THE REBECCA SHOAL DOLOMITE BARRIER REEF OF PALEOCENE AND UPPER CRETACEOUS AGE - PENINSULAR FLORIDA AND ENVIRONS

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TABLE OF CONTENTS

FIGURES

ABSTRACT

The Upper Cretaceous-Paleocene Rebecca Shoal is a completely dolomitized reef complex. It is usually 15 to 20 miles wide and is 1,000 miles long. In its late stages (Tavernier), it is in the form of an atoll which completely encloses the Florida Peninsula. The deposition of the lagoonal anhydrite-dolomite Cedar Keys facies occurred in the restricted back-reef lagoon of the Rebecca Shoal barrier reef complex.

The Rebecca Shoal Dolomite consists of three varieties: anhedral, cryptocrystalline, and fine to coarse crystalline euhedral. Porosity is common, but not universally present. Caverns up to 60 feet high have been reported at or near the base of the reef or its various Tongues.

Locally, three tongues of the main reef extend into the lagoonal facies. The basal Card Sound Tongue has been penetrated only in two locales: the upper Keys and offshore on the West Florida Shelf. There are no intervening data to indicate whether these two occurrences are connected. The absence of dolomite in the lagoonal Pine Key facies consisting of white chalky limestone, suggests that they do not connect. The younger dolomite of the Plantation Tongue has, in one well, coalesced with the older Card Sound Tongue. In several other wells dolomites of the youngest tongue (Tavernier) of the Rebecca Shoal coalesce with the older Plantation Tongue. Elsewhere the Plantation is an independent tongue of the reef protruding into the lagoonal facies. The youngest (Tavernier) tongue extends farther into the lagoon than do the other two.

In certain offshore areas where well control is lacking, seismic data confirm the presence of the reef.

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INTRODUCTION

The Rebecca Shoal dolomite reef (Fig. 1) has been penetrated by 44 wells in Florida (on-and offshore) and in southeastern Georgia. It consists of a narrow band of dolomite in marked contrast to the rocks inside and outside of the feature. Due to high intercrystalline porosities as well as occasional large cavities or caverns, circulation in oil test wells was frequently lost; this resulted in no sample recovery or poor-quality samples.

Lithologic data are 99.99% cuttings, and 0.01% core. I have examined all available cuttings, and core material from four short intervals in three wells, using a 10X stereoscopic microscope.

Formal formational data for the Rebecca Shoal Dolomite, and the Card Sound, Tavernier and Plantation Tongues are included in the Appendices.

As the Banks' (1950) Oil & Gas Journal article detailing drilling problems in the Rebecca Shoal Dolomite (see Bibliography) will be hard for the reader to come by, I have included it as Appendix 2.

The purpose of this study is to complete the investigation of the Rebecca Shoal Barrier Reef presented by myself in 1978. Lithologic and stratigraphic terms which may be unfamiliar to the reader are included in the Glossary.

PREVIOUS INVESTIGATIONS

The first reference to the Rebecca Shoal Dolomite (known as the "deep Boulder Zone" until 1978), was made by Banks (1950). He described in detail the drilling problems caused by cavities in the Rebecca Shoal Dolomite.

Winston (1971) named a basal Upper Cretaceous dolomite in Well 148 on Key Largo the Card Sound Dolomite, and equated it to a similar section in the Bahamian Andros well some 120 miles to the east. The Card Sound was not at this time identified as a reef section.

Puri and Winston (1974) described the dolomite zones of the Rebecca Shoal in the coastal area of the Peninsula and the Keys. One of these wells (108) was used to illustrate the subsequently-named Tavernier and Plantation Tongues. They did not identify these zones as reefal.

Winston (1978) identified the Upper Cretaceous and Paleocene dolomite complex along the western and northern flanks of the Florida Straits as a barrier reef, and named it the Rebecca Shoal Dolomite; further identified were two subdivisions, the Tavernier and Plantation Tongues.

Winston (1989) included the Card Sound Dolomite within the reef facies of the Rebecca Shoal. The reef facies was shown to encircle the Florida Peninsula.

STRATIGRAPHY

OCCURRENCE

The Rebecca Shoal occurs in a 15 to 20-mile wide band completely surrounding the Florida Peninsula, expanding to 50 miles wide on the western Sarasota Arch (Fig. 20).

The northwestern Peninsula is the only area where Rebecca Shoal backreef to forereef well control is closely spaced (Figs. 3 & 20). Here the width is some 15 miles.

On the Sarasota Arch (Fig. 15) the width appears to be about 50 miles, if Wells 3917, 3906 and 3909 are considered to have Tavernier Tongue facies rather than a thick Cedar Keys A unit. No lithologic data are available on these three wells to establish the presence of reef rock. Onshore in Well 178 Cedar Keys A unit is some 200 feet thick. On the E-logs of each of the above-mentioned wells there is a 600-foot interval of highly-resistive rock in the same stratigraphic position. These greater thicknesses would suggest that the section is Tavernier facies rather than Cedar Keys A.

In the Keys the reef appears to be a minimum of 20 miles wide. The length of the Rebecca Shoal reef is some 1000 miles; this is comparable to the length of the Australian Great Barrier Reef. The Great Barrier Reef, however, is linear whereas the Rebecca Shoal reef resembles a giant atoll.

The maximum thickness of the Rebecca Shoal Dolomite is 2970 feet in Well 4950 on the Sarasota Arch (Fig. 20). From this well and from Well 148 the reef thins northward to a thickness of about 600 feet in southeastern Georgia.

There is no evidence to connect the Card Sound Tongue (Fig.2) in Well 148 on Key Largo to the occurrence of Card Sound rock on the Sarasota Arch. Both of these areas were structurally high at the beginning of the Upper Cretaceous, as shown by the high concentrations of dolomite in the upper Lower Cretaceous formations at both localities. These high areas would have provided a favorable environment for the commencement of reef growth. Seismic investigation of the area seaward from the Keys well control (Fig. 20) tailored to reveal the reef at 4000 to 8000 feet is the only method which could reveal the presence of Card Sound Dolomite between the two areas. No wells can be drilled until the environmental restraints now in place are lifted.

LITHOLOGY

The Rebecca Shoal Dolomite consists of anhedral or fine to medium crystalline euhedral dolomite with occasional intervals of cryptocrystalline dolomite (see Glossary). It is interpreted as a reef by regional stratigraphic comparison with the cherty limestones of the forereef MADco Suite (Fig. 5 & Appendix 8) and with the backreef dolomite-anhydrite of the Cedar Keys facies (Fig. 1). As the lithological data occur in discrete clusters of wells with the large areas between lacking control (Fig. 20), the lithologic details will be presented for six control regions as follows.

<u>Florida Keys</u> (Figs. 6, 7 & 20)

Only Wells 296, 284 and 292 have reasonably complete lithologic data. For Wells 298, 148 and E, drill cutting recovery ranged from incomplete to practically non-existent. No lithologic data were available for Wells 108, 22, 280, 16, 275 and 290.

The <u>Card Sound Tongue</u> (Figs. 2 & 6) is present in only two closely-spaced wells, E and 148. Well 148 consists of tan, brown and cream anhedral and fine crystalline euhedral dolomite. Vug porosity up to 10% is present in scattered beds.

The <u>Plantation Tongue</u> (Figs. 3, 6 & 7) is present in Wells 108, 22, 280, 292 and 16. Only in Well 292 are cuttings available. Here, the unit is anhedral, cryptocrystalline and fine to medium crystalline euhedral dolomite. Colors are orange-tan, brown and gray. Vug porosity ranges up to 15% in anhedral dolomite, and up to 5% in the euhedral variety. The GRN log of

Well 292 indicates that non-reef carbonates occur over and under the Tongue.

The Tavernier Tongue (Figs. 4, 6 & 7) is present in Wells E, 148, 108, 22, 280, 16, 275 and 292. Only in Well 292 are cuttings available. Here, the dolomite is orange-tan and brown, anhedral and fine to coarse crystalline euhedral. Up to 25% intercrystalline porosity is present in the euhedral variety; 5% vug porosity is present in some anhedral dolomites.

E-log interpretation on Wells 16, 22, 292 and 148 where no lithologic data are present suggests that the Tavernier Tongue is underlain and overlain by Cedar Keys lithology. In Wells 108 and 275 it appears from geophysical logs to be overlain by the basal Black Point Delray Dolomite, and underlain by Cedar Keys lithology.

In Wells 284 and 296 the Plantation and Tavernier Tongues are inseparable, either by lithology or on geophysical logs. In these wells the dolomite of the combined units consists of brown, tan, cream and white, anhedral, cryptocrystalline and fine to coarse crystalline euhedral textures. Anhedral dolomite contains up to 15% pinpoint and vug porosity; euhedral dolomite contains up to 15% vug and intercrystalline porosity. The combined section overlies white, chalky Pine Key limestone.

Well 290 was junked in the upper Rebecca Shoal Dolomite.

Sarasota Arch (Figs. 8 & 9)

Of the six wells drilled here, three have no lithologic data, and three have very limited lithologic data.

The Card Sound Tongue is present in Wells 3903, 3912 and 4950. In Well 3912 on the north side of the Arch, it is some 300 feet thick and occurs near the top of the Card Sound interval; no lithologic data are available. Well 3903 has 700 feet of Card Sound, also at the top of the interval, and also without lithologic data. In Well 4950, the Card Sound has merged with the younger Plantation Tongue. Some 700 feet of cuttings at the base of the combined unit consists of tan, cream, light gray and brown anhedral and fine to coarse crystalline dolomite, the latter containing up to 15% intercrystalline and vug porosity.

The Plantation Tongue in these same three wells is not a separate unit. In Wells 3903 and 3912 it is combined with the overlying Tavernier section and in Well 4950 with the underlying Card Sound. Limited sample data in Well 3912 show that the Plantation Tongue consists of white and tan anhedral dolomite with only a trace of pinpoint porosity. A short core in well 3903 was gray, anhedral and cryptocrystalline, non-porous dolomite.

The Tavernier Tongue has merged with the Plantation Tongue in Wells 3903 and 3912. A short core in Well 3903 consists of gray, anhedral and cryptocrystalline, non-porous dolomite. The E-log of the Tavernier in Well 4950 shows that it is separated from the underlying Plantation Tongue by what appears to be non-reef carbonate. Other than the above-mentioned short core, no lithologic data are available in this unit.

In Wells 3906, 3909 and 3917 there are some 600 feet of probable Tavernier section on the E-log. Without lithologic data, it is not possible to tell if it is true Tavernier reef rock, or an overthickened Unit A (Winston 1994) of the lagoonal Cedar Keys facies. Onshore, in Well 178, the Cedar Keys A is 225 feet thick; considering the much thicker section in the above

-mentioned wells, it would seem reasonable to consider them to contain Tavernier reef facies.

East-Central Peninsula (Fig. 10)

Only three wells, 772, 259 and its twin 254 (located 1320 feet to the north) completely penetrate the Rebecca Shoal reef in this area. Seven injection wells, of which five have drill cuttings, bottom in the upper 300 feet of the Rebecca Shoal.

Well 259 penetrated a combined Tavernier and Plantation section consisting of anhedral, cryptocrystalline and fine to medium crystalline euhedral dolomite. Up to 20% intercrystalline porosity is present in the euhedral variety. In Well 772, two miles to the west of Well 259, microcrystalline to fine crystalline euhedral dolomite of the Tavernier Tongue was encountered with up to 10% vug and pinpoint porosity. The lower 400 feet may belong to the Plantation.

Cores at 4770-4820 in Well 259 and 5034-40 in Well 254 both reported "brecciated, vuggy" dolomite. A first-hand examination of samples from these cores (Fig. 11) indicates that they represent a talus deposit with numerous varieties of dolomite textures, instead of the reported "brecciated" dolomite. The intervals of the above cores indicate that some 300 feet of talus is present.

Injection Wells - Seven injection wells (Fig. 20) penetrated between 90 and 350 feet of Tavernier Tongue without reaching the base. Lithologies consist of anhedral, cryptocrystalline and very fine to medium crystalline euhedral dolomite in varying proportions. Anhedral dolomite occasionally had zones of up to 5% pinpoint and vug porosities. Euhedral dolomite had up to 15% intercrystalline, pinpoint and vug porosity. Colors include orange-tan, orange-brown, tan, cream and light gray.

West-Central Peninsula (on and offshore) (Fig. 12)

Five wells in this sector encountered Rebecca Shoal lithology; only one (304) is without some lithologic data. None contained Card Sound Dolomite - the interval is occupied by Pine Key white chalky limestone.

A thin Plantation Tongue is present in Well 304 as indicated by E-log correlation; no lithologic data are available.

The Tavernier Tongue is present in all five wells. Onshore to the northeast of Well 304, Well 608 exhibits a unique lithology, probably representing a far backreef facies. It is non-porous, tan and gray, cryptocrystalline and lithographic dolomite some 800 feet thick.

To the north in Wells 382, 383 and 66 the Tavernier becomes progressively thinner, and overlies Cedar Keys anhydritic dolomite. In these wells the Tavernier consists of cream, tan, gray and orange-brown anhedral, cryptocrystalline and fine to medium crystalline euhedral dolomite. Up to 20% intercrystalline vug and pinpoint porosity is present in the euhedral variety.

The Cedar Keys anhydritic dolomite beneath the Tavernier facies suggests that the main reef lies to the west of these wells.

Northwest Peninsula (Figs. 13 & 14)

No Card Sound or Plantation section is present.

In the Northwest Peninsula, thirteen wells penetrated Tavernier lithology. Of these, four had no cuttings (Wells 114, 67, 1052 and B). Of the remaining nine, only two (Wells D and C) were complete; the missing section in each of the remaining seven is in the upper part.

The forereef section (Well A) consists of MADco Suite (Appendix 8 & Fig. 5) cherty, glauconitic, white, skeletal wackestone. The backreef section consists of Cedar Keys finely microcrystalline dolomite with relic skeletal, pellet or oolite textures along with nodules and beds of anhydrite.

Three wells (97, 1015 and D) penetrated the core of the reef. This section consists predominantly of euhedral dolomite fine to medium crystalline, with up to 20% intercrystalline porosity. Anhedral dolomite is common, occasionally exhibiting 5% vug porosity. Colors are white, green, tan, orange-tan and brown.

The remaining wells (116, 120, 119, 90, 724 and C) are located on the flanks of the reef. Their lithologies differ from the core in containing a finer crystalline euhedral dolomite; fewer beds are porous and the porosity is lower.

Well 119 is in the immediate reef-forereef transition, and exhibits three thin reef tongues in the middle of a section characterized by the interbedding of limestone with dolomite and calcareous dolomite, characteristic of the MADco Suite cherty limestones facies (Appendix 8) to the west and east (Fig. 5).

In Well C, a 100-foot section of Cedar Keys relic skeletal dolomite is present in the middle of the reef facies.

The Northwest Peninsula area is the only one with sufficient well density to make construction of cross-sections which include forereef, reef and backreef facies.

Southeast Georgia (Fig. 20)

Of the six wells to penetrate the reef, only GGS 362 was without samples. All of the remaining five sample sets were complete. The six wells were drilled near the crest of the reef in Tavernier Tongue section as indicated by their thicknesses. Very fine to medium crystalline euhedral dolomite with up to 15% intercrystalline pinpoint and vug porosity is the dominant lithology. Occasional anhedral beds contain zones of pinpoint and vug porosity up to 10%. The infrequent cryptocrystalline dolomites show no porosity.

Colors include cream, tan, orange-brown and gray.

CAVERNOUS POROSITY

On occasion large cavities up to 50 feet high have been encountered. Below is a listing of these features by well and tongue as reported to the Florida Geological Survey.

In all cases, these cavities and caverns occur at or near the base of a Tongue (Figs. 6, 7 & 10).

P 254 (twin to 259) 17-foot cavern (5277-94) and possible 5-foot cavern (5273-78) in basal Plantation-Tavernier

P 117 15-foot cavern at 4285-4300 in basal Tavernier

P 108 7-foot (5615-22), 10 foot (4648-58) & 10 foot (5705-15) caverns, all in basal Plantation

P 292 (twin to 298) 50 foot cavern (5270-5320) in basal Plantation

P 298 (drilled 790 feet southeast of 292) encountered a 42-foot cavern (5210-52) in basal Plantation - note: although this cavern is 60 feet higher in the section, it is probably the same cavern.

These are all of the caverns that have been recorded in the Florida Geological Survey files. Others have probably been encountered in the Rebecca Shoal reef, but were not reported. Considering the thick Rebecca Shoal section on the Sarasota Arch, caverns should have been encountered here.

AGE

There are no paleontologic data to determine the age of the Rebecca Shoal Dolomite or its various Tongues.

The earliest appearance of reef rock (Card Sound Tongue) is some 100 feet above the Lower Cretaceous, in Well 4950 on the Sarasota Arch. This establishes an Early Upper Cretaceous age for the lower Card Sound reef section. By regional correlation, the upper section (Tavernier Tongue) is shown to be the lateral equivalent of the Cedar Keys Formation. The Cedar Keys was dated as Paleocene by Cole (1944) with paleontology. These are the only dating data available.

Interval correlations of the Plantation Tongue from Wells 108, 298 and 259 into the basin, suggest a Late Upper Cretaceous age for this unit. The Rebecca Shoal barrier reef existed for some 40 million years.

STRUCTURE

Subsea elevations on the Rebecca Shoal range from -1300 feet in the northwestern Peninsula to -3500 feet in the Keys. Local basin and arch features are shown on Figure 15.

Presenting a regional structure map of a feature 15 miles wide and 1000 miles long is impractical; however, where the Rebecca Shoal widens to some 50 miles on the Sarasota Arch (Fig. 20), a structure map is presented (Fig. 16). An anomalous condition exists here--whereas Well 4950 is 500 feet higher on the Rebecca Shoal than Well 3903 to the west, it is 500 feet lower on top of the Lower Cretaceous. No samples are available to establish the top of the Rebecca Shoal in Well 4950. Even if the top is moved down to an E-log kick 300 feet deeper, this well is still 200 feet high on top of the Rebecca Shoal.

