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LOWER CRETACEOUS CARBONATE TIDAL FACIES OF CENTRAL TEXAS

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BUREAU OF ECONOMIC GEOLOGY
THE UNIVERSITY OF TEXAS AT AUSTIN
W. L. Fisher, *Director*

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Field Trip Guidebook

Lower Cretaceous Carbonate Tidal Facies

by

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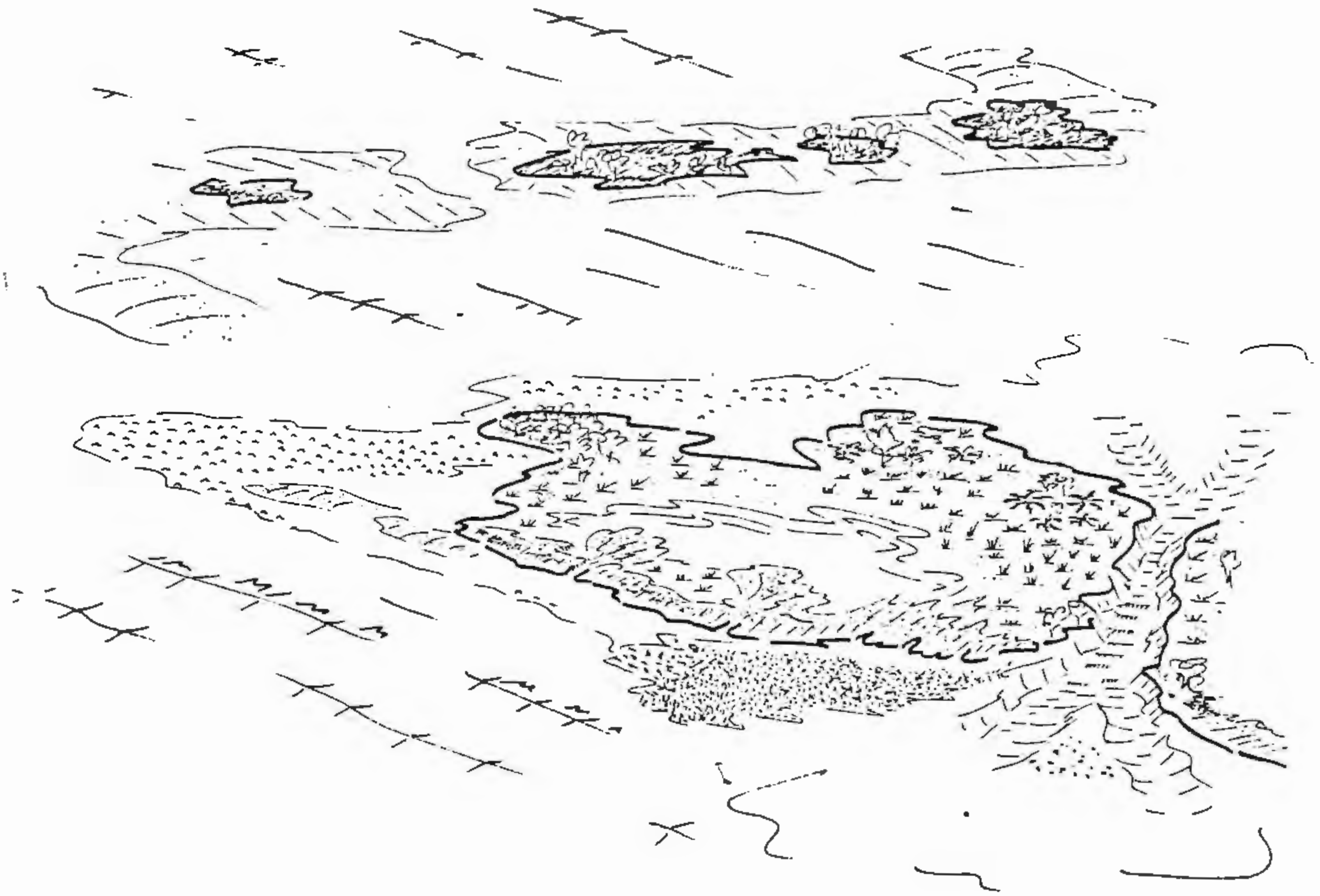

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INTRODUCTION

In Texas the Lower Cretaceous was deposited on an extensive broad, flat platform which extended from the Stuart City shelf margin on the downdip or seaward side, to the area of Abilene in North Texas, on the updip or landward side (fig. 1). Shallow-water shelf carbonate deposition, which took place over an area of more than 160 thousand square miles, was influenced by three major structural elements--the more rapidly subsiding McKnight and North Texas/Tyler Basins and the more positive Llano uplift. Depositional patterns on this platform were controlled by these structural elements as they affected deposition by a transgressing sea. The carbonates observed on this field trip in the Austin area were most affected by the positive Llano uplift and the subsiding North Texas/Tyler basin.

Lower Cretaceous rocks of Aptian and Albian age (fig. 2) are well exposed in the Central Texas area, in which the city of Austin lies. The section representing the Aptian and lower part of the Albian is characterized by a considerable amount of sandstone and shale interbedded with the more abundant limestone. Exposed here are the Sycamore Sandstone (equivalent to the subsurface Hosston Sandstone and Sligo Limestone), the Pearsall Formation (Hammett Shale and Cow Creek Limestone), and Glen Rose Limestone (characterized by significant quantities of shale). The terrigenous clastics were derived from the subareally exposed Llano uplift. In contrast, rocks of the upper part of the Albian consist almost entirely of limestone and contain only minor amounts of shale. During this time the Llano uplift was entirely covered and was not contributing terrigenous sediment to the Fredericksburg/Edwards carbonates.

This field trip in the Austin area (fig. 3) is designed to illustrate and contrast the carbonate rock types which resulted from deposition on extremely low-energy supratidal flats and marshes and intertidal flats, where marine conditions were very restricted, with those of high-energy open-marine conditions, where grainstone bars and rudist banks were abundant. The low-energy restricted-marine carbonates are well illustrated at the first two stops in the Glen Rose Limestone. High-energy open-marine limestones of Fredericksburg age will be studied at the third stop in the Whitestone quarries northwest of Austin.

The depositional processes and carbonate sediment types now accumulating in Florida Bay, the Florida back-reef track, and Cat Cays in the Bahamas are believed to represent closely those which took place in the Central Texas area during the Lower Cretaceous.

ACKNOWLEDGMENTS

We should like to express our appreciation to W. L. Tredemeyer, Texas Quarries, and to M. E. Ruby, Jr., Ruby Crushed Limestone, for permitting access to the stops in the Whitestone Lentil. These quarry operators do require, however, that anyone wishing to conduct further studies in these quarries must obtain their permission.

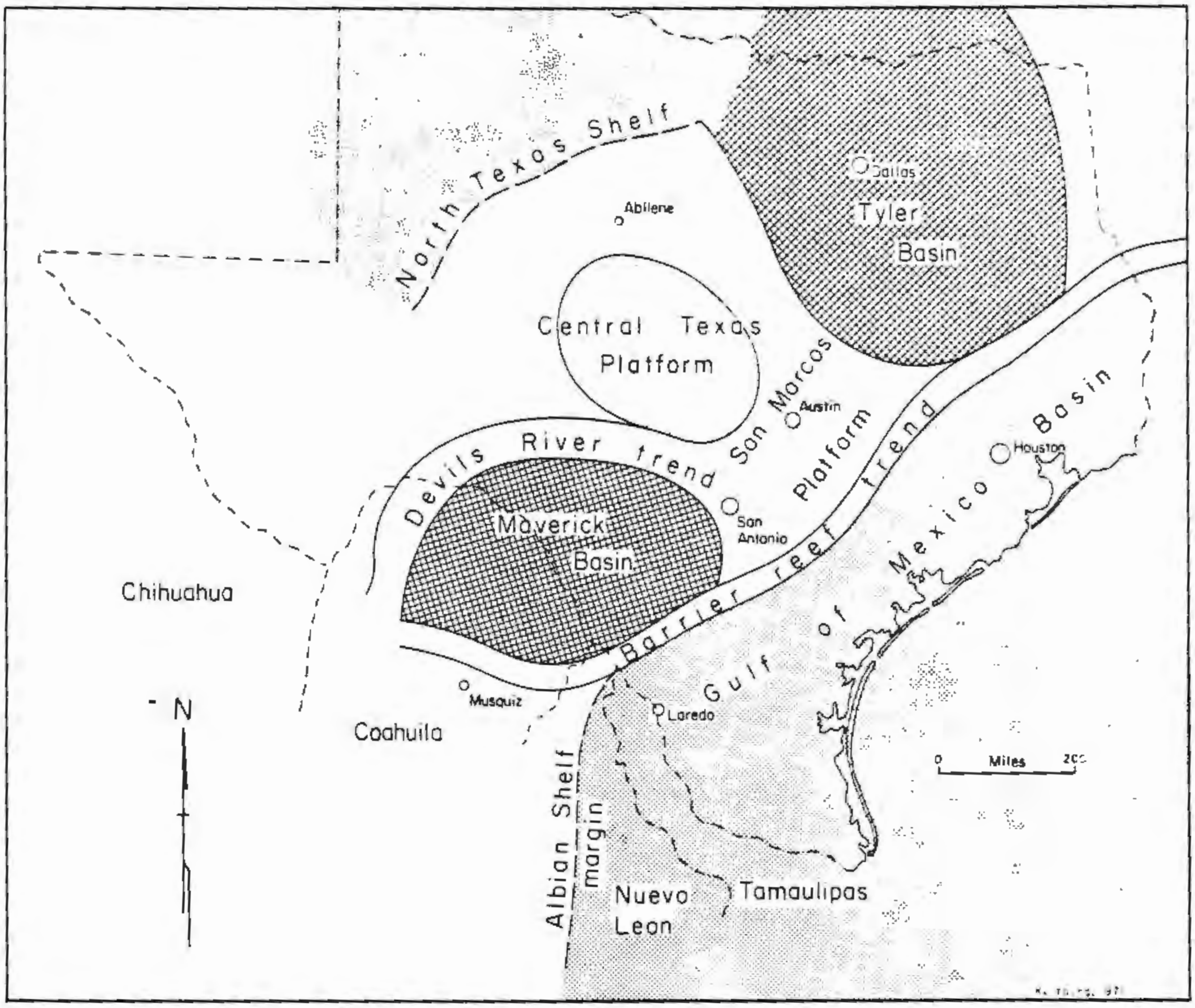


Figure 1. Paleogeography of the Lower Cretaceous of Texas. From Young, 1972.

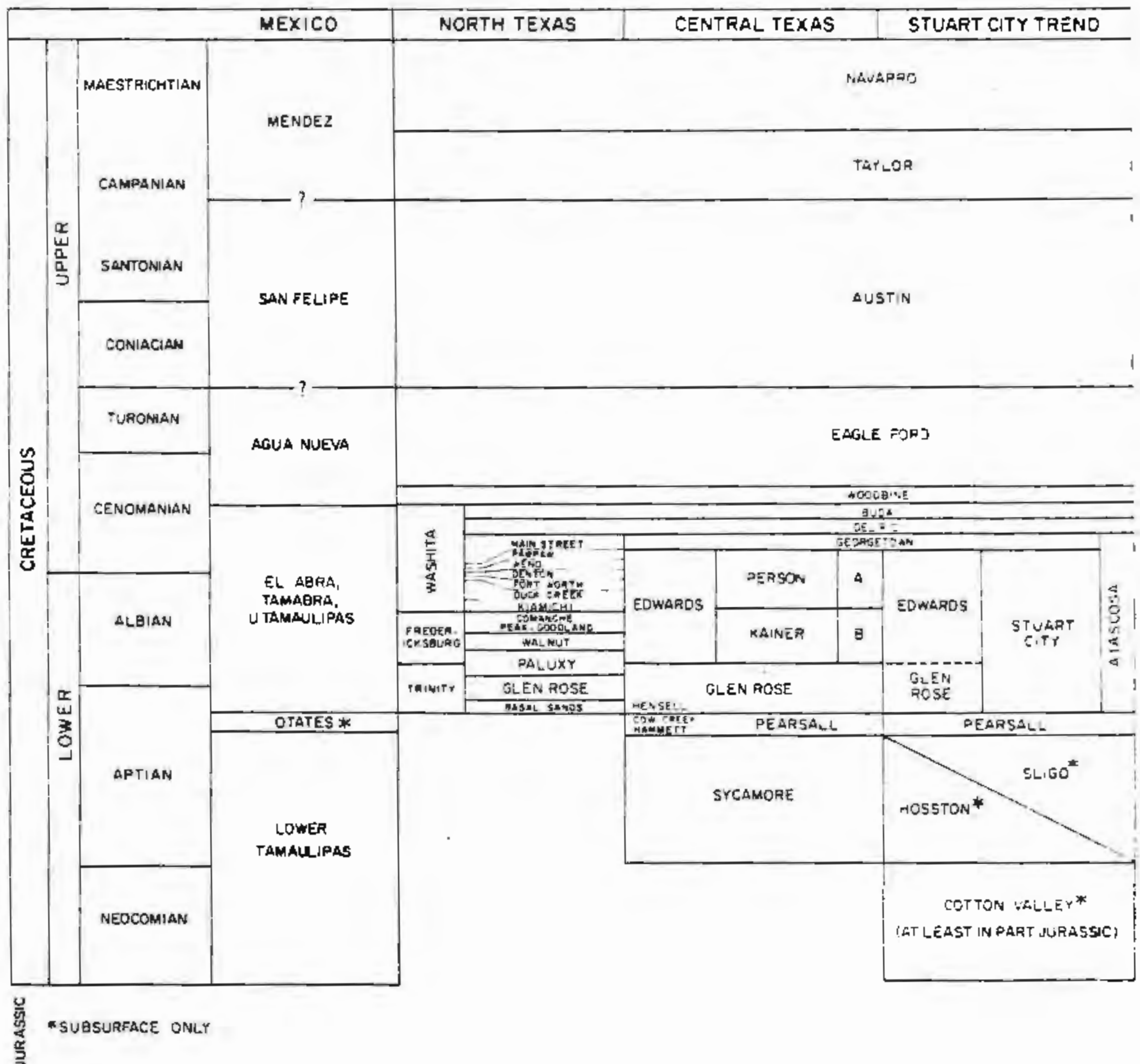


Figure 2. Correlation of Lower Cretaceous formations, western Gulf of Mexico. From Bebout and Loucks, 1974.

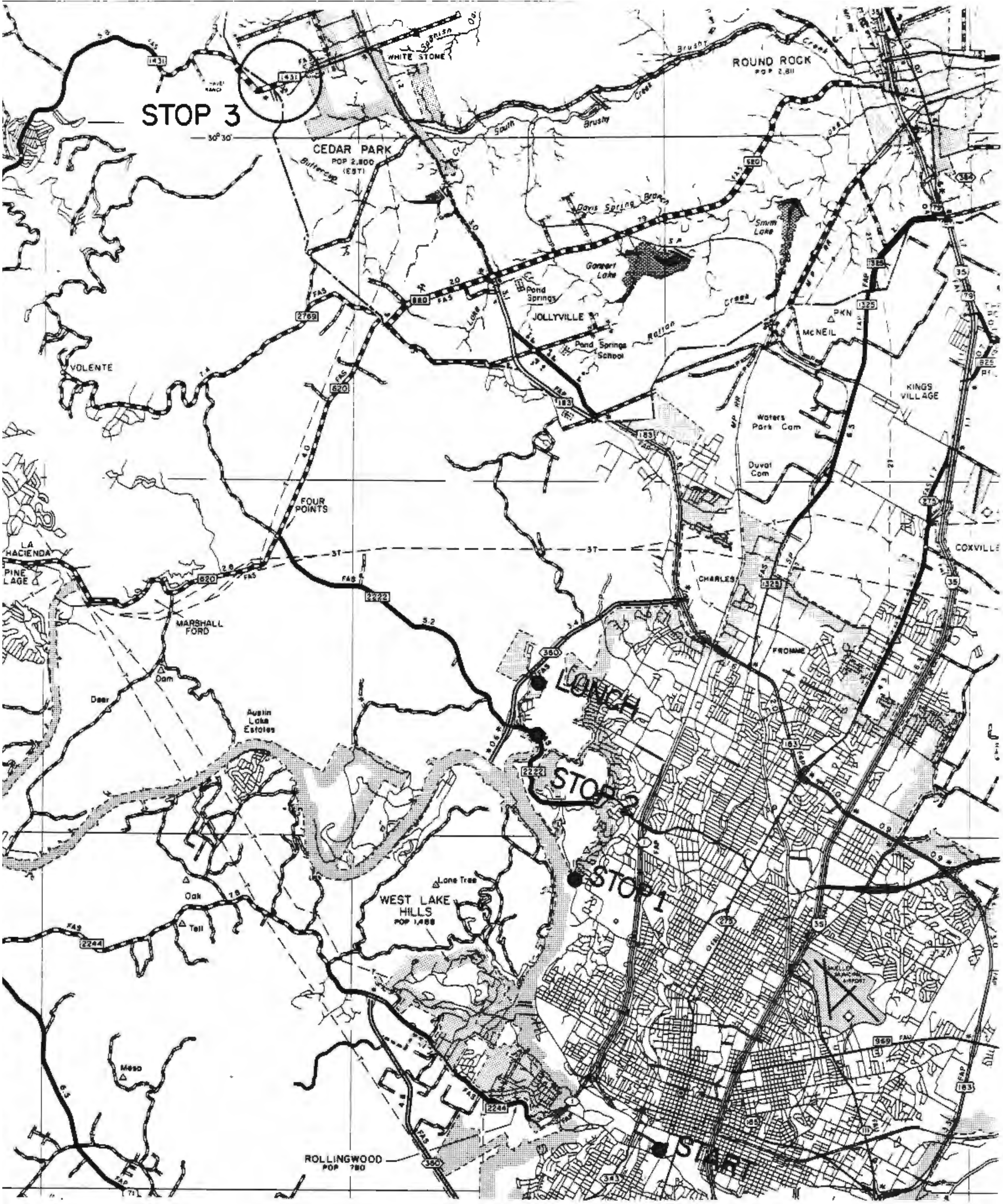


Figure 3. Field-trip stops.

