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July 1983

THE POST EOCENE STRATIGRAPHY OF SOUTHERN COLLIER COUNTY, FLORIDA

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Roland Peacock

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(Revised)

RESOURCE PLANNING DEPARTMENT
SOUTH FLORIDA WATER MANAGEMENT DISTRICT
WEST PALM BEACH, FLORIDA

JULY 1983

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THE POST EOCENE STRATIGRAPHY OF SOUTHERN COLLIER COUNTY, FLORIDA

by

Roland Peacock

Final Project Report
USF-SFWMD Cooperative Program,
Collier County Stratigraphic Mapping Project

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July 1983

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PREFACE

Over the past several years, the South Florida Water Management District has funded applied research through the State University system in subject areas appropriate to its responsibilities in water resources management.

This study was undertaken for several reasons. Based on preliminary studies, District staff recognized that stratigraphic definition of the lithologic sequence in Collier County was vital to the understanding and assessment of the groundwater resources of the county. Although considerable data existed, no comprehensive attempt to define the geologic framework of the area had previously been made. Knowledge of the geologic framework forms a basis for understanding water quality relationships, variations in water availability both vertically and areally, and the potential of the aquifer for use as storage reservoirs or for waste disposal.

This investigation is one of a series of studies being undertaken by or in cooperation with the District to assess the fresh water resources of the county. Extensive surface DC resistivity studies have been completed to define the fresh water/saline water relationships in the area and to assess the usefulness of this technique in defining shallow lithologies (SFWMD Technical Publications 82-5 and 82-6 by Layton and Stewart, 1982; and Stewart, Lizanec and Layton, 1982). Hydrogeologic studies in the Naples area have been completed by Gee & Jenson, Inc. (Big Cypress Basin Board Report, 1980) and Jakob (SFWMD Technical Publication 83-3, 1983). A deep well drilling program consisting of nine wells has also been completed. At present four series of aquifer tests are being carried out in the county.

The previously mentioned studies will form the basis for a comprehensive reconnaissance level summary, which is now being undertaken by District staff to determine the availability of groundwater in the western part of the county, facilitate optimization of strategies and alternatives to meet the increased demands for water in future years, and assist in the management and allocation of groundwater.

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ACKNOWLEDGEMENTS

The author wishes to express his gratitude to the South Florida Water Management District which provided funding and support for this project. Credit is also given to the Florida Bureau of Geology and to Exxon Company, U.S.A., for providing valuable samples and geophysical information.

Many thanks are also due to committee members Dr. J. B. Cowart, Dr. W. C. Parker, and especially Dr. S. W. Wise. Dr. J. K. Osmond, Dr. W. F. Tanner, and Dr. R. C. Wright also provided helpful discussions and information.

I would personally like to thank Mssrs. Dennis Cassidy, Tom Scott, Walter Schmidt, and David Watkins.

ABSTRACT

The post-Eocene, pre-Pleistocene sediments of southern Collier County, Florida, consist of three formations: the Suwannee Limestone, the Hawthorn Formation, and the Tamiami Formation. The Tampa Formation is not recognized in the study area.

The Suwannee Limestone stratigraphically overlies the Ocala Limestone and is subdivided into an upper and lower unit, Su-2 and Su-1, respectively. Even though the top of the Ocala Limestone has relief in excess of 300 feet (91 m), there is no systematic thickening or thinning of unit Su-1 over the Ocala lows and highs. Unit Su-2 does thicken over the lows and pinches out over the highs, suggesting tectonic activity after the deposition of unit Su-1 but before or during the deposition of unit Su-2.

In the past, the Suwannee-Hawthorn contact in South Florida has been picked at the first occurrence of *Miogypsina hawkinsi*. In this study, a lithologic criterion, the first consistent up-hole occurrence of appreciable amounts of phosphorite (1% or more) was used to mark this boundary.

The Hawthorn Formation overlies the Suwannee Limestone and has been divided into seven informal units, units H-1 through H-6 and H-X. *Miogypsina sp.* was found in unit H-2 and *Arachaias floridanus* in unit H-3. Unit H-2, containing *Miogypsina sp.*, is an excellent marker bed within the study area. Cole (1941) would have placed unit H-2 within the Suwannee Limestone and part of unit H-3 within the Tampa Formation. In the past, sediments in units H-4, H-5, H-6, and H-X have been included in the Tamiami Formation by some authors.

Following the deposition of unit H-3, a north-south trending trough-shaped depression existed in the central part of the study area. This

depression served as a "funnel" through which clastic sediments from the north were introduced into the marine environment of the study area.

The Tamiami Formation is represented by the uppermost limestone unit in western Collier County. This formation, which represents a major transgression, thickens toward the west.

INTRODUCTION

There has been much uncertainty about the subsurface geology of post-Eocene sediments in Collier County, Florida, because most subsurface information in the past has been collected primarily from either shallow water wells or the deeper intervals of oil wells. The resulting gap in geologic knowledge extends from approximately 250 feet (76 m) to a few thousand feet and includes the majority of the post-Eocene section.

Cuttings and geophysical information from 25 boreholes (Table 1; Figure 1) in southern Collier County, recently supplied by the South Florida Water Management District and Exxon Company, U.S.A., have provided an opportunity to examine the post-Eocene section to greater depth and in more detail than previously possible. It should be noted, however, that the present borehole spacing is still on the order of six to eight miles, thus this study should be regarded as a reconnaissance.

TABLE 1

Location and Depth of Study Boreholes

Well #	Depth (feet) below MSL)	Latitude*	Longitude *	Gamma-Ray	Electrical Resistivity
W-2004	498	25°48'30"	81°43'40"		
W-2420	1320	26°05'17"	81°41'50"		
W-4937	398	25°55'00"	81°43'20"		
W-8899	1032	26°02'00"	81°19'45"		
W-8951	1247	25°55'00"	81°21'30"		
W-9413	1491	26°01'10"	81°15'15"		
W-9905	1265	26°10'35"	81°07'40"		
W-10014	1198	26°02'05"	81°09'25"		
W-10180	1282	25°57'08"	81°18'45"		X
W-10183	1151	25°55'30"	81°04'25"		X
W-10184	1171	25°55'55"	81°02'45"		X
W-10187	1140	25°55'50"	81°00'25"		X
W-10188	1112	26°13'00"	81°13'45"		
W-10190	1302	25°55'00"	81°14'05"		X
W-10201	1373	26°01'12"	81°25'10"		X
W-10202	1380	26°01'02"	81°25'00"		X
W-10223	1359	26°06'00"	81°29'30"		X
W-14534**	529	26°09'05"	81°42'15"	X	X
W-14601**	998	26°09'08"	81°33'17"	X	X
W-14918**	887	26°09'10"	81°25'39"	X	X
W-14919**	1205	26°09'16"	81°18'53"	X	X
W-14920**	1234	26°56'23"	81°28'08"	X	X
W-14921**	798	25°58'57"	81°42'52"	X	X
W-14922**	494	25°59'10"	81°35'55"	X	X
W-14934**	785	25°57'30"	81°21'11"	X	X

*approximate values; accurate to within 45 seconds
**drilled by the South Florida Water Management District

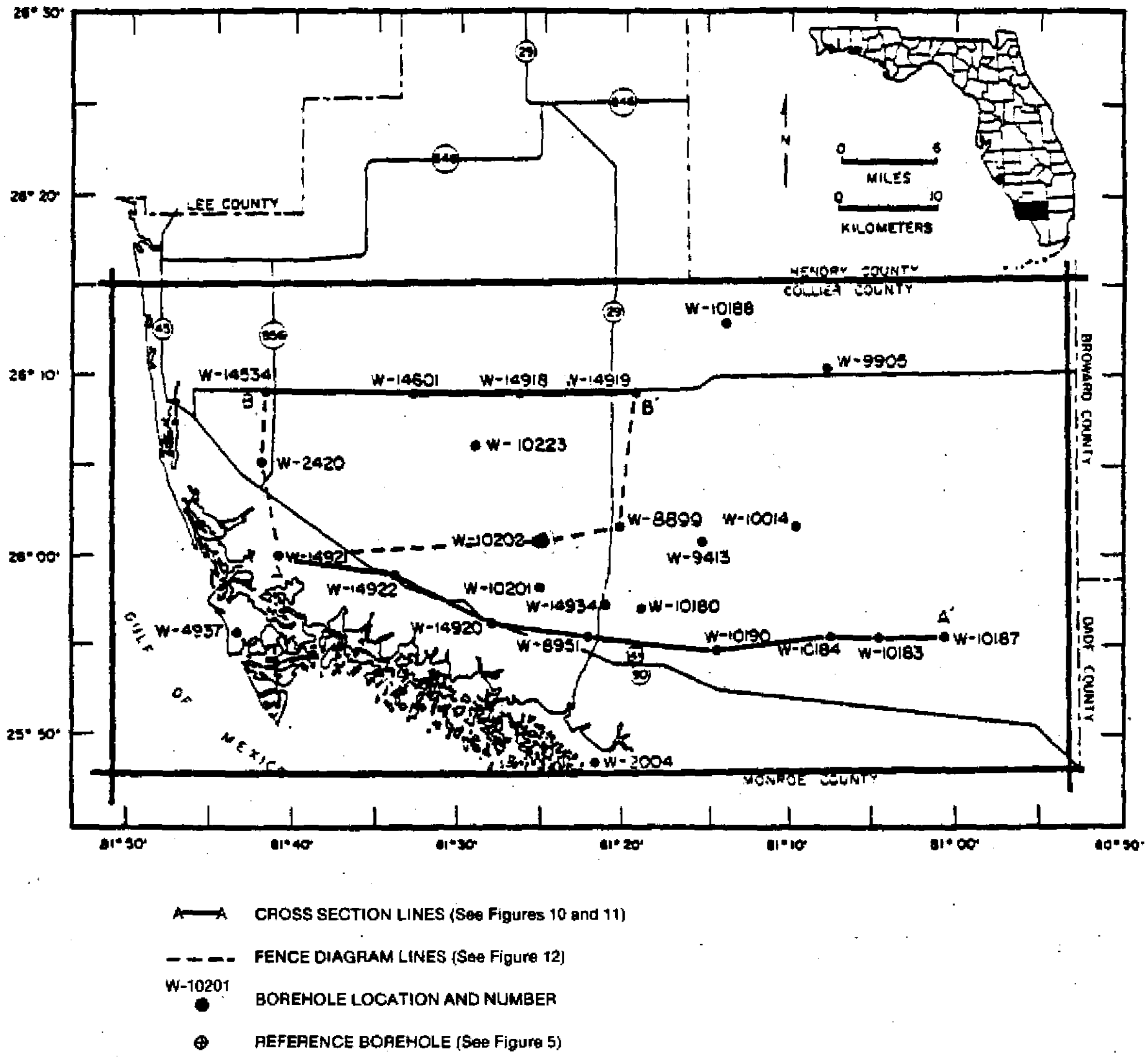

FIGURE 1 Location of the Study Area, the 25 Boreholes Used in Study, Cross Section Lines and Fence Diagram Lines.

PREVIOUS STUDIES

Regional studies encompassing various portions of the post-Eocene section in South Florida have been conducted by Toulmin (1955), Chen (1965), Stringfield (1966), Stringfield and LeGrand (1966), and Puri and Winston (1974). These studies have been summarized by Mooney, *et al.* (1980) who also traced the evolution of the stratigraphic nomenclature applied to the Eocene and Oligocene units in south Florida. Studies dealing more specifically with Collier County or surrounding areas are those by Cole (1941), Myers (1952), Klein (1954), McCoy (1962), Deju and Miller (1974), Anonymous (1977), Jakob (1980), Meeder (1980), Nettles (1980), and Peck, *et al.* (1979).

Myers (1952) examined the insoluble residue of cuttings from a well in north-central Collier County. The studies of Klein (1954), McCoy (1962), Nettles (1980), and Jakob (1980) were water-resource studies for parts of Collier County. They briefly described the geologic framework of the upper 400 feet (122 m) of sediment in their study area. While also investigating water resources, Deju and Miller (1974) and Anonymous (1977) examined sediments within Collier County to a greater depth than the other studies mentioned. However, Anonymous (1977) examined only three wells, all within a 500 foot (152 m) radius, and Deju and Miller (1974) based their lithologic information on drillers' logs and electrical resistivity logs. Meeder (1980) drilled a series of shallow cores in southern Lee and northwestern Collier Counties and traced a reef complex in the upper Tamiami Formation. Peck, *et al.* (1980) also traced the evolution of the stratigraphic nomenclature applied to the upper Neogene sediments in southwest Florida.

For the present study, it is important to note the work of Cole (1941) because of the criteria and precedents he established for recognizing the Tampa Formation and Suwannee Limestone in south Florida. Cole used the occurrence of *Archaias floridanus* as a criterion for extending the Tampa Formation into south Florida. A recent study by King and Wright (1979), however, restricts the Tampa Formation to west central Florida, and in the present paper their recommendations are followed.

Cole (1938,1941) recognized three species of *Miogypsina* in Florida. He considered all three species to be restricted to the Suwannee Limestone of Oligocene age and used *Miogypsina hawkinsi* to mark the top of the Suwannee Limestone. This concept was followed as late as 1974 by Puri and Winston. Cole's criterion, however, is paleontologic and is not suitable for subdivision of the rock-stratigraphic section. A lithologic criterion, namely the first consistent uphole occurrence of appreciable amounts of phosphorite (1% or more), therefore, will be used in this paper to pick the top of the Suwannee Limestone.

The definitions of the Hawthorn and Tamiami Formations and their boundaries have followed a convoluted history. The Tamiami Limestone was first described by Mansfield (1939). The term "Tamiami Formation" was originally used by Parker (1942), although a proper type section had never been established by Mansfield (1939). Parker (1951) redefined the Tamiami Formation to include parts of the Hawthorn Formation of late Miocene age. Hunter and Wise (1980) suggested that the Tamiami Formation be redefined back to the concept outlined by Parker and Cooke (1944), which would exclude the former Hawthorn sediments. In essence, this concept as suggested by Hunter and Wise, will be used in this paper.

FIELD METHODS

Cuttings used in the study were recovered from boreholes drilled by the rotary method with a circulating drilling fluid. Except for well W-2420, which had cuttings collected at 30 foot (9 m) intervals, all other cuttings were collected at 10 foot (3 m) intervals. No cores were available. For those boreholes drilled by the South Florida Water Management District (Table 1), cuttings were collected by straining the drilling fluid with a wire-mesh screen. At 10 foot intervals the drilling process was stopped, but the drilling fluid was allowed to continue to circulate through the hole until a marked decrease in cutting return at the surface was noted. This not only minimized contamination, but permitted the depth which the cutting represented to be established with confidence.

Of the 25 boreholes used for this study, 16 have some geophysical information (Table 1). Eight drilled by the South Florida Water Management District have an extensive suite of geophysical logs including natural-gamma, neutron, 64 inch normal, 16 inch normal, and caliper. The other eight boreholes, drilled by Exxon Company, U.S.A., have only a self-potential curve and one very short-spaced resistivity curve. The short-spaced resistivity curve has proven to be an excellent discriminator of lithologies in this study; however, for the eight boreholes logged by the South Florida Water Management District, the natural-gamma log has proven to be more useful than electrical resistivity logs. A more detailed discussion of geophysical logging techniques, tools, and the utility of the various curves in the lithologies found in Florida is given by Mooney, et al. (1980).

LABORATORY METHODS

Lithologic determinations of the cuttings (Appendix B) were made using a binocular microscope. The lithologies generally were composed of some mixture of three minerals - - calcite , quartz, and dolomite. For some intervals, the dominant mineral was difficult to determine with the binocular microscope and x-ray diffraction was used to determine composition.

A quantitative x-ray analysis was made using the calibrations graphed in Figures 2, 3, and 4. These graphs relate the ratio of two minerals in a sample to their ratio of relative peak intensities. The graphs were constructed by mixing known quantities of two minerals in varying proportions and calculating the corresponding relative peak ratio.

Lithologic descriptions of limestones include the terms calcarenite and calcilutite from Grabau (1904). Both terms were applied to the rock as a whole and, therefore, may be an indication of either allochem or matrix grain size. This is a purely descriptive classification and has no genetic implication. The term "limestone" was used to indicate a recrystallized calcarenite or calcilutite. In Folk's (1959) classification, "limestone" as used in this paper would be a sparite (recrystallized); "calcarenite" could be either a biomicrite or a biosparite, and "calcilutite" would probably be a biomicrite.

Due to the small cutting chip size, original rock textures were impossible to determine; therefore, the Dunham (1962) classification cannot be related to the terms used in this paper.

Smear slides of raw sediment were made for one lithologic unit (unit H-4) from boreholes W-10188 and W-10187. Using these smear slides, diatom bearing zones were identified in W-10188 from a depth of 130 to 190 feet

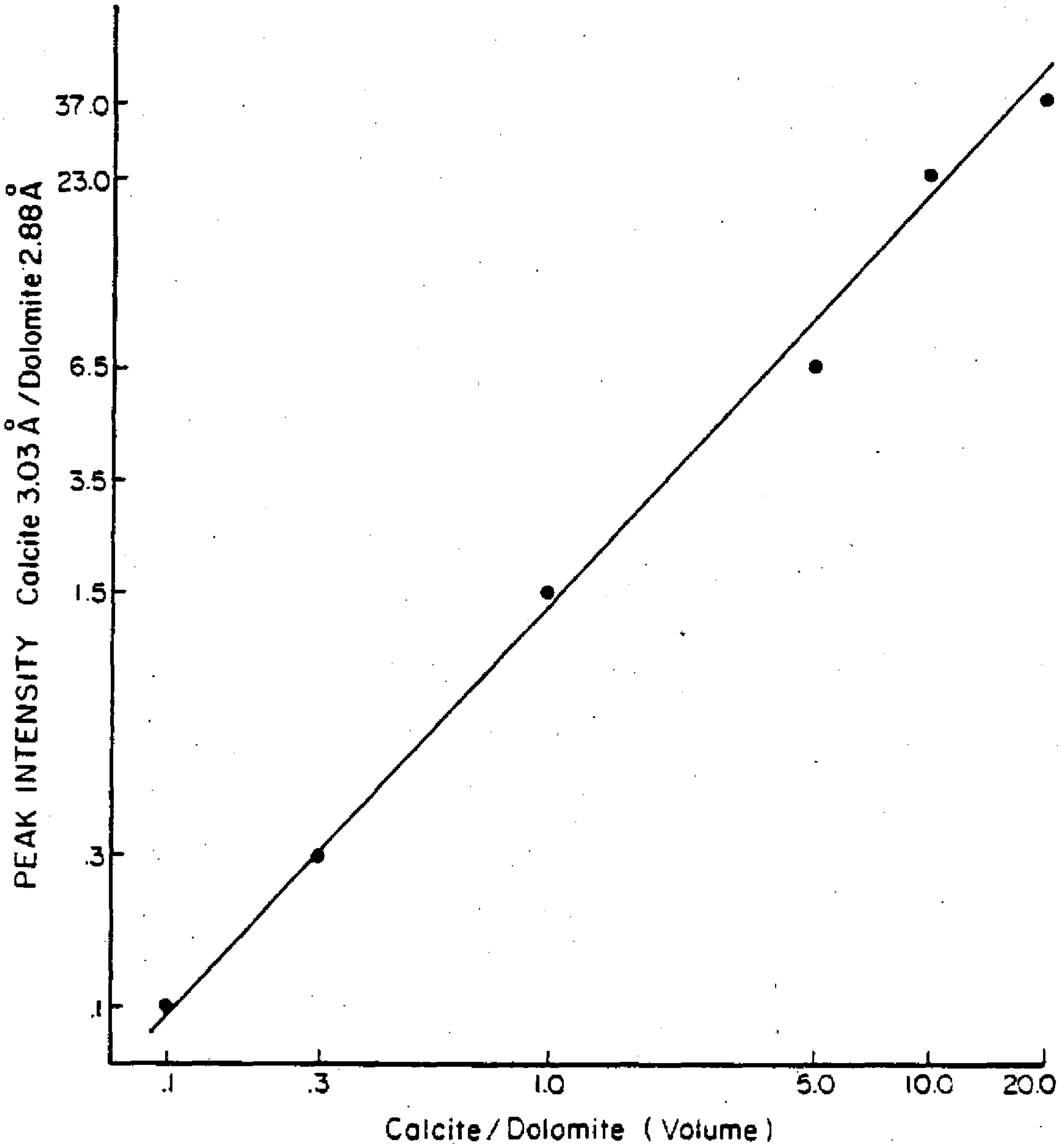

FIGURE 2 The Relationship of the Peak Intensity of Calcite and Dolomite to the Ratio of the Volume of the Two Minerals in a Sample.

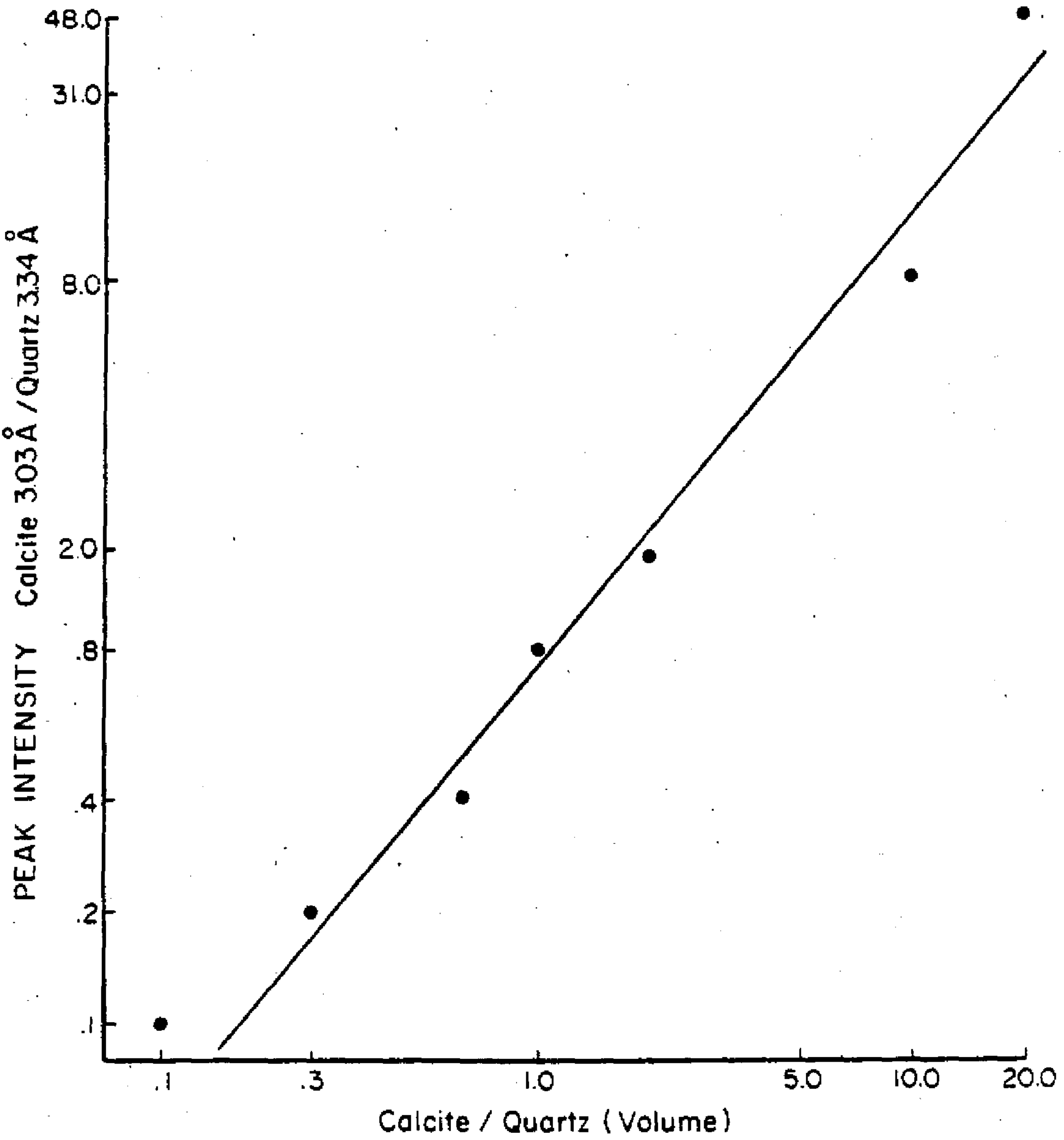

FIGURE 3 The Relationship of the Peak Intensity of Calcite and Quartz to the Ratio of the Volume of the Two Minerals in a Sample.

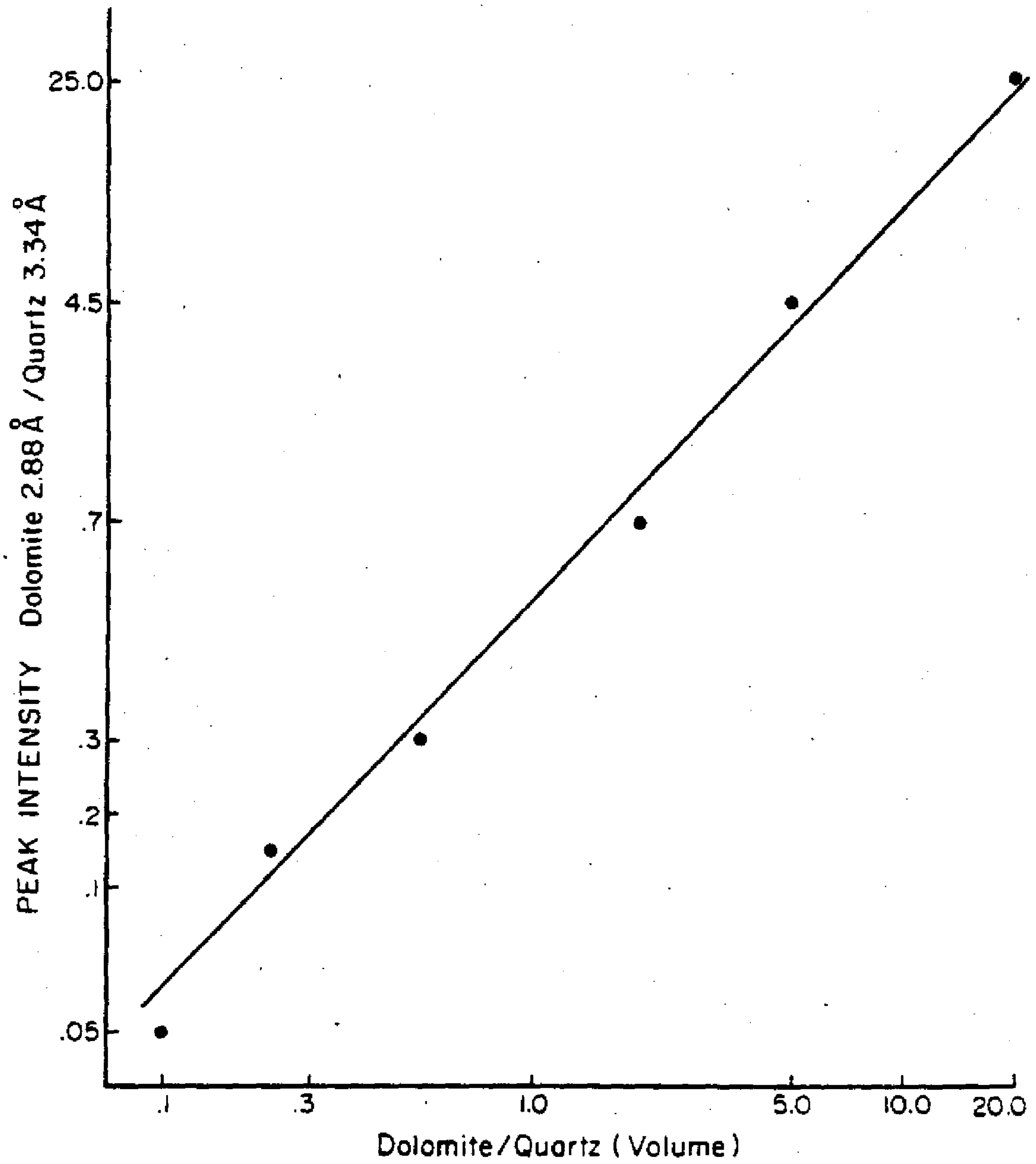

FIGURE 4 The Relationship of the Peak Intensity of Dolomite and Quartz to the Ratio of the Volume of the Two Minerals in a Sample.

(40-58 m) and in W-10187 from a depth of 140 to 260 feet (43-79 m). Samples of the intervals containing diatoms were then scraped into beakers containing distilled water. The samples were stirred, and after 30 seconds the suspension was poured off and saved. The suspended materials were stirred again, left for 30 minutes, and the supernatant poured off at the end of this time. The diatom rich residues were examined with a scanning electron microscope to identify environmental and age indicators.

Columnar sections were constructed from the lithologic descriptions for all 25 boreholes. The geophysical information was used to adjust lithologic contacts in a few cases.

STRATIGRAPHY

Lithologies

Eleven lithologic units were recognized in this study. For the following description, borehole W-10202 (Figure 5) was chosen as a reference borehole because it penetrated all lithologic units and shows important facies relationships.

The Ocala Limestone of Eocene age underlies the post-Eocene section. The top of this unit is a very hard, white limestone containing small *Lepidocyclina sp.* and numerous fragments of a coralline red algae (David Watkins, 1981, personal communication). In a few of the boreholes penetrating a greater thickness of Ocala, a soft, white limestone, containing numerous *Camerina sp.*, was encountered.

Above the Ocala is the Suwannee Limestone, traditionally considered Oligocene in age by most authors. This formation was divided into a lower and upper unit , Su-1 and Su-2, respectively.

The top of the Ocala Limestone was separated from the Suwannee Limestone on the basis of very subtle lithologic changes. These included a change from a very white to a beige limestone with no *Lepidocyclina sp.* In other parts of the state, the contact is easily picked from numerous large *Lepidocyclina sp.* in the Ocala Limestone, and because an unconformity accentuates the lithologic contact.