The extra section could represent a local terminal stage of the reef extending upward into the rocks of the lower Black Point Format (Appendix 7 & Fig. 5).

GEOLOGIC HISTORY

The 40 MY existence of the Rebecca Shoal barrier reef extends from shortly after the end of the Lower Cretaceous through the Paleocene.

In Well 4950 the Card Sound Tongue appears 100 feet above the Lower Cretaceous, and in Well 148, 200 feet above. The Card Sound Tongue does not appear in any other area (Fig. 2).

Whether this Tongue connects along the continental shelf seaward of the well-control in the Keys cannot be determined from available data. Deep penetration seismic loses shallow reflections before reaching the Keys area from the Florida Straits, and local shallow penetration seismic has not reached the reef. Neither evaporites nor dolomites are present lagoonward from the Keys; therefore, a circulation-restricting reef between the two known occurrences of the Card Sound (Fig. 2) cannot be inferred from lithologic data.

Possibly the reef was confined to the two areas throughout Card Sound deposition, expanding in a sudden surge to form the Plantation Tongue, connecting the two Card Sound occurrences to the south, while expanding northward along the west and east coasts of the Peninsula to Wells 304 and 259 (Fig. 3).

Continued rapid extension of the reef to the north on both sides of the Peninsula, completely encircled the Peninsula in the Late Upper Cretaceous or Early Paleocene (Fig. 4). This enclosure resulted in the deposition of the thick anhydrites in the mid-Cedar Keys.

Growth continued throughout the Paleocene (Tavernier Tongue) and possibly into the Early Eocene. The widespread basal Delray Dolomite of the Black Point Format (Fig. 1), conventionally assigned to the Eocene, might be the last lagoonal deposition caused by the presence of the reef. The sudden demise of this long-lived feature is without an obvious explanation.

SEISMIC DATA

A shallow penetration seismic profile (Fig. 17) was described by Uchupi (1970) as "...structural in origin or ...a carbonate ridge". This feature is undoubtedly the Rebecca Shoal reef. The seismic feature occurs between the MADco forereef facies in Wells 3686 and 3695 to the east, and the backreef Cedar Keys facies onshore to the west (Wells 449 & E). Also, the feature occurs about where the reef would be if it were extended from Well 362 in southeastern Georgia to Well 259 in the east-central Peninsula.

On the West Florida Shelf, the trend of the Rebecca Shoal reef from the Sarasota Arch northeastward to Well 304 (Fig. 20) is controlled by the seismic profiles studied by Jee in his 1993 dissertation. An example of the reef masking deep reflections is shown on Figure 19.

The deep-penetration offshore seismic profiles of GSI in both the northern and southern Florida Straits lose all shallow reflections on the continental shelf-slope before they reach the estimated position of the reef. Shallow-penetration seismic reflection profiles on the continental shelf do not reach the reef.

The Rebecca Shoal reef adversely affects seismic results wherever it is encountered--either by blocking deep returns, or by giving a false structural picture due to changes in velocity caused by the extensive high porosity and occasional caverns within the Rebecca Shoal Dolomite.

SPECULATIONS

1. Although the Rebecca Shoal barrier reef is entirely dolomite where lithologic data are available, it was probably deposited originally as an organic limestone.

2. Dolomitization of the Plantation and Tavernier Tongues (equivalents of the Cedar Keys) can be accounted for by reflux from the lagoonal evaporitic facies of the Cedar Keys.

3. Dolomitization of the Card Sound cannot be accounted for in this way, as there were no lagoonal evaporites; the lagoonal facies of the Card Sound is the white, chalky limestone of the Pine Key. Perhaps the younger dolomitizing waters filtered downward while they were dolomitizing the overlying Plantation Tongue.

4. Although there must have been a major effect on the reef from the tsunami caused by the Yucatan meteoric impact, none is discernable in drill cuttings or on geophysical logs (especially the gamma ray).

5. The demise of the Rebecca Shoal barrier reef may have been caused by a cooling of the climate toward the end of the Paleocene, or by the drift of North America northward into cooler latitudes, or both.

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TABLE 1

Well List

Permit	Operator	Lease	
1	Ohio	1	Hernasco
4	Sun	1	Crapps
8	Humble	1	Carroll
11	Stanolind	1	Forest
16	Gulf	1	State 374
19	Sun	1	Powell
22	Gulf	1	State
47	Humble	1	Tucson
66	Coastal	1	Ragland
67	Humble	1	Henderson
75	Coastal	1	Wright
77	Humble	1	Cone
85	Humble	1	Hodges
90	McCord	1-B	Starling
97	Sun	1	Crapps
108	Coastal	1	State
114	Gulf	1	Brooks Blk 49
115	Coastal	1	State 340
116	Gulf	1	Brooks Blk 42
117	Coastal	1	Williams
119	Gulf	1	Brooks Blk 33
120	Gulf	1	Brooks Blk 37
148	Sinclair	1	Williams
178	Gulf	1	Vanderbilt
232	Gulf	1	State 826 G
259	Amerada	2	Cowles Magazine
275	Gulf	1	State 826 Y
280	California	1	State 1011
284	Gulf-Cal	1	OCS Blk 28
290	Gulf-Cal	1	OCS Blk 44
296	Gulf-Cal	1	OCS Blk 46
298	California	3	State 1011
304	California	3	State 224 B
350	Mobil	1	Garvy
382	Mobil	1-A	State 224 A
383	Mobil	1-B	State 224 A
449	Pan American	2	Rayonier
608	ARCO	16-4	Starkey
710	Shell	35-1	Sloan
723	Hunt	1	Hurst
724	Hunt	1	Howes
772	Amoco	16-1	Peacock
1015	Amoco	1	Exum
1052	Amoco	1	Crapps
A	Hunt	2	Gibson
B	Hunt	1	Gibson
C	Hunt	4	Gibson
D	Hunt	3	Gibson
E	USGS		D-425
F	Republic	1	Robertson

TABLE 1 (continued)

Georgia

GGS	Operator	Lease	
150	Hunt	3	Superior Pine
153	California	1	Buie
166	Hunt	1	Superior Pine
169	Hunt	2	Superior Pine
338	Grace Drlg.	1	Griffis
362	Larue	1	Massey
719	Humble	ST-1	McDonald
724	Humble	ST-1	Union
1198	Pan American	1-B	Union

OCS

2523	Texaco		Blk 100
3341	Mobil		Blk 915
3686	Tenneco		Blk 208
3395	Tenneco		Blk 427
3903	Mobil		Blk 654
3906	Gulf		Blk 144
3909	Odeco		Blk 188
3912	Shell		Blk 265
3917	Tenneco		Blk 672
4950	Shell		Blk 512

Appendix 1

GLOSSARY

Euhedral dolomite - rhombic crystals are visible; sucrosic dolomite is always euhedral, but euhedral dolomite need not be sucrosic.

Anhedral dolomite - light reflections indicate a crystalline structure, but rhombic crystals are not visible. In this variety the crystals are interlocking.

Cryptocrystalline - has a smooth appearance with no crystal reflections; in some cases it is lithographic and may have conchoidal fracture, thus resembling chert.

Boulder Zone - a section of any dolomite interval which, either from breaking in the roof of a cavity by the drill bit, or the collapse of highly-fractured dolomite in the wall of the drill hole, deposits large pieces of dolomite in the bottom of the hole. These, when drilled, behave as if they were in-place boulders, hence the name bestowed by the early drillers in Florida.

Suite - a vertical grouping of lithologies distinguished from adjoining vertical groups by a distinctive lithologic assemblage.

WILDCATTING IN FLORIDA

by J. E. Banks

THE frontier of the Gulf Coast oil business lies in Florida and extends from Pensacola to Key West, the longest tidelands belt of any state. This large, prospective oil territory has attracted attention because prolific limestone production might be found in South Florida as well as "Woodbine" production around the Ocala uplift in North Florida, and also partly because it is free from proration.

Geologically, Florida is part of the Cretaceous oil and gas belt which continues through Mississippi, northern Louisiana, southern Arkansas, Texas, and Mexico. Cretaceous sediments of northern Florida grade vertically from chalk to sand and shale; but in southern Florida the gradation is from chalk to lime and anhydrite. In both North and South Florida the maximum thickness of the Cretaceous is estimated to be in excess of 10,000 ft.; over the Ocala uplift the section thins to 1,500 ft.

In Florida, the wildcatter has not been assisted by oil and gas seeps or by surface indications of deep structures. Nature has masked the Cretaceous oil fields with a thick covering of "reef type" Tertiary limestone. So far only one deep anticline is known. This Cretaceous structure is productive from a thin limestone near the top of the Sunniland zone, of Glen Rose age, and which is the most persistent zone of oil and gas shows in Florida. The Sunniland zone in general is marine, thin bedded, and grades vertically from dolomite, to coquina, to chalky limestone, to marl. It is 250 ft. thick and is overlain and underlain by thick anhydrite beds.

The search for oil and gas in Florida has been difficult. The thick blanket of cavernous and irregularly bedded lime of Tertiary age greatly reduces the value of core drill and seismograph exploration. In addition, Florida has a Paleozoic "basement" complex of sedimentary and igneous rocks which obscures the interpretation of gravity and magnetic data. For the present the oil deposits of Florida are well hidden but the expected development of sharper exploration tools adapted to limestone areas may soon give renewed hope to the Florida wildcatters.

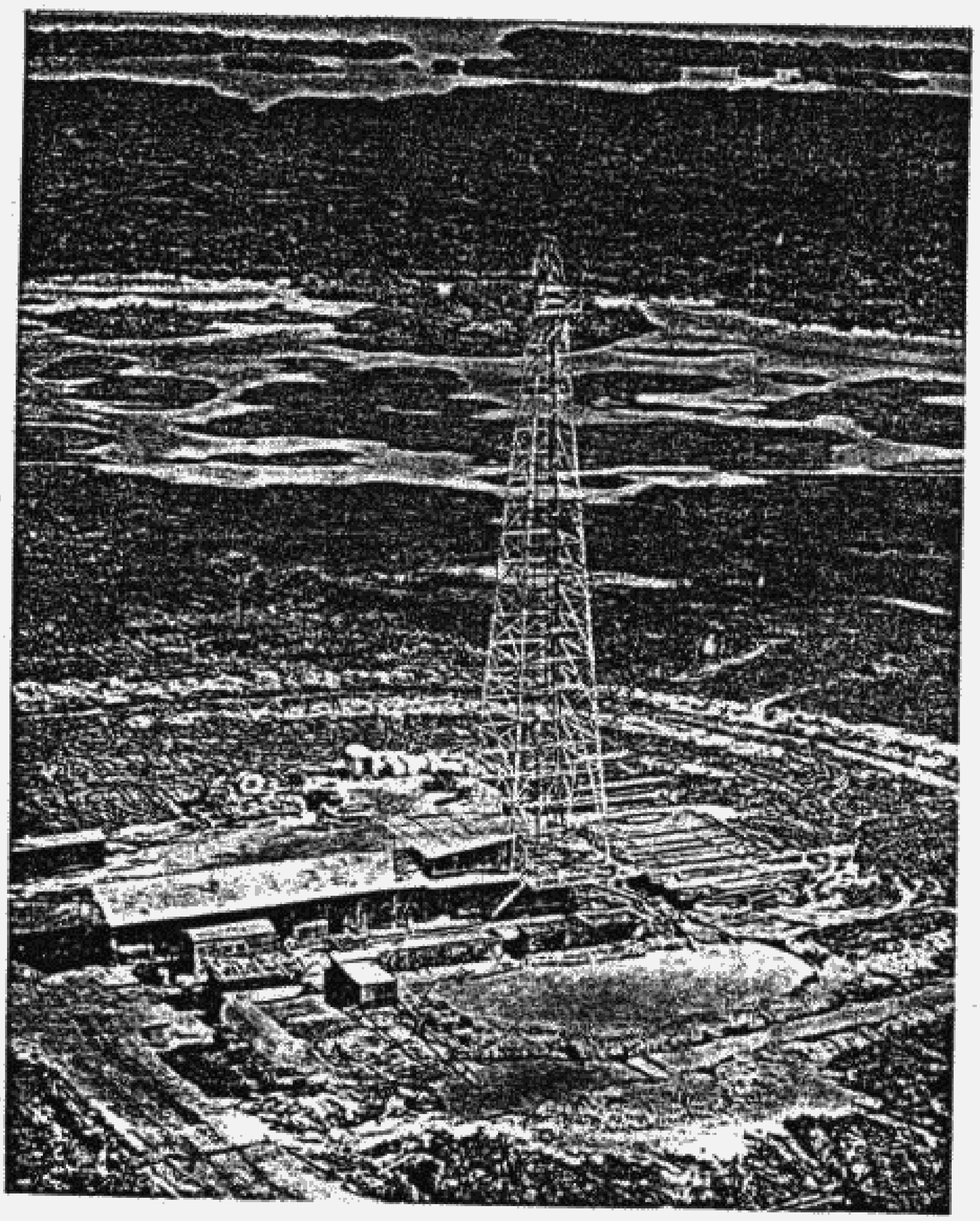
Drilling Costs for Florida

Florida oil activities are located 500 to 1,000 miles from most supplies and services. This factor alone greatly increases drilling costs. Typical examples of Florida drilling operations are the seven wildcats recently completed by Coastal Petroleum Co. at an average cost of $15.70 per foot. The individual well costs appear in Table 1.

East and south of Tallahassee the Florida wildcatter does not have the protection of the footage contract. Unusual drilling problems start at the surface and continue until the widespread zone of lost circulation or water flow is completely penetrated and cased.

Central Florida is covered with loose sand, in part resting on cavernous limestone and in part separated from the limestone by clay beds. For many years the surface sand has been sifting down into the cavernous limestone, leaving small and large sink holes at the surface. Drilling operations can easily speed up this natural process.

Cave-ins under the derrick foundations are common, necessitating quick cement jobs, more casing, or skidding the entire rig on very short notice. Operators usually provide two surface strings of casing. The first is set just into the limestone before circulation can be lost. The second is set a hundred feet or so into the lime-



The Coastal Petroleum Co. 1 Wright, located near Old Tampa Bay, 4 miles north of St. Petersburg, Fla., was drilled to a depth of 11,507 ft. in 137 days. Contractor for the wildcat was Parker Drilling Co. of Tulsa. All of the cavities in the hole could not be cased off because of the casing shortage of early 1948. As a result, the test was drilled to a total depth with salt water rather than mud.

The Author

J. E. Banks, chief geologist for Coastal Petroleum Co., St. Petersburg, Fla., received his bachelor of arts degree from Wabash College in 1935. He did graduate work at University of Iowa, receiving an M.E. degree in geology in 1937. Following college, Banks worked 3 years for The Texas Co. as a geologist in that firm's Barco concession in Colombia, S.A. From 1940 to 1942, he did further graduate work at Cornell University. He then spent a little over a year with the U. S. Engineers at Ithaca, N. Y., before returning to Texaco in Midland, Tex. Banks entered Florida geological work in 1945 as a geological scout for Stanolind Oil & Gas Co. in Tallahassee. He has been in his present position since 1947.

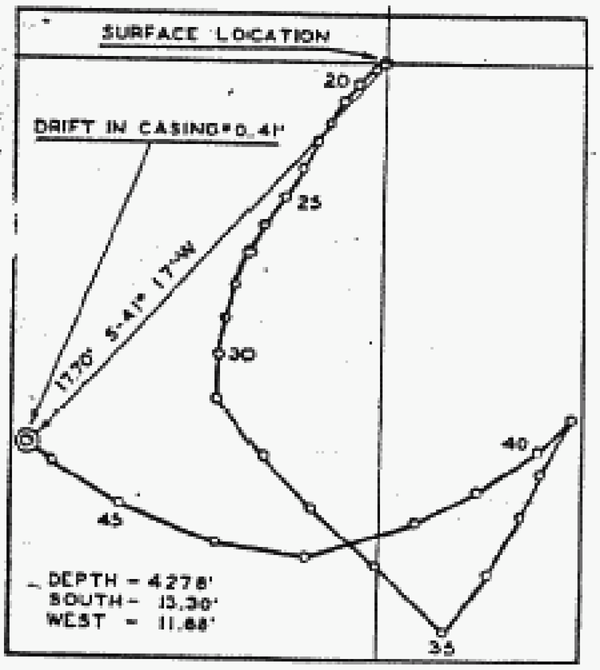


Fig. 1—This interesting directional survey shows that a Coastal well actually reversed direction in a cavernous limestone zone. This reversal occurred at about 3,600 ft. in a 10,500-ft. test, resulting in obvious drilling difficulties.

