New Contributions to the Geodynamics of the Caribbean through Structural Transects in the Gulf of Venezuela and its Implications in the Definition of Petroleum Systems*

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Abstract

The tectonic evolution of the Gulf of Venezuela is intrinsically connected to the evolution of the collision between the Caribbean and South America plates. Its history shows evidence of the Late Cretaceous-Paleocene collision, Paleocene-Eocene emplacement of the Caribbean Plate, and Eocene-Pleistocene extension.

In this study, a new structural interpretation in the Gulf of Venezuela (Figure 1) has been developed using 2D seismic data and stratigraphic information from wells located into the Gulf and surrounding basins. The scope of this study was focused on describing the structural evidence associated with different stages of tectonic deformation in the Gulf of Venezuela. The aim is to contribute to the tectonic studies related with the Caribbean-South American interaction and its implications on the petroleum systems. In order to explain this interaction, taking into account different palinspastic reconstructions done in the north of South America, the tectonic evolution has been divided in four chronologic stages: (1) The Proto-Caribbean aperture and the Gondwana-Laurasia separation, (2) Thermal subsidence of the Proto-Caribbean below the South America Plate and development of passive margins at the north of South America, (3) Caribbean-South America collision and emplacement of the Caribbean crust over the continental margin, and (4) Development of the right-lateral fault system as a response of the oblique Caribbean-South America collision (Figure 2).

Results and Discussion

Taking into account information from wells, the domains defined in the Gulf of Venezuela, Urumaco Trough and Guajira-Dabajuro Platform are stratigraphically separable. Furthermore, the tectonic evolution has generated structural differences between these domains from the Cretaceous to Neogene (Figure 3).

Urumaco Trough Domain

The Urumaco Trough Domain is characterized by a thick Neogene sedimentary sequence, lying unconformably over an allochtonous metamorphosed Cretaceous (?) basement. This sequence was deposited into a tectonic transtensive regime associated with the right-lateral displacement of the Oca-Ancon Fault system and the aperture of the pull-apart basin of the Urumaco Trough. Deposition was controlled by the development of NW-SE Miocene-Pleistocene normal faults, with sediments probably sourced from the south, at least during the Early-Middle Miocene period. Reverse faults at the base of the Neogene demonstrates the continuity of compressional regime at least until the Lower Miocene (Figure 4).

Guajira-Dabajuro Shelf Domain

In this domain, the Neogene sequence is recognized as a thinner continuity of the Neogene sequence of the Urumaco Trough, which is overlapping unconformably the Jurassic-Cretaceaous sequence correlated with the Maracaibo Lake domain.

In the Guajira-Dabajuro Platform domain, fault-bend-fold structures with ramps verging northwest involving Jurassic to Paleocene sequences were identified. These structures form a thrust-belt in the NE-SW direction, and is the result of NW-SE compressive events which might be associated with the Caribbean-South America oblique collision that began in the Late Cretaceous (Campanian-Maastrichtian) (Figure 5, Figure 6, Figure 7). In a NE-SW correlation (Figure 8), the Eocene-Oligocene sequence is preserved in the northwestern part of the Venezuelan Gulf, and it was eroded to the southeast. To the north (Guajira Peninsula) the Oligocene sequence is present; however, this is confined to a NE-SW depression and loses thickness in the northeast direction. Reverse faulting, affecting these Oligocene sediments in the northwest part of the domain, indicates that the compressive regime was active at least until the Oligocene in this region (Figure 9). Lateral variations in thickness and internal unconformities are indicative of at least three compressive events that might be of local importance. Two Oligocene sequences are separated by a Cretaceous thrust belt (Figure 8), indicating that both depressions, the northwest and the West of Venezuelan Gulf, were filled simultaneously.

Conclusions

In the Gulf of Venezuela, prior to the extensional Neogene period, the rocks have recorded the existence of a compressional period. The thrusting involves imbrications and duplex systems with a northwest vergence and decollement levels in the Jurassic, Early and Late Cretaceous.

The stratigraphic (Miocene and Oligocene sequences over Jurassic and Cretaceous rocks deposited in the Maracaibo-Perija domain) and structural features (imbrications and duplex systems) of the Guajira-Dabajuro Platform convert the western part of the Gulf of Venezuela in a prospective zone because petroleum systems can be expected from the Cretaceous sequences and the structural traps are present and vertically repeated in the imbrications and duplex systems.

