Seismostratigraphy Sequence Model of the Rio Grande Cone, Brazil*

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Abstract

The Rio Grande Cone (RGC) has been characterized seismo-stratigraphically as a sedimentary geoform from the Miocene era. It was built offshore, in front of the Lagoa dos Patos and Lagoa Mirim (Figure 1). Sequence stratigraphy permits an approximation of the geological elements in deep water zones. The RGC comprises the shelf to the northwest and the slope to the southeast, including the shelf break. The Cone includes sequences which are thin at the near offset and have a pinched-outer layer at the far offset (seaward) where the sequences are thicker. Faults are well defined in these thicker areas and they cross all of the Rio Grande Cone sequences. It extends seaward and contains fine-grained sediments (mudstones and shale) as its dominant facies.

The analyses and modeling were based on seismic line grids from LEPLAC-IV and the Brazilian Oil National Agency (Agencia Nacional do Petróleo - ANP, Brazil). The survey extended from the end of the shelf to the deep abyssal plain, and attribute analyses assist the identification of anomalies in the seismic data (Figure 2).

Sequence Stratigraphy

According to previous authors, the area is comprised of several sequences that could be determined by the seismic terminations and geometry associated with the chronostratigraphic and biostratigraphic information (Figure 3). The different sequences of the Rio Grande Cone have been identified previously through horizons delineated by seismic reflections from analysis of the Pelotas Basin

and Cone areas for hydrocarbon exploration (Fontana, 1996; Abreu, 1998); at least 12 sequences have been described. Parts of the RGC appear to have hydrate gas reservoir potential.

The Rio Grande Cone is considered a depositional feature formed in the drift phase from the Miocene to the Recent that is more than 4000 m thick. Its megasequences are 50 Ma and can be divided into second and third order sequences (Fontana, 1996). Other authors have used geophysical information (interpretation with some seismic lines) to describe some sequences related to the Rio Grande Cone (Simões, 2004; Rosabela, 2007); sedimentation was considered the dominant process, and subsidence was related to tectonic and eustasic parameters. We assumed that the sequences originated from the Miocene to the Recent. The cone comprised a sedimentary package with different depocenters that were affected by tectonic influences, sediment supply and eustasy (Figure 4).

This interpretation included the definition of a genetic sequence, the nomenclature of system tracts and the timing sequence boundaries for stratigraphic models (Catuneanu et al., 2008). The system tract provided the basic division of the Miocene sequences into genetic packages for the Rio Grande Cone and shows stratigraphic trends according to strata stacking and sea level changes.

Tectono-Sedimentary Evolution of the Rio Grande Cone

The sedimentary supply through the RGC was derived from sediments from the cratonic areas, i.e. Paraná Basin sediments and Serra Geral Volcanic rocks, including sediments of Camaquã and Jacuí River and de la Plata River (Martins et al., 2005). The continuous deposition increased the lithostatic load, starting slip on the master fault, and together stacking the sediments. The deposition continues during this stage, and during the synsedimentary faulting produces slicing of the sequences. Those packages were settled into the master fault, with thick progradational sequences filling as lowstand system regressive deposits, with few structural influences except by the presence of the master fault (Figure 5A). This basal sequence is followed by the retrogradational sequences deposition, which represents the transgressive system (Figure 5B). This sequence is crossed by faults located at the northeast of the cone area. Sediment accumulation during the Tertiary show their maximum sediment supply during Middle Miocene. Pliocene to Recent accumulation registered a sedimentary charge lower than earlier periods. The last accumulation corresponds to the highstand regressive system (Figure 5C).

To the southern Brazilian offshore, in the far offset, it is possible to identify folds and faults propagration and reverse faults; they could be described in this work as a fault system not as well developed as those from the extensional system. This characteristic of faults with little size does not allow modeling (Figure 5D). The fault geometry of kilometer-scale results from interaction of tectonic style, mass movement and submarine setting. One of the principal structural elements is characterized by a listric fault associated with a fragile zone, with vertical and semi-parallel fractures, that leads the main structural dip to the southeast. Thus, these faults are posterior to the deposition with vergence toward the southeast and are of Pliocene age. The Rio Grande Cone morphology is

influenced by an offshore fault plane steeply dipping toward the shelf where it is truncated by another plane with east-southeastern vergence; this plane flattens seaward. In this principal fault convergance, another ones planar failure surfaces that propagates across it to the southeast. The detachment is an extensional plane of 20 km with a width of 70 km.