DRIFT IN ZONE OF CAVITIES

	Depth, ft.	Direction	Angle
30	2,743	S08W	0°45'
31	2,837	South	0°55'
32	2,931	S37E	1°30'
33	3,023	S40E	1°30'
34	3,135	S48E	1°50'
35	3,208	S47E	2°00'
36	3,301	N35E	1°30'
37	3,393	N28E	1°30'
38	3,486	N22E	1°00'
39	3,580	N30E	1°15'
40	3,673	S45W	1°00'
41	3,766	S55W	1°30'
42	3,859	S62W	1°30'
43	3,953	S72W	2°20'
44	4,047	N80W	1°50'
45	4,142	N69W	2°00'
46	4,236	N58W	1°40'
47	4,278	N51W	1°30'

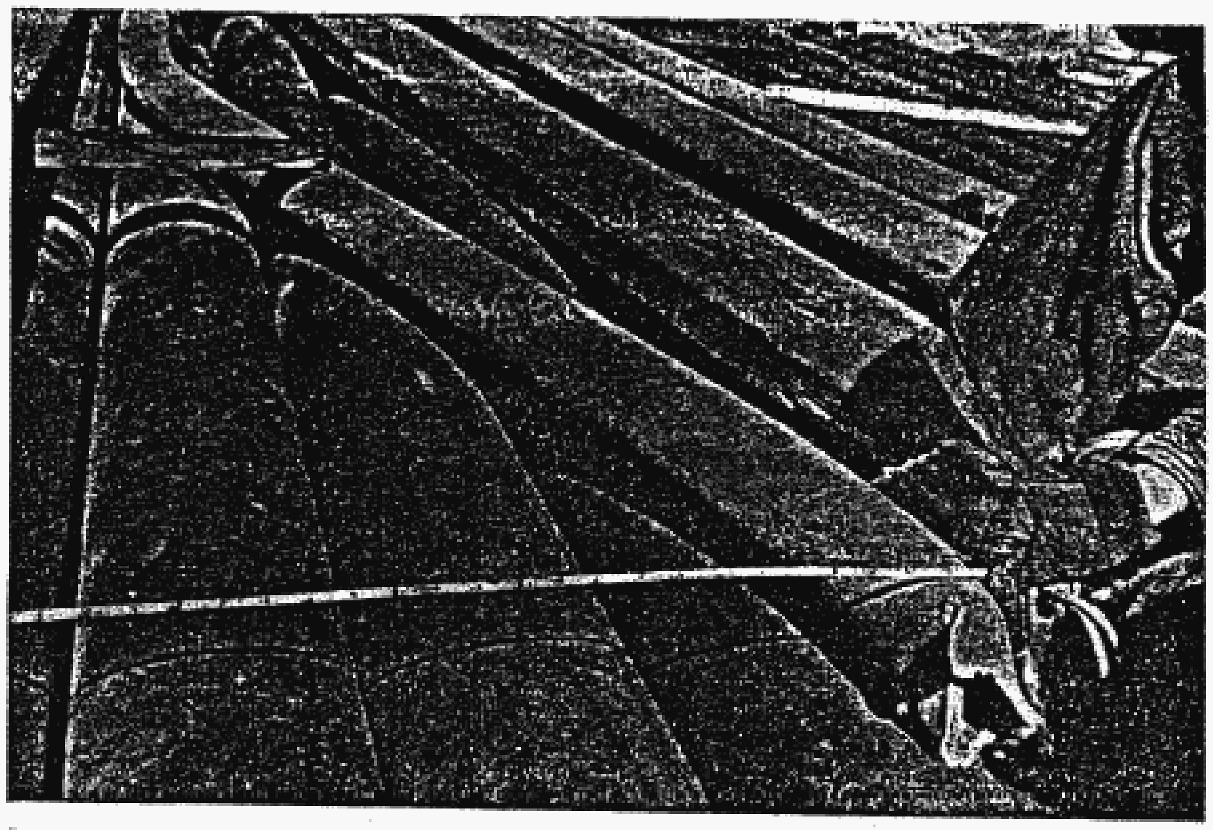


Fig. 2—This bent drill pipe resulted from insufficient wall support while drilling in cavernous limestone. The fish was recovered with difficulty through the 13⅜-in. surface casing in the hole.

stone or below any additional sand.

In South Florida the loose sand zone is covered by several hundred feet of younger limestone. If the derrick is built on these limestones there are no foundation problems; however, two surface strings of casing may still be needed because circulation may be lost in the limestones above the loose sand as well as in the older limestones below. In both North and South Florida, operators mud up to drill the sand zones of Pleistocene and Miocene ages.

The most common drilling hazard in Florida is loss of circulation in thick cavernous limestones. Drilling blind for 1,500 to 6,000 ft. is expected of the drilling contractors. In North Florida this zone of repeated cavities is thin and in places exposed at the surface. In South Florida the same zone of lost circulation is much thicker and is covered by 1,000 to 2,000 ft. of Miocene to Recent sediments. The individual cavities are characteristically thin and may not be noticed by the driller until the mud has disappeared.

Technically a cavity is a zone of

TABLE 1—FLORIDA WILDCATS DRILLED BY COASTAL PETROLEUM CO.

County, well and farm—	Footage	Drilling days	Date comp.	Contractor	Gross cost	Participation by others
Levy, 1 Ragland	5,850	65	10-19-47	Crow	$96,900	$50,000
Pinellas, 1 Wright	11,507	139	7- 8-48	Parker	192,800	65,000
Jefferson, 1 Larsh	7,913	60	1-13-49	Parker	100,700	46,000
Lafayette, 1 Sapp	*6,000	30	3-19-49	Parker	53,900	27,000
Monroe, 1 State Lse. 363	7,559	78	9-30-49	Parker	118,500	15,000
Dade, 1 State Lse. 340-A	11,520	77	12-18-49	Loffland	198,000	138,600
Monroe, 1 Williams	6,702	97	2- 5-50	Parker	136,000	22,300
Totals	57,051	546			$896,800	$363,900

*This test was actually bottomed at 3,507 ft. in Paleozoic basement but Coastal received 6,000 ft. credit toward its 60,000-ft. drilling obligation with the state of Florida on 4,800,000 acres of water bottom lands.

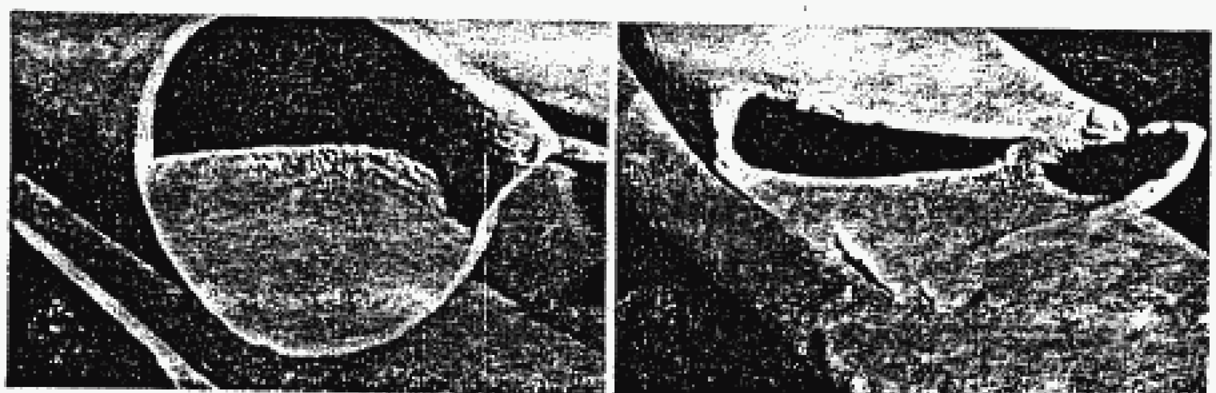


Fig. 3—In these two pictures can be seen the ends of the 1,387-ft. fish in Fig. 2. On the left is shown the initial twistoff. On the right can be seen the secondary break at the bottom end of the drill pipe.

excessive permeability and porosity formed in limestone by circulating ground water. Numerous small and large cavities are present throughout the zone of lost circulation. An individual cavity can usually be sealed off using cement and crushed rock, but the job of sealing off multiple cavities is at present uneconomic. Many of the cavities are large enough to permit the drill cuttings to escape into the formation. More numerous are the smaller cavities capable of taking fluid but not cuttings. The repeated loss of cuttings in large cavities is the ideal drilling condition. Also, chalk lends itself to drilling without returns because it disintegrates into the drilling fluid. Under ideal conditions the over-all drilling rate without returns in cavernous limestone or chalk can easily exceed that of conventional methods. On the other hand, if the cavities are small and the large cavities widely spaced, the problems of drilling without returns greatly increase and the drilling rate suffers.

Much Water Required

At Coastal Petroleum 1 State, Lease 363, located on Plantation Key in Monroe County, 600 ft. of cuttings accumulated in the hole while drilling 1,200 ft. before being flushed out in a large cavity at 5,620 ft. This required 2 to 6 hours' additional time to wash and ream to bottom with a new bit and 15 to 30 minutes to make each connection while drilling.

Usually a large volume of water is needed to keep the cuttings out of the way of the bit. Even then, large cuttings and cave-ins called "boulders" are continually wedging around the bit and drill collars. At times it is impossible to determine if the bit is drilling or reaming because the same amount of weight and torque may be required. Stuck pipe may occur when the drilling fluid flows into a cavity near the bit instead of lifting the cuttings. A plugged bit, pump failure, twistoff, or delayed connection can also stick the drill pipe.

Stuck pipe is the most common type of fishing job within the zone of lost circulation. Experience has shown that if fluid can be pumped through the bit the pipe can usually be worked loose. Freeing the pipe may take just a few anxious minutes or several long days. The Coastal Petroleum Co. 1 State Lease 363 penetrated the entire zone of cavities. In doing so, the pipe was stuck six times with a loss of 63 hours' drilling time, the longest single period being 2 days.

Cavities affect the drilling operations in other ways. For example, they may cause a sharp directional change in an otherwise normal drilling spiral. The bit on penetrating the floor of a cavity may not deviate appreciably from vertical but can reverse its horizontal direction, as shown in Fig. 1. Such sharp bends in the horizontal component of drilling spiral undoubtedly put an additional strain on the drill pipe.

Drilling-Time Curves

Cavities are associated with hard and broken drilling. The maximum weight of the drill collars is required to drill hard lime beds at a rate of 1 to 4 ft. per hour. Drilling-time curves within the zone of lost circulation correlate poorly at best and frequently not at all. The over-all drilling time for this zone also varies from well to well. In one well it will average 5 minutes per foot, whereas in another within 10 miles the average may be 15 minutes per foot. Apparently the local amount of rock hardening determines the drilling rate at each location.

Hole-size surveys indicate the position of large cavities, but more noticeable is the loss of gage resulting from drilling. Thirty days of drilling with water can double the original hole size opposite chalk and certain shales. Indurated limestone beds tend to remain in gage. A twistoff while drilling without returns through cavities and enlarged hole can be serious, because the drill pipe is not supported and centered by the walls of the hole at all points. A case in point is the Coastal Petroleum Co. 1 Williams located on Key Largo south of Miami. Here the operators set surface casing at 253 and 989 ft.; then attempted to drill 5,800 ft. of chalk and cavernous limestone with salt water using five 8-in. drill collars, 4½-in. drill pipe, and diesel-electric power.

To a depth of 6,702 ft., the hard lime formation dulled thirty-three 12¼-in. rock bits. Time lost in reaming to bottom amounted to 168 hours and freeing the pipe 25 times took 119 hours. At this depth, while reaming preparatory to running casing, the bit stuck 18 ft. off bottom and the drill pipe twisted off at 2,200 ft.

Fishing operations revealed that the drill pipe had dropped, bent into the large cavities, and sheared off at several places. The first 1,387-ft. piece of drill pipe was recovered from 3,028 ft., indicating that it had dropped 828 ft. and bypassed the second piece by 122 ft. Photographs of this fish are shown in Figs. 2 and 3. The top of the second fish was located in a cavity at 4,293 ft. but could not be recovered.

Hole-Size Variations

Hole-size variations also affect the casing program. Running one string of casing completely through a long interval of enlarged and tight hole is obviously difficult and hazardous. An intermediate mud string proved very successful in the Coastal 1 Ragland in Levy County because the remainder of the Tertiary section was drilled without loss of circulation, and the hole was completed to basement without the usual long mud string.

Since large quantities of water are used in drilling without returns, it is fortunate that in most parts of Florida there is an abundance of fresh water within a few feet to a few hundred feet of the surface. On the Florida Keys, however, fresh water is not available and drilling costs are therefore greater. Not only is the bill for pump parts excessive but the mud lines and drill pipe can be worn out in one or two locations.

On the bright side of the Florida drilling picture is the almost complete absence of problems after the mud string has been cemented below the cavernous limestone section. Expensive mud treatment is not required. At the Coastal 1 Larsh in Jefferson County, 2,500 ft. of chalky limestone and 4,500 ft. of sand and shale were drilled successfully, using thin bentonite mud and no chemicals. At the 1 Sapp in Lafayette County untreated bentonite mud was used in wire-line coring 200 ft. of sand and shale, resulting in 87 per cent recovery. The Coastal 1 State Lease 340-A in Dade County west of Miami was drilled below the mud string to a depth of 10,600 ft. with fresh water before mudding up. To this depth the water cuttings gave reliable mud-log readings for oil and gas, the formation changes were sharp, and the hole below the chalk section remained in gage.

Appendix 3

REBECCA SHOAL DOLOMITE

<u>Type Well</u>: Gulf-California OCS Blk 46 P 296, Monroe Co.
24 36'N, 82 36'W.

<u>Type Interval</u>: 3875-5648 feet E-log; 3890-5645 feet samples (revised 1989).

<u>Name Derivation</u>: From the bathymetric feature 11 miles north of the type well.

<u>Type Description</u>: "...is composed of gray, tan and white, very fine to fine crystalline euhedral and anhedral dolomite with numerous vugs, cavities and occasional caverns." (Winston 1971 p. 124).

<u>Comments</u>: Due to the poor quality of the cuttings in P 296 caused by loss of circulation in the very porous sections (particularly at the base), the boundaries are best determined by E-log character. Well 296 was the only one in the area with a reasonably complete set.

<u>Thickness</u>: A maximum thickness of 3120 feet was penetrated in Well 4950.

<u>Age</u>: Upper Cretaceous and Paleocene by stratigraphic position.

<u>Fauna</u>: None.

<u>Upper Boundary</u>: (conformable) Defined in the type well by the change from skeletal limestone of the Black Point Format above to cream and gray anhedral dolomite below. Elsewhere brown anhedral or cryptocrystalline dolomite may be present in the basal Black Point Format.

<u>Lower Boundary</u>: (conformable) In the type well, circulation was lost at or near the lower boundary. From the E-log, the rock below the base appears to be of low resistivity, probably chalky limestone. Underlying this section is a 200-foot high resistivity zone, possibly another Plantation Tongue of the reef. Beneath this, is another low resistivity section, probably the Pine Key chalky limestone. Where the Card Sound Tongue is present, the lower Rebecca Shoal boundary is defined by the change from tan anhedral or euhedral dolomite above to gray limestone of the Grassy Point below.

<u>Correlatives</u>: Pine Key and Cedar Keys.

<u>Synonymies</u>: Includes "deep Boulder Zones" of the oil industry.

Appendix 4

CARD SOUND TONGUE
of the
Rebecca Shoal Dolomite

Type Well: Sinclair 1 Williams P 148, 24-59S-40E, Monroe Co.

Type Interval: 5280-6690 feet E log: 5280-6675 feet samples.

Name Derivation: From Card Sound 2 miles west of the type well.

Type Description: "...composed entirely of tan to gray, fine to medium crystalline [euhedral] dolomite" (Winston 1971 p. 28).

Comments: The Card Sound was added to the Rebecca Shoal Dolomite by Winston (1989).

Thickness: In the type well it is 1350 feet thick. On the Sarasota Arch in Well 4950, it is combined with the overlying Plantation Tongue.

Age: Upper Cretaceous by stratigraphic position.

Fauna: None.

Upper Boundary: (conformable) In the type well no samples were available over the contact. From the E-log, the top is characterized by a change from low readings on the resistivity curve above to high readings in the dolomite below.

Lower Boundary: (conformable) Defined by the change from the brown euhedral and anhedral dolomite of the Card Sound above to brown and cream micritic limestone of the Grassy Point below.

Correlatives: Part of the Pine Key.

Appendix 5

PLANTATION TONGUE
of the
Rebecca Shoal Dolomite

Type Well: Coastal 1 State (363) P 108, 32-63S-38E, Monroe Co.

Type Interval: 5010-5725 feet E-log (no samples).

Name Derivation: From the Key on which the type well is located.

Type Description: "Although no samples were recovered [from the type well] in the interval, data from other wells indicate a lithology similar to that of the main reef complex [Rebecca Shoal Dolomite]" (Winston 1978 p. 124-25). No other well with a well-developed section had samples.

Comments: The type well had drilling difficulties in this unit. Three cavity zones were recorded by the operator.

Thickness: Variable from 310 feet to 1275+ feet depending on the position of the well in the reef complex. When the Plantation Tongue is in contact with the overlying Tavernier Tongue or the underlying Card Sound Tongue, it is indistinguishable.

Age: Upper Cretaceous by stratigraphic position.

Fauna: None.

Upper Boundary: (conformable) Indistinguishable when in contact with the overlying Tavernier Tongue. In none of the wells where this tongue was separated from the Tavernier were samples recovered; from E-log character the overlying rock appears to be either Pine Key chalky limestone or Cedar Keys microcrystalline dolomite.

Lower Boundary: (conformable) Indistinguishable when in contact with the underlying Card Sound Tongue. In none of the wells where the Plantation Tongue was a separate unit were samples recovered; from E-log character the underlying lithology appears to be Pine Key chalky limestone.

Correlatives: Part of the Pine Key.

Synonymies: Part of the "deep Boulder Zone" of the oil industry.

Appendix 6

TAVERNIER TONGUE
of the
Rebecca Shoal Dolomite

Type Well: Coastal 1 State (363) P 108, 32-63S-38E, Monroe Co.

Type Interval: 3875-4660 feet E-log (no samples).

Name Derivation: From a town 1 mile from the type well.

Type Description: "Although no samples were recovered [from the type well] in the interval, data from other wells indicate a lithology similar to that of the main reef complex [Rebecca Shoal Dolomite]." (Winston 1978 p. 124). No other well with a well-developed section had samples.

Comments: None.

Thickness: Variable from 55 feet to 800+ feet, depending to the position of the well on the reef complex. In some cases the Tavernier Tongue is in contact with the underlying Plantation Tongue, and is thus indistinguishable from it.

