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NOTE

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Structural termination of the southern end of the Belize Barrier Reef

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Background

There is widespread agreement that the Holocene reefal carbonate shoals of the Belize Southern Shelf Lagoon are predicated on antecedent topography but there is disagreement on the origin of that topography. Purdy (1975a) interpreted the antecedent topography as largely a product of structurally directed karst erosion. Subsequently Haley et al. (1977) recovered pre-Holocene antecedent coral limestone in a borehole beneath a patch reef in the Southern Shelf Lagoon and suggested that Pleistocene reefs probably formed antecedent topography beneath many patch reefs in the central and southern parts of the Belize shelf lagoon. This possibility had been considered previously by Purdy (1975b) who reported the occurrence of similar antecedent coral limestones, but noted that pushing the origin of the Holocene carbonate shoal pattern back to the Pleistocene provided no apparent reason for the origin of the Pleistocene pattern, a problem which Haley et al. (1977) also recognized. With this in mind the occurrence of an onshore Upper Cretaceous karst limestone pattern similar to that of the offshore Holocene shelf atolls persuaded Purdy (1975b) that the antecedent topography was primarily a reflection of karst erosion on an underlying structural framework that was probably older than Pleistocene in inception. The weakness of this argument then, as now, is that there is only one karst shelf atoll analogue on the aerial photographs of the Belize mainland. The reason for this is unknown, nonetheless one example is better than none, but the disparity is puzzling.

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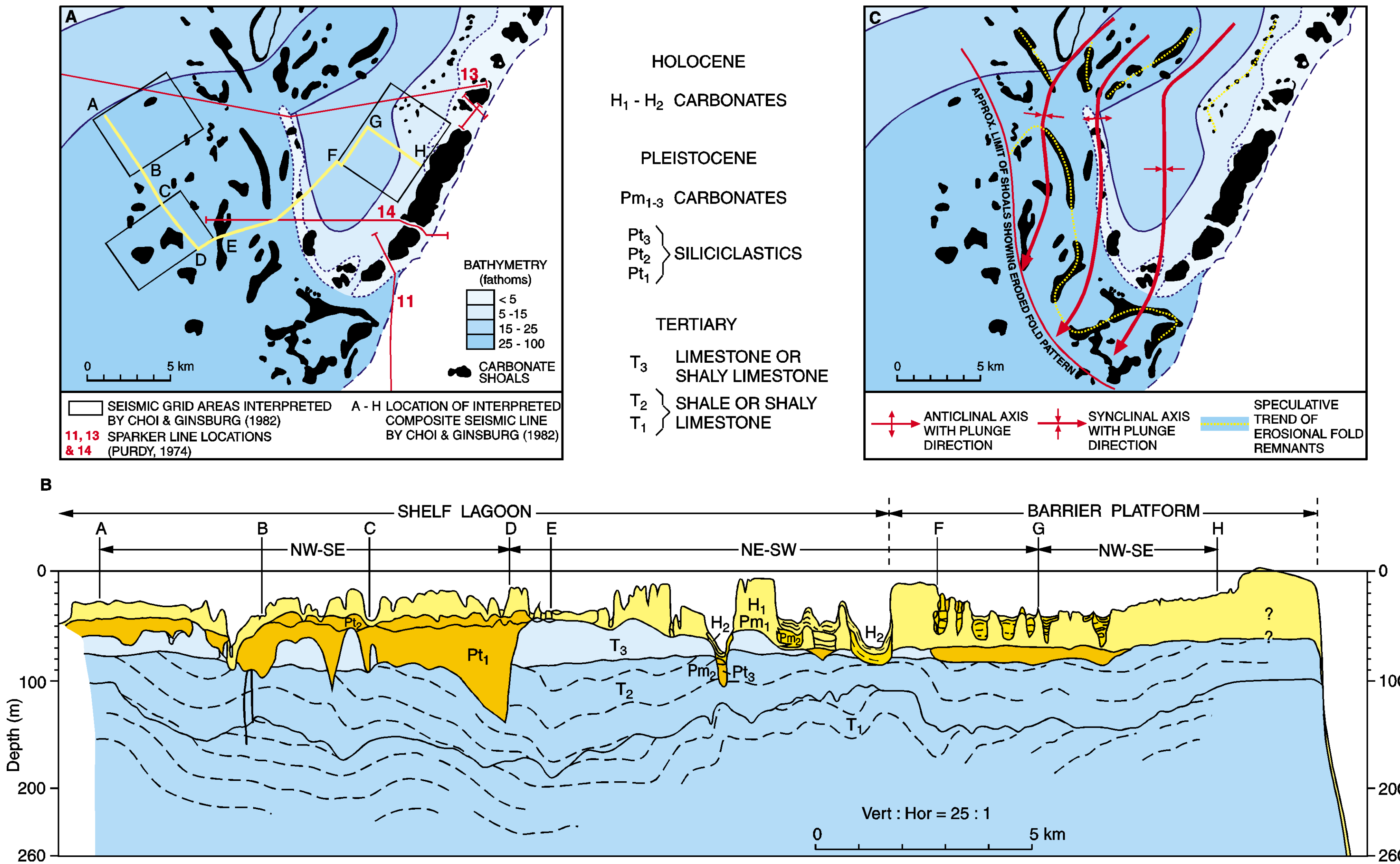
In contrast Choi (1981), Choi and Holmes (1982) and Ginsburg and Choi (1983) accepted the antecedent control for the development of the shelf atolls but preferred to consider that the antecedent control was exercised by fluvial clastics, for which they offered little evidence and failed to consider the previously presented evidence of structural control or to account for the presence of the similar karst landform on the Belize mainland. Choi and Ginsburg (1982) interpreted a series of closely spaced seismic profiles South of the shelf atoll area as suggesting that the Holocene carbonate shoals were growing on siliciclastics that had an alluvial and delta-like morphology. The occurrence of antecedent siliciclastic foundations for two of the carbonate shoals north of the area considered by Choi and Ginsburg (1982) had previously been reported by Purdy (1974a) who considered these to be erosional remnants of folds, particularly in the Snake Cays area.

