 | | | | | | |
| 780 | 810 | 65 | | | | 4 | 10 | | 9 | 2 | 2 | 2 | 4 | 7 | | 10 | | 3 | 2 | 10 | | | | | | |
| 810 | 840 | 63 | | | | 2 | 16 | | 5 | 2 | 1 | | 9 | 4 | | 14 | | 8 | | 2 | | | | | | |
| 840 | 870 | 65 | | 3 | | | 9 | | 6 | 2 | | | 4 | 6 | | 4 | | 5 | | 2 | | | | 8 | | 16 |
| 870 | 900 | 83 | 1 | | | 1 | 7 | | 1 | 2 | 3 | | 7 | 2 | | 7 | | 2 | | | | | | 9 | | 41 |
| 900 | 930 | 29 | | 6 | | | 0 | | | | | | | | | | | 1 | | | | | | 9 | | 13 |
| 930 | 960 | 34 | | | | 1 | | | 1 | 1 | | | 2 | | | 1 | | | | | | 1 | | 7 | | 13 |
| 960 | 990 | 37 | | | | 1 | 7 | | 2 | 2 | | | | | | 2 | | 3 | | 3 | | 5 | | 2 | | 8 |
| 990 | 1020 | 47 | | | | 4 | 7 | | 2 | 1 | 1 | | 1 | 4 | | 8 | | 3 | | 2 | | 8 | 1 | 3 | | 2 |
| 1020 | 1050 | 40 | | 10 | | 1 | 1 | | 2 | | 7 | | 1 | | | 3 | | 2 | | 3 | | 4 | | 2 | | 3 |
| 1050 | 1080 | 48 | | | | 8 | 10 | | 7 | 3 | 1 | | 4 | | | 1 | | 7 | | 2 | | 2 | | | | 3 |
| 1080 | 1110 | 39 | | 3 | | 0 | 5 | | | | 1 | | 2 | 4 | | 3 | | 3 | | 3 | | 13 | | 1 | | 1 |
| 1110 | 1140 | 54 | | 2 | | 2 | 11 | | 2 | 9 | 1 | | 5 | 3 | | 8 | | | | 8 | | 2 | 1 | | | |
| 1140 | 1170 | 15 | | 15 | | | | | | | | | | | | | | | | | | | | | | |
| 1170 | 1200 | 29 | | 12 | | 1 | | | 2 | 2 | 4 | | | | | 1 | | 3 | | 3 | | | | | | 1 |

HY-OT-6-59/SWINDELL #1

| start (Feet) | finish | **N=** | shale | siltstone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 350 | 390 | 17 | | 5 | 0 | 2 | 1 | | 1 | 4 | | | | | 1 | | 4 | | | | | | | | | |
| 390 | 420 | 11 | | 5 | | | | | | | | | | | | | 5 | | 1 | | | | | | | |
| 420 | 450 | 48 | | | 9 | 3 | | 3 | 2 | | | 6 | 9 | | 12 | | 2 | | 2 | | | | | | | |
| 450 | 480 | 26 | | 26 | | | | | | | | | | | | | | | | | | | | | | |
| 480 | 510 | 33 | | 30 | | | | 1 | | 1 | | | | | | | 1 | | | | | | | | | |
| 510 | 540 | 61 | | 32 | 0 | 1 | | | | 12 | | | | | | | 2 | | 13 | | | | | | | |
| 540 | 570 | 71 | | | | | | | | 35 | 28 | | | | | | | | 8 | | | | | | | |
| 570 | 600 | 54 | | | 19 | 1 | | 5 | 1 | 18 | 4 | 1 | | | | | 4 | | 1 | | | | | | | |
| 600 | 630 | 71 | | | 9 | 9 | | 12 | 13 | 5 | | 1 | 1 | | | 7 | 7 | | 6 | | | 1 | | | | |
| 630 | 660 | 80 | | | | 2 | | | 21 | | | 4 | 17 | | 6 | | 22 | | 8 | | | | | | | |
| 660 | 690 | 36 | | | | | | | 1 | | 2 | 1 | 9 | | 4 | | 17 | | 1 | | | 1 | | | | |
| 690 | 720 | 66 | | | 15 | 16 | | 2 | 6 | 3 | | | 6 | | 6 | 1 | 10 | | | 1 | | | | | | |
| 720 | 750 | 54 | | | 8 | 15 | | 1 | | | | | 1 | | 9 | | 16 | | 4 | | | | | | | |
| 750 | 780 | 62 | | | 4 | 11 | | 1 | 5 | 1 | 1 | 9 | 5 | | 11 | | 11 | | 3 | | | | | | | |
| 780 | 810 | 47 | | | 3 | 8 | | 1 | 2 | | | 4 | 3 | | 9 | | 16 | | 1 | | | | | | | |
| 810 | 840 | 35 | | | 2 | 5 | | | 2 | | | 5 | 2 | | 8 | | 10 | 1 | | | | | | | | |
| 840 | 870 | 41 | | | 2 | 5 | | | 6 | 1 | | 6 | 7 | | 6 | | 7 | | 1 | | | | | | | |
| 870 | 900 | 37 | | | 1 | 4 | | 3 | 3 | 2 | 1 | 5 | 3 | | 7 | | 4 | | 4 | | | | | | | |
| 900 | 930 | 28 | | 6 | 1 | 2 | | 1 | 2 | 3 | 2 | 6 | 1 | | 2 | | 3 | | | | | | | | | |
| 930 | 960 | 30 | | | 4 | 3 | | | 2 | 1 | | 14 | 4 | | 2 | | | | | | | | | | | |
| 960 | 990 | 20 | | 1 | | 7 | | 1 | 2 | | 2 | 3 | | | | | 3 | | 1 | | | | | | | |
| 990 | 1020 | 38 | | | 3 | 7 | | 1 | | 3 | 1 | 8 | | | 2 | | 1 | | 1 | | 3 | | 2 | | 6 | |
| 1020 | 1050 | 34 | | | | | | | | 1 | | | | | | | | | | | | | 5 | | 20 | 8 |
| 1050 | 1080 | 71 | | | | 2 | | | 3 | | | 1 | | | | | | | | | | | 10 | 5 | 30 | 20 |
| 1080 | 1110 | 41 | | | 5 | 4 | | 1 | 4 | 2 | | 6 | 1 | | 4 | | | | | | | | 2 | 2 | 4 | 6 |
| 1110 | 1140 | 27 | | | | | | | | 2 | | | | | | | | | | | 11 | | 5 | | 9 | |
| 1140 | 1170 | 27 | | 3 | | | | | | 3 | | | 3 | | 1 | | | | 5 | | 9 | | | | 2 | 1 |
| 1170 | 1200 | 29 | | 14 | | | | | | 10 | | | | | | | | | 2 | | 3 | | | | | |
| 1200 | 1230 | 18 | | | 3 | | | | | 8 | | | | | | | | | | | 6 | | | | 1 | |

HY-OT-1-65/MOBIL #3

| start (Feet) | finish | **N=** | shale | silty sand | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 990 | 1000 | 35 | | | | 1 | 28 | 2 | 1 | | | 3 | | | | | | | | | | | | | | |
| 1000 | 1010 | 53 | | | 14 | 12 | | 13 | 0 | | | | | 1 | | 2 | 1 | 5 | 4 | | | 1 | | | | |
| 1010 | 1020 | 49 | | | 19 | 16 | | 1 | | | | | | | | 3 | 6 | 2 | 1 | 1 | | | | | | |
| 1020 | 1030 | 38 | | | 22 | 7 | | 8 | | | | | | | | | | | | 1 | | | | | | |
| 1030 | 1040 | 4 | | | 1 | 1 | | 2 | | | | | | | | | | | | | | | | | | |
| 1040 | 1050 | 5 | | | | 3 | | | | | | | | 1 | | | | | 1 | | | | | | | |
| 1050 | 1060 | 28 | | | 13 | 6 | 5 | 1 | | | | | | 1 | | | 1 | | | | | 1 | | | | |
| 1060 | 1070 | 31 | | | 13 | 4 | | 6 | 6 | 1 | | | | 1 | | | | | | | | | | | | |
| 1070 | 1080 | 59 | | | 9 | 1 | 13 | 13 | 11 | 4 | | 5 | | | | | | | 2 | | | 1 | | | | |
| 1080 | 1090 | 76 | | | 12 | 4 | 26 | 2 | 7 | 10 | | 2 | | 1 | | 4 | 3 | | 4 | | | | 1 | | | |
| 1090 | 1100 | 26 | 1 | | 3 | | 7 | | 8 | 3 | | 2 | | | 1 | | | | 1 | | | | | | | |
| 1100 | 1110 | 42 | | | 4 | | 11 | 4 | 15 | 1 | | 3 | | | | | 2 | | 2 | | | | | | | |
| 1110 | 1120 | 27 | | | 3 | | 3 | 4 | 14 | 1 | | 2 | | | | | | | | | | | | | | |
| 1120 | 1130 | 41 | | | 5 | | 15 | 3 | 12 | 2 | 4 | | | | | | | | | | | | | | | |
| 1130 | 1140 | 50 | | | 2 | | 8 | 5 | 23 | 2 | | 8 | | 2 | | | | | | | | | | | | |
| 1140 | 1150 | 34 | | | 1 | 12 | 2 | | 6 | 1 | | 1 | | | | 3 | | 4 | | | | 1 | 3 | | | |
| 1150 | 1160 | 26 | | 2 | 0 | 3 | 2 | 1 | 10 | 0 | | 2 | | 0 | | 1 | 0 | | | | | | 3 | | 2 | |
| 1160 | 1170 | 34 | | | | 4 | | | 2 | | | | | | | | | | | | | | 5 | | | |
| 1170 | 1180 | 17 | | 3 | 3 | 5 | | | 2 | 2 | | | | | | | | 2 | | | | | | | | |
| 1180 | 1190 | 14 | | | 1 | 1 | 2 | 1 | 2 | | | | | | | | | | | | | | 7 | | | |
| 1190 | 1200 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1200 | 1210 | 44 | | 5 | 2 | 6 | 4 | 2 | 7 | 1 | | | | | | | | 6 | 1 | | | 2 | 8 | | | |
| 1210 | 1220 | 17 | | | | | | | 5 | | | | | | | 4 | | | 7 | | | | 1 | | | |
| 1220 | 1230 | 36 | | | 5 | 5 | | 8 | | | | 2 | | 0 | 3 | 2 | 3 | 1 | 6 | | | 1 | | | | |
| 1230 | 1240 | 20 | | | 1 | 3 | 5 | 7 | 1 | | | | | | | | 1 | 1 | 1 | | | | | | | |
| 1240 | 1250 | 24 | | | 5 | 4 | 1 | 2 | 8 | | | | | 1 | 2 | | | | | | | | 1 | | | |
| 1250 | 1260 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1260 | 1270 | 45 | | | 7 | 7 | | 5 | 6 | 1 | 1 | | 7 | | | | 8 | | 2 | | | 1 | | | | |
| 1270 | 1280 | 33 | 5 | 3 | | 5 | | 6 | 3 | | | 1 | | 1 | 1 | | 3 | 1 | | | | | 4 | | | |
| 1280 | 1290 | 12 | 1 | | 1 | 3 | 1 | | | | | | | | | | 3 | | | | | | 3 | | | |
| 1290 | 1300 | 41 | 2 | 2 | 2 | 7 | | 1 | 7 | 1 | 6 | | | 1 | 2 | | | 1 | 1 | | | | | | | |
| 1300 | 1310 | 6 | | | | 3 | | | | | 1 | | 1 | | | | | 1 | | | | | | | | |
| 1310 | 1320 | 5 | | | | 5 | | | | | | | | | | | | | | | | | | | | |
| 1320 | 1330 | 10 | | | 4 | 4 | | | | | | | | 1 | | | | | 1 | | | | | | | |
| 1330 | 1340 | 27 | | | 2 | 5 | | 3 | 4 | | | 1 | | 3 | | 1 | 5 | | 1 | | | 1 | | | 1 | |
| 1340 | 1350 | 23 | | 1 | 3 | | | | | | | | | | 4 | 1 | 7 | | | 1 | | 6 | | | | |
| 1350 | 1360 | 31 | | | 1 | | | | 3 | | | 4 | | 1 | 1 | 1 | 14 | 1 | 4 | 1 | | | | | | |