Age: Paleocene by stratigraphic position.

Fauna: None.

Upper Boundary: (conformable) Defined by the change from brown anhedral dolomite of the basal Black Point Format to a cryptocrystalline or anhedral gray or tan dolomite of the Tavernier Tongue below. In Wells 108 and 148 E-log character and regional lithologic considerations suggest the presence above the Tavernier Tongue of Cedar Keys microcrystalline dolomite.

Lower Boundary: (conformable) Indistinguishable from the underlying Plantation Tongue in the main reef facies; elsewhere it is underlain by Cedar Keys microcrystalline dolomite.

Correlatives: Cedar Keys.

Synonymies: Part of the "deep Boulder Zone" of the oil industry.

Appendix 7

Black Point Format

Type Well: MDWS 5 Injection (W-13768, M57) 21-56S-40E Dade County

Type Interval: Top 1030 feet samples, 1035 feet GR log; base 3160 feet samples, 3165 feet GR log

Name Derivation: From Black Point on Biscayne Bay, one mile east of the type well

Thickness Range: 1170 to 2735 feet

Description of contained lithologies: Highly variable - includes light-colored chalky micrite, dense micrite, skeletal wackestone, packstone and grainstone, orange-brown and tan euhedral, anhedral and occasionally cryptocrystalline dolomite. Euhedral dolomite ranges from very fine microcrystalline to medium crystalline.

Comments: Used to refer to the carbonate interval between the base of the Miocene Hawthorn and the top of the Paleocene Cedar Keys regardless of Suite; includes Suwannee, Ocala, Avon Park, Oldsmar formations and their lateral rock equivalents.

The Black Point Format includes the LAFco, PINco, ORco, ChAco and DAco Suites.

Distribution: Entire Peninsula except for Madison and Taylor Counties.

Upper Boundary: Defined, when not outcropping, by the change from the phosphatic carbonates and clastics of the Miocene Hawthorne above to non-phosphatic carbonates of the Black Point Format below.

Lower Boundary: Defined by the change from orange-brown anhedral dolomite of the Delray Dolomite (Winston in prep) above to gray anhedral or cryptocrystalline lithographic dolomite of the Cedar Keys below. Identifying this boundary is aided by regional correlation using gamma ray logs. In the northernmost Peninsula, limestone instead of the Delray Dolomite dolomite overlies the Cedar Keys.

Age: Eocene and Oligocene (may include some Miocene in the Keys).

Reference: Winston 1993

Appendix 8

MADco Suite

Type Well: Hunt 1 Gibson (W-1596) 6-1S-10E, Madison County.

Type Interval: 0-2350 feet E-log, 0-2380 feet samples.

Name Derivation: from Madison County.

Thickness Range: 2350-3150 feet.

Description of contained lithologies:

The MADco is 80-90% limestone, which consists of wackestones and packstones with very fine to fine skeletal grains in a chalky matrix. Colors are cream, white, tan and light gray. Dolomite crystal inclusions are common.

Minor dolomite, occasionally calcareous, is euhedral, microcrystalline, cream and tan. Occasional dolomite skeletal packstones may be present. Dolomite is most prevalent in the middle section.

Cherty beds are scattered throughout the section, but are most common in the lower (Paleocene) section. In the Jacksonville offshore well cluster, glauconite is prevalent throughout; but in the northwestern Peninsula, only a few glauconite beds are present.

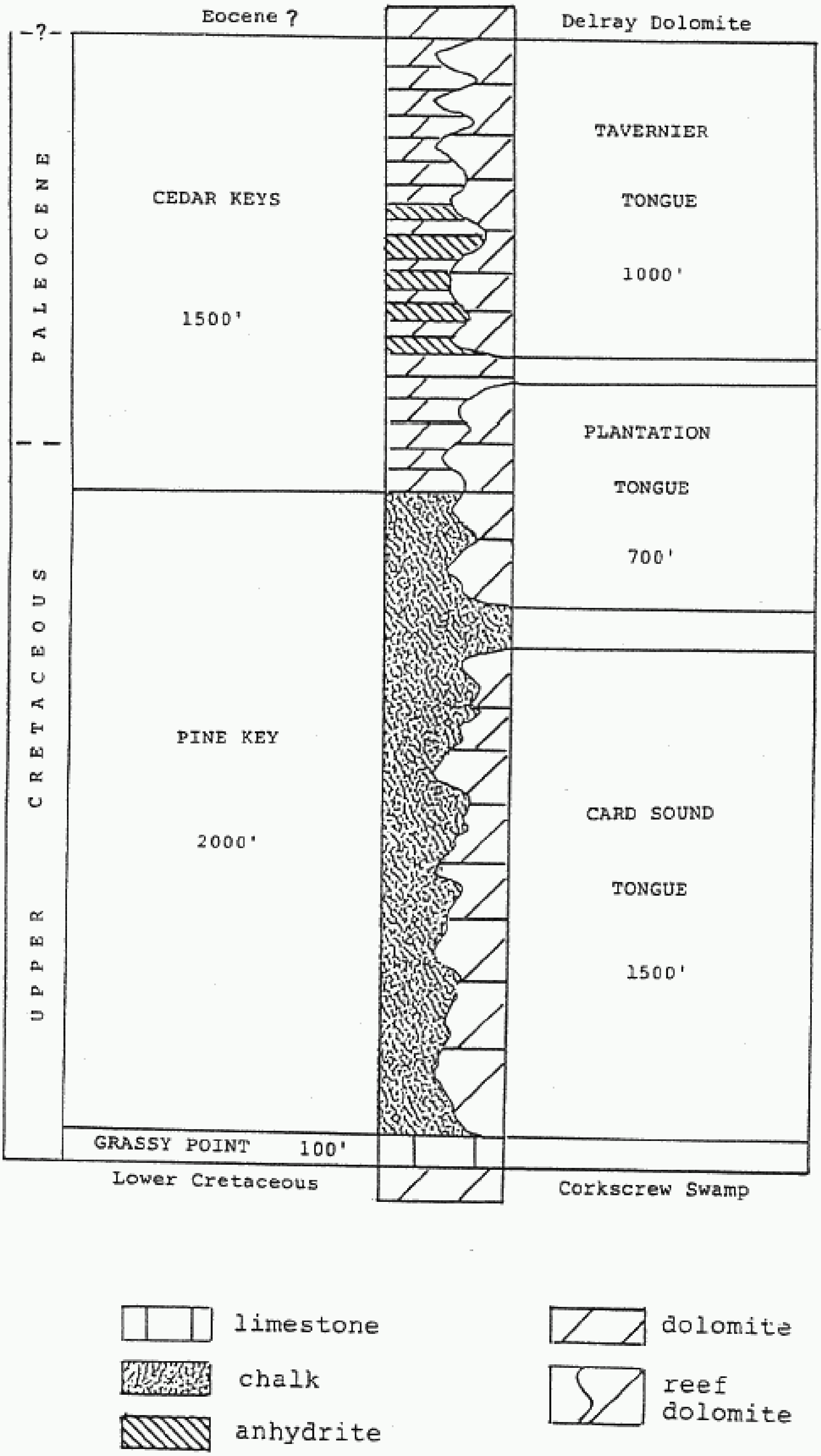
Comments: The Eocene-Paleocene boundary in this Suite is not identifiable by lithology nor by paleontology; only a rough correlation by E-log is possible.

Distribution: The MADco occurs in the eastern third of the Panhandle and extends into the northwest corner of the Peninsula. It is also present offshore on the East Florida Shelf (Jacksonville Well Cluster).

Upper Boundary: Defined by the change from Miocene phosphatic dolomite or clastics above to non-phosphatic carbonate below.

Lower Boundary: Defined by the change from dolomitic, skeletal, cherty packstone above to a white chalk, chalky skeletal wackestone, or micrite containing Inoceramos prisms of the Pine Key-Selma below.

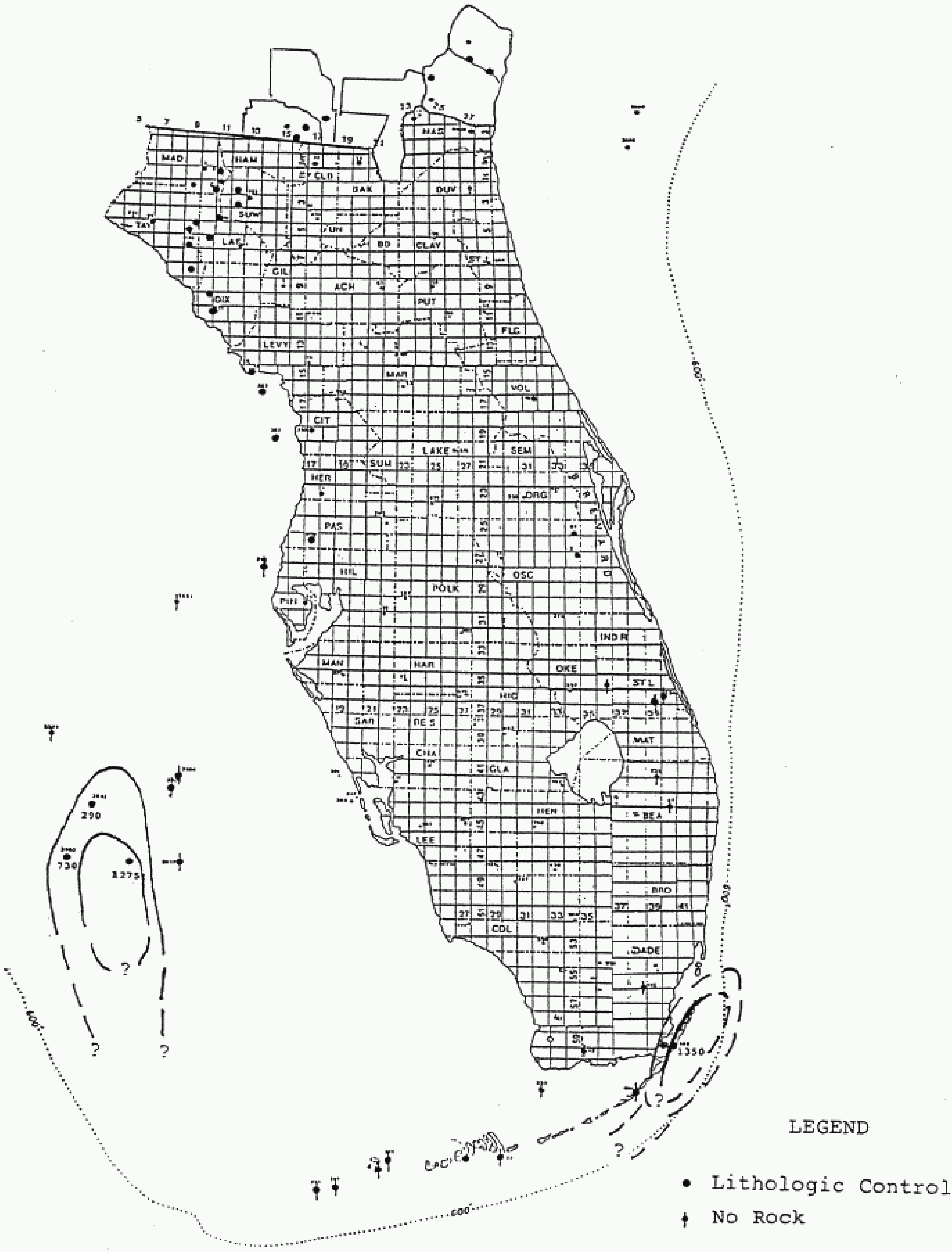
Age: Paleocene, Eocene and Oligocene.