In 1993 Lara concluded that a comparison between Southern Shelf deep multichannel seismic reflection structures and bathymetry supported the judgement that parts of the bathymetry, including the shelf atoll area, reflected underlying structural highs and lows. Judging by her published seismic records, however, the comparison is hampered by shallow data quality in the upward extrapolation of deep structures toward the bathymetric surface.

Considering the continued interest in the Belize shelf in general and the reason for the location of reefs on that shelf in particular, it seems appropriate to communicate here an observation made on the southern termination of the Belize barrier reef several years ago.

Hook termination of Barrier Reef

The plan view inset (Fig. 1A) of the southern end of the Belize barrier reef shows the distribution of carbonate shoals taken from aerial photographs. These are mostly



Modified from Choi and Ginsburg (1982)

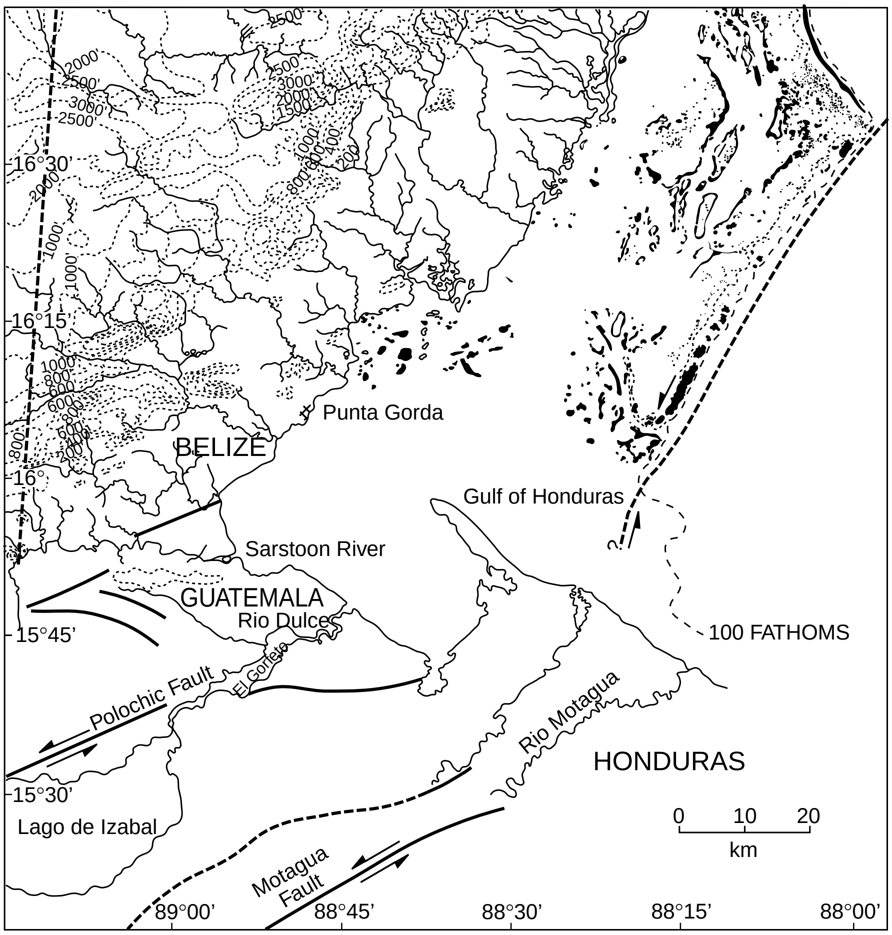


Fig. 2. Compressional strike-slip interpretation of fold geometry at the southern end of the Belize barrier reef. Topographic contours on land are in feet. Black areas designate the distribution of carbonate shoals as determined from aerial photographs. Heavy lines identify faults which are dashed where speculative. The change in strike direction of a left-lateral strike slip fault is shown as creating the compression leading to the generation of folds at the southern end of the barrier reef. The faults shown in Guatemala are from the 1970 Mapa Geológico de la República de Guatemala. How some of these connect with the faults on the Belize shelf is unknown, although it certainly seems likely that there is a change in strike direction from west-northwest onshore to more north easterly on the shelf. Farther south in Guatemala these same faults have a more east-west orientation and appear to change strike progressively toward the northeast as they approach the offshore. Significantly Late Miocene or Pliocene folds have been reported near the mouth of the Rio Dulce in the Gulf of Honduras (Dengo and Bohenberger 1969)