STOPS 1 AND 2

GLEN ROSE LOW-ENERGY RESTRICTED FACIES

Lagoonal facies of the Glen Rose Formation will be examined at Stop 1, Mount Bonnell, and Stop 2, Cat Mountain (fig. 1). Both exposures illustrate the cyclic facies pattern and low-energy characteristics of the Glen Rose in the Austin area.

The basic Glen Rose depositional cycle is an offlapping or progradational facies sequence. The lowest unit of most cycles is a relatively thick (3-5 foot) marly wackestone containing a diverse fossil assemblage. These marls are laterally persistant and were deposited subtidally in a broad lagoonal setting. Thin (1-3 foot) beds with numerous mudshrimp burrows (Ophiomorpha) may overlie the subtidal unit and are overlain by crossbedded packstone/grainstones or plant-bearing dolomitic mudstone/wackstones. These intertidal and supratidal beds are laterally variable and represent several distinct depositional environments. The upper beds of the cycle may be dolomitic and are more resistant to weathering than the marls, giving the Glen Rose its characteristic stairstep topographic expression in the hill country west of Austin.

Detailed examination of Glen Rose exposures reveals many departures from the basic cycle both in relative facies thickness and vertical sequence. As will be emphasized at both stops such variations are within the limits expected in a shallow lagoonal setting.

The Holocene South Florida carbonates accumulating in Florida Bay and in back-reef environments of the associated reef tract (fig. 2) represent a modern facies analog for the Glen Rose Formation. Numerous papers have described selected localities in South Florida and field trip guidebooks by Ginsburg (1964), Multer (1969, 1975), and others have familiarized many sedimentologists with Florida carbonate environments. Graduate students from The University of Texas have also worked in this area in conjunction with several summer field courses. The generalized facies cross sections presented in Figures 3-6 are based on profiles, probes, and cores taken during these courses and incorporates information from the publications cited.

Low-Energy Mud Banks and Islands

Peterson Bank (fig. 3) is a low-energy mud bank in Florida Bay located in a relatively protected setting. Circulation is sufficent for development of clumps of the mat-forming coral Porites divaricata. Cross Bank (Multer, 1969), another mud bank located in a more restricted area, has insufficient circulation for these corals. The mud bank or shoal facies capped by lenses of winnowed grains and burrowed extensively by mudshrimp is a common Glen Rose facies. Intervals illustrating this sequence are present at Stop 1, Mt. Bonnell (figs. 7, 8; 6-12 feet and 16-22 feet), and at Stop 2, Cat Mountain (figs. 9, 10; 22-34 feet).

Islands fringed by mangroves and having central ponds and marshes develop along the crests of many of the mud banks in central Florida Bay. Multer (1975) illustrates the distribution of surface facies on Crane Key as described by Pray (1966). Spy Key (fig. 4), a similar island cored by University of Texas graduate students, has a low-energy beach and shell berm developed along its windward margins and a central pond fringed by marshes. This facies tract bears remarkable similarity to the vertical sequence of beds observed in the Glen Rose at Mount Bonnell (figs. 7, 8; 25-32 feet) and at Cat Mountain (figs. 9, 10; 2-7 feet). The more protected or leeward margins of many of the islands in Florida Bay and along the Texas coast are bordered by marshes and intertidal mudflats. Sandy or shelly beaches are not developed in such areas. Facies sequences representing similar protected island settings are common in the Glen Rose and can be observed at Mt. Bonnell (figs. 7, 8; 45-50 feet) and Cat Mountain (figs. 9, 10; 46-51 feet).

Moderate-Energy Banks

Terms such as "low-energy" and "high-energy" are always relative. With the possible exception of local storm deposits the Glen Rose beds were influenced by very low physical energies. The presence of some coated grains and monopleurid rudist biostromes suggest that more exposed areas may have been present in the Glen Rose lagoon. These facies are described as "moderate-energy banks" realizing that conditions were quite different from the processes that were associated with the Whitestone beds (Stop 3).

Whale Harbor (fig. 5) is a large tidal-delta complex located between Windley Key and Upper Matecumbe Key in south Florida. The ebb delta forms a shoal that is affected by moderate wave-energy conditions. This facies tract is similar to and intermediate in wave energy to the facies relationships described from Rodriguez Bank by Turmel and Swanson (1976), which has higher energy and more open conditions, and Matecumbe Keys tidal bank (Ebanks and Bubb, 1975), which has a more restricted setting.

Strong tidal currents and an open setting influence Bethel Bank (fig. 6) and result in coarse sediments shielded by wave-resistant beds of *Porites divaricata* The four Florida locations cited above are similar in that they are prograding in the direction of wave approach by the accretion of organic mats of corals and red algae (*Goniolithon*). Branching corals and red algal beds are not associated with the Glen Rose Formation in the vicinity of Austin. The monopleurid rudist beds observed at Cat Mountain (figs. 9, 10; 11-14 feet) may represent a similar environment to the Whale Harbor ebb tidal-delta shoals.

Glen Rose Facies Model

Regional setting, facies characteristics and sequences suggest that the Glen Rose Formation near Austin was deposited in a restricted low-energy lagoon. Facies variations, especially in intertidal and supratidal facies, indicate that many shoals and islands were present in this lagoon (fig. 11). Lateral facies changes may be explained by differences in exposure to wave-energy and/or storms.

Presence of abundant plant fossils and root-mottled marsh deposits suggest that the climate was more humid that that which prevailed during deposition of the overlying Edwards Formation.

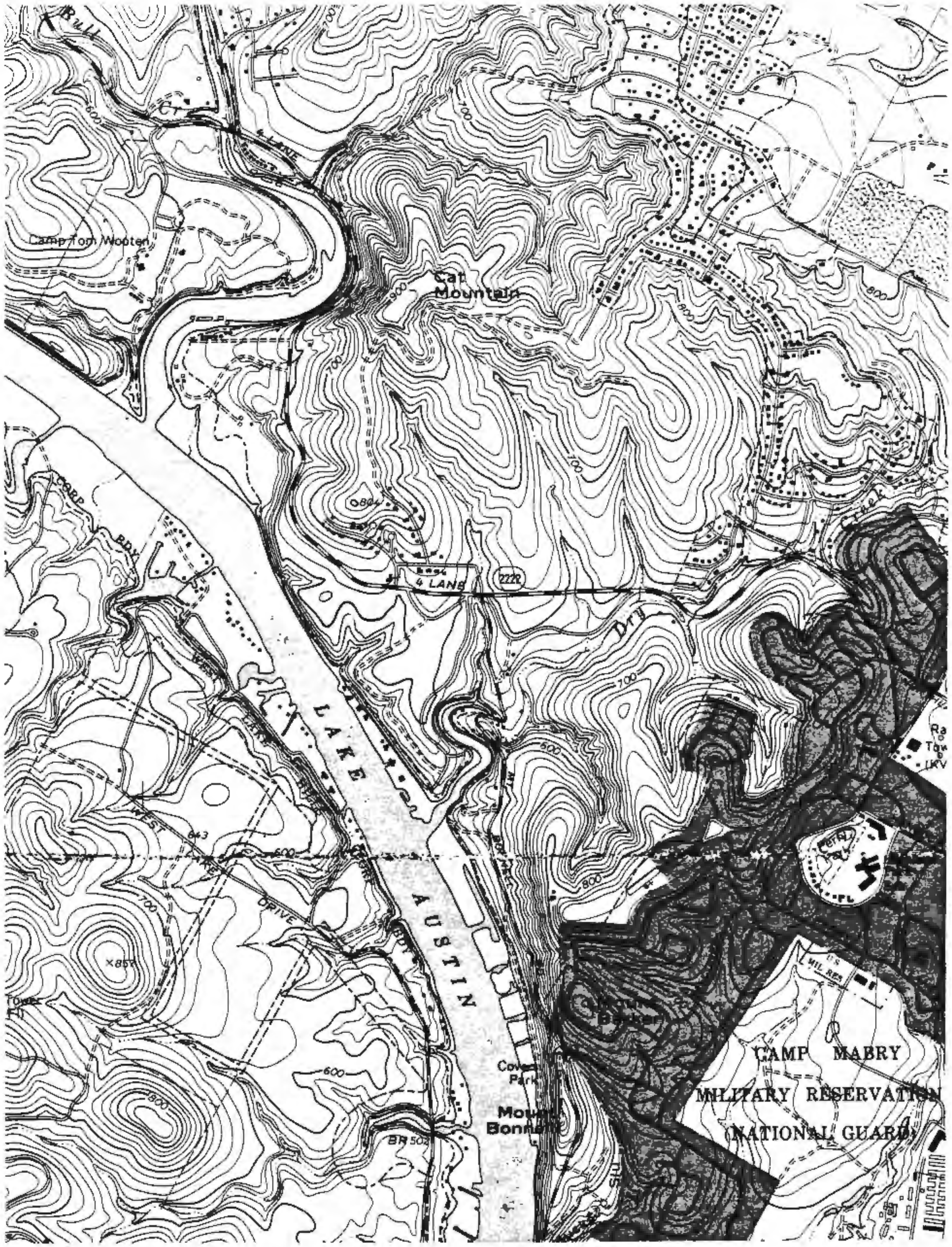
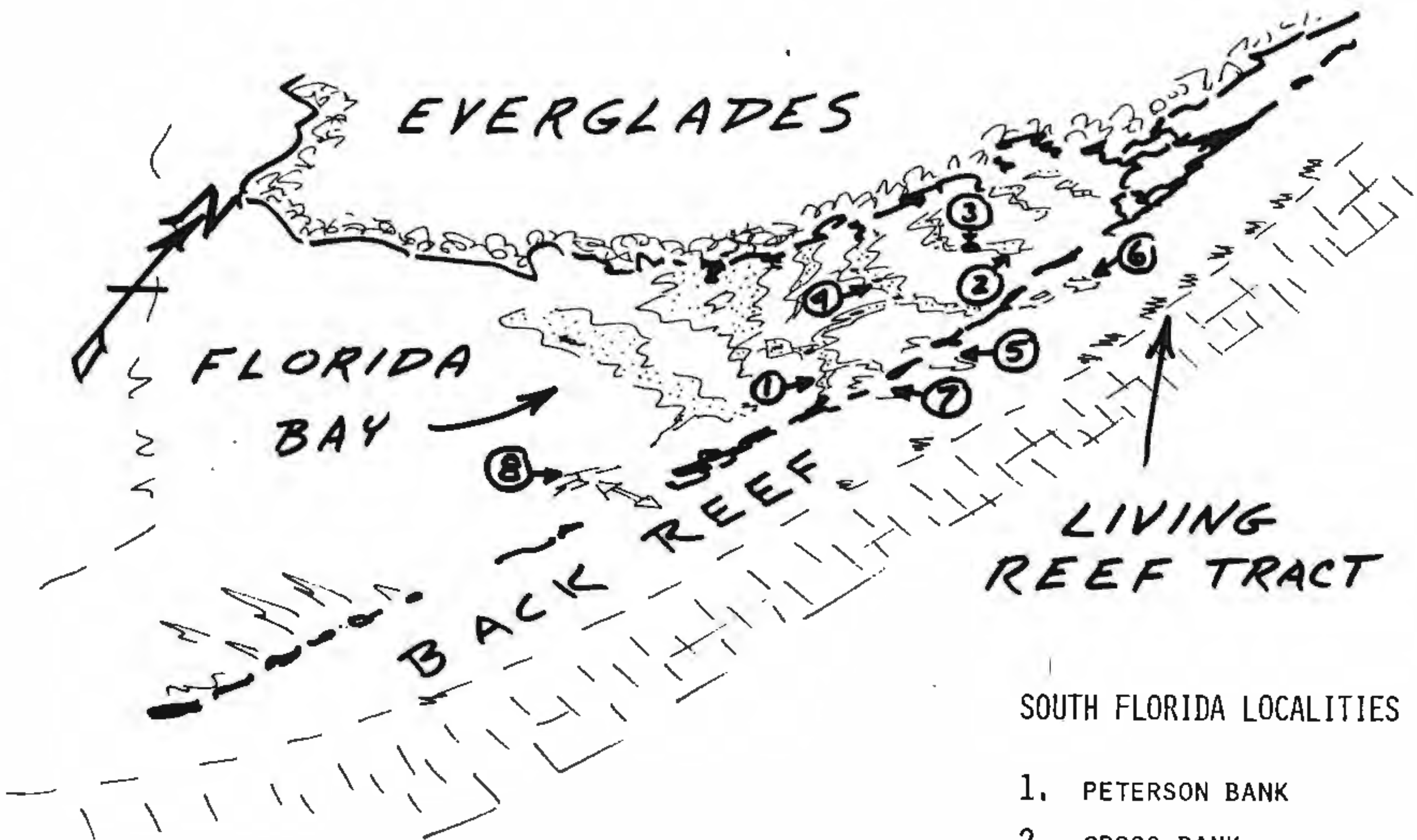


Figure 1. Location of measured sections at stops 1 and 2.



SOUTH FLORIDA LOCALITIES

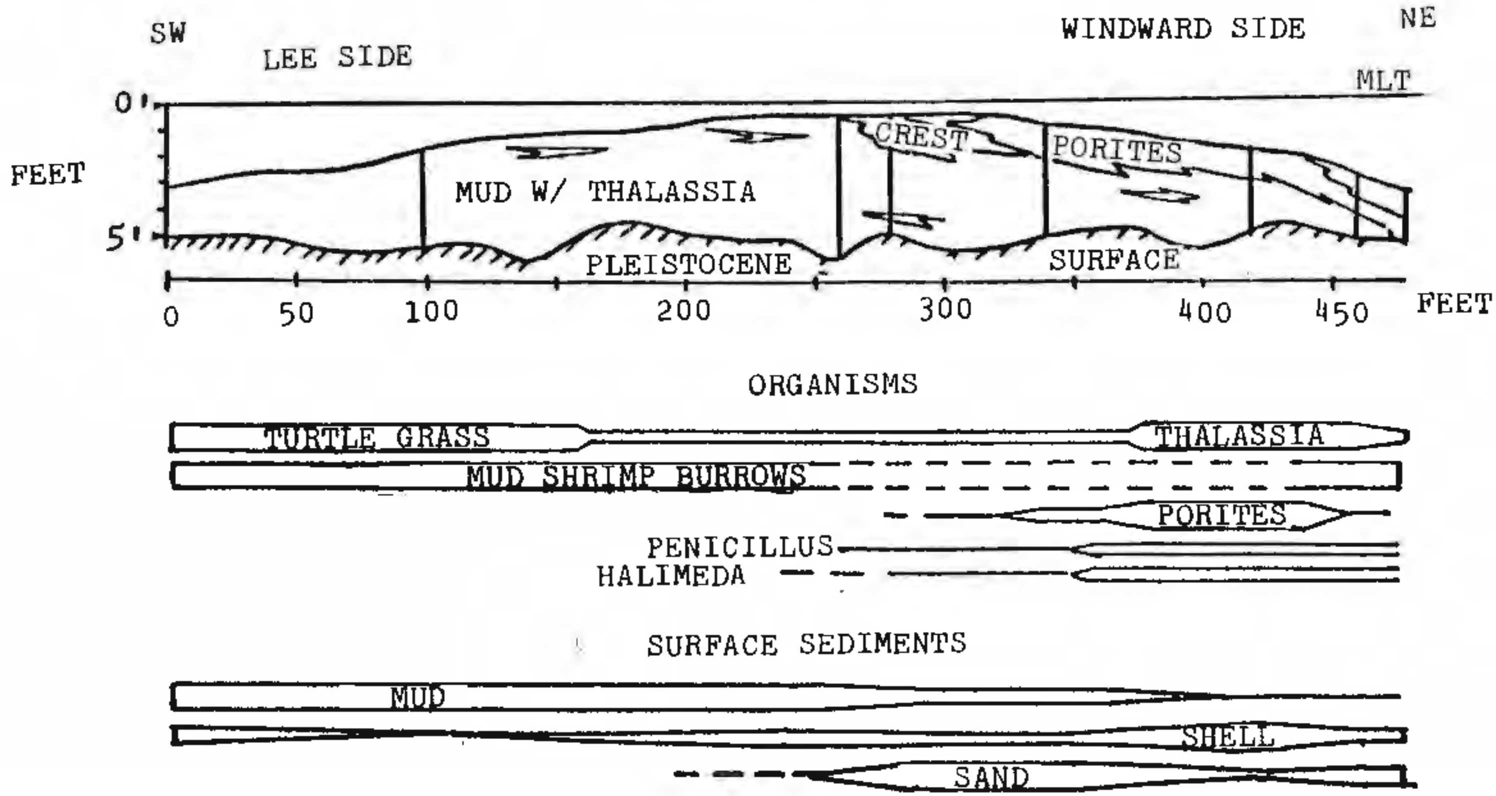
1. PETERSON BANK
2. CROSS BANK
3. CRANE KEY
4. SPY KEY
5. WHALE HARBOR
6. RODRIQUEZ BANK
7. MATECUMBE KEYS TIDAL BANK
8. BETHEL BANK