Conclusions

These analyses include geomorphologic elements that integrate structural and stratigraphic interpretation, demonstrating the influence of tectono-stratigraphy on the package sequence geoform, which was affected by tectonics, sedimentary supply and isostasy. Tectonic subsidence played a very important role during the formation of the Rio Grande Cone, mainly by overloading sediment (due to a very high sedimentation rate) and extensional faulting in the proximal and intermediate areas. In the distal portion, reverse faults are the main characteristics of the RGC.

The generation of three-dimensional models offer a good understanding of the structural trends, fault types, features, geoforms and the relationships between subsurfaces and therefore provides the necessary information to estimate the sediment supply volume and outline the hydrate gas reservoir in the RGC.

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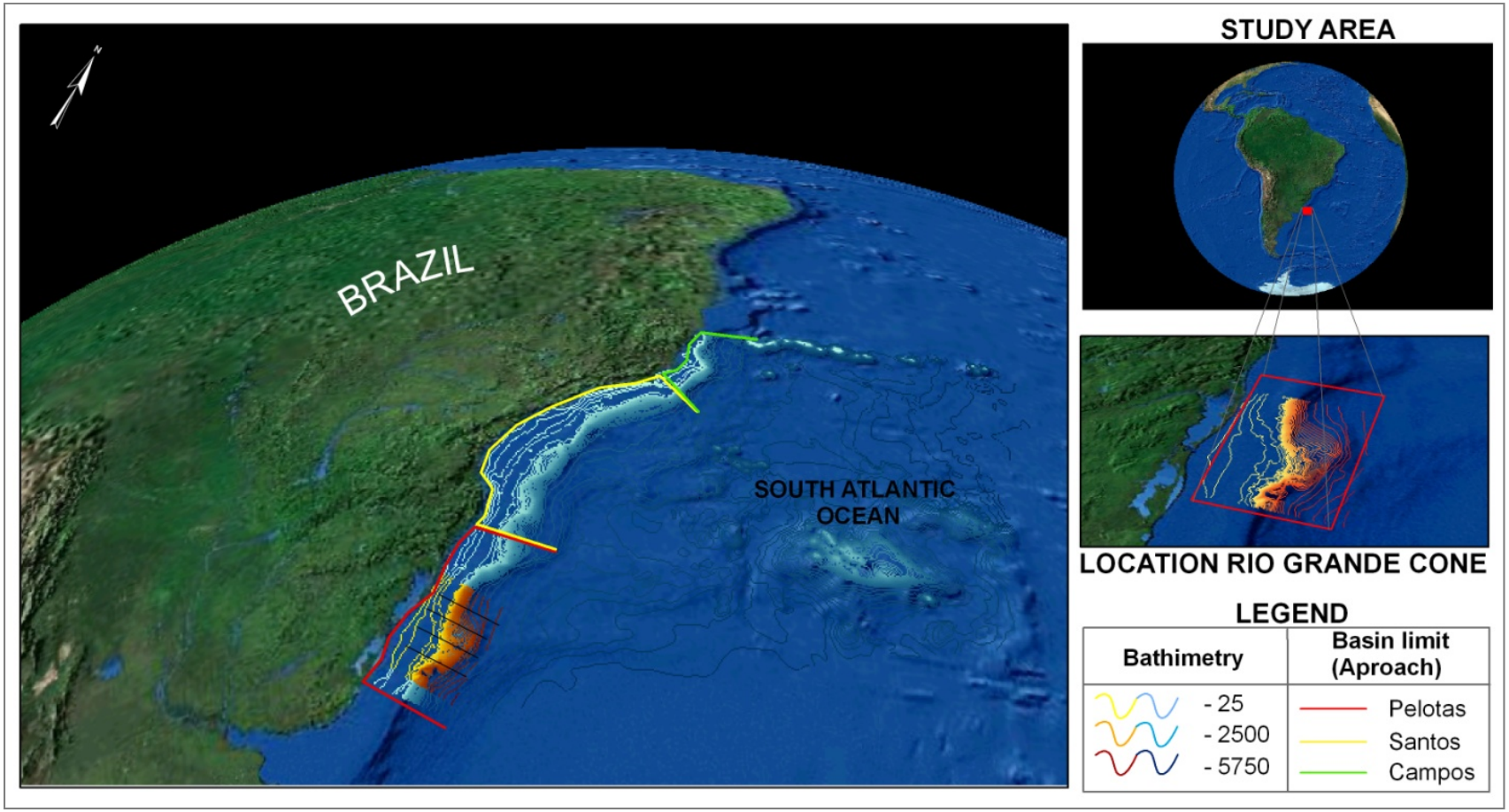

