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GEOLOGIC NOTES

Foundations of Quaternary Reefs in South-Central Belize Lagoon, Central America[1]

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ABSTRACT

Seismic profiles and drilling show that the Quaternary (late Pleistocene and Holocene) lagoon reefs in the south-central Belize Lagoon have grown on topographic highs constructed by fluvial, deltaic, and/or marine processes.

The basic pattern of the Quaternary reefs was determined in the early Pleistocene when the entire Belize Shelf was exposed. The levees of the rivers that flowed across the exposed shelf produced topographic highs which became major sites for late Pleistocene coral colonization. The Holocene reefs have grown on these carbonate mounds, atop deltaic sediments deposited during latest Pleistocene to earliest Holocene and on marine sand bars in the near coastal lagoon area.

The unique (rhomboidal and long-sinuous) reefs are derived from the underlying early Pleistocene river morphology (Victoria River) rather than from a fault-dominated karst morphology. The swarm of reefs in the coastal lagoon area reflects the differences in their foundations and geologic history. This study supports a model of lagoonal reef formation and/or modification of reef foundation controlled by alternating sea level fluctuation and coastal plain fluvial processes.

INTRODUCTION

Purdy (1974b) proposed that the Quaternary reefs, particularly those with unique rhomboidal and long-sinuous shape in the south-central lagoon, were founded on a faulted karstic morphology. Seismic and drilling data (Purdy, 1974a, 1974b; Choi and Ginsburg, 1982) in the southernmost part of the lagoon, however, have demonstrated that the presence of siliciclastic deposits beneath the reefs. The relationships of these deposits suggest that the reefs in the area are founded on fluvial and deltaic deposits. As a result, a new model of reef development for this region was formulated (Choi and Ginsburg, 1982). This model infers that the reef distribution within the lagoon is controlled by the constructional deposits produced by fluvial and/or deltaic systems during the regressional periods of the Pleistocene Epoch.

In order to test this model, an investigation was made of the reef distribution in the vicinity of the Victoria Channel (Figs. 1 and 2) where numerous cays and unique alignments provide varied test sites. The results of a high-resolution seismic reflection survey form the basis of this report.

METHOD OF STUDY

The seismic survey was made in July 1981 aboard the R/V *Calanus*. The sound source was a Uniboom[4] system capable of producing 300 joules. The signals were received by a 24-element hydrophone and the signal analog was recorded on paper and magnetic tape. In the initial phases of the survey, the positions were determined by a Mini-Ranger[4] system; because of an electronic malfunction, positions in the second part of the survey were located by radar and visual triangulation. With the numerous and easily identifiable cays in the areas, navigational error was not significantly increased by this substitute method. Tracklines for the survey are shown in Figure 2.

SEISMIC STRATIGRAPHY AND DISCUSSION

What controlled the reef distribution in Belize Lagoon? The uniquely shaped rhomboidal and long-sinuous reefs in the study area (Pelican Cay, Channel Cay, etc) have been studied by many researchers, and drillings were made on two cays: Laughing Bird Cay (Purdy, 1974b) and Channel Cay (Shinn and others, 1979). Differences in interpretation of the two types of data led to controversy over the Holocene reef foundations. Purdy (1974a) considered that karst morphology was essential in controlling reef distribution and regarded the rhomboidal reefs as a result of fault-controlled karst morphology. This was contrary to the assertion of a constructive foundation by Shinn and others (1979) who had recovered coral-bearing Pleistocene limestone underneath the Holocene reef sediments of Channel Cay.

In the study area, as in the southernmost areas of Belize Lagoon (Choi and Ginsburg, 1982), we have detected the presence of siliciclastics beneath the Quaternary reefs. Here repeated erosional events are represented by strong incision into the underlying formations which has contributed to the localization of Quaternary reef development. Our argument

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[4]Use of trade names in this report is for descriptive purpose only and does not constitute endorsement by U. S. Geological Survey.

