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Revitalizing the Poza Rica Field: New insights into the Tamabra reservoir and a tale of a paradigm lost

Introduction Models for the Tamabra Limestone of the Poza Rica field initially indicated a 'reef' system downfaulted from its original depositional position alongside the Tuxpan Platform. This was based upon the facies encountered in the most highly productive core of the field (Salas, 1949; Barnetche and Illing; 1956, Gúzman, 1967, Coogan et al., 1972). However, work carried out during the late 1960's and 1970's which integrated new data from the flanks of the field, plus information from 2-D seismic lines which crossed both the field and the Tuxpan Platform towards the NE, resulted in a generally-accepted re-interpretation of the model as an unfaulted slope carbonate system (Viniegra and Castillo, 1970; Enos, 1977, 1985, 1988). In turn, this resulted in the Poza Rica field being recognised as one of the largest slope carbonate fields in the world (Enos, 1985) with consequent widespread implications for this play type and play risk. The concept of the 'Tamabra' play that has emerged, is one of slope carbonates that pinch-out updip into tight, laterally-sealing basinal facies.

Aim We aim to show that detailed analysis of recently-acquired 3-D seismic data over the Poza Rica field and Tuxpan Platform margin (the 'Golden Lane') together with study of selected cores, has indicated that a substantial modification of the present-day understanding of field may be required. The resulting model has more in common with pre-1970 models than with post-1970 models, and in turn, opens up many new possibilities for step-out field extensions to the SW of current production.

Seismic The new 3D survery reveals that the Poza Rica field and Tuxpan Platform are separated by a basin (Fig. 1a), contrary to existing models which show a continuously dipping slope system between the Tuxpan Platform and the eastern limit of the Tamabra reservoir. Seismically-defined units are present in this basin which are not developed over the Poza Rica field itself. Additional stratigraphy is seen within the Tamaulipas Inferior and Tamaulipas Superior formations, parts of the Tamabra Formation, most of the Agua Nueva Formation and parts of the San Felipe Formation (Fig. 2). The Mendez Formation appears to be universally present but thins over the crest of the Poza Rica field. The Poza Rica field is therefore developed upon a paleohigh that had topographical elevation throughout the Cretaceous; it appears that this high plunges to the SE, and that there is also some expression of another basin at the limit of 3D acquisition to the SW side of the field (between the Poza Rica and Tajin fields). Within the Poza Rica field, the Tamabra Formation shows a variety of seismic facies. There are strong, parallel to mounded seismic facies over the main productive area (Fig. 2), passing into relatively opaque and topographically elevated seismic facies (Fig. 3), prior to descending into adjacent basins via stronger amplitude but often chaotic/lensoid/mounded seismic facies. The belt of opaque/elevated geometries have been mapped where they occur in the SE part of the field, these can be seen to be trending SW-NE on the SW margin of the 3D cube (Fig. 1a). Seismic coherency maps of the top-Tamabra (Fig. 1b) have also revealed 100-200m diameter ring-shaped structures which are best developed on the slopes of the Poza Rica field. Such features are analogous to karstic doline features reported from the Italian field of Rospo Mare (e.g. Heritier et al., 1991).

Core and Lithofacies A thorough revision of core and core descriptions in internal reports and in published literature, reveals that the central part of the Poza Rica field, is dominated by thick packages of rudist rudstone facies, whilst breccia deposits are mostly encountered on the SE and NE flanks of the field. There is no evidence that there is any significant increase in interbedding of basinal facies towards the SW of the field; indeed, many wells with almost completely cored sections on the extreme (present) SW limit have very coarse-grained breccia or rudist rudstone facies with under 10% of fine-grained basinal sediment. In addition, the wells drilled outside the field limit in the Coatzintla area to the SW, are uncored. These wells show broadly similar log stratigraphies as wells within the field, and contain porous/permeable intervals as indicated by porosity and SP logs (Fig. 4). One well updip and one well downdip of the seismically-opaque and seismically-elevated facies were selected for core logging (Fig. 5). The results of this exercise show conclusively that the updip well is dominated by massive rudist rudstone facies (Fig. 6), whilst the well in a downdip position, is dominated by massive pebble to cobble grade or coarser breccias which often consist of reworked rudist framestone (Fig. 7). In addition, in the updip well, are numerous, irregular erosional surfaces which have been covered in pale grey-green claystone, which can also be seen to infill fissures that descend from the erosional breaks (Fig.6). These surfaces are consistent with interpretation of karstic horizons and karstic fissures.