Figure 1. Image showing the study area and Pelotas Basin. The location of Rio Grande Cone shows the survey grid with seismic lines. The image shows geomorphology of the bottom sea and continental onshore (including Lagoa dos Patos).

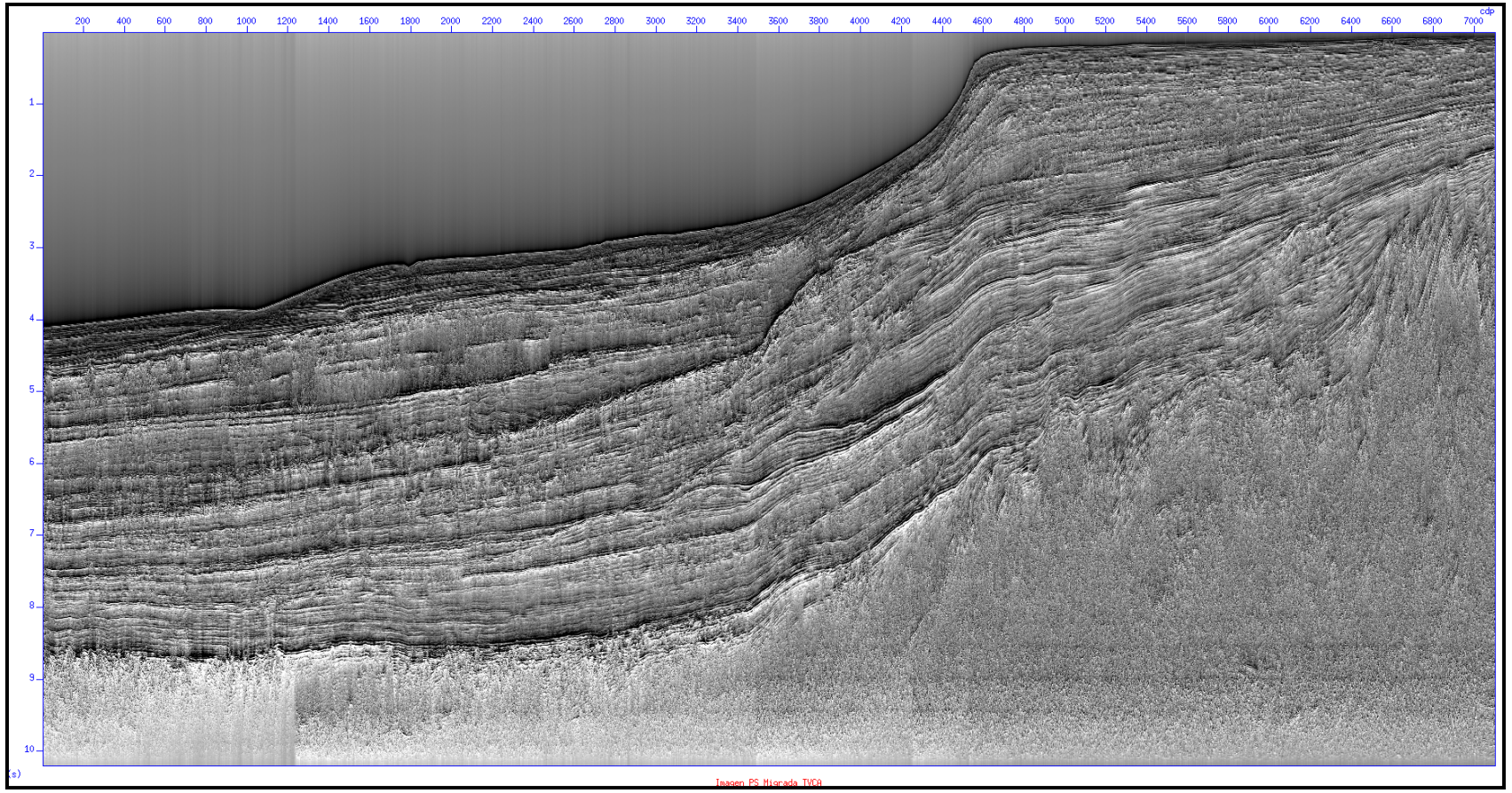

Figure 2. Seismic dip line from the study area into the Pelotas Basin.

