Deep Structure and Evolution of the Gulf of Mexico Basin, Based on 15-second Record Seismic with 2-D Pre-stack Depth Migration, and Risking a Frontier Hydrocarbon Play in the Sub-salt Foldbelts

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Interpretation and mapping of new regional 15-second record seismic grids in the Louisiana and Texas shelf and slope reveal new details of structure and stratigraphic architecture underneath a massive canopy of allochthonous salt. We present a preliminary interpretation of the structural configuration under the salt. Although interpretation of the depth structure at the Mid-Cretaceous sequence boundary and younger events under the salt is difficult, iterative flattening of successive horizons in time during the interpretation contributes to confidence in the resulting depth mapping. Conversion to depth of the time interpretation files follows a straightforward procedure using isochron and interval velocity layering to develop approximate sub-sea depth contours. Conversion to depth is critical for realistic understanding of the early development and subsequent structural evolution under the salt.

In Walker Ridge, the south-southwest trending structural continuation of the Mississippi fan foldbelt (Fig.1) underneath the salt is best imaged on prestack depth migrated long regional lines. Attractive depth structures, now largely leased, represent a frontier sub-salt opportunity currently widely recognized in the industry. The mapped structures apparently do not continue to the west to connect with the Perdido foldbelt (Fig.2) in Alaminos Canyon. This reinforces earlier suggestions that the formation of the two fold belts occurred in two separate events, one in the Oligocene (Perdido), and the second in the Miocene(Mississippi fan). Conversely, in Keathley Canyon, a relatively unstructured sub-salt section can be mapped with little if any similar compressional deformation. Most attractive plays here are truncated against deep-rooted salt walls that may provide

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migration pathways from buried source rocks of lower Tertiary and Mesozoic age.

We attribute the location and orientation of the foldbelts to the original seaward depositional limit of Louann salt (Fig.3) coupled with the gradual migration of Cenozoic depocenters from the west(Oligocene) to the east (Miocene). Compressional structures in the Port Isabel foldbelt(Fig.4) may have a somewhat different origin; high-angle reverse faults with complex associated faulting contrast sharply with the more symmetrical double-plunging anticlines in the Perdido and Mississippi fan foldbelts. There is good evidence on the newer seismic data for a deep structural detachment underlying the western Port Isabel growth fault systems. This detachment surface appears to tie back to the listric fault systems offshore North Padre Island and Mustang Island. Back-to-back or “tee-pee” structures, in may respects identical to those in the salt-free shelf and slope offshore Nigeria, may be a result of less salt in the original depositional package in this part of the Gulf of Mexico. More regionally, original salt thicknesses of 4 km or more seem to have been isolated to an east-northeast trending depo-trough. Thick salt later became remobilized to form allochthonous salt sheets. From the Sigsbee scarp, the sheets thicken to the north and northwest, largely limiting the currently practical sub-salt exploration play in the vicinity of the Sigsbee scarp to a zone about 20-30 km behind the scarp or its buried equivalent.

The structural evolution of areas of thinner salt farther north of the Sigsbee scarp(Fig.5) appears to be related to the complex interplay between slope sedimentation and ductile salt flow. Attractive exploration targets between 5000 and 7000 meters sub-sea are widespread.

Still unresolved are 1) the nature of the connection between the fold belts and the relatively unstructured section at deep levels in the upper and shelf, 2) the lithostratigraphy of the pre-salt section and 30 the influence or lack of influence of basement structures in the overlying Mesozoic and Cenozoic structural complexes. With respect to evaluating and risking the sub-salt foldbelt play(s), the lack of reliable seismic hydrocarbon indicators, the lack of well control and the large number of individual structural prospects suggest modifications of traditional approaches are required The normal critical parameters:″Does the play even exist,?” must all be evaluated as quantitatively as possible. The Neptune discovery in Atwater Valley and the BAHA discovery in Alaminos Canyon suggest the answer to the last question is yes.