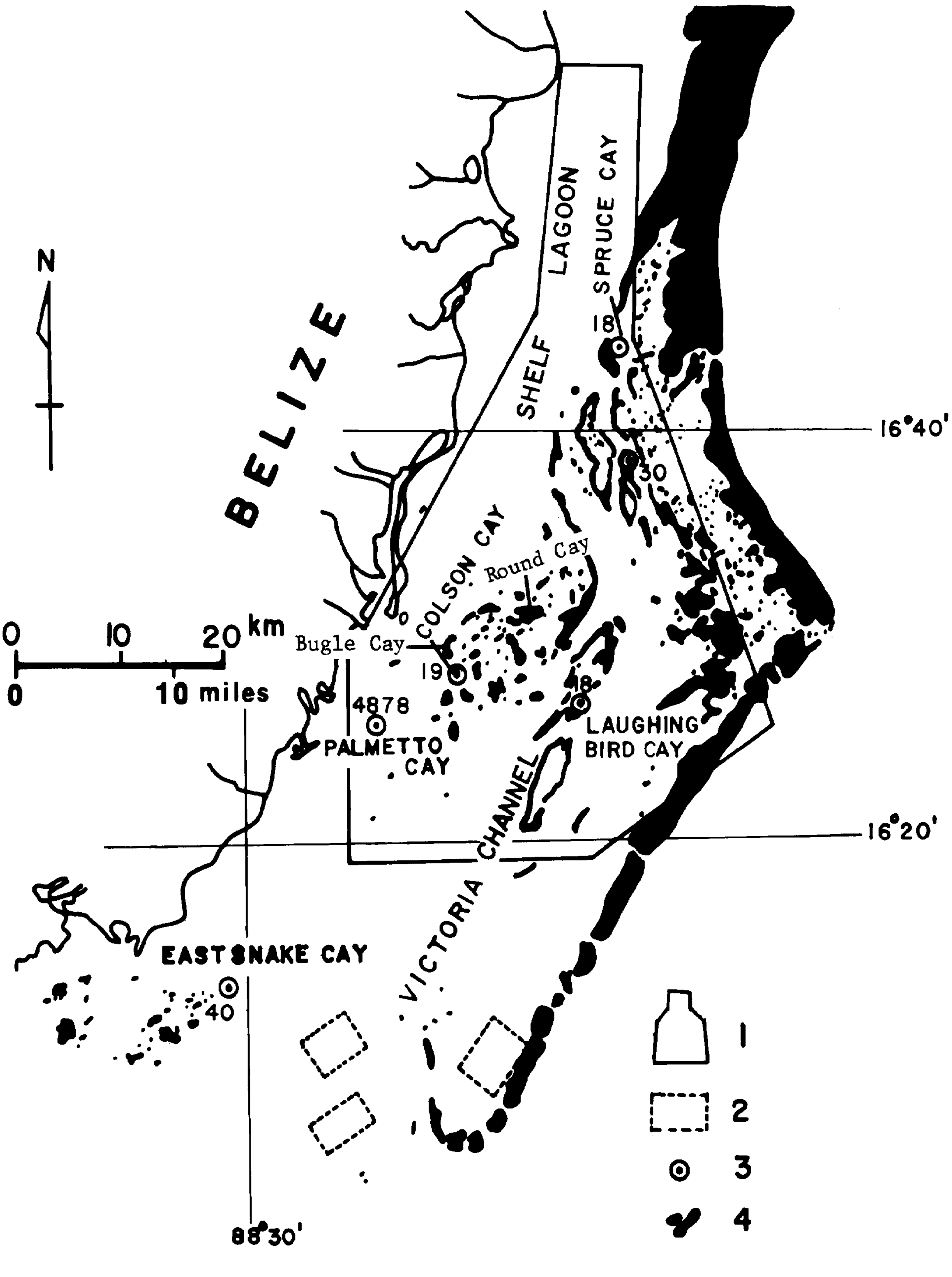

FIG. 1 — Index map outlining the two study areas, and drill hole locations. (1) Area studied in this paper; (2) previous study area (Choi and Ginsburg, 1982); (3) drill holes (Purdy, 1974b; Halley and others, 1977; Shinn and others, 1979 and 1982); (4) shallow shoals (shallower than 3 fathoms).