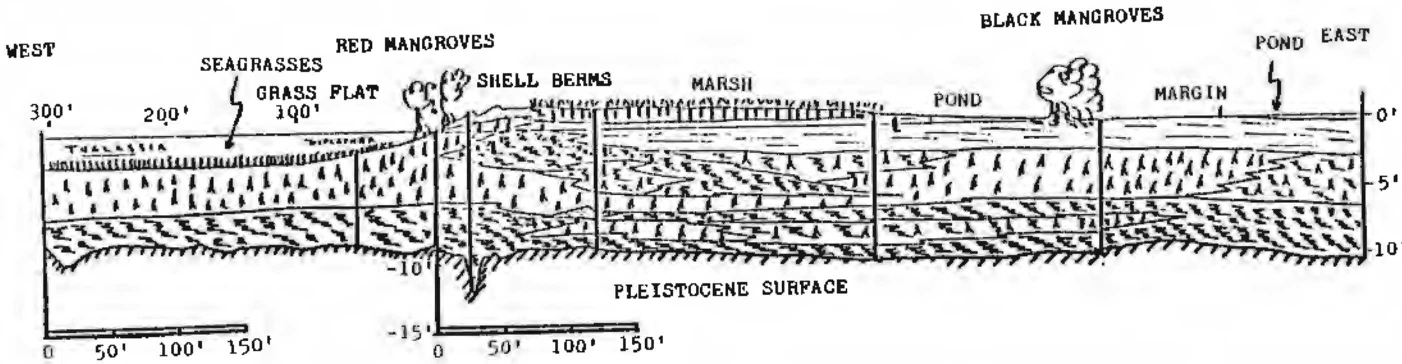
FIGURE 2

FIGURE 3

LOW ENERGY MUD SHOAL

PETERSON BANK
FACIES RELATIONSHIPS





FACIES

- SHELL BERMS
- GRASSFLAT MUDS
- MANGROVE PEATS
- PEATY MUDS
- MARSH (OXIDIZED MUDS)
- POND MUDS (LAMINATED ALGAL MATS)

FIGURE 4

FACIES RELATIONSHIPS SPY KEY, FLORIDA BAY

A LOW ENERGY MANGROVE ISLAND

FIGURE 5

WHALE HARBOR EBB TIDAL DELTA

A MODERATE ENERGY ORGANIC FRAMEWORK SHOAL

SCHEMATIC CROSS SECTION

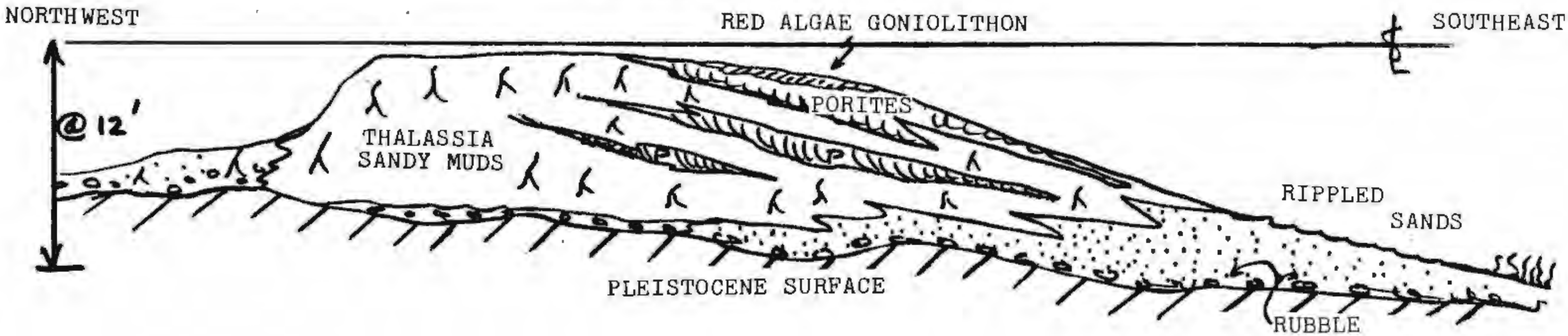
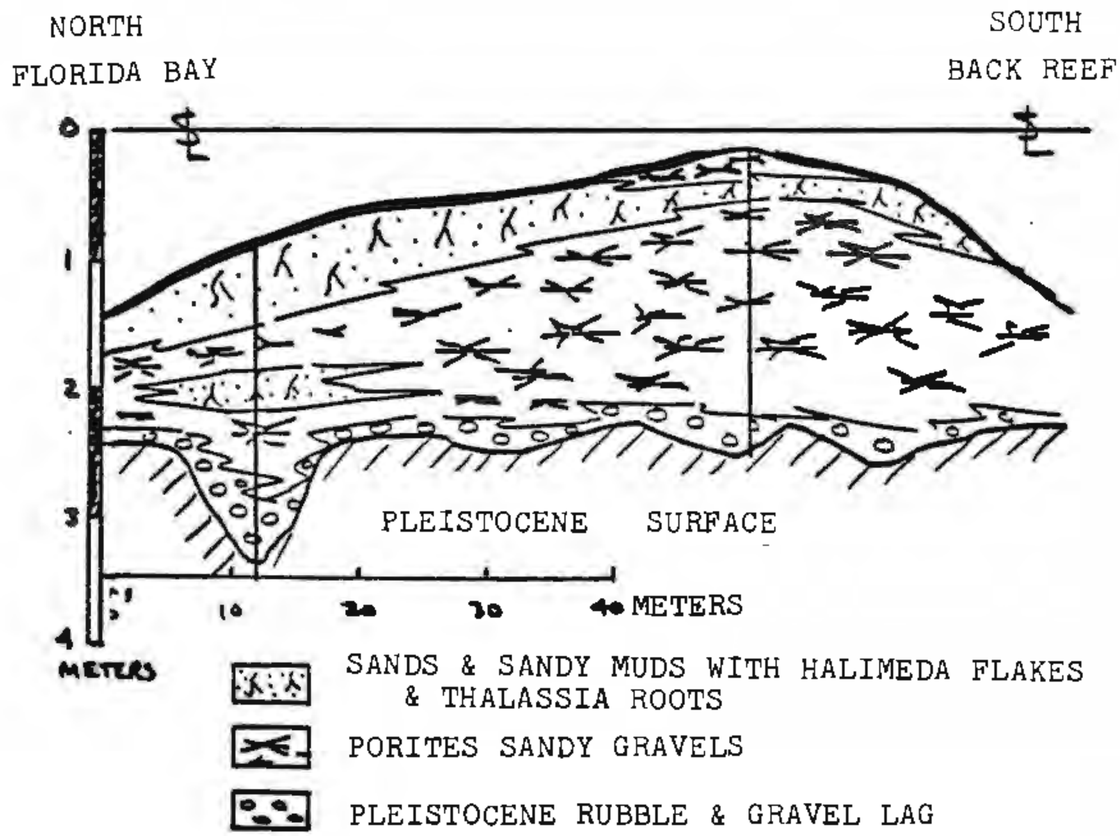


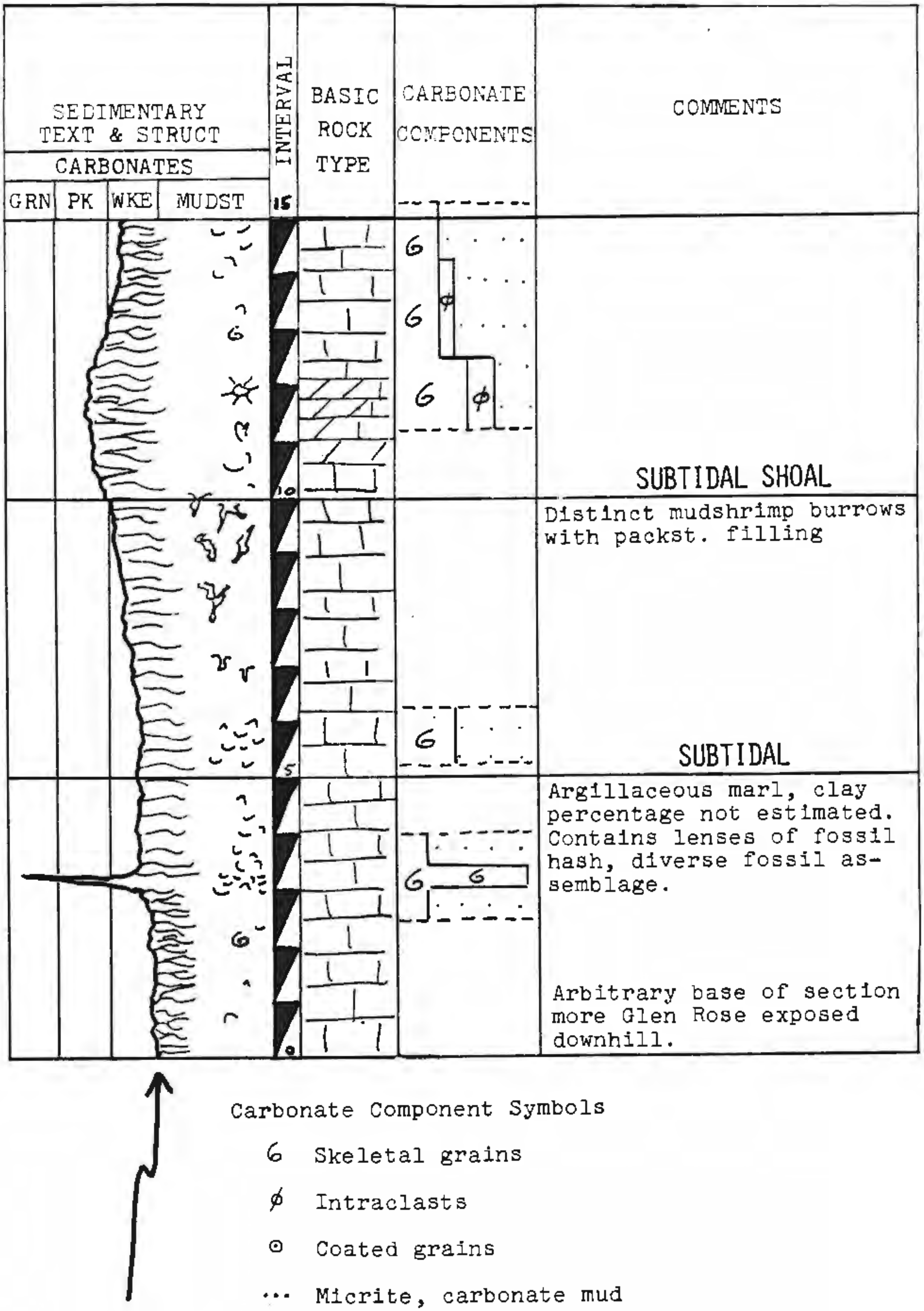
FIGURE 6
BETHEL BANK
A HIGH ENERGY FLOOD TIDAL BAR



STOP 1 MOUNT BONNELL

Glen Rose Formation

FIGURE 7a.



Carbonate Component Symbols

- 6 Skeletal grains
- ϕ Intraclasts
- ⊙ Coated grains
- ··· Micrite, carbonate mud

LINE REPRESENTS CARBONATE TYPE (DUNHAM CLASS.) NOT WEATHERING PROFILE.

FIGURE 7b.

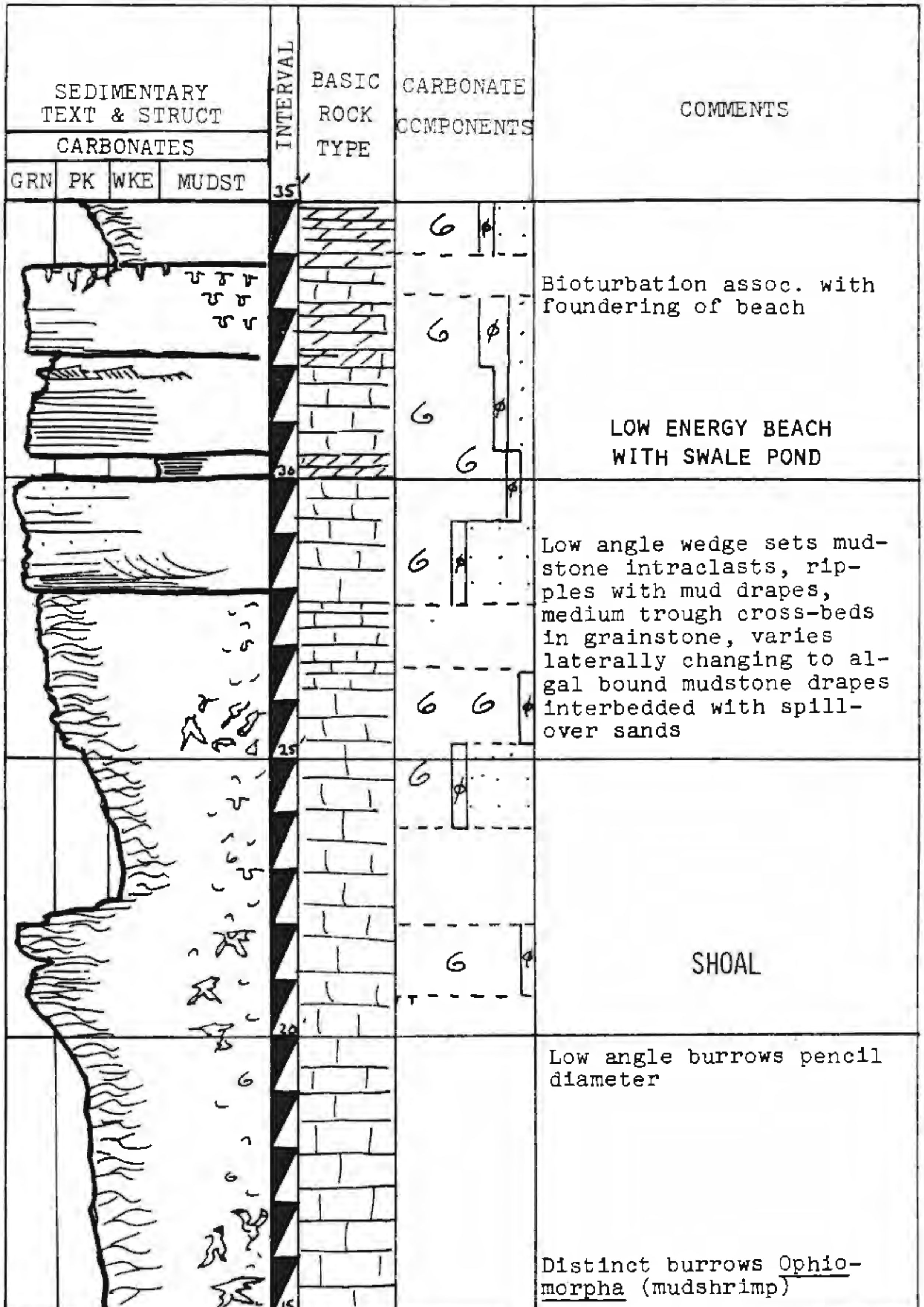

SEDIMENTARY TEXT & STRUCT
CARBONATES
GRN
PK
WKE
MUDST
INTERVAL
BASIC ROCK TYPE
CARBONATE COMPONENTS
COMMENTS
35
30
25
20
15
Bioturbation assoc. with foundering of beach
LOW ENERGY BEACH WITH SWALE POND
Low angle wedge sets mudstone intraclasts, ripples with mud drapes, medium trough cross-beds in grainstone, varies laterally changing to algal bound mudstone drapes interbedded with spillover sands
SHOAL
Low angle burrows pencil diameter
Distinct burrows Ophiomorpha (mudshrimp)

FIGURE 7c.

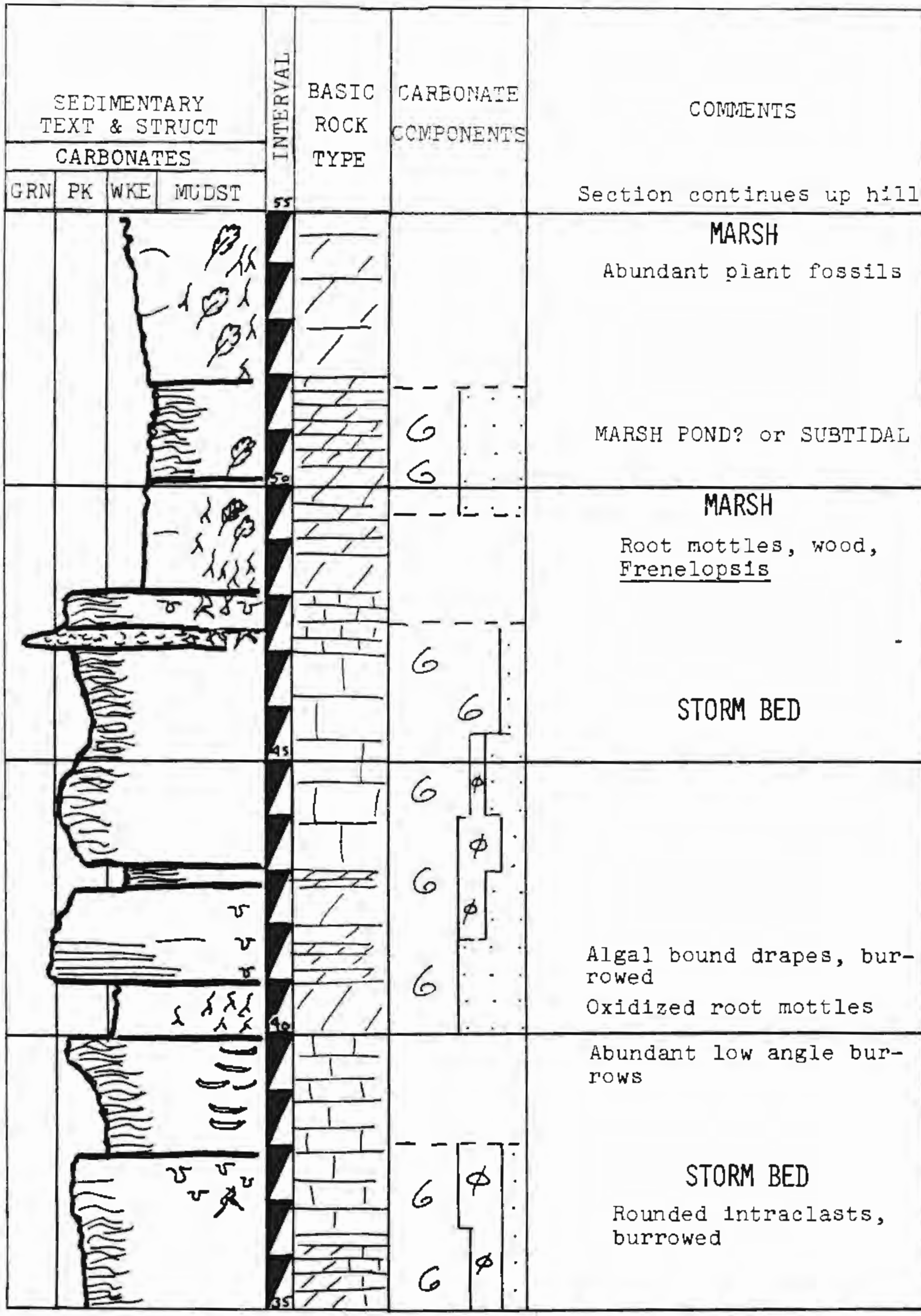

SEDIMENTARY TEXT & STRUCT
CARBONATES
GRN
PK
WKE
MUDST
INTERVAL
BASIC ROCK TYPE
CARBONATE COMPONENTS
COMMENTS
Section continues up hill
55
MARSH
Abundant plant fossils
MARSH POND? or SUBTIDAL
50
MARSH
Root mottles, wood, Frenelopsis
STORM BED
45
Algal bound drapes, bur-rowed
Oxidized root mottles
40
Abundant low angle bur-rows
STORM BED
Rounded intraclasts, burrowed
35

Figure 8. Representative facies from the low-energy tidal belt, Mt. Bonnell section (Stop 1).