Major shortcomings in the current generation of risk analyses are illustrated by the sub-salt foldbellt play. All the seismic uncertainties are typically captured under geological categories, such as probability of structure and hydrocarbon trapping. We suggest the differences in uncertainty among projects variously utilizing depth migration, evaluation and modeling of converted waves and multiples are significant and merit independent ranking as well.

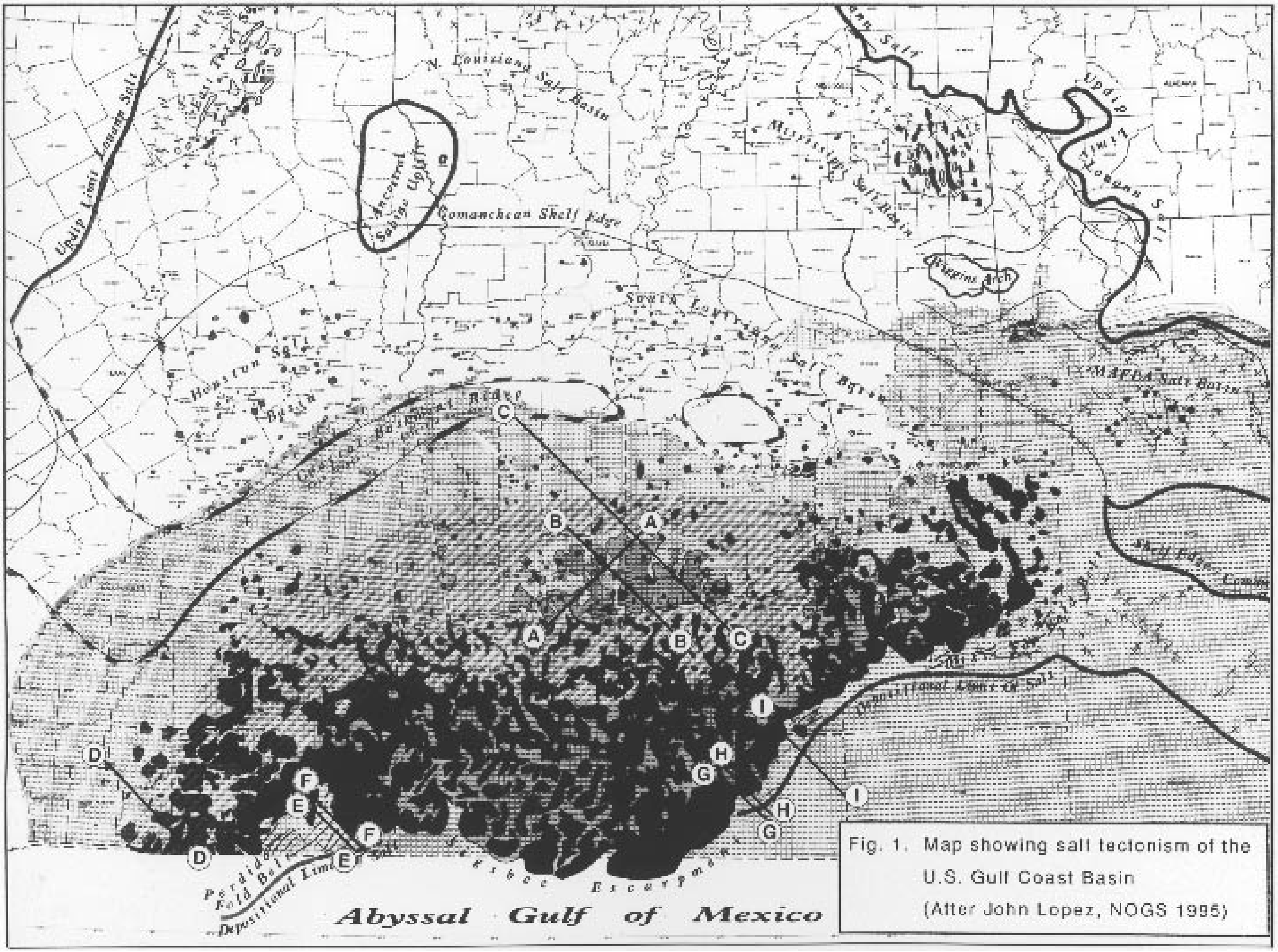

Figure 1 Map showing salt tectonism of the U.S. Gulf Coast Basin (After John Lopez, NOGS 1995