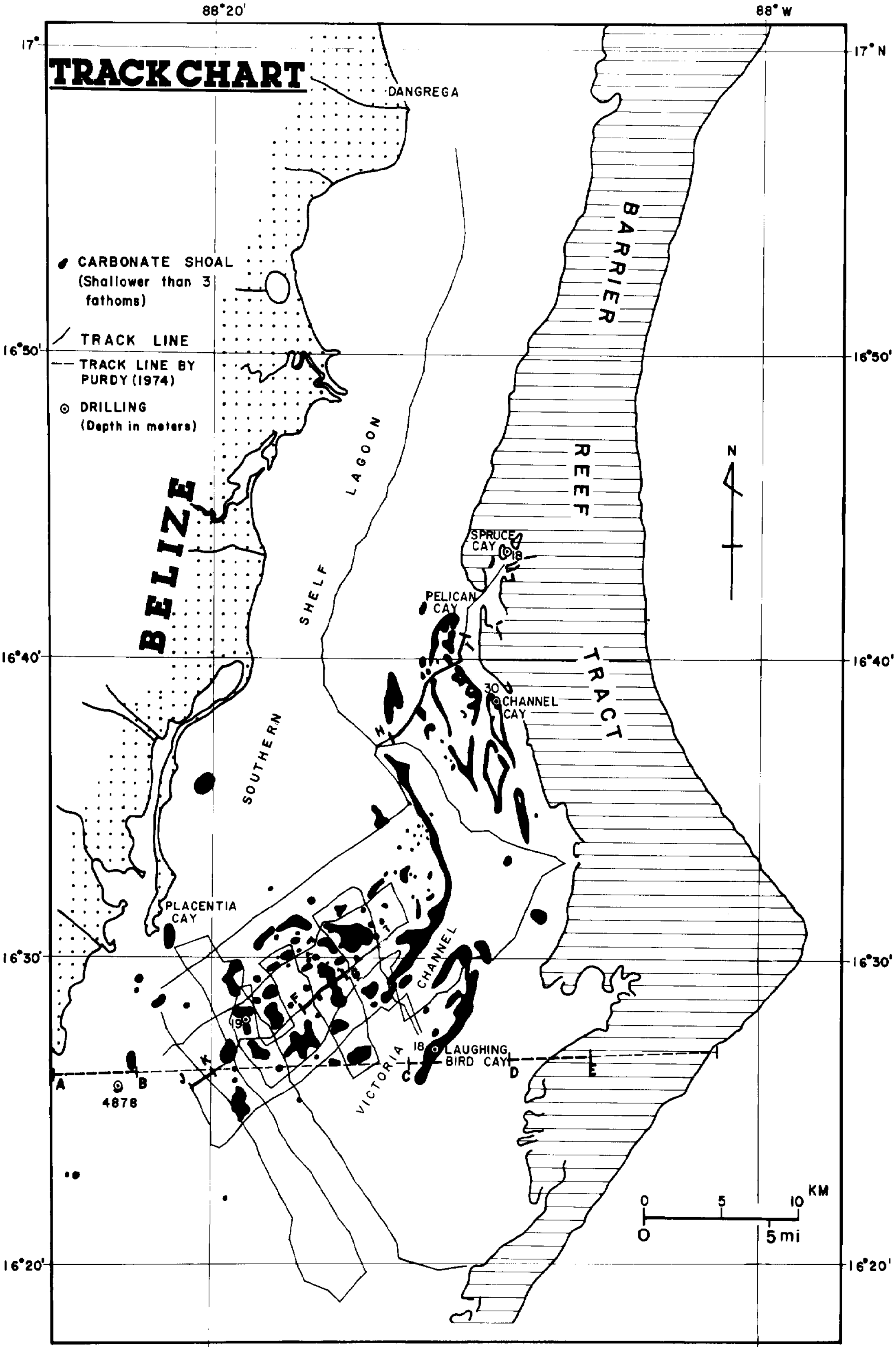

FIG. 2 — Track chart for high-resolution seismic reflection surveys.

is based on the following seismic statigraphy.

Unit T. — The lowest unit, Unit T, is characterized by strong internal reflectors and a deeply incised upper surface (Figs. 3-6). The reflectors are nearly horizontal throughout the lagoon with some minor folding noted near the present shore line (Fig. 3, A-B). Evidence from the Palmetto Cay borehole (Purdy, 1974b) indicates that this unit is composed of shaly limestone.