Armstrong (1980) suggested that the Ocala Limestone in part of south Florida may have been deposited in deeper water than in most of the rest of the state. This would account for the presence in some sections of only a few small *Lepidocyclina sp.*, which is presumed to be a shallow water fauna. It could also indicate that the unconformity between the Ocala Limestone and the overlying formation might not be present in south Florida due to

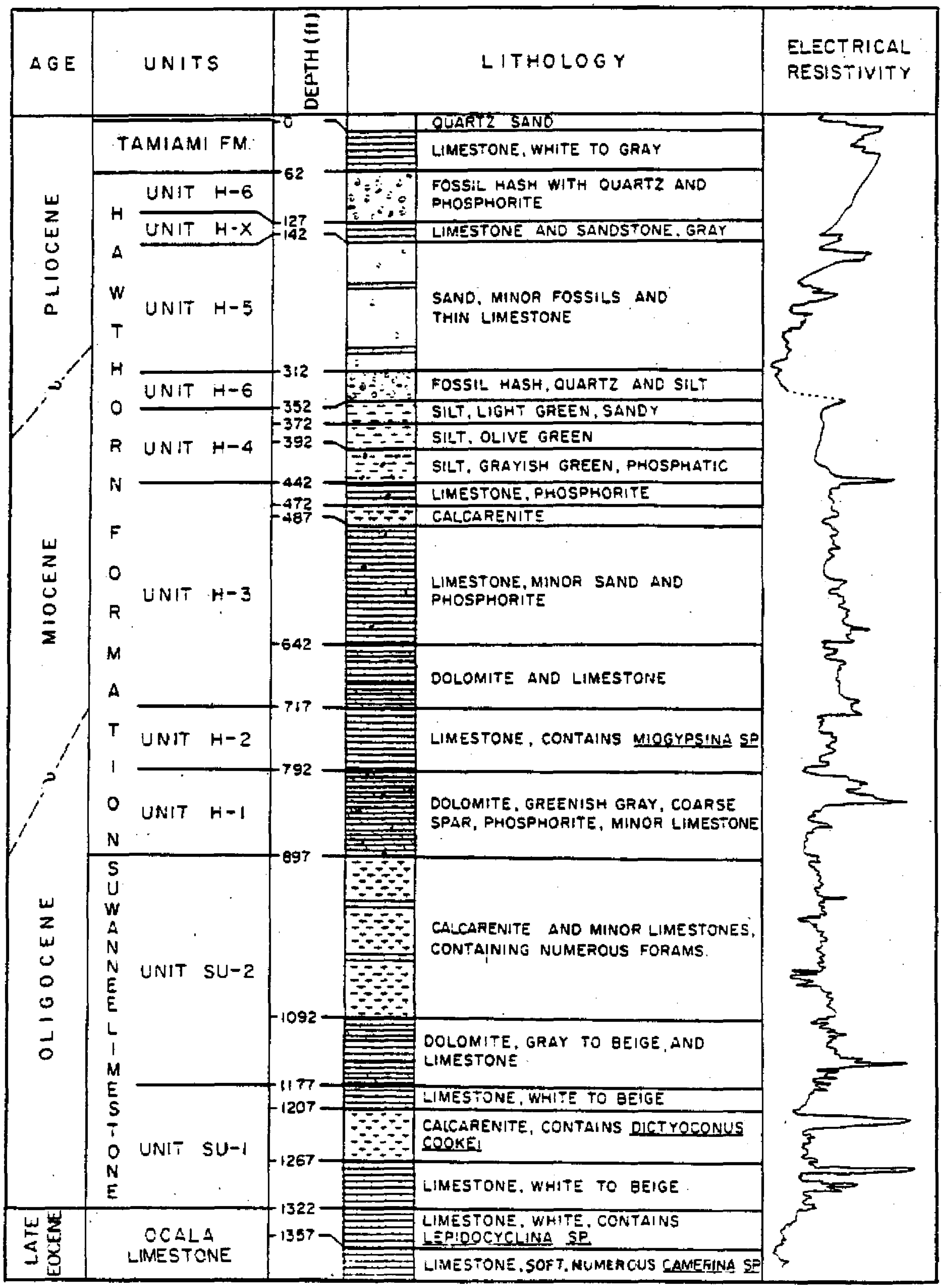

FIGURE 5 **Stratigraphic Columnar Section for Borehole W-10202, the Reference Section for this Study.**

continuous deposition. Continuous deposition across the Ocala-Suwannee boundary could account for the lack of a sharp lithologic, paleontologic, or geophysical break between the two formations in the study area.

Unit Su-1 is composed of recrystallized limestone, calcarenite, and calcilutite. The unit has a low quartz sand content, usually less than 2%, and trace amounts of phosphorite (less than 1%). Gamma logs for this unit show a very low level of activity. As seen in Figure 5, unit Su-1 exhibits some of the highest electrical resistivity readings of the post-Eocene section. Only within this unit was *Dictyoconus cookei,* a characteristic Suwannee Limestone fossil (Applin and Jordan, 1945), found.

The upper unit of the Suwannee Limestone, unit Su-2, is also composed of recrystallized limestone, calcarenite, and calcilutite. Unit Su-2 is rich in benthic foraminifers and ostracods. The foraminifers were sufficiently abundant in some intervals that the lithologies could be termed biocalcarenites and foraminiferal limestones. These microfossils, however, are poorly preserved.

Unlike the lower unit of the Suwannee Limestone, unit Su-2 has a high quartz sand content, approaching 12% in a few instances. One facies of this unit is a coarse biocalcarenite made of foraminifers and polished shell fragments with some quartz.

Unit Su-2 exhibits a much lower electrical resistivity than unit Su-1 (Figure 5). An exception is the high electrical resistivity reading given by a dolomite subunit at the base of unit Su-2. This dolomite subunit, where present, facilitates the division of the two Suwannee units.

Stratigraphically above the Suwannee Limestone is the Hawthorn Formation. In this study, the Hawthorn Formation is separated from the Suwannee Limestone by a lithologic criterion, the first consistent up-hole occurrence of appreciable amounts (1% or greater) of phosphorite. Cole

(1941) used a paleontologic criterion, the first down-hole occurrence of *Miogypsina hawkinsi*. It is important to note the difference in these two approaches.

Cole (1939) considered all species of *Miogypsina* in Florida to be resticted to the upper Oligocene. The Suwannee Limestone had traditionally been considered Oligocene in age; therefore, Cole reasoned *Miogypsina* should mark the top of the Suwannee Limestone.

The error in this method stems from the fact that a formation is a rock stratigraphic unit (ACSN, 1970) and may cross time lines. Armstrong (1980) demonstrated with planktonic foraminifers that the base of the Hawthorn Formation in his study area was Oligocene in age. It would not be surprising, then, to find *Miogypsina* within the Hawthorn Formation. Based on lithologic criteria, the unit containing *Miogypsina sp.*, unit H-2 (Figure 6), has been included in the Hawthorn Formation.

Cole (1941) also used the occurrence of *Archaias floridanus* as a criterion for extending the Tampa Formation into south Florida. Cole himself noted that this was a poor criterion. With this precedent, however, the Tampa Formation has become thoroughly entrenched in south Florida nomenclature. The occurrence of *Archaias floridanus* has been noted in the basal Hawthorn sediments of this study (Figure 6).

Mooney, et al. (1980) stated, "The range of lithologic characteristics attributed to the Tampa is sufficiently wide that almost any limestone could be regarded as the Tampa Limestone using published criterion." Work by King and Wright (1979) indicates that the Tampa Formation is limited in areal extent to southwest central Florida.

In view of the work by King and Wright (1979) and the selection of a poor criterion by Cole (1941), which does not agree with the present code of stratigraphic nomenclature, the example set by Bishop (1956) is followed in

<table>
<tr><th colspan="2">This paper</th><th>Concepts of Cole, 1941, and Parker, 1951.</th></tr>
<tr><td colspan="2">TAMIAMI FORMATION</td><td rowspan="5">TAMIAMI FORMATION</td></tr>
<tr><td rowspan="8">HAWTHORN FORMATION</td><td>UNIT H-6</td></tr>
<tr><td>UNIT H-X</td></tr>
<tr><td>UNIT H-5</td></tr>
<tr><td>UNIT H-4</td></tr>
<tr><td rowspan="2">UNIT H-3</td><td>HAWTHORN FORMATION</td></tr>
<tr><td>TAMPA FORMATION</td></tr>
<tr><td>UNIT H-2</td><td rowspan="4">SUWANNEE LIMESTONE</td></tr>
<tr><td>UNIT H-1</td></tr>
<tr><td rowspan="2">SUWANNEE LS.</td><td>UNIT Su-2</td></tr>
<tr><td>UNIT Su-1</td></tr>
<tr><td colspan="2">OCALA LIMESTONE</td><td>OCALA LIMESTONE</td></tr>
</table>

FIGURE 6 Formational Division of Units in this Paper Compared to the Division Based on Concepts Currently in the Literature.

this study. Bishop included sandy limestones of possible Tampa equivalency in the Hawthorn Formation.

For this study, the Hawthorn has been divided into seven informal units. As indicated in the section on previous work, some of the upper Hawthorn units, units H-4, H-5, H-6, and H-X have in the past been included in the Tamiami Formation (Parker, 1951) (Figure 6). The exclusion of these units from the Tamiami follows a suggested redefinition of the Tamiami Formation by Hunter and Wise (1980) who suggested that the Tamiami Formation be regarded strictly as a rock-stratigraphic unit. Presently, under Parker's (1951) definition, the formation is in part a rock stratigraphic unit and in part a time-stratigraphic unit.

Unit H-1 is a hard, coarsely sparry dolomite unit containing a few minor zones of limestone. A high secondary porosity for this unit is indicated by cavities encountered by drilling, vugs seen while making lithologic descriptions, and a high borehole geophysical flow-meter reading. This unit often marks what the drillers term a "lost circulation zone", a zone where drilling fluid is rapidly lost by flow into the rock.

The unit has a moderate to high (4 to 15%) phosphorite content and a corresponding high gamma activity. The highest electrical resistivity readings of the entire post-Eocene section is given by unit H-1.

Unit H-2 is composed of recrystallized limestones, calcarenites, and calcilutites. It is characterized by a low to moderate (1 to 5%) phosphorite content, low to moderate gamma activity, a low quartz content, and low electrical resistivity readings. This is the only unit in which *Miogypsina sp.* was found and it was found in all boreholes. This biofacies, therefore, is quite useful for correlation in the area.

Recrystallized limestones, calcarenites, and calcilutites constitute the next unit, unit H-3. Unit H-3 had a moderate to high (3 to 25%) phosphorite and quartz content, moderate gamma activity, and moderate electrical resistivity. ***Archaias floridanus*** is noted within this unit.

The lithology of unit H-4 contrasted sharply with the units below. Unit H-4 is an unconsolidated, dolomitic-quartzitic, clayey, gray-to-green silt unit containing a few very thin limestone lenses. In no case were clay minerals detected, although clay sized particles were not uncommon. This type of silt has often been referred to as a "green clay" in the local literature. Quantitative x-ray analysis of the silt (Figures 7, 8, and 9) showed that the quartz and dolomite content varied sympathetically, with quartz generally dominant in the section studied.

This silt unit was divided into three subfacies. The lower facies contains an almost constant 8% silt-sized phosporite content along with minor quartz sand. A second facies has both a low quartz sand and a low phosphorite content, while a third facies has a low phosphorite content but a high quartz sand content.

As a whole, unit H-4 exhibits a low electrical resistivity. The unit also has a low gamma activity except for the basal facies with the high phosphorite content that gives extremely high gamma peaks. This basal subunit is widespread in south Florida and is an excellent gamma marker (Missimer, 1978).

In an expanded section of this unit, a diatom zone was recognized in boreholes W-10188 and W-10187. These diatoms indicate a coastal environment (W. I. Miller, 1981, personal communication) and possibly a Pliocene age (S. W. Wise, 1981, personal communication).

Unit H-5 is a unit of well sorted, fine clastics. It includes a subunit of very clean quartz sand, a few thin limestone lenses, and a very sandy, marly calcilutite. Only a few phosphorite grains are found in the unit, accounting for the low gamma activity.

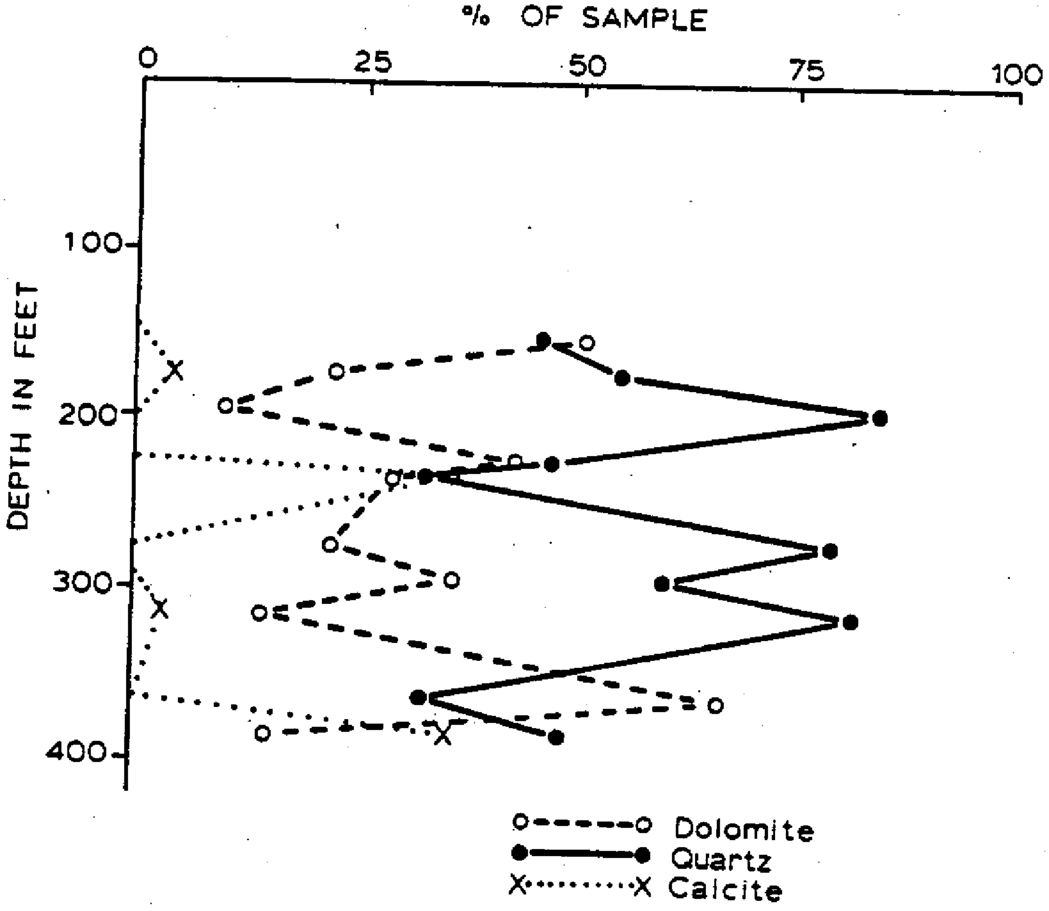

FIGURE 7 **Graph of the Quantitative X-Ray Data of Unit H-4 from Borehole W-10184.**

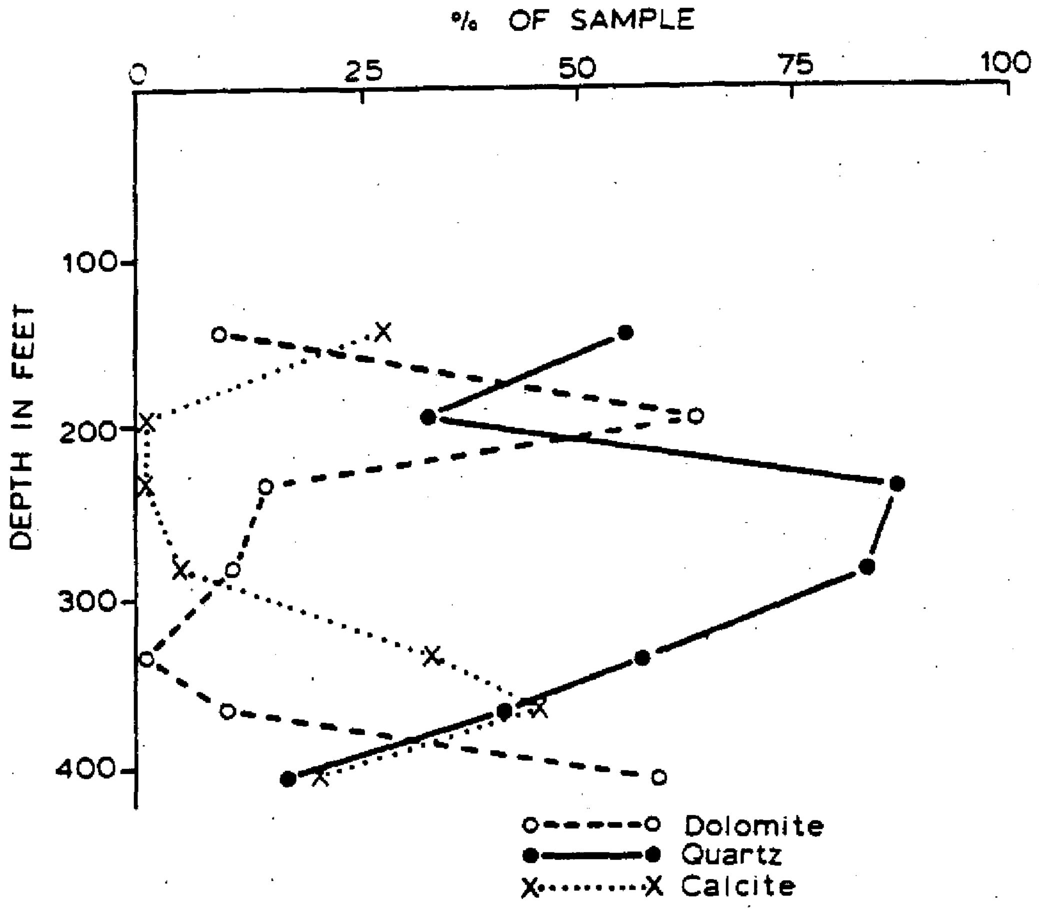

FIGURE 8 Graph of the Quantitative X-Ray Data of Unit H-4 from Borehole W-10187.

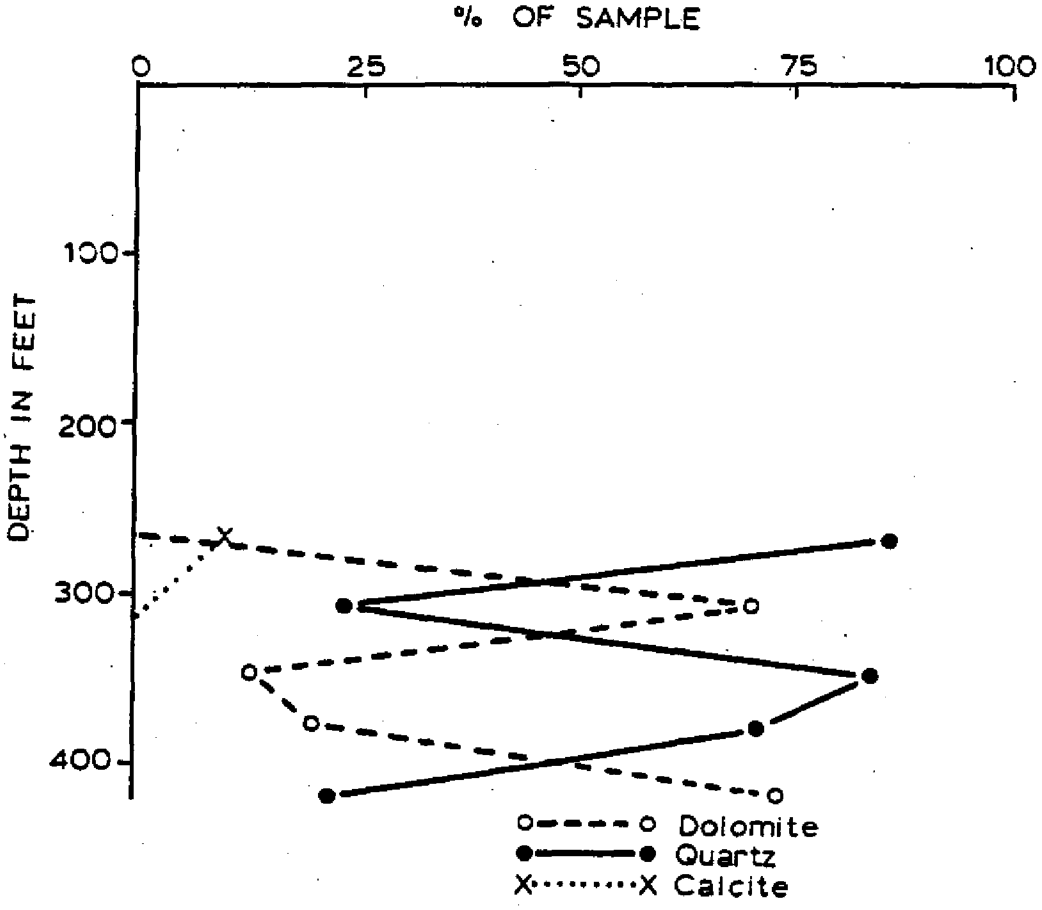

FIGURE 9 Graph of the Quantitative X-Ray Data of Unit H-4 from Borehole W-10201.

Figure 5 shows a thin limestone unit labeled unit H-X. Unit H-X is a gray limestone (moldic after macrofossils) and usually contains only minor amounts of sand and phosphorite. A hard gray sandstone may also be found within this unit. The stratigraphic position of unit H-X with reference to the Tamiami Formation varies as units H-5 and H-6 interfinger and pinch out. Because there is some ambiguity in the placement of this unit with respect to the Tamiami Formation, it is not numbered in sequence with the other Hawthorn units.

Unit H-6 is a gradational facies equivalent of unit H-5. This unit is composed of shelly, poorly sorted, coarse clastics ranging from sand to pebble sizes. A shell-hash subfacies was delineated in a few of the boreholes. A few thin limestone lenses were also found.

Both of the clastic units, H-5 and H-6, contain lenses of a green dolomitic silt resembling unit H-4. In addition, the clastics often have a slight greenish matrix resembling unit H-4

The Tamiami Formation, as delineated in this study, is primarily a hard limestone (moldic after macrofossils) with a low phosphorite content and low gamma activity. The quartz content generally decreases up section from a lithology of a sandy limestone or, in a few cases, a calcareous sandstone.

The portion of the Tamiami Formation encountered in the study area is primarily the Ochopee Limestone facies as described by Hunter (1968). Minor occurrences of marly calcilutites and sandy calcilutites were also noted in the Tamiami Formation. The latter may be comparable to the Pinecrest facies described by Hunter (1968).

Disposition of the Lithologic Units

The heterogenous nature of the lithologic units can be seen from cross-sections A-A' (Figure 10) and B-B' (Figure 11). Figure 12 gives more of a three-dimensional view of the units.

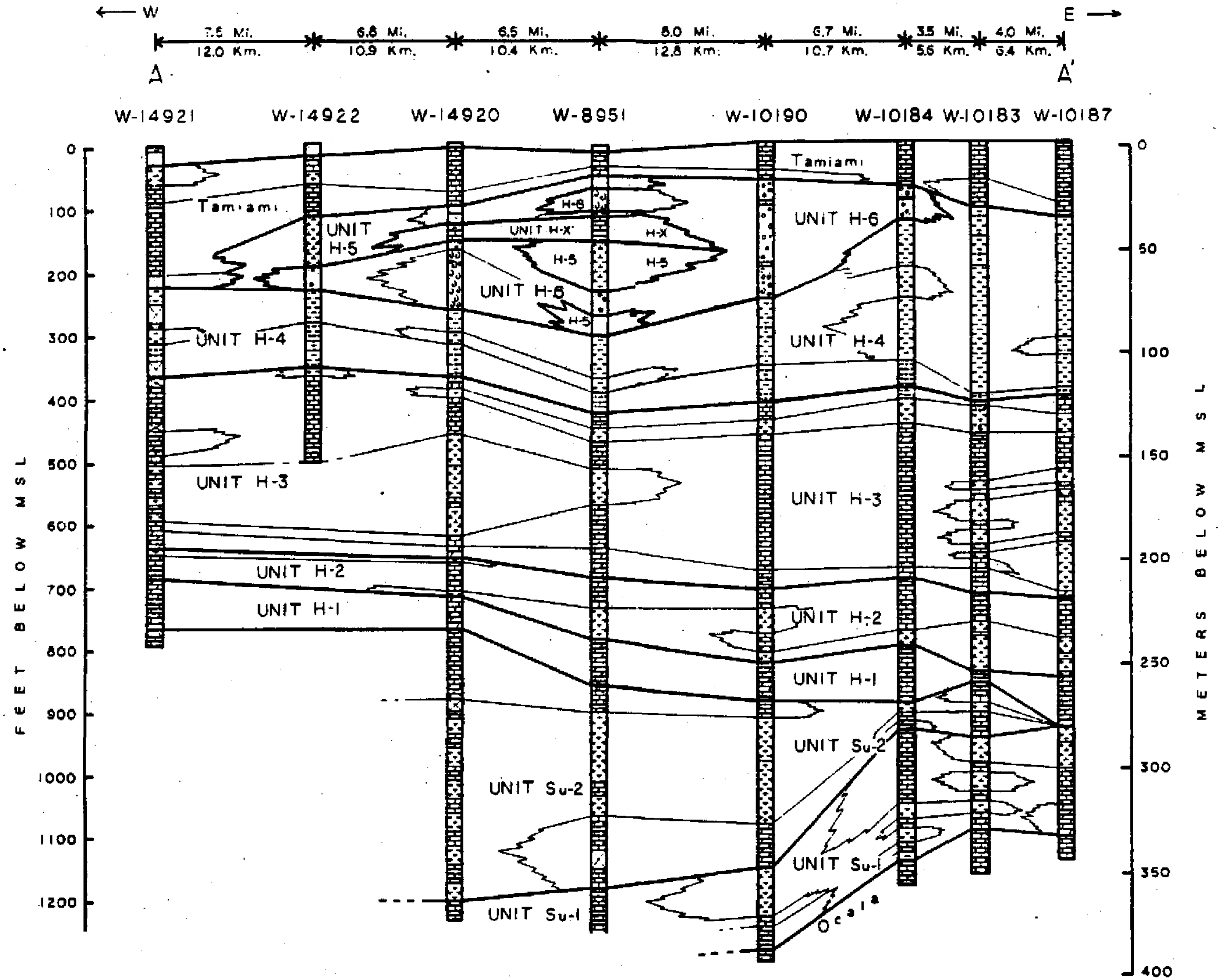

FIGURE 10 Cross-Section A-A'. Location of the Line of Cross Section can be Found in Figure 1.

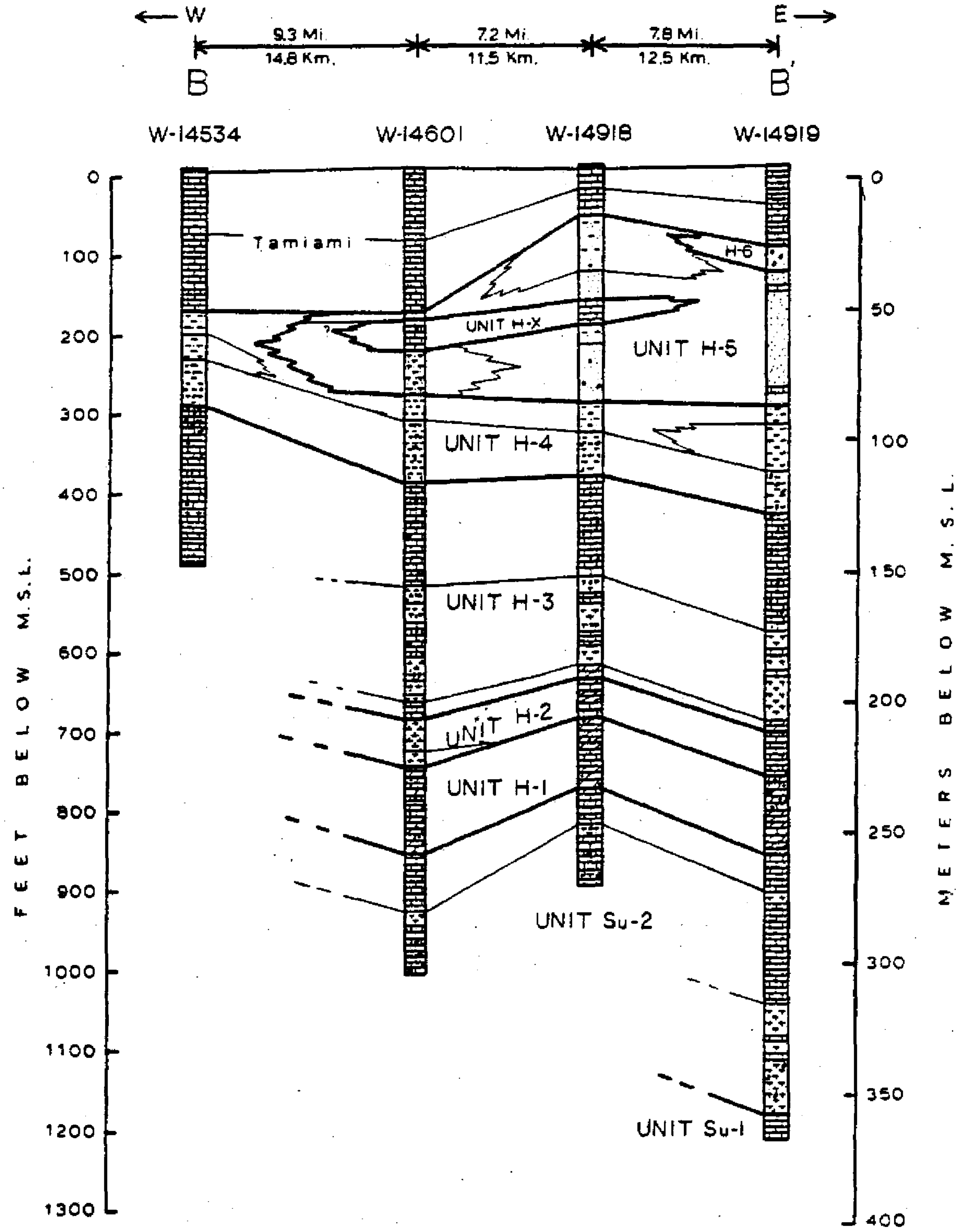

FIGURE 11 Cross-Section B-B'. Location of the Line of Cross-Section can be Found in Figure 1.