A. Miliolid wackestone (storm beds) interbedded with very finely laminated mudstone (algal mats and/or muddrapes). At 29.5 feet.

B. Crossbedded miliolid grainstone with packstone laminae and micrite intraclasts. Environment: beach. At 31 feet.

C. Burrowed arenaceous foraminifer-miliolid wackestone. Environment: lagoon. At 34 feet.

D. Dolomitized, root-mottled, oxidized wackestone. Environment: marsh. At 40 feet.

E. Poorly sorted miliolid intraclast packstone/grainstone. Environment: storm bed. At 44 feet.

F. Burrowed miliolid wackestone/packstone. Environment: subtidal. At 47.5 feet.

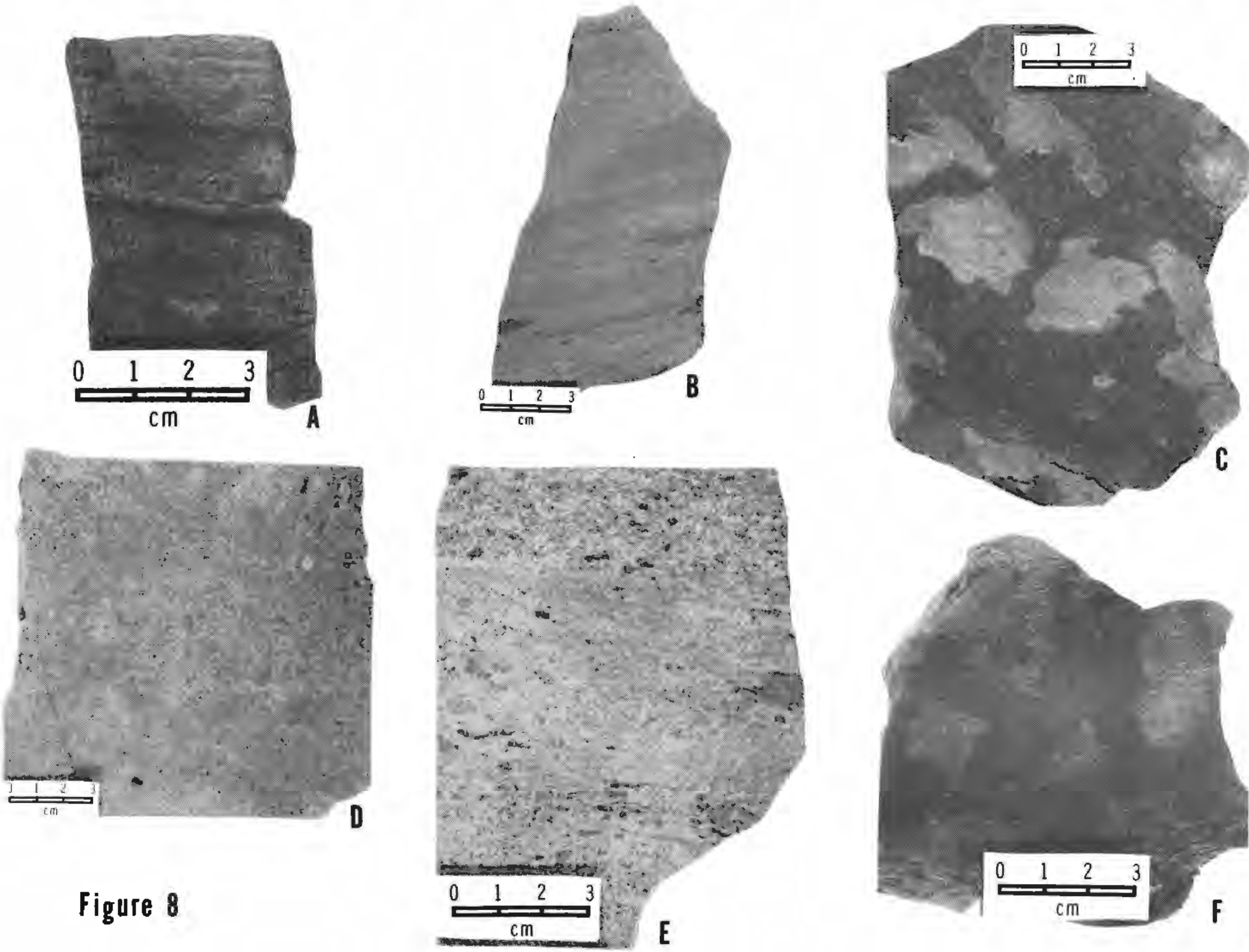


Figure 8

STOP 2 CAT MOUNTAIN

Glen Rose Formation

FIGURE 9a.

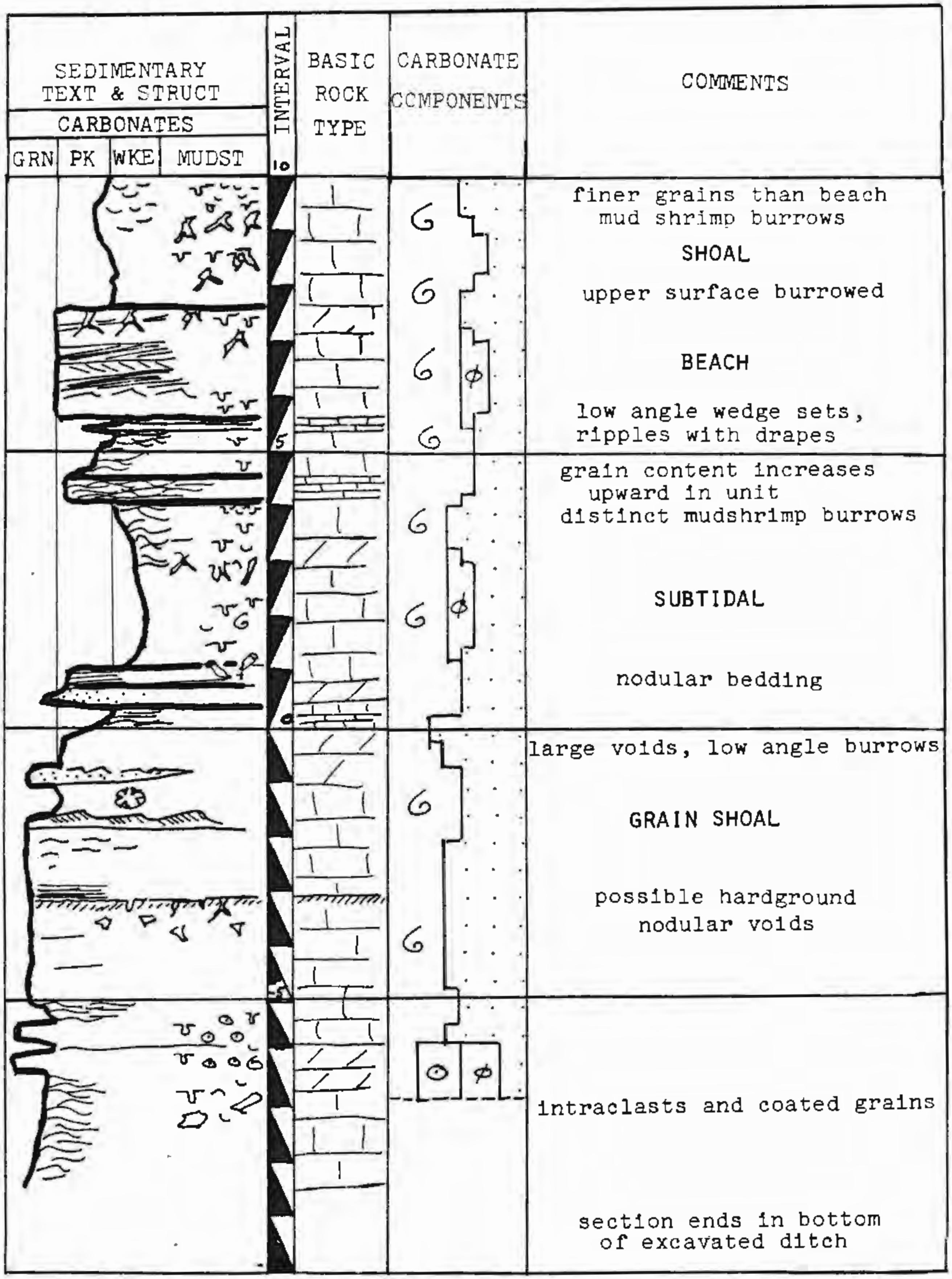


FIGURE 9b.

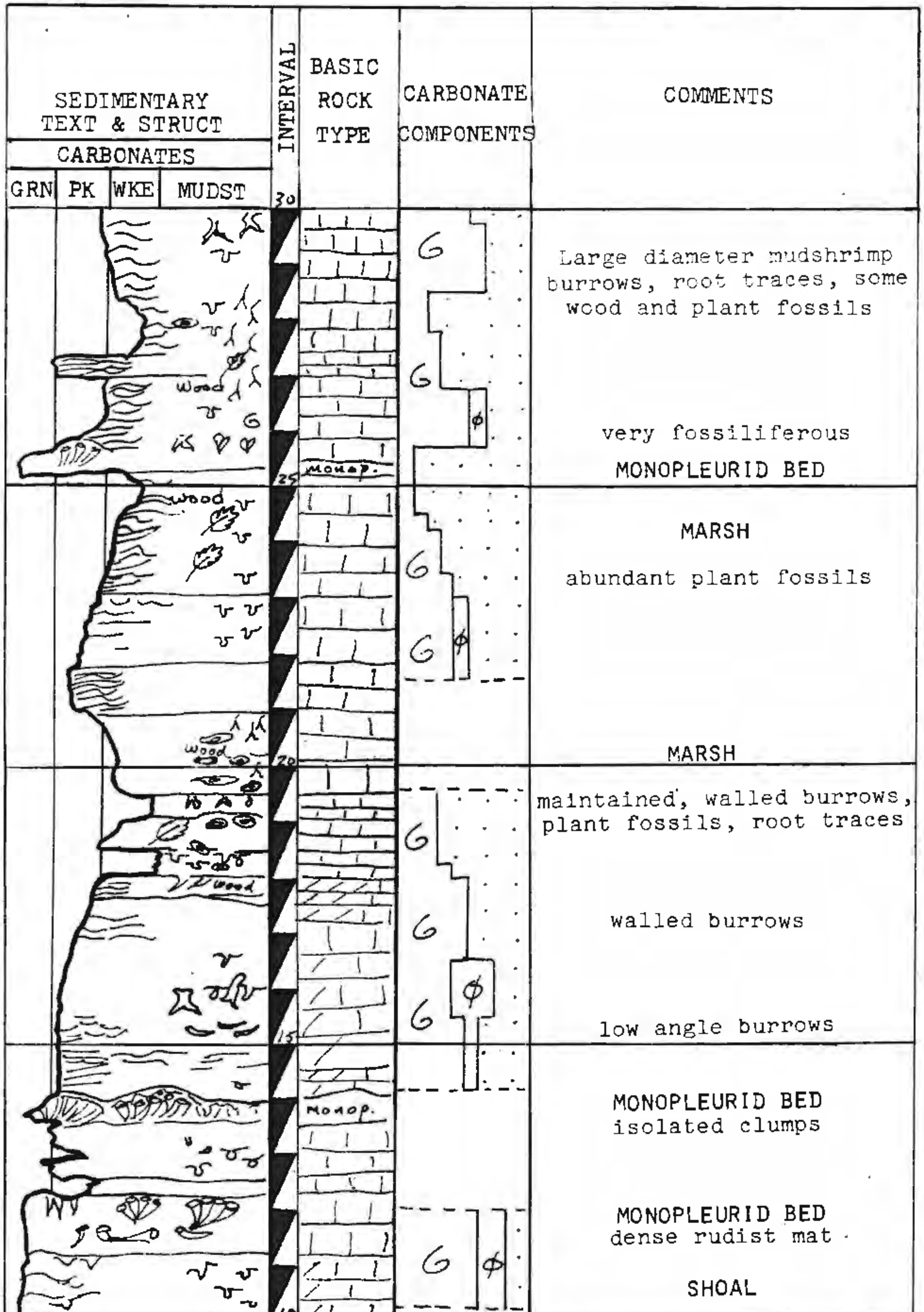

SEDIMENTARY TEXT & STRUCT
CARBONATES
GRN
PK
WKE
MUDST
INTERVAL
BASIC ROCK TYPE
CARBONATE COMPONENTS
COMMENTS
30
25
20
15
10
Monop.
wood
Large diameter mudshrimp burrows, root traces, some wood and plant fossils
very fossiliferous
MONOPLEURID BED
MARSH
abundant plant fossils
MARSH
maintained, walled burrows, plant fossils, root traces
walled burrows
low angle burrows
MONOPLEURID BED
isolated clumps
MONOPLEURID BED
dense rudist mat
SHOAL

FIGURE 9c.

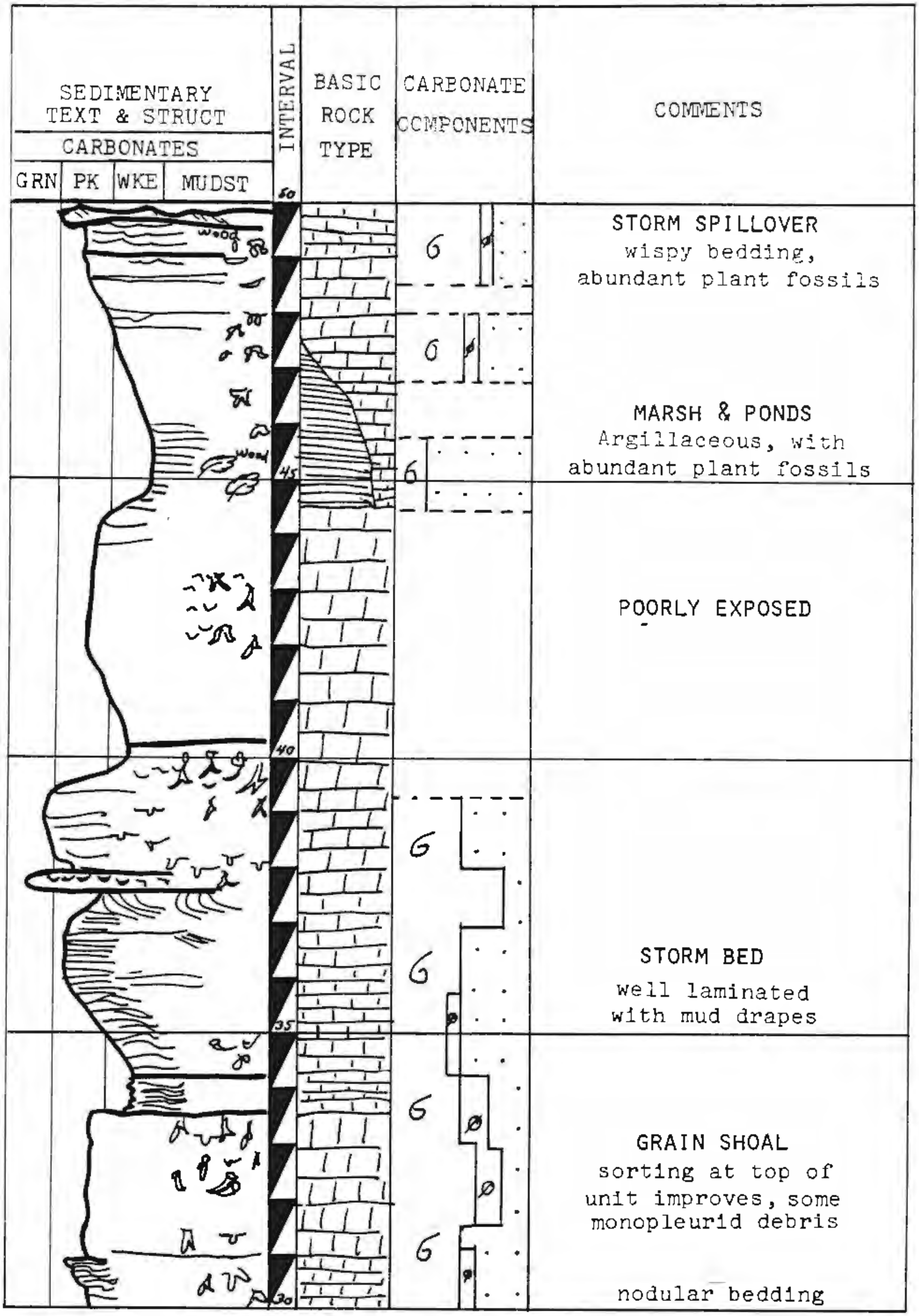

SEDIMENTARY TEXT & STRUCT
CARBONATES
GRN
PK
WKE
MUDST
INTERVAL
BASIC ROCK TYPE
CARBONATE COMPONENTS
COMMENTS
50
45
40
35
30
STORM SPILLOVER
wispy bedding, abundant plant fossils
MARSH & PONDS
Argillaceous, with abundant plant fossils
POORLY EXPOSED
STORM BED
well laminated with mud drapes
GRAIN SHOAL
sorting at top of unit improves, some monopleurid debris
nodular bedding

FIGURE 9d.