HY-OT-1-65/MOBIL #3

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1360 | 1370 | 52 | | | 1 | 3 | | | | | | 8 | 2 | 3 | 11 | 5 | 6 | 4 | 5 | | | 3 | 1 | | | |
| 1370 | 1380 | 34 | | | | 2 | | | 2 | | | 5 | | 2 | 7 | 1 | 3 | 3 | 9 | | | | | | | |
| 1380 | 1390 | 22 | | | 3 | | | | | | | 2 | 1 | 1 | 4 | | 4 | 1 | 6 | | | | | | | |
| 1390 | 1400 | 22 | | 1 | | 2 | | | 5 | 1 | | 2 | 3 | | | 1 | 1 | 3 | 3 | | | | | | | |
| 1400 | 1410 | ### | | | | 6 | | | 7 | | | 4 | 1 | 2 | 7 | | 3 | 2 | 2 | 1 | | | 1 | | | |
| 1410 | 1420 | 19 | | 2 | 2 | 4 | | | 1 | | | | | | | | 4 | 2 | | | | 4 | | | | |
| 1420 | 1430 | 31 | | | 2 | 2 | | | | | | 9 | | 2 | 7 | 3 | 4 | 1 | | 1 | | | | | | |
| 1430 | 1440 | 13 | | | | 2 | | | 2 | | | 2 | | | 4 | 1 | | 2 | | | | | | | | |
| 1440 | 1450 | 56 | | | 3 | 6 | 3 | 1 | 2 | | | 13 | | 6 | 15 | 3 | 2 | 1 | 1 | | | | | | | |
| 1450 | 1460 | 16 | | | | 3 | | | 1 | | | 4 | | | 1 | 1 | 6 | | | | | | | | | |
| 1460 | 1470 | 30 | | | | 1 | 2 | 1 | 2 | | | 6 | | 2 | 6 | 4 | 2 | 4 | | | | | | | | |
| 1470 | 1480 | 43 | | | | 3 | | | 1 | | | 7 | | 3 | 20 | 2 | 1 | 5 | | | | 1 | | | | |
| 1480 | 1490 | 104 | | | 2 | 9 | | | 8 | | | 28 | 0 | 10 | 33 | | 2 | 10 | 2 | | | | | | | |
| 1490 | 1500 | 20 | | | 1 | | | | | | | 5 | | | 7 | | 1 | 3 | | 1 | | 2 | | | | |
| 1500 | 1510 | 74 | | | 1 | 13 | | 1 | | | | 17 | | 7 | 26 | | 1 | 6 | | 1 | | | 1 | | | |
| 1510 | 1520 | 93 | | | 2 | 7 | | 4 | | | | 22 | | 8 | 32 | 3 | 3 | 10 | | 1 | | | 1 | | | |
| 1520 | 1530 | 34 | | | | 1 | | | | | | 10 | | 2 | 9 | | 6 | 4 | | 1 | | 1 | | | | |
| 1530 | 1540 | 40 | | | | 3 | | 2 | | | | 18 | 2 | 4 | 5 | | 3 | | 1 | | | 2 | | | | |
| 1540 | 1550 | 35 | | | 1 | 5 | | | 1 | | | 14 | | 3 | 3 | | 4 | 3 | | 1 | | | | | | |
| 1550 | 1560 | 85 | | | | 9 | | | | | | 42 | 12 | 3 | 14 | | | 2 | | 1 | | 1 | 1 | | | |
| 1560 | 1570 | 98 | | | | 5 | | | 1 | | | 52 | | 3 | 11 | | 17 | 6 | 2 | | | | 1 | | | |
| 1570 | 1580 | 98 | | | | 13 | | | 4 | | | 34 | | 7 | 14 | | 15 | 9 | | | | | 2 | | | |
| 1580 | 1590 | 34 | | | | 7 | | | 2 | | | 10 | | | 5 | | 5 | 5 | | | | | | | | |
| 1590 | 1600 | 40 | | | | 5 | | | 6 | 2 | | 13 | | | 3 | | 3 | 7 | | | | 1 | | | | |
| 1600 | 1610 | 53 | | | | 6 | | | 1 | | | 17 | 14 | 1 | 6 | | 2 | 4 | | | | | 2 | | | |
| 1610 | 1620 | 92 | | | | 8 | | | 1 | | | 31 | 28 | | 3 | | 5 | 11 | | | | 3 | 2 | | | |
| 1620 | 1630 | 58 | | 2 | | 3 | | | | | | 11 | 21 | 2 | 1 | | 6 | 8 | 1 | | | | 1 | | 2 | |
| 1630 | 1640 | 62 | | | | 7 | | | | | | 11 | | 31 | 2 | | 3 | 5 | | | | | 3 | | | |
| 1640 | 1650 | 50 | | | | 6 | | | | 1 | | 6 | 19 | | 1 | | 12 | 2 | | 1 | | | | | 2 | |
| 1650 | 1660 | 57 | | | 1 | 4 | | 1 | | | | 7 | 31 | | 1 | | 5 | 2 | 3 | | | | 1 | | 1 | |
| 1660 | 1670 | 39 | | | 1 | 5 | | | | | | 3 | 9 | 1 | 4 | | 10 | 1 | | | | 4 | | | 1 | |
| 1670 | 1680 | 29 | | | 2 | 4 | | 6 | 3 | | | 8 | 3 | | | | | | | | | 3 | | | | |
| 1680 | 1690 | 61 | | 1 | 1 | 4 | | | 1 | | | 19 | 20 | | 6 | 1 | 4 | | 3 | | | | 1 | | | |
| 1690 | 1700 | 40 | | | | 4 | | 2 | | | | 11 | 8 | | 2 | | 7 | 3 | 1 | | | 1 | | | 1 | |
| 1700 | 1710 | 70 | | 11 | 4 | 6 | | 2 | 4 | | | 16 | 14 | | 1 | | 7 | 1 | | | | | 3 | | 1 | |
| 1710 | 1720 | 70 | | | | 5 | | | | | | 20 | 28 | | 4 | | 9 | 4 | | | | | | | | |
| 1720 | 1730 | 54 | | | 1 | 3 | | 1 | | | | 18 | 17 | | 2 | | 4 | 7 | | | | | 1 | | | |
| 1730 | 1740 | 56 | | | | 2 | | | | | | 10 | 24 | 1 | 8 | 3 | 8 | | | | | | | | | |

HY-OT-1-65/MOBIL #3

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1740 | 1750 | 78 | | | | 2 | | | 1 | | | 19 | 28 | | 9 | | 11 | 7 | 1 | | | | | | | |
| 1750 | 1760 | 62 | | | | 1 | | | | | | 12 | 23 | 1 | 12 | | 7 | 2 | | | | 3 | | | 1 | |
| 1760 | 1770 | 71 | | | | 2 | | | | 1 | | 22 | 17 | 2 | 19 | | 7 | 1 | | | | | | | | |
| 1770 | 1780 | 65 | | 1 | 0 | 4 | | | 3 | | | 7 | 22 | 2 | 7 | | 18 | 1 | | | | | | | | |
| 1780 | 1790 | 52 | | | | | | | | | | 10 | 15 | 2 | 8 | | 14 | 1 | | | | | | | 2 | |
| 1790 | 1800 | 68 | | 1 | | 1 | | 2 | | | | 13 | 29 | 1 | 5 | | 14 | | | | | | 2 | | | |
| 1800 | 1810 | 37 | | | 2 | 5 | | | | | 2 | 13 | 9 | | 1 | 1 | 4 | | | | | | | | | |
| 1810 | 1820 | 48 | 2 | | 1 | 9 | | | | | 2 | 5 | 21 | 1 | 3 | | 3 | | | | | | 1 | | | |
| 1820 | 1830 | 43 | | | | 5 | | 1 | | | | 5 | 16 | | 4 | | 11 | | | | | | 1 | | | |
| 1830 | 1840 | 44 | | | | 4 | | | | 1 | | 6 | 15 | 0 | 10 | | 6 | | | | | | | | 2 | |
| 1840 | 1850 | 25 | | | 3 | 4 | | | | | | 7 | 8 | | | | 3 | | | | | | | | | |
| 1850 | 1860 | 18 | | | 1 | 1 | | | | | | 2 | 13 | | | | 1 | | | | | | | | | |
| 1860 | 1870 | 23 | | | | | | | | | | 7 | 4 | 4 | | 5 | | 1 | | | | | | | 2 | |
| 1870 | 1880 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1880 | 1890 | 31 | | 5 | 2 | 10 | | 1 | | | | 6 | 1 | | 1 | | 5 | | | | | | | | | |
| 1890 | 1900 | 60 | | 2 | | 3 | | 3 | 5 | | | 10 | 16 | | 7 | | 12 | 1 | | | | | 1 | | | |
| 1900 | 1910 | 35 | | | | 8 | | 3 | 2 | | | 3 | 12 | | 2 | | 1 | | 1 | | | 3 | | | | |
| 1910 | 1920 | 38 | | | | 6 | | 2 | 9 | 2 | | 6 | 2 | | 2 | 1 | 5 | | 3 | | | | | | | |
| 1920 | 1930 | 37 | | | | 11 | | 6 | 1 | | 1 | | 6 | | 4 | | 6 | 1 | 1 | | | | | | | |
| 1930 | 1940 | 91 | | 9 | 9 | 2 | | 2 | 2 | | | 2 | 35 | | 3 | | | | | | | | 4 | | 23 | |
| 1940 | 1950 | 76 | | 16 | 0 | 6 | | | | | | | | | 2 | | | | 1 | | 27 | | 15 | | 9 | |
| 1950 | 1960 | 50 | | 8 | 3 | | | 3 | | | | 7 | 7 | | 3 | | | | | | 9 | | 8 | | 2 | |
| 1960 | 1970 | 65 | | 11 | 3 | 4 | | 3 | | | | 4 | 3 | | 1 | | | | | | 18 | | 12 | | 7 | |
| 1970 | 1980 | 53 | | 3 | 0 | 1 | | 2 | 2 | 2 | | 3 | 7 | | | | | | | | 10 | | 12 | | 11 | |
| 1980 | 1990 | 77 | | 2 | 3 | 7 | | 1 | 1 | | | 1 | | | | | | | | | 6 | | 46 | | 10 | |
| 1990 | 2000 | 65 | | 4 | 0 | 5 | | 4 | | | | 10 | 8 | | 3 | | | | 1 | | 8 | | 13 | | 9 | |
| 2000 | 2010 | 74 | | 6 | | | | | | | | | | | | | | | | | | | 23 | | 45 | |
| 2010 | 2020 | 29 | | 1 | | | | | | | | | | | | | | | | | | | 8 | | 20 | |
| 2020 | 2030 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2030 | 2040 | 28 | | 4 | | | | | | | | | 2 | | | | | | | | | | 14 | | 8 | |
| 2040 | 2050 | 20 | | | | | | | | | | | | | | | | | | | | | 15 | | 5 | |
| 2050 | 2060 | 36 | | | | | | 1 | | | | | | | | | | | | | | | 29 | | 6 | |
| 2060 | 2070 | 67 | | | | | | | | | | 1 | | | | | | | | | | | 49 | | 17 | |
| 2070 | 2080 | 67 | | | | | | | 1 | | | | | | | | | | | | | | 49 | | 17 | |
| 2080 | 2090 | 48 | | | | | | | | | | | | | | | | | | | 1 | | 28 | | 19 | |
| 2090 | 2100 | 59 | | 1 | | | | | | | | | | | | | | | | | | | 31 | | 27 | |
| 2100 | 2110 | 47 | | | | | | | | | | | | | | | | | | | | | 13 | 3 | 31 | |
| 2110 | 2120 | 44 | | | | | | | | | | | | | | | | | | | | | 27 | | 17 | |