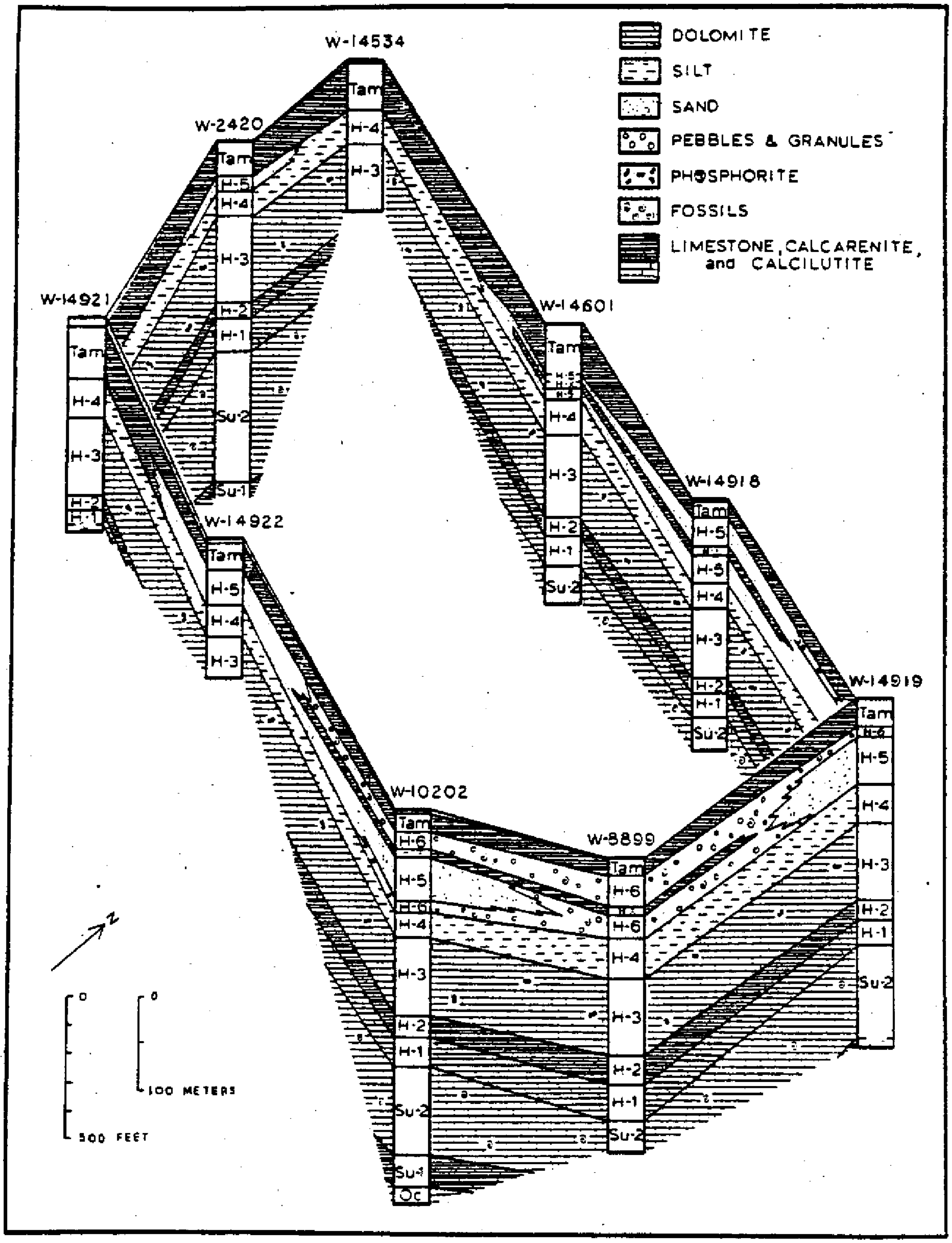

FIGURE 12 Fence Diagram Showing General Stratigraphic and Facies Relationships of Units in this Study.

In Figure 10, the top of the Ocala Limestone rises sharply in the three easternmost wells. A structure contour map on top of the Ocala Limestone (Figure 13) shows that in this area, and in one other to the north, the top of the Ocala lies at a higher elevation than in the rest of the study area. Relief on this Ocala surface is 310 feet (95 m).

Regional structure contour maps of the top of the Ocala limestone by Chen (1965) and Puri and Winston (1974) suggest that these two high areas are part of a regional trend encompassing the eastern part of the study area and all of northern Collier County.

The first unit above the Ocala Limestone is a unit of the Suwannee Limestone, Su-1. This is an extensive unit, covering the entire study area. An isopach map of unit Su-1 (Figure 14) does not show this unit to thin over the high areas of the Ocala Limestone. The maximum thickness of unit Su-1 is 265 feet (81 m). The only noticeable irregularity in the more or less constant thickness of this unit is the localized thickening in borehole W-10014 (see Figure 1).

A structure contour map on the top of unit Su-1 (Figure 15) shows the top of the unit to closely approximate the shape of the top of the Ocala Limestone (Figure 13). The top of unit Su-1 has 338 feet (103 m) of relief.

Figure 10 shows that the upper unit of the Suwannee Limestone, Su-2, pinches out over the high areas of the top of the Ocala Limestone. The isopach of unit Su-2 (Figure 16) also shows this unit to thin progressively toward the northeast and to pinch out over the two high areas. Where this unit pinches out, unit Su-1 is in contact with the post-Suwannee sediments. A structure contour map of the top of the Suwannee Limestone, whether it be unit Su-1 or Su-2, is given in Figure 17.

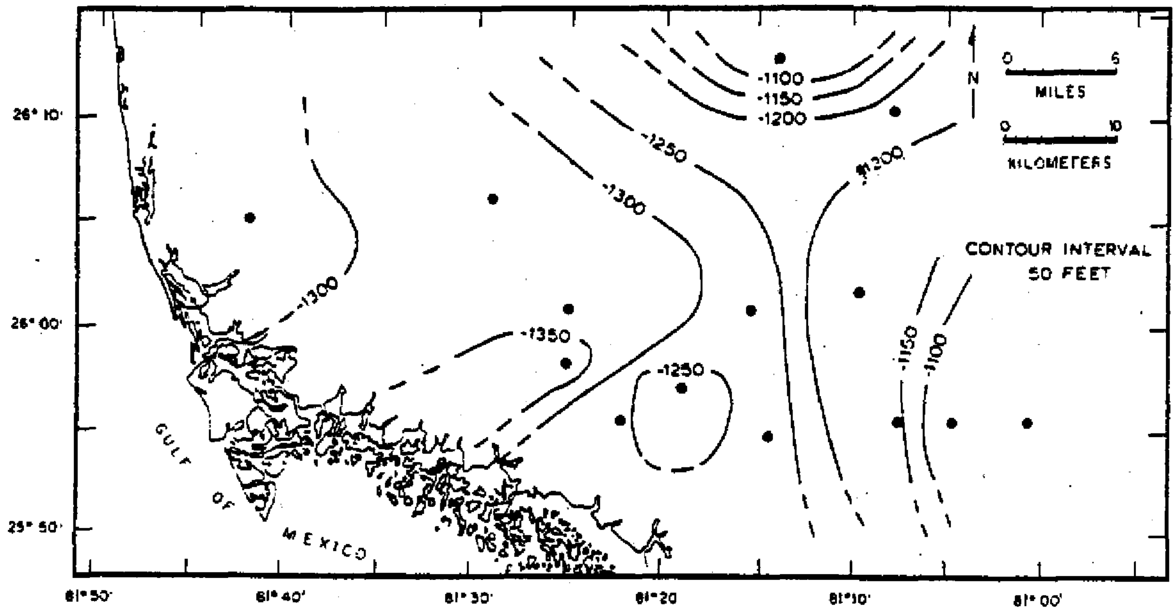

FIGURE 13 Structure Contour Map of the Top of the Ocala Limestone. Elevations are in Feet Below Mean Sea Level.

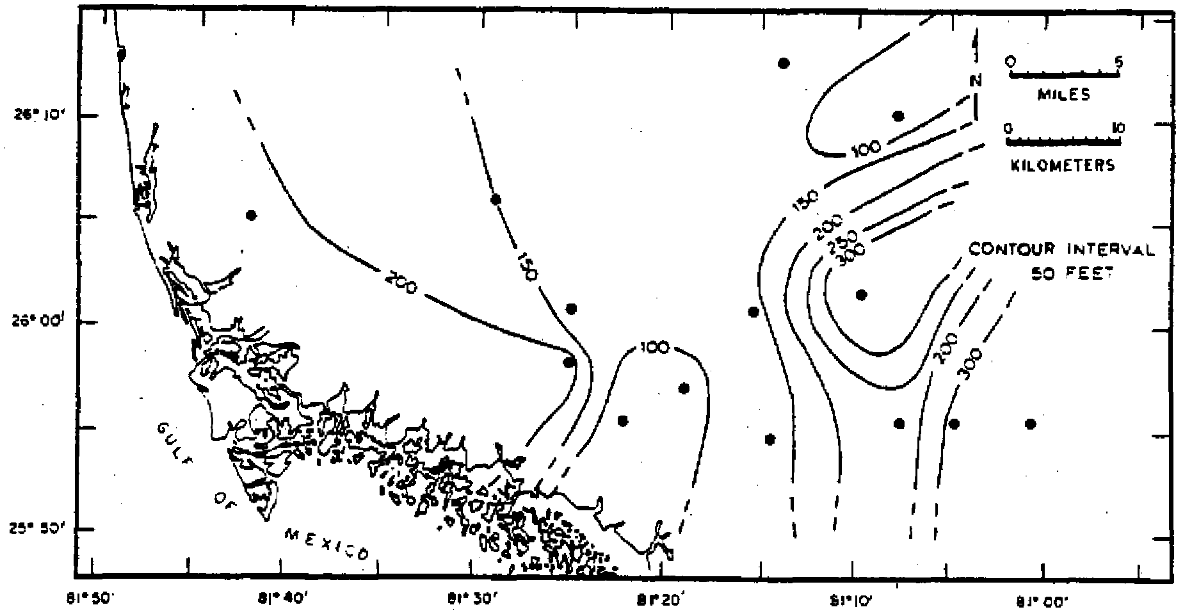

FIGURE 14 Isopach Map of Unit SU-1.

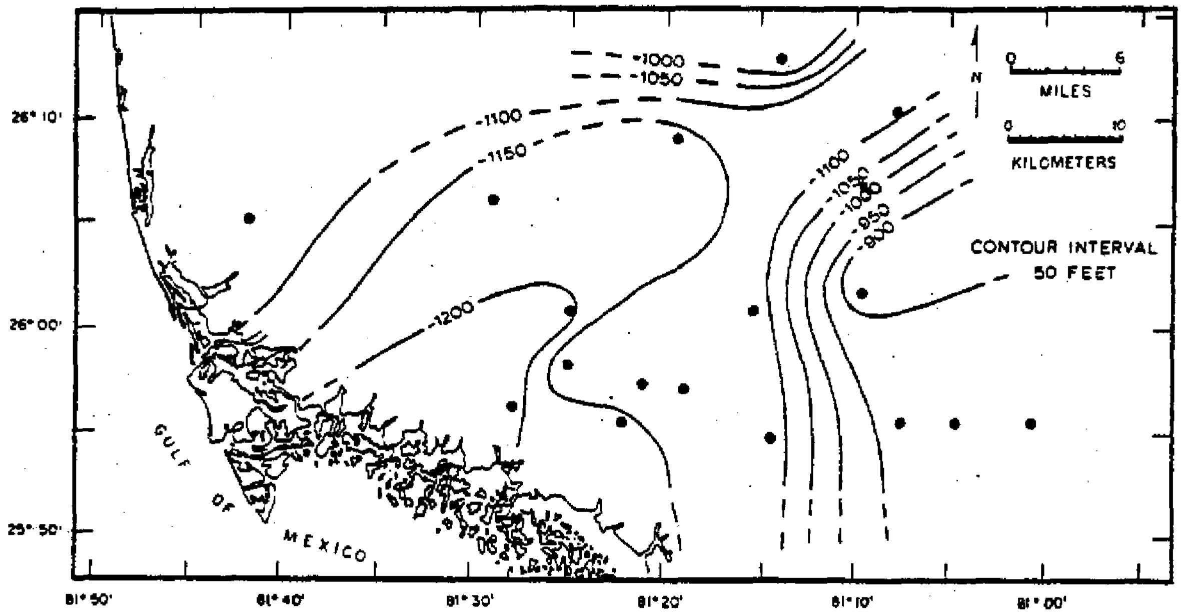

FIGURE 15 Structure Contour Map of the Top of Unit SU-1. Elevations are in Feet Below Mean Sea Level.

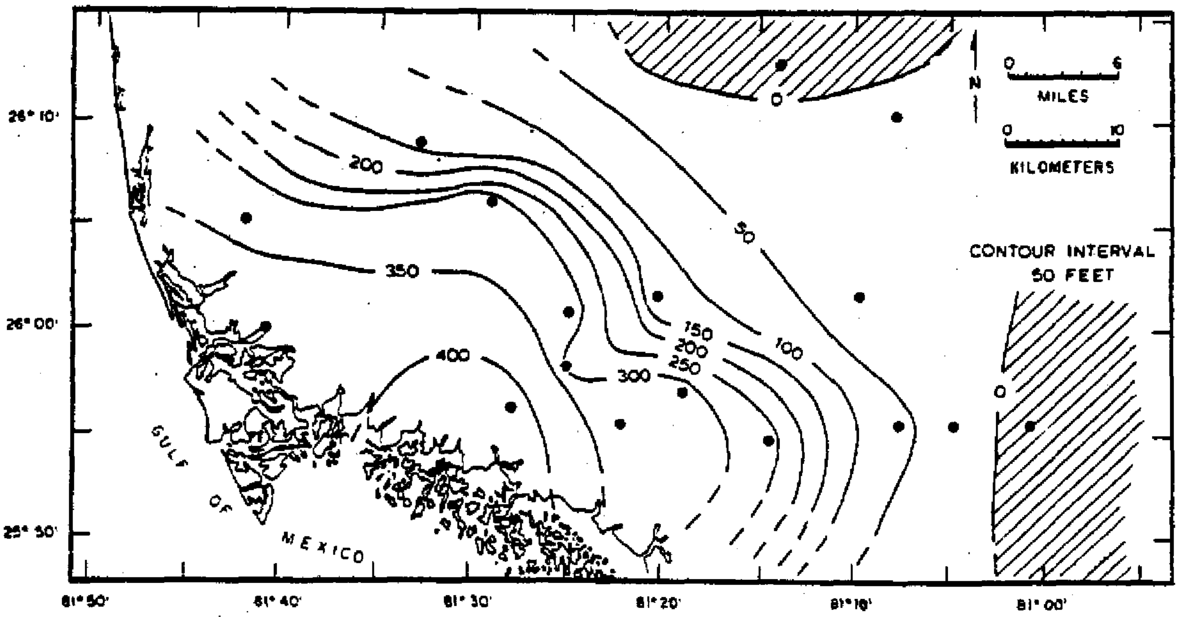

FIGURE 16 Isopach Map of Unit SU-2.

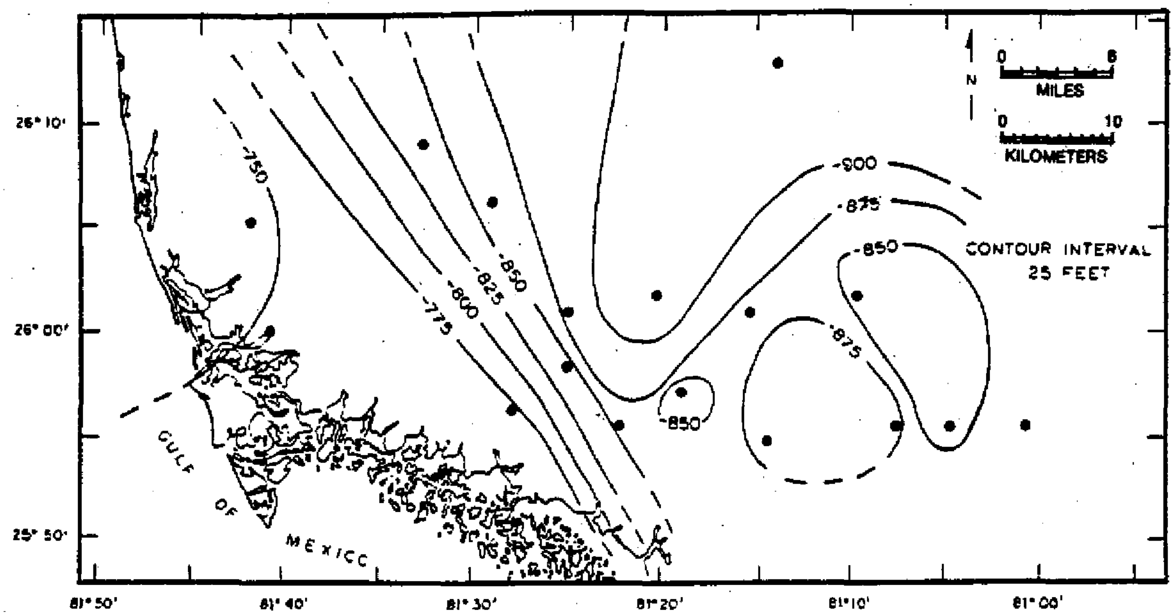

FIGURE 17 Structure Contour Map of the Top of Suwannee Limestone. Elevations are in Feet Below Mean Sea Level.

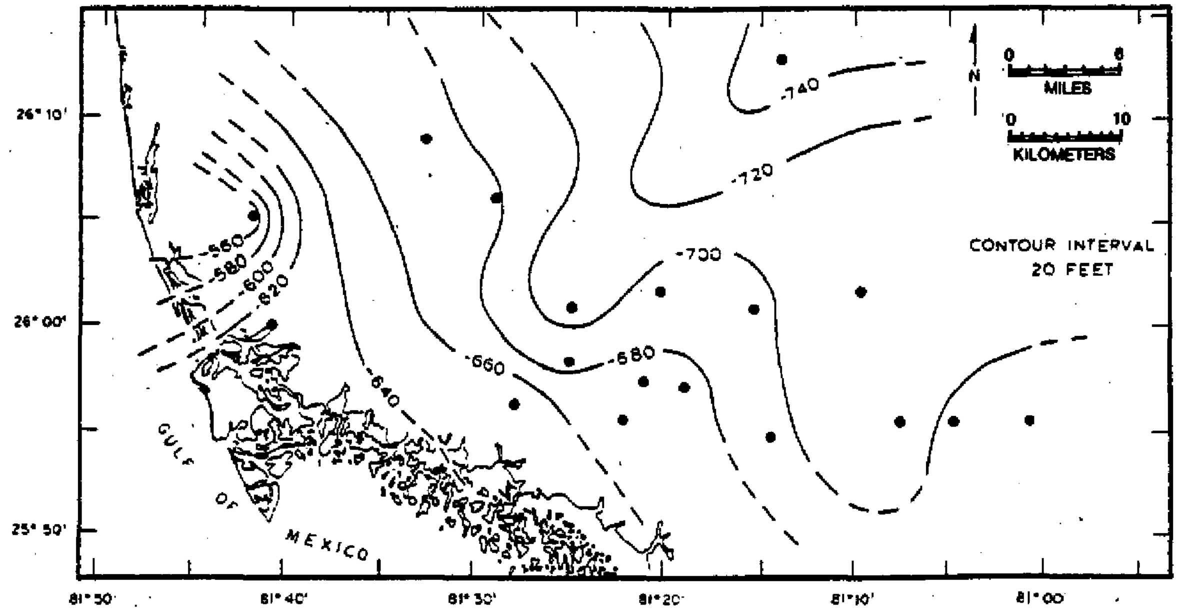

FIGURE 18 Structure Contour Map of the Top of Unit H-2. Elevations are in Feet Below Mean Sea Level.

The base of the Hawthorn Formation everywhere within the study area is marked by the dolomite unit H-1. Superjacent to unit H-1 is unit H-2. This is a relatively thin unit which dips toward the northeast (Figure 18).

Unit H-3 is one of the thickest units of the post-Eocene section in the study area. A structure contour map on the top of this unit (Figure 19) reveals a well-developed bowl or trough shaped depression. This feature is also expressed in the top of the Suwannee Limestone (Figure 17) and unit H-2 (Figure 18), but none of the earlier depressions were as extensive or as well developed. This may reflect accentuation of the deeper structure by either erosional or depositional patterns. Missimer (1978) and Peck, et al. (1979) considered the top of this unit to be an erosional surface.

Unit H-4, the clayey silt unit, thickens greatly in the eastern quarter of the study area (Figure 20). This expansion of the section is accomplished by the introduction of new subunits which are lithologically identical to the rest of the unit. One subunit is diatomaceous. Diatoms extracted from boreholes W-10188 and W-10187 indicate a coastal environment (W. I. Miller, 1981, personal communication) and possibly a Pliocene age (S. W. Wise, 1981, personal communication). A diatom bed at the same stratigraphic position in Lee County has been dated as Pliocene by Klingzing (1980).

The upper subunits of unit H-4 can be traced on electrical resistivity logs until they grade into units H-5 and H-6. This strongly suggests units H-5 and H-6 are facies of the upper part of unit H-4. A facies analysis is given in the next section.

Unit H-5 and unit H-6 are lateral facies and often show an interfingering relationship. The interfingering is indicated in Figure 5 and is shown in Figures 10, 11, and 12.

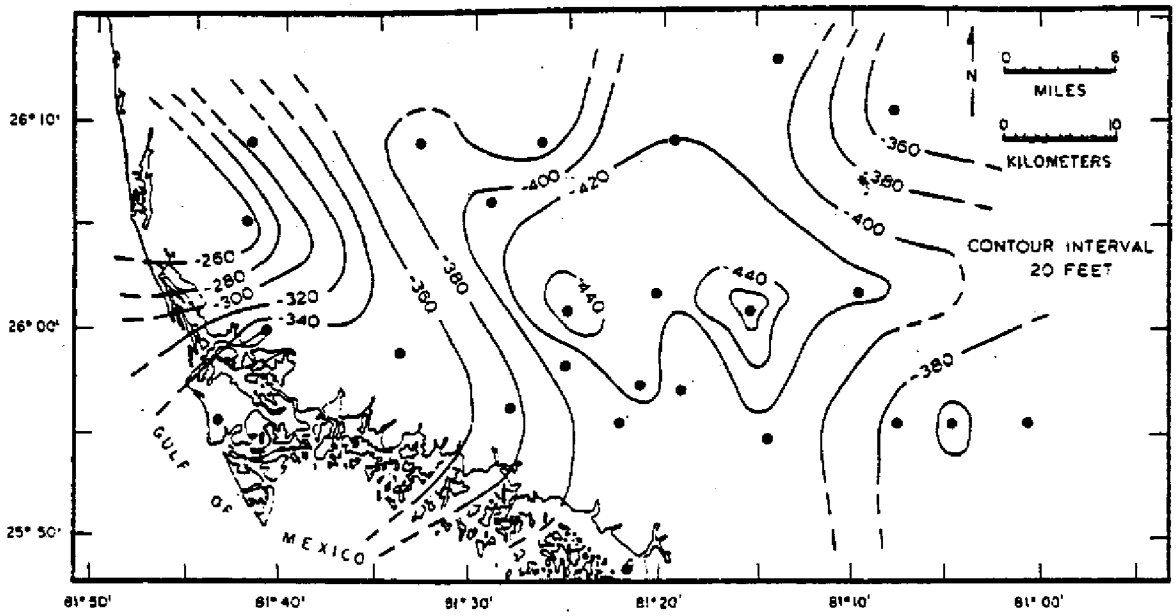

FIGURE 19 Structure Contour Map of the Top of Unit H-3. Elevations are in Feet Below Mean Sea Level.

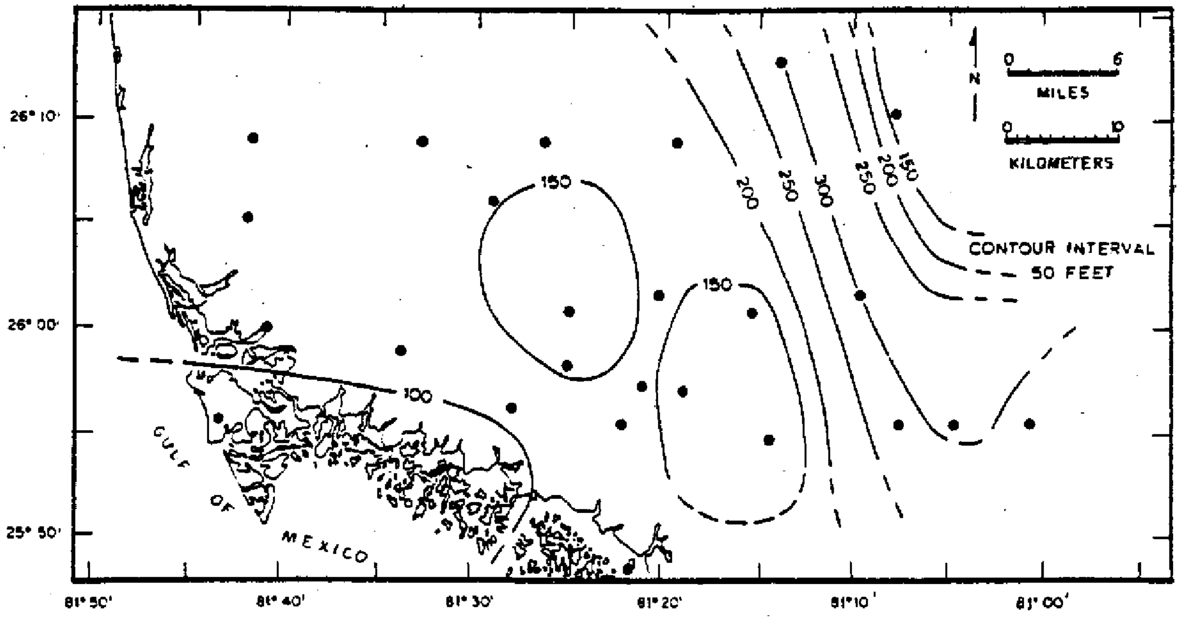

FIGURE 20 Isopach Map of Unit H-4.

Figures 21 and 22 are isopach maps of units H-5 and H-6. Unit H-5 (Figure 21) is an extensive unit which covers the majority of the study area. Figure 22 shows that unit H-6 is restricted to a wide belt in the central portion of the study area. This belt corresponds with the depression in the top of unit H-3, which has been discussed previously.

Unit H-X is a limestone occurring within the clastic units (Figure 23). The relationship of unit H-X of the Tamiami and Hawthorn Formations is not entirely clear, however, and for this reason it was not numbered in sequence with the Hawthorn units. There is some geophysical and lithologic evidence to suggest that unit H-X can be correlated with the lowermost Tamiami beds in the extreme western boreholes of the study area (boreholes W-14534, W-2420, W-14921, and W-4937). Although considered here a member of the Hawthorn Formation, it may actually be a tongue of the Tamiami Formation. Well spacing, however, is too great to allow one to determine if this correlation can actually be made.

The Tamiami Formation caps the Hawthorn Formation in all areas of this study. This formation (Figure 24) thickens toward the northwest and in the extreme eastern portions of the study area. A belt of relatively thin Tamiami, defined by the 100 foot (30 m) contour line, extends down through the study area. This thin zone mirrors the depression in the top of unit H-3 (Figure 19) and coincides with the geographic extent of unit H-6 (Figure 22)

The thickening of the clastic units at the expense of the Tamiami Formation, and the increasing sand content of the Tamiami downsection, suggest that the lower portion of the Tamiami Formation is time equivalent to at least the upper portions of units H-5 and H-6.

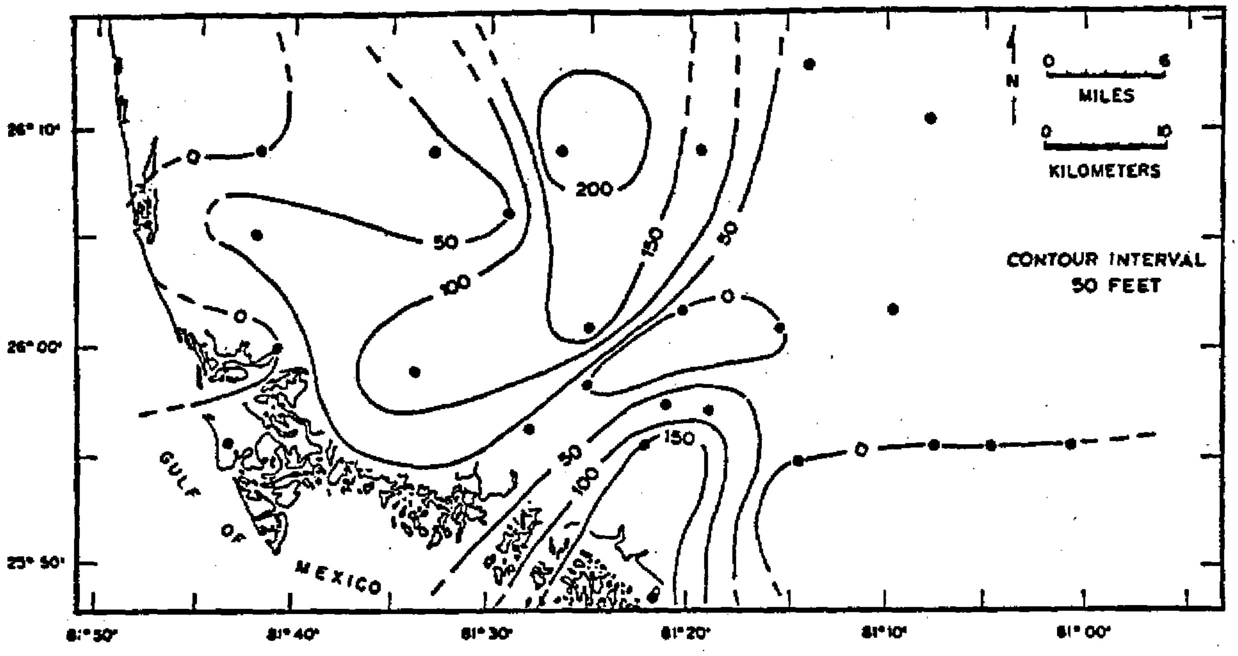

FIGURE 21 Isopach Map of Unit H-5.

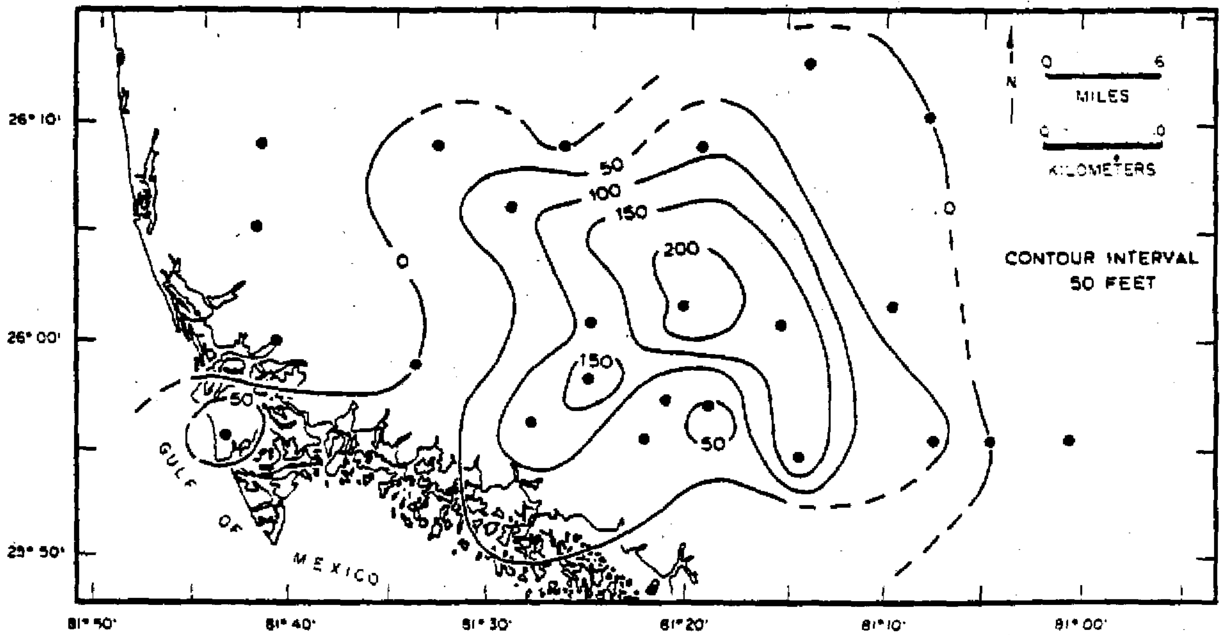

FIGURE 22 Isopach Map of Unit H-6.