Unit Pt. — The upper boundary of this intermediate unit is clearly erosional. Repeated erosional events are numerous in the present Victoria Channel area (Fig. 3, C-D-E; Fig. 4), implying that the geometry of Victoria Channel originated by fluvial action during the Pleistocene sea level lowstands. In velocity-corrected (see Table 1) profiles, the paleo-Victoria River is 200 to 216 ft (60 to 65 m) deep in the Pelican Cay region, 316 to 333 ft (95 to 100 m) deep in the Laughing Bird Cay region, and exceeds 466 ft (140 m) depth in the southernmost region (Choi and Ginsburg, 1982). The confirmation of lithology of this unit (Pt) comes from a log of boring at Palmetto Cay in the study area (Purdy, 1974b); terrigenous clastics were recovered from 120 to 300 ft (36 to 90 m) (see Fig. 3).

Unit Pm. — This unit consists of three subunits representing distinct sedimentary events; all unconformably overlie the two lower sequences. The basal part of this unit (Pm) either forms mounds (Pml) or fills minor depressions (Pm2). In the seismic reflection profiles, Pml is characterized by numerous hyperbolic reflectors which obliterate much of the underlying information. This characteristic contrasts with the continuous reflectors of subunit Pm2. Borings by Halley and others (1977) and Shinn and others (1979 and 1982) indicate that Pml is composed of carbonate mounds with coral, probably remnants of lagoonal patch reefs, and that Pm2 consists of intereef sediments.

Unit D. — A unit characterized by short, weak discontinuous reflectors with numerous internal V-shaped incisions overlies the Pm strata. In some places this unit (D) appears to form low relief mounds (Figs. 3 and 5). These characteristics are similar to those of the deltaic sediments mapped in the southernmost lagoon (Table 1; Pt2 subunit by Choi and Ginsburg, 1982). Because of this and the areal distribution of the D unit (Fig. 7), the sediment is also interpreted to be deltaic.

Unit H. — The uppermost acoustical unit (H) has a distinctive reflector pattern similar to that of the Pm (reef-interreef) unit. H unit is divided into mounds with steep flanks (Hl); basin-filling sediments with weak, continuous internal reflectors (H2); and lenticular sediments that form a gentle bottom-surface topography (H3 in Figs. 3 and 6) in nearshore areas of the lagoon. The mounds are clearly reefs; basin fills are interreef sediments; and lenticular sediments are marine sand bar sediments. Thickness of the Holocene reef mounds in the study area ranges from 40 to 63 ft (12 to 19 m) (Halley and others, 1977; Shinn and others, 1979; Purdy, 1974b), thickening toward the southernmost lagoon where they are as thick as 83 to 100 ft (25 to 30 m) (Purdy, 1974b; Choi and Ginsburg, 1982).

The seismic stratigraphy established in the southernmost Belize Lagoon by Choi and Ginsburg (1982) is largely applicable to the south-central lagoon. Seismic profiles taken across the Pelican Cay (Fig. 4) and Victoria Channel (Fig. 3) demonstrate that the Pleistocene reefs have grown on topographic highs formed by paleo-river systems established during the lowered sea level (Fig. 7), and the Holocene reefs have in turn grown on these late Pleistocene carbonate highs. No faulting was observed in records that could have caused rhomboidal reef distribution. The restored Victoria River ran south, joined by numerous tributaries along its course, and flowed into the present Gulf of Honduras (Fig. 7; Choi and Ginsburg, 1982). Therefore, the shapes of rhomboid and long-sinuous forms were determined by underlying river morphology rather than by fault-dominated karst morphology as Purdy (1974b) inferred.

The cluster of reefs and carbonate shoals in the coastal lagoon area (viz. Bugle Cay, Round Cay, etc in Figure 1) result from complex depositional and erosional events in the Quaternary (Fig. 7): paleo-rivers, deltas, old carbonate mounds, and marine banks or bars.

Although the lithology of each unit must be confirmed by core boring, the seismic stratigraphy supports the model of Choi and Ginsburg (1982) and Choi (in press), and suggests the location of late Pleistocene and Holocene lagoon reefs was basically controlled by coastal plain fluvial processes during times of lowered sea level.