HY-OT-1-65/MOBIL #3

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2120 | 2130 | 44 | | | | | | | | | | | | | | | | | | | | | 22 | 2 | 20 | |
| 2130 | 2140 | 56 | | | 1 | 3 | | 1 | | | | | | | | | | | | | 5 | | 14 | 2 | 30 | |
| 2140 | 2150 | 69 | | | | | | | | | | | | | | | | | | | | | 17 | 7 | 45 | |
| 2150 | 2160 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2160 | 2170 | 58 | | | 1 | | | | | | | | | | | | | | | | | | 11 | 6 | 40 | |
| 2170 | 2180 | 52 | | | | | | | | | | | | | | | | | | | | | 8 | 7 | 37 | |
| 2180 | 2190 | 70 | | | | | | | | | | | | | | | | | | | | | 5 | 7 | 55 | 3 |
| 2190 | 2200 | 40 | | | | | | | | | | | | | | | | | | | | | 2 | 2 | 30 | 6 |
| 2200 | 2210 | 44 | | | | | | | | | | | | | | | | | | | | | 1 | 3 | 40 | |
| 2210 | 2220 | 105 | | | | | | | | | | | | | | | | | | | | | 25 | 5 | 75 | |
| 2220 | 2230 | 103 | | | | | | | | | | | | | | | | | | | | | 30 | 4 | 69 | |
| 2230 | 2240 | 32 | | | | | | | | | | | | | | | | | | | | | 12 | | 20 | |
| 2240 | 2250 | 12 | | | | | | | | | | | | | | | | | | | | | 2 | | 10 | |
| 2250 | 2260 | 35 | | | | | | | | | | | | | | | | | | | | | 13 | | 22 | |
| 2260 | 2270 | 27 | | | | | | | | | | | | | | | | | | 1 | | | 8 | 1 | 17 | |
| 2270 | 2280 | 23 | | | | | | | | | | | | | | | | | | | | | 9 | | 14 | |
| 2280 | 2290 | 53 | | | | | | | | | | | | | | | | | | | 6 | | 1 | | 46 | |
| 2290 | 2300 | 44 | | | | | | | | | | | | | | | | | | | 2 | | 5 | | 37 | |

HY-OT-2-65/BALLANCE #1

| start (Feet) | finish | **N=** | shale | siltstone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 700 | 710 | 23 | | | | | | 1 | 2 | 20 | | | | | | | | | | | | | | | | |
| 710 | 720 | 34 | 2 | | | | | | | 27 | 2 | 1 | | | | | | | 1 | 1 | | | | | | |
| 720 | 730 | 41 | 1 | 1 | | 1 | | 2 | | 29 | 4 | | | | | | 1 | | 1 | | | 1 | | | | |
| 730 | 740 | 19 | 2 | 2 | | | | | | 8 | 3 | | | | | 1 | | | 1 | 1 | | 1 | | | | |
| 740 | 750 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 750 | 760 | 38 | 2 | 1 | 22 | 4 | | | 1 | 6 | | | | | | 1 | | | | | | 1 | | | | |
| 760 | 770 | 34 | | | 15 | | | | | 10 | 2 | | | | 1 | | 1 | | 2 | 2 | | | 1 | | | |
| 770 | 780 | 43 | 1 | 2 | 15 | 4 | | | 1 | 18 | | | | | | | | | | 2 | | | | | | |
| 780 | 790 | 54 | 1 | | 5 | 2 | | 1 | | 9 | 1 | 8 | 22 | | 2 | | | | 1 | 2 | | | | | | |
| 790 | 800 | 60 | | 1 | 7 | | | | 1 | 11 | | 1 | 25 | | 2 | | 1 | | | 4 | 7 | | | | | |
| 800 | 810 | 83 | 4 | 0 | 24 | | | 3 | | 30 | 4 | 1 | 4 | | 1 | | 3 | | 4 | 2 | | 3 | | | | |
| 810 | 820 | 106 | | | 2 | | | | | 2 | | 18 | 17 | | 18 | | 13 | 3 | 13 | 8 | 1 | 11 | | | | |
| 820 | 830 | 126 | | | | | | 5 | 29 | 2 | | 23 | | 4 | 29 | | 15 | | 10 | 5 | | 4 | | | | |
| 830 | 840 | 82 | | | 2 | | | | 23 | 1 | | 15 | | 4 | 15 | | 7 | 2 | 4 | 3 | | 6 | | | | |
| 840 | 850 | 103 | | | 1 | | | 11 | | 4 | | 9 | 2 | | 16 | 6 | 21 | | 13 | 4 | | 16 | | | | |
| 850 | 860 | 73 | | | | | | | 8 | 3 | 1 | 8 | 5 | | 6 | 5 | 16 | | 13 | 2 | | 6 | | | | |
| 860 | 870 | 99 | | | 2 | 1 | | 1 | 9 | 1 | 1 | 23 | 16 | 3 | 15 | 1 | 16 | 3 | 2 | 1 | | 4 | | | | |
| 870 | 880 | 120 | | | 3 | 3 | | 3 | 7 | 5 | | 22 | 6 | 7 | 30 | 11 | 13 | | 6 | 2 | | 2 | | | | |
| 880 | 890 | 102 | | | 6 | | | | 9 | 2 | | 17 | 3 | 4 | 23 | 4 | 10 | 10 | 7 | 4 | | 3 | | | | |
| 890 | 900 | 135 | | | 8 | 1 | | 1 | 5 | 2 | | 14 | 17 | 5 | 27 | 4 | 16 | 15 | 7 | 4 | | 9 | | | | |
| 900 | 910 | 119 | | | 52 | 29 | | | | | | 7 | 3 | | 8 | 7 | 3 | 1 | 4 | | | 5 | | | | |
| 910 | 920 | 143 | | | 38 | 41 | | 4 | | | | 10 | 1 | 4 | 13 | 14 | 12 | | 4 | | | 2 | | | | |
| 920 | 930 | 95 | | | 7 | 42 | | 8 | | | | 6 | | 1 | 15 | 4 | 9 | | 3 | | | | | | | |
| 930 | 940 | 153 | | | 40 | 35 | | 13 | | 2 | | 10 | 3 | 2 | 23 | 8 | 12 | | 1 | 3 | | 1 | | | | |
| 940 | 950 | 40 | | | 5 | 3 | | | 1 | | | 8 | | 1 | 9 | 1 | 7 | 2 | | 1 | | 2 | | | | |
| 950 | 960 | 65 | | | 9 | 9 | | 2 | 3 | 3 | 1 | 6 | | 2 | 5 | | 13 | 3 | 1 | 2 | | 5 | 1 | | | |
| 960 | 970 | 73 | | | 12 | 9 | | 1 | | 7 | | 6 | | | 7 | 7 | 7 | 1 | 4 | | | 12 | | | | |
| 970 | 980 | 86 | | | 11 | 7 | | 3 | 1 | | | 15 | 4 | 2 | 14 | 1 | 15 | 6 | 3 | | | 4 | | | | |
| 980 | 990 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 990 | 1000 | 124 | | | 6 | 11 | | 6 | 3 | | | 40 | | 8 | 17 | 7 | 15 | | 3 | 6 | | 2 | | | | |
| 1000 | 1010 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1010 | 1020 | 104 | | | 8 | 8 | | 9 | 8 | | | 33 | 2 | 2 | 9 | 3 | 13 | | 6 | 1 | | 2 | | | | |
| 1020 | 1030 | 118 | | | 0 | 10 | | 3 | 8 | | | 15 | 5 | | 21 | 1 | 42 | | 8 | 2 | | 3 | | | | |
| 1030 | 1040 | 128 | | | 3 | | | 2 | 10 | 3 | | 17 | 3 | 1 | 23 | 5 | 18 | 18 | 10 | 7 | | 8 | | | | |
| 1040 | 1050 | 99 | | | 4 | 2 | | 0 | 11 | 1 | 1 | 17 | 1 | 1 | 18 | 4 | 14 | 10 | 1 | 6 | | 4 | 4 | | | |
| 1050 | 1060 | 114 | | | 15 | 8 | | 3 | 3 | 3 | | 21 | 7 | | 10 | 13 | 11 | 3 | 3 | 6 | | 5 | 3 | | | |
| 1060 | 1070 | 145 | | | 5 | 13 | | 3 | 11 | 1 | | 35 | 3 | 10 | 10 | 7 | 19 | 7 | 7 | 6 | | 7 | 1 | | | |