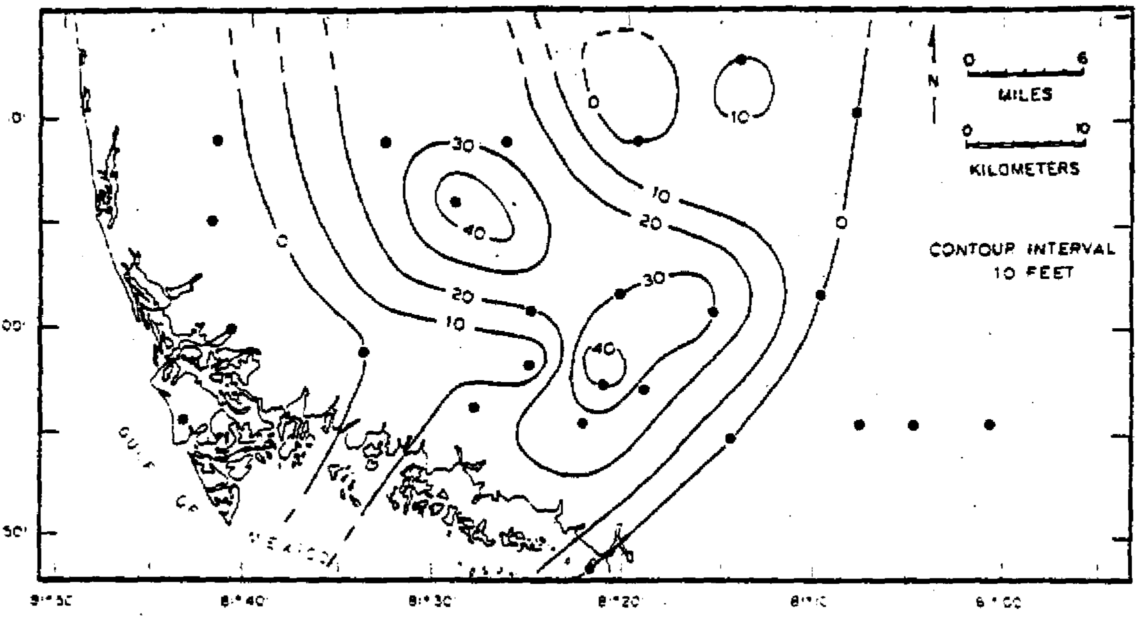

FIGURE 23 Isopach Map of Unit H-X.

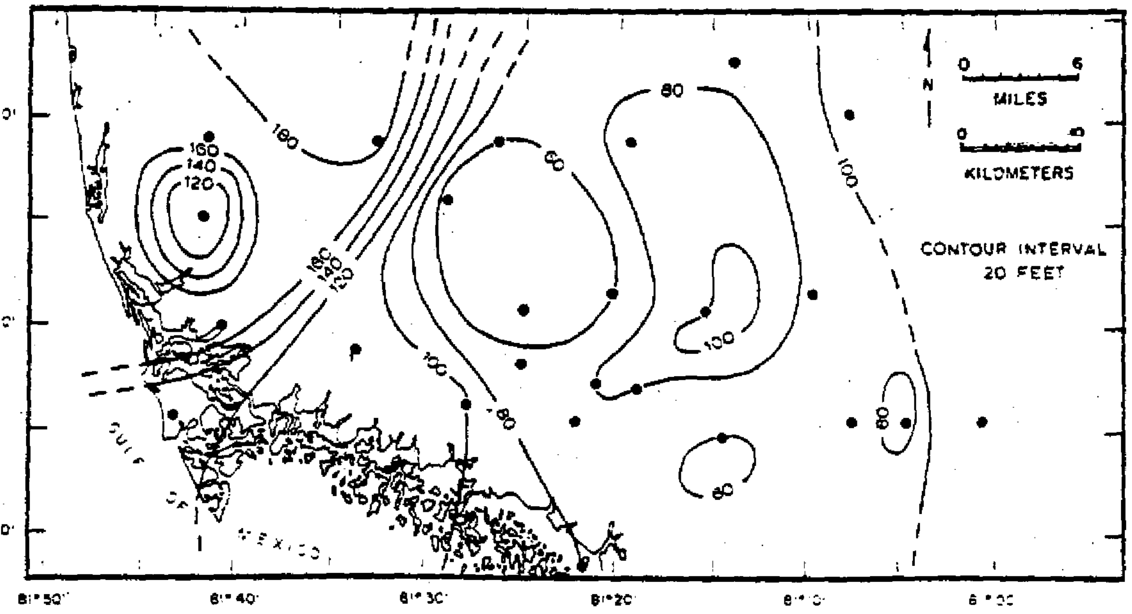

FIGURE 24 Isopach Map of the Tamiami Formation.

DISCUSSION

Controls on Deposition and Facies Analysis

Puri and Winston (1974) attributed the relief on the top of the Eocene in south Florida to erosion. The evidence from southern Collier County suggests a second possibility for the study area.

As pointed out in Figure 13, the relief on the Ocala is in excess of 300 feet (91 m). If this relief were created by erosion, then the sculpturing of the surface would have pre-dated the deposition of unit Su-1. One would expect a unit only 265 feet (81 m) thick deposited on an errosional surface with 300 feet (91 m) of relief, to thin and thicken over the highs and lows. The isopach map of unit Su-1 (Figure 14) does not show this. This does occur, however, in unit Su-2 (Figure 16). This suggests that the relief shown by the top of the Ocala Limestone was not created by erosion, but by warping after the deposition of Unit Su-1 and before or during the deposition of unit Su-2. This would place the time of warping in the mid-Oligocene, a time of tectonic movement in other parts of the state (Vernon, 1951).

A regional structure contour map of the top of the Ocala Limestone by Puri and Winston (1974) shows that the areas in which unit Su-2 pinches out (Figure 16) are part of a trend which curves to include all of northern Collier County. Unit Su-2, therefore, can be modeled as having been deposited in a basin created by the warping of the Ocala and unit Su-1. With the -1100 foot (335 m) contour line on the top of the Ocala marking the areal extent of the basin, unit Su-2 would be restricted to southern Collier County, northern Monroe County, and western Broward and Dade Counties.

Structure contour maps on the top of the Suwannee Limestone (Figure 17) and unit H-2 (Figure 18) show that by the early Miocene, the basin had been essentially filled in. These structure contour maps also reveal shallow, ill-defined troughs extending through the northeastern sector of the study area. The structure contours of the top of unit H-3, however, show these troughs most clearly. The position of the troughs may have been controlled by the configuration of the Oligocene sediments of unit Su-2.

As pointed out previously, the clastics of units H-5 and H-6 are facies of each other and of the upper portion of unit H-4. Evidence for this includes (1) zones of a dolomitic silt resembling unit H-4 found within units H-5 and H-6, (2) clastics of units H-5 and H-6 often found with a matrix similar to unit H-4, and (3) the ability to trace the upper subunits of unit H-4 on electrical logs until they lose their geophysical characteristics by taking on those of units H-5 and H-6.

Figure 25 is a modified, highly diagramatic version of cross-section A-A' (Figure 10) . This schematic diagram shows the facies relationship of the clastic units to unit H-4. Also shown is the relative stratigraphic position of the diatomaceous subunit which is probably Pliocene in age. If this age determination is correct, units H-5 and H-6 may also be Pliocene.

The source of the coarse clastics is somewhat of an enigma. Bishop (1956) suggested that a large river existed in peninsular Florida during the Hawthorn time and that this river was a source of coarse clastics. If such a river did exist, then the trough in the top of unit H-3 could have exerted a control on either paleo-drainage or current patterns to bring some of these clastics into southern Collier County. This is a very attractive idea, especially when the depositional center of unit H-6 (Figure 22) is compared with the center of the depression in the top of unit H-3 (Figure 19). These two centers not only coincide, but are approximately of the same shape.

A plot of the depositional centers of units H-4, H-5, H-6, and of the Tamiami Formation (from Figures 20, 21, 22, and 24, respectively) on the same map (Figure 26), allows the following paleoenvironmental interpretation.

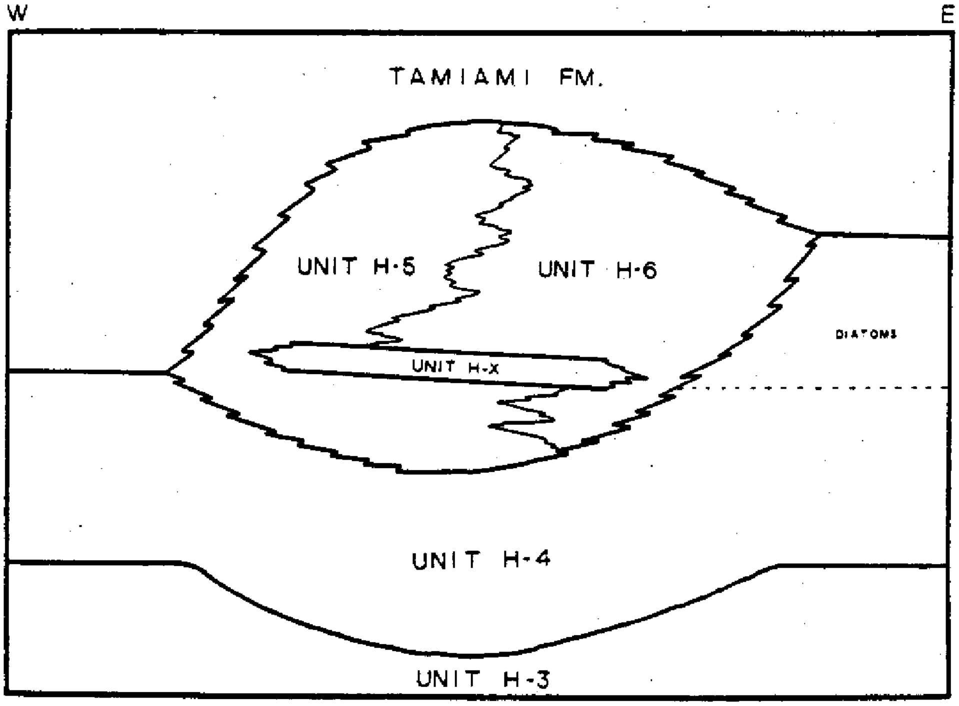

FIGURE 25 Diagramatic Version of Cross-Section A-A'.

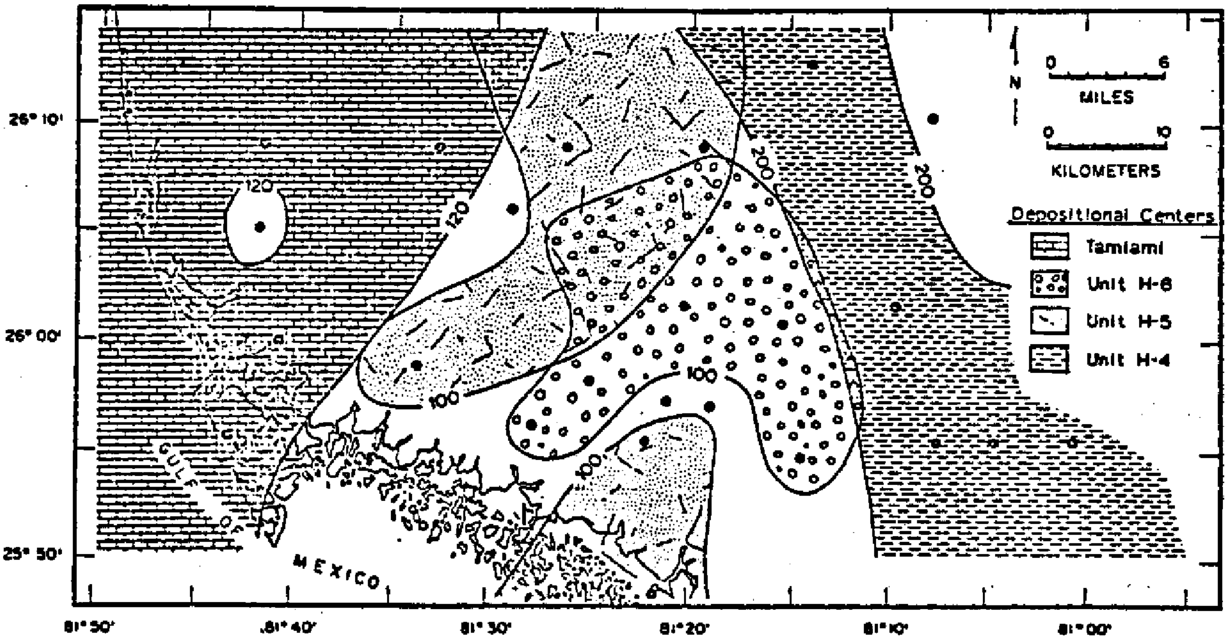

FIGURE 26 Thickest Accumulation of the Upper Facies or Time Related Units.

Although there is some overlap, the depositional centers reveal an off-shore to on-shore pattern of deposition. The clastics of units H-5 and H-6 reflect the input of sediment from the north, into near shore environment, with the coarse clastics of unit H-6 deposited nearest the shore. The shell has subfacies of unit H-6 which attests to the marine environment of deposition.

Seaward of unit H-6, the depositional center of unit H-5 reflects deeper water, lower energy, or a greater distance from clastic input. This is also indicated by the finer grain size and better sorting of unit H-5. Further seaward from the clastic influx is the depositional center of the Tamiami Limestone (Figure 26).

No modern analog is known for the deposition of the green, dolomitic-quartzitic silts of unit H-4. Therefore, it is reasonable to assume these sediments are the product of diagenetic alteration, probably of a carbonate mud (algal needles?) fraction of the original sediment. Baker, et al. (1981) described a model of dolomization in organic rich sediment involving the reaction of methane and calcite. This model is especially attractive for the silts of unit H-4 since these sediments were deposited in nutrient-rich waters (Peck, et al. 1979) and sedimentation rates were probably high, thus enhancing the preservation of organic materials.

X-ray diffraction shows that the green color of unit H-4 silts is not due to mixed layered clays. Although not documented, it is believed that reduced iron may be responsible for the color. Diatoms indicate the original sediments were deposited in a nutrient-rich, coastal environment. Taking into consideration the landward position of the depositional center of unit H-4 (Figure 26),it is reasonable to interpret the environment of deposition as an estuary or a lagoon. The decaying organics, which may have helped produce the dolo-silts, could also have caused the reduction of iron, thereby producing a green color.

SUMMARY AND CONCLUSIONS

1. The post-Eocene section in Collier County was divided into ten lithologic units (Su-1, Su-2, H-1, H-2, H-3, H-4, H-5, H-6, H-X, and the Tamiami Formation based on lithologic criteria. These units were traced throughout the study area.
2. Mid-Oligocene warping is indicated from the Suwannee Limestone, Su-1 and Su-2, to the Ocala Limestone.
3. A depression existed in the top of unit H-3, the location of which may have been controlled by deeper structure.
4. The Hawthorn depression influenced the depositional centers of the facies related units H-4, H-5, and H-6, and the partially time-equivalent Tamiami Formation by exerting a control on either paleo-drainage or offshore paleo-current patterns. This depression facilitated the delivery of coarse clastics to south Florida from the north.

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APPENDIX A

INTERPRETATION OF X-RAY DATA

X-RAY ANALYSIS

Well #	Depth(feet)	Calcite	Dolomite	Quartz	Apatite*
W-8899	260-290		88%	12%	
	650-660		78%	2%	
W-9413	210-220			100%	
	260-270	34%	20%	41%	5%
	310-320		42%	55%	3%
	340-350	33%	33%	31%	3%
	360-370		30%	65%	5%
	400-410	11%	43%	43%	3%
	430-440	9%	35%	52%	4%
	460-470	21%	21%	51%	7%
	800-810	9%	75%	13%	3%
	1070-1080		79%	18%	3%
W-10014	460-470			93%	7%
	590-600	2%		93%	5%
	650-660	2%	98%		
	810-820		100%		
	880-890	65%			35%
	1090-1100	5%	95%		
W-10018	1060-1070		63%	37%	
W-10183	460-470		97%	3%	
	670-680		100%		
	1060-1070		90%	10%	
W-10184	140-150		51%	46%	3%
	160-170	3%	22%	55%	20%
	180-190		9%	85%	6%
	210-220		43%	47%	10%
	220-230	35%	28%	31%	6%
	260-270		21%	79%	
	280-290		36%	60%	4%
	300-310	2%	13%	82%	3%
	350-360		68%	32%	
	370-380	35%	14%	48%	3%
	470-480	100%			
	920-930		100%		
W-10187	130-140	27%	8%	55%	10%
	180-190		64%	32%	4%
	220-230		13%	87%	
	270-280	3%	9%	83%	5%
	320-330	33%		57%	10%
	350-360	45%	9%	41%	5%

*Estimated from optical examination.

X-RAY ANALYSIS

Well #	Depth(feet)	Calcite	Dolomite	Quartz	Apatite**
W-10187	390-400	19%	59%	16%	6%
	810-820	52%	41%	7%	
	840-850	52%	31%	17%	
	860-870	9%	87%	4%	
	900-910	92%		8%	
	1060-1070		100%		
W-10190	700-710		100%		
	1080-1090	5%	77%	18%	
	1260-1270		100%		
W-10201	250-260	9%		86%	5%
	290-300		71%	23%	6%
	330-340		12%	84%	4%
	360-370		19%	71%	10%
	400-410		73%	21%	
	680-690	6%	94%		
	780-790		100%		
	800-810		100%		
W-10202	1210-1220	4%	96%		
	1270-1280	4%	96%		
W-10223	110-120	91%		9%	
	180-190	16%	18%	56%	10%
	210-220	22%	40%	38%	
	270-280		35%	57%	8%
	370-380		15%	75%	10%
	730-740		97%	3%	
	780-790	1%	92%	7%	
	800-810		91%	9%	
W-14601	230-240		87%	13%	
	260-270		72%	24%	4%
	312-320	3%	53%	37%	7%
	650-660	54%	33%	7%	6%
	730-740*	12%	73%	8%	
W-14922	550-560	47%	47%	6%	
	640-650	48%	48%	4%	
	740-750	14%	81%	5%	
	810-820	69%	16%	15%	
	1230-1240	60%	30%	10%	

*Based on an estimated 7% clay content
**Estimated from optical examination

APPENDIX B

GEOLOGIC LOGS

W-2004

Depth (Feet)	Description
0-10	Shell, grayish matrix
10-30	Quartz, sand, shelly
30-70	Limestone, white, hard, moldic, fossiliferous
70-110	Limestone, white, moldic, sandy; quartz, sand
110-120	Calcilutite, fossiliferous, grayish white, sandy
120-180	Quartz, sand, marly matrix increasing downwards
180-200	Calcilutite, sandy, gray to greenish
200-230	Quartz, sand, minor grayish matrix, minor phosphorite and shell
230-260	Shelly quartz, sand with minor granules
260-300	Quartz, sand, minor shell; trace of light green silt at base
300-380	Silt, clayey texture, light green to olive green, sandy minor phosphorite
380-400	Silt, clayey texture, olive green, up to 6 percent fine phosphorite sand, minor quartz
400-428	Silt, clayey, grayish-olive green, tough plastic, up to 8 percent phosphorite
428-490	Silt, clayey, sandy, green, 5 percent phosphorite carbonate particles.
490-497	Dolomite, beige; limestone, minor, white

W-2420

Depth(Feet)	Description
0-30	Limestone, white, hard, moldic, minor sand and fossils
30-60	Calcarenite, grayish white, hard; limestone of above
60-115	Limestone, white hard, sandy
115-145	Silt, clayey, green, minor quartz; calcareous sandstone, minor, light grayish green
145-175	Quartz, sand through granule; sandy calcilutite, minor
175-205	Silt, clayey, green, sandy, plastic
205-235	Silt, clayey, olive green, plastic, minor quartz and phosphorite; quartz, and phosphorite, minor, sand through granule
235-265	Silt, clayey, olive green, plastic, eight percent phosphorite
265-385	Limestone, white, minor phosphorite; minor calcarenite, grayish white
385-415	Calcarenite, white to beige, minor quartz and phosphorite; minor limestone
415-535	Limestone, white, hard, minor phosphorite
535-595	Limestone, as above; calcarenite, minor, five percent phosphorite; Dolomite, minor, beige
595-625	Limestone, white, hard, dense, fossils include *Miogypsina sp.*
625-685	Limestone, white; Dolomite, minor, grayish beige
685-745	Dolomite, beige
745-805	Limestone, white, minor to sandy, numerous forams

805-955	Limestone, as above; Calcarenite, grayish white, minor quartz, numerous forams
955-1030	Limestone, beige, hard, very numerous forams and ostracods
1030-1090	Dolomite, beige, forams
1090-1210	Dolomite, as above; Calcarenite
1210-1240	Dolomite, tan
1240-1270	Limestone, grayish white
1270-1290	No sample
1290-1300	Dolomite, grayish white
1300-1330	Limestone, white, hard, contains Lepidocyclina sp. and Gypsina globosa

W-4937

Depth(Feet)	Description
0-43	Shell, fragments, slight grayish matrix; quartz, minor sand
43-63	Limestone, hard; very sandy biocalcarenite, soft;shell, as above
63-113	Limestone, white, minor quartz, mildly fossiliferous
113-183	Limestone, white, sandy with quartz, trace phosphorite
183-203	Sandy calcilutite, marly, trace phosphorite
203-263	Quartz, sand through pebble; shell, fragments; limestone, minor
263-293	Clayey quartz, sand, greenish gray
293-313	Sandy silt, greenish gray, clayey
313-323	Fossiliferous silt, clayey, grayish green, minor quartz sand
323-348	Silt, clayey, grayish green, plastic, minor quartz sand up to nine percent fine phosphorite sand
348-353	Limestone, white, up to eight percent medium phosphorite sand; dolomite, trace, in upper part
353-363	No sample
363-413	Limestone, white, minor quartz and phosphorite sand

W-8899

Depth(Feet)	Description
0-30	Limestone, white, medium hardness, minor quartz
30-60	Limestone, white, hard, sandy, trace phosphorite; fossils, minor; quartz and phosphorite, minor, sand
60-160	No sample
160-170	Fossils, fragments; limestone, grayish white; quartz and phosphorite, minor, sand
170-180	Limestone, grayish white; quartz and phosphorite, minor, sand
180-190	Calcilutite, marly, grayish white, minor quartz
190-200	Limestone, grayish white, trace quartz
200-250	Quartz, sand to pebble, minor shell
250-300	Quartz, as above; limestone, minor, white to greenish
300-320	Sandy silt, clayey, grayish green, minor shell, trace phosphorite
320-400	Silt, clayey, green to olive green, minor quartz, phosphorite, and shell
400-430	Silt, clayey, olive green to grayish green, five percent phosphorite, minor quartz
430-460	Limestone, white, hard, moldic, trace phosphorite; calcarenite, beige to white, minor quartz, phosphorite,and fossils
460-480	Fossiliferous calcarenite, beige, shell and bryozoan
480-500	Limestone, white, moldic; quartz and phosphorite, minor
500-520	Calcarenite, grayish white, minor quartz;limestone, white
520-530	Limestone, beige, minor phosphorite, trace quartz
530-570	Calcilutite, beige, minor phosphorite,

	fossiliferous
570-580	Quartz and phosphorite, sand; shell fragments; limestone ,white, hard
580-600	Limestone, grayish white; quartz, minor, granule
600-610	Limestone, white; calcilutite, white, minor phosphorite,fossiliferous
610-630	Limestone, white, hard
630-650	Limestone, white; calcilutite, grayish white
650-690	Dolomite, beige; phosphorite and quartz sand; limestone, minor, white
690-710	Limestone, white, hard, fossils include Miogypsina sp.
710-720	Calcilutite, white, trace quartz
720-740	Limestone, white, contains Miogypsina sp.
740-770	Calcilutite, beige, minor quartz, trace phosphorite
770-810	Limestone, white, slightly moldic, Miogypsina sp. in upper part
810-850	Dolomite, grayish white; limestone, minor
850-920	Limestone, white, up to 15 percent phosphorite; dolomite,minor
920-1040	Limestone, white, minor quartz; calcarenite, beige, contains forams; quartz, sand; shell, trace phosphorite

W-8951

Depth(Feet)	Description
0-10	Silt, clayey, sandy, fossiliferous; limestone, minor yellowish
20-30	Limestone, white, moldic, minor quartz
30-50	Limestone, white, sandy
50-70	Limestone, white, sandy
70-100	Fossil hash, quartz, sand; calcareous sandstone in lower part
100-110	As above plus limestone, minor, beige , minor quartz
110-120	Limestone, sandy, grayish white
120-150	Quartz, sand, grayish matrix; minor limestone and shell
150-200	Silty quartz, clayey, greenish gray, sand, minor phosphorite; minor fossil hash and limestone
200-230	Sandy calcilutite, marly, grayish white, trace phosphorite; limestone, minor, grayish white, minor quartz
230-260	Quartz, sand through pebble, slight grayish matrix, minor phosphorite; calcareous sandstone, beige, hard
260-270	As above plus limestone, minor, grayish green, hard,minor quartz
270-300	Calcareous sandstone, greenish gray, becoming a sandy limestone downwards; limestone, minor, blackish, dense
300-310	Silt, clayey, grayish black, minor quartz
310-370	Silt, clayey, sandy to silty with quartz, grayish black to grayish green, minor shell
370-390	Silt, clayey, olive green, plastic, minor quartz and phosphorite
390-420	Silt, clayey, olive green, up to seven percent, silt phosphorite

420-440	Limestone, grayish white, up to five percent phosphorite, minor quartz
440-470	Calcarenite, grayish white, up to seven percent phosphorite, minor quartz; minor limestone, grayish white, minor phosphorite
470-500	Dolomite, beige; limestone, white, moldic
500-510	Limestone, white, moldic, fossiliferous
510-570	Calcarenite, white to grayish white, minor quartz and phosphorite, fossiliferous; limestone, white, moldic, fossiliferous
570-640	Limestone as above plus dolomite, beige, minor phosphorite
640-690	Dolomite, beige, up to ten percent phosphorite; limestone, minor, trace phosphorite
690-730	Limestone, white, fossils, includes *Miogypsina sp.*
730-780	Calcarenite, grayish white, fossiliferous (including *Miogypsina sp.*); trace of a soft, sparry clay
780-860	Dolomite, grayish white to beige, coarse spar, up to eight percent phosphorite; limestone, minor,. white up to 20 percent phosphorite.
860-1030	Limestone, white, hard, dense, foraminiferal; calcarenite, grayish white, foraminiferal and minor ostracods; trace dolomite
1030-1070	Foraminiferal calcarenite, blackish gray, minor quartz
1070-1120	Limestone, grayish white, minor quartz (up to 10 percent) and forams; fossils, minor, shell fragments rounded into clasts
1120-1240	Limestone, white, minor quartz and forams
1240-1260	Limestone, white to grayish white, trace phosphorite;quartz, sand

W-9413

Depth (Feet)	Description
0-20	Limestone, grayish white, fossiliferous, minor quartz
20-50	Sandy limestone, white, moldic
50-90	No sample
90-100	Limestone, grayish white, minor quartz
100-150	Quartz, sand through granule; phosphorite, minor granule, minor limestone at base
150-200	Limestone, grayish white, moldic, minor quartz; fossils, minor, shell; quartz, minor, from a black clayey matrix
200-260	Quartz, sand through pebble; silt, clayey, grayish green, very sandy; fossils, minor
260-300	Fossils, hash; quartz, sand; trace phosphorite
300-310	Silt, clayey, light olive green, minor quartz; calcareous sandstone, minor, white
310-340	Silt, clayey, olive green, sandy, minor fossils and phosphorite
340-360	Fossil hash; silt, clayey, grayish green; quartz, sand through granule
360-430	Silt, clayey, black, minor quartz and phosphorite; limestone near base
430-470	Silt, clayey, olive green, plastic, up to eight percent phosphorite, minor quartz; limestone minor, white
470-500	Limestone, white, minor phosphorite
500-530	Limestone, as above; calcarenite, minor quartz and phosphorite
530-650	Quartz, sand; phosphorite, minor; shell, worn; calcarenite, trace
650-710	Limestone, grayish-white, mildly moldic, minor phosphorite; fossil shell, rounded; phosphorite, minor
710-800	Limestone, white, fossils include *Miogypsina sp.*

	in upper part
800-880	Dolomite, beige, coarsely sparry; limestone, minor, white
880-910	Calcarenite, grayish white, sandy with quartz, numerous forams
910-940	Calcarenite of above plus limestone, sandy, white, minor
1040-1060	Limestone, grayish white, numerous forams; fossils, minor, rounded shell; quartz, minor, sand
1060-1080	As above plus dolomite, beige
1080-1110	Limestone, white, hard, dense
1110-1270	Limestone, light beige, mildly moldic; calcilutite, grayish white; fossils, minor, includes trace of D. cookei
1270-1310	Limestone, very white, hard, dense; fossils include Lepidocyclina sp. and algal structures
1310-1340	Calcilutite, white, soft, contains Lepidocyclina sp., algal structures, and Camerina sp. at the base.