Fig. 1 A Plan-view of the hook termination of the southern end of the Belize barrier reef. The distribution of the reef-bearing carbonate shoals is based on aerial photographs and no depth limit is intended though obviously there is one that is dependant upon the clarity of the overlying water. **B** Interpreted composite seismic line modified from a drawing by Choi and Ginsburg (1982); location shown in Fig. 1 A. The stratigraphy illustrated is that of Choi and Ginsburg (1982). The colour unification of the Tertiary T1 and T2 units is based on the fact that their respective reflections seem to pass uninterrupted through the unconformity shown separating them in the general *A* to *E* area. It is therefore questionable whether the separating unconformity exists in that area. Similarly, the light blue Tertiary T3 unit seems to be an arbitrary separation from the underlying T2 interval in several places, but particularly in the *F* area of the cross section. This contact is always dashed in the other figures by Choi and Ginsburg (1984) which gives cause for concern as to whether the indicated unconformity separating the two really exists. In addition the plan-view location of *F* relative to its position on the cross section looks like the former should be moved significantly closer to the western edge of the Barrier Platform. There are no well ties to the cross section and the velocities used by Choi and Ginsburg (1982) seem to be a somewhat arbitrary assumption of what the lithologies ought to be, based on vertical lithologic successions encountered by wells on the Southern Belize shelf. The important point however is the synclinal form of the section beneath the hook configuration of the barrier reef. It is difficult to escape the implication that the hook reflects reefal carbonate build-up on the eroded limbs of a syncline. **C** Plan-view interpretation of the fold-based geometry of the southern end of the Belize barrier reef and associated carbonate shoals. A major Pleistocene erosional channel separates the hook termination of the barrier reef platform from the largely parallel line of carbonate shoals to the West and South. Note that more than one fold is involved in Holocene carbonate shoal expression, although the illustrated trend of erosional fold remnants is highly speculative. Faulting is probably also involved reef complexes and the indicated bathymetric relationships demonstrate that the barrier reef terminates southward in the form of a peculiar hook-shaped configuration. Located on this inset is a composite seismic line from which Choi and Ginsburg (1982) have interpreted the geologic profile shown here in colour (Fig. 1B) to emphasize relationships.

Other than colour the only change made to their interpretation is to identify their T1 and T2 units with the same colour rather than the different patterns used to distinguish between them originally. Nothing else is changed from their interpretation, although there are several points of concern noted in Fig. 1B. Of particular concern is the absence of well ties to the seismic they have interpreted, since the assumption as to what velocities to use, particularly with respect to clastics versus carbonates, seems largely predicated on a not very convincing *a priori* assumption as to what the stratigraphic lithologies ought to be.

It is evident from the reflections they have drawn that the underlying T1 and T2 sections are folded and further that the hook-shaped termination of the barrier reef is dictated largely by the eroded limbs of an underlying syncline. Neither of these points were recognized by Choi and Ginsburg (1982), although speculation on this possibility had been published previously without the advantage of significant shallow seismic control (Purdy 1974a). At that time the suggestion was made that the syncline plunged to the north, based on the concept that the acute angle between the strike of wrench-fault generated folds and the responsible fault opened in the direction of wrench fault movement. The disappearance of carbonate shoals to the south, however, makes it seem more likely that the barrier reef syncline plunges southward (Fig. 1C). There is also more than one fold involved (Figs. 1 B and C), and it seems probable that faulting is also present, although no faults are indicated by Choi and Ginsburg (1982) on the interpreted seismic line.

Regional considerations

On the shelf area immediately to the northwest, Lara (1993) has provided evidence of Pliocene or younger southwest-northeast trending divergent wrench structures. According to Lara (1993), compressional stresses appear to pre-date normal faulting and compressional features seem to occur where their are minor changes in strike along a strike-slip fault. Presumably the barrier reef syncline reflects the same tectonic control, in this case perhaps reflecting a major north-easterly shift in strike direction from that of the west-northwest trending left lateral Polochic-Motagua fault zone as it heads into the offshore area of the Gulf of Honduras (Fig. 2).

Elsewhere on the Belize shelf, faulting rather than folding predominates (Lara 1993), and in some places the compressional features have been completely bevelled by erosion and have had no influence on overlying bathymetric relief (see for example Purdy 1974a, Fig. 21). In contrast, the bathymetric expression of eroded compressional folds in the hook area of the Belize barrier reef perhaps reflects the relative difficulty of marine wave planation in removing cemented carbonate versus uncemented siliciclastics from a previously subaerially-exposed surface.

Regardless of this point, the importance of eroded, wrench-generated compressional features in contributing to the distribution of Holocene reefal carbonate shoals on the Belize shelf seems to be demonstrated on a local scale, and perhaps merits further attention on a more regional basis.

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