HY-OT-2-65/BALLANCE #1

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1070 | 1080 | 100 | | 1 | 4 | | | 1 | 9 | 3 | | 12 | 5 | 2 | 30 | 2 | 13 | 8 | 3 | 4 | | 2 | 1 | | | |
| 1080 | 1090 | 135 | | 1 | 2 | 5 | | | 12 | 2 | | 16 | 5 | 5 | 32 | 3 | 21 | 6 | 1 | 12 | | 7 | 5 | | | |
| 1090 | 1100 | 110 | 1 | 3 | 4 | | | 2 | 6 | 13 | 1 | 12 | 12 | 3 | 24 | | 7 | 7 | 1 | 6 | | 1 | 7 | | | |
| 1100 | 1110 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1110 | 1120 | 102 | | | 1 | 2 | | 2 | 4 | 3 | | 22 | 3 | 4 | 16 | 3 | 12 | 6 | 1 | 9 | | 9 | 5 | | | |
| 1120 | 1130 | 127 | | 1 | 4 | 19 | | 9 | 4 | 5 | | 37 | 8 | | 12 | 3 | 11 | 4 | 1 | 1 | | 8 | | | | |
| 1130 | 1140 | 117 | | 1 | 7 | 10 | | 4 | 2 | 5 | | 32 | 7 | | 14 | 7 | 11 | 2 | 2 | 3 | | 10 | | | | |
| 1140 | 1150 | 126 | | | 4 | 6 | | 3 | 2 | 2 | 1 | 41 | 10 | 2 | 22 | 8 | 4 | 5 | 3 | 3 | | 9 | 1 | | | |
| 1150 | 1160 | 111 | | | 5 | 13 | | | 12 | 7 | | 22 | 8 | 6 | 15 | 8 | 2 | 6 | 3 | 1 | | 3 | | | | |
| 1160 | 1170 | 123 | | | 2 | 8 | | 10 | 8 | 9 | 1 | 26 | 4 | 2 | 28 | 3 | 5 | 4 | 2 | 7 | | 4 | | | | |
| 1170 | 1180 | 197 | | 1 | 20 | 11 | | 2 | 13 | 14 | | 49 | 6 | 9 | 23 | 8 | 8 | 5 | 10 | 7 | | 6 | | | 5 | |
| 1180 | 1190 | 75 | | | 5 | 1 | | 1 | 1 | | | 45 | | | 9 | 3 | 1 | 2 | 2 | 4 | | 1 | | | | |
| 1190 | 1200 | 116 | | | 11 | 2 | | 4 | 1 | 5 | | 53 | | 5 | 13 | 7 | 4 | 2 | | 4 | | 5 | | | | |
| 1200 | 1210 | 107 | | | 4 | 10 | | 7 | 9 | 3 | | 29 | | 4 | 19 | 8 | 1 | 3 | 5 | | 4 | 1 | | | | |
| 1210 | 1220 | 77 | | 2 | 9 | 3 | | 2 | | | 1 | 28 | | 1 | 13 | 3 | | 1 | 3 | 3 | | 8 | | | | |
| 1220 | 1230 | 127 | | 1 | 19 | 8 | | 1 | 6 | 4 | 2 | 20 | 2 | 5 | 16 | 10 | 4 | 3 | 6 | 4 | | 15 | | | 1 | |
| 1230 | 1240 | 122 | | 1 | 25 | 12 | | 4 | 6 | 4 | | 15 | 2 | 6 | 20 | 11 | | 3 | 3 | 4 | | 6 | | | | |
| 1240 | 1250 | 118 | | | 22 | 11 | | 3 | 14 | 4 | | 15 | 3 | 5 | 14 | 4 | 10 | 3 | 6 | 1 | | 3 | | | | |
| 1250 | 1260 | 125 | | 1 | 21 | 5 | | 7 | 10 | 4 | | 29 | 1 | 3 | 17 | 3 | 9 | 6 | 3 | 1 | | 3 | | | 2 | |
| 1260 | 1270 | 140 | | | 27 | 13 | | 4 | 5 | 5 | | 27 | 7 | 6 | 30 | | 4 | 2 | 2 | 2 | | 5 | 1 | | | |
| 1270 | 1280 | 99 | | | 24 | 5 | | 3 | 13 | 3 | 3 | 18 | | | 11 | 2 | 5 | 4 | 3 | 1 | | 3 | | | 1 | |
| 1280 | 1290 | 137 | | 1 | 11 | 7 | | | 6 | 9 | | 44 | 3 | 1 | 22 | 1 | 16 | 3 | 3 | 4 | | 3 | | | 3 | |
| 1290 | 1300 | 139 | | | 33 | 15 | | | 8 | 9 | | 27 | 5 | 3 | 12 | 2 | 7 | 5 | 6 | | | 6 | 1 | | | |
| 1300 | 1310 | 133 | | 2 | 39 | 11 | | 6 | 8 | 8 | | 17 | 2 | 3 | 12 | 3 | 11 | 4 | 3 | 1 | | 1 | | | 2 | |
| 1310 | 1320 | 90 | | | 8 | 26 | | 1 | 2 | 2 | | 19 | 1 | 4 | 7 | 2 | 4 | 2 | | | | | 12 | | | |
| 1320 | 1330 | 92 | | | 11 | 21 | | 1 | 2 | 1 | | 26 | 1 | 3 | 9 | | | | | | | | 17 | | | |
| 1330 | 1340 | 97 | | 4 | 11 | 21 | | 2 | 3 | | | 21 | | 2 | 5 | 1 | | 1 | 1 | 1 | | 1 | 7 | | 16 | |
| 1340 | 1350 | 53 | | 2 | 15 | 6 | | 6 | | | | 3 | | 3 | | | 1 | | | | | | 13 | | 4 | |
| 1350 | 1360 | 42 | | 15 | 3 | 4 | | | | 1 | | | | | | | | | | | | | 17 | | 2 | |
| 1360 | 1370 | 43 | | 10 | 6 | 15 | | | | | | | | | 1 | | | | | | | | 9 | | 2 | |
| 1370 | 1380 | 35 | | 23 | 6 | 5 | | | | | | | | | | | | | | | | | 1 | | | |
| 1380 | 1390 | 64 | | 44 | 1 | 5 | | | | | | 2 | 1 | | | | | 1 | | | | | 10 | | | |
| 1390 | 1400 | 14 | | 13 | 0 | 0 | | | | | | 1 | | | | | | | | | | | | | | |
| 1400 | 1410 | 13 | | 5 | | 8 | | | | | | | | | | | | | | | | | 5 | | | |
| 1410 | 1420 | 21 | 2 | 11 | 1 | 3 | | | | | | | | | | | | | | | | | | | 4 | |
| 1420 | 1430 | 39 | | 6 | 0 | | | | | | | | | | | | | | | | | | 10 | | 23 | |
| 1430 | 1440 | 27 | | 2 | | | | | | | | | | | 1 | 1 | | | | | | | 5 | 1 | 17 | |
| 1440 | 1450 | 43 | | | | | | | | | | | | | | | | | | | | | 3 | | 40 | |

HY-OT-2-65/BALLANCE #1

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1450 | 1460 | 38 | | 2 | | | | | | | | | | | | | | | | | | | 2 | | 34 | |
| 1460 | 1470 | 32 | | 2 | | | | | | | | | | | | | | | | | | | | | 30 | |
| 1470 | 1480 | 37 | 4 | 5 | 0 | | | | | | | | | | | | | | | | | | 1 | 12 | 15 | |
| 1480 | 1490 | 37 | | 1 | | | | | | | | | | | | | | | | | | | 2 | 6 | 28 | |
| 1490 | 1500 | 40 | 1 | | | | | | | | | | | | | | | | | | | | 4 | 5 | 30 | |
| 1500 | 1510 | 45 | | 7 | 0 | 0 | | | | | | | | | | | | | | | | | 20 | | 18 | |
| 1510 | 1520 | 20 | | | | | | | | | | | | | | | | | | | | | 3 | | 17 | |
| 1520 | 1530 | 16 | | | | | | | | | | | | | | | | | | | | | 3 | | 13 | |
| 1530 | 1540 | 21 | | | | | | | | | | | | | | | | | | | | | 2 | | 19 | |
| 1540 | 1550 | 26 | | | | | | | | | | | | | | | | | | | | | | | 26 | |
| 1550 | 1560 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1560 | 1570 | 26 | | | | | | | | | | | | | | | | | | | | | 3 | 3 | 20 | |
| 1570 | 1580 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1580 | 1590 | 11 | | | | | | | | | | | | | | | | | | | | | | | 8 | 3 |
| 1590 | 1600 | 18 | | | | | | | | | | | | | | | | | | | | | | | 18 | |
| 1600 | 1610 | 8 | | | | | | | | | | | | | | | | | | | | | | | 6 | 2 |
| 1610 | 1620 | 8 | | | | | | | | 1 | | | | | | | | | | | 3 | | | | | 4 |
| 1620 | 1630 | 12 | | | | | | | | | | | | | | | | | | | 1 | | | | 3 | 8 |
| 1630 | 1640 | 47 | | 9 | 0 | 1 | | | | 29 | | | | | | | 1 | | | | 2 | 1 | | | 2 | 2 |
| 1640 | 1650 | 45 | | 1 | | | | | | 2 | | | | | | | | 1 | | | 1 | | | | 40 | |
| 1650 | 1660 | 38 | | 2 | | 1 | | | | 24 | | | | | | | 1 | | | | | | | | 10 | |
| 1660 | 1670 | 10 | | | | | | | | 2 | 1 | | | | | | 1 | | | | 6 | | | | | |
| 1670 | 1680 | 17 | | | 1 | | | | | | | | | | | | | | | | 16 | | | | | |

JO-C-4-79

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 22.8 | 20 | | 20 | 0 | | | | | | | | | | | | | | | | | | | | | |
| 22.75 | 24.5 | 39 | | | 35 | | | | | 4 | | | | | | | | | | | | | | | | |
| 24.5 | 30.6 | 39 | | | | 2 | 30 | | | 3 | | | | | | | 4 | | | | | | | | | |
| 30.6 | 35.6 | 38 | | | | 4 | 2 | | 3 | | 7 | | 20 | | 2 | | | | | | | | | | | |
| 35.6 | 46 | 28 | | | | | 13 | | | | | | | | 14 | | | 1 | | | | | | | | |
| 46 | 47.5 | 49 | | 34 | 0 | 2 | 1 | 2 | 1 | 7 | | | | | | | | | 2 | | | | | | | |
| 47.5 | 52.5 | 8 | | | | 6 | | 2 | | | | | | | | | | | | | | | | | | |
| 52.5 | 53.5 | 47 | | | 4 | 23 | | 4 | 2 | | | | | | | | 5 | | 8 | | | 1 | | | | |
| 53.5 | 54.8 | 15 | | | | 9 | | 1 | | 2 | | | | | | | 1 | | 2 | | | | | | | |
| 54.75 | 58.5 | 47 | | | 4 | 23 | | 4 | 2 | | | | | | | | 5 | | 8 | | | 1 | | | | |
| 58.5 | 62 | 40 | | | 9 | 25 | | 0 | 4 | 0 | | 2 | | | | | 0 | | 0 | | | | | | | |
| 62 | 67.5 | 9 | | | | 9 | | | | | | | | | | | | | | | | | | | | |
| 67.5 | 73 | 22 | | | | 1 | | 16 | 2 | | | | | | | | 3 | | | | | | | | | |
| 73 | 78 | 28 | | | | 21 | | 4 | | 3 | | | | | | | | | | | | | | | | |
| 78 | 87 | 21 | | | | 1 | | 16 | | 4 | | | | | | | | | | | | | | | | |
| 87 | 87.5 | 9 | | | 2 | 6 | | | | 1 | | | | | | | | | | | | | | | | |
| 87.5 | 96 | 11 | | | 2 | 1 | | 8 | | | | | | | | | | | | | | | | | | |
| 96 | 112 | 34 | | | 17 | 4 | | 2 | 5 | 5 | | | | | 1 | | | | | | | | | | | |
| 112 | 113 | 16 | | 10 | 0 | 5 | | | | | | | | | | | | | | | | | | | | |
| 113 | 116 | 7 | | | | 0 | | 7 | | | | | | | | | | | | | | | | | | |
| 115.5 | 120 | 19 | | | | 15 | | 4 | | | | | | | | | | | | | | | | | | |
| 119.5 | 124 | 7 | | | | 7 | | | | | | | | | | | | | | | | | | | | |
| 124.25 | 125 | 9 | | | | 9 | | | | | | | | | | | | | | | | | | | | |
| 124.5 | 130 | 10 | | | | | | | | | | 10 | | | | | | | | | | | | | | |