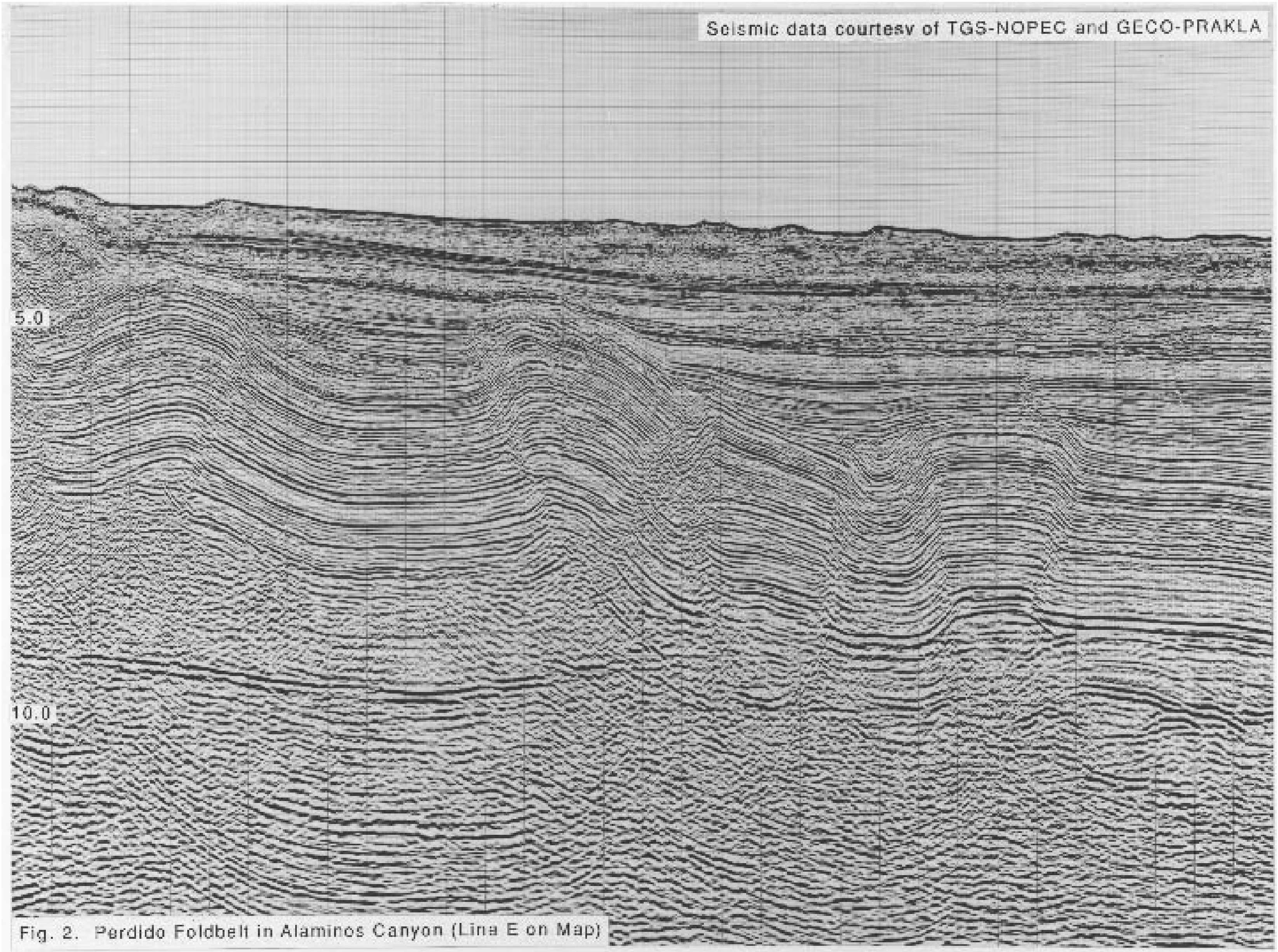

Figure 2 Perdido Foldbelt in Alaminos Canyon (Line E on Map) Seismic data courtesy of TGS-NOPEC and GECO-PRAKLA