Interpretation Our interpretation of the above data, suggest that early models for the field were largely correct in that they interpreted the central, most productive, part of the field as an in-situ platform, although these models are still flawed in that they assume chronostratigraphic equivalence of the Poza Rica 'reefs' with the Tuxpan Platform. Subsequent models (Viniegra and Castillo, 1970; Enos, 1977, 1985) dismiss the 'reefal' model probably because these workers focussed on the abundant new data which had just been acquired from the flanks of the field and thus re-interpreted the whole system as a carbonate slope. Our model would suggest that the most productive Tamabra facies both in the Poza Rica field and the Pital y Mozutla field on the flanks of the Tuxpan Platform, largely represent second-order shallow-water lowstand platforms passing downdip into slope deposits, that were deposited during the Cenomanian-?Turonian when the crest of the Tuxpan Platform (and also most other Mexican 'middle' Cretaceous platforms; Smith, 1986; Basáñez et al., 1993) were subject to subaerial exposure and massive karstification. The cause of this event has recently been suggested by Horbury et al. (2004) as being due to early Laramidic uplift of the Gulf continental margin, which in turn was a consequence of Pacific margin subduction which re-commenced in the Aptian (Pindell and Kennen, 2001). We think that the carbonates within the field are dominated by three 3rd order highstand systems tracts, whilst the full sequence stratigraphy (highstand, lowstand and transgressive systems tracts) are only complete in the basin between the Poza Rica high and the Tuxpan Platform. Facies in the most productive parts of the high are most closely comparable to grainy, sand-rich rudist margins as known from both the Sierra de El Abra (Griffith et al., 1969; Minero, 1988; 1991), and Cretaceous platform margins in Italy (Carbone and Catenacci, 1978; Eberli et al., 1993; Di Stefano and Ruberti, 2000) and Arabia (Qamchuqa of the Kirkuk Field; Wilson, 1975 and the Mishrif of Abu Dhabi: Burchette, 1993). On the evidence of both core and seismic facies, facies belts at the historically-defined SW margin of the field, actually trend SW-NE; in addition, dynamic data (mostly well productivities and present-day production) implies that the productive facies should extend further towards the SW. A platform model also much better explains the doline-like features identified on coherency maps as well as the evidence of extensive meteoric diagenesis of the Tamabra Reservoir as presented by Enos (1988).

We have found no evidence that the field passes towards the SW into basinal carbonates; indeed, the likely problem with productivities and Sw ('water invasion') towards the SW may be a consequence of low porosity/microporous platform interior carbonates with high irreducible water (high Sw), just as the centre of the Tuxpan platform is less prospective than its rim (cf. Viniegra and Castillo, 1970). Previous models fail to take into account the very coarse grained nature of much of the sediment right up to the perceived SW limit of the field, which lies some 20-25km from the proposed sediment source on the other side of a basin. In addition, previous models fail to give mechanisms for differences in provenance of sediment 'along strike'. In reality, a pure slope model is not tenable, although we do recognise many of the breccia facies within the field as being of a slope origin.