W-9905

Depth (Feet)	Description
0-10	Limestone, white, minor sand; calcilutite, marly, minor quartz
10-50	Marly quartz, gray, minor fossils
50-80	Limestone, blackish gray to white, moldic, fossiliferous, minor quartz sand
80-100	Limestone, sandy, white, fossiliferous, trace phosphorite
100-110	Calcareous sandstone, white, trace phosphorite
110-120	Marly quartz, grayish white, fossiliferous, up to six percent phosphorite
120-180	Silt, clayey, olive green, tough, plastic, numerous forams and ostracods, minor quartz and phosphorite
180-210	Silt, clayey, olive green, sandy, fossiliferous, minor phosphorite; limestone, minor, sandy, white
210-230	Silt, clayey, green to olive green, tough, plastic, minor quartz
230-290	Silt, clayey, green, sandy, minor phosphorite; limestone, trace, white
290-350	Silt, clayey, olive green, plastic, minor quartz, up to eight percent phosphorite
350-360	Limestone, white, moldic, minor phosphorite
360-370	Calcarenite, fossiliferous, minor quartz and phosphorite; limestone, as above
370-390	Calcarenite, as above, seven percent phosphorite
390-430	Fossiliferous calcarenite, minor quartz, up to three percent phosphorite
430-480	Limestone and calcarenite, grayish white, moldic, fossiliferous, minor quartz and phosphorite
480-520	Calcarenite, as above
520-550	Calcarenite, as above, plus limestone, white, mildly fossiliferous, minor quartz and

	phosphorite
550-600	Limestone, white to grayish beige, mildly fossiliferous, minor phosphorite
600-1100	No samples
1100-1130	Dolomite, greenish beige, minor phosphorite; limestone, minor, white, minor quartz and phosphorite; phosphorite, 10 percent, sand
1130-1140	Dolomite, beige, limestone, white, minor Dictyoconus cookei
1140-1160	Calcarenite, grayish, white, fossils include D. cookei; dolomite, minor
1160-1200	Limestone, calcarenite, and calcilutite, beige, fossiliferous
1200-1240	Dolomite, beige; limestone, white, hard, dense
1240-1280	Limestone, white, hard, mildly moldic, fossils include numerous algal structures, Gypsina globula, and a few small Lepidocyclina sp.

W-10014

Depth (Feet)	Description
0-10	Quartz, sand, yellowish; limestone, sandy
10-20	Limestone, yellowish to white, minor quartz, trace phosphorite
20-30	Calcilutite, marly, white, minor quartz
30-40	Limestone, blackish gray, moldic, minor quartz
40-70	Sandy limestone to calcareous sandstone, gray to white, mildly fossiliferous
70-110	Quartz, sand through granule; fossil hash; sandy limestone, minor, moldic
110-160	Sandy silt, clayey, olive green, minor phosphorite;quartz, minor, sand; limestone, minor, white
160-200	Silt, green, plastic, minor quartz and phosphorite, plastic; limestone, trace
200-220	Silt, clayey, grayish green to olive green, minor quartz and phosphorite; quartz, sand through pebble
220-280	Silt, clayey, olive green to grayish green, minor quartz and phosphorite, dense, plastic
280-310	Silt, clayey, dark grayish green, minor quartz and phosphorite; limestone, minor, sandy; calcareous sandstone, minor, greenish white
310-370	Silt, clayey, green, plastic, sandy, up to five percent phosphorite, numerous forams
370-380	No sample
380-400	Silt, clayey, grayish green to olive green, plastic, up to eight percent phosphorite
400-420	Calcilutite, grayish white, minor quartz and phosphorite, minor fossils; limestone, minor, white, moldic
420-430	Limestone, white, moldic, mildly fossiliferous
430-440	Calcarenite, beige, very fossiliferous; limestone as above

440-450	Calcarenite as above
450-500	Limestone, grayish white, very moldic, minor quartz and fossils, up to eight percent phosphorite
500-530	Limestone as above plus calcarenite, minor, grayish white, minor fossils and phosphorite
530-570	Limestone, white to grayish white, moldic, fossiliferous, minor quartz and phosphorite
570-580	Calcilutite, white, minor phosphorite and shell
580-600	Calcilutite as above plus limestone, white; dolomite,minor, grayish beige
600-640	Limestone, white, minor phosphorite; fossils, minor; calcareous sandstone, trace
640-650	Calcilutite, white, minor quartz and phosphorite; limestone, white
650-660	Dolomite, beige, minor phosphorite
660-690	Limestone, white, minor phosphorite and fossils; dolomite, minor, beige
690-740	Limestone, very white, very moldic, fossils include Miogypsina sp.
740-750	Limestone, as above plus dolomite, minor
750-770	Calcilutite, white, fossiliferous; dolomite, minor
770-800	Limestone, white, hard; dolomite, grayish beige, up to seven percent phosphorite; minor fossils include trace Miogypsina sp.
800-810	Limestone, white, phosphatic
810-830	Dolomite, gray to beige, coarse spar; limestone, white, contains Miogypsina sp.
830-850	Limestone, grayish white
850-930	Limestone, white, primarily sandy, numerous forams; fossils, minor
930-970	Limestone, calcarenite, and calcilutite, beige, minor quartz and phosphorite, fossiliferous
970-1020	Limestone, grayish white, moldic; fossils, minor

1010-1080	Calcarenite, becoming a calcilutite downwards, white,minor fossils include *D. cookei*
1080-1130	Limestone, grayish white, slightly moldic, fossils include *D. cookei*
1130-1140	Calcilutite, white
1140-1170	Limestone, grayish, vuggy, trace D. cookei in upper part
1170-1210	Limestone, white, mildly moldic, fossils include numerous algal structures and a few *Lepidocyclina sp.*

W-10188

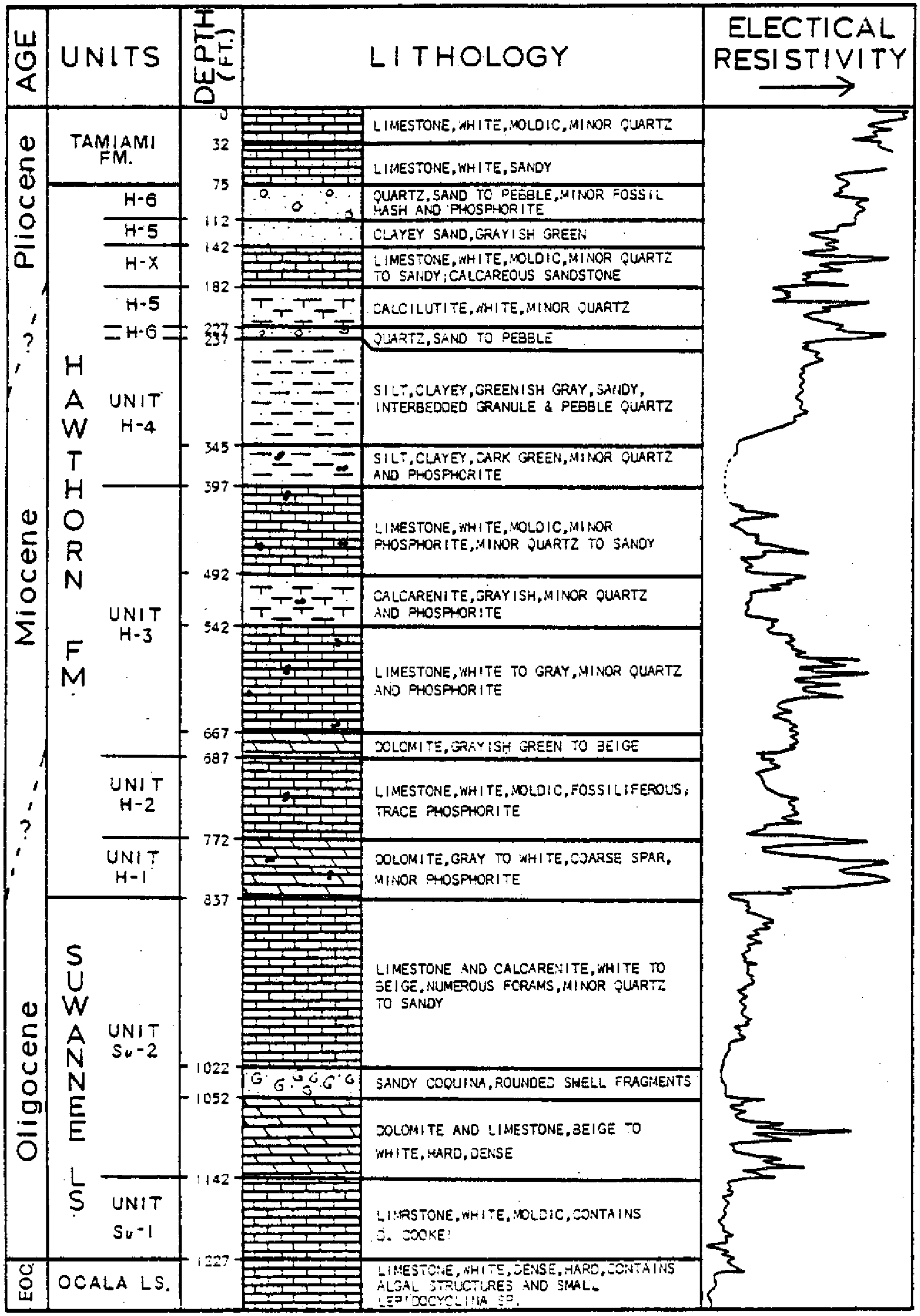
Depth (Feet)	Description
0-40	Limestone, yellowish to white, moldic, minor quartz and fossils
40-50	Biocalcarenite, white, vuggy
50-60	Limestone, gray, vuggy, very fossiliferous
60-70	Limestone, gray, sandy, fery fossiliferous
70-90	Fossils, from a marly calcilutie, minor quartz and phosphorite
90-100	Calcilutite, white, marly, sandy, fossiliferous
100-110	Limestone, grayish white, moldic, fossiliferous, minor quartz
110-120	Silt, clayey, grayish green, fossiliferous, minor quartz and phosphorite
120-130	Silt, clayey, olive green, sandy, minor phosphorite
130-160	Silt, clayey, olive green, tough, plastic, numerous forams, minor quartz and phosphorite
160-190	Silt, clayey, olive green, sandy, minor phosphorite
190-230	Silt, clayey, dark green, tough, plastic, impermeable
230-300	Silt, clayey green, minor quartz and phosphorite
300-380	Silt, clayey, olive green, up to four percent phosphorite, numerous forams
380-390	Bio-calcarenite, very moldic, gray
390-410	Calcilutite, marly, gray, clayey, up to eight percent phosphorite
410-450	Limestone, grayish white, moldic and fossiliferous, up to four percent phosphorite, minor quartz
450-490	Calcarenite, light beige, up to seven percent phosphorite
490-520	Limestone, white, mildly moldic

520-530	Calcilutite, grayish white, fossiliferous
530-550	Limestone, grayish white, mildly moldic, minor quartz and phosphorite
550-590	Calcarenite, minor quartz, phosphorite and fossils
590-600	Limestone, white, moldic, minor phosphorite
600-640	Calcilutite, marly, minor fossils and phosphorite
640-680	Limestone, white, moldic, minor phosphorite
680-720	Calcilutite, white, minor phosphorite
720-750	Calcarenite, grayish white, minor phosphorite; dolomite, minor, greenish beige, up to 10 percent phosphorite
750-830	Limestone, white, hard, dense, mildly moldic, fossils include Miogypsina sp.
830-870	Calcarentie, white, very fossiliferous (includes Miogypsina sp.)
870-920	Limestone, white, fossils include trace of Miogypsina sp.; dolomite, trace, greenish beige
920-940	Limestone, grayish white, fossiliferous
940-950	Limestone, as above; dolomite, beige, very coarsely sparry
950-980	Limestone, grayish white, minor quartz, minor fossils include D. cookei
980-1000	Biocarcarenite, beige, foraminiferal, trace, D. cookei
1000-1050	Limestone, white to beige, trace quartz and phosphorite
1050-1070	Limestone, white, hard, dense
1070-1090	Limestone, white, fossils include numerous algal structures and Lepidocyclina sp.
1090-1120	Calcilutite, fossiliferous, algal structures and Lepidocyclina sp.

APPENDIX C

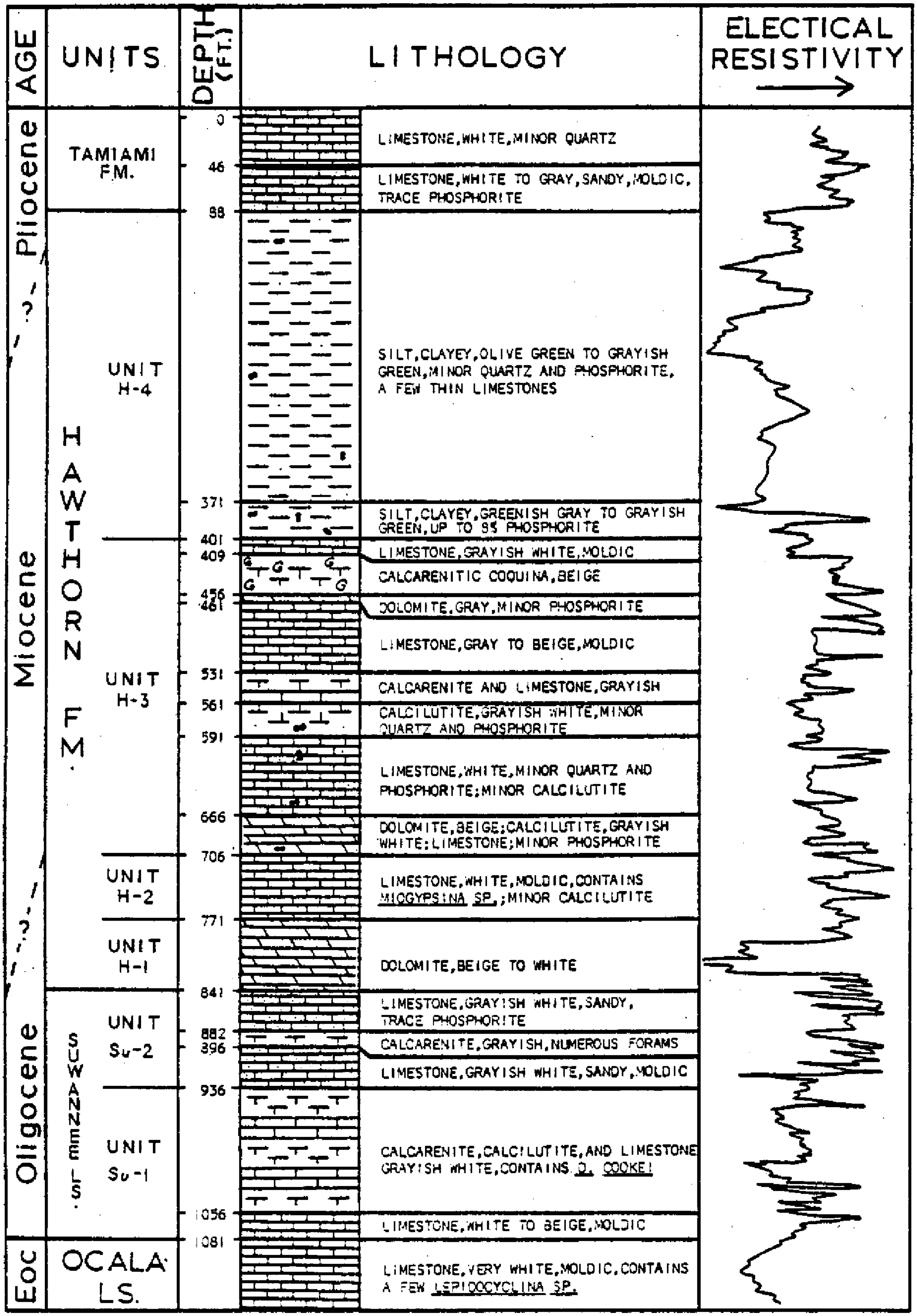
STRATIGRAPHIC COLUMNAR SECTIONS

W- 10180

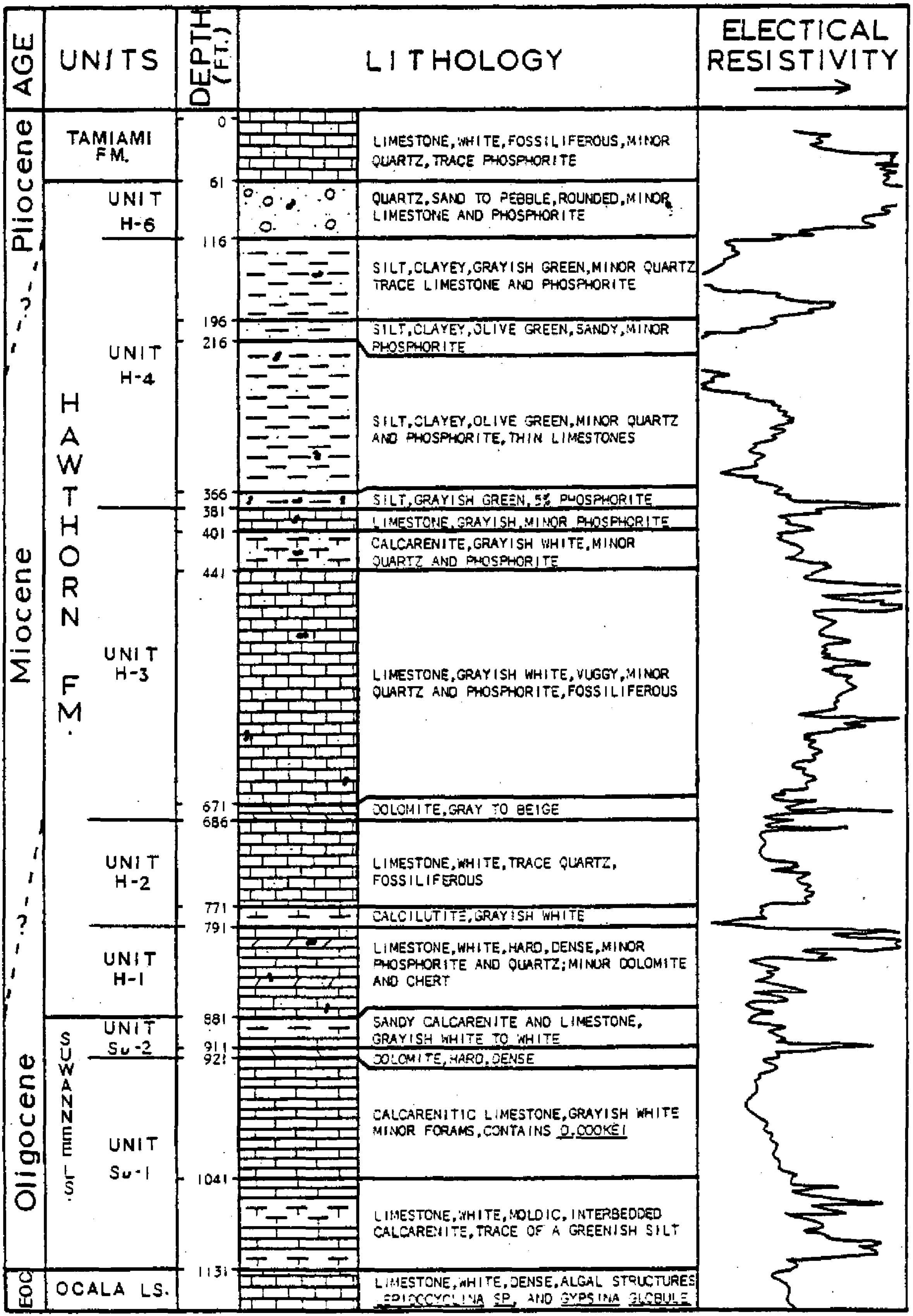


AGE	UNITS		DEPTH (FT.)	LITHOLOGY
Pliocene	TAMIAMI FM.		0	LIMESTONE, WHITE, MOLDIC, MINOR QUARTZ
			32	LIMESTONE, WHITE, SANDY
	HAWTHORN FM	H-6	75	QUARTZ, SAND TO PEBBLE, MINOR FOSSIL HASH AND PHOSPHORITE
		H-5	112	CLAYEY SAND, GRAYISH GREEN
		H-X	142	LIMESTONE, WHITE, MOLDIC, MINOR QUARTZ TO SANDY; CALCAREOUS SANDSTONE
?		H-5	182	CALCILUTITE, WHITE, MINOR QUARTZ
		H-6	227	QUARTZ, SAND TO PEBBLE
Miocene		UNIT H-4	237	SILT, CLAYEY, GREENISH GRAY, SANDY, INTERBEDDED GRANULE & PEBBLE QUARTZ
			345	SILT, CLAYEY, DARK GREEN, MINOR QUARTZ AND PHOSPHORITE
		UNIT H-3	397	LIMESTONE, WHITE, MOLDIC, MINOR PHOSPHORITE, MINOR QUARTZ TO SANDY
			492	CALCARENITE, GRAYISH, MINOR QUARTZ AND PHOSPHORITE
			542	LIMESTONE, WHITE TO GRAY, MINOR QUARTZ AND PHOSPHORITE
			667	DOLOMITE, GRAYISH GREEN TO BEIGE
?		UNIT H-2	687	LIMESTONE, WHITE, MOLDIC, FOSSILIFEROUS, TRACE PHOSPHORITE
		UNIT H-1	772	DOLOMITE, GRAY TO WHITE, COARSE SPAR, MINOR PHOSPHORITE
Oligocene	SUWANNEE LS	UNIT Su-2	837	LIMESTONE AND CALCARENITE, WHITE TO BEIGE, NUMEROUS FORAMS, MINOR QUARTZ TO SANDY
			1022	SANDY COQUINA, ROUNDED SHELL FRAGMENTS
			1052	DOLOMITE AND LIMESTONE, BEIGE TO WHITE, HARD, DENSE
		UNIT Su-1	1142	LIMRSTONE, WHITE, MOLDIC, CONTAINS S. COOKEI
EOC	OCALA LS.		1227	LIMESTONE, WHITE, DENSE, HARD, CONTAINS ALGAL STRUCTURES AND SMALL LEPIDOCYCLINA SP.

W - 10183

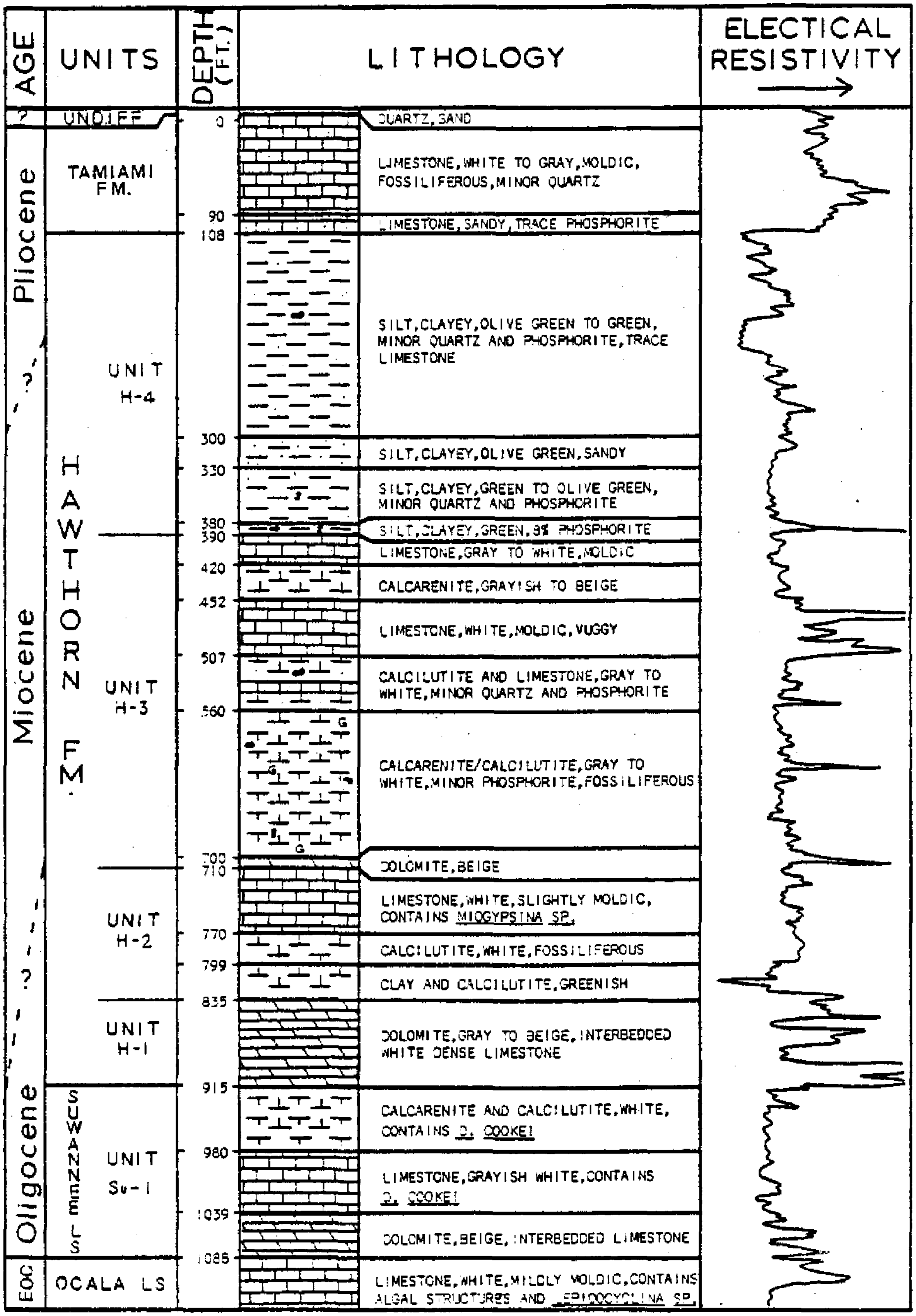

AGE
UNITS
DEPTH (FT.)
LITHOLOGY
ELECTICAL RESISTIVITY
Pliocene
?
Miocene
?
Oligocene
Eoc
TAMIAMI FM.
HAWTHORN FM.
UNIT H-4
UNIT H-3
UNIT H-2
UNIT H-1
SUWANNEE LS.
UNIT Su-2
UNIT Su-1
OCALA LS.
0
46
88
371
401
409
456
461
531
561
591
666
706
771
841
882
896
936
1056
1081
LIMESTONE,WHITE,MINOR QUARTZ
LIMESTONE,WHITE TO GRAY,SANDY,MOLDIC, TRACE PHOSPHORITE
SILT,CLAYEY,OLIVE GREEN TO GRAYISH GREEN,MINOR QUARTZ AND PHOSPHORITE, A FEW THIN LIMESTONES
SILT,CLAYEY,GREENISH GRAY TO GRAYISH GREEN,UP TO 5% PHOSPHORITE
LIMESTONE,GRAYISH WHITE,MOLDIC
CALCARENITIC COQUINA,BEIGE
DOLOMITE,GRAY,MINOR PHOSPHORITE
LIMESTONE,GRAY TO BEIGE,MOLDIC
CALCARENITE AND LIMESTONE,GRAYISH
CALCILUTITE,GRAYISH WHITE,MINOR QUARTZ AND PHOSPHORITE
LIMESTONE,WHITE,MINOR QUARTZ AND PHOSPHORITE;MINOR CALCILUTITE
DOLOMITE,BEIGE;CALCILUTITE,GRAYISH WHITE;LIMESTONE;MINOR PHOSPHORITE
LIMESTONE,WHITE,MOLDIC,CONTAINS MIOGYPSINA SP.;MINOR CALCILUTITE
DOLOMITE,BEIGE TO WHITE
LIMESTONE,GRAYISH WHITE,SANDY, TRACE PHOSPHORITE
CALCARENITE,GRAYISH,NUMEROUS FORAMS
LIMESTONE,GRAYISH WHITE,SANDY,MOLDIC
CALCARENITE,CALCILUTITE,AND LIMESTONE GRAYISH WHITE,CONTAINS D. COOKEI
LIMESTONE,WHITE TO BEIGE,MOLDIC
LIMESTONE,VERY WHITE,MOLDIC,CONTAINS A FEW LEPIDOCYCLINA SP.