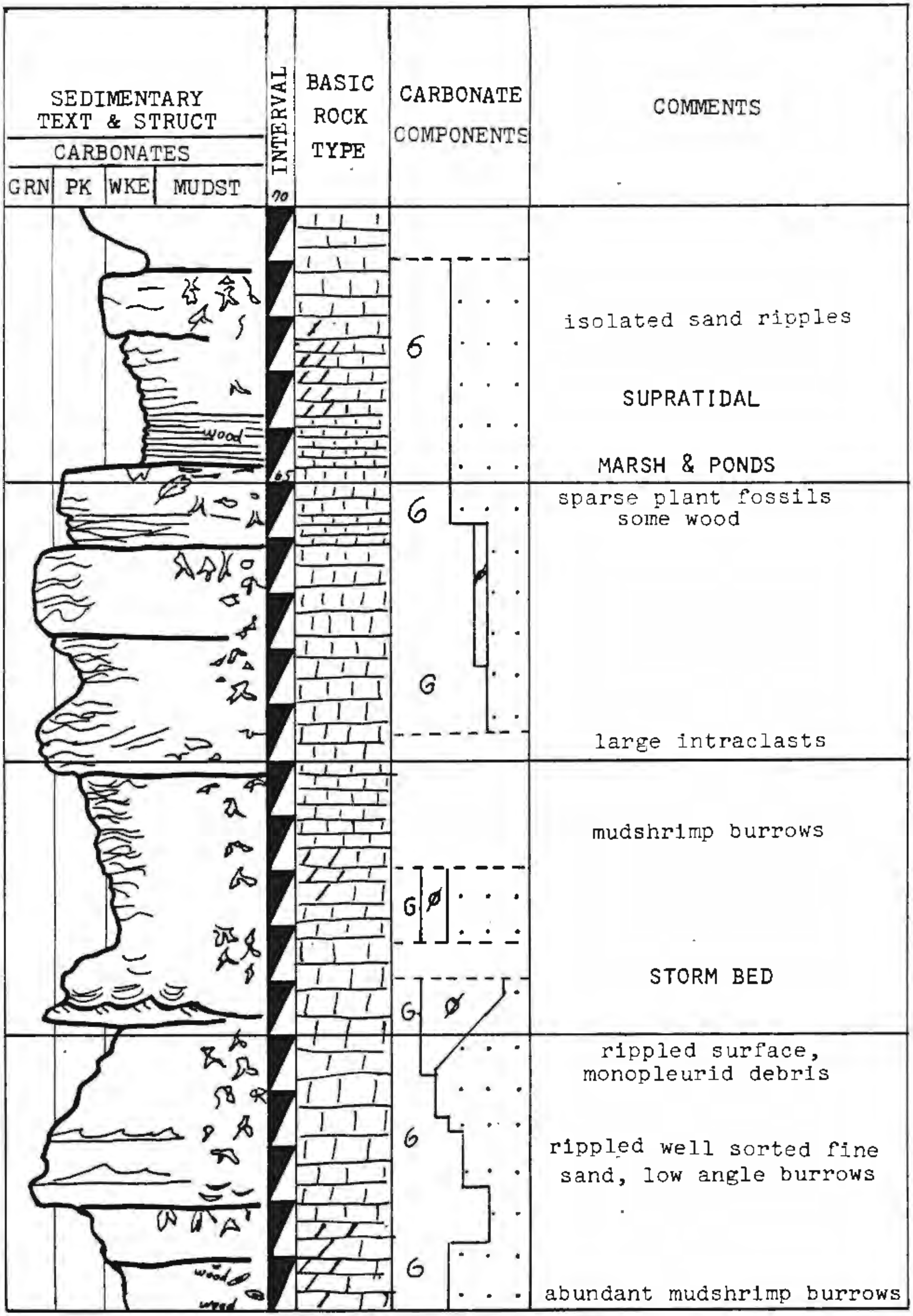

SEDIMENTARY TEXT & STRUCT
CARBONATES
GRN
PK
WKE
MUDST
INTERVAL
70
65
BASIC ROCK TYPE
CARBONATE COMPONENTS
COMMENTS
wood
isolated sand ripples
SUPRATIDAL
MARSH & PONDS
sparse plant fossils
some wood
large intraclasts
mudshrimp burrows
STORM BED
rippled surface,
monopleurid debris
rippled well sorted fine
sand, low angle burrows
abundant mudshrimp burrows

Figure 10. Representative facies from the low-energy tidal belt, Cat Mountain section (Stop 2).

A. Bored hardground in a miliolid grainstone. Borings are filled by overlying echinoid-mollusk packstone/grainstone. Environment: shoal. At 9.5 feet.

B. Monopleurid boundstone with a echinoid-miliolid wackestone matrix. Environment: moderate-energy subtidal bank. At 12.3 feet.

C. Burrowed laminated mudstone (pond) underlying a crab burrowed miliolid wackestone (marsh). Crab burrows have dark outlines. At 18.5 feet.

D. Miliolid-arenaceous foraminifer packstone. Environment: storm bed. At 32 feet.

E. Interbedded miliolid mudstone and laminated packstone from lower shoreface of a beach sequence. At 36.5 feet.

F. Laminated mudstone interbedded with miliolid wackestone/packstone. Environment: broad tidal flat. At 65 feet.

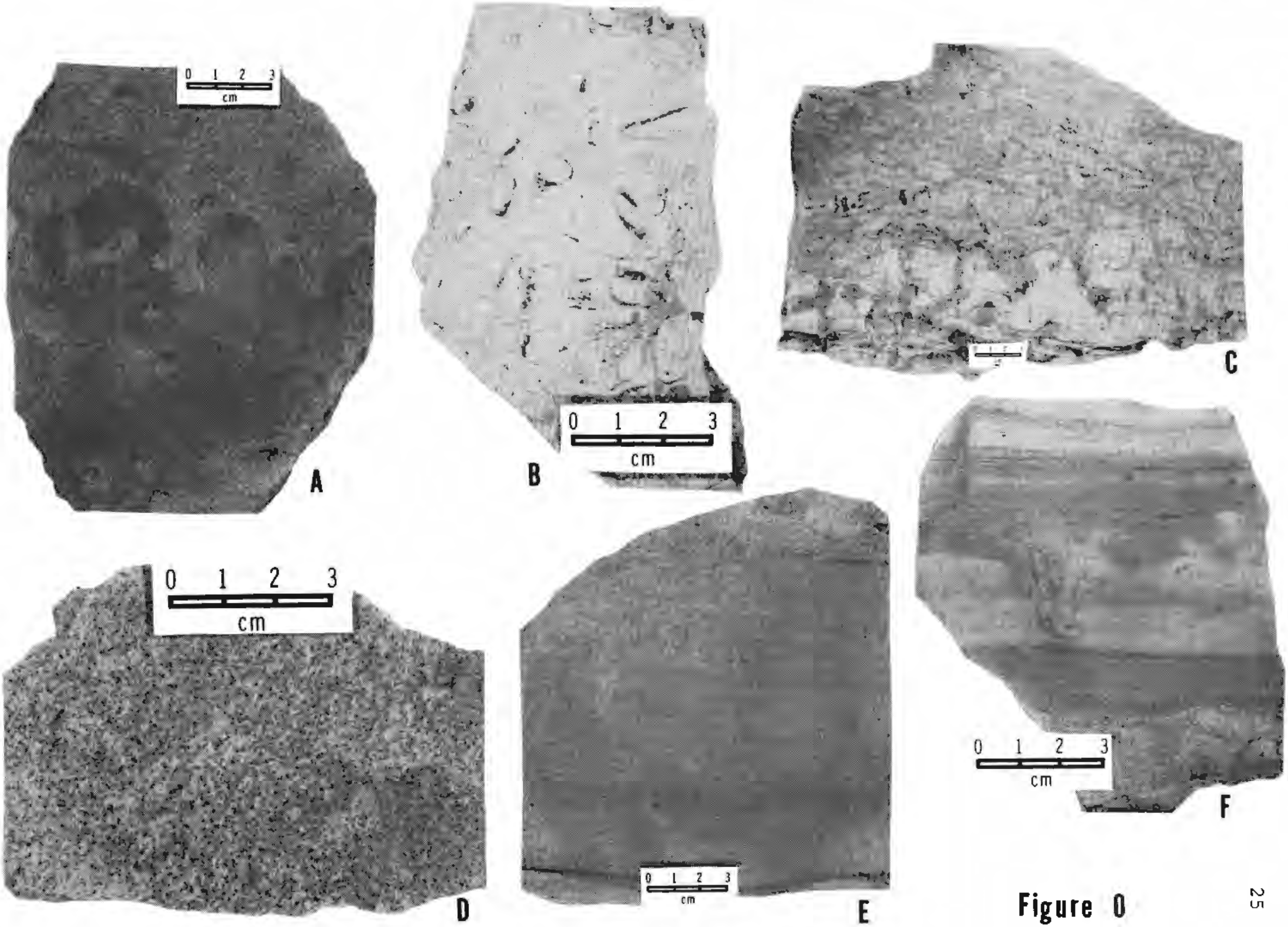
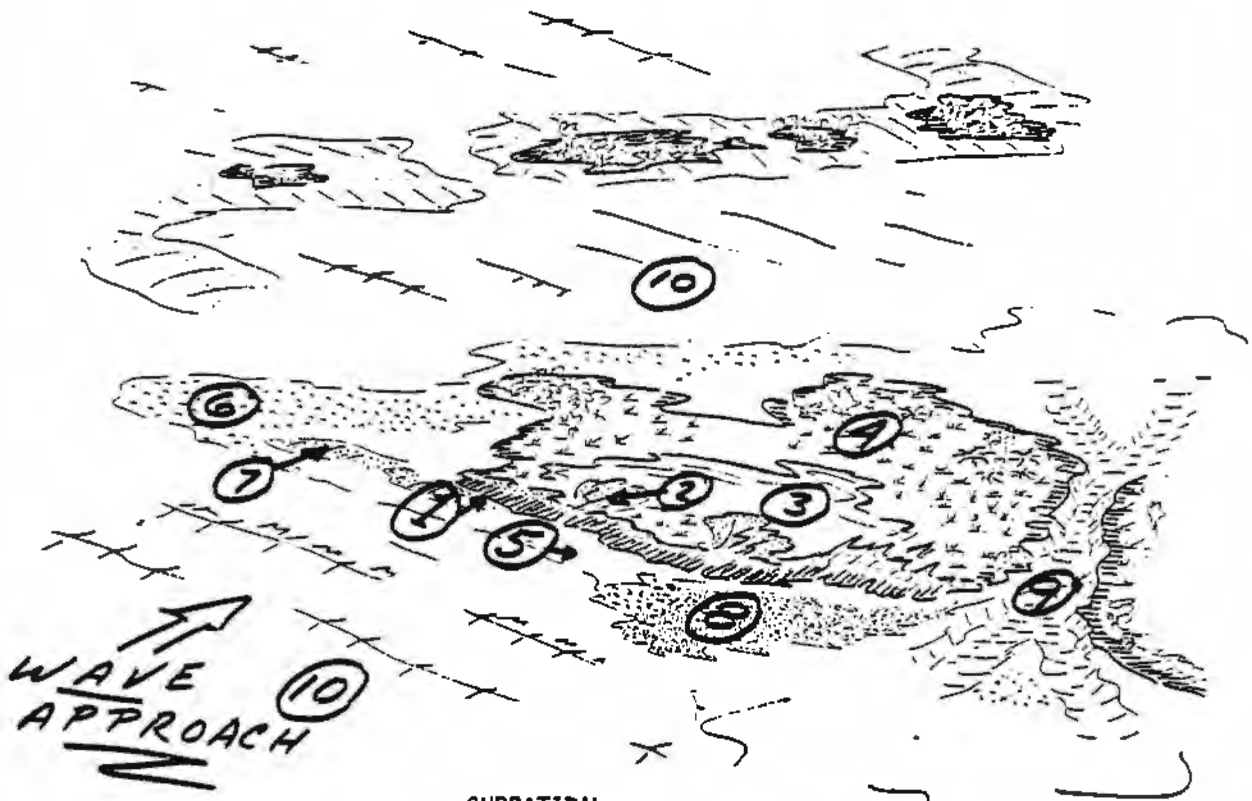


Figure O

FIGURE 11
GLEN ROSE LOW-ENERGY ENVIRONMENTS



SUPRATIDAL
1. BEACHES & BERMS
2. SPILLOVERS
3. PONDS
4. MARSHES

INTERTIDAL
5. MUDFLATS
6. BURROWED MUD SHOALS
7. GRAIN SHOALS
8. MONOPLEURID RUDIST BEDS

SUBTIDAL
9. TIDAL CHANNELS
10. BASINS

STOP 3

WHITESTONE QUARRIES — HIGH-ENERGY TIDAL FACIES

INTRODUCTION

The Whitestone Lentil is an elongate grainstone belt which trends northwest along the Williamson-Travis County line (fig. 1) and is exposed in a series of quarries near the town of White Stone along State Highway 1431 (fig. 2). The Whitestone Lentil is interpreted to be an ancient marine carbonate sand belt, analogous to Cat Cays, Great Bahama Bank, a modern marine carbonate sand belt (Ball, 1967).

The Whitestone beds have been quarried for many years for building stone, known commercially as the "Cordova Shell" and the "Cordova Cream," and for crushed limestone (Rodda and others, 1966). Moore (1961, 1964) described the stratigraphy of the area and Moore and Martin (1966) interpreted the Whitestone Lentil as a high-energy carbonate deposit laid down in highly agitated, relatively clear, shallow-marine water. Other relevant studies have been published by Tucker (1962), Rogers (1967), Rose (1972), and Evans (1972).

STRATIGRAPHY

Moore (1964), in a study of the stratigraphy of the Fredericksburg Division in south-central Texas, recognized the oolite and pellet grainstone from the Cedar Park Limestone Member of the Walnut Formation and named it the Whitestone Limestone Member of the Walnut Formation (fig. 3). In the study area, the Whitestone Lentil is interpreted to be a genetic package composed of a bioclastic facies and oolite facies bounded above and below by local unconformities indicated by pholad borings.

To the southwest or seaward side of the Whitestone Lentil is the Edwards Formation. The Cedar Park Limestone Member of the Walnut Formation underlies the Whitestone Lentil. This can be seen in quarries number one (fig. 2, 4d) and three which are on the seaward and middle part of the sand belt, but on the lagoonal side of the sand belt, quarry number five, the basal contact of the Whitestone Lentil is not exposed (fig. 5).

The Keys Valley Marl Member of the Walnut Formation lies laterally to the northwest or lagoonal side of the Whitestone Lentil and also onlaps it (fig. 5), but it is not present southwest of the sand belt.

PETROGRAPHY OF THE WHITESTONE LENTIL

The Whitestone Lentil is divided into two facies, the upper oolite facies and the lower Trigonia grainstone facies (figs. 4d, 5, 6).

Upper Oolite Grainstone Facies

This facies is composed primarily of pellet and oolite grainstone. Fossils include small rounded fragments of Trigonia sp., oysters and echinoids (Moore, 1964), and Turritella sp. These fossils occur as lag deposits and also are randomly scattered. Compound accretion sets and accretion cosets of crossbedding are the most abundant form of stratification (fig. 7). Less common forms are avalanche sets of crossbedding, ripple marks, and laminae. Common inverse festoon crossbedding occurs as spillover lobes on the lagoonal side of the sand belt (fig.5). Moore and Martin (1966) described the oolites in this facies as "very well-sorted ooliths and coated grains, averaging 0.2mm in diameter in a medium to coarsely crystalline, sparry calcite matrix" and "the nuclei of oolites are pellets or pelletoids, shell fragments, and unrecognizable recrystallized grains."

Lower Trigonia Grainstone Facies

This facies is composed mainly of unsorted to rounded Trigonia grainstone. Varying amounts of oolites and pellets occur in the matrix. The Trigonia grainstone tends to be more broken and current-oriented in the lower part of the facies than in the upper part. The most dominant and characteristic fossil is Trigonia sp., a shallow-water infaunal suspension feeder. Other fossils include Turritella sp., oysters, and a few fragments of rudists. Several accretionary-crossbedded oolite grainstone and lenses of gastropod pellet grainstone are interbedded with the Trigonia grainstone. Several traces of crossbedding were noticed, but most were destroyed by bioturbation.

DEPOSITIONAL SETTING OF THE WHITESTONE LENTIL

Setting

Ball (1967) described the setting of Cat Cays as parallel to the slope break that separates the Bahama platform from the deep water of Florida Straits. The top of this sand belt may be awash at low tide or very near the surface and the water adjacent to the sand belt is ten to fifteen feet deep. He concluded that the setting of

Cat Cays is related to bottom topography. Bottom topography is believed to have controlled the setting beneath the Whitestone sand belt.