The exposition to erosion of the Paleogene and Cretaceous sequences, and the deposition of an important Oligocene sequence in the northwest depression, may indicate the association of thrusting with the Paleogene Caribbean-South America collision, and the evolution of foredeep with its respective forebulge near Perija.

The Urumaco Trough may represent a pull-apart basin developed from Eocene right-lateral slip of the Oca-Ancon Fault system (Muessig, 1984; Mascellari, 1995), and it was filled by an important Neogene sequence which could be sourced from the south, at least in the Early and Middle Miocene.

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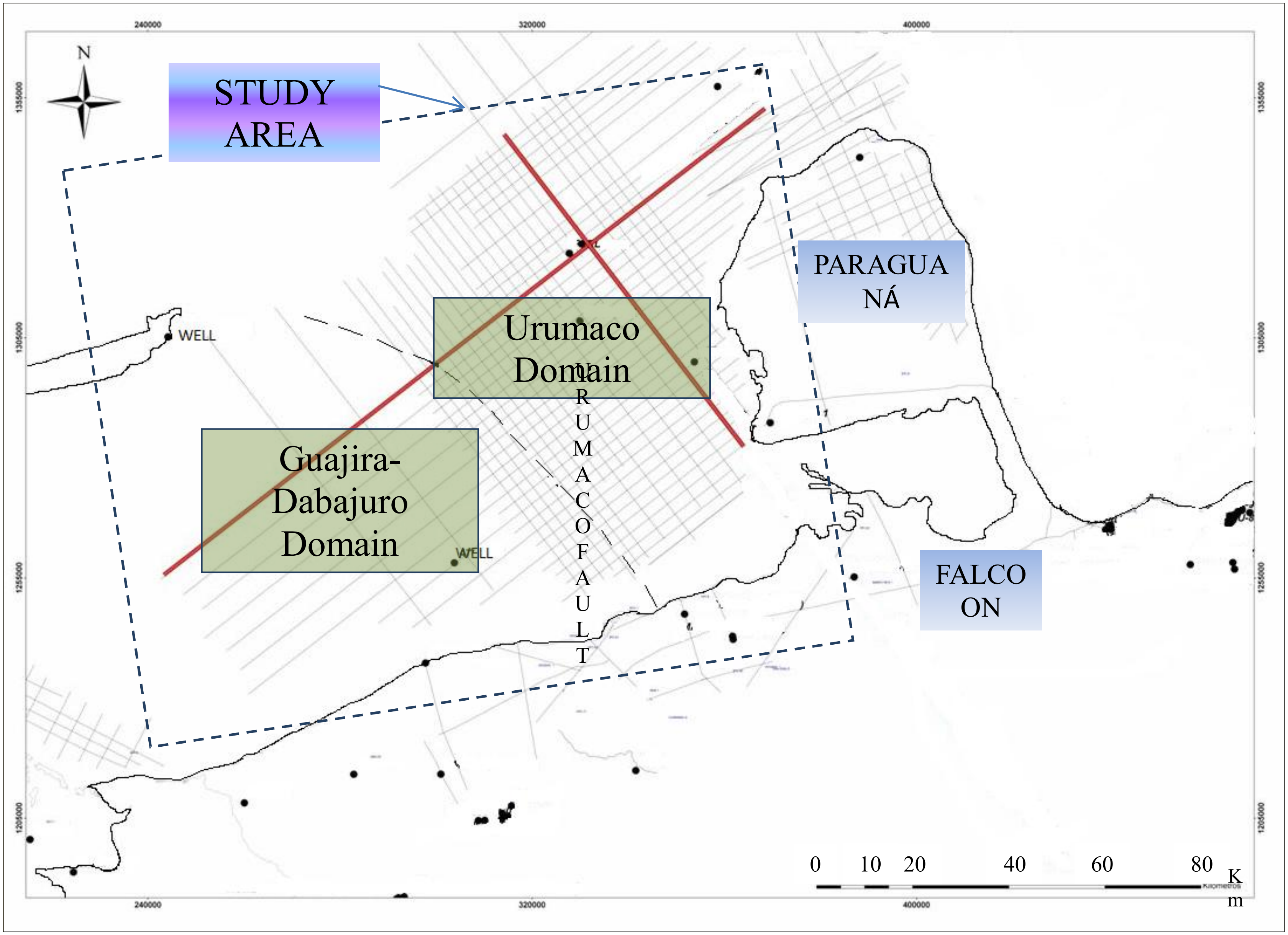

Figure 1. The Gulf of Venezuela study area is outlined by the box. Two domains are separated by the Urumaco Fault.