NH-T-85/ WRIGHTSVILLE BEACH

| start | finish | N= | shale | Dolo stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. Wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc Sand | lime mud | plank sandy marl | spic pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 | 50 | 50 | | | 50 | | | | | | | | | | | | | | | | | | | | | |
| 50 | 60 | 54 | | | | | | | | 16 | | | | | 23 | | 8 | | 6 | 1 | | | | | | |
| 60 | 70 | 72 | | | | | | | 3 | | | 1 | 13 | | 25 | | 26 | | 3 | | | 1 | | | | |
| 70 | 80 | 59 | | | | | | | | | | 2 | 5 | | 23 | | 24 | | 3 | | | 2 | | | | |
| 80 | 90 | 49 | | | 3 | 4 | | | | 1 | 1 | 4 | 7 | | 9 | | 11 | 2 | 7 | | | | | | | |
| 90 | 100 | 17 | | | 8 | | | | | | | 2 | | | 3 | | 3 | | 1 | | | | | | | |
| 100 | 110 | 82 | 1 | 43 | 9 | 2 | | | | | | | 3 | | 8 | | 11 | | 5 | | | | | | | |
| 110 | 120 | 40 | | 3 | 15 | 3 | | | | 1 | | 4 | 1 | | 5 | | 5 | | 3 | | | | | | | |
| 120 | 130 | 135 | | 99 | 5 | 9 | | 5 | | | | 5 | | 1 | 1 | | 5 | 1 | | | | 2 | | | 2 | |
| 130 | 140 | 71 | | 51 | 3 | 5 | | 4 | | 1 | | 2 | | | | | | | 3 | | | | | | 2 | |
| 140 | 150 | 121 | | | 21 | 29 | | 47 | 22 | | | 1 | | | | | | | | | | 1 | | | | |
| 150 | 160 | 81 | | 13 | 15 | 17 | | 11 | 9 | 4 | | | | | 1 | | 5 | | 6 | | | | | | | |
| 160 | 170 | 75 | | 2 | 10 | 31 | | 22 | 7 | 1 | | | | | | | 2 | | | | | | | | | |
| 170 | 180 | 72 | | | 9 | 23 | | 17 | 20 | 1 | | | | | | | 2 | | | | | | | | | |

ON-OT-3-67/EVANS #1

| start | finish | **N=** | shale | siltysand | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sandst | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. Wkst | benthic wacke | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | spicule pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 | 50 | 78 | | 30 | 0 | 1 | | 3 | | 6 | | | | | | | | | 1 | | | | | | | |
| 50 | 60 | 44 | | 23 | 2 | 7 | | | | | | 1 | | | | | | | 4 | | | | 5 | | 2 | |
| 60 | 70 | 31 | | 8 | 6 | 8 | | 2 | | | | 2 | | | | | | | | | | | 4 | | 1 | |
| 70 | 80 | 32 | | 17 | 1 | 12 | | | 1 | | | | | | | | | | 1 | | | | 2 | | | |
| 80 | 90 | 34 | | 12 | 0 | 16 | | | | 1 | | | | | | | | | | | | | 5 | | | |
| 90 | 100 | 55 | | 8 | | 17 | | | | | | | | | | | | | | | | | 20 | | 10 | |
| 100 | 110 | 43 | | 5 | | 15 | | | | | | | | | | | | | | | | | 19 | | 4 | |
| 110 | 120 | 43 | | 5 | 1 | 8 | | | 1 | | | | 11 | | 2 | | 12 | | 1 | | | | 2 | | | |
| 120 | 130 | 66 | | | | | | | 1 | | | | 9 | | 10 | | 39 | 2 | 5 | | | | | | | |
| 130 | 140 | 65 | | | | 1 | | | 3 | | | 1 | 16 | | 11 | | 31 | | 2 | | | | | | | |
| 140 | 150 | 52 | | | | 2 | | | 2 | | | 10 | | | 11 | | 24 | | 3 | | | | | | | |
| 150 | 160 | 54 | | | | | | 1 | | | | | 2 | | 19 | | 23 | | | | | | | | | 9 |
| 160 | 170 | 71 | | | 1 | | | 1 | 3 | | | 1 | 1 | | 21 | | 21 | | | | | 1 | | | | 21 |
| 170 | 180 | 67 | | | | | | | 1 | 1 | | | 3 | | 20 | | 31 | | | | | | | | | 11 |
| 180 | 190 | 69 | | | | | | | | | | | 7 | | 12 | | 30 | | | | | | | | | 20 |
| 190 | 200 | 64 | | | | | | | 1 | | | 2 | 8 | | 18 | | 15 | | | | | 2 | | | | 18 |
| 200 | 210 | 81 | | | | | | | 1 | | | | 2 | | 22 | | 25 | | | | | 1 | | | | 30 |
| 210 | 220 | 68 | | | | 4 | | 1 | 2 | 4 | | 1 | 13 | | 21 | | 14 | 2 | 2 | | | | | 2 | | 2 |
| 220 | 230 | 60 | | | 1 | 5 | | | 1 | | | | 10 | | 31 | | 10 | | | | 2 | | | | | |
| 230 | 240 | 64 | | | 1 | | | | 4 | 1 | | 2 | 12 | | 28 | | 15 | | 1 | | | | | | | |
| 240 | 250 | 77 | | | 2 | 7 | | | 1 | 3 | | | 16 | | 28 | | 12 | | 3 | | | | 5 | | | |
| 250 | 260 | 46 | | 12 | 8 | 14 | | | 1 | | | | 6 | | 1 | | 1 | | 1 | | | | | | | 2 |
| 260 | 270 | 32 | | 16 | 1 | 12 | | | 2 | | | | | | | | | 1 | | | | | | | | |
| 270 | 280 | 38 | | 16 | 4 | 10 | | | | | | | 7 | | 1 | | | | | | | | | | | |
| 280 | 290 | 54 | | 16 | 8 | 10 | | | | | | | 3 | | 3 | | 2 | 4 | | | | | 4 | | | 4 |
| 290 | 300 | 53 | | 14 | 4 | 10 | | 3 | 1 | 3 | | | 5 | 1 | 3 | | 3 | | 1 | | | 2 | 1 | | 2 | |
| 300 | 310 | 59 | | 9 | 22 | 6 | | 9 | 2 | 1 | | 2 | | | 2 | | 5 | | | | | | | | 1 | |
| 310 | 320 | 52 | | 14 | 8 | 21 | | | | 1 | | 1 | 2 | | 2 | | | 2 | | | | | | | | 1 |
| 320 | 330 | 48 | | 27 | 0 | 10 | | 1 | | | | | 2 | | 4 | | 4 | | | | | | | | | |
| 330 | 340 | 40 | | 15 | 4 | 17 | | | | | | | | | | | 4 | | | | | | | | | |
| 340 | 350 | 36 | | 20 | 4 | 6 | | | | 3 | | | | | 1 | | 2 | | | | | | | | | |
| 350 | 360 | 29 | | 23 | 0 | 4 | | | | | | | | | 1 | | 1 | | | | | | | | | |
| 360 | 370 | 58 | | 36 | 2 | 16 | | | 1 | | | | | | | | 3 | | | | | | | | | |
| 370 | 380 | 50 | | 25 | 0 | 12 | | 2 | | 1 | | 1 | 1 | | 4 | | 2 | | 2 | | | | | | | |

ON-OT-4-66/JUSTICE #1

| start (Feet) | finish | **N=** | shale | Silt stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | Spic. pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 80 | 70 | | | 16 | 37 | | 7 | | | | 1 | 2 | | | | 4 | | 2 | | | 1 | | | | |
| 80 | 90 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 90 | 100 | 35 | | | 8 | 21 | | 3 | | | | 1 | | | | | 1 | | 1 | | | | | | | |
| 100 | 110 | 35 | | | 1 | 25 | | 2 | | | | 3 | | | 2 | | 1 | | 1 | | | | | | | |
| 110 | 120 | 99 | | | 39 | 39 | | 9 | 1 | | | 6 | | | 2 | | 3 | | | | | | | | | |
| 120 | 130 | 66 | | | 16 | 36 | | 6 | 1 | | 1 | 1 | | | 1 | | 3 | | 1 | | | | | | | |
| 130 | 140 | 82 | | | 19 | 47 | | 6 | | | | 3 | | 6 | | 0 | 1 | | | | | | | | | |
| 140 | 150 | 73 | | | 23 | 35 | | 3 | 2 | | | 3 | | | | | 1 | | 6 | | | | | | | |
| 150 | 160 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 160 | 170 | 66 | | | 16 | 30 | | 16 | 1 | | | | 2 | | | | 1 | | | | | | | | | |
| 170 | 180 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 180 | 190 | 75 | | | 18 | 39 | | 5 | | | 2 | | | | 4 | | 6 | | 1 | | | | | | | |
| 190 | 200 | 73 | | | 17 | 29 | | 11 | 2 | | | 2 | | | 5 | | 6 | | 1 | | | | | | | |
| 200 | 210 | 61 | | | 29 | 20 | | 4 | 2 | | | 2 | | | 1 | | 3 | | | | | | | | | |
| 210 | 220 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 220 | 230 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 230 | 240 | 57 | | | 14 | 28 | | 6 | | | | 3 | | | 1 | | 5 | | | | | | | | | |
| 240 | 250 | 52 | | | 7 | 29 | | 11 | | 2 | | | | | | | 3 | | | | | | | | | |
| 250 | 260 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 260 | 270 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 270 | 280 | 24 | | | 3 | 5 | | 1 | | | | | | | 1 | | 2 | | | | | | 12 | | | |
| 280 | 290 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 290 | 300 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 300 | 310 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 310 | 320 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 320 | 330 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 330 | 340 | 70 | | | 3 | 8 | | 1 | | 1 | | 1 | 10 | | 11 | | 32 | | 1 | | | | 2 | | | |
| 340 | 350 | 52 | | | 14 | 10 | | 1 | 3 | | | 1 | 5 | | 1 | | 8 | | | | | | 5 | | 4 | |
| 350 | 360 | 37 | | | 11 | 6 | | 3 | | 1 | | | 3 | | 1 | | 5 | | 3 | | | | 3 | | 1 | |
| 360 | 370 | 51 | | | 9 | 10 | | 1 | 11 | 1 | | 2 | 2 | | 2 | | 10 | | 2 | | | | | | 1 | |
| 370 | 380 | 105 | | | 12 | 4 | | 30 | 45 | | | 2 | | | 3 | | 9 | | | | | | | | | |
| 380 | 390 | 99 | | | 7 | 8 | | 16 | 52 | | | 1 | | | 6 | | 6 | | 3 | | | | | | | |
| 390 | 400 | 106 | | | | 1 | 8 | 13 | 77 | | | | | | | | 7 | | | | | | | | | |
| 400 | 410 | 93 | | | 3 | 5 | 2 | 18 | 56 | | | | | | 1 | | 8 | | | | | | | | | |
| 410 | 420 | 78 | | | 7 | 4 | | 12 | 51 | | | | | | | | 4 | | | | | | | | | |
| 420 | 430 | 73 | | | 4 | 5 | | 13 | 42 | | | | 1 | | 2 | | 5 | | 1 | | | | | | | |
| 430 | 440 | 74 | | 16 | 7 | | | 6 | 14 | 7 | | | | | 2 | | 16 | 1 | 5 | | | | | | | |
| 440 | 450 | 49 | | | 18 | 2 | 0 | 3 | 20 | 1 | | | | | | | 5 | | | | | | | | | |