The structural geology of the area of the Whitestone Lentil was discussed by Tucker (1962) and Rogers (1963). The lentil is in the Round Rock Syncline located between the Belton High to the north and the San Marcos Arch to the south (fig. 8). The water in this synclines was shallow and even shoaling in many areas, evidenced by a series of shoals in the limestone underlying the Whitestone Lentil. The Whitestone Lentil originated on top of these topographically high shoals and built seaward (fig. 9).

Geometry

The outcrop pattern of the Whitestone Lentil shows it to be a linear belt parallel to a paleoslope break similar to that described by Ball (1967) for the Cat Cays sand belt.

The cross section through the sand belt in the study area (fig. 10) shows it to thin from 18 feet (nine feet of oolite facies and nine feet of bioclastic facies) on the lagoonal side to ten or less feet on the seaward side. This thinning is due in part to the sand belt overlying a rudist shoal (fig. 9). The extreme edges of the sand belt are not exposed. The belt in this area is approximately one mile wide, and the length of the sand belt parallel to the slope break is reported by Moore (1964) as 40 miles. However, this length may include more than just the length of the Whitestone sand belt.

Internal Structure

Ball (1967) describes crossbedding dipping toward the platform as the dominant internal structure of Cat Cays. He also describes large spillover lobes on the lagoonal side of the sand belt and smaller ones on the seaward side. Numerous small- and medium-scale ripple marks occur along its surface. The Whitestone Lentil has many of these same internal structural features.

The seaward side of the Whitestone sand belt is divided into the upper shoreface, represented by the oolite grainstone facies, and the lower shoreface, represented by the *Trigonia* grainstone facies.

The upper shoreface has structures indicative of a high-energy environment. A current rose of this facies shows that sediment transport was the result of several types of currents of varying strengths acting on the sand belt (fig. 9). These include tidal current acting in a northeast and southwest direction and longshore current moving along the strike of trend of the sand belt. The thinness of the sand belt allowed the carbonate sand to be reworked many times. The dominant feature is the accretionary crossbedding probably resulting from the migration of wave breaker bars during storms. In general, the sets of crossbedding are larger at the bottom than at the top of the upper shoreface (fig. 7c). This indicates more reworking near the top by lower-energy processes in shallower water.

The effects of storms are well shown by large spillover lobes on the lagoon side of the sand belt (figs. 5, 10) and storm channels and smaller spillover lobes on the seaward side (fig. 7a). The spillover lobes indicate sediment movement over the sand belt (Ball, 1967). The channels are the result of storms as indicated by the large intraclast (up to 12 inches) lag deposits and gradation upward to large trough crossbedding. A large storm bed is exposed for approximately fifty feet along a wall in quarry number one (fig. 4a). This bed contains unsorted, rounded intraclasts of pellet grainstone and oolite grainstone (fig. 4b). Current-oriented palm leaves (fig. 4c) occur on the top of some bedding planes. Some other small channels occur in other parts of the sand belt (quarries two and three). Other features of the oolite facies are oscillation ripple laminae (fig. 7b), animal burrows, algae (fig. 11d), and remnants of medium-scale ripples along the surface.

The lower shoreface of the Trigonia grainstone facies indicates a lower energy with short periods of very high energy. The lower energy periods are represented by whole shells of Trigonia sp. and Turritella sp. in a pellet matrix. This facies was more thoroughly reworked by organisms than the oolite facies. However, the energy was strong enough to orient the shells of Turritella and to leave most of the Trigonia shells convex-side up. The higher energy periods in the lower shoreface, resulting from storms, are indicated by unsorted, current-oriented shell hash layers and lenses of oolite grainstone. The latter must have been washed in from the upper shoreface.

Channels which cut into the underlying limestone are filled with the Trigonia grainstone facies. Three of these channels occur in quarry number one (fig. 2, 4), on the seaward side and are evidenced by scouring of the pholad borings and fossil hash fill.

Composition and Texture

The Cat Cays sand belt is composed of well-sorted oolites with a sparse megafauna of gastropods and pelecypods in the oolite sand facies and more skeletal and pelletal facies in the slightly deeper water next to the sand belt.

In the Whitestone Lentil the oolite facies contains well-sorted oolites and a sparse megafauna. The structures were little affected by bioturbation, and cross-bedding was preserved. The unsorted, rounded intraclasts reflect the effect of storms. The Trigonia grainstone facies which was deposited in slightly deeper water contains more skeletal material and more pellets. The sorting of the skeletal material varies from unsorted, where the fossils are whole, to sorted, where the skeletal material was fragmented and reworked. Composition and texture are extremely good tools for delineating the two facies.

SUMMARY AND DISCUSSION OF THE PALEOSETTING AND MODEL OF THE WHITESTONE LENTIL

The limestone tongue underlying the Whitestone Lentil in the study area indicates that this was an area of shoaling before the deposition of the Whitestone sand belt. The exposure of this limestone in quarry number one (fig. 2) shows two periods of shoaling separated by a lower energy subtidal phase (figs. 4, 9). The periods of shoaling are represented by rudist grainstone and pelletal oolite grainstone. The rudists are attached epifaunal suspension feeders which need a relatively high-energy environment and stable substrate on which to live. Therefore, the rudists were able to grow during periods when they could attach to a stable substrate or form one themselves. However, the rudist frameworks were torn up and reworked during periods of higher energy. The interlensing of the rudist grainstone with other high-energy deposits demonstrates these variations in the energy of this environment. A few small rudist bioherms are preserved (fig. 4d).

The lower energy subtidal phase is shown by a nodular-bedded wackestone to grainstone. The energy in this environment was too low to permit rudists to live here and too weak to winnow out the micrite from the sediments. Figure 9 shows the interpreted relationship of the units in this tongue.

Before the deposition of the Whitestone Lentil, the area was subaerially exposed and lithified as indicated by pholad borings along the upper surface.

This bored surface was later submerged and the Whitestone sand belt began to develop. The series of channels cut into the underlying surface line up along a northeast direction, which would indicate the slope of this surface to be southwest. The Whitestone deposition was initiated by a sequence of Trigonia grainstone facies, followed by the deposition of the oolite facies. Then through accretionary growth of the upper shoreface out and over the lower shoreface, the sand belt built seaward. It also built platformward by means of storm-transported sediment which accumulated in spillover lobes.

The model of the Whitestone presented in Figures 9 and 10 shows the vertical and lateral relationships in the sand belt. From the seaward side toward the lagoon, the following facies tract is represented: 1) the deeper-water facies of the Edwards "sea" borders the lower shoreface of the Whitestone sand belt; 2) the lower shoreface Trigonia grainstone facies consists of interlensing of high- and low-energy bioclastic sediments; 3) the upper shoreface comprises a series of wave-breaker bars whose upper surface was only a few feet below low tide and was at times in the swash zone; 4) on the lagoonal side, spillover lobes developed from storm currents carrying sediment across the sand belt; 5) the Keys Valley Marl lagoonal sediments. Deposition of the Whitestone was terminated by a relative fall in sea level which subaerially exposed and lithified it. The flat, bored upper surface of the oolite grainstone could have resulted from lithification at the top of a ground-water table.

The upper lithified surface was partly submerged again and bored by myriads of the pholad Lithophaga sp. (figs. 11a, 11b). Also, abundant oysters grew in tidal pools along this surface (fig. 11a), and some shallow channels were cut down into the hard surface (fig. 11c). With further submergence and the development of a lower energy environment, the Keys Valley Marl overlapped the old Whitestone sand belt.

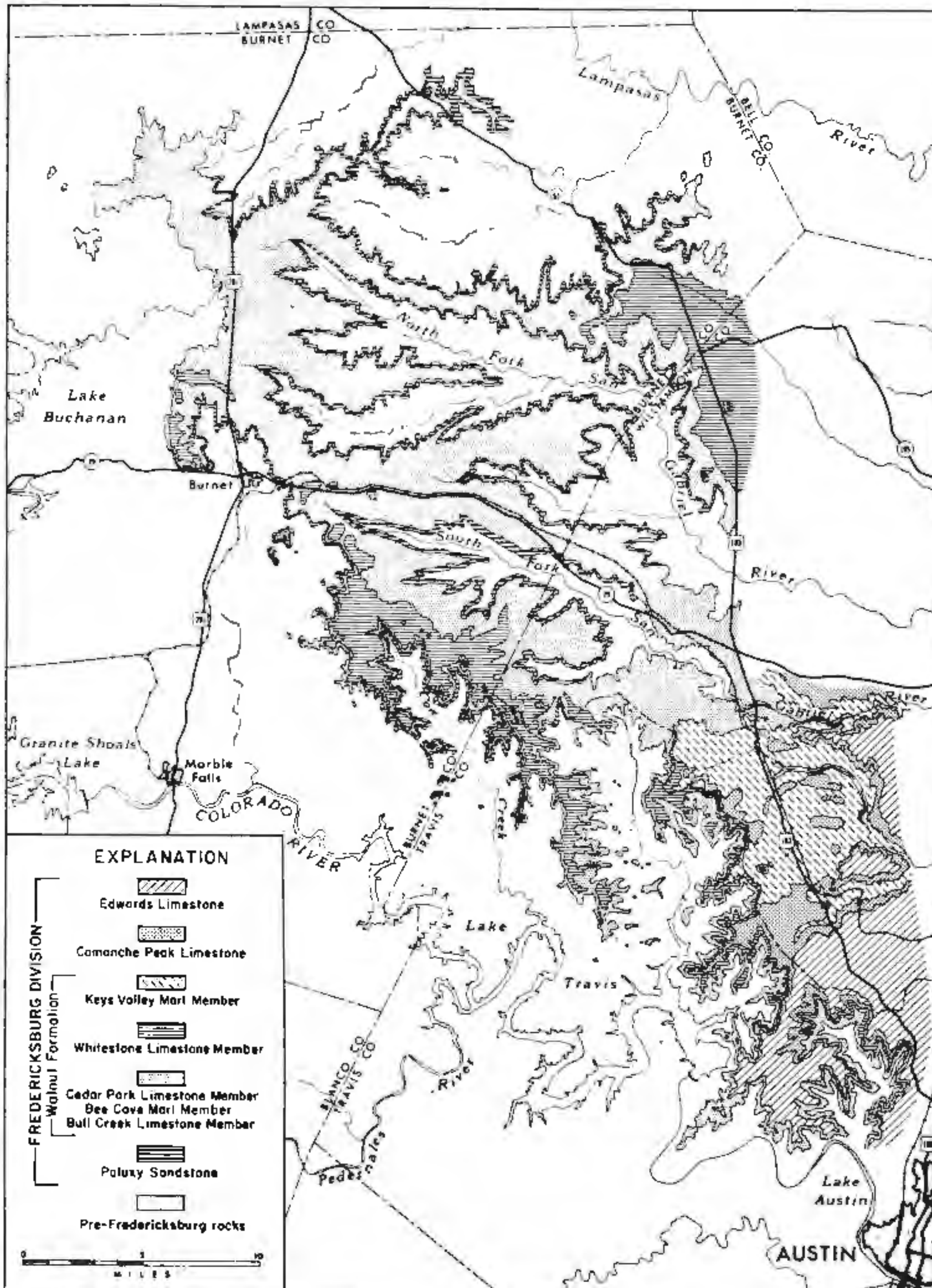


Figure 1. Geologic map of parts of Burnet, Williamson, and Travis counties, Texas. From Moore, 1964.

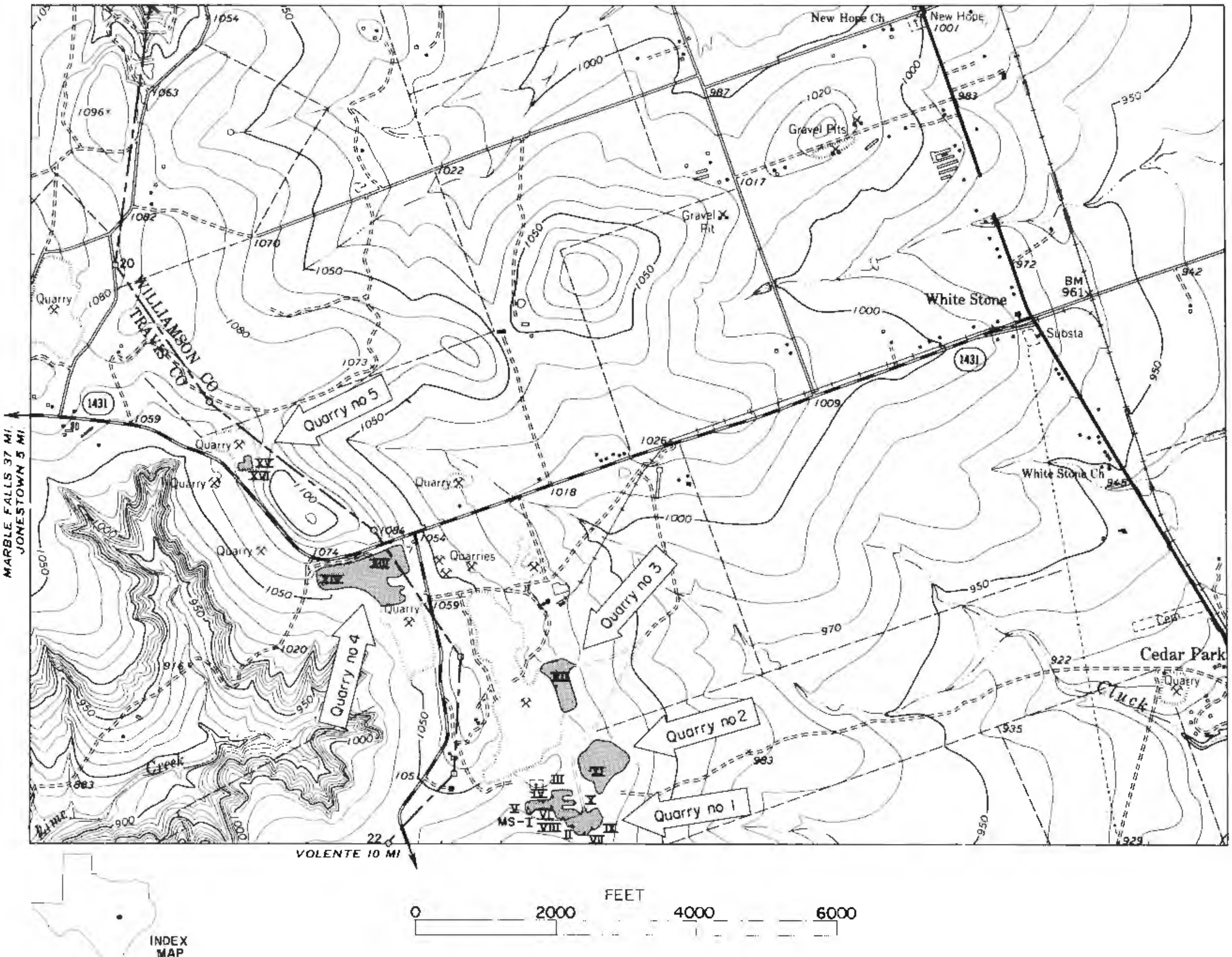


Figure 2. Location of quarries.

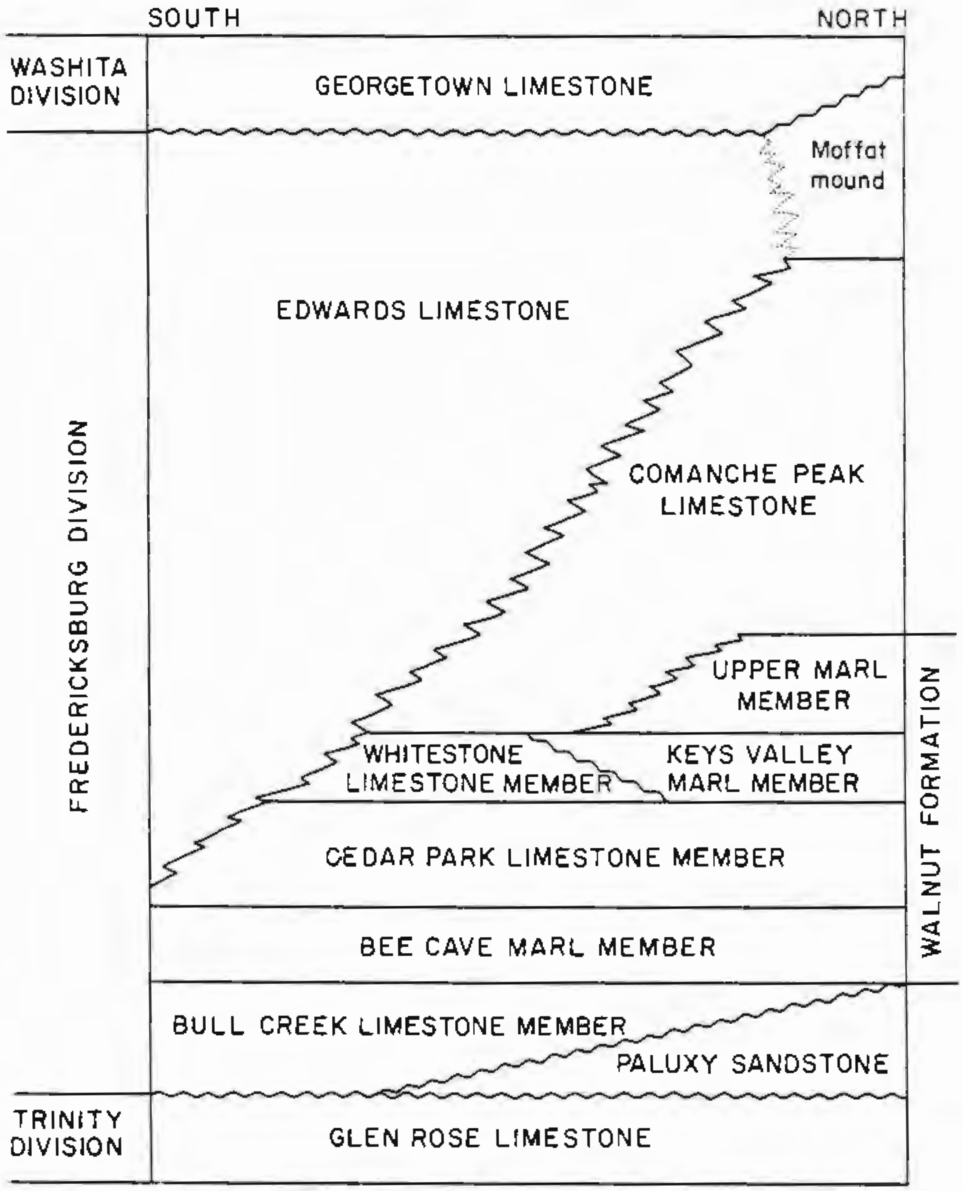
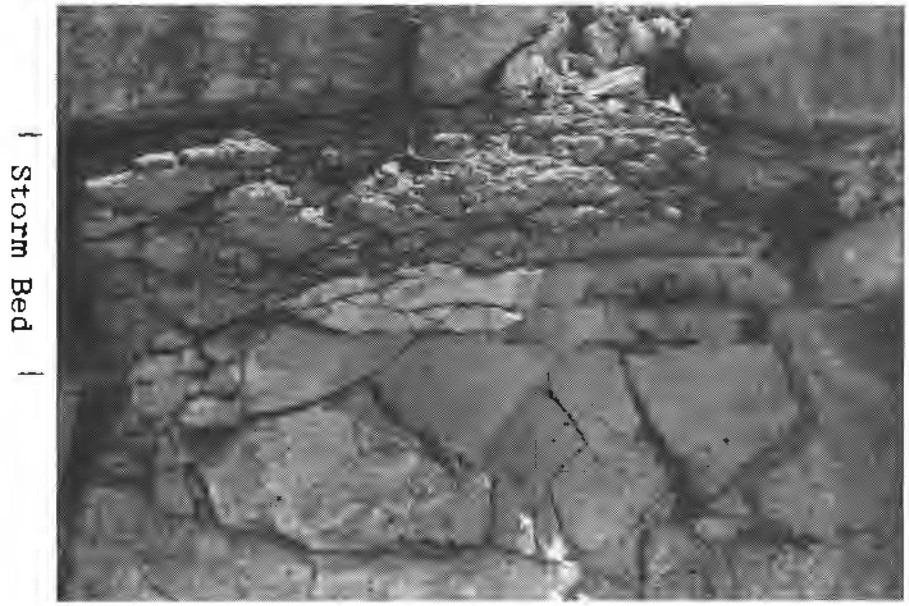