W - 10184



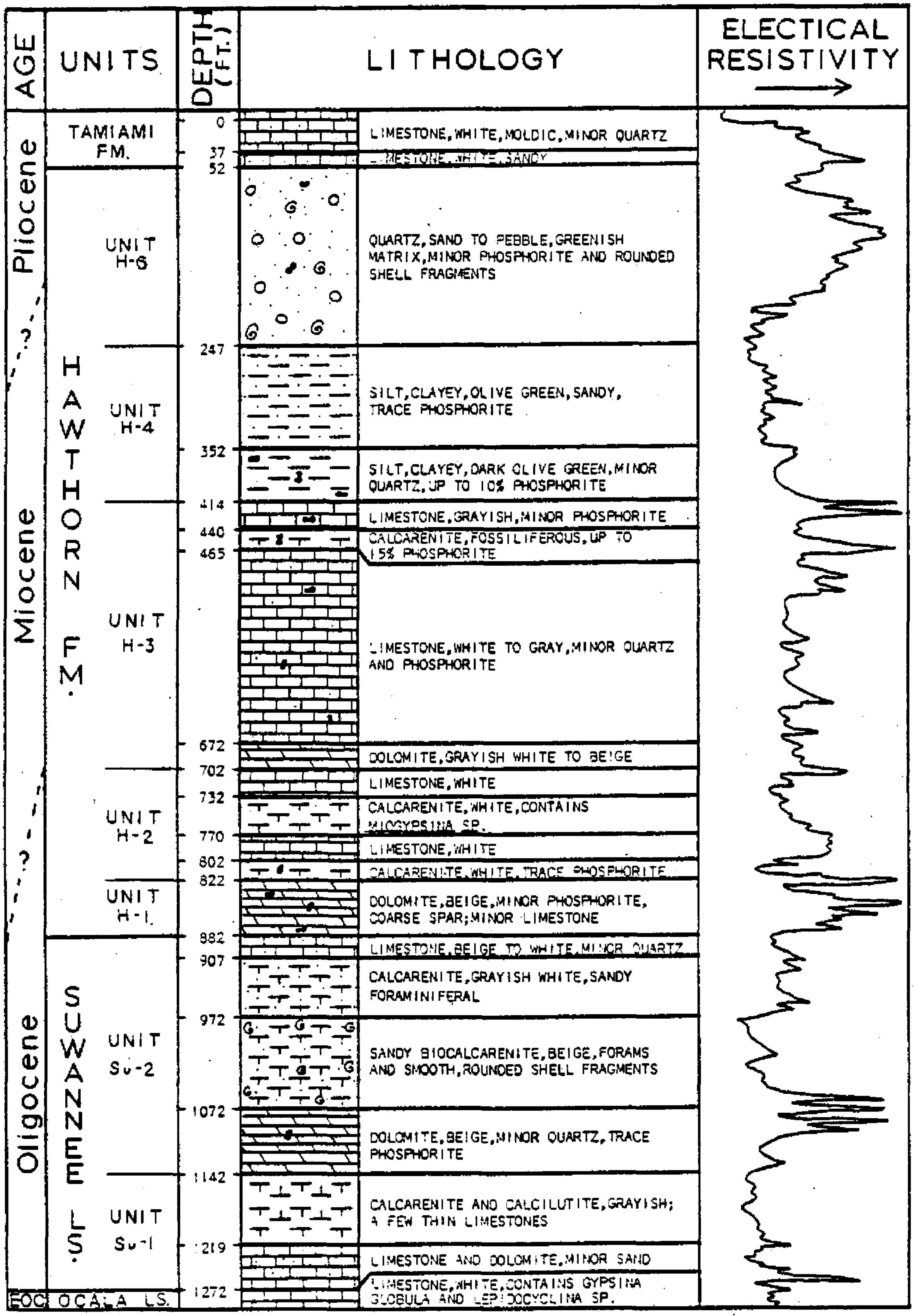
AGE	UNITS	DEPTH (FT.)	LITHOLOGY
Pliocene	TAMIAMI FM.	0	LIMESTONE, WHITE, FOSSILIFEROUS, MINOR QUARTZ, TRACE PHOSPHORITE
	HAWTHORN FM. UNIT H-6	61	QUARTZ, SAND TO PEBBLE, ROUNDED, MINOR LIMESTONE AND PHOSPHORITE
?	HAWTHORN FM. UNIT H-4	116	SILT, CLAYEY, GRAYISH GREEN, MINOR QUARTZ TRACE LIMESTONE AND PHOSPHORITE
		196	SILT, CLAYEY, OLIVE GREEN, SANDY, MINOR PHOSPHORITE
Miocene		216	SILT, CLAYEY, OLIVE GREEN, MINOR QUARTZ AND PHOSPHORITE, THIN LIMESTONES
		366	SILT, GRAYISH GREEN, 5% PHOSPHORITE
	HAWTHORN FM. UNIT H-3	381	LIMESTONE, GRAYISH, MINOR PHOSPHORITE
		401	CALCARENITE, GRAYISH WHITE, MINOR QUARTZ AND PHOSPHORITE
		441	LIMESTONE, GRAYISH WHITE, VUGGY, MINOR QUARTZ AND PHOSPHORITE, FOSSILIFEROUS
		671	DOLOMITE, GRAY TO BEIGE
	HAWTHORN FM. UNIT H-2	686	LIMESTONE, WHITE, TRACE QUARTZ, FOSSILIFEROUS
?		771	CALCILUTITE, GRAYISH WHITE
	HAWTHORN FM. UNIT H-1	791	LIMESTONE, WHITE, HARD, DENSE, MINOR PHOSPHORITE AND QUARTZ; MINOR DOLOMITE AND CHERT
Oligocene	SUWANNEE LS. UNIT Su-2	881	SANDY CALCARENITE AND LIMESTONE, GRAYISH WHITE TO WHITE
		911	DOLOMITE, HARD, DENSE
	SUWANNEE LS. UNIT Su-1	921	CALCARENITIC LIMESTONE, GRAYISH WHITE MINOR FORAMS, CONTAINS O. COOKEI
		1041	LIMESTONE, WHITE, MOLDIC, INTERBEDDED CALCARENITE, TRACE OF A GREENISH SILT
EOC	OCALA LS.	1131	LIMESTONE, WHITE, DENSE, ALGAL STRUCTURES LEPIDOCYCLINA SP. AND GYPSINA GLOBULE

W - 10187

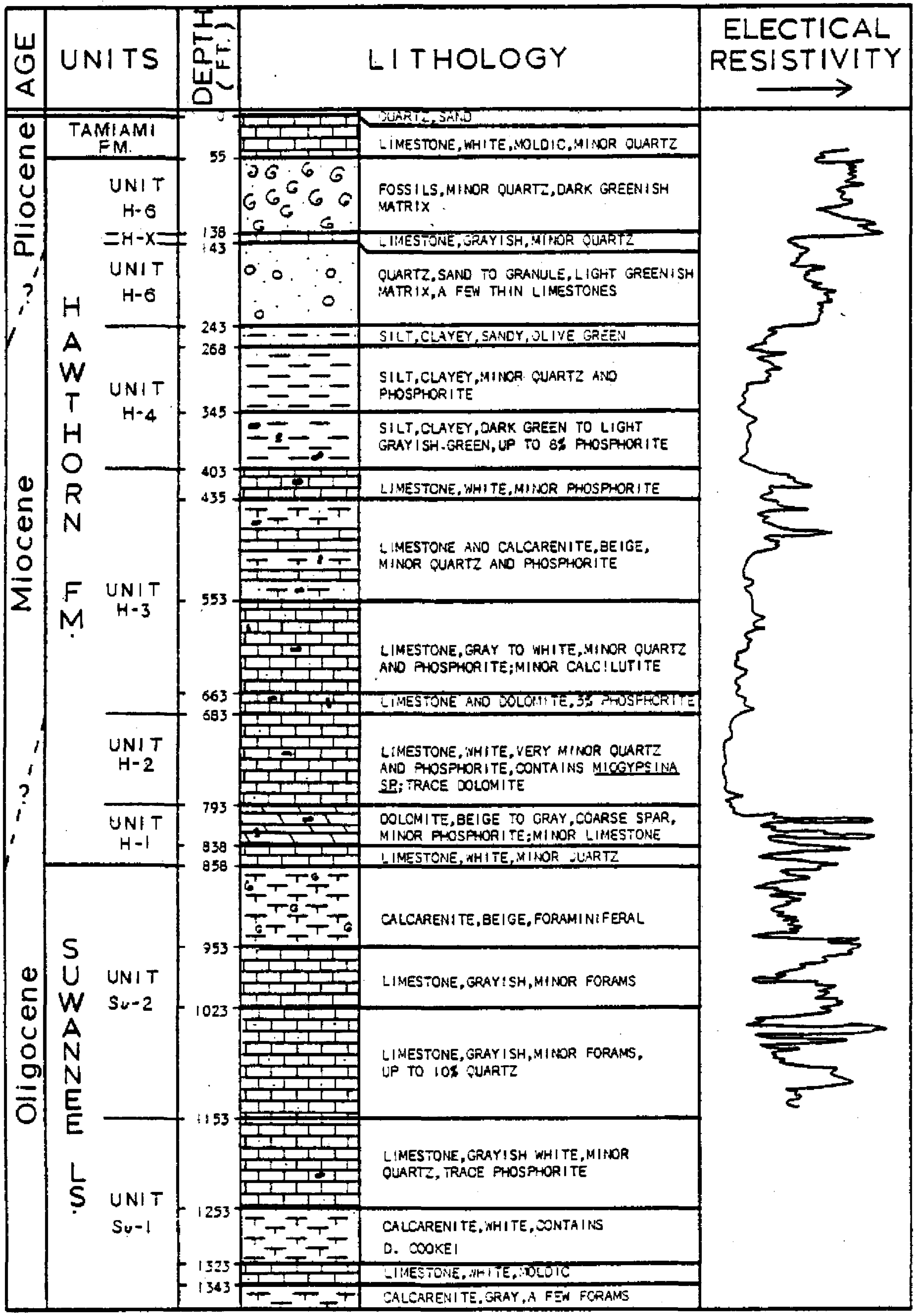


AGE	UNITS	DEPTH (FT.)	LITHOLOGY
?	UNDIFF	0	QUARTZ, SAND
Pliocene	TAMIAMI FM.		LIMESTONE, WHITE TO GRAY, MOLDIC, FOSSILIFEROUS, MINOR QUARTZ
		90	LIMESTONE, SANDY, TRACE PHOSPHORITE
?	HAWTHORN FM. UNIT H-4	108	SILT, CLAYEY, OLIVE GREEN TO GREEN, MINOR QUARTZ AND PHOSPHORITE, TRACE LIMESTONE
Miocene		300	SILT, CLAYEY, OLIVE GREEN, SANDY
		330	SILT, CLAYEY, GREEN TO OLIVE GREEN, MINOR QUARTZ AND PHOSPHORITE
		380	SILT, CLAYEY, GREEN, 3% PHOSPHORITE
	UNIT H-3	390	LIMESTONE, GRAY TO WHITE, MOLDIC
		420	CALCARENITE, GRAYISH TO BEIGE
		452	LIMESTONE, WHITE, MOLDIC, VUGGY
		507	CALCILUTITE AND LIMESTONE, GRAY TO WHITE, MINOR QUARTZ AND PHOSPHORITE
		560	CALCARENITE/CALCILUTITE, GRAY TO WHITE, MINOR PHOSPHORITE, FOSSILIFEROUS
		700	DOLOMITE, BEIGE
?	UNIT H-2	710	LIMESTONE, WHITE, SLIGHTLY MOLDIC, CONTAINS *MIOGYPSINA SP.*
		770	CALCILUTITE, WHITE, FOSSILIFEROUS
		799	CLAY AND CALCILUTITE, GREENISH
	UNIT H-1	835	DOLOMITE, GRAY TO BEIGE, INTERBEDDED WHITE DENSE LIMESTONE
Oligocene	SUWANNEE LS UNIT Su-1	915	CALCARENITE AND CALCILUTITE, WHITE, CONTAINS *D. COOKEI*
		980	LIMESTONE, GRAYISH WHITE, CONTAINS *D. COOKEI*
		1039	DOLOMITE, BEIGE, INTERBEDDED LIMESTONE
EOC	OCALA LS	1086	LIMESTONE, WHITE, MILDLY MOLDIC, CONTAINS ALGAL STRUCTURES AND *LEPIDOCYCLINA SP.*

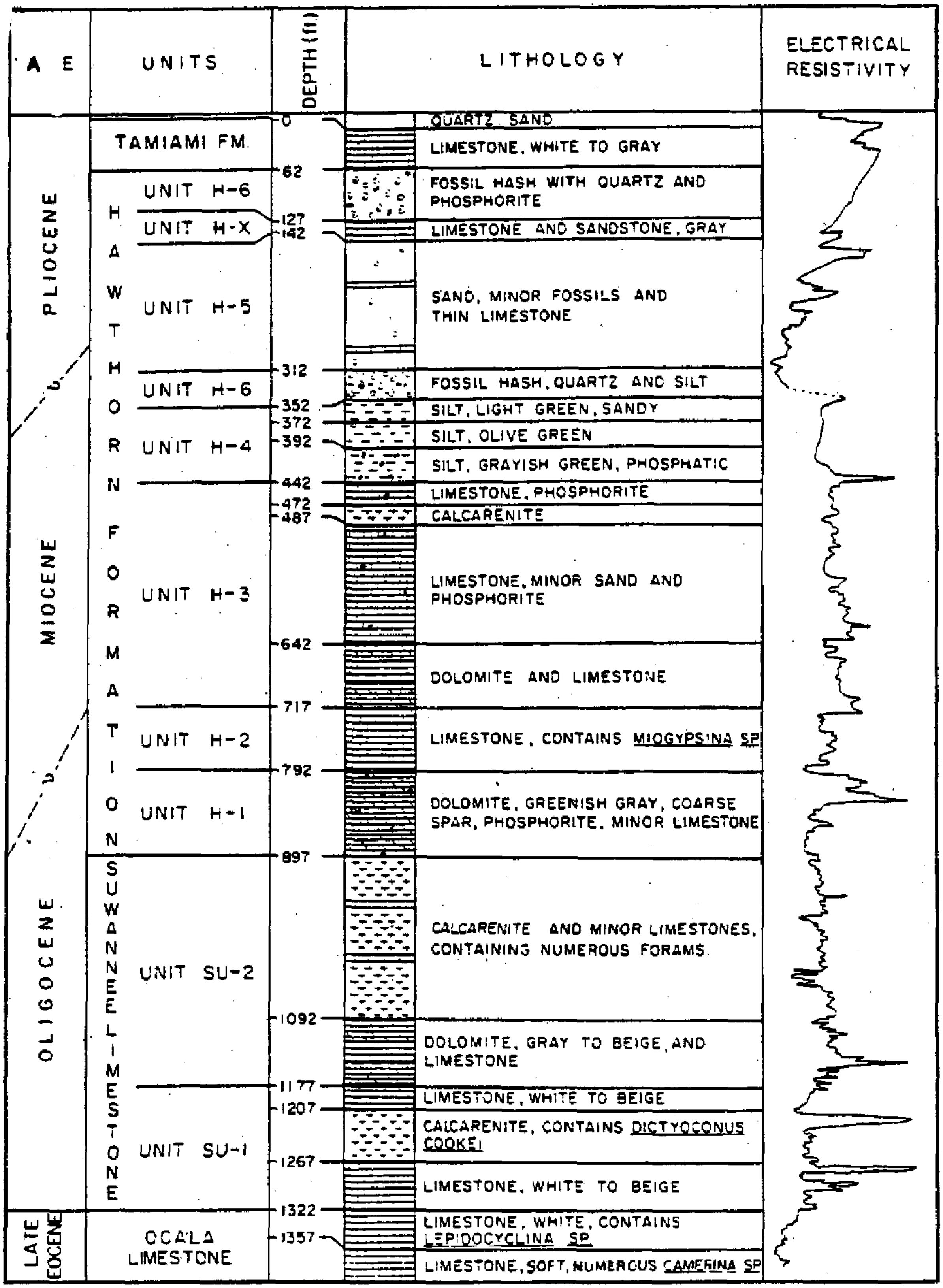
W - 10190


AGE
UNITS
DEPTH (FT.)
LITHOLOGY
ELECTICAL RESISTIVITY
Pliocene
?
Miocene
?
Oligocene
EOC.
TAMIAMI FM.
HAWTHORN FM.
UNIT H-6
UNIT H-4
UNIT H-3
UNIT H-2
UNIT H-1
SUWANNEE LS.
UNIT Su-2
UNIT Su-1
OCALA LS.
0
37
52
247
352
414
440
465
672
702
732
770
802
822
882
907
972
1072
1142
1219
1272
LIMESTONE, WHITE, MOLDIC, MINOR QUARTZ
LIMESTONE, WHITE, SANDY
QUARTZ, SAND TO PEBBLE, GREENISH MATRIX, MINOR PHOSPHORITE AND ROUNDED SHELL FRAGMENTS
SILT, CLAYEY, OLIVE GREEN, SANDY, TRACE PHOSPHORITE
SILT, CLAYEY, DARK OLIVE GREEN, MINOR QUARTZ, UP TO 10% PHOSPHORITE
LIMESTONE, GRAYISH, MINOR PHOSPHORITE
CALCARENITE, FOSSILIFEROUS, UP TO 15% PHOSPHORITE
LIMESTONE, WHITE TO GRAY, MINOR QUARTZ AND PHOSPHORITE
DOLOMITE, GRAYISH WHITE TO BEIGE
LIMESTONE, WHITE
CALCARENITE, WHITE, CONTAINS MIOGYPSINA SP.
LIMESTONE, WHITE
CALCARENITE, WHITE, TRACE PHOSPHORITE
DOLOMITE, BEIGE, MINOR PHOSPHORITE, COARSE SPAR; MINOR LIMESTONE
LIMESTONE, BEIGE TO WHITE, MINOR QUARTZ
CALCARENITE, GRAYISH WHITE, SANDY FORAMINIFERAL
SANDY BIOCALCARENITE, BEIGE, FORAMS AND SMOOTH, ROUNDED SHELL FRAGMENTS
DOLOMITE, BEIGE, MINOR QUARTZ, TRACE PHOSPHORITE
CALCARENITE AND CALCILUTITE, GRAYISH; A FEW THIN LIMESTONES
LIMESTONE AND DOLOMITE, MINOR SAND
LIMESTONE, WHITE, CONTAINS GYPSINA GLOBULA AND LEPIDOCYCLINA SP.

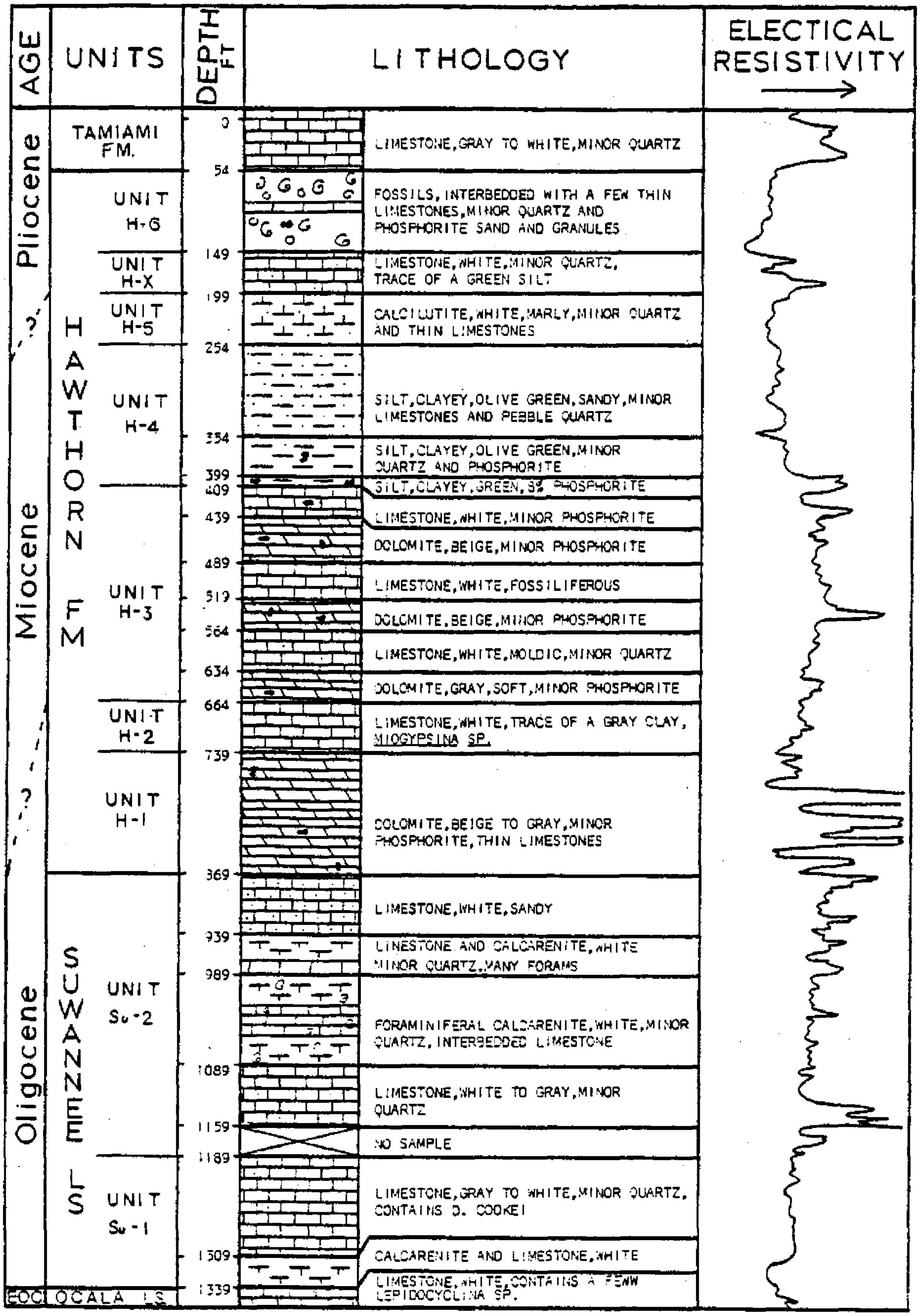
W - 10201


AGE
UNITS
DEPTH (FT.)
LITHOLOGY
ELECTICAL RESISTIVITY
Pliocene
?
Miocene
?
Oligocene
TAMIAMI FM.
HAWTHORN FM.
UNIT H-6
H-X
UNIT H-6
UNIT H-4
UNIT H-3
UNIT H-2
UNIT H-1
SUWANNEE LS.
UNIT Su-2
UNIT Su-1
0
55
138
143
243
268
345
403
435
553
663
683
793
838
858
953
1023
1153
1253
1323
1343
QUARTZ, SAND
LIMESTONE, WHITE, MOLDIC, MINOR QUARTZ
FOSSILS, MINOR QUARTZ, DARK GREENISH MATRIX
LIMESTONE, GRAYISH, MINOR QUARTZ
QUARTZ, SAND TO GRANULE, LIGHT GREENISH MATRIX, A FEW THIN LIMESTONES
SILT, CLAYEY, SANDY, OLIVE GREEN
SILT, CLAYEY, MINOR QUARTZ AND PHOSPHORITE
SILT, CLAYEY, DARK GREEN TO LIGHT GRAYISH-GREEN, UP TO 8% PHOSPHORITE
LIMESTONE, WHITE, MINOR PHOSPHORITE
LIMESTONE AND CALCARENITE, BEIGE, MINOR QUARTZ AND PHOSPHORITE
LIMESTONE, GRAY TO WHITE, MINOR QUARTZ AND PHOSPHORITE; MINOR CALCILUTITE
LIMESTONE AND DOLOMITE, 3% PHOSPHORITE
LIMESTONE, WHITE, VERY MINOR QUARTZ AND PHOSPHORITE, CONTAINS MIOGYPSINA SP; TRACE DOLOMITE
DOLOMITE, BEIGE TO GRAY, COARSE SPAR, MINOR PHOSPHORITE; MINOR LIMESTONE
LIMESTONE, WHITE, MINOR QUARTZ
CALCARENITE, BEIGE, FORAMINIFERAL
LIMESTONE, GRAYISH, MINOR FORAMS
LIMESTONE, GRAYISH, MINOR FORAMS, UP TO 10% QUARTZ
LIMESTONE, GRAYISH WHITE, MINOR QUARTZ, TRACE PHOSPHORITE
CALCARENITE, WHITE, CONTAINS D. COOKEI
LIMESTONE, WHITE, MOLDIC
CALCARENITE, GRAY, A FEW FORAMS

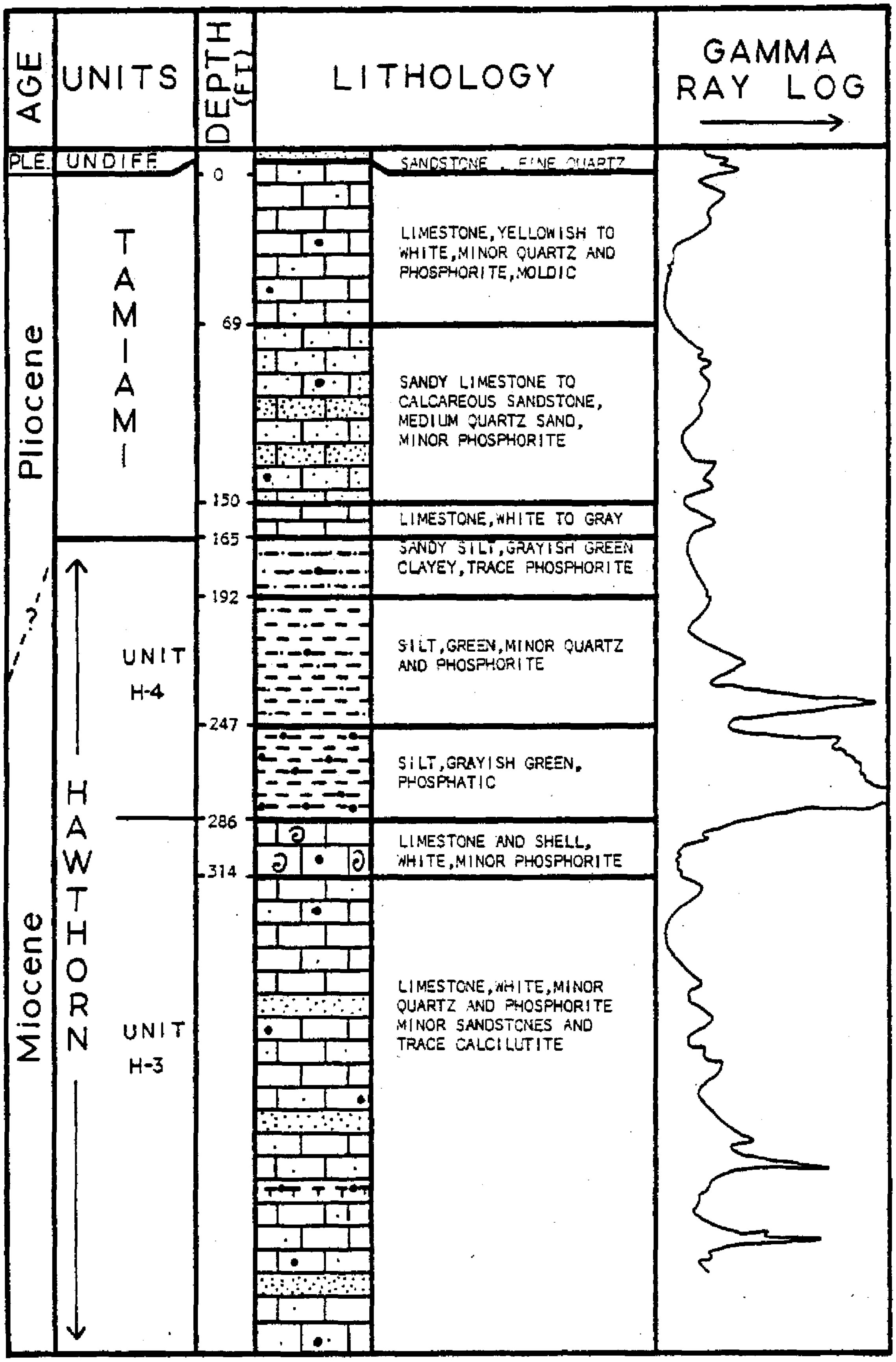
W-10202


A E
UNITS
DEPTH (ft)
LITHOLOGY
ELECTRICAL RESISTIVITY
PLIOCENE
MIOCENE
OLIGOCENE
LATE EOCENE
TAMIAMI FM.
HAWTHORN FORMATION
UNIT H-6
UNIT H-X
UNIT H-5
UNIT H-6
UNIT H-4
UNIT H-3
UNIT H-2
UNIT H-1
SUWANNEE LIMESTONE
UNIT SU-2
UNIT SU-1
OCALA LIMESTONE
0
62
127
142
312
352
372
392
442
472
487
642
717
792
897
1092
1177
1207
1267
1322
1357
QUARTZ SAND
LIMESTONE, WHITE TO GRAY
FOSSIL HASH WITH QUARTZ AND PHOSPHORITE
LIMESTONE AND SANDSTONE, GRAY
SAND, MINOR FOSSILS AND THIN LIMESTONE
FOSSIL HASH, QUARTZ AND SILT
SILT, LIGHT GREEN, SANDY
SILT, OLIVE GREEN
SILT, GRAYISH GREEN, PHOSPHATIC
LIMESTONE, PHOSPHORITE
CALCARENITE
LIMESTONE, MINOR SAND AND PHOSPHORITE
DOLOMITE AND LIMESTONE
LIMESTONE, CONTAINS MIOGYPSINA SP
DOLOMITE, GREENISH GRAY, COARSE SPAR, PHOSPHORITE, MINOR LIMESTONE
CALCARENITE AND MINOR LIMESTONES, CONTAINING NUMEROUS FORAMS.
DOLOMITE, GRAY TO BEIGE, AND LIMESTONE
LIMESTONE, WHITE TO BEIGE
CALCARENITE, CONTAINS DICTYOCONUS COOKEI
LIMESTONE, WHITE TO BEIGE
LIMESTONE, WHITE, CONTAINS LEPIDOCYCLINA SP.
LIMESTONE, SOFT, NUMEROUS CAMERINA SP

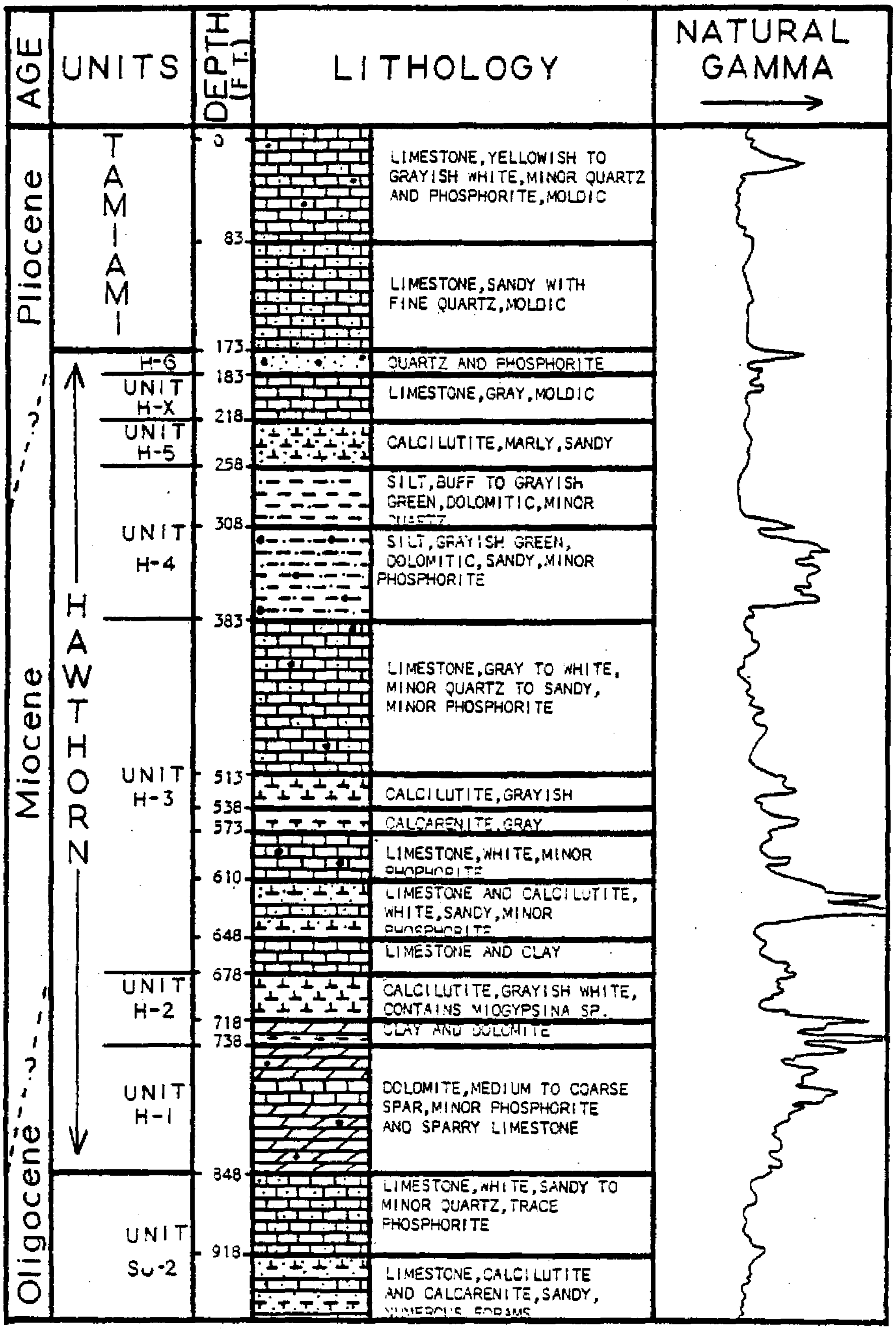
W - 10223


AGE
UNITS
DEPTH FT
LITHOLOGY
ELECTICAL RESISTIVITY
Pliocene
?
Miocene
?
Oligocene
EOC
TAMIAMI FM.
HAWTHORN FM
UNIT H-G
UNIT H-X
UNIT H-5
UNIT H-4
UNIT H-3
UNIT H-2
UNIT H-1
SUWANNEE LS
UNIT Su-2
UNIT Su-1
OCALA LS
0
54
149
199
254
354
399
409
439
489
519
564
634
664
739
369
939
989
1089
1159
1189
1309
1339
LIMESTONE, GRAY TO WHITE, MINOR QUARTZ
FOSSILS, INTERBEDDED WITH A FEW THIN LIMESTONES, MINOR QUARTZ AND PHOSPHORITE SAND AND GRANULES
LIMESTONE, WHITE, MINOR QUARTZ, TRACE OF A GREEN SILT
CALCILUTITE, WHITE, MARLY, MINOR QUARTZ AND THIN LIMESTONES
SILT, CLAYEY, OLIVE GREEN, SANDY, MINOR LIMESTONES AND PEBBLE QUARTZ
SILT, CLAYEY, OLIVE GREEN, MINOR QUARTZ AND PHOSPHORITE
SILT, CLAYEY, GREEN, 3% PHOSPHORITE
LIMESTONE, WHITE, MINOR PHOSPHORITE
DOLOMITE, BEIGE, MINOR PHOSPHORITE
LIMESTONE, WHITE, FOSSILIFEROUS
DOLOMITE, BEIGE, MINOR PHOSPHORITE
LIMESTONE, WHITE, MOLDIC, MINOR QUARTZ
DOLOMITE, GRAY, SOFT, MINOR PHOSPHORITE
LIMESTONE, WHITE, TRACE OF A GRAY CLAY, MIOGYPSINA SP.
DOLOMITE, BEIGE TO GRAY, MINOR PHOSPHORITE, THIN LIMESTONES
LIMESTONE, WHITE, SANDY
LINESTONE AND CALCARENITE, WHITE MINOR QUARTZ, MANY FORAMS
FORAMINIFERAL CALCARENITE, WHITE, MINOR QUARTZ, INTERBEDDED LIMESTONE
LIMESTONE, WHITE TO GRAY, MINOR QUARTZ
NO SAMPLE
LIMESTONE, GRAY TO WHITE, MINOR QUARTZ, CONTAINS D. COOKEI
CALCARENITE AND LIMESTONE, WHITE
LIMESTONE, WHITE, CONTAINS A FENW LEPIDOCYCLINA SP.