Implications and applications The correct interpretation of the Poza Rica field important for ongoing field re-activation because it opens up the possibility of extending the field to the SW. There are concerns about increased Sw in this direction, but given the fact that the Poza Rica palaeohigh (and therefore closure) extends to the SW the important issue is finding the 'sweet spots' in which rudist rudstone facies are present with their high macroporosity and therefore high permeability and low Sw, compared to high Sw platform interior microporous facies or low porosity/low permeability 'true' slope breccias. The extent of the rudist rudstone facies belt is at present not well-defined outside of the 3D survey because of the poor quality of the 2D lines towards the SW. Rudist rudstones are thought most likely to be developed as a donut-shaped body of which only the NE side has been drilled. Step-out wells targeted at tracking this zone are planned and are thought to be much more likely to add significant reserves than infill wells within the field, or step-out wells situated in updip (platformal) or downdip (slope) settings. There are also implications for exploration models within this and other basins in Mexico. Many breccia fields presently interpreted as slope carbonates may require re-interpretation as in-situ lowstand platform, or as karst brecciated platform. Additionally, the Poza Rica field presently stands as the largest example of a slope carbonate field in the world; it and perhaps associated fields awaiting re-examination therefore bias the statistical importance of the carbonate slope play system in global terms. Many exploration models have used the field as their principal analog for wildcat wells, therefore re-definition and a better understanding of why the Tamabra play is successful is of paramount importance to global exploration models.

Future work The study was undertaken on a sector of the field in which there are significant lateral changes in both seismic and core facies and in which there were perceived to be opportunities for field extension towards the SW. Further study is required of seismic, wells and cores towards the NW. In the longer term, drilling of step-out wells would be best constrained by extending the 3D coverage towards the SW.

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Figure Captions

Fig. 1a: Location map, showing the Poza Rica field outline, extent of 3D seismic data studied, identified faults (black), and position of opaque seismically-defined platform margin facies and cored wells on either side of the margin. To the NE is the basin axis between the Faja de Oro slope to the NE and the Poza Rica high to the SW.

Fig. 1b: Coherency map of the Top-Tamabra showing areas with rounded doline anomalies.

Fig. 2: Line 700 (SW-NE) showing the paleohigh with mounded features and onlaps, passing into slope and then basin; with clear loss of units by both onlap and truncation.

Fig. 3: Trace 150 (NW-SE) showing the transition from 'Platform' via opaque elevated 'margin' into chaotic 'slope/basin'. The wells in fig. 5 are located on this line.

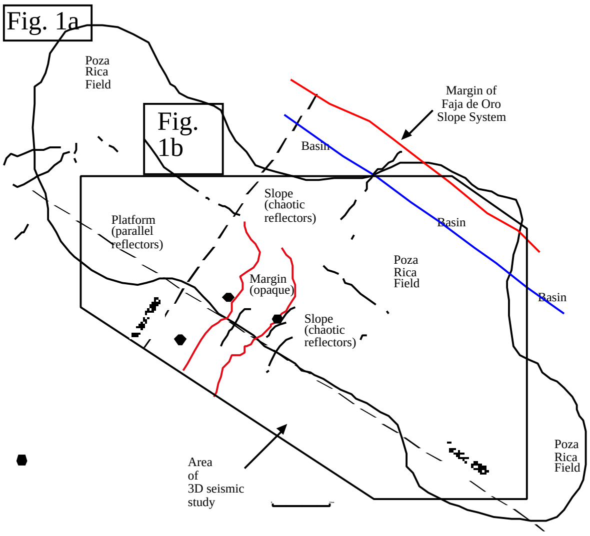


Fig. 1a
Poza Rica Field
Fig. 1b
Margin of Faja de Oro Slope System
Basin
Slope (chaotic reflectors)
Platform (parallel reflectors)
Basin
Poza Rica Field
Margin (opaque)
Basin
Slope (chaotic reflectors)
Area of 3D seismic study
Poza Rica Field