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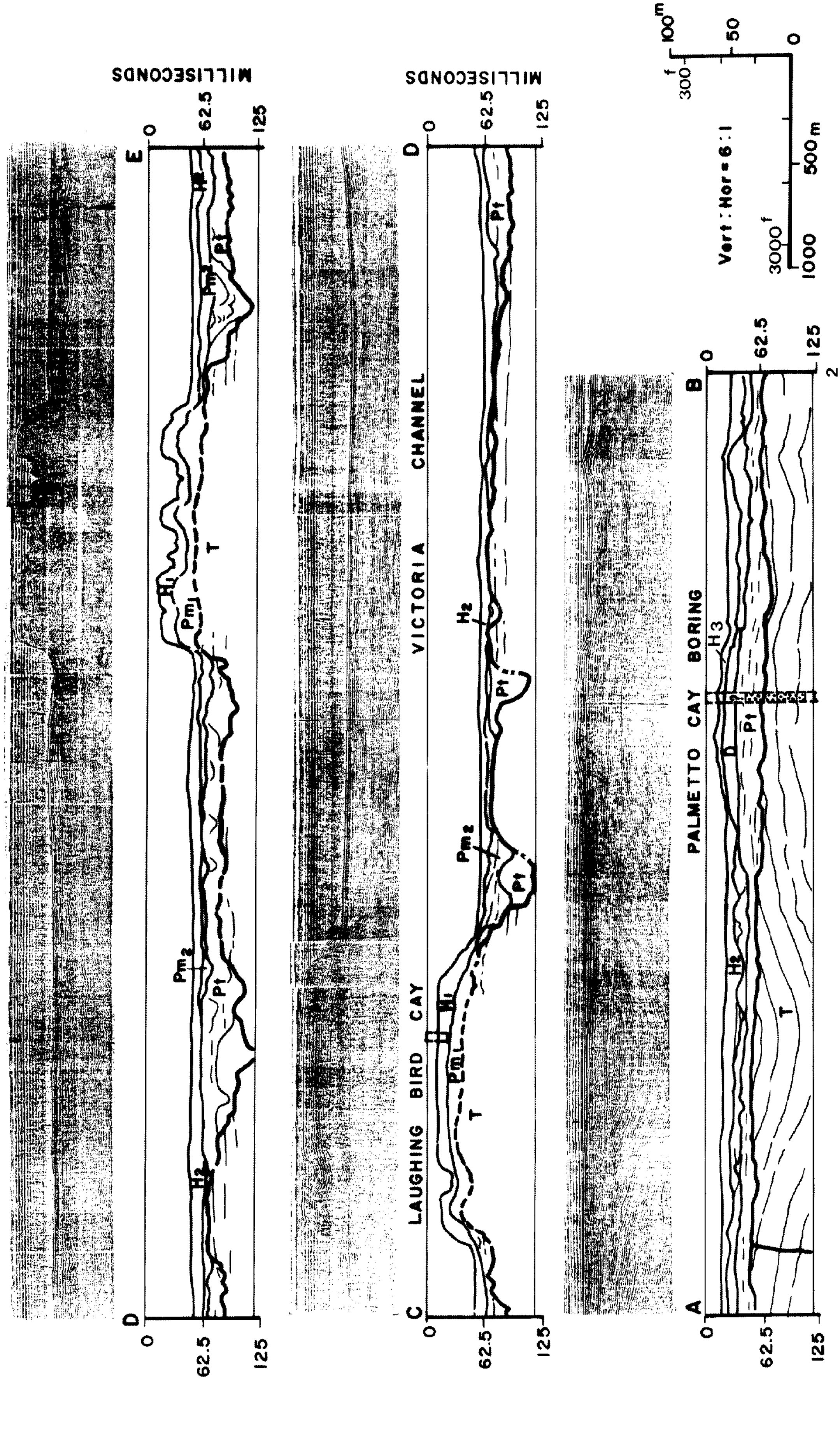

FIG. 3 — Reinterpreted sparker seismic profile (line J of Purdy, 1974b). For location of track line see Figure 2.

TABLE 1. Seismic stratigraphic units of southern Belize Shelf.