PE-OT-1-66

| start | finish | N= | shale | dolostone | sandstone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. Wkst | benth wkst | fine wkst | glauc. Lime mud | glauc Sand | lime mud | plank sandy marl | Spic pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 10 | 36 | 36 | | 0 | | | | | | | | | | | | | | | | | | | | | |
| 10 | 20 | 40 | 40 | | 0 | | | | | | | | | | | | | | | | | | | | | |
| 20 | 30 | 90 | 3 | | | | | | | | | 4 | 19 | 0 | 44 | | 17 | | 3 | | | | | | | |
| 30 | 40 | 69 | | | | 2 | | 1 | 1 | 2 | | 2 | 24 | | 25 | | 9 | 1 | 2 | | | | | | | |
| 40 | 50 | 71 | 1 | 0 | 5 | 45 | | 4 | | | | | 4 | | 3 | | 9 | | | | | | | | | |
| 50 | 60 | 112 | | | 27 | 26 | | 4 | | | | 2 | 29 | | 6 | | 14 | 2 | 2 | | | | | | | |

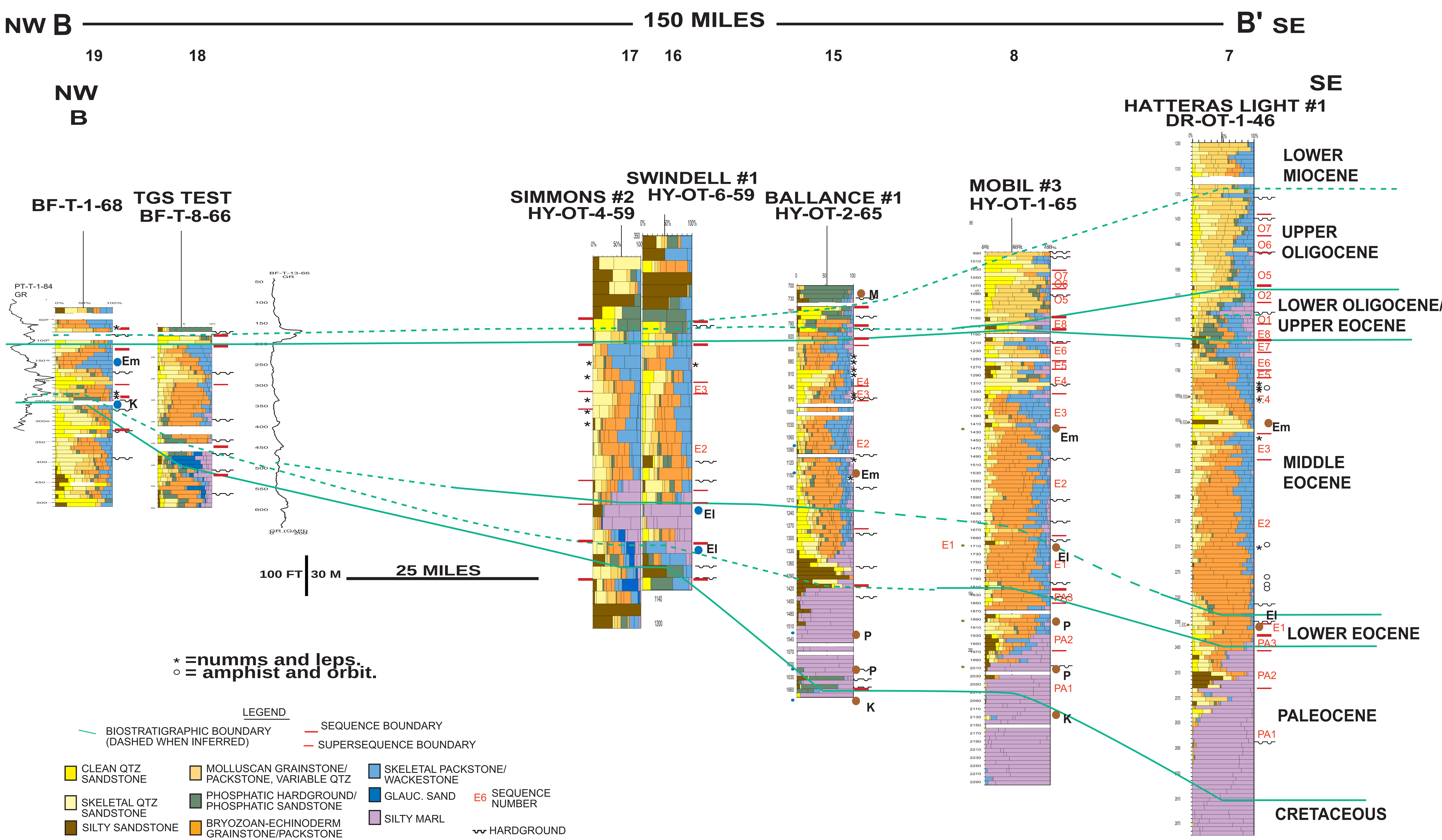
PE-OT-3-66

| start | finish | N= | shale | Dolo stone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sandst | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. Wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc Sand | lime mud | plank sandy marl | spic pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 90 | 100 | 72 | | | 4 | 4 | | 1 | 1 | 2 | | | 20 | | 35 | | 4 | | 1 | | | | | | | |
| 100 | 110 | 37 | | | 4 | 14 | | | | | | | 5 | | 7 | | 7 | | | | | | | | | |
| 110 | 120 | 96 | | | 8 | 4 | | | | | | 1 | 22 | | 43 | | 16 | 2 | | | | | | | | |
| 120 | 130 | 16 | | | | 2 | | | | | | | 2 | | 11 | | | | 1 | | | | | | | |
| 130 | 140 | 14 | | | 1 | 2 | | | | | | | 3 | | 6 | | 2 | | | | | | | | | |
| 140 | 150 | 20 | | | 1 | 8 | | | | | | | 7 | | 2 | | 1 | | 1 | | | | | | | |
| 150 | 160 | 23 | | | 1 | 3 | | | | 1 | | | 6 | | 7 | | 4 | 1 | | | | | | | | |
| 160 | 170 | 37 | | | 9 | 4 | | | | | | | 6 | | 14 | | 1 | 2 | 1 | | | | | | | |
| 170 | 170 | 14 | | | 1 | | | | | | | | 8 | | 2 | | 3 | | | | | | | | | |
| 170 | 180 | 24 | | | 3 | 6 | | | | | | | 5 | | 8 | | 2 | | | | | | | | | |
| 180 | 190 | 36 | | | 17 | 8 | | | 1 | | | | 3 | | 5 | | 2 | | | | | | | | | |
| 190 | 200 | 16 | | | 2 | 6 | | | | 1 | | | 2 | | 3 | | 2 | | | | | | | | | |
| 200 | 210 | 43 | 2 | | 12 | 16 | | | 1 | | | | 5 | | 5 | | 1 | | 1 | | | | | | | |
| 210 | 220 | 29 | 6 | 0 | 11 | 7 | | | 1 | 1 | | | | | 2 | | | 1 | | | | | | | | |
| 220 | 230 | 22 | 2 | | 6 | 10 | | | | | | 1 | | | 3 | | | | | | | | | | | |
| 230 | 240 | 20 | | | 8 | 4 | | | 1 | | | | 3 | | 3 | | 1 | | | | | | | | | |

PE-OT-5-66

| start | finish | N= | shale | dolostone | sand stone | skel. Sand | barn. Grst | sandy moll. Grst | moll. Grst | phos. H.g. | phos pebb. Sand | echin grst | skel. Pkst. | brach pkst | bryo grst | sandy lime mud | skel. Wkst | Benth wkst | fine wkst | glauc. Lime mud | glauc. Sand | lime mud | plank sandy marl | spic pkst | plank. Silty marl | plank shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | 60 | 26 | 26 | | | | | | | | | | | | | | | | | | | | | | | |
| 60 | 70 | 16 | 10 | | 0 | | | | | | | | | | | | | | 6 | | | | | | | |
| 70 | 80 | 74 | | | 5 | | | | | | | | 15 | | 35 | | 13 | | 6 | | | | | | | |
| 80 | 90 | 93 | | | | | | | | | | | 25 | | 55 | | 10 | 1 | 2 | | | | | | | |
| 90 | 100 | 30 | | | | | | | | | | | 16 | | 10 | | 3 | | 1 | | | | | | | |
| 100 | 110 | 65 | | | | 1 | | | | | | 1 | 33 | | 17 | | 13 | | | | | | | | | |
| 110 | 120 | 75 | | | | | | | | | | 1 | 23 | | 28 | | 19 | | 4 | | | | | | | |
| 120 | 130 | 83 | | | | | | | | | | | 43 | | 23 | | 11 | 3 | 3 | | | | | | | |
| 130 | 140 | 46 | | | | | | | | | | | 27 | | 12 | | 5 | | 2 | | | | | | | |
| 140 | 150 | 35 | | | | | | | 1 | | | | 14 | | 15 | | 4 | | 1 | | | | | | | |
| 150 | 160 | 48 | | | 4 | 6 | | | 1 | 4 | | | 9 | | 16 | | 3 | 1 | 3 | 1 | | | | | | |
| 160 | 170 | 59 | | | 9 | 10 | | | | 2 | | | 13 | | 16 | | 6 | | 3 | | | | | | | |
| 170 | 180 | 63 | | | 10 | 12 | | 14 | 7 | 3 | | | 8 | | 5 | | 2 | | 1 | 1 | | | | | | |
| 180 | 190 | 60 | | | 19 | 16 | | 17 | 2 | | | 1 | 1 | | 1 | | 1 | | 2 | | | | | | | |
| 190 | 200 | 0 | | | | | | | | | | | | | | | | | | | | | | | | |
| 200 | 210 | 49 | | | 14 | 25 | | | 2 | 1 | | | 2 | | 3 | | 1 | | | | 1 | | | | | |
| 210 | 220 | 51 | | | 14 | 20 | | 8 | 3 | | | | | | 4 | | 2 | | | | | | | | | |
| 220 | 230 | 39 | | | 7 | 10 | | 3 | | 1 | | | 6 | | 10 | | 2 | | | | | | | | | |
| 230 | 240 | 45 | | | 12 | 8 | | 2 | 1 | | | | 5 | | 13 | | 4 | | | | | | | | | |
| 240 | 250 | 61 | | | 14 | 7 | | | 1 | | | 1 | 19 | | 12 | | 4 | | 3 | | | | | | | |
| 250 | 260 | 46 | | | 41 | 2 | | | 2 | | | | | | 1 | | | | | | | | | | | |


APPENDIX D. LITHOLOGIC, BIOSTRATIGRAPHIC, AND SEISMIC DATA FROM STRIKE SECTION A-A'.




APPENDIX E. LITHOLOGIC, BIOSTRATIGRAPHIC, AND SEISMIC DATA FROM DIP SECTION B-B'.