Generalized Geologic Column

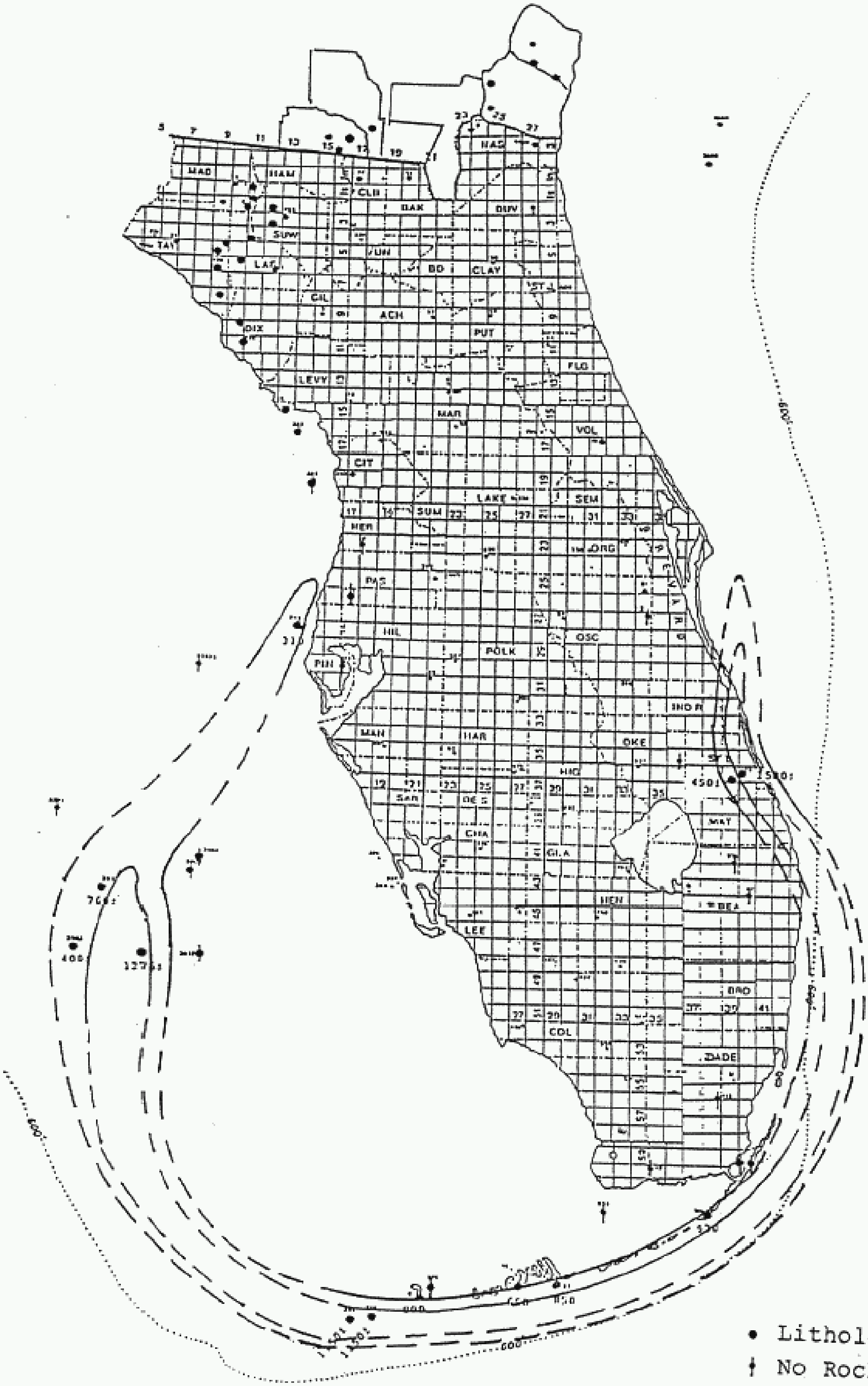
Rebecca Shoal Reef and Lagoonal Facies

Fig. 1



Isopach Card Sound Tongue

Fig. 2



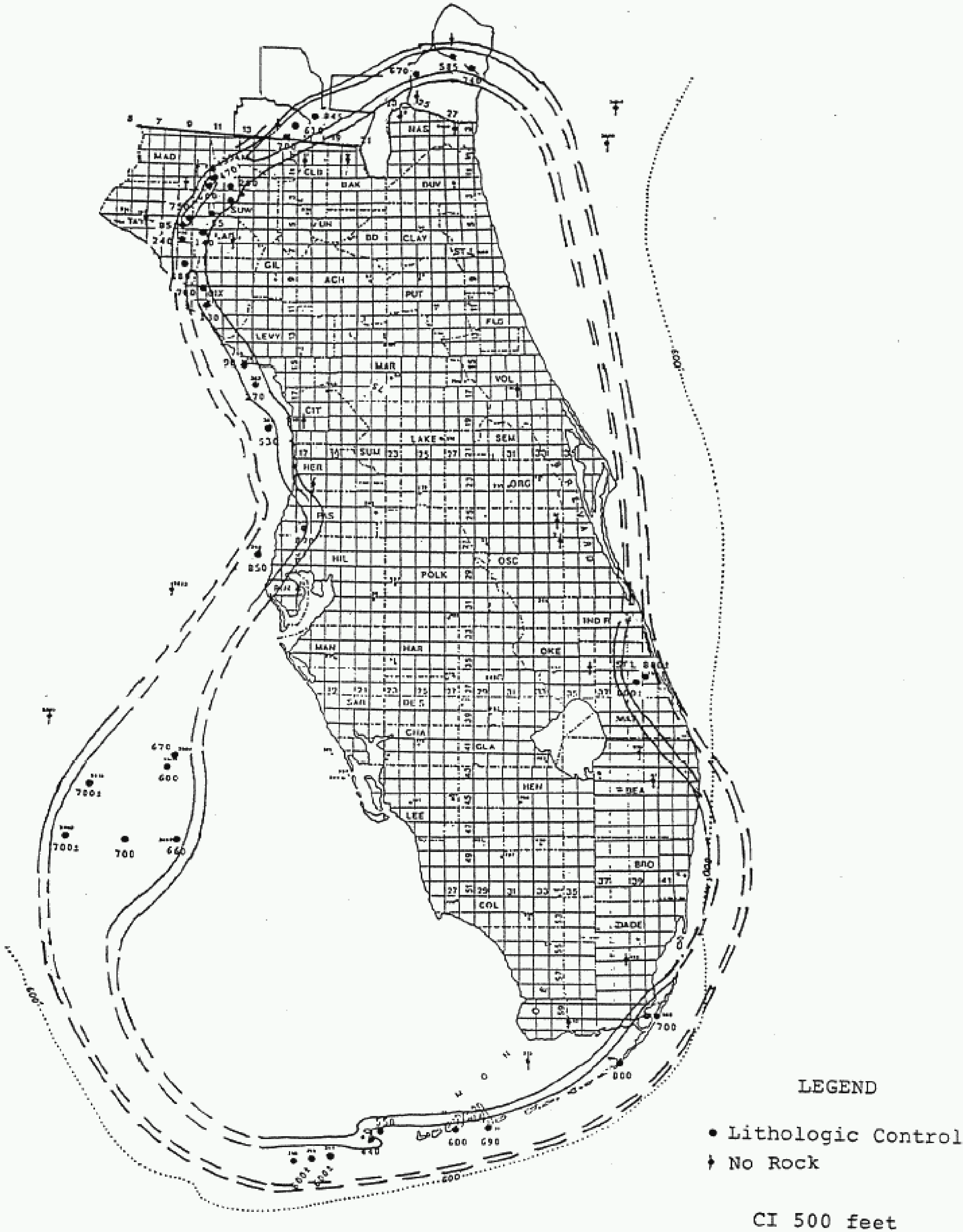
LEGEND

- • Lithologic Control
- † No Rock

CI 1000 feet

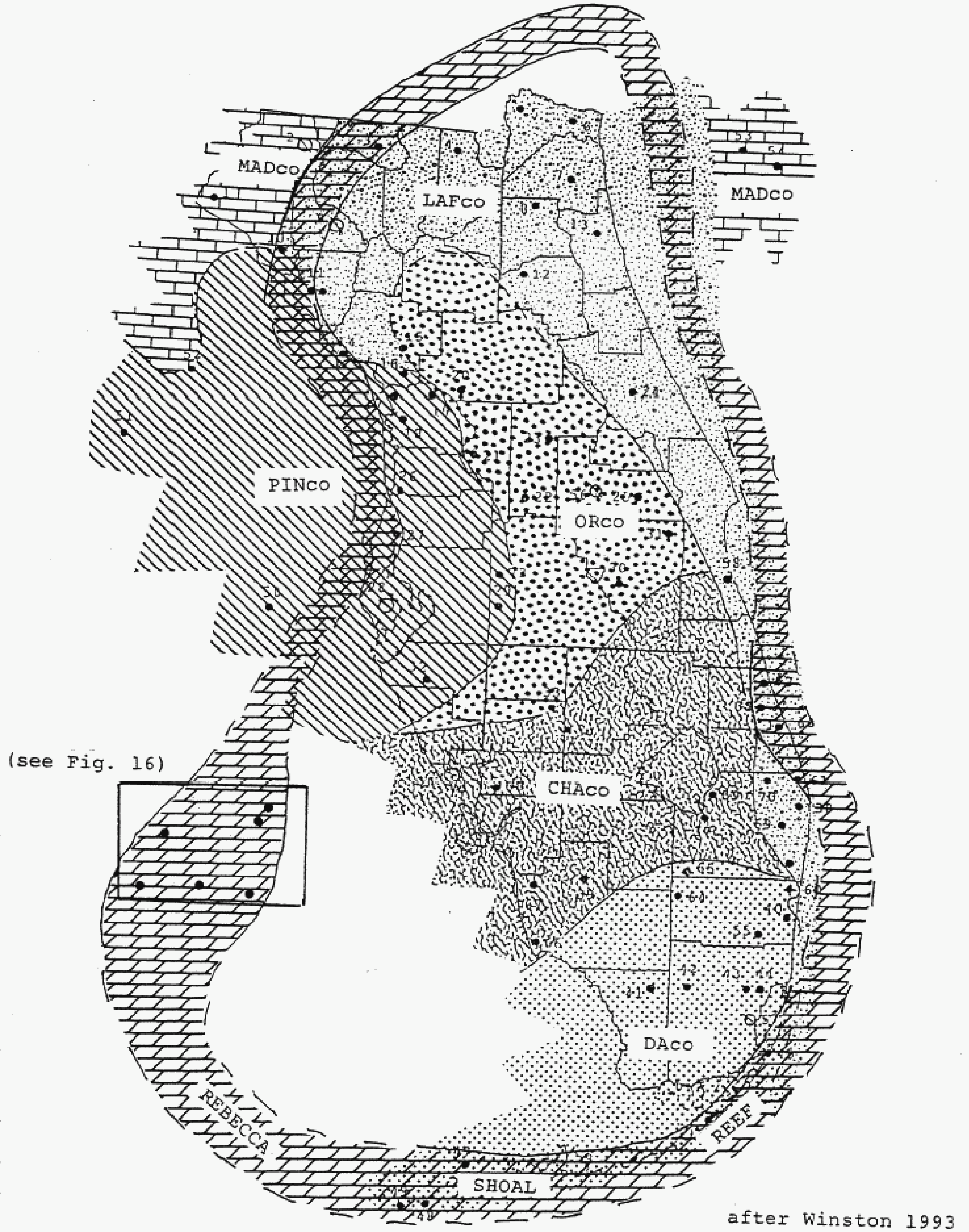
Isopach Plantation Tongue

Fig. 3



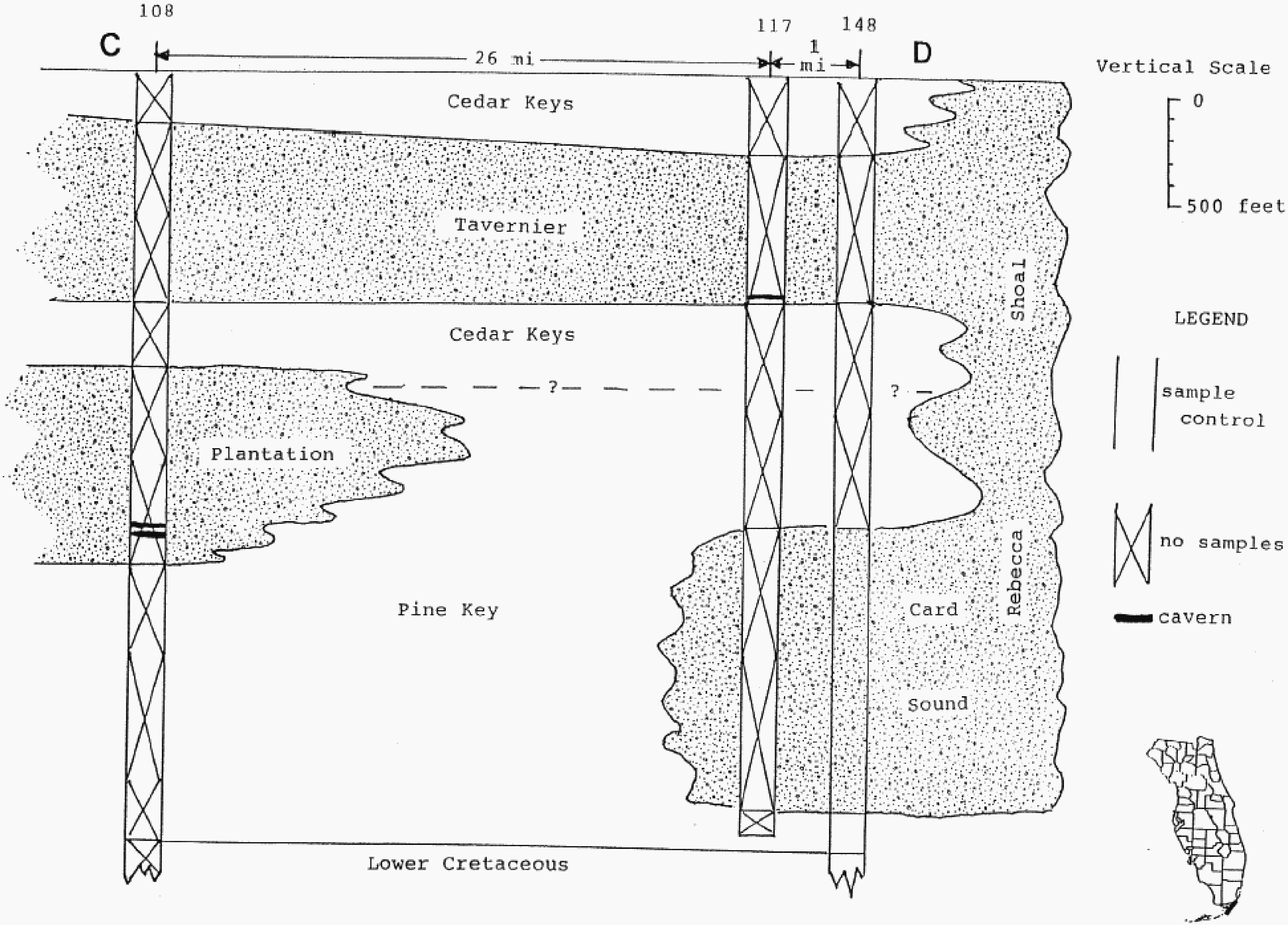
Isopach Tavernier Tongue

Fig. 4



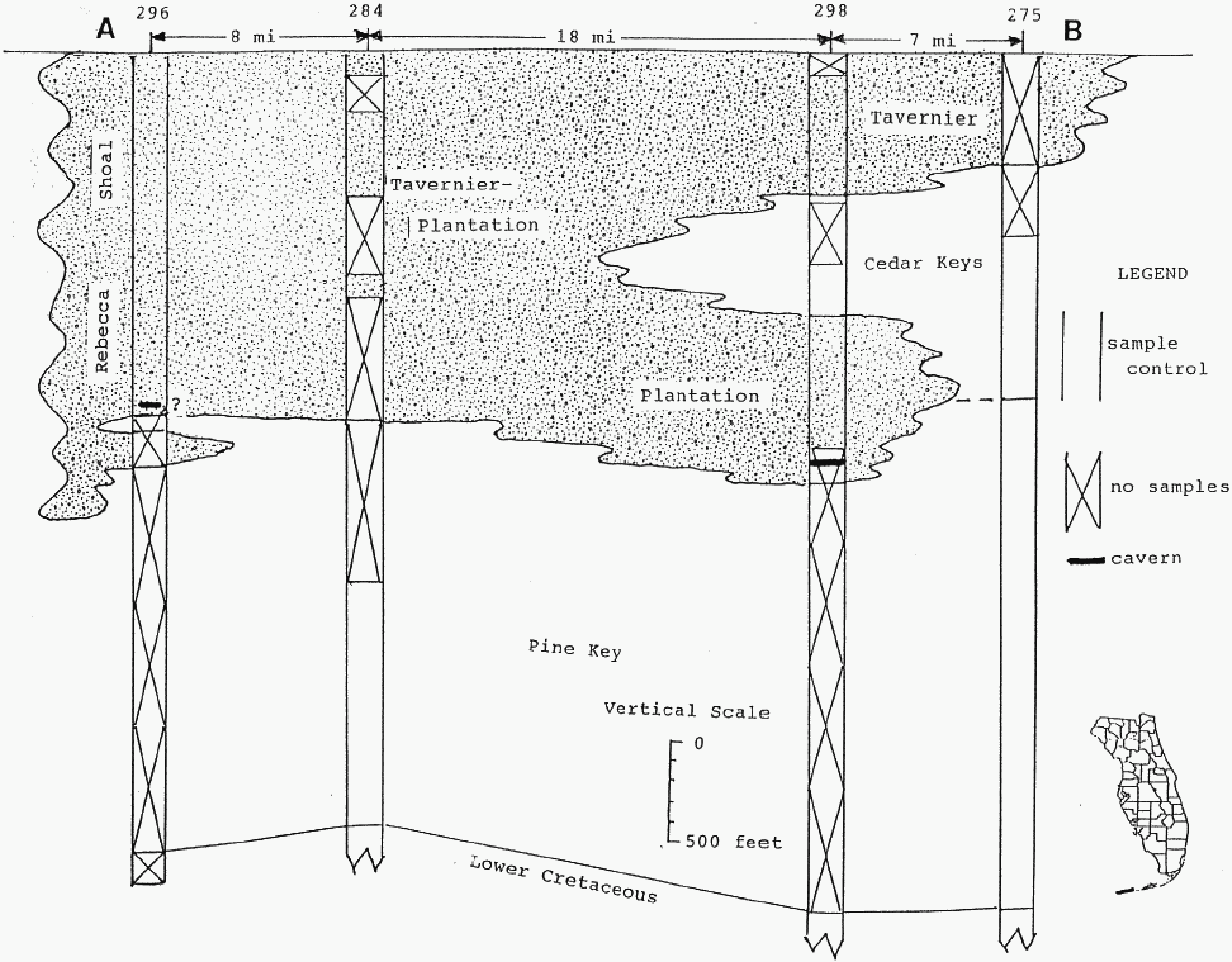
Distribution of Black Point Suites
and Rebecca Shoal Reef