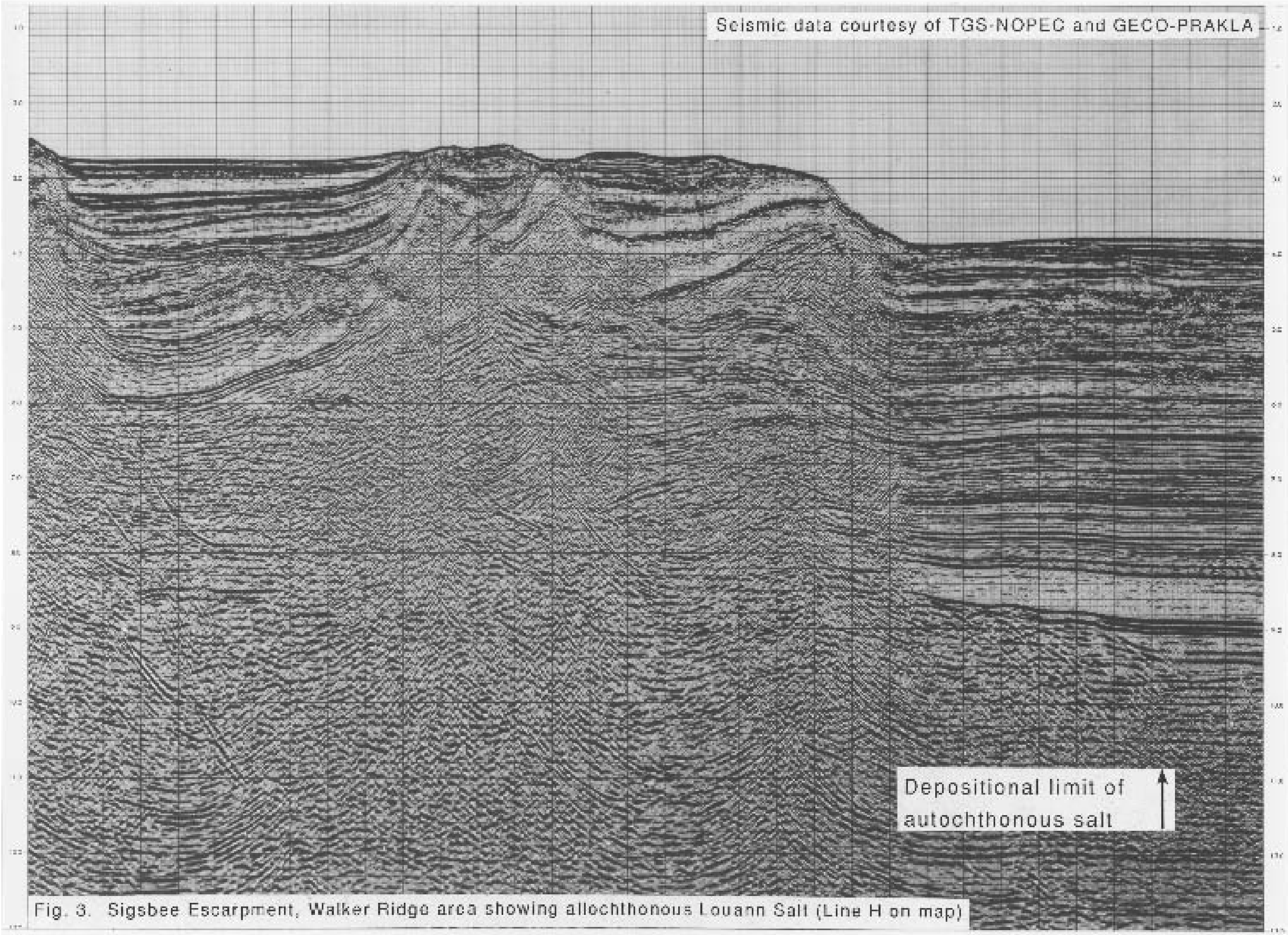

Figure 3 Sigsbee Escarpment, Walker Ridge area showing allochthonous Louann Salt(line H on map) Depositional limit of autochthonous salt Seismic data courtesy of TGS-NOPEC and GECO-PRAKLA