APPENDIX F. COMPILATION OF AVAILABLE BIOSTRATIGRAPHIC DATA FROM WELLS.

Well: Atlantic Beach #1
No data

Well: Ballance #1
Brown et al. (1972)
1065:M. Eocene
1133:M. Eocene
1521:Paleocene
1609:Paleocene

Well: Batts #2
No data

Well: Baylands #1
Brown et al. (1972)
681:Oligocene
785:M. Eocene
965:M. Eocene
1615:L. Eocene
1790:Paleocene

Laws (unpublished)
680-780: Oligocene-M. Eocene
1650-1755: L.- M. Eocene (NP11-16)
1755-1860: U. Cretaceous (CC22-26)

Well: BF-C-1-68
Bralower (unpublished)
187': M. Eocene (NP 16)

Well: BF-T-1-68
Bralower (unpublished)
260: U. Cretaceous
340: U. Cretaceous

Well: BF-T-1-68
Bralower (unpublished)
260: U. Cretaceous
340: U. Cretaceous

Well: Cowan #1
Brown et al. (1972)
27:M. Eocene
52:Cretaceous

Well: Esso #2
Brown et al. (1972)
1480:M. Eocene

Zarra (1989)
1319:L. Oligocene
1419:M. Eocene
1919:U. Paleocene
1939:U. Paleocene
2179:U. Paleocene
2239:U. Cretaceous

Laws (unpublished)
1350-1400: Oligocene
1890-1900: L. Oligocene (NP21-22)
1900-1940: U. Eocene (NP19-20)
2000-2010: M. Eocene (NP15-17)
2060-2210: L-M. Eocene (NP12-14)

Well: Evans #1
No data

Well: Hatteras Light #1
Brown et al. (1972)
1853:M. Eocene
1910:M. Eocene
2400:L. Eocene
Laws (unpublished)
1650-1760:L. Oligocene-M. Eocene
2490-2850: M. Eocene

Well: Huntley-Davis #1
Brown et al. (1972)
407:Oligocene
430:Oligocene
805:M. Eocene
1015:M. Eocene
1470:L. Eocene

APPENDIX F. COMPILATION OF AVAILABLE BIOSTRATIGRAPHIC DATA FROM WELLS.

Well: Justice #1
No data

Well: Lea #1
Brown et al. (1972)
45:Oligocene
56:Oligocene
141:M. Eocene
235:Cretaceous

Well: Mobil #1
Brown et al. (1972)
889: M. Eocene
1250:Paleocene
1335:Cretaceous

Zarra (1989)
1226:U. Paleocene
1266:U. Paleocene
1316:U. Cretaceous

Well: Mobil #2
Brown et al. (1972)
1568:M. Eocene
2020:L. Eocene
2289:L. Paleocene

Zarra (1989)
1216:U. Oligocene
1226:U. Oligocene
1426:L. Oligocene
1476:U. Eocene
1496:U. Eocene
1536:M. Eocene
2156:U. Paleocene
2176:U. Paleocene
2236:L. Paleocene
2436:U. Cretaceous

Well: Mobil #3
Brown et al. (1972)
1268:M. Eocene
1525:M. Eocene
1827:Paleocene
2015:L. Paleocene
2135:Cretaceous

Zarra (1989)
No diagnostic faunas

Well: Marshall Collins #1
Brown et al. (1972)
1180:M. Eocene
1678:Paleocene
1803:Cretaceous

Zarra (1989)
1006:U. Oligocene
1016:U. Oligocene
1086:L. Oligocene
1146:M. Eocene
1206:M. Eocene
1566:L. Eocene
1586:U. Paleocene
1726:L. Paleocene
1746:L. Paleocene
1766:L. Paleocene
1786:U. Cretaceous

Well: Simmons #2
No data

APPENDIX F.  COMPILATION OF AVAILABLE BIOSTRATIGRAPHIC DATA FROM WELLS.

Well:  Swindell #1

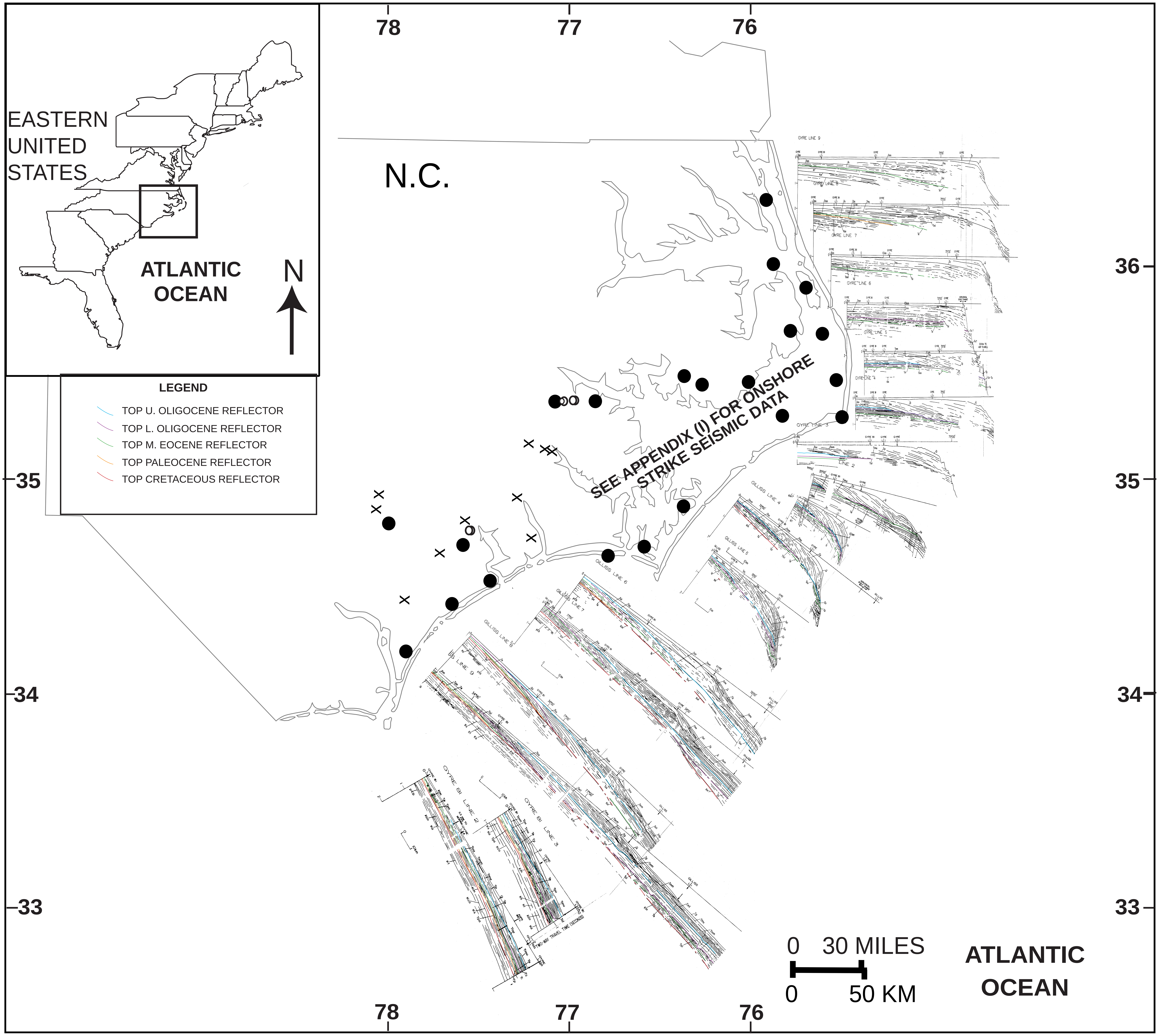
Bralower (unpublished)
1020: L. Eocene (NP 12-13)
1100: L. Eocene (NP 12-13)

Well:  TGS Test
No data, but projected from BEA-T-31:
Brown et al. (1972)
156: M. Eocene
430: Paleocene
515: U. Cretaceous

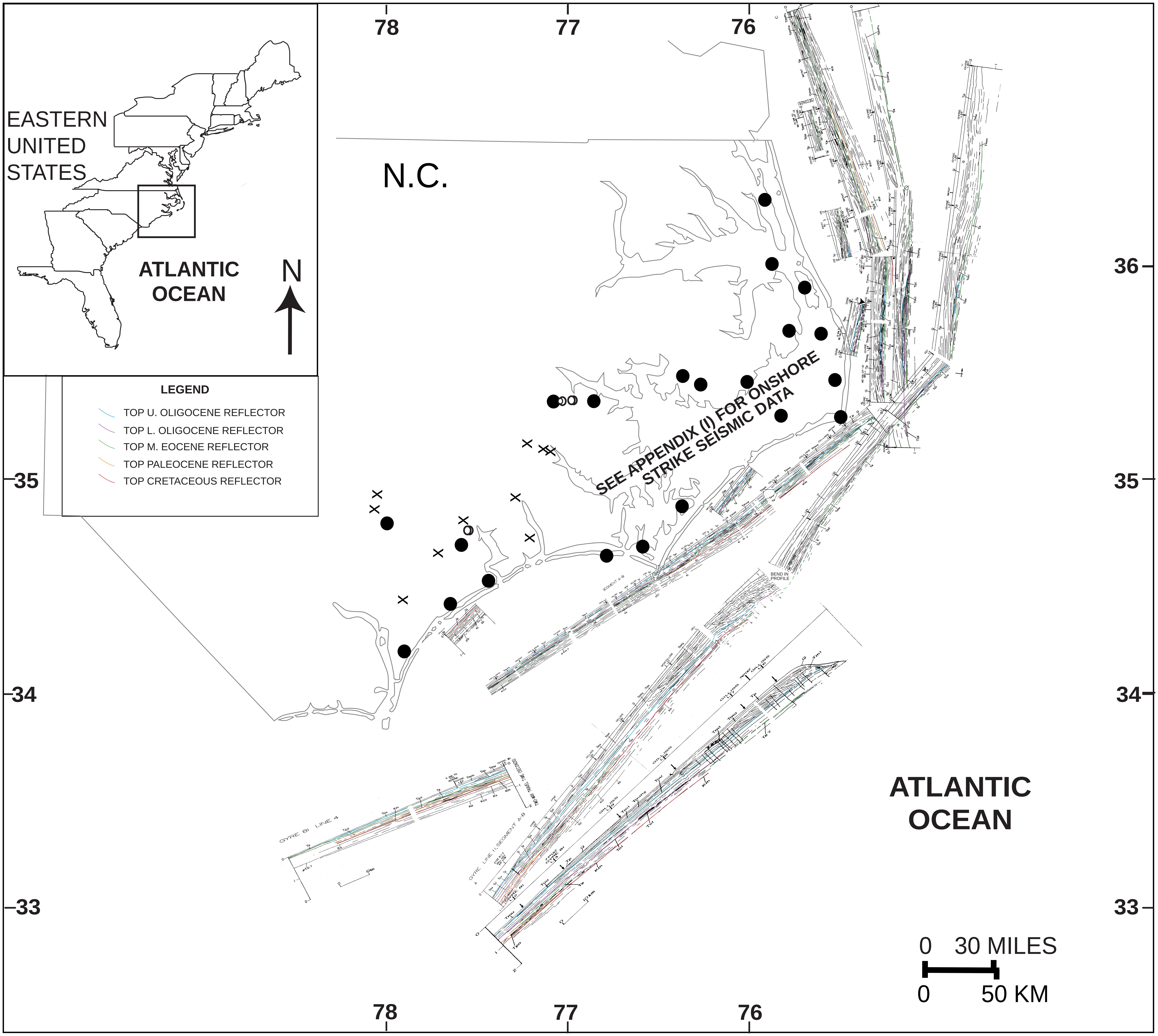
Well:  Twiford #1
Brown et al. (1972)
692:Miocene
765:M. Eocene
885:M. Eocene
940:L. Eocene
1009:Paleocene
1039:Paleocene
1096:Cretaceous