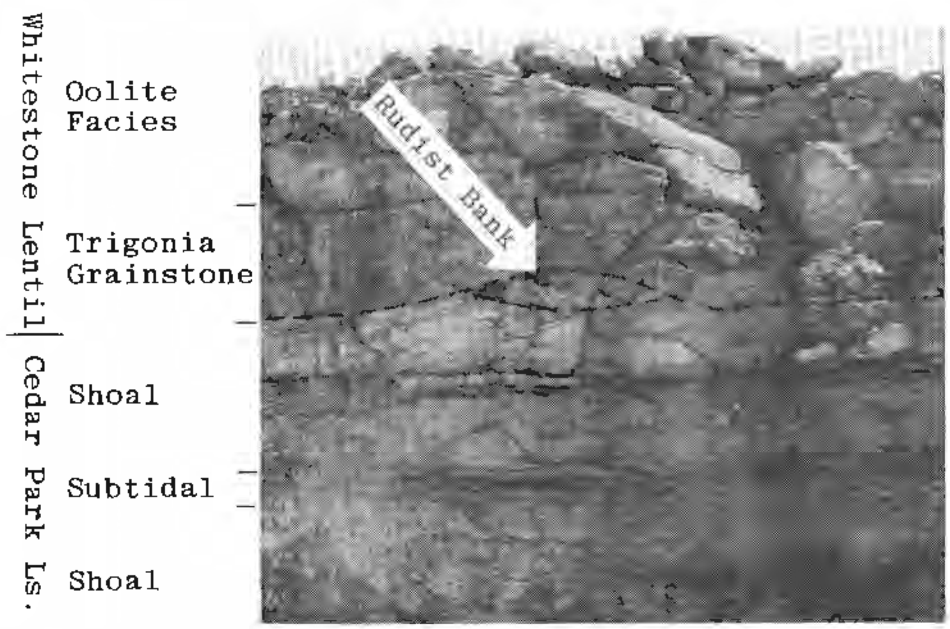
Figure 3. Stratigraphic units of south-central Texas (modified after Moore, 1964).



A. Quarry I, Measured Section IX

B. Storm conglomerate, Quarry I

C. Storm bed of palm leaves.

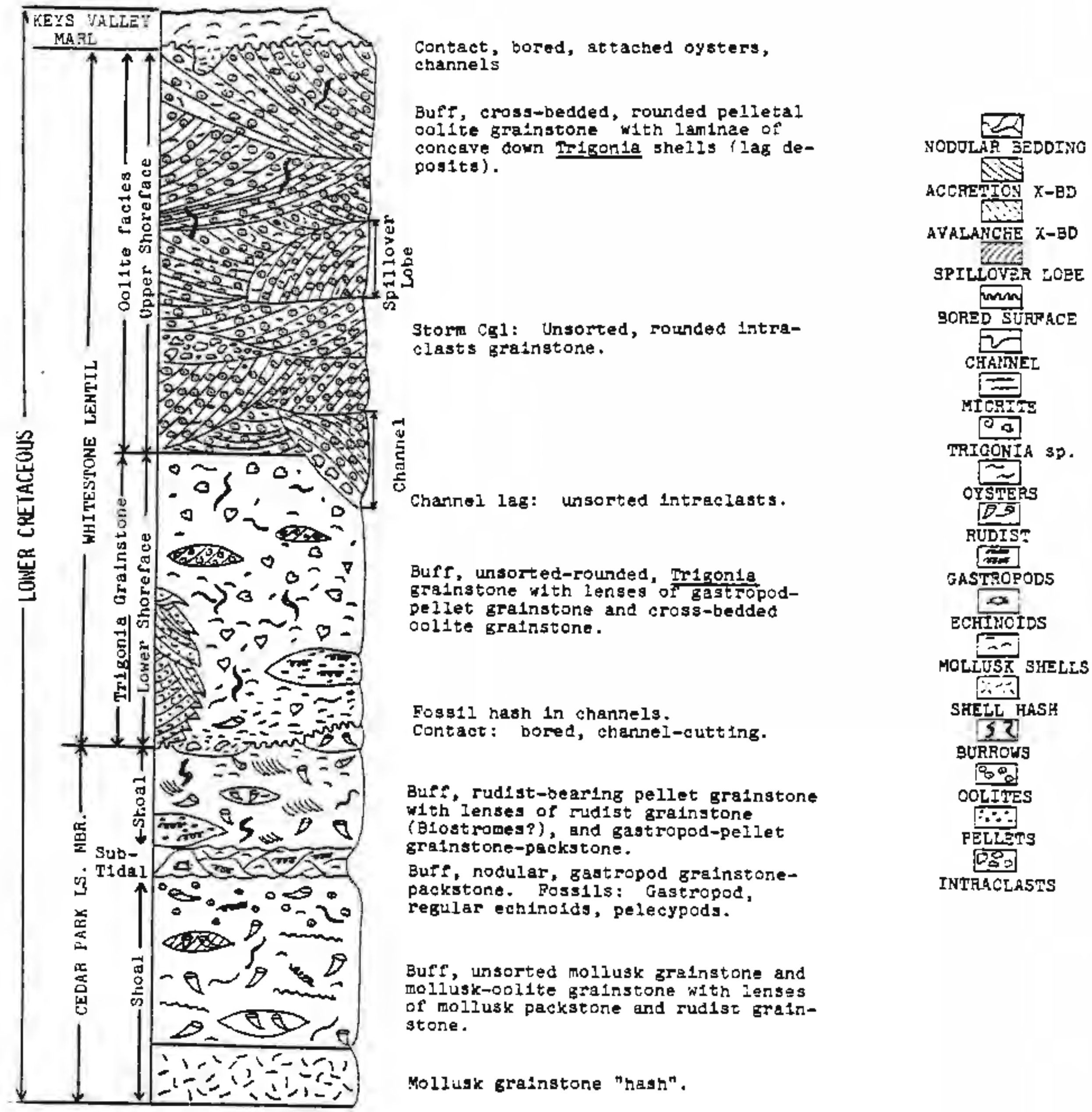


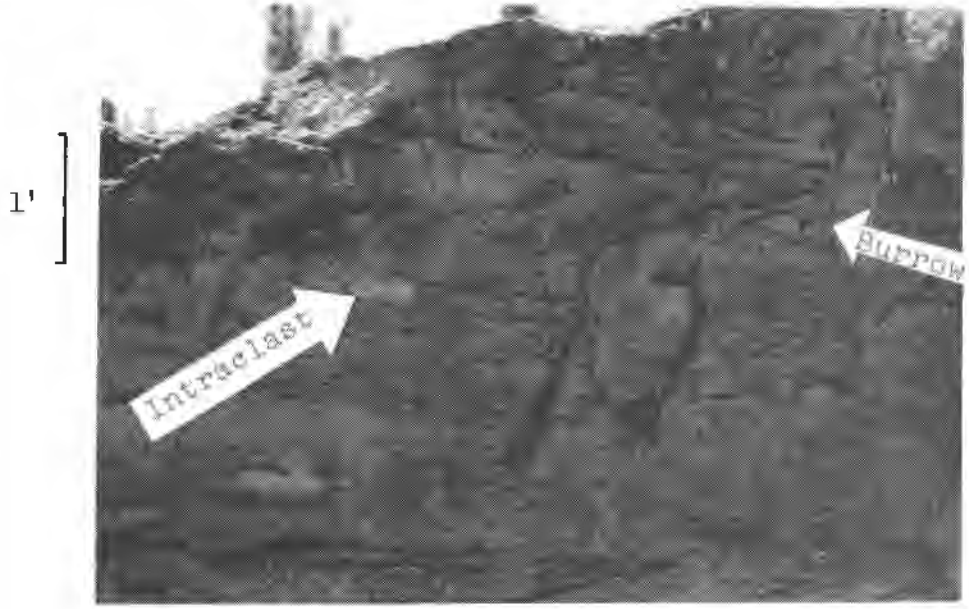
D. Quarry I, Measured Section VII

Quarry V, Measured Section XV

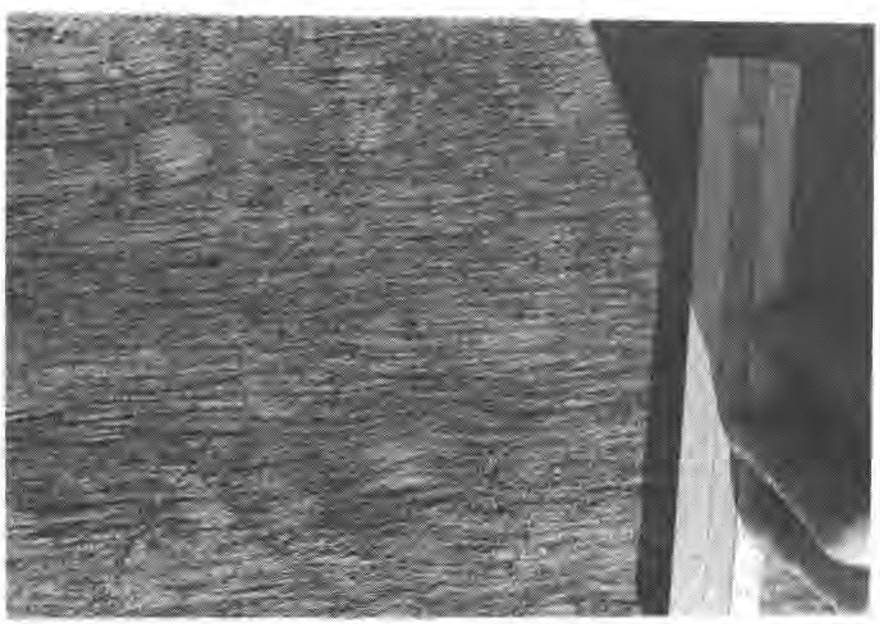
Figure 5

FIGURE 6
COMPOSITE STRATIGRAPHIC SECTION





A. Storm Channel, Quarry II



B. Oscillation ripple laminge

C. Crossbedded Oolite Facies, Quarry IV

Figure 7

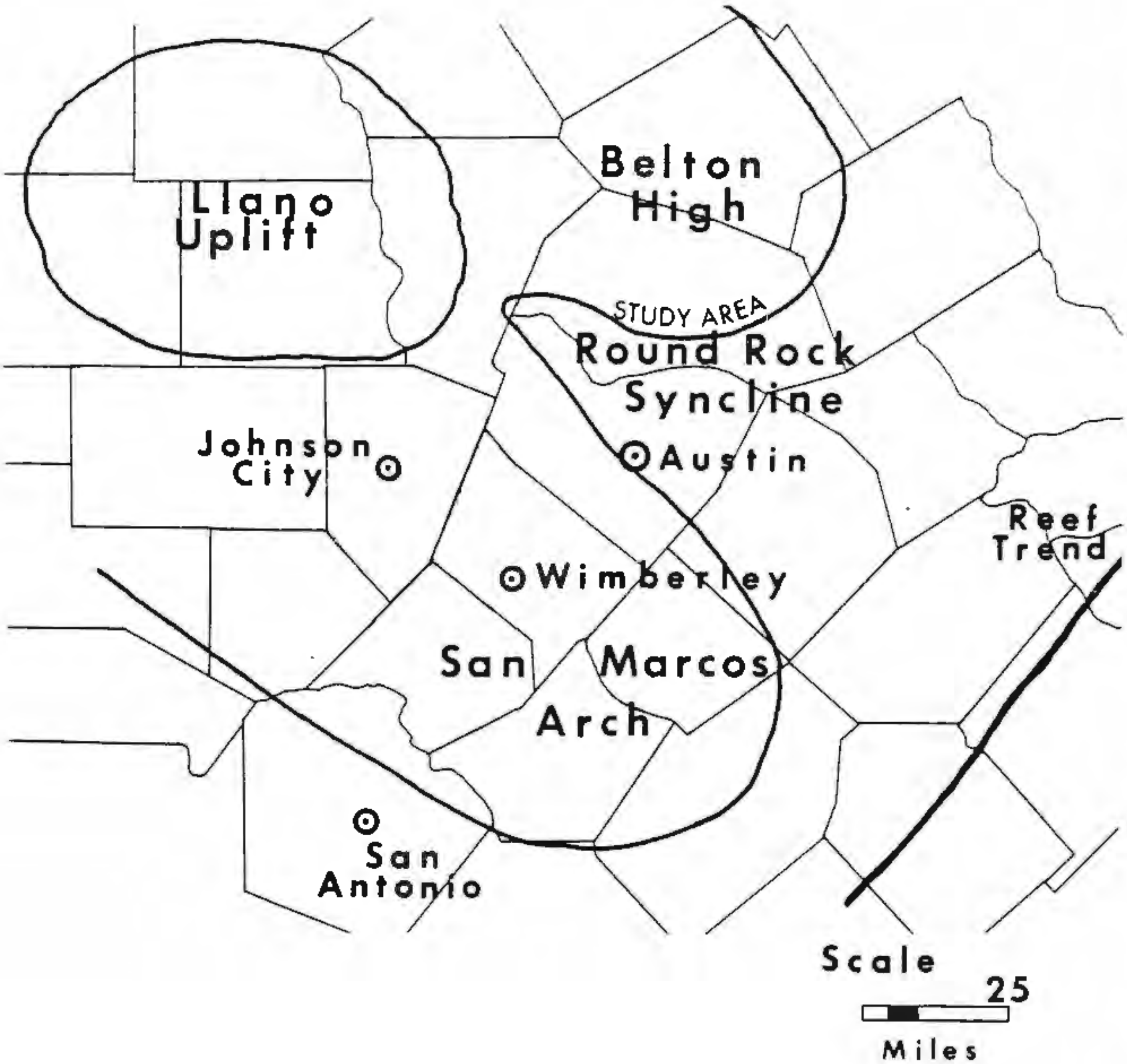
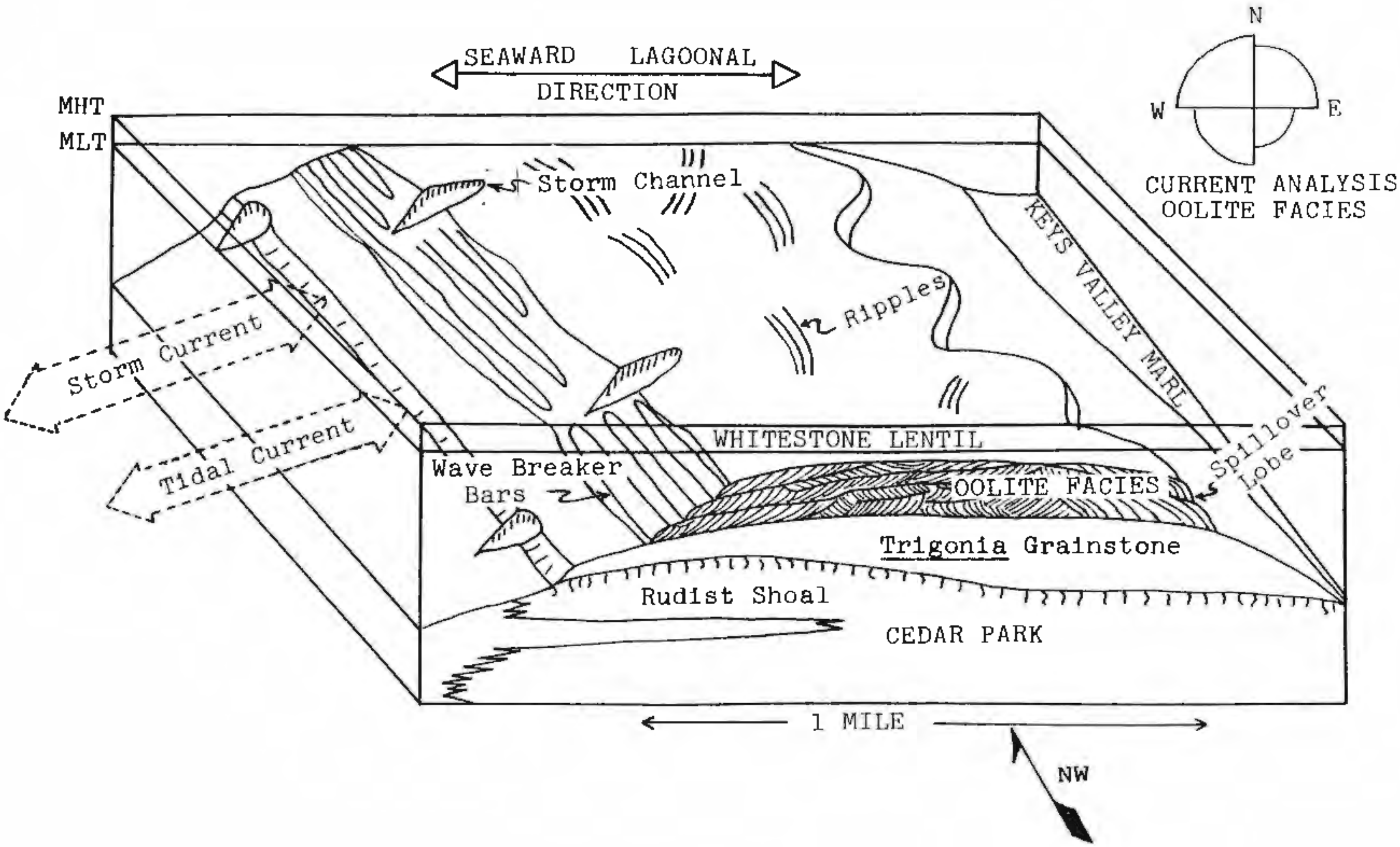


Figure 8. Central Texas tectonic elements. From Cleaves, 1972.