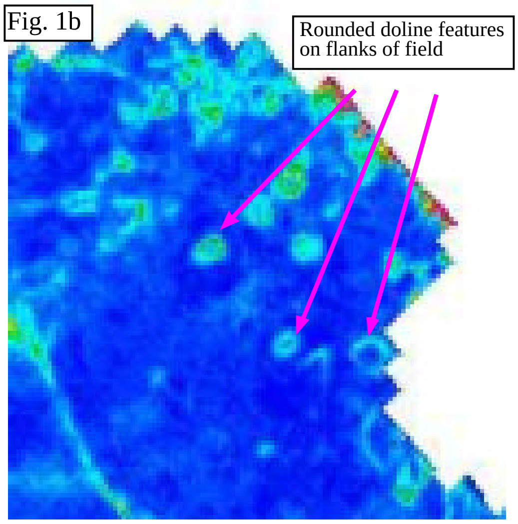
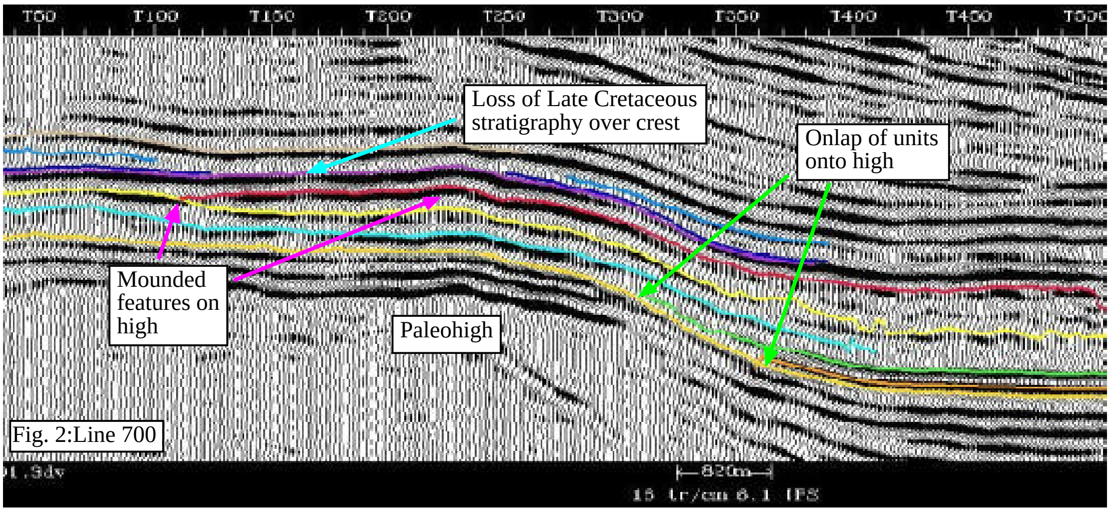


Fig. 1b
Rounded doline features on flanks of field


Loss of Late Cretaceous stratigraphy over crest
Onlap of units onto high
Mounded features on high
Paleohigh
Fig. 2:Line 700

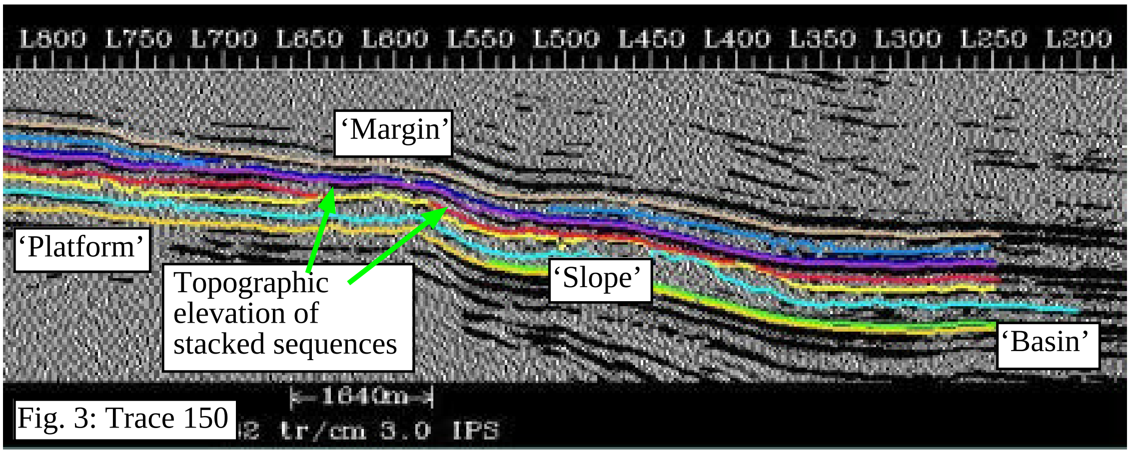

L800 L750 L700 L650 L600 L550 L500 L450 L400 L350 L300 L250 L200
'Margin'
'Platform'
Topographic elevation of stacked sequences
'Slope'
'Basin'
Fig. 3: Trace 150

Fig. 4: Correlation of wells to the SW of the field, tied to the PR-210 well with its good core coverage. Note the similarity of units within the correlation and the SP log behaviour, indicating that porous/permeable carbonates extend some distance SW of the field limit.