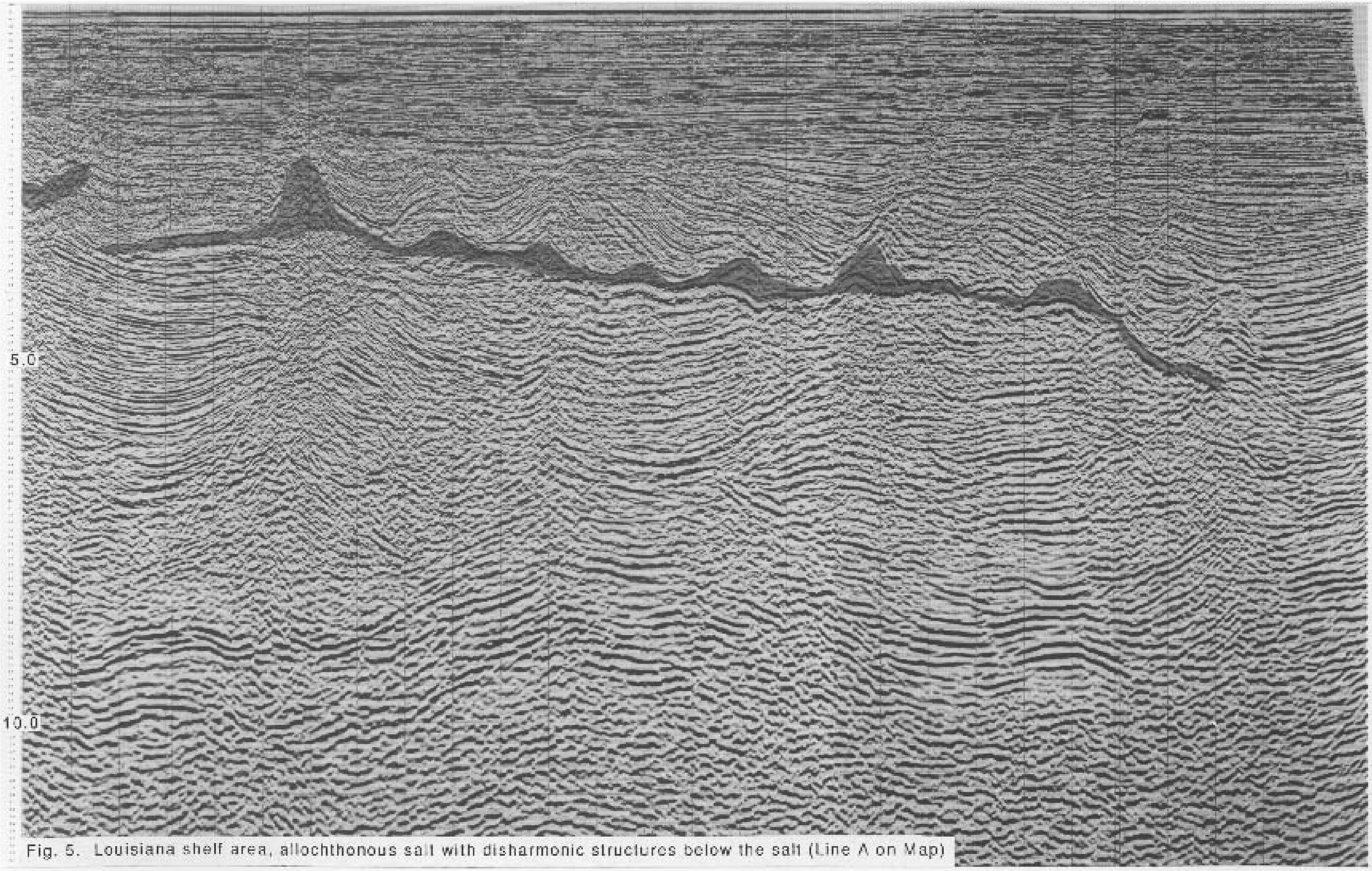

Fig. 5. Louisiana shelf area, allochthonous salt with disharmonic structures below the salt (Line A on Map)