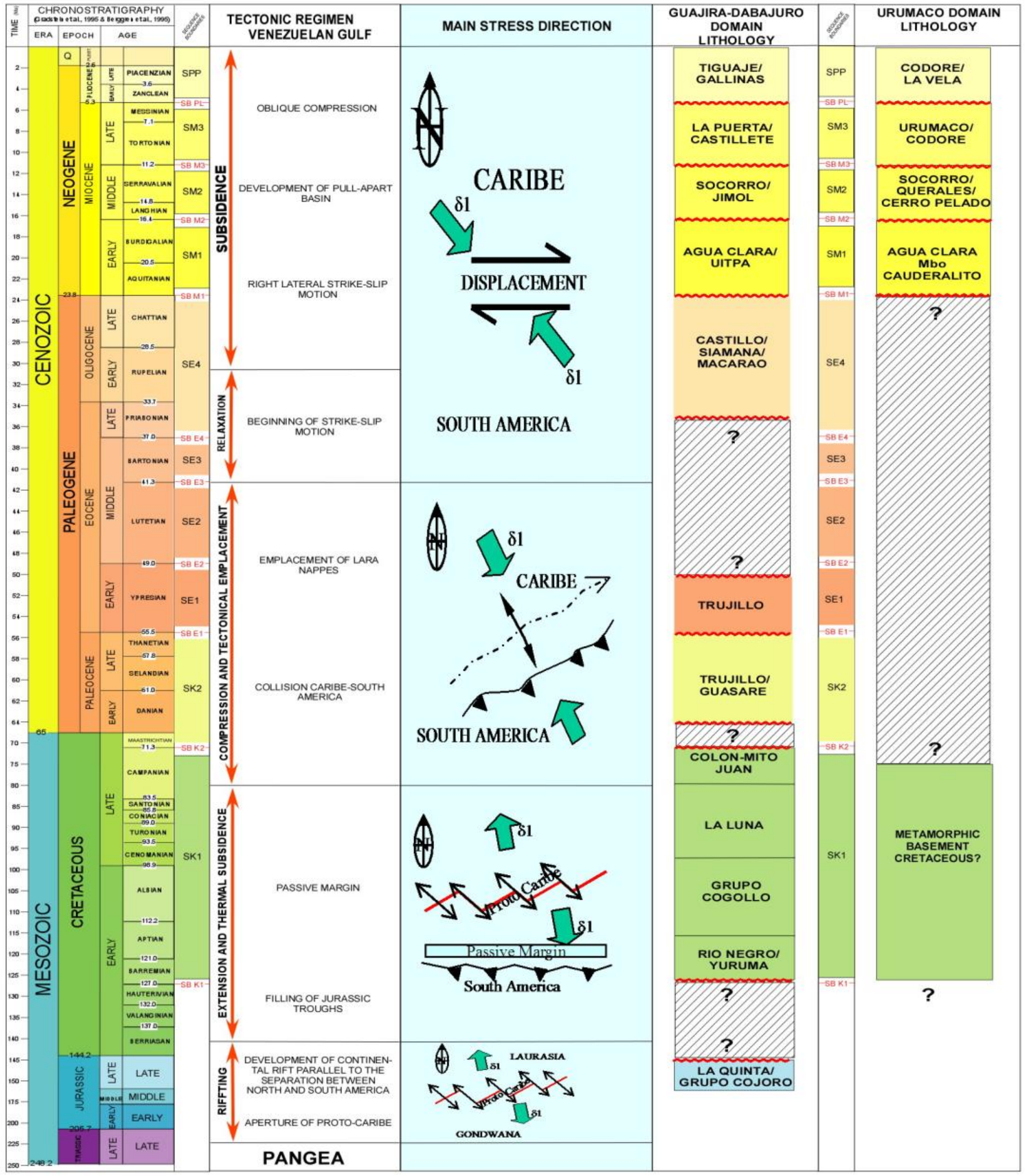

Figure 2. Generalized stratigraphic column for the Guajira-Dabajuro and Urumaco domains. A tectonic evolution with schematic stress representation and structural features is showed for each period of time, taking into account the main tectonic events.