Fig. 5: Correlation of cores in the PR-201 well in an updip setting behind the seismically-opaque platform margin, and the PR-389 well downdip to the SE. Blue cores represent rudist rudstone facies, yellow cores represent breccias. Green and brown facies are the volumetrically minor low-energy interbeds.

Fig. 6: Massive rudist rudstone (calcarenite) cut by a sediment filled fissure that descends from an irregular, eroded surface. Interpreted as an intraformational karstic horizon. PR-210, core 9, 2162m.

Fig. 7: Block of rudist reef within the breccia facies of PR-389. No material such as this was recorded updip of the seismically-opaque reefal facies. From Core 6, 2771m

Fig. 6

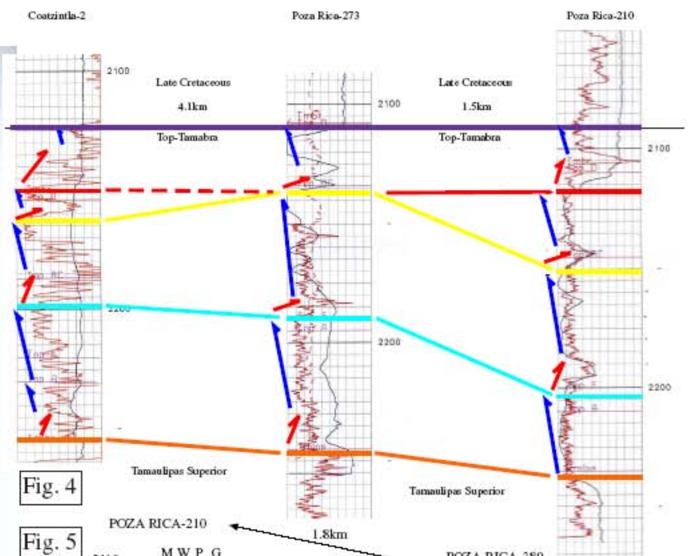


Fig. 4

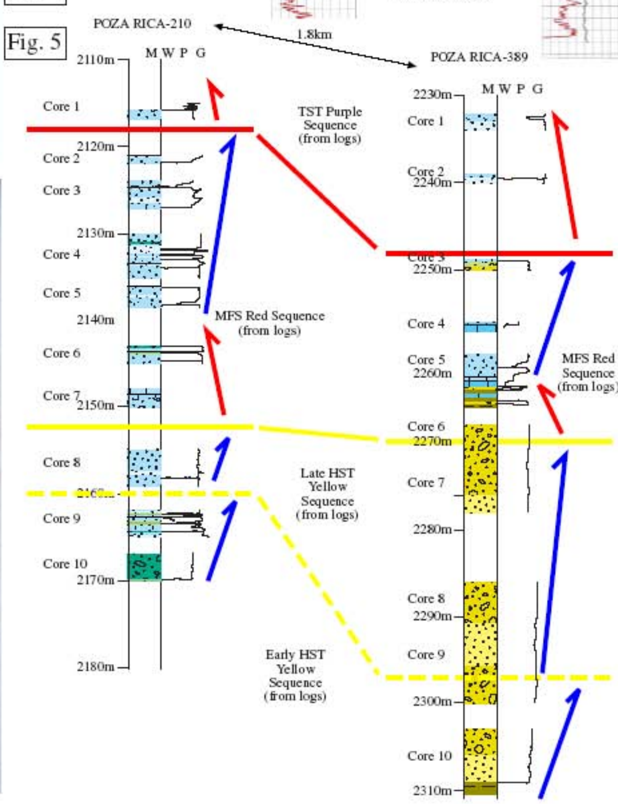


Fig. 5

Fig. 7