Figure 5 Louisiana shelf area, allochthonous salt with disharmonic structures below the salt (Line A on Map)

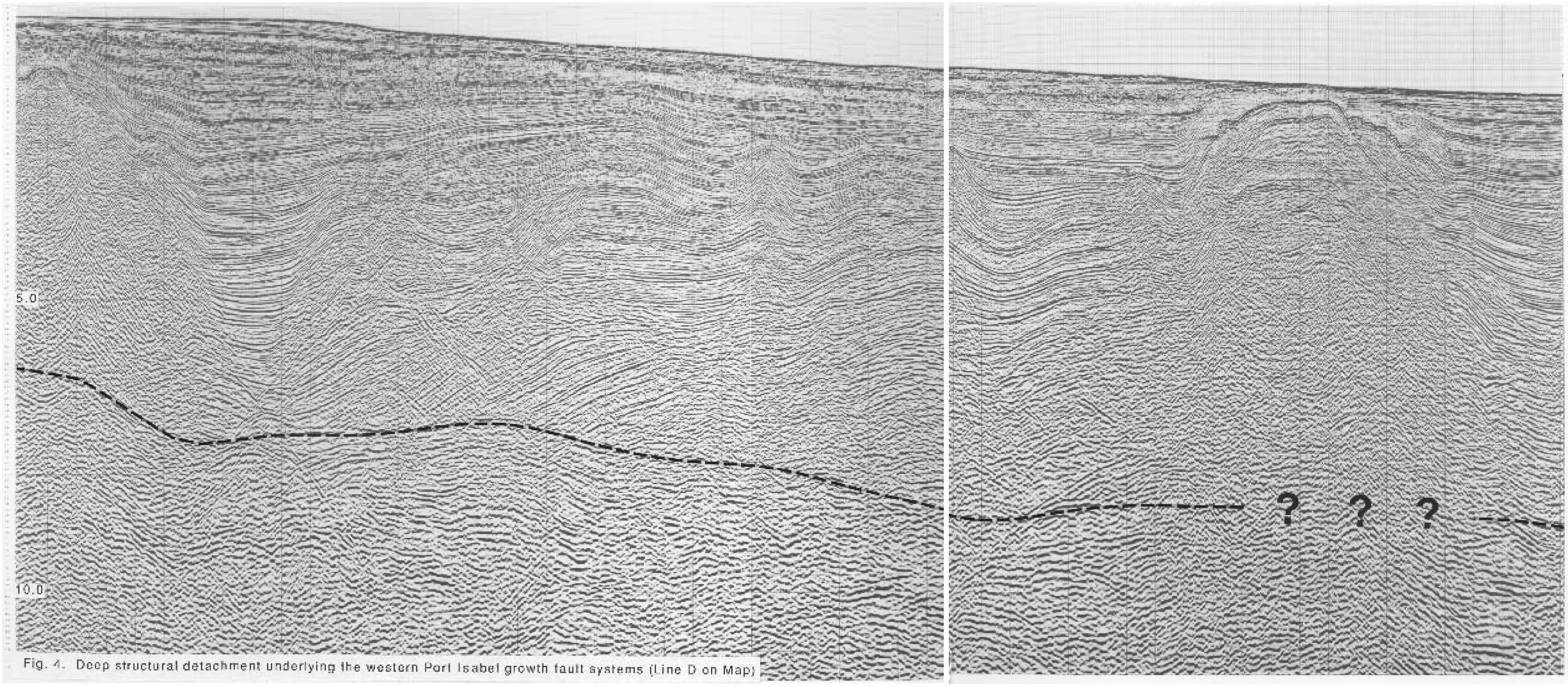

Figure 5 Deep structural detachment underlying the western Port Isabel growth fault systems (Line D on Map)