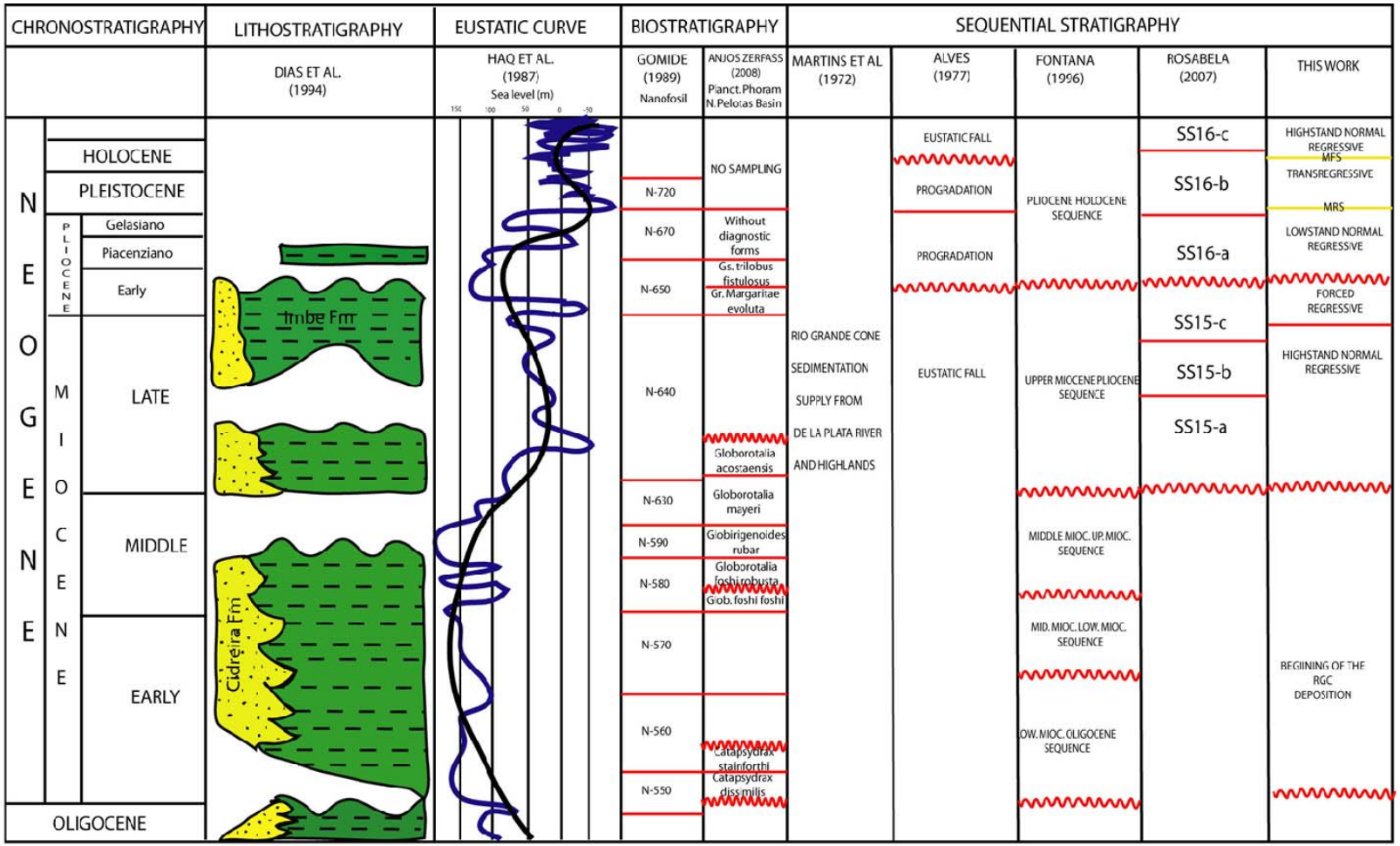

Figure 3. Different stratigraphic sequences for the Neogene section in the Rio Grande Cone, with biostratigraphy, geologic description and eustatic curve data. The sketch shows compilation of the sequence stratigraphy of the Rio Grande Cone. After Martins (1972), Alves (1977), Fontana (1996), Rosabela (2007).