SCHEMATIC BLOCK DIAGRAM OF THE
WHITESTONE LENTIL MARINE CARBONATE SANDBELT

Figure 9.

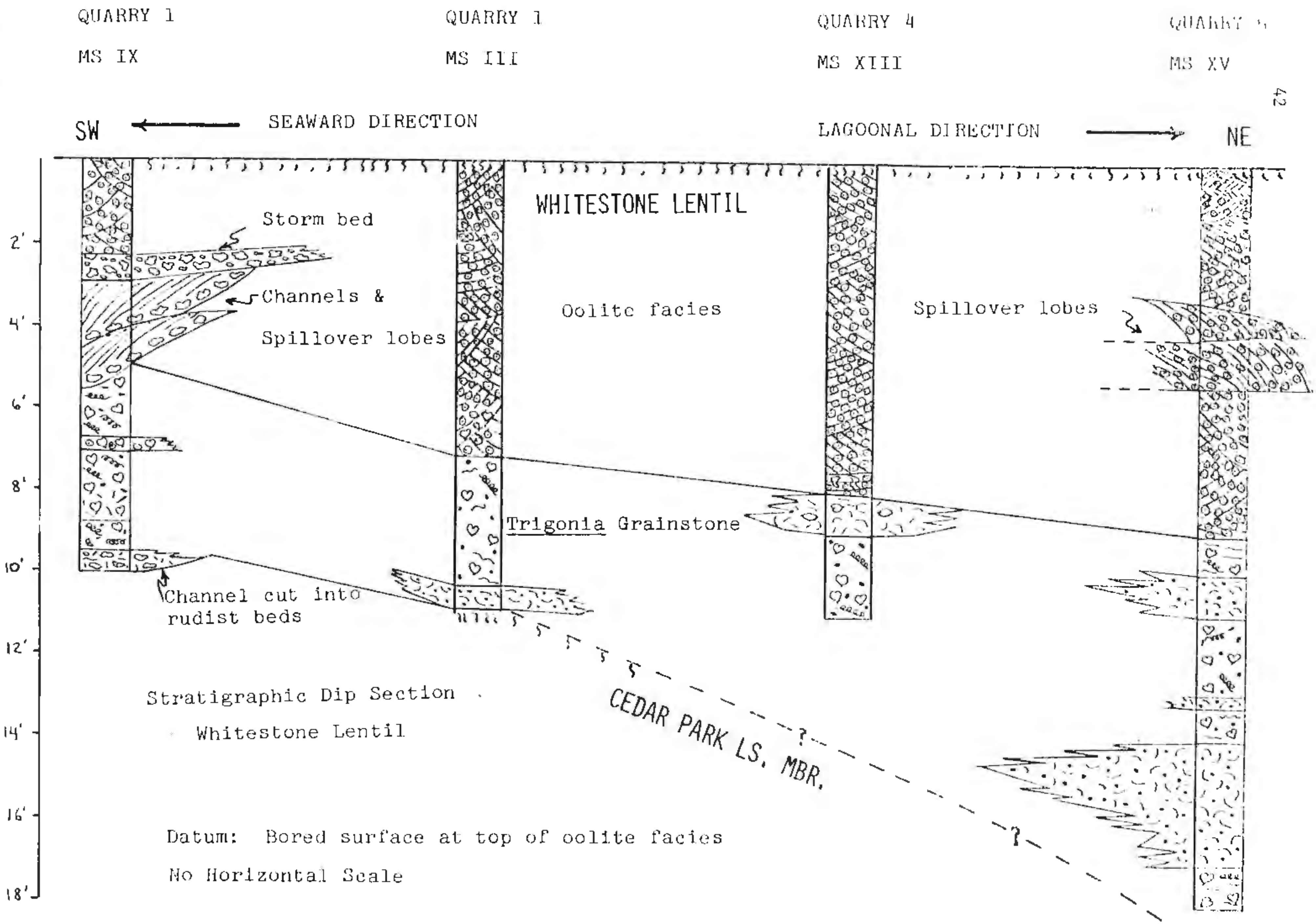
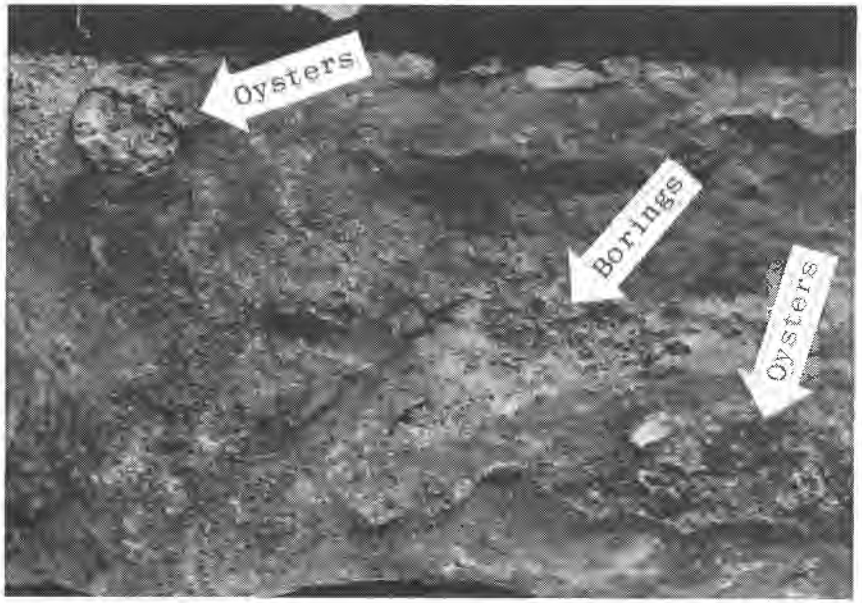
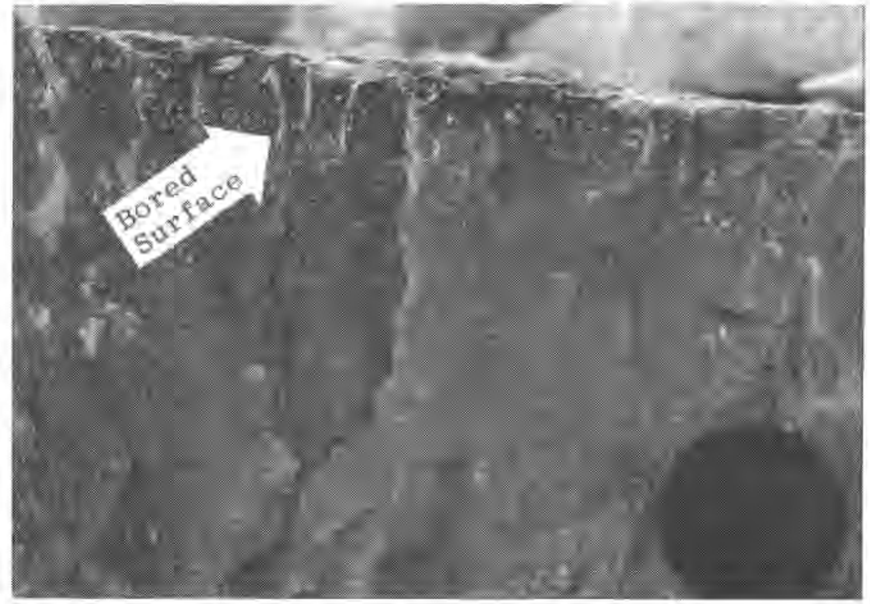

QUARRY 1
MS IX
QUARRY 1
MS III
QUARRY 4
MS XIII
MS XV
SW
SEAWARD DIRECTION
LAGOONAL DIRECTION
NE
WHITESTONE LENTIL
Storm bed
Channels &
Spillover lobes
Oolite facies
Spillover lobes
Trigonia Grainstone
Channel cut into
rudist beds
CEDAR PARK LS. MBR.
Stratigraphic Dip Section
Whitestone Lentil
Datum: Bored surface at top of oolite facies
No Horizontal Scale
2'
4'
6'
8'
10'
12'
14'
16'
18'

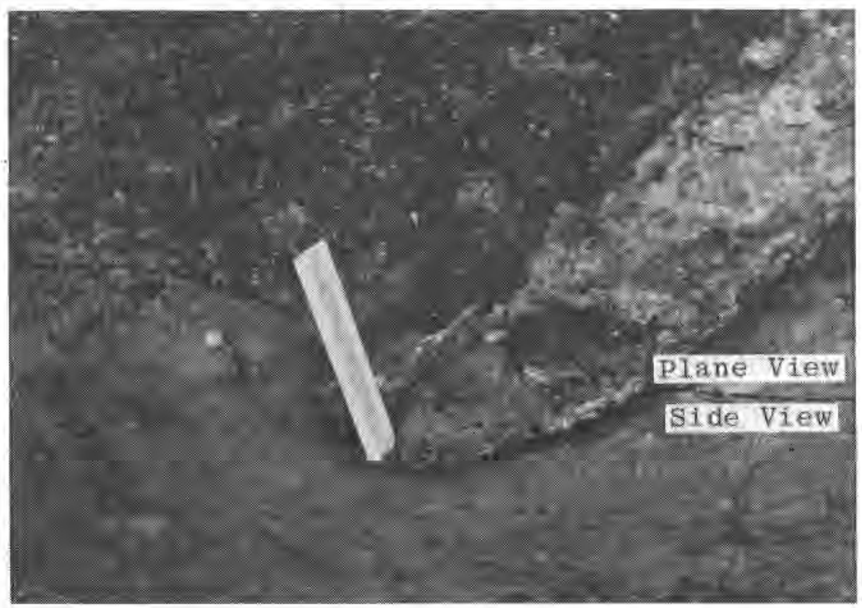
Figure 10



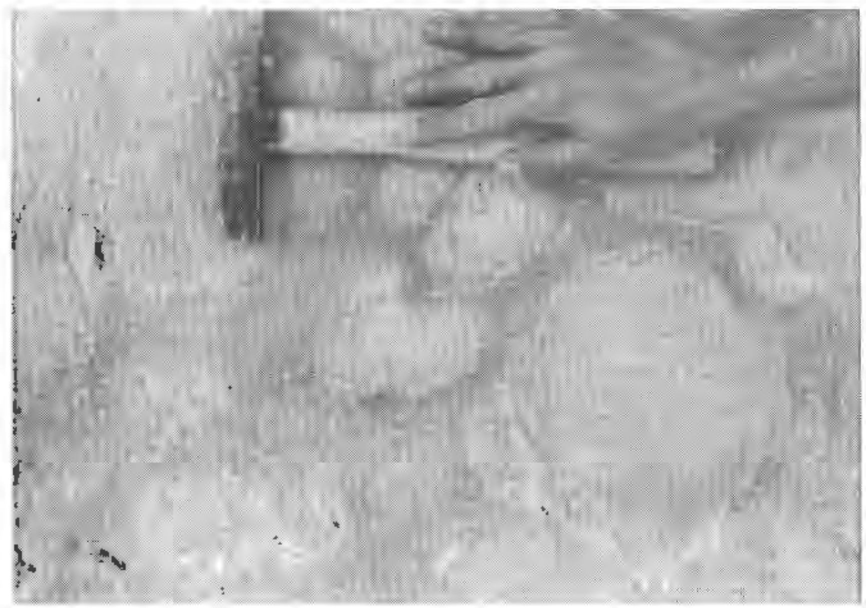
A. Hardground Surface of the Whitestone Lentil



B. Bored surface at the top of the Whitestone Lentil



C. Channel Cut into top of the Whitestone Lentil



D. Algae in the oolite facies (plane view).

Figure 11

REFERENCES

Ball, M. M., 1967, Carbonate sand bodies of Florida and the Bahamas: Jour. Sed. Pet., v. 37, no. 2, p. 556-591.

Bebout D. G., and Loucks, R. G., 1974, Stuart City Trend, Lower Cretaceous, South Texas: A carbonate shelf-margin model for hydrocarbon exploration: Univ. Texas Bur. Econ. Geology Rept. Inv. 78, 80 p.

Cleaves, A. W. II, 1972, Depositional environments in the middle part of the Glen Rose Limestone (Lower Cretaceous), Blanco and Hays Counties, Texas: Unpublished M.A. thesis, Univ. of Texas at Austin, 194 p.

Ebanks, W. J. Jr., and Bubb, J. N., 1975, Holocene carbonate sedimentation, Matecumbe Keys tidal bank, South Florida: Jour. Sed. Pet., v. 45, no. 2, p. 422-439.

Evans, Ian, 1972, A palaeoecological analysis of the Whitestone Member of the Walnut Formation, Lower Cretaceous, Travis and Williamson Counties, Texas: Unpublished Ph.D. dissertation, Texas A&M University, 204 p.

Ginsburg, R. M., 1964, South Florida carbonate sediments, a guidebook for Field Trip No. 1: Geol. Soc. Am. Annual Convention, Miami, p. 26-33.

Moore, C. H., Jr., 1961, Stratigraphy of the Walnut Formation, south-central Texas: Texas Jour. Sci., v. 13, no. 1, p. 17-40.

__________, 1964, Stratigraphy of the Fredericksburg Division, south-central Texas: Univ. of Texas Bur. Econ. Geology Rept. Inv. 52, 48 p.

__________, and K. G. Martin, 1966, Comparison of quartz and carbonate shallow marine sandstones, Fredericksburg Cretaceous, central Texas: Am. Assoc. Petroleum Geologists Bull., v. 50, no. 5, p. 981-1000.

Multer, H. Gray, 1969, Field guide to some carbonate rock environments, Florida Keys and Western Bahamas: Fairleigh Dickinson University, Madison, New Jersey, 158 p.

__________, 1975, Field Guide to Some Carbonate Rock Environments, Florida Keys and Western Bahamas (revised): Fairleigh Dickinson University, Madison, New Jersey, 175 p.

Pray, L. C., 1966, Hurricane Betsey (1965) and near shore carbonate sediments of the Florida Keys: Geol. Soc. Am. Annual Meeting, San Francisco, 1966, program, p. 168-169.

Rogers, C. W., 1963, Structural geology of Round Rock Quadrangle, Williamson County, Texas: unpublished M.A. thesis, Univ. of Texas at Austin, 48 p.

Rogers, M.A.C., 1967, Stratigraphy and structure of the Fredericksburg Division (Lower Cretaceous), northeast quarter Lake Travis quadrangle, Travis and Williamson Counties, Texas: unpublished M.A. thesis, Univ. of Texas at Austin, 49 p.

Rodda, P. U. and others, 1966, Limestone and dolomite resources, Lower Cretaceous rocks, Texas: Univ. of Texas Bur. Econ. Geology Rept. Inv. 56, 286 p.

Rose, P. R., 1972, Edwards Formation, surface and subsurface, central Texas: Univ. of Texas Bur. of Econ. Geology Rept. of Inv. 74, 198 p.

Tucker, D. R., 1962, Subsurface Lower Cretaceous stratigraphy, central Texas: unpublished Ph.D. dissertation, Univ. of Texas at Austin, 137 p.

Turmel, R. J., and Swanson, R. G., 1976, The development of Rodriguez Bank, Holocene mudbank in the Florida Reef Tract: Jour. Sed. Pet., v. 46, no. 3, p. 497-518.

Young, Keith, 1972, Cretaceous paleogeography: Implications of endemic ammonite faunas: Univ. of Texas Bur. of Econ. Geology, Geol. Circ. 72-2, 13 p.