Tentative Age		Southernmost Lagoon (Choi and Ginsburg, 1982) Stratigraphic Unit	Thickness (m)	Estimated Lithology	South-Central Lagoon (This Paper) Stratigraphic Unit	Thickness(m); (Assumed velocity)	Estimated Lithology
QUATERNARY	HOLOCENE	H_1; H_2	15-30; 3-10	Reef*; Inter-reef sediments	H_1; H_2; H_3	14-19 (2.2); 2-10 (1.5); 4-6 (1.5)	Reef*; Inter-reef sediments; Marine bank/bar
					D	3-6 (1.7km/sec)	Deltaic sediments
	PLEISTOCENE	Pm_1; Pm_2; Pm_3	18-30; 10-20; 5-10	Reef*, bank; Inter-reef sediments; Marine channel fills	Pm_1; Pm_2	15-20 (2.2); 6-16 (2.0)	Reef*; Inter-reef sediments
		Pt_3	0-45	Fluvial sediments	Pt	30-59 (2.0)	Siliciclastics, fluvial sediments (channel fills, fluvial plain sediments)*
		Pt_2	0-32	Deltaic sediments			
		Pt_1	15-90	Fluvial sediments*			
TERTIARY		T_3	+32	Limestone or shaley limestone	T	+100 (2.5)	Limestone and/or Shaley limestone*
		T_2	+100	Shaley limestone*			
		T_1	+160				

* Drillings at East Snake Cay and Palmetto Cay recovered these lithologies (Purdy, 1974a, 1974b)

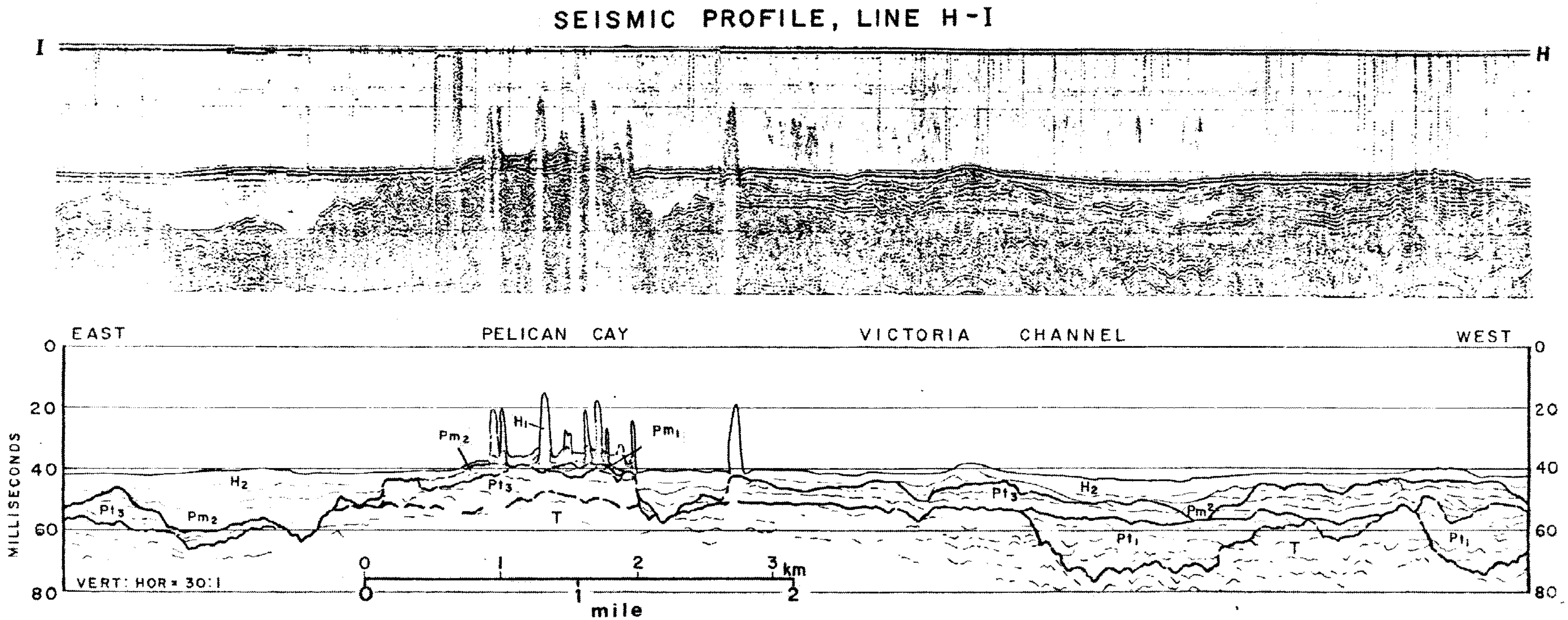

FIG. 4 — Uniboom seismic profile across Pelican Cay and Victoria Channel, and its interpretation. Note erosional lower boundary and thick internal reflectors of Pt unit, suggesting that the Pt unit is composed of fluvial sediments.