Fig. 5



Cross-section C - D

Fig. 6



Cross-section A - B

Fig. 7

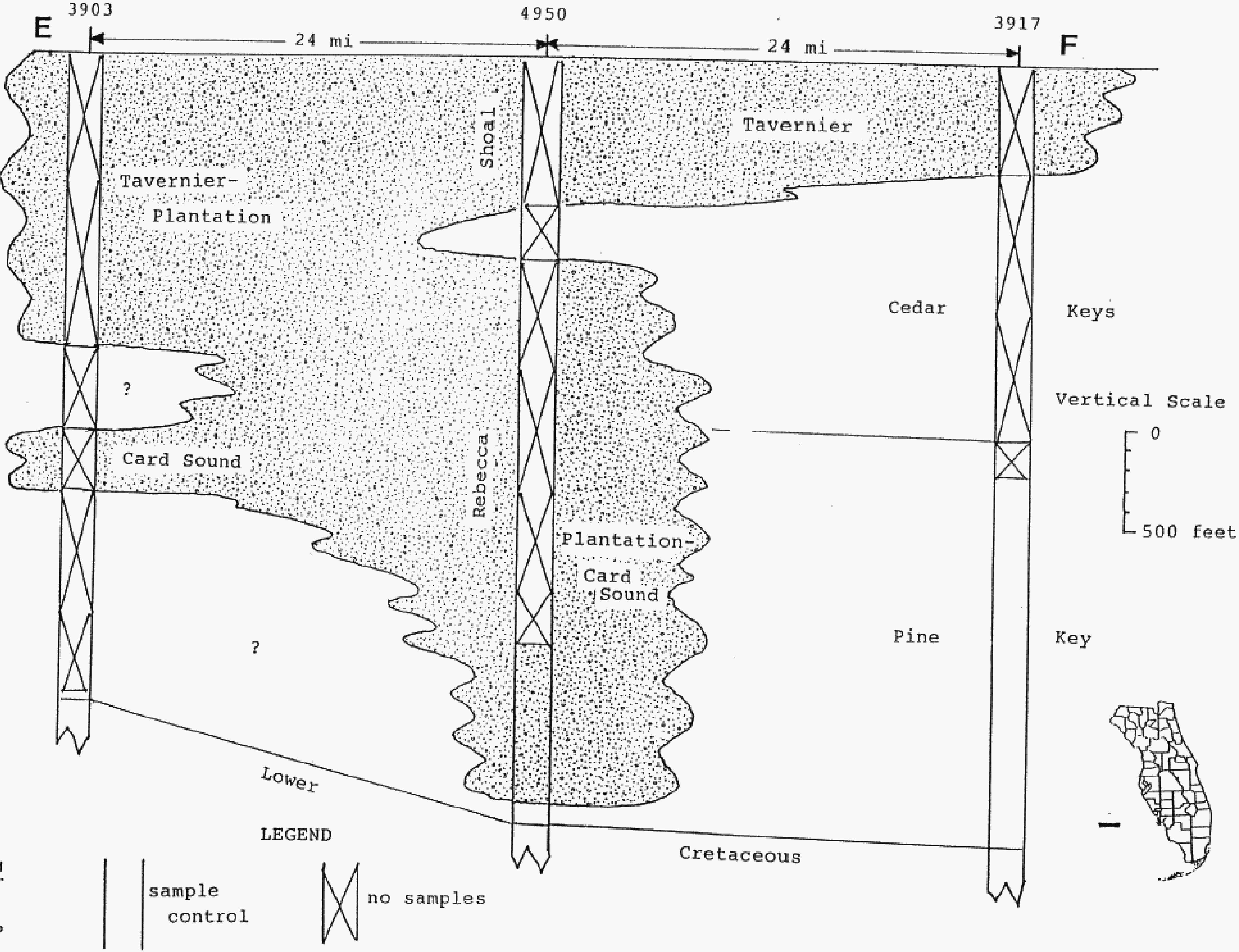


Fig. 8 Cross-section E - F

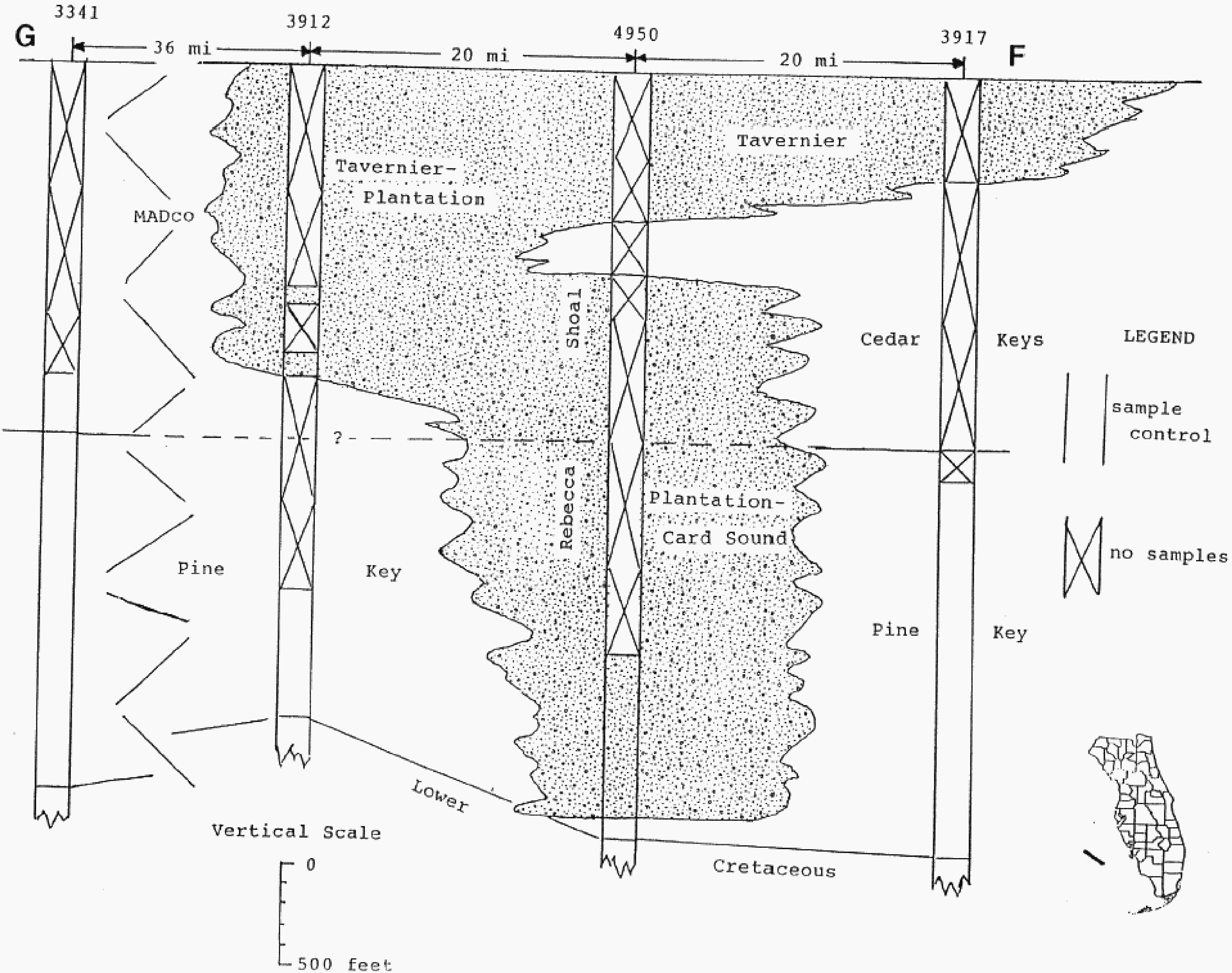


Fig. 9 Cross-section G - F

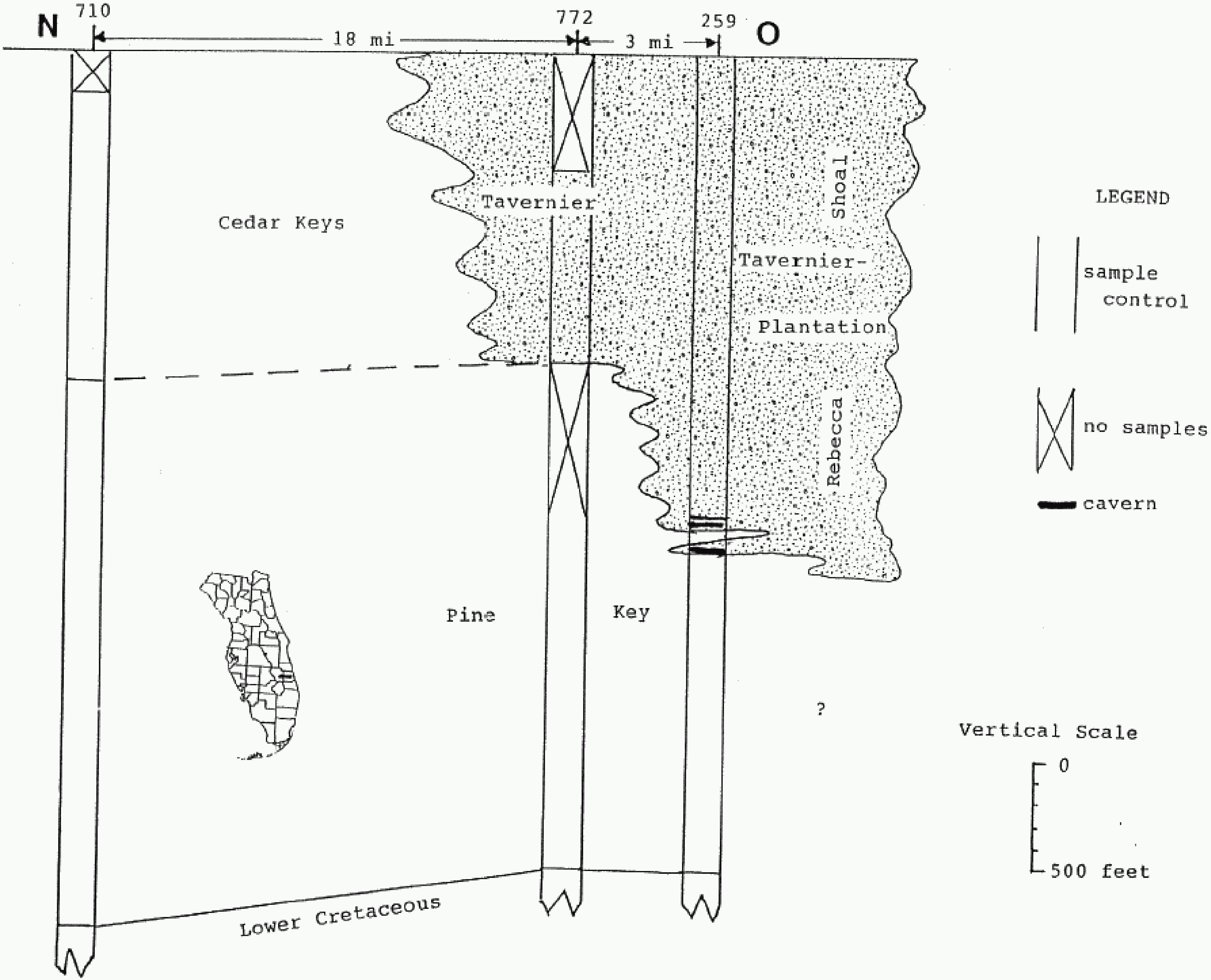


Fig. 10 Cross-section N - O

Fig. 11 Cores Showing Reef Talus from Well 259

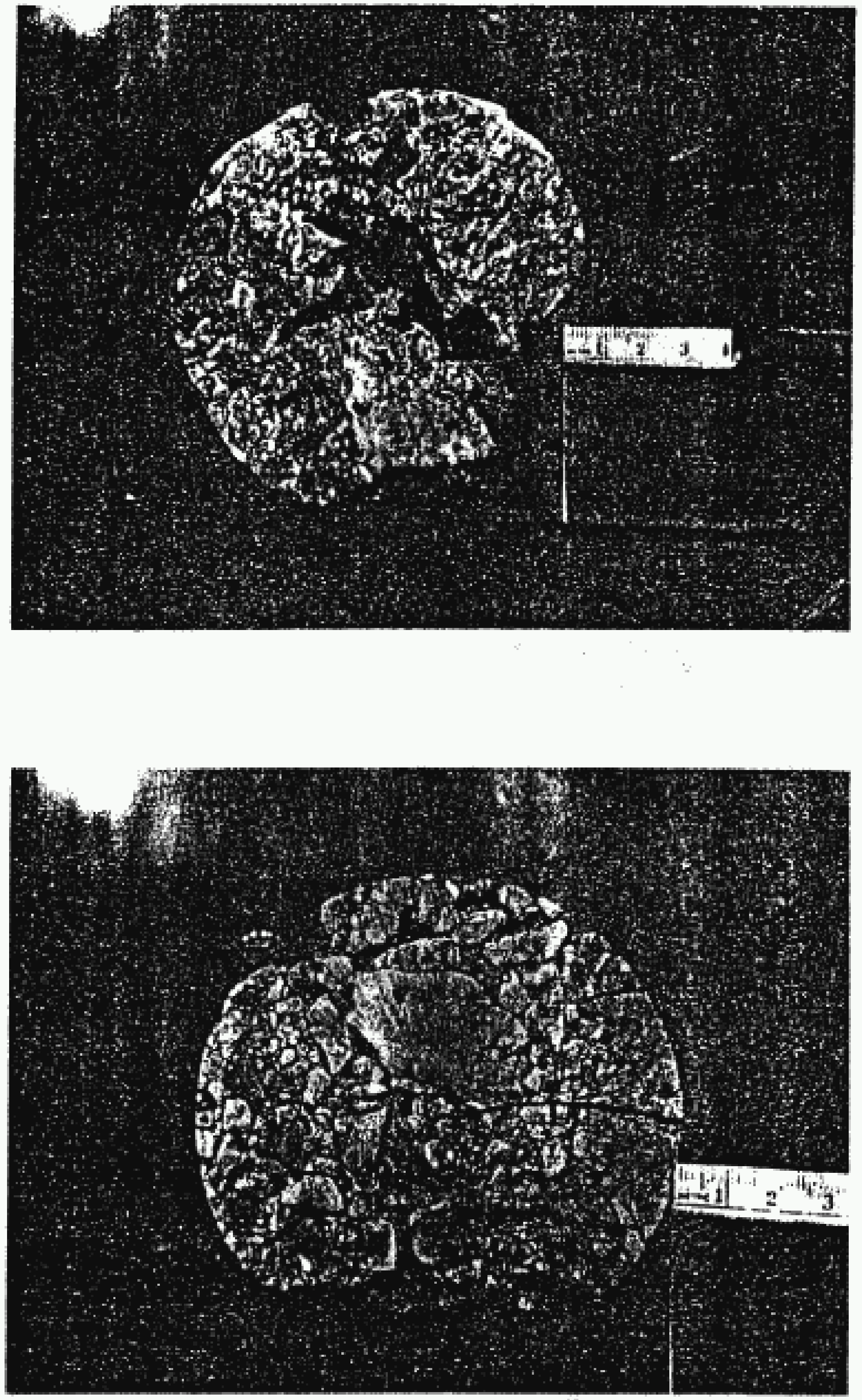


Figure 25 A sawed face of core from Upper Cretaceous 5034 - 40½ in Amerada No. 2 Cowles - Magazine (Well 6), St. Lucie County (top); Other side of the same core (bottom).

A core contributed by E. J. Henderson (Figs. 24 to 28) from 5034 - 5040 feet in Well 6 shows a rubble rock, probably of reef talus, characterized by round fragments. The fragments, some of which are algal, are tan to light brown, and are microcrystalline anhedral dolomite. A few of the fragments were originally split in place and re-cemented. The fragments are incompletely cemented together by medium crystalline dolomite, apparently a replacement of calcite cement. The labyrinthine cavities between some fragments are lined with drusy dolomite crystals. Porosity in the two specimens varies 5 to 15%, with very high permeability.

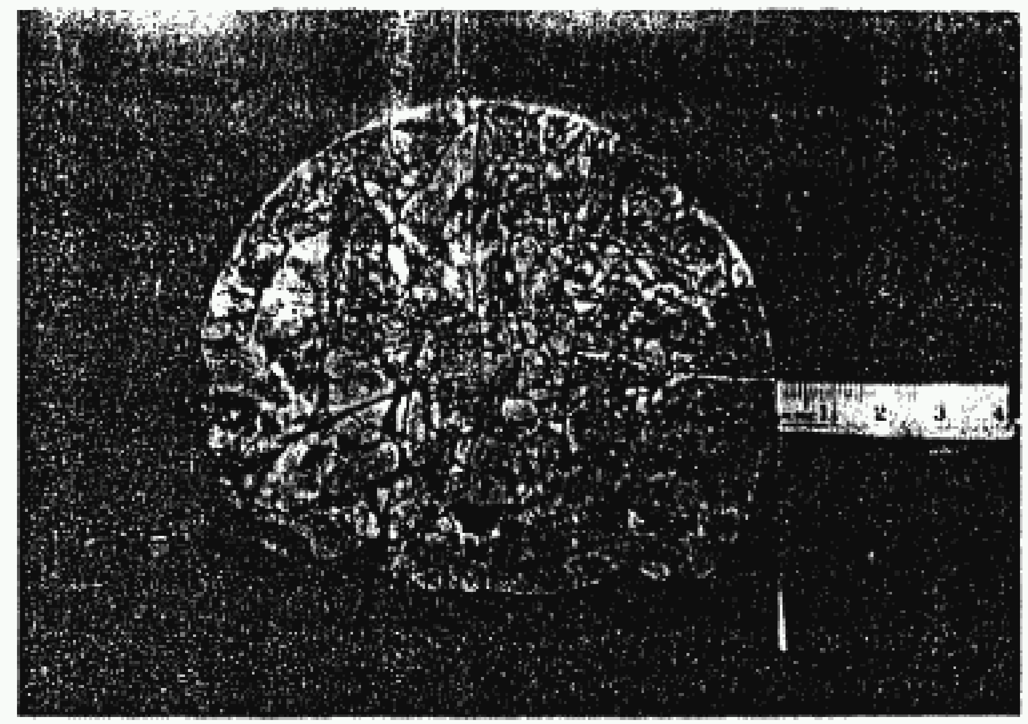
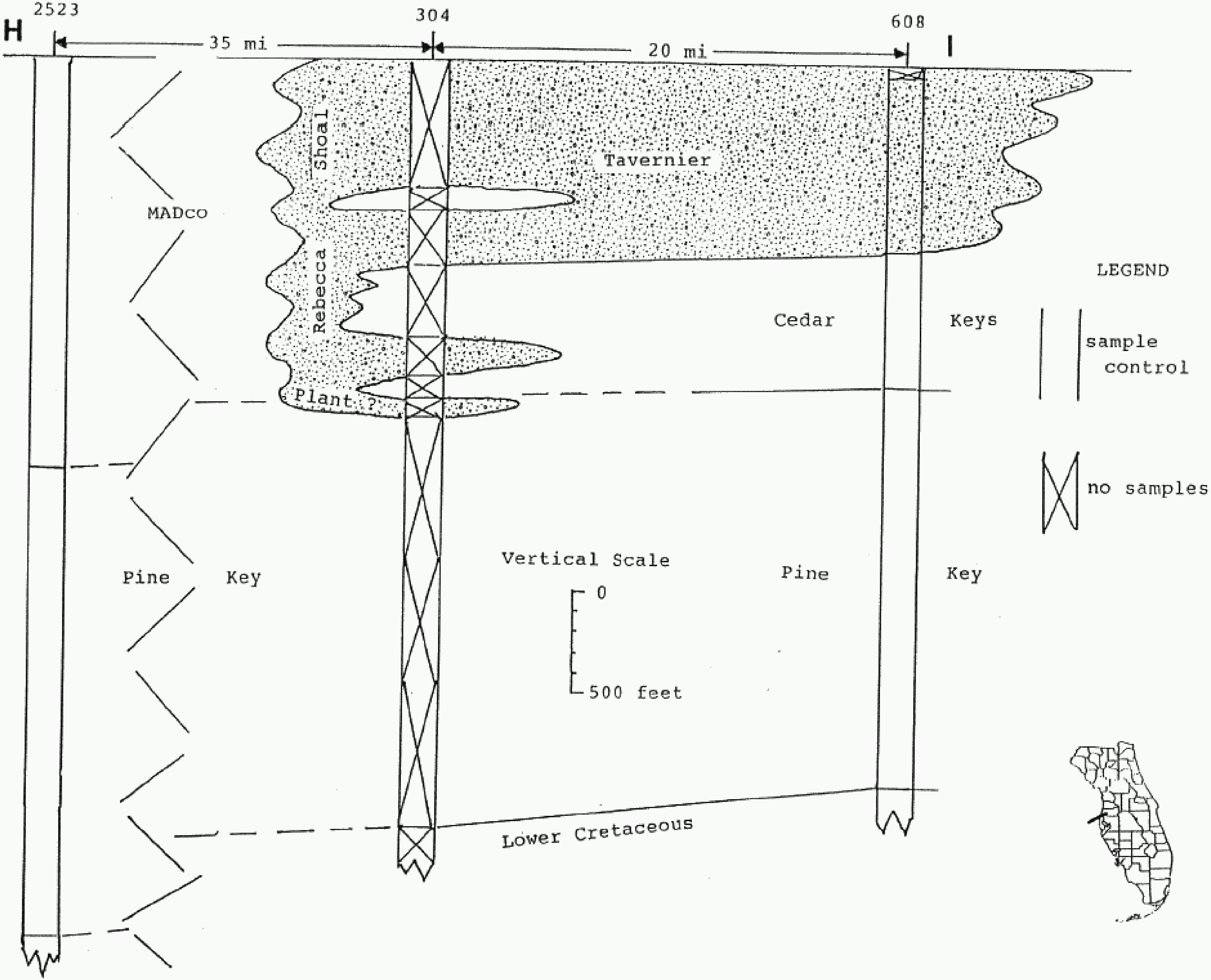