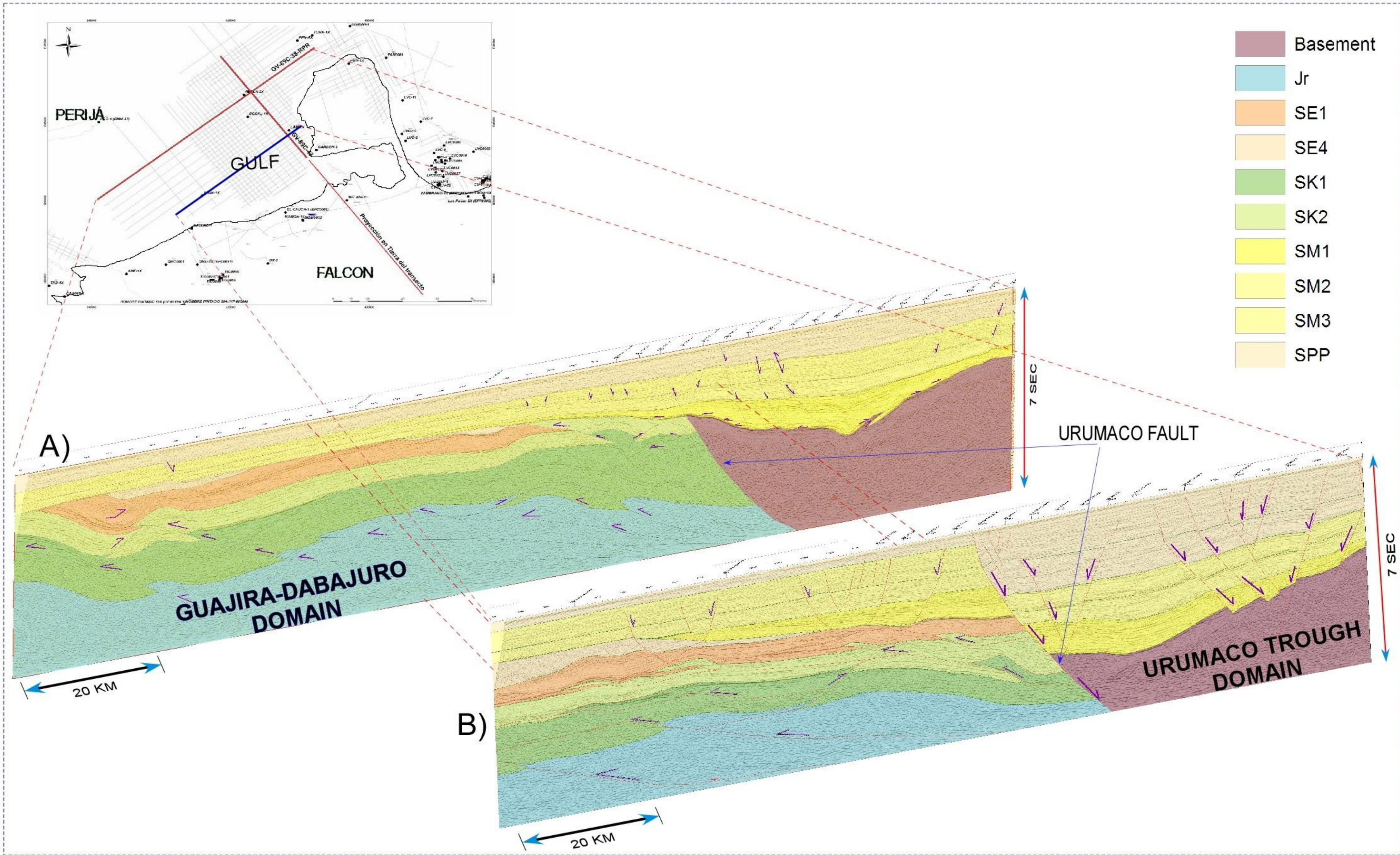

Figure 3. Two interpreted NE-SW lines. It is possible to note two different domains which are geologically differentiable. Note the erosive behaviour of the Neogene sequence from the Guajira-Dabajuro Shelf to the Urumaco Trough.