Well:  Westvaco #1
No Data

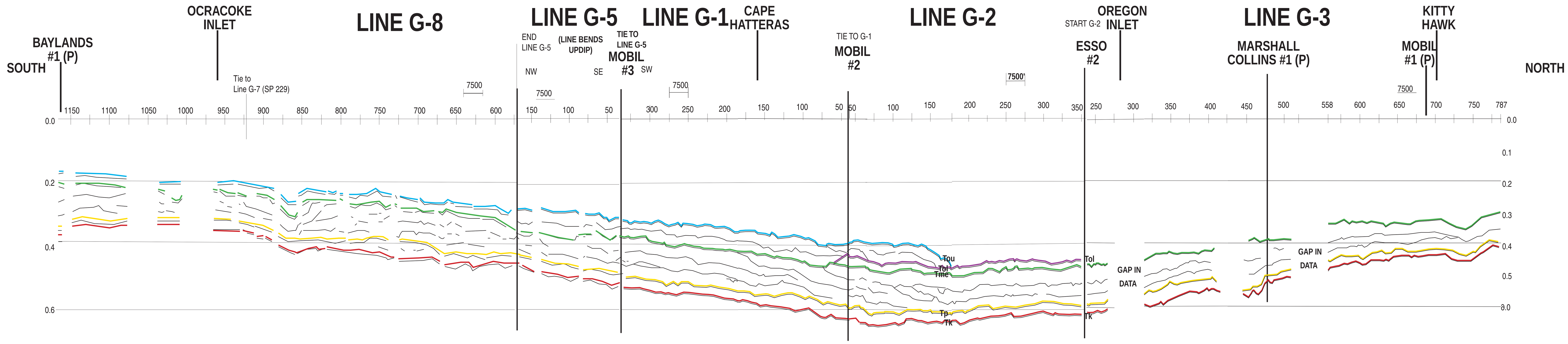
Well:  Wrightsville Beach
No data



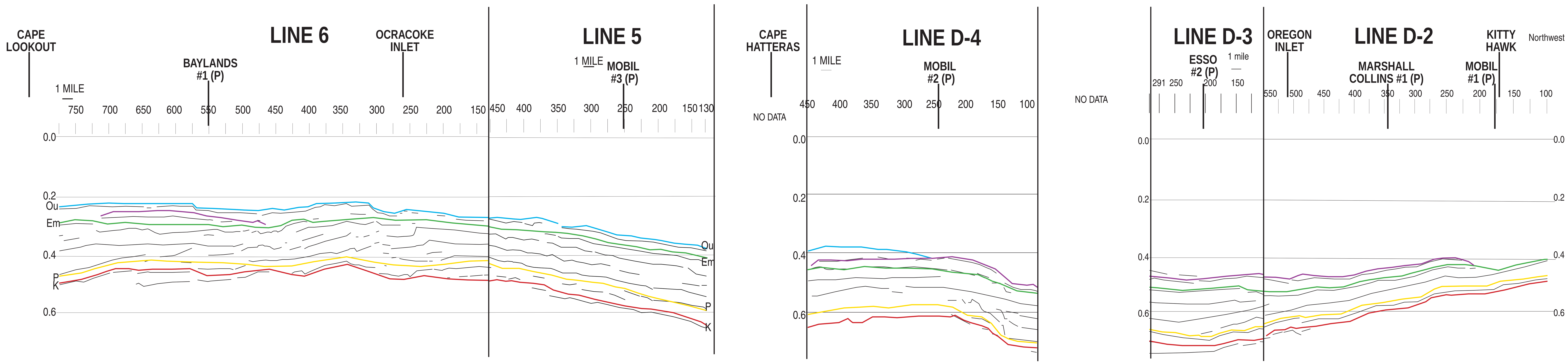

APPENDIX H. SHELF SEISMIC DIP LINES FROM POPENOE (1985).



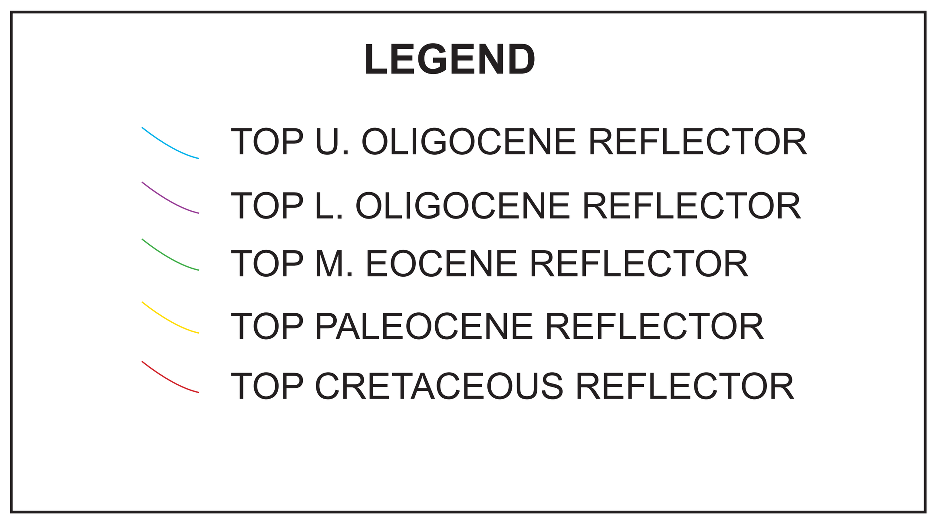

APPENDIX H. SHELF SEISMIC STRIKE LINES FROM POPENOE (1985).

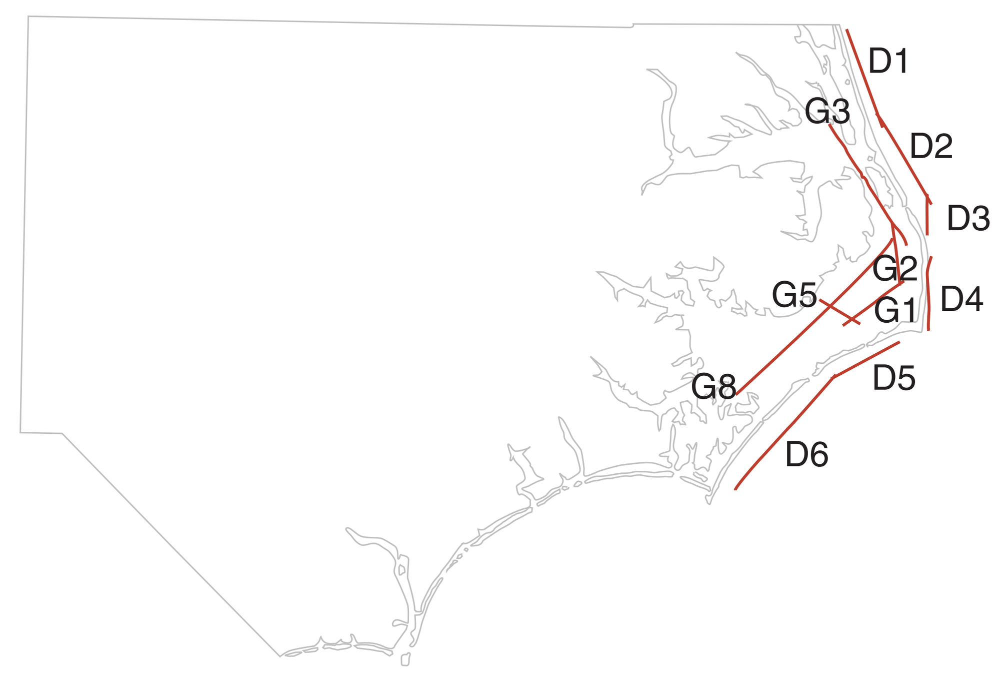



Pamlico/Albemarle Sound Seismic surveys G3, G2, G1, G5, and G8 (Geoph. Service, Inc.)




Offshore Barrier Island Seismic surveys D2, D3, D4, D5, and D6 (Digicon)




Appendix I. Interpreted strike seimic data from Pamlico and Albemarle Sounds, and just seaward of the barrier island complexes. (See inset for locations). Hard copies of data obtained from the N. C. Geological Survey.

## CURRICULUM VITAE

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**PERSONAL INFORMATION:**

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**EDUCATION:**

Ph.D., Geology, Virginia Tech, August 1995-December 1999

B.S., Geology, 1995, University of North Carolina at Chapel Hill

**POSITIONS HELD:**

| | |
|---|---|
| Intern, Amerada Hess Corporation, | Summer 1998 |
| Graduate teaching assistant, Virginia Tech, | Fall 1995 to Fall 1999 |
| Field research assistant, Sierra Nevada, CA,<br>University of North Carolina | Summer 1995 |
| Research assistant,<br>Research Laboratories of Anthropology<br>University of North Carolina | 1991-1995 |

**TEACHING EXPERIENCE:**

Instructor for Sedimentology/Stratigraphy, Historical, and Physical Geology laboratories
Organized and taught lower and upper level undergraduate classes in both classroom and field exercises, specializing in stratigraphy and petrology of carbonate and siliciclastic sedimentary rocks

**AWARDS:**

Outstanding senior in geology, University of North Carolina, 1995

Phi Beta Kappa, University of North Carolina, 1995

Phi Kappa Phi, VPI&SU, 1998

Tillman award for teaching excellence, VPI&SU, 1996

Eagle Scout, Boy Scouts of America, 1988

**GRANTS:**

American Association of Petroleum Geologists, 1998, 1999

Society of Professional Well Log Analysts, 1997, 1999

Geological Society of America, 1997, 1999

**PUBLICATIONS:**

Coffey, B. P. and Read J. F., 1999, Facies and sequence stratigraphic development of Paleogene mixed carbonate-siliciclastic units, North Carolina coastal plain and continental shelf: 1999 GSA Annual Meeting, Abstracts with Program, p. A-182.

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Peyer, K., Carter, J., Campbell, D., Campbell, M., **Coffey, B.**, Olsen, P., and Sues, H., 1999 An articulated skeleton of a new rauisuchian archosaur, with gut contents, from the Late Triassic of North Carolina: 1999 GSA Annual Meeting, Abstracts with Program, p. A465.

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Coffey, B. P. and Textoris, D. A., 1995, Using Paleosols to derive paleoclimatic evolution in the Durham sub-basin of the Triassic Deep River Basin, NC; Abstracts with Programs, Geological Society of America Southeastern Section, v. 27, no. 2., p. A-44.

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