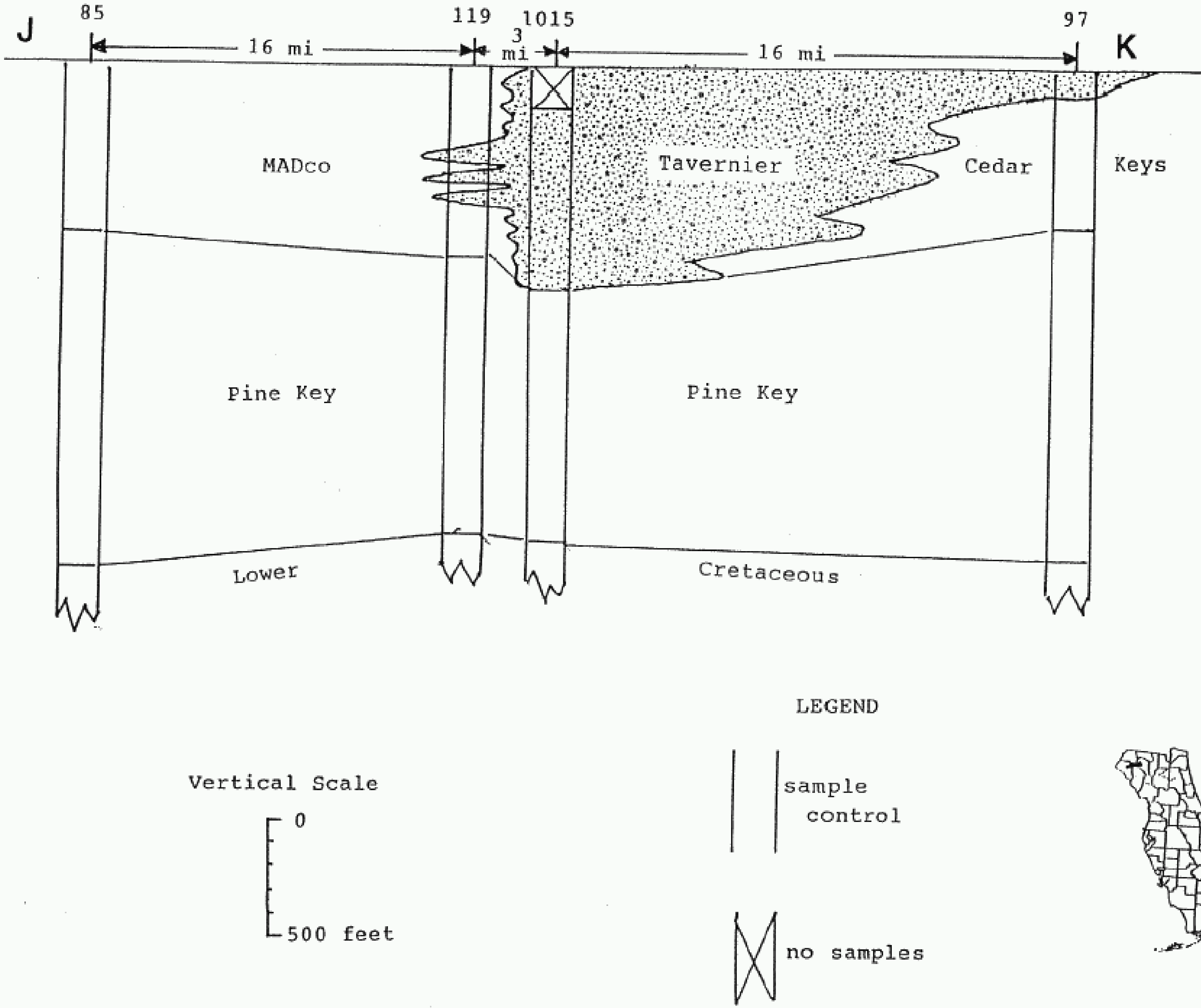
Figure 26 Sawed face of core from Upper Cretceous 5034 - 40 in Amerada No. 2 Cowles - Magazine (Well 6), St. Lucie County.

from Puri & Winston 1974



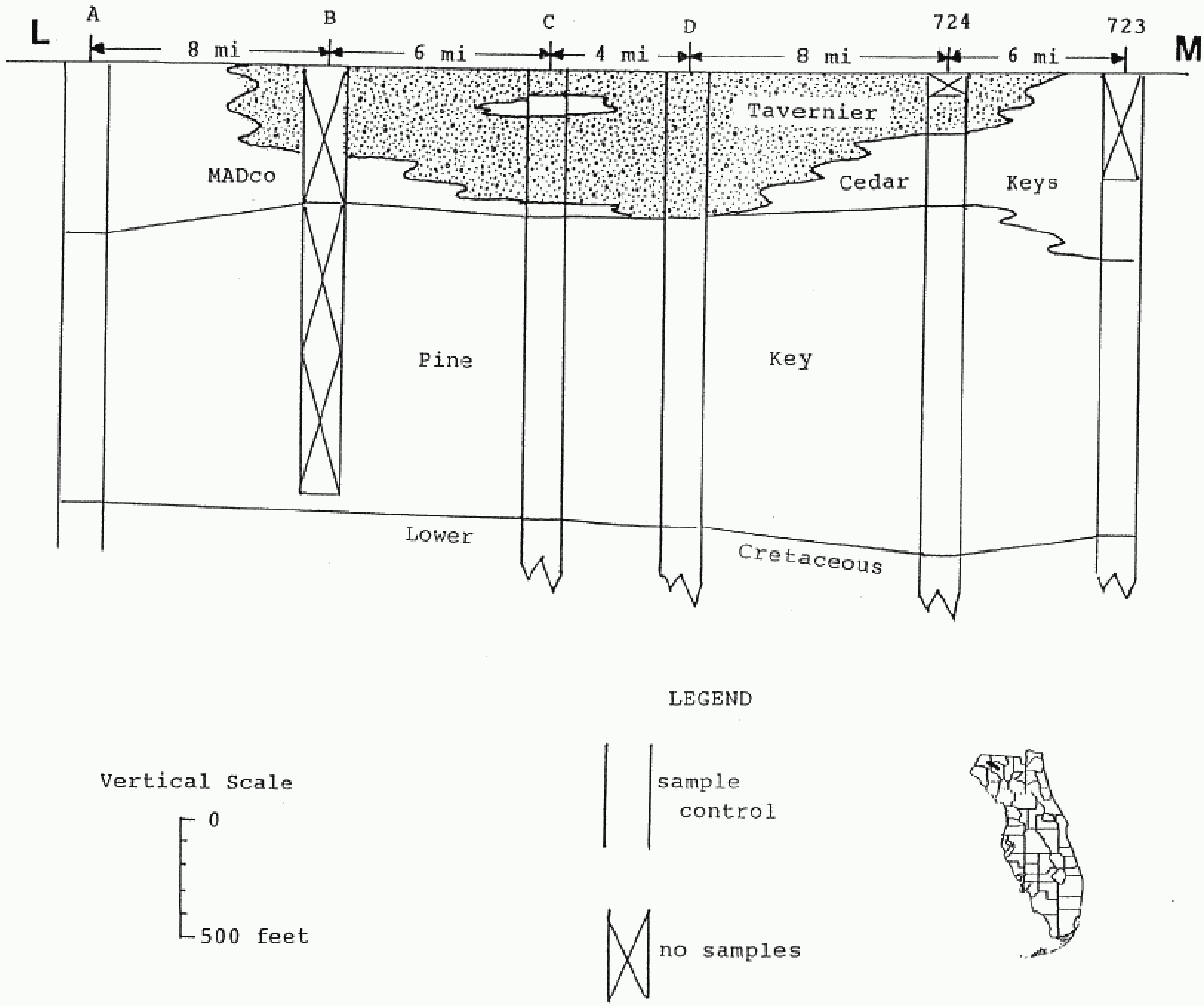
Cross-section H - I

Fig. 12



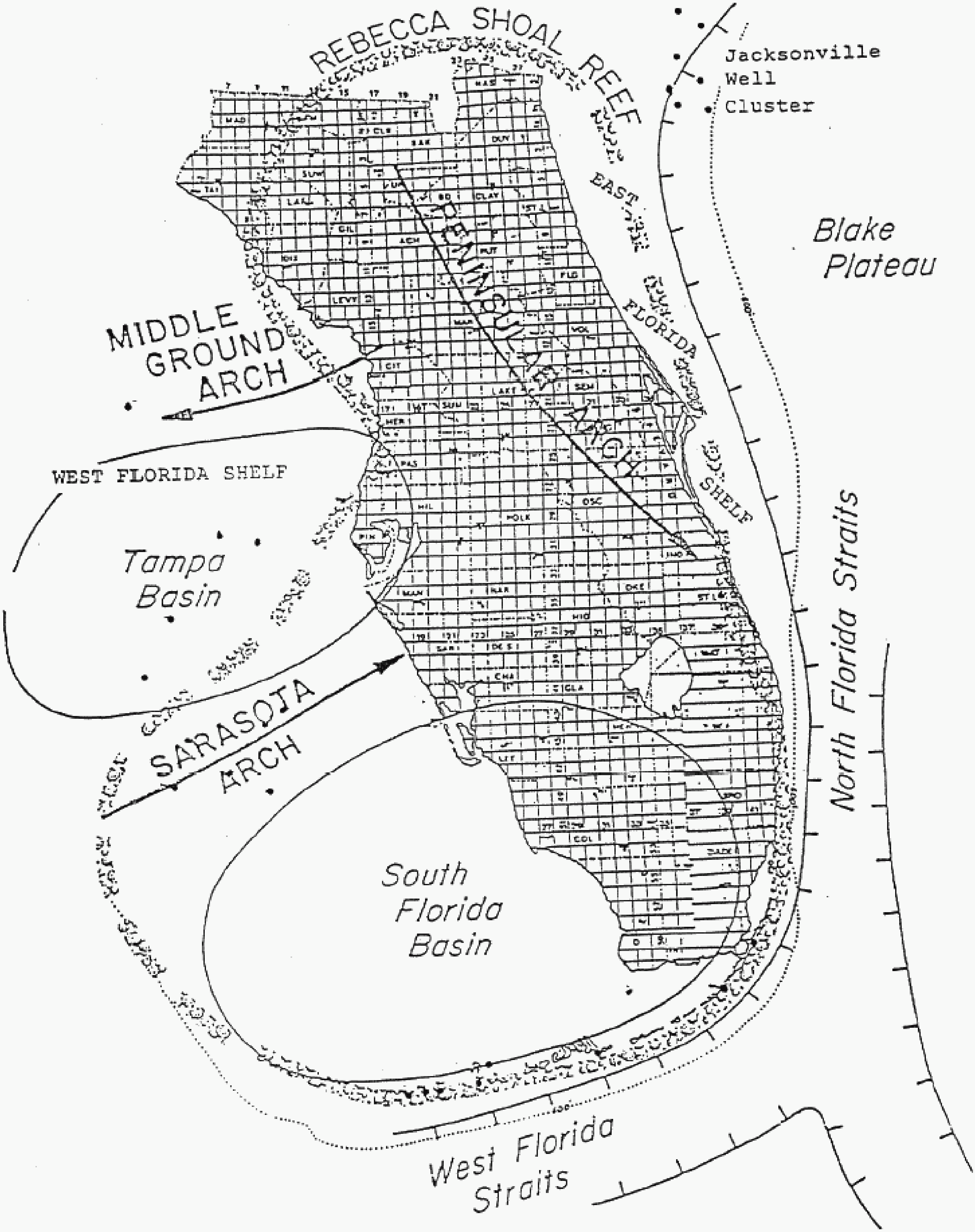
Cross-section J - K

Fig. 13



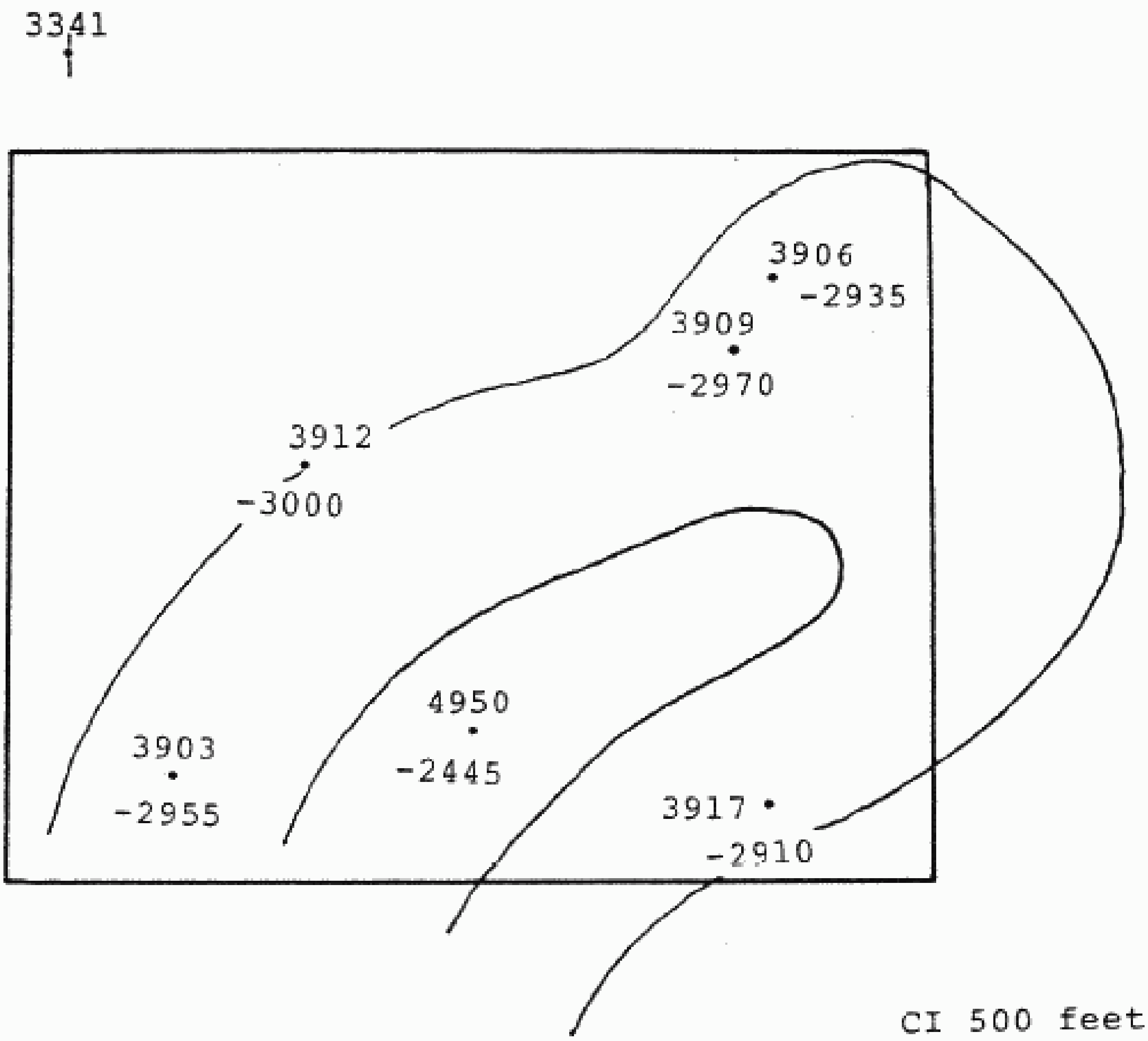
Cross-section L - M

Fig. 14



Regional Structure

Fig. 15

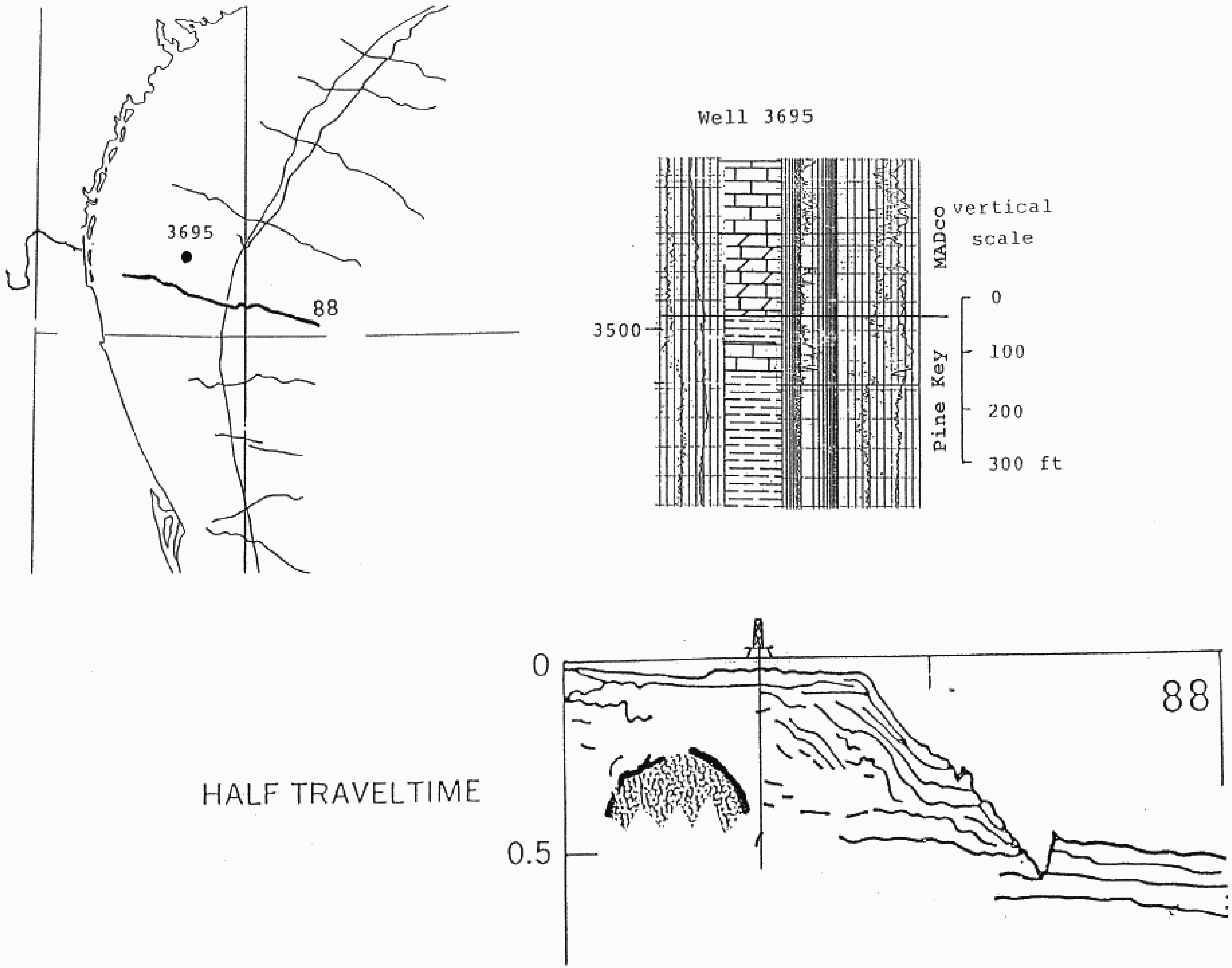


(see Fig. 5 for area location)