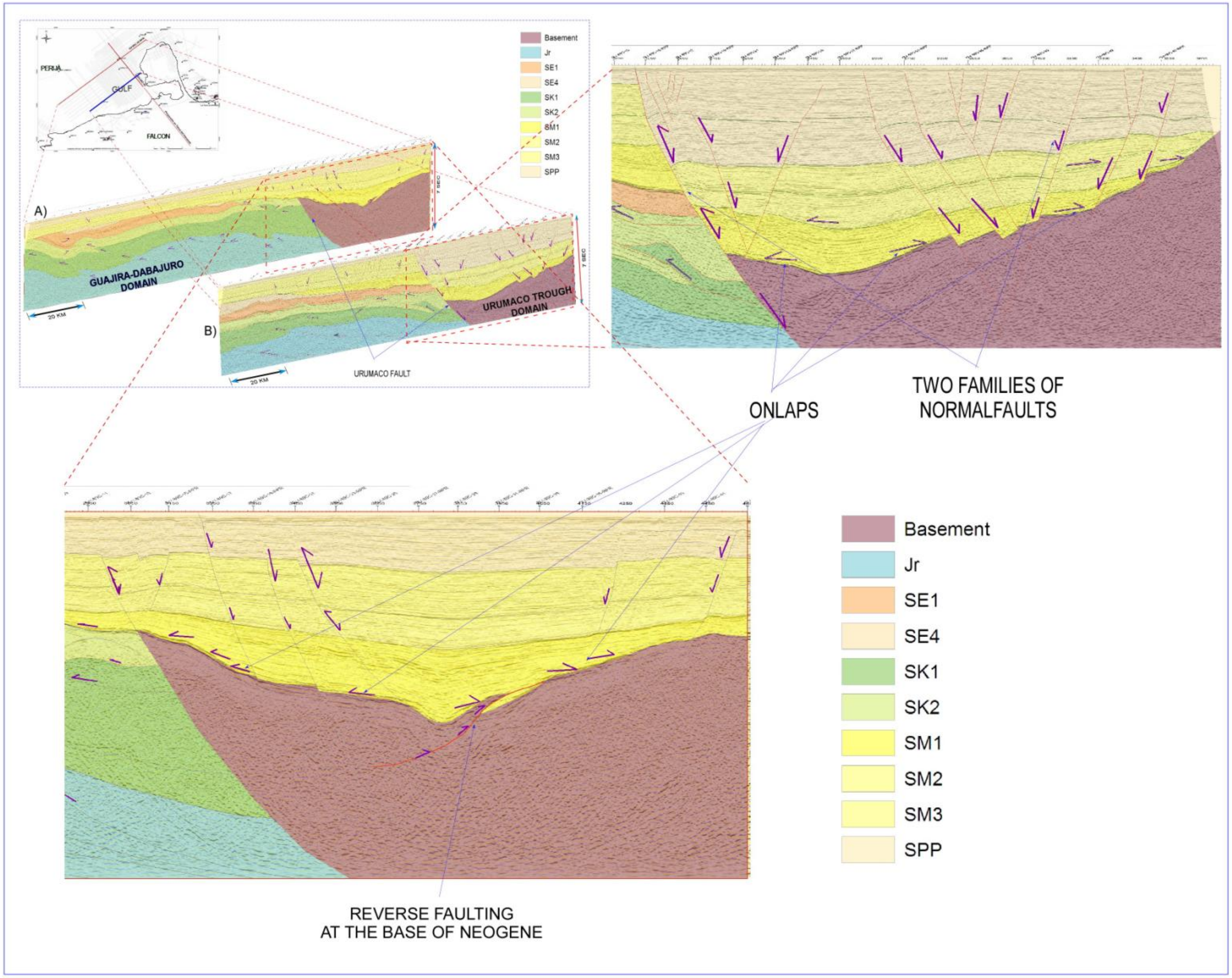

Figure 4. Close-up of the NE-SW lines in the Urumaco domain. The Urumaco Trough domain is characterized by an extensional regime where two families of normal faults are developed.