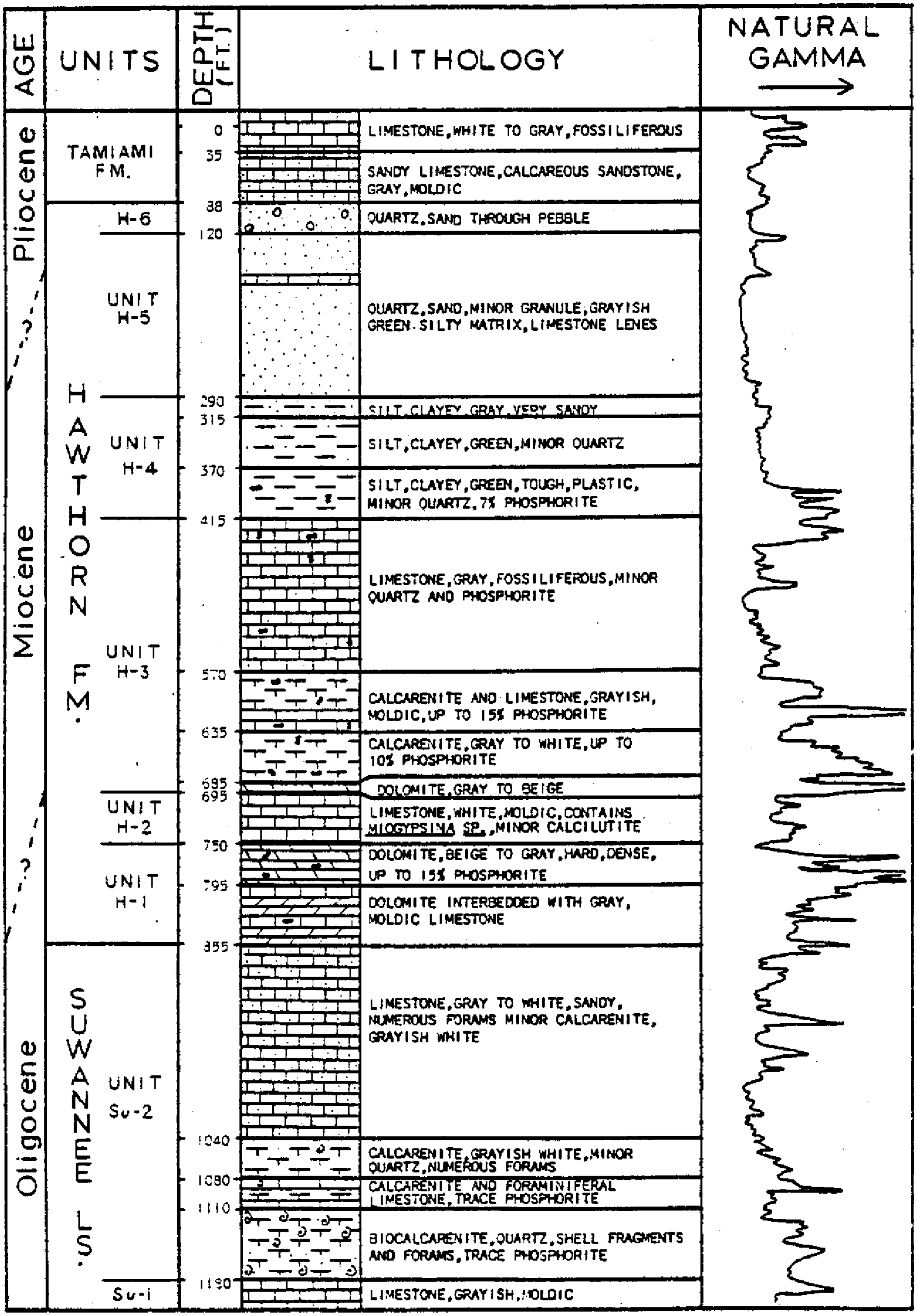
W-14534


AGE
UNITS
DEPTH (FT)
LITHOLOGY
GAMMA RAY LOG
PLE.
UNDIFF.
SANDSTONE, FINE QUARTZ
0
Pliocene
TAMIAMI
LIMESTONE,YELLOWISH TO WHITE,MINOR QUARTZ AND PHOSPHORITE,MOLDIC
69
SANDY LIMESTONE TO CALCAREOUS SANDSTONE, MEDIUM QUARTZ SAND, MINOR PHOSPHORITE
150
LIMESTONE,WHITE TO GRAY
165
SANDY SILT,GRAYISH GREEN CLAYEY,TRACE PHOSPHORITE
?
192
UNIT H-4
SILT,GREEN,MINOR QUARTZ AND PHOSPHORITE
247
SILT,GRAYISH GREEN, PHOSPHATIC
Miocene
HAWTHORN
286
LIMESTONE AND SHELL, WHITE,MINOR PHOSPHORITE
314
UNIT H-3
LIMESTONE,WHITE,MINOR QUARTZ AND PHOSPHORITE MINOR SANDSTONES AND TRACE CALCILUTITE

W-14601

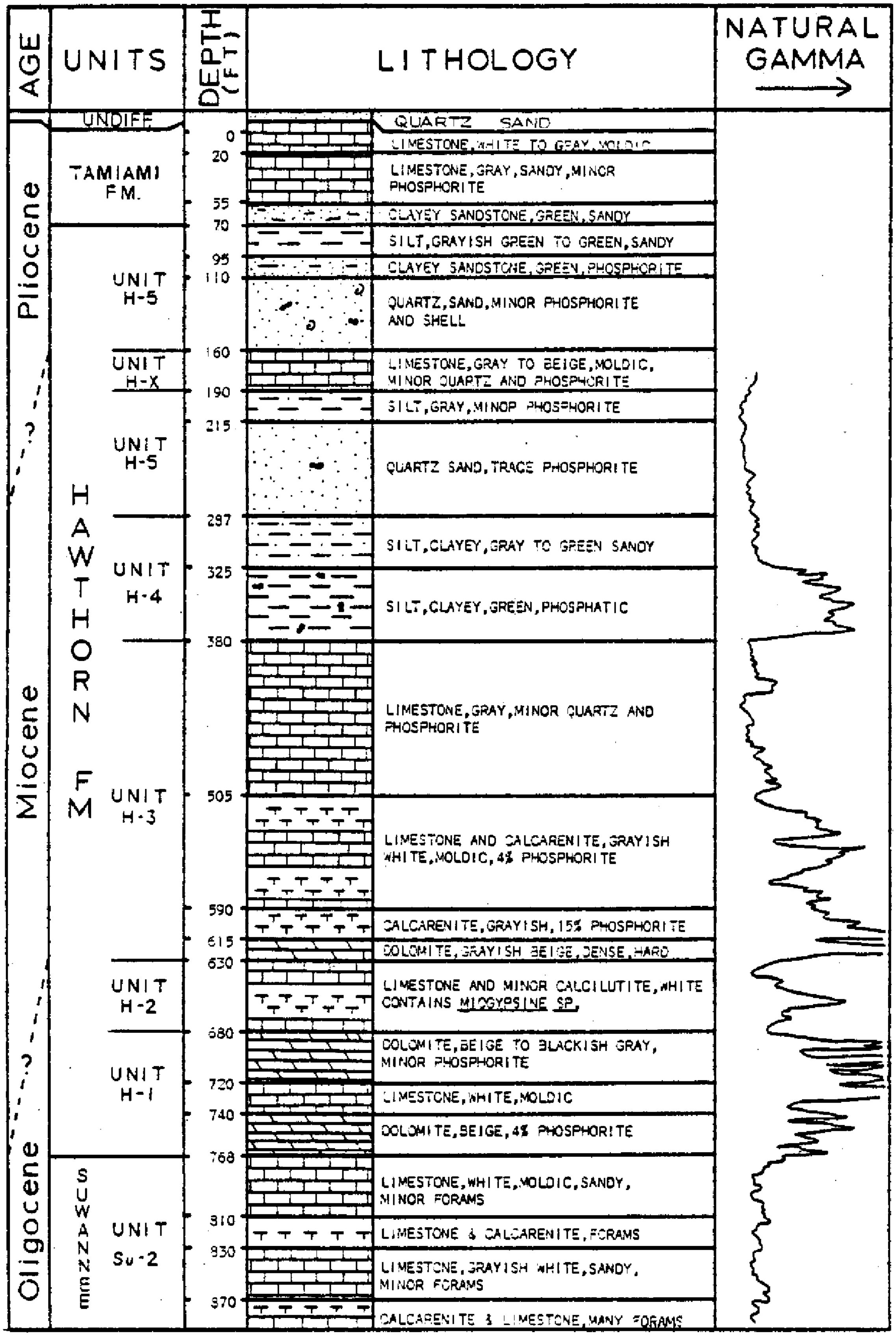

AGE
UNITS
DEPTH (FT.)
LITHOLOGY
NATURAL GAMMA
Pliocene
Miocene
Oligocene
?
?
TAMIAMI
HAWTHORN
H-6
UNIT H-X
UNIT H-5
UNIT H-4
UNIT H-3
UNIT H-2
UNIT H-1
UNIT Su-2
0
83
173
183
218
258
308
383
513
538
573
610
648
678
718
738
848
918
LIMESTONE,YELLOWISH TO GRAYISH WHITE,MINOR QUARTZ AND PHOSPHORITE,MOLDIC
LIMESTONE,SANDY WITH FINE QUARTZ,MOLDIC
QUARTZ AND PHOSPHORITE
LIMESTONE,GRAY,MOLDIC
CALCILUTITE,MARLY,SANDY
SILT,BUFF TO GRAYISH GREEN,DOLOMITIC,MINOR QUARTZ
SILT,GRAYISH GREEN, DOLOMITIC,SANDY,MINOR PHOSPHORITE
LIMESTONE,GRAY TO WHITE, MINOR QUARTZ TO SANDY, MINOR PHOSPHORITE
CALCILUTITE,GRAYISH
CALCARENITE,GRAY
LIMESTONE,WHITE,MINOR PHOSPHORITE
LIMESTONE AND CALCILUTITE, WHITE,SANDY,MINOR PHOSPHORITE
LIMESTONE AND CLAY
CALCILUTITE,GRAYISH WHITE, CONTAINS MIOGYPSINA SP.
CLAY AND DOLOMITE
DOLOMITE,MEDIUM TO COARSE SPAR,MINOR PHOSPHORITE AND SPARRY LIMESTONE
LIMESTONE,WHITE,SANDY TO MINOR QUARTZ,TRACE PHOSPHORITE
LIMESTONE,CALCILUTITE AND CALCARENITE,SANDY, NUMEROUS FORAMS

W - 14919

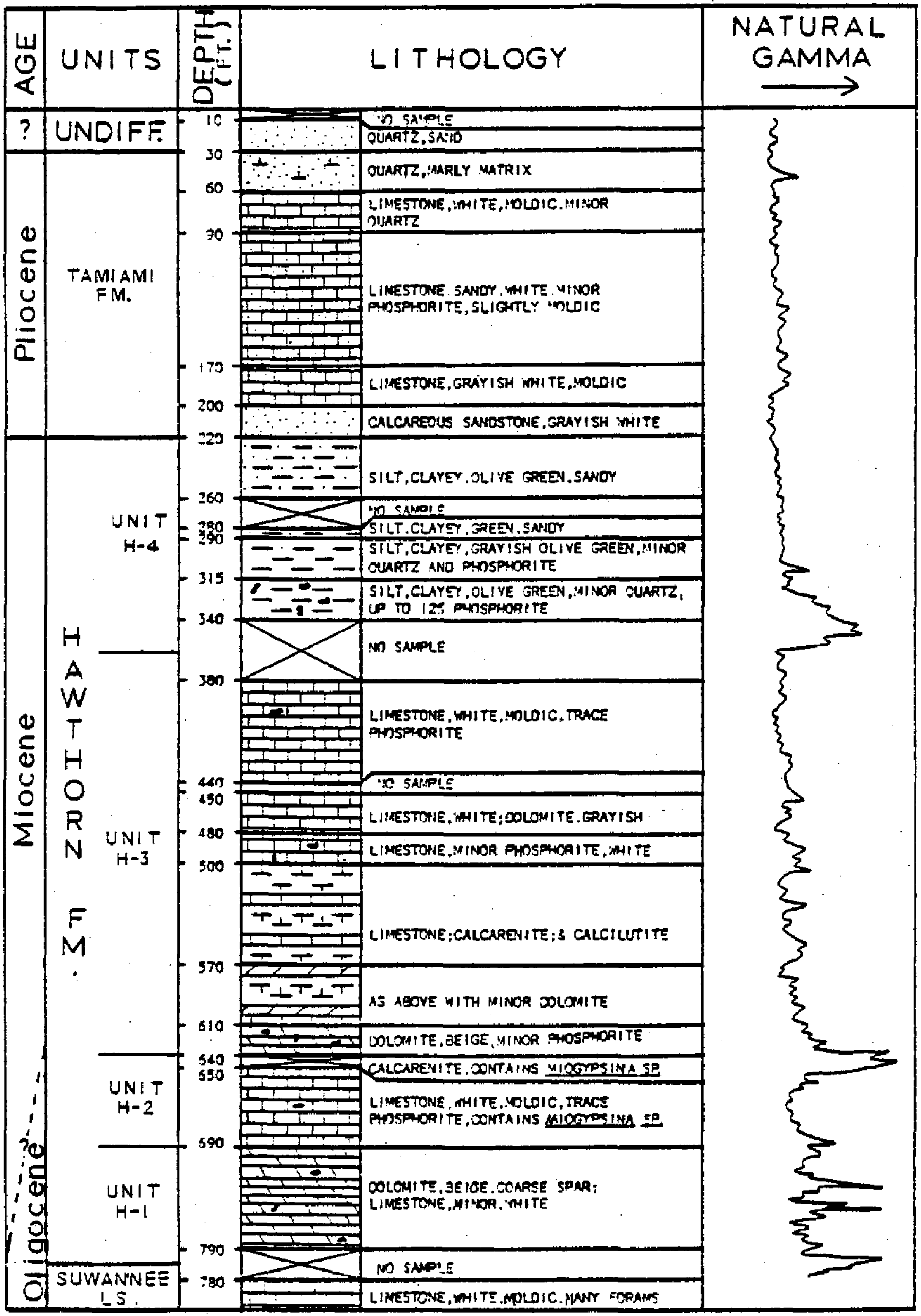


Units	Depth (ft.)	Lithology
TAMIAMI FM.	0	LIMESTONE, WHITE TO GRAY, FOSSILIFEROUS
	35	SANDY LIMESTONE, CALCAREOUS SANDSTONE, GRAY, MOLDIC
H-6	38	QUARTZ, SAND THROUGH PEBBLE
UNIT H-5	120	QUARTZ, SAND, MINOR GRANULE, GRAYISH GREEN SILTY MATRIX, LIMESTONE LENES
UNIT H-4	290	SILT, CLAYEY, GRAY, VERY SANDY
	315	SILT, CLAYEY, GREEN, MINOR QUARTZ
	370	SILT, CLAYEY, GREEN, TOUGH, PLASTIC, MINOR QUARTZ, 7% PHOSPHORITE
UNIT H-3	415	LIMESTONE, GRAY, FOSSILIFEROUS, MINOR QUARTZ AND PHOSPHORITE
	570	CALCARENITE AND LIMESTONE, GRAYISH, MOLDIC, UP TO 15% PHOSPHORITE
	635	CALCARENITE, GRAY TO WHITE, UP TO 10% PHOSPHORITE
	685	DOLOMITE, GRAY TO BEIGE
UNIT H-2	695	LIMESTONE, WHITE, MOLDIC, CONTAINS *MIOGYPSINA SP.*, MINOR CALCILUTITE
UNIT H-1	750	DOLOMITE, BEIGE TO GRAY, HARD, DENSE, UP TO 15% PHOSPHORITE
	795	DOLOMITE INTERBEDDED WITH GRAY, MOLDIC LIMESTONE
UNIT Su-2	855	LIMESTONE, GRAY TO WHITE, SANDY, NUMEROUS FORAMS MINOR CALCARENITE, GRAYISH WHITE
	1040	CALCARENITE, GRAYISH WHITE, MINOR QUARTZ, NUMEROUS FORAMS
	1080	CALCARENITE AND FORAMINIFERAL LIMESTONE, TRACE PHOSPHORITE
	1110	BIOCALCARENITE, QUARTZ, SHELL FRAGMENTS AND FORAMS, TRACE PHOSPHORITE
Su-1	1190	LIMESTONE, GRAYISH, MOLDIC

W 14918

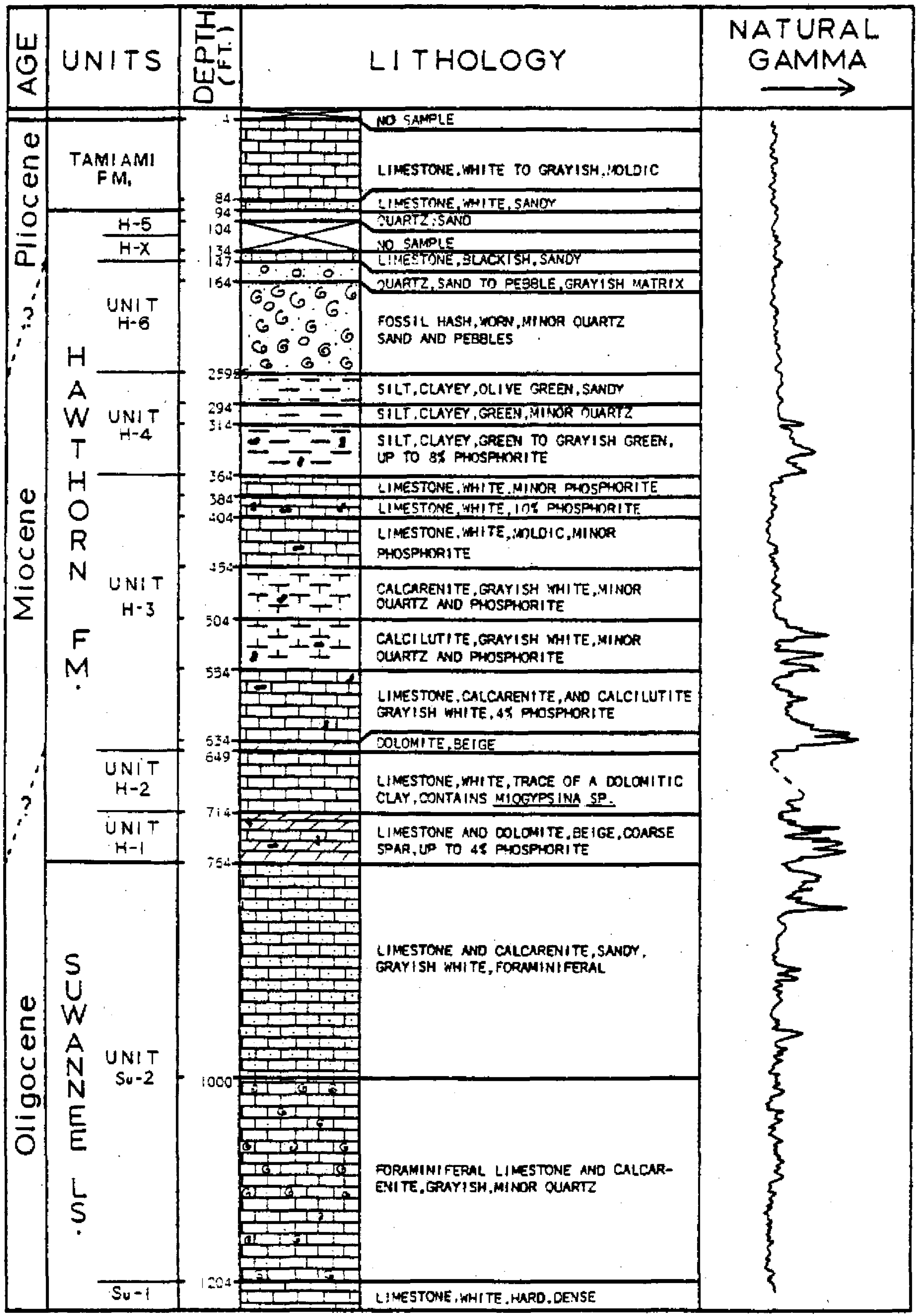

AGE
UNITS
DEPTH (FT)
LITHOLOGY
NATURAL GAMMA
Pliocene
?
Miocene
?
Oligocene
UNDIFF.
TAMIAMI FM.
HAWTHORN FM
UNIT H-5
UNIT H-X
UNIT H-5
UNIT H-4
UNIT H-3
UNIT H-2
UNIT H-1
SUWANNEE
UNIT Su-2
QUARTZ SAND
0
LIMESTONE, WHITE TO GRAY, MOLDIC
20
LIMESTONE, GRAY, SANDY, MINOR PHOSPHORITE
55
CLAYEY SANDSTONE, GREEN, SANDY
70
SILT, GRAYISH GREEN TO GREEN, SANDY
95
CLAYEY SANDSTONE, GREEN, PHOSPHORITE
110
QUARTZ, SAND, MINOR PHOSPHORITE AND SHELL
160
LIMESTONE, GRAY TO BEIGE, MOLDIC, MINOR QUARTZ AND PHOSPHORITE
190
SILT, GRAY, MINOR PHOSPHORITE
215
QUARTZ SAND, TRACE PHOSPHORITE
297
SILT, CLAYEY, GRAY TO GREEN SANDY
325
SILT, CLAYEY, GREEN, PHOSPHATIC
380
LIMESTONE, GRAY, MINOR QUARTZ AND PHOSPHORITE
505
LIMESTONE AND CALCARENITE, GRAYISH WHITE, MOLDIC, 4% PHOSPHORITE
590
CALCARENITE, GRAYISH, 15% PHOSPHORITE
615
DOLOMITE, GRAYISH BEIGE, DENSE, HARD
630
LIMESTONE AND MINOR CALCILUTITE, WHITE CONTAINS MIOGYPSINE SP.
680
DOLOMITE, BEIGE TO BLACKISH GRAY, MINOR PHOSPHORITE
720
LIMESTONE, WHITE, MOLDIC
740
DOLOMITE, BEIGE, 4% PHOSPHORITE
768
LIMESTONE, WHITE, MOLDIC, SANDY, MINOR FORAMS
810
LIMESTONE & CALCARENITE, FORAMS
830
LIMESTONE, GRAYISH WHITE, SANDY, MINOR FORAMS
870
CALCARENITE & LIMESTONE, MANY FORAMS

W - 14921



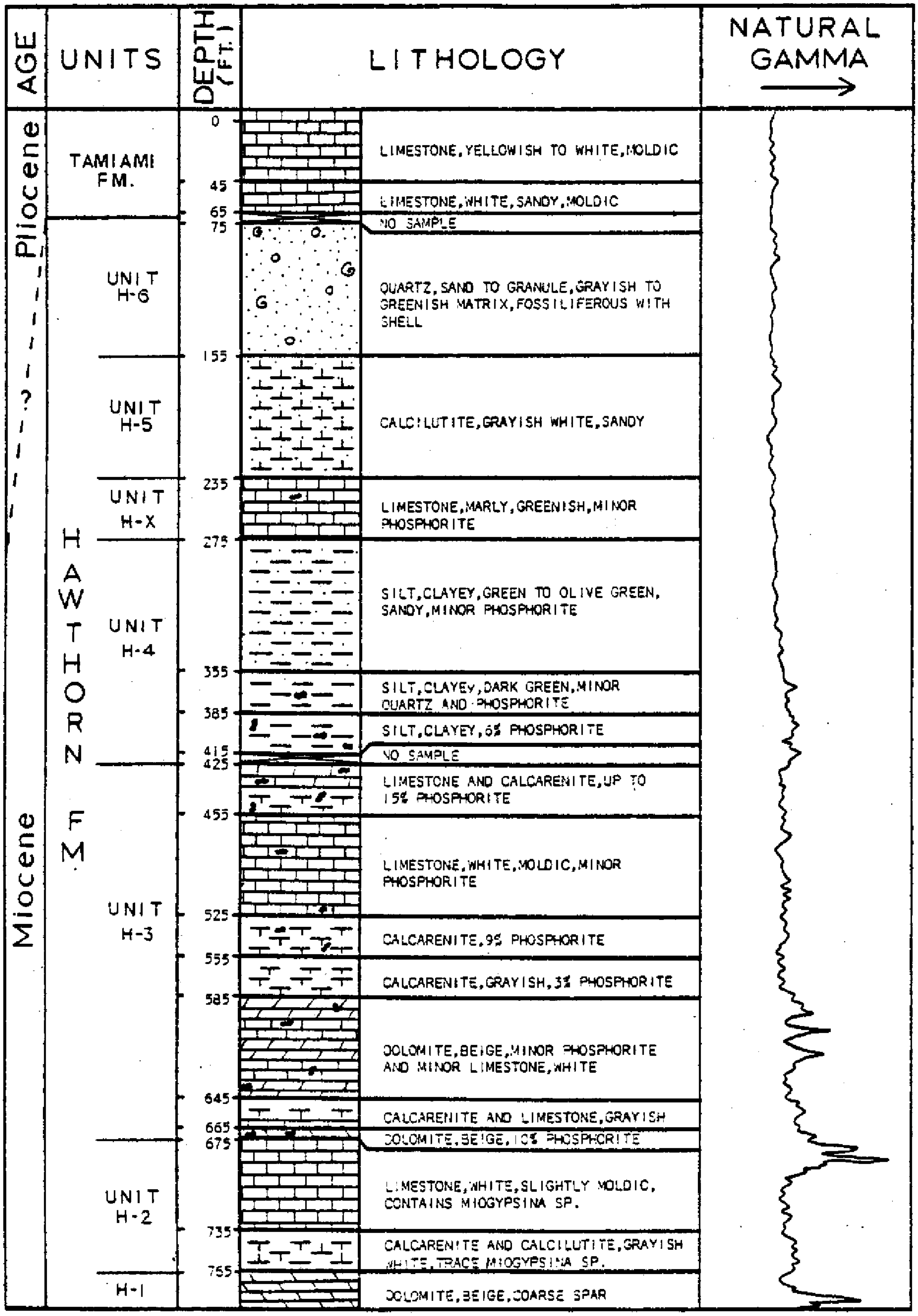
DEPTH (FT.)	LITHOLOGY
	NO SAMPLE
10	QUARTZ,SAND
30	QUARTZ,MARLY MATRIX
60	LIMESTONE,WHITE,MOLDIC,MINOR QUARTZ
90	LIMESTONE SANDY,WHITE MINOR PHOSPHORITE,SLIGHTLY MOLDIC
170	LIMESTONE,GRAYISH WHITE,MOLDIC
200	CALCAREOUS SANDSTONE,GRAYISH WHITE
220	SILT,CLAYEY,OLIVE GREEN,SANDY
260	NO SAMPLE
280	SILT,CLAYEY,GREEN,SANDY
290	SILT,CLAYEY,GRAYISH OLIVE GREEN,MINOR QUARTZ AND PHOSPHORITE
315	SILT,CLAYEY,OLIVE GREEN,MINOR QUARTZ, UP TO 12% PHOSPHORITE
340	NO SAMPLE
380	LIMESTONE,WHITE,MOLDIC,TRACE PHOSPHORITE
440	NO SAMPLE
450	LIMESTONE,WHITE;DOLOMITE,GRAYISH
480	LIMESTONE,MINOR PHOSPHORITE,WHITE
500	LIMESTONE;CALCARENITE;& CALCILUTITE
570	AS ABOVE WITH MINOR DOLOMITE
610	DOLOMITE,BEIGE,MINOR PHOSPHORITE
540	CALCARENITE,CONTAINS *MIOGYPSINA SP.*
650	LIMESTONE,WHITE,MOLDIC,TRACE PHOSPHORITE,CONTAINS *MIOGYPSINA SP.*
690	DOLOMITE,BEIGE,COARSE SPAR; LIMESTONE,MINOR,WHITE
790	NO SAMPLE
780	LIMESTONE,WHITE,MOLDIC,MANY FORAMS