Structure - Top of Rebecca Shoal

Western Sarasota Arch

Fig. 16



Uchupi Seismic Profile

Fig. 17

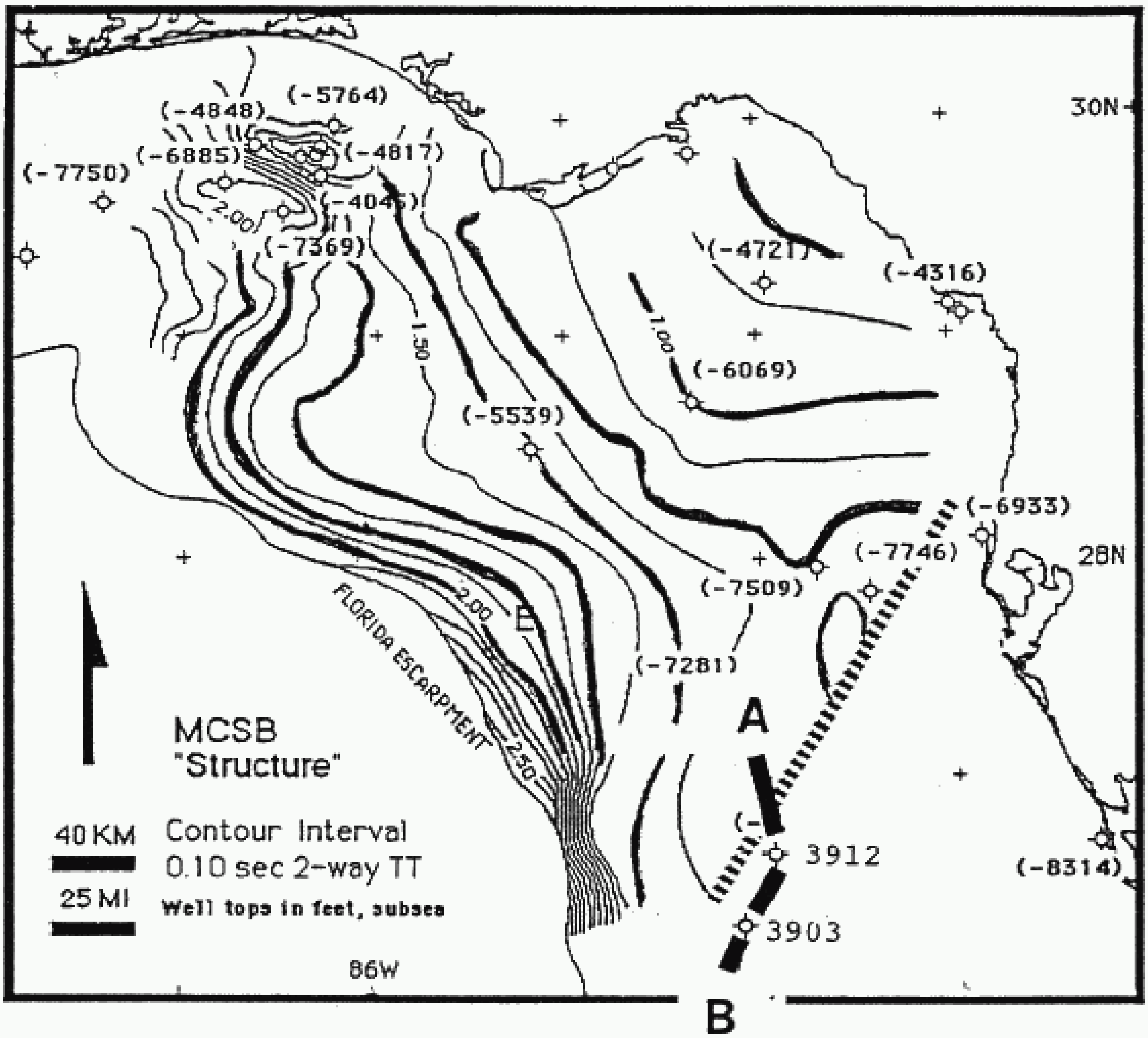


Figure 28. "Structure" map of the configuration of the mid-Cretaceous sequence boundary (MCSB) surface contoured in 2-way traveltime. The heavy dashed line delineates the location of the change in the character of the seismic data.

Line A-B shows location of seismic profile on Fig. 19

from Jee 1993

Limit of Deep Reflections
and
Seismic Profile Trace

Fig. 18

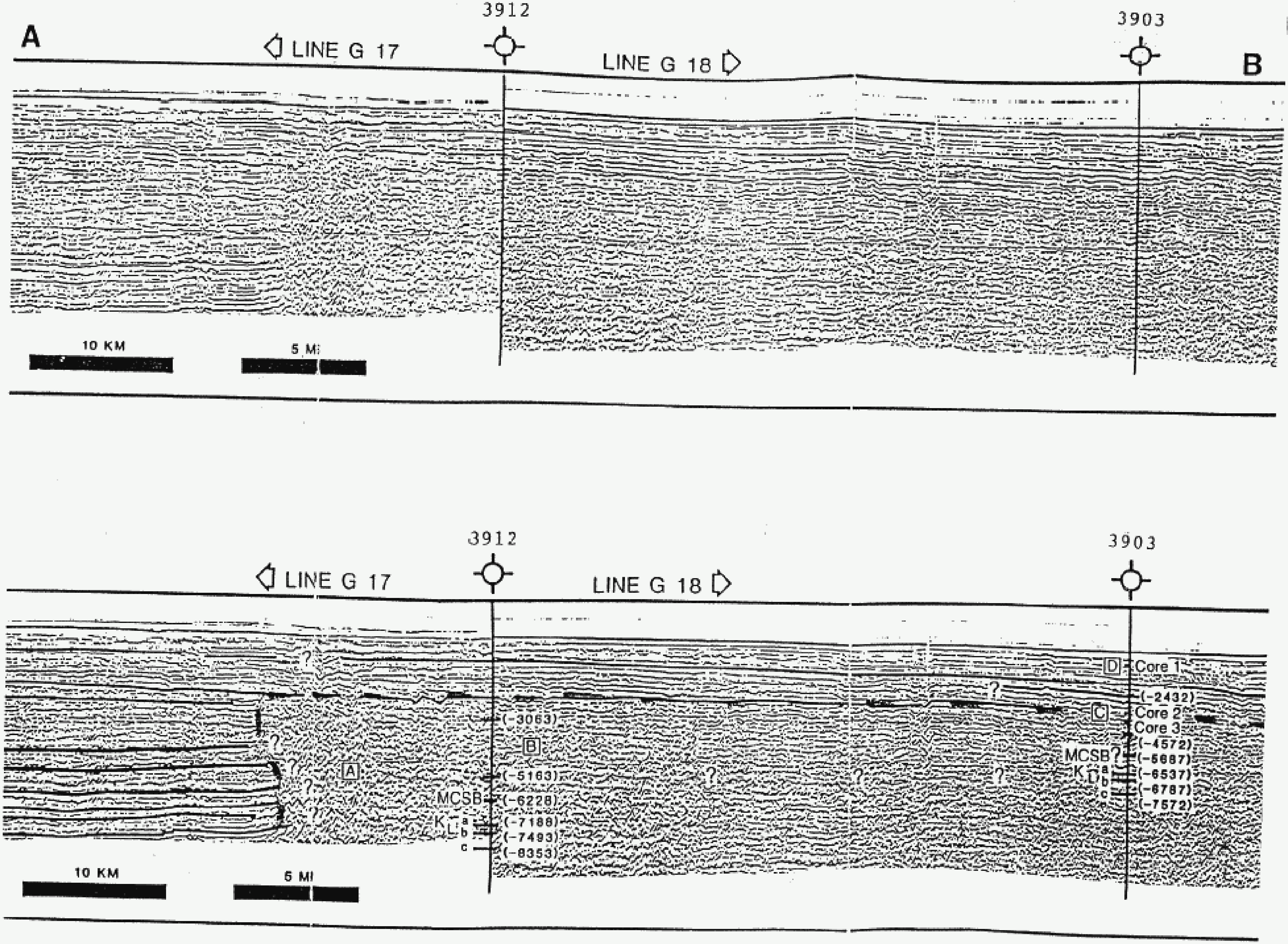


Fig. 19 Seismic Profile of Rebecca Shoal Reef

from Jee 1993

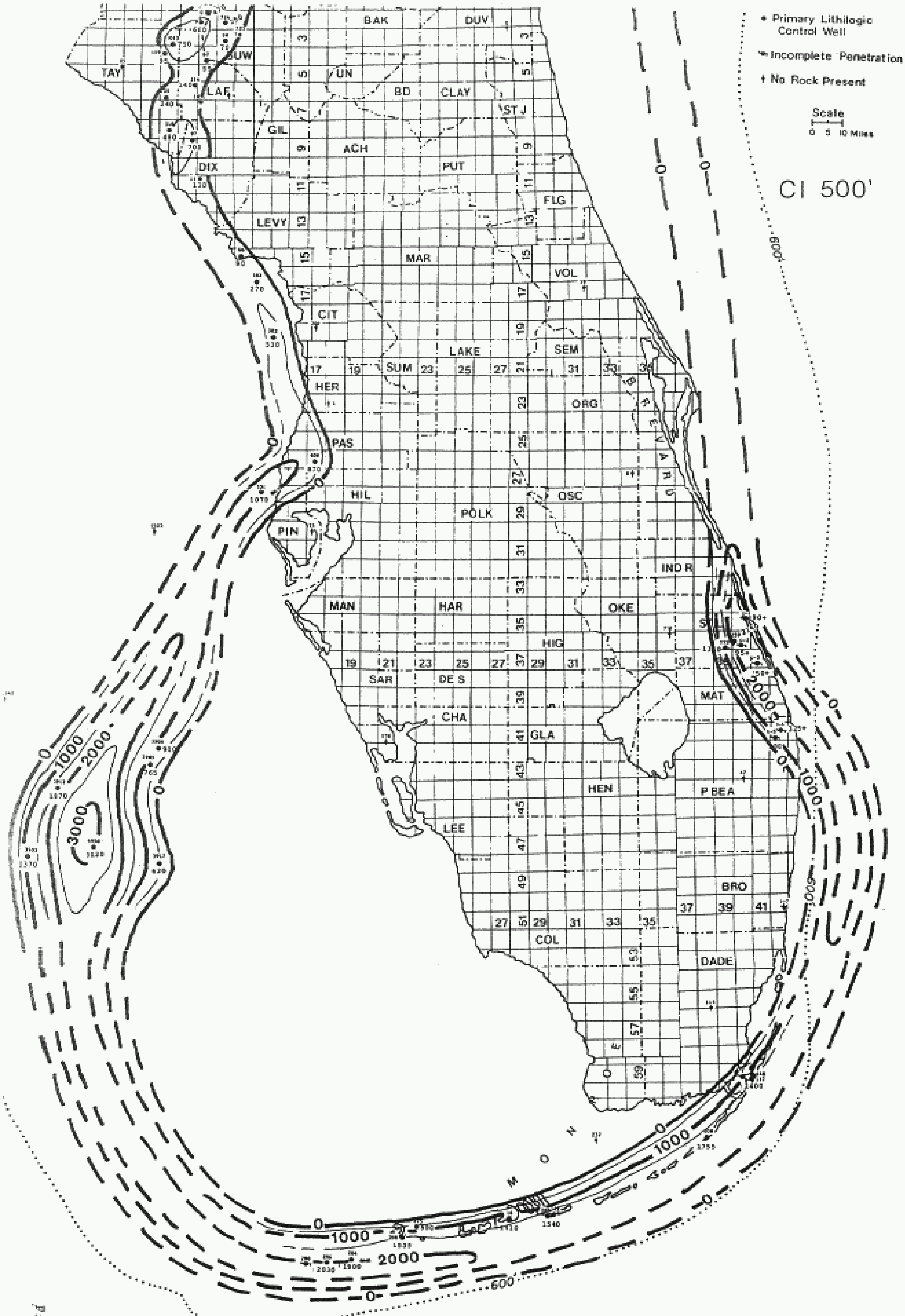
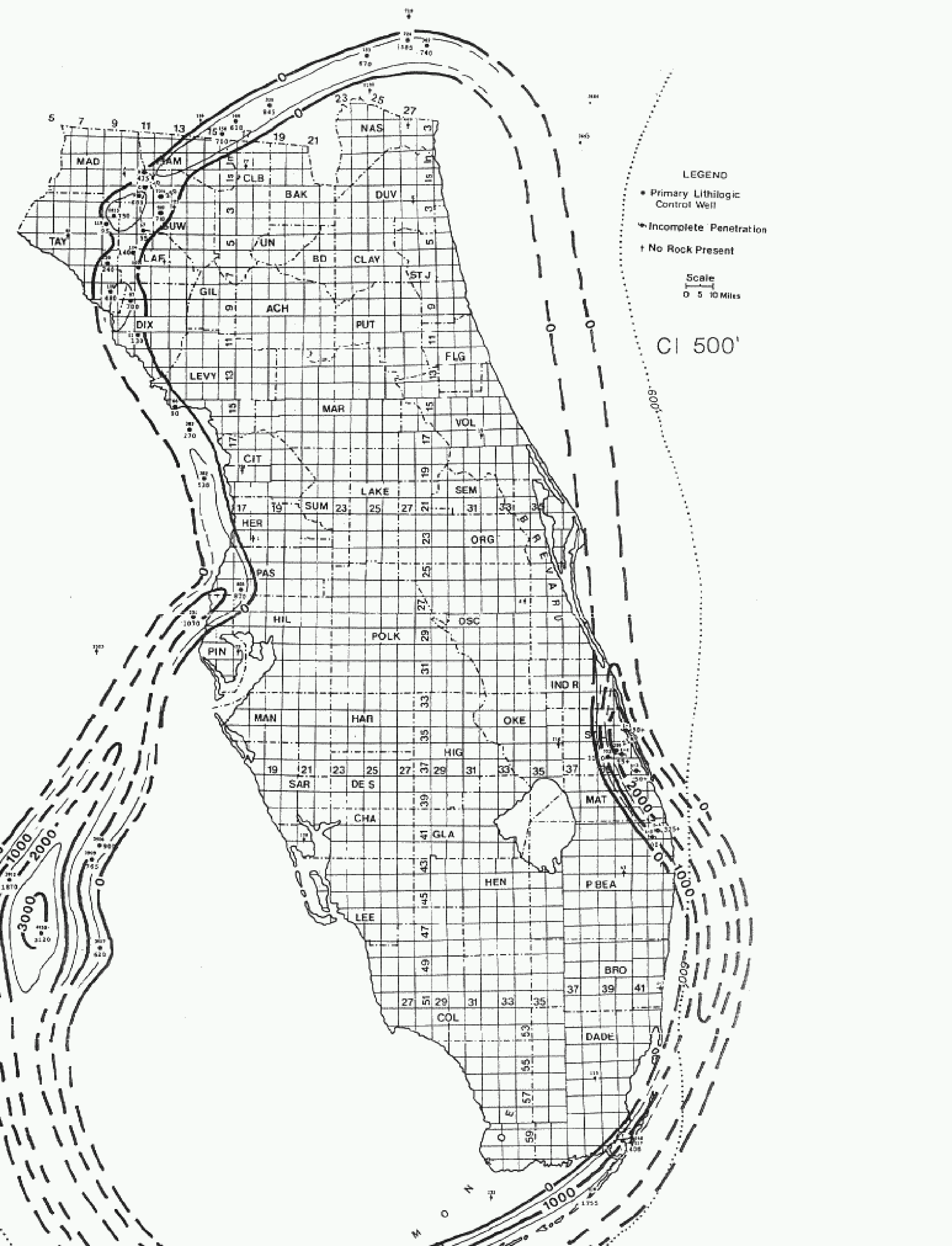


Fig. 20

Isolith Rebecca Shoal Dolomite


LEGEND
• Primary Lithologic Control Well
Incomplete Penetration
† No Rock Present
Scale
0 5 10 Miles
CI 500'
MAD
HAM
CLB
BAK
NAS
DUV
TAY
SUW
UN
LAF
BD
CLAY
ST J
GIL
ACH
PUT
DIX
LEVY
FLG
MAR
VOL
CIT
LAKE
SEM
SUM
HER
ORG
BREVARD
PAS
HIL
OSC
POLK
PIN
IND R
MAN
HAR
OKE
HIG
ST L
SAR
DE S
MAT
CHA
GLA
HEN
P BEA
LEE
BRO
COL
DADE
MONROE