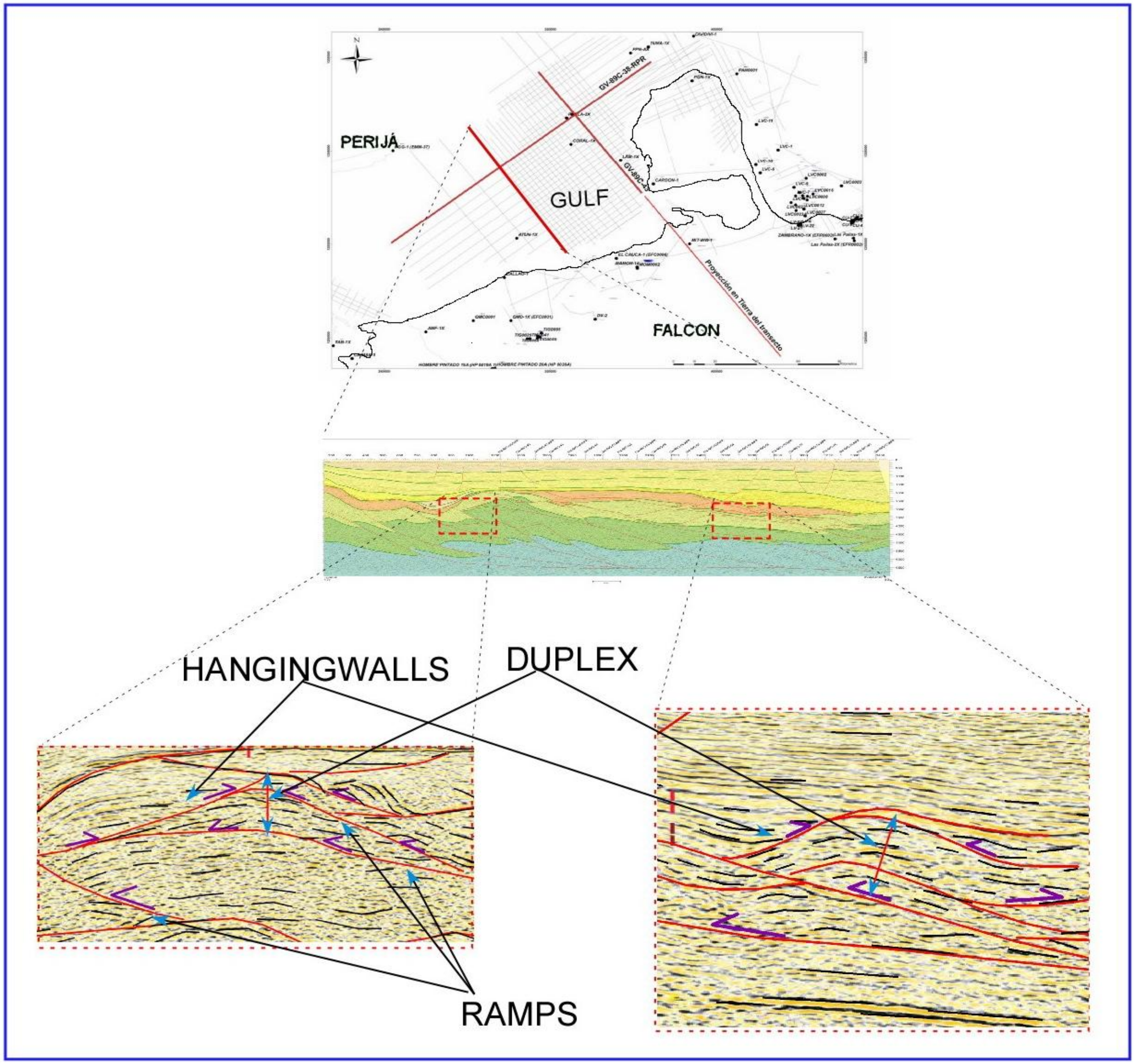

Figure 5. Fault-bend-fold structures affected the Jurassic-Paleocene sequence, and the decollments levels can be identified from the Jurassic to Cretaceous sequences.