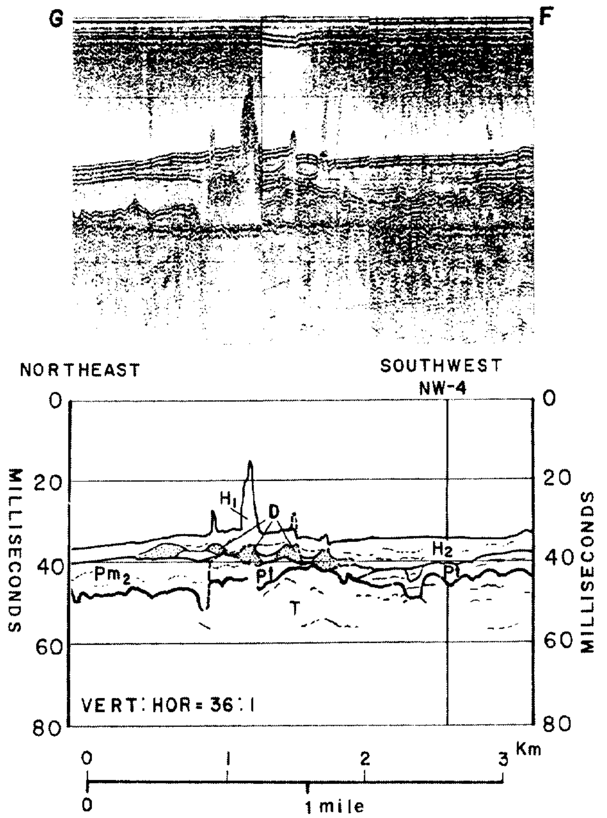

FIG. 5 — Uniboom seismic profile (line NE-3) showing acoustic natures of deltaic sediments (D), channel fills (Pt), and other marine sediments.

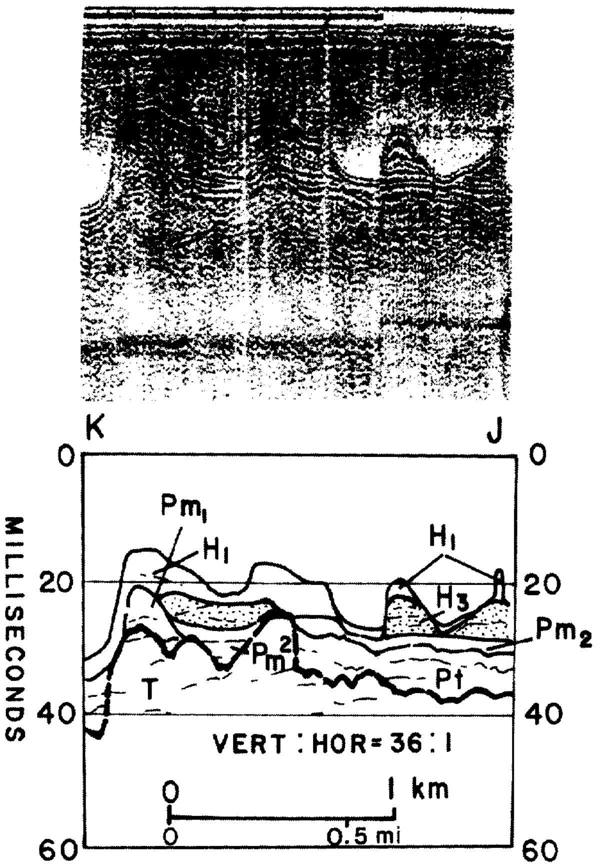

FIG. 6 — Uniboom seismic profile showing topography and acoustic characteristics of marine sand bar. Note reefs (H1) growing on top of H3.