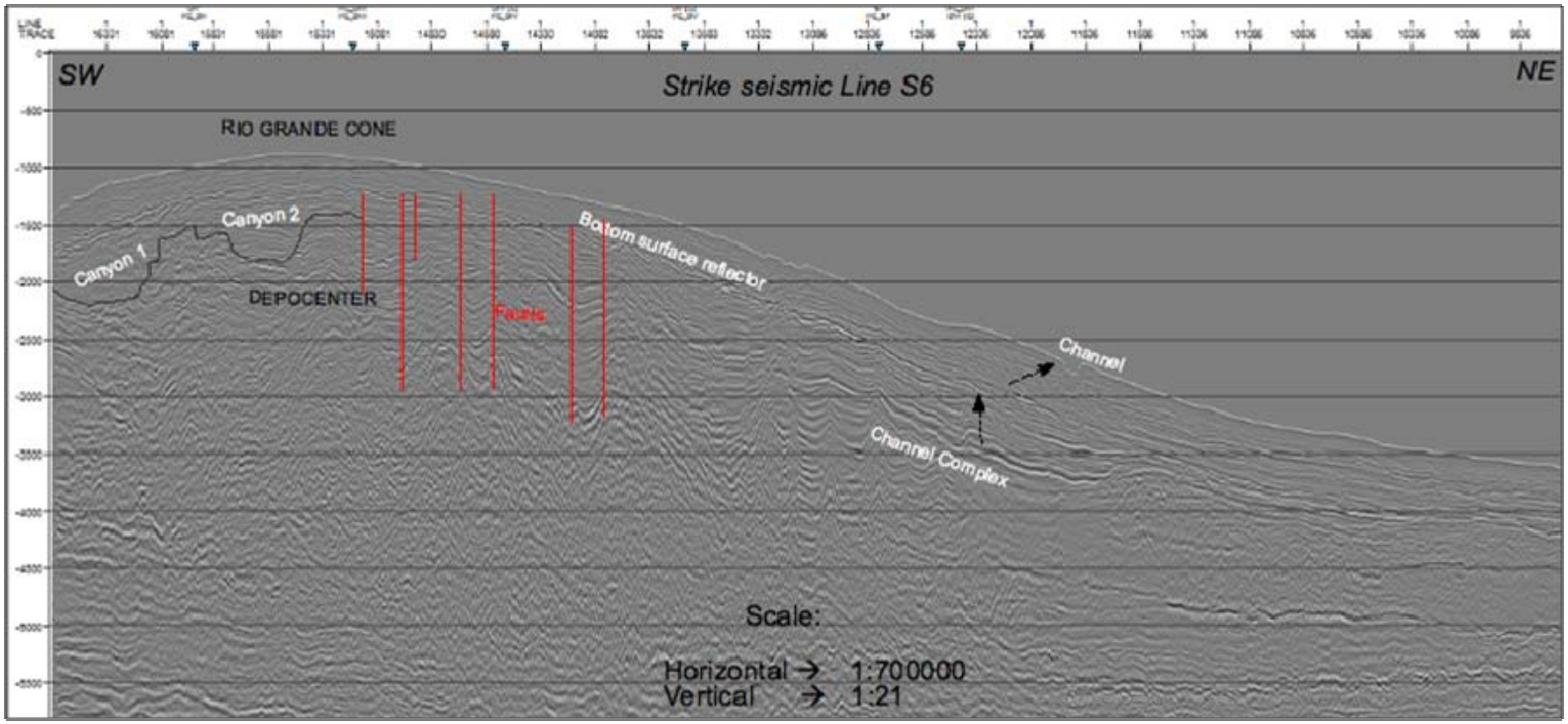

Figure 4. Seismic strike line from the study area into the Pelotas Basin.