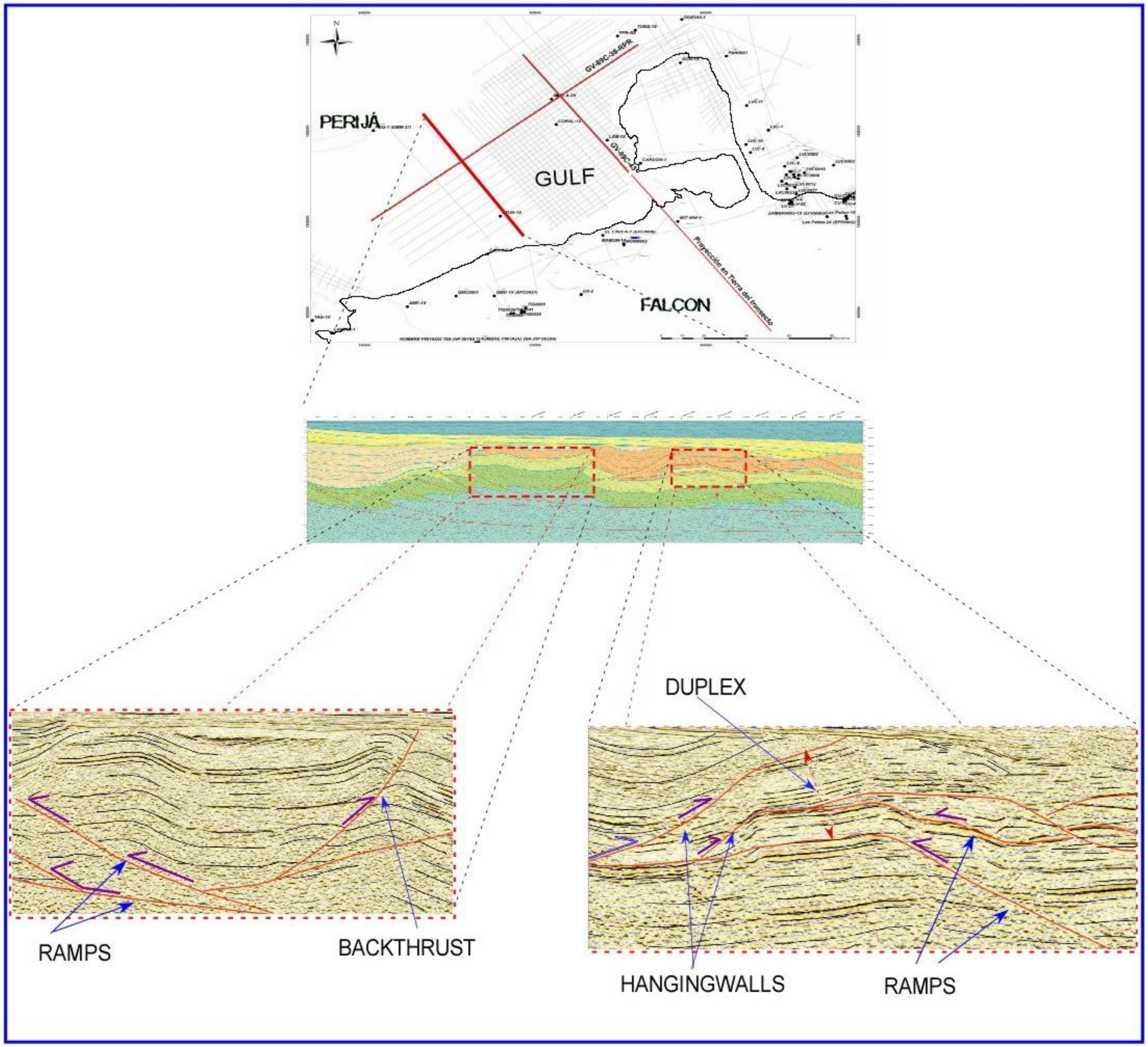

Figure 6. Fault-bend-fold structures affected the Jurassic-Paleocene sequence, and the decollments levels can be identified from the Jurassic to Cretaceous sequences.