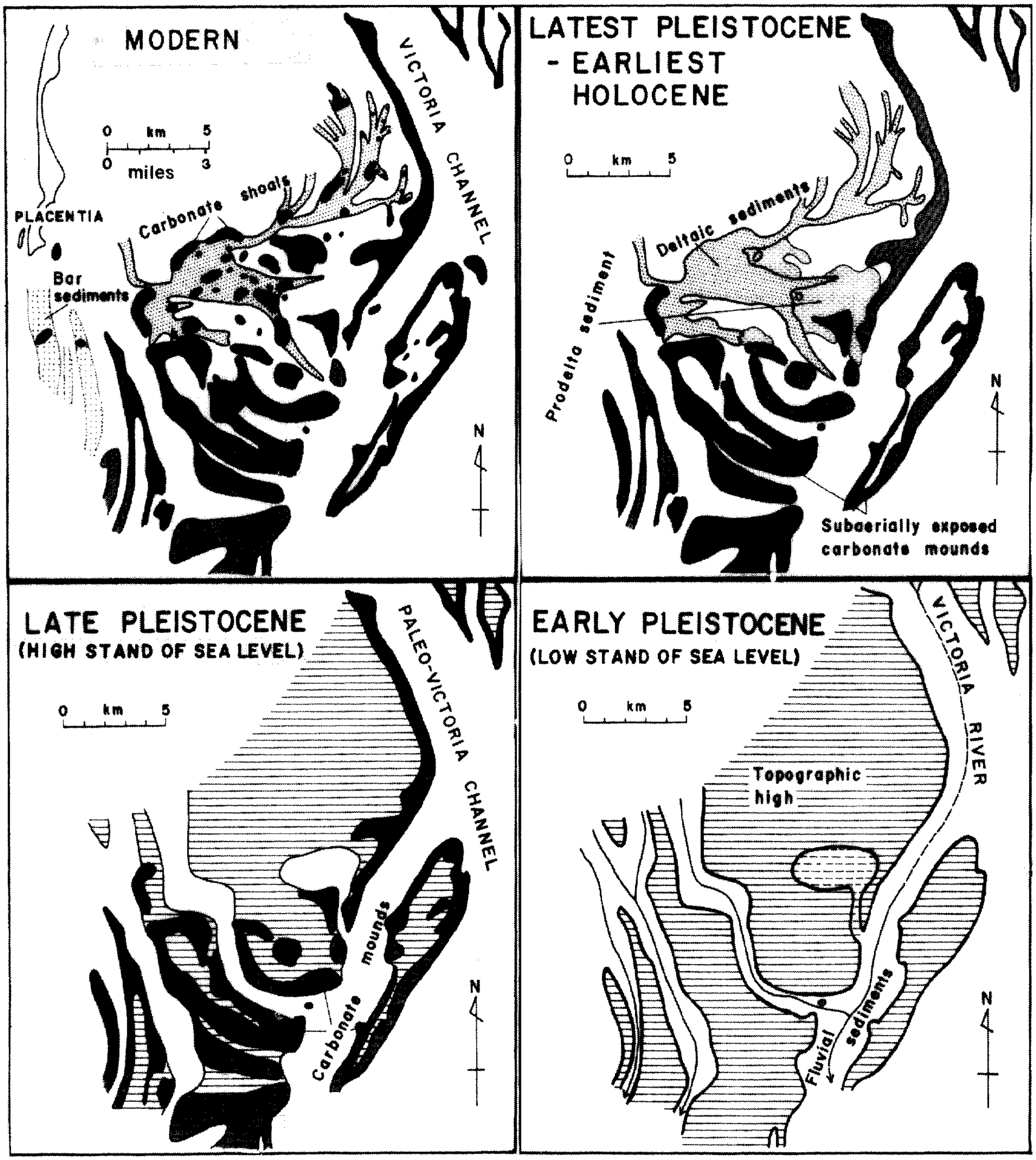

FIG. 7 — Reconstructed paleogeography of south-central Belize Lagoon during Quaternary showing foundations for late Pleistocene and Holocene reefs, transgression sequence, and variety of foundations available for Holocene reef development.