W - 14920

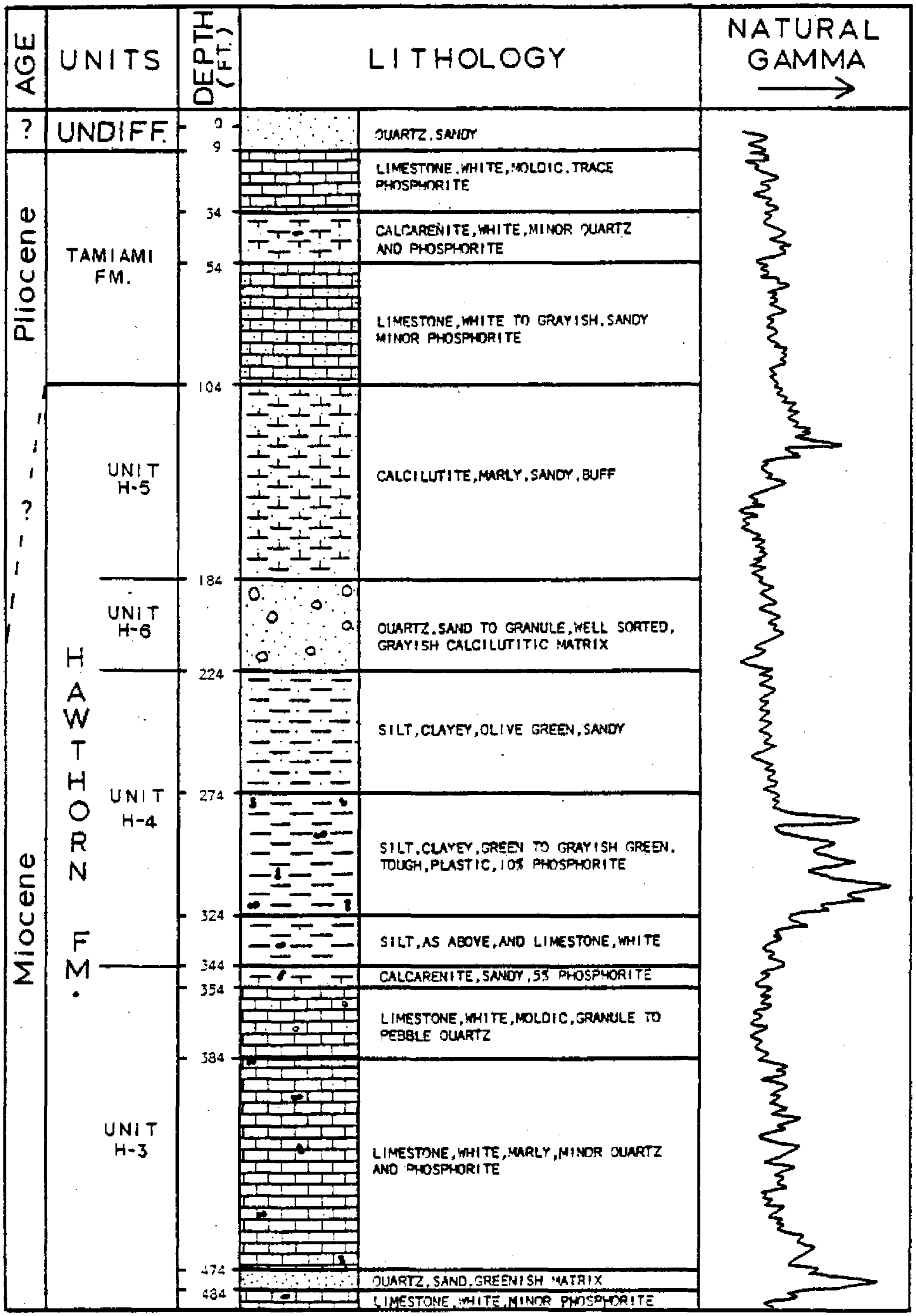


Units	Depth (ft.)	Lithology
	4	NO SAMPLE
TAMIAMI FM.		LIMESTONE, WHITE TO GRAYISH, MOLDIC
	84	LIMESTONE, WHITE, SANDY
H-5	94	QUARTZ SAND
H-X	104	NO SAMPLE
	134	LIMESTONE, BLACKISH, SANDY
UNIT H-6	147	QUARTZ, SAND TO PEBBLE, GRAYISH MATRIX
	164	FOSSIL HASH, WORN, MINOR QUARTZ SAND AND PEBBLES
UNIT H-4	259	SILT, CLAYEY, OLIVE GREEN, SANDY
	294	SILT, CLAYEY, GREEN, MINOR QUARTZ
	314	SILT, CLAYEY, GREEN TO GRAYISH GREEN, UP TO 8% PHOSPHORITE
UNIT H-3	364	LIMESTONE, WHITE, MINOR PHOSPHORITE
	384	LIMESTONE, WHITE, 10% PHOSPHORITE
	404	LIMESTONE, WHITE, MOLDIC, MINOR PHOSPHORITE
	454	CALCARENITE, GRAYISH WHITE, MINOR QUARTZ AND PHOSPHORITE
	504	CALCILUTITE, GRAYISH WHITE, MINOR QUARTZ AND PHOSPHORITE
	554	LIMESTONE, CALCARENITE, AND CALCILUTITE GRAYISH WHITE, 4% PHOSPHORITE
	634	DOLOMITE, BEIGE
UNIT H-2	649	LIMESTONE, WHITE, TRACE OF A DOLOMITIC CLAY, CONTAINS <u>MIOGYPSINA SP.</u>
UNIT H-1	714	LIMESTONE AND DOLOMITE, BEIGE, COARSE SPAR, UP TO 4% PHOSPHORITE
UNIT Su-2	754	LIMESTONE AND CALCARENITE, SANDY, GRAYISH WHITE, FORAMINIFERAL
	1000	FORAMINIFERAL LIMESTONE AND CALCARENITE, GRAYISH, MINOR QUARTZ
Su-1	1204	LIMESTONE, WHITE, HARD, DENSE

W - 14934


AGE
UNITS
DEPTH (FT.)
LITHOLOGY
NATURAL GAMMA
Pliocene
?
Miocene
TAMIAMI FM.
UNIT H-6
UNIT H-5
UNIT H-X
UNIT H-4
UNIT H-3
UNIT H-2
H-1
HAWTHORN FM.
0
45
65
75
155
235
275
355
385
415
425
455
525
555
585
645
665
675
735
765
LIMESTONE, YELLOWISH TO WHITE, MOLDIC
LIMESTONE, WHITE, SANDY, MOLDIC
NO SAMPLE
QUARTZ, SAND TO GRANULE, GRAYISH TO GREENISH MATRIX, FOSSILIFEROUS WITH SHELL
CALCILUTITE, GRAYISH WHITE, SANDY
LIMESTONE, MARLY, GREENISH, MINOR PHOSPHORITE
SILT, CLAYEY, GREEN TO OLIVE GREEN, SANDY, MINOR PHOSPHORITE
SILT, CLAYEY, DARK GREEN, MINOR QUARTZ AND PHOSPHORITE
SILT, CLAYEY, 6% PHOSPHORITE
NO SAMPLE
LIMESTONE AND CALCARENITE, UP TO 15% PHOSPHORITE
LIMESTONE, WHITE, MOLDIC, MINOR PHOSPHORITE
CALCARENITE, 9% PHOSPHORITE
CALCARENITE, GRAYISH, 3% PHOSPHORITE
DOLOMITE, BEIGE, MINOR PHOSPHORITE AND MINOR LIMESTONE, WHITE
CALCARENITE AND LIMESTONE, GRAYISH
DOLOMITE, BEIGE, 10% PHOSPHORITE
LIMESTONE, WHITE, SLIGHTLY MOLDIC, CONTAINS MIOGYPSINA SP.
CALCARENITE AND CALCILUTITE, GRAYISH WHITE, TRACE MIOGYPSINA SP.
DOLOMITE, BEIGE, COARSE SPAR

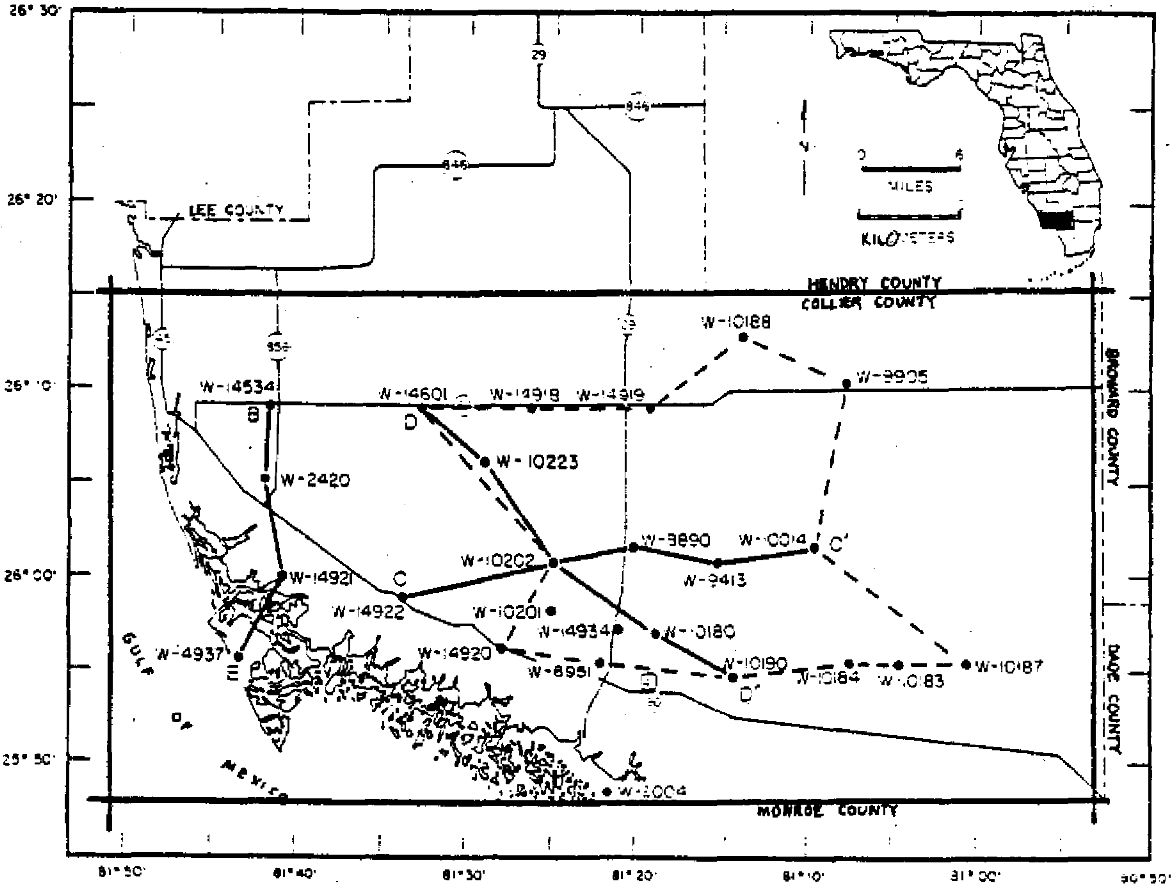
W - 14922



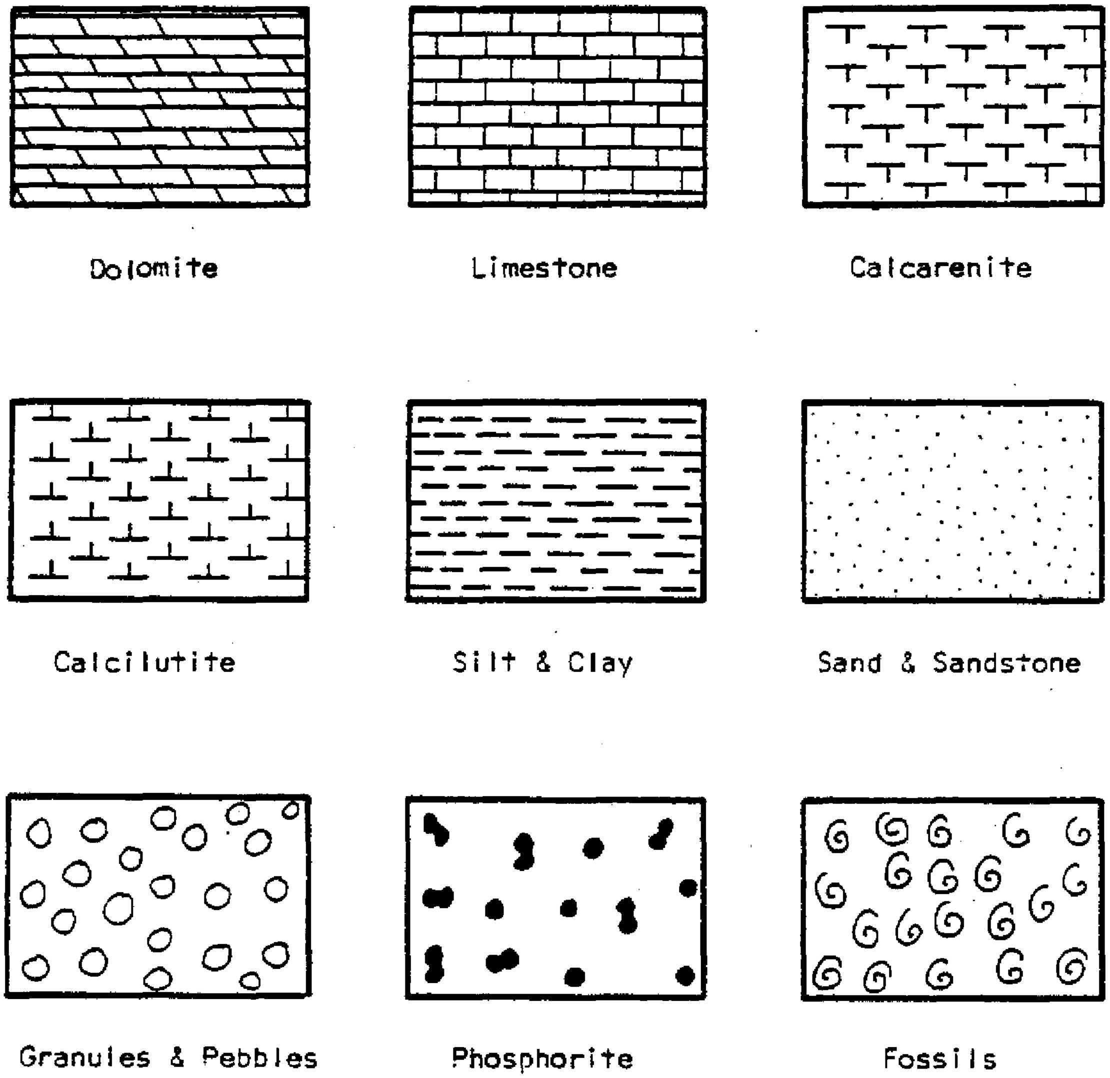
AGE	UNITS		DEPTH (FT.)	LITHOLOGY
?	UNDIFF.		0	QUARTZ, SANDY
Pliocene	TAMIAMI FM.		9	LIMESTONE, WHITE, MOLDIC, TRACE PHOSPHORITE
			34	CALCARENITE, WHITE, MINOR QUARTZ AND PHOSPHORITE
			54	LIMESTONE, WHITE TO GRAYISH, SANDY MINOR PHOSPHORITE
?	HAWTHORN FM.	UNIT H-5	104	CALCILUTITE, MARLY, SANDY, BUFF
		UNIT H-6	184	QUARTZ, SAND TO GRANULE, WELL SORTED, GRAYISH CALCILUTITIC MATRIX
		UNIT H-4	224	SILT, CLAYEY, OLIVE GREEN, SANDY
			274	SILT, CLAYEY, GREEN TO GRAYISH GREEN, TOUGH, PLASTIC, 10% PHOSPHORITE
			324	SILT, AS ABOVE, AND LIMESTONE, WHITE
Miocene		UNIT H-3	344	CALCARENITE, SANDY, 5% PHOSPHORITE
			354	LIMESTONE, WHITE, MOLDIC, GRANULE TO PEBBLE QUARTZ
			384	LIMESTONE, WHITE, MARLY, MINOR QUARTZ AND PHOSPHORITE
			474	QUARTZ, SAND, GREENISH MATRIX
			484	LIMESTONE, WHITE, MINOR PHOSPHORITE

APPENDIX D

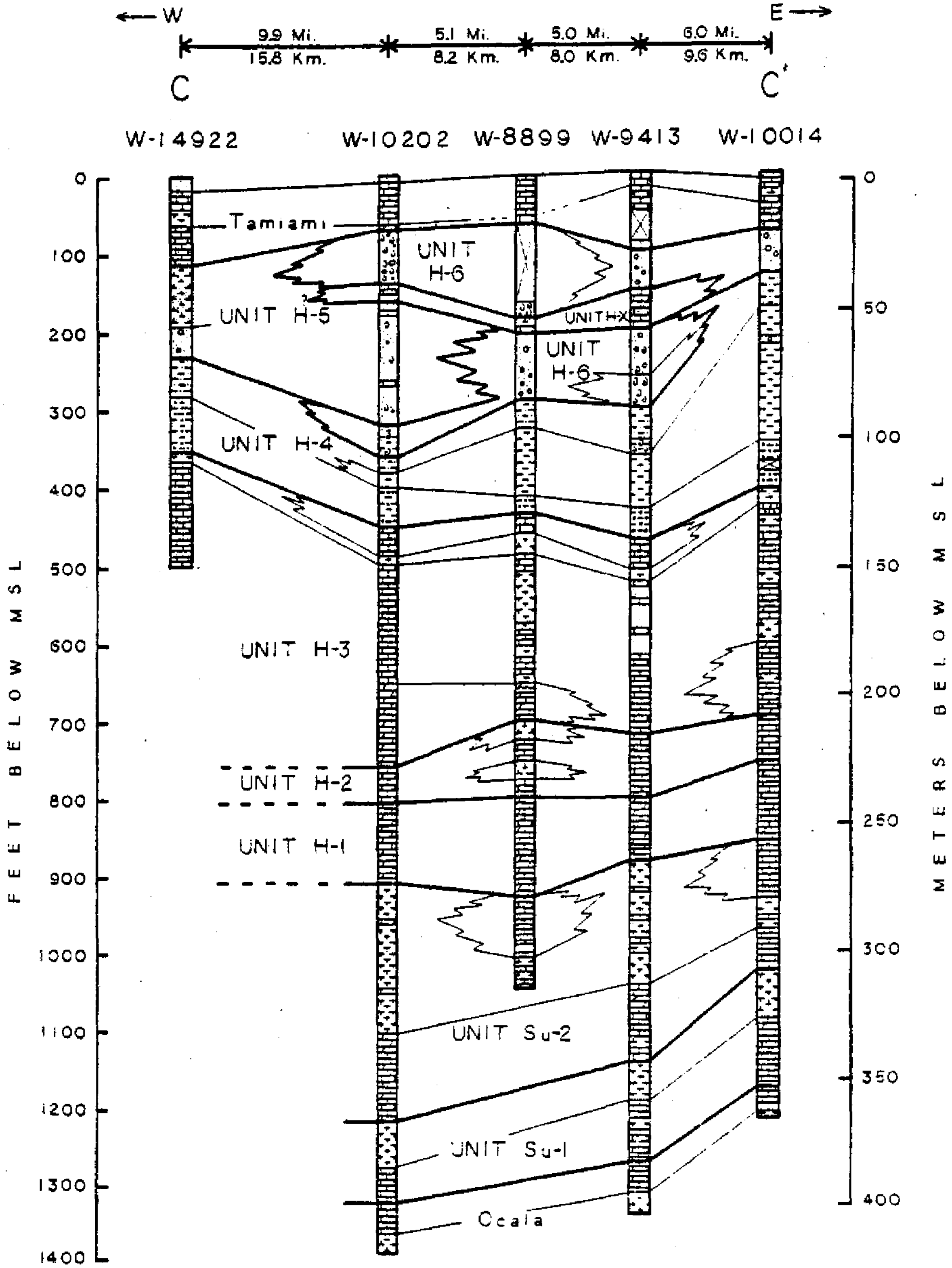
CROSS-SECTIONS, FENCE DIAGRAMS, AND MAPS NOT SPECIFICALLY REFERRED TO IN THIS PAPER



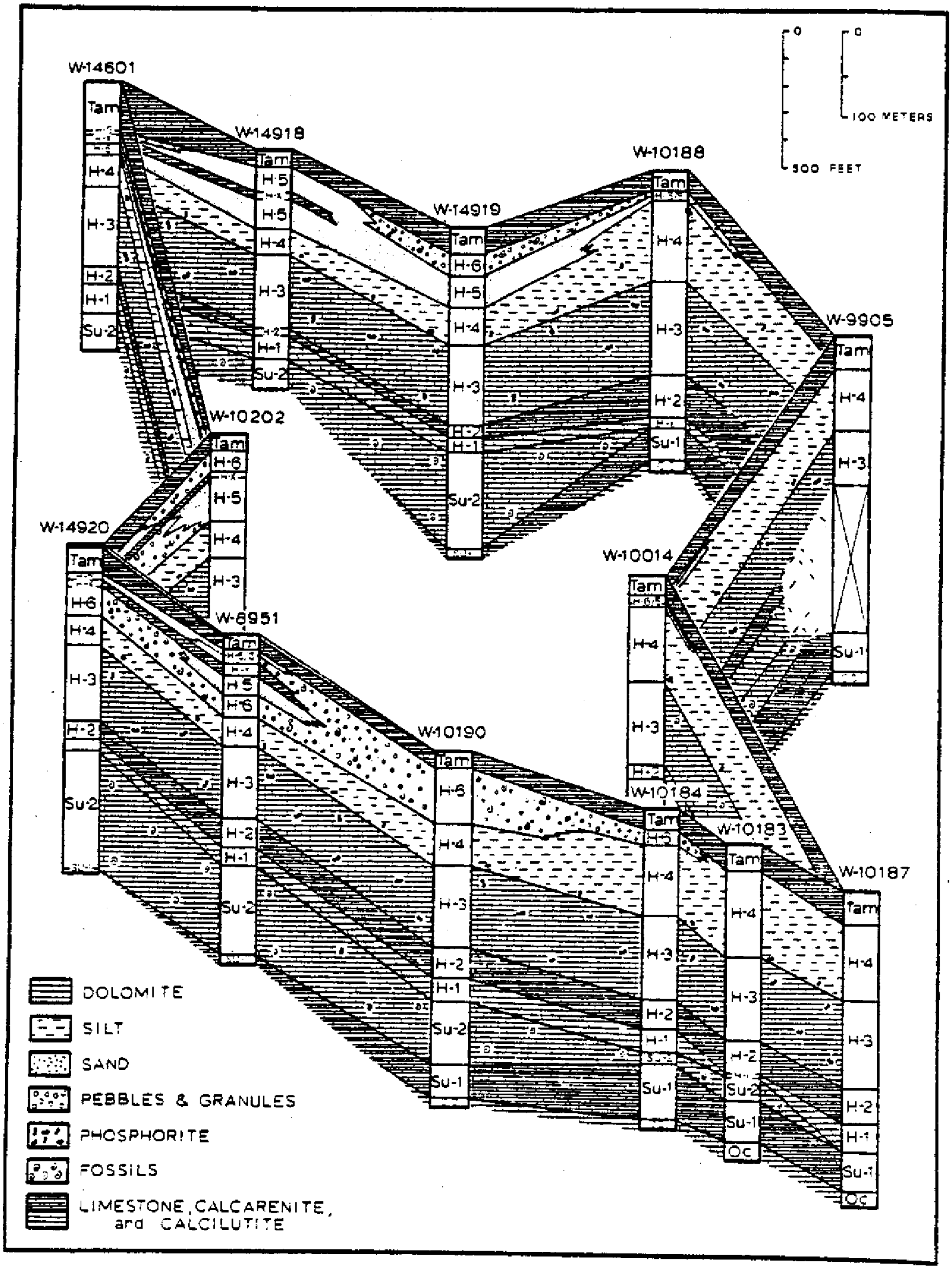
Map showing lines of cross-sections and fence diagram



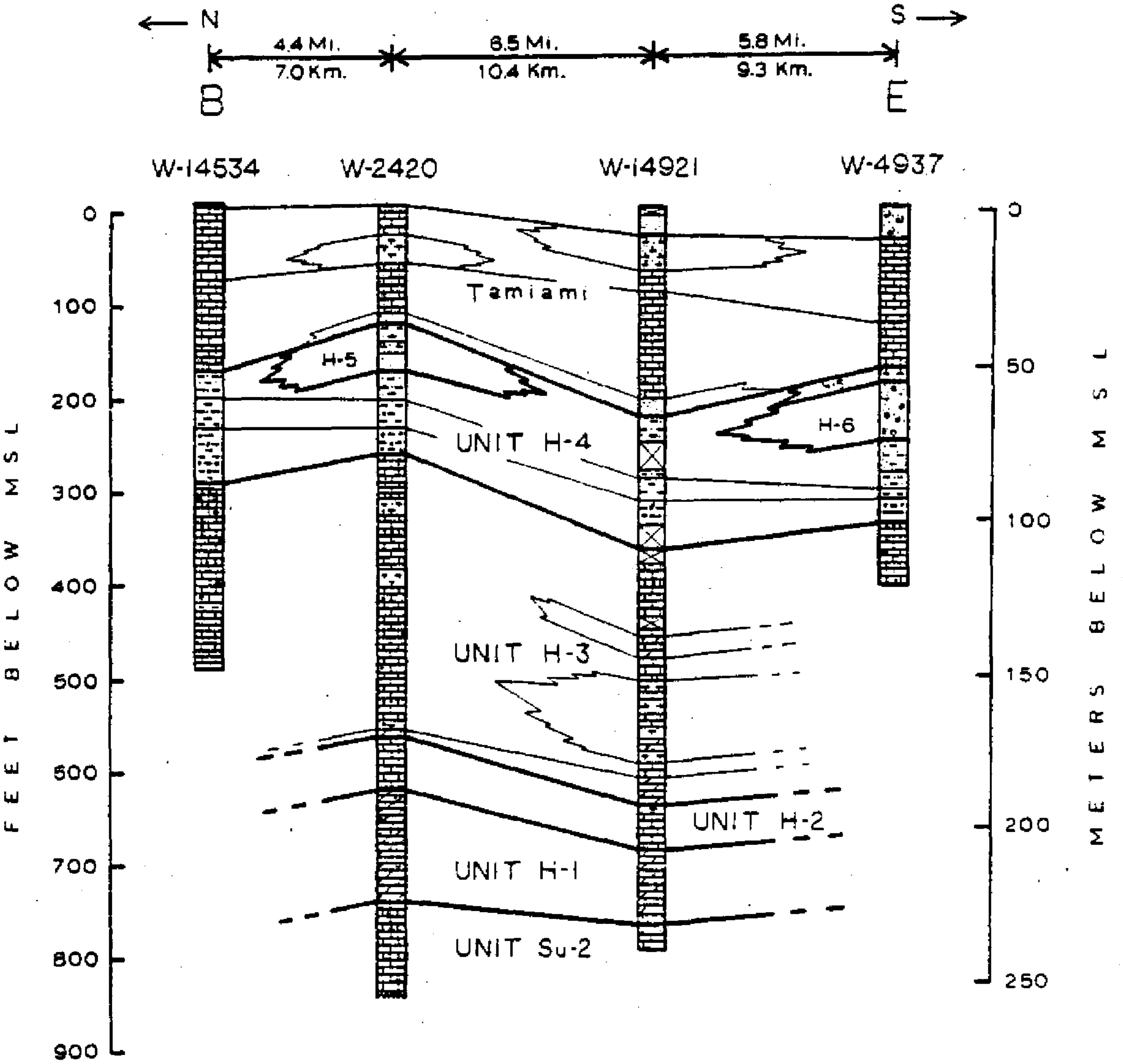
Lithologic symbols used for figures in this paper unless otherwise stated



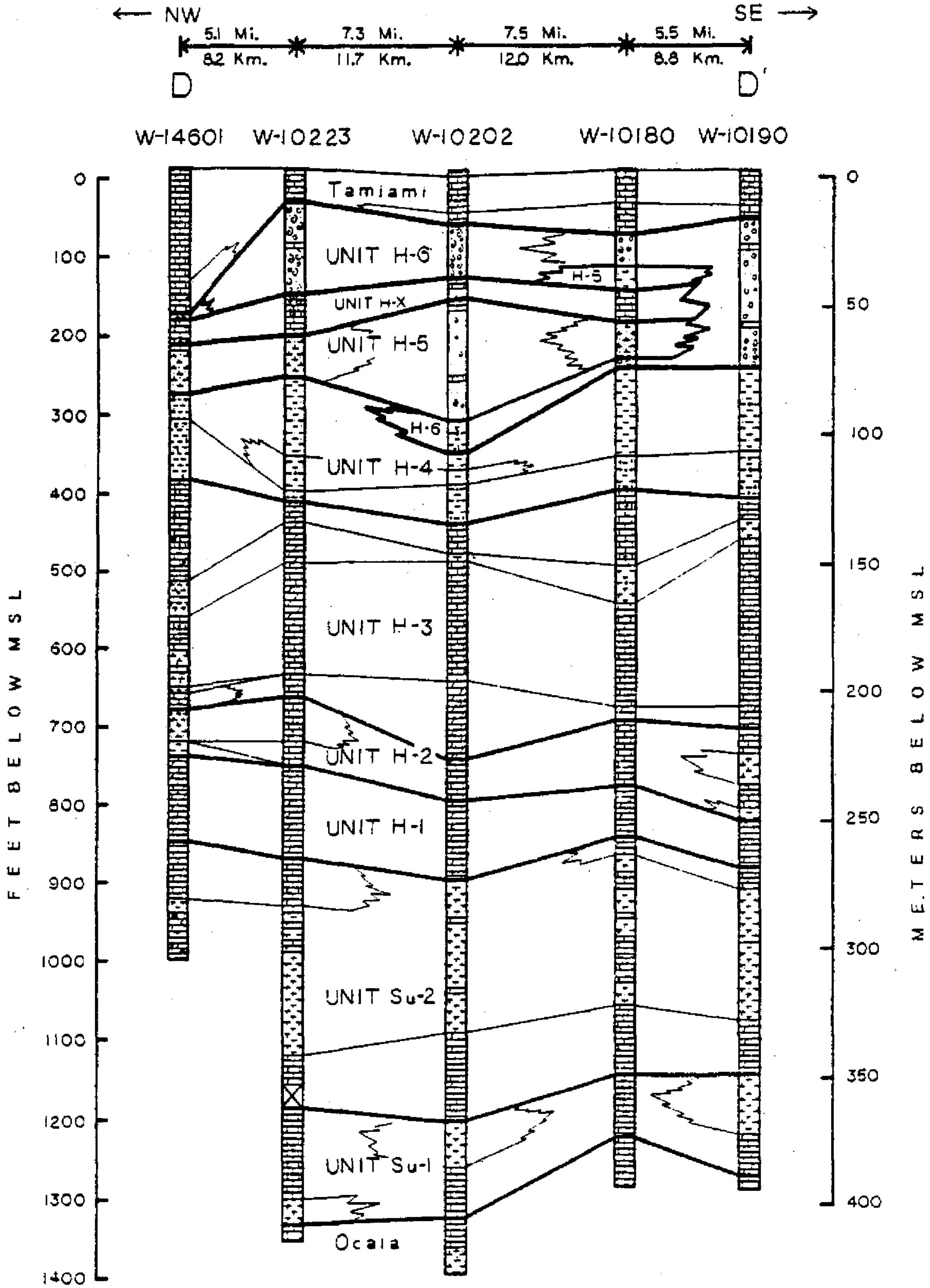
Cross-section C-C'



Fence Diagram



Cross-section B-E'



Cross-section D-D'