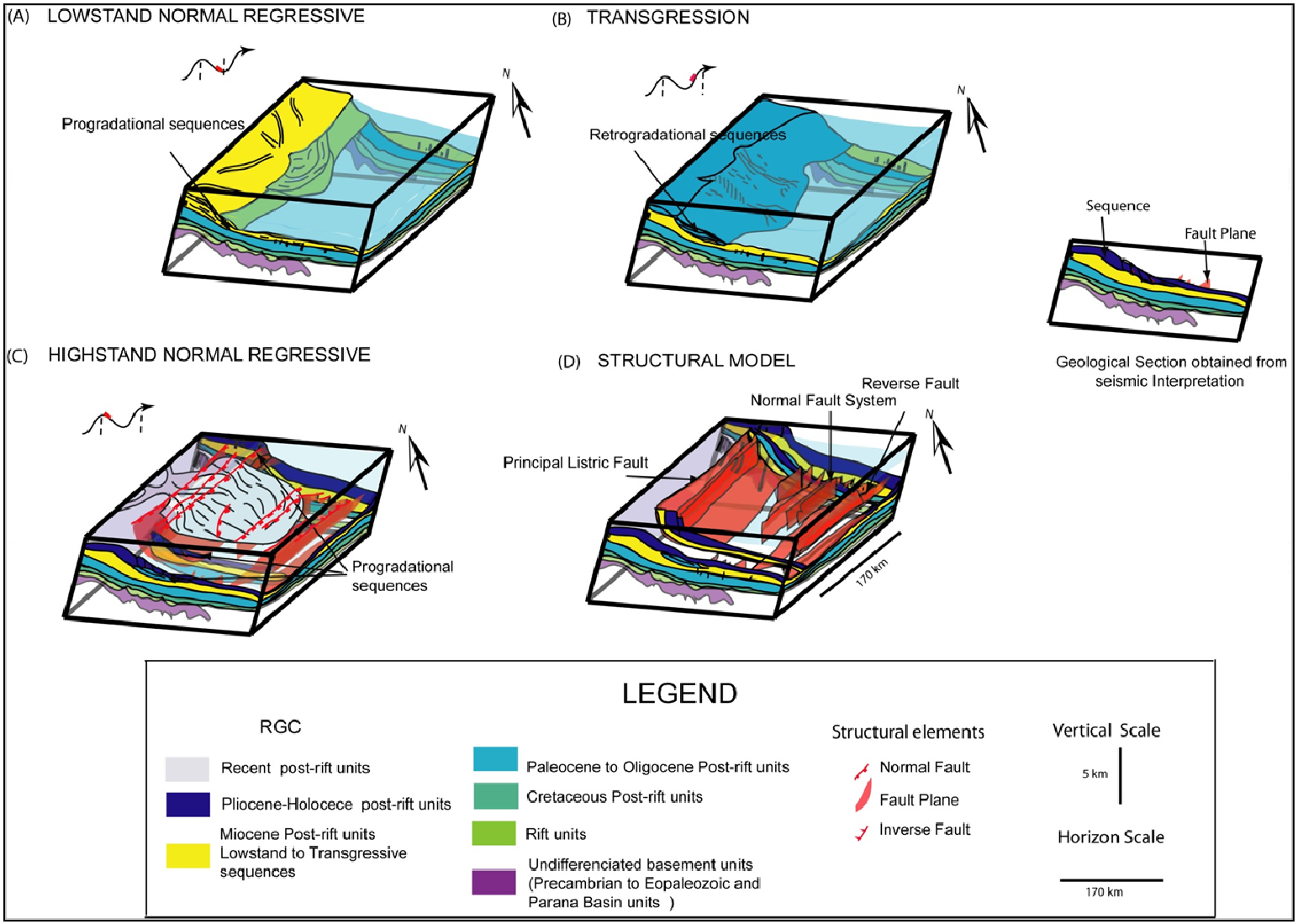

Figure 5. Stratigraphy and structural evolution model of the Rio Grande Cone. The sedimentary packages settle into the master fault, with thick prograding sequences fill as Lowstand Normal Regressive deposits (A), with few structural influences except the presence of the master fault, followed by the deposition of retrogradational sequences that represent the transgressive system (B). This sequence is crossed by faults (normal faults) located at the northeast of the cone area (D). Tertiary sediment accumulations are at their maximum sediment supply during Middle Miocene. Pliocene to Recent accumulation registered a sedimentary charge lower than earlier periods. The last sedimentary deposition corresponds to the Highstand Normal Regressive, with a broad accumulation through the Middle Miocene (C).