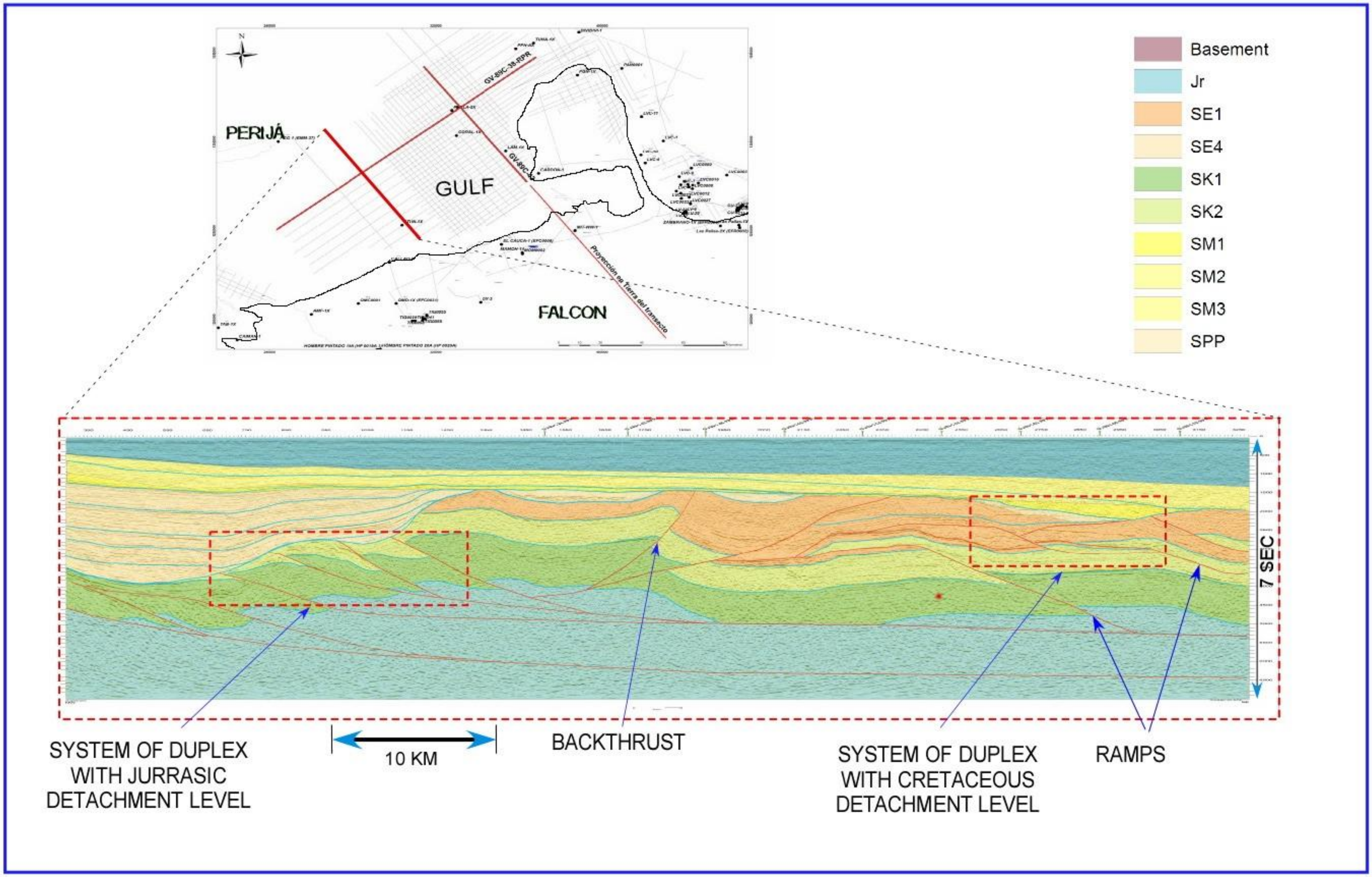

Figure 7. Compressive deformation along a NW-SE seismic line. To the north, the imbrications affected the Cretaceous sequences with decollement level within the Jurrasic; note the Oligocene sequence deposited in the depression is affected by this compressive movement. To the south, the deformation goes through the Paleocene sequence which is eroded by Oligocene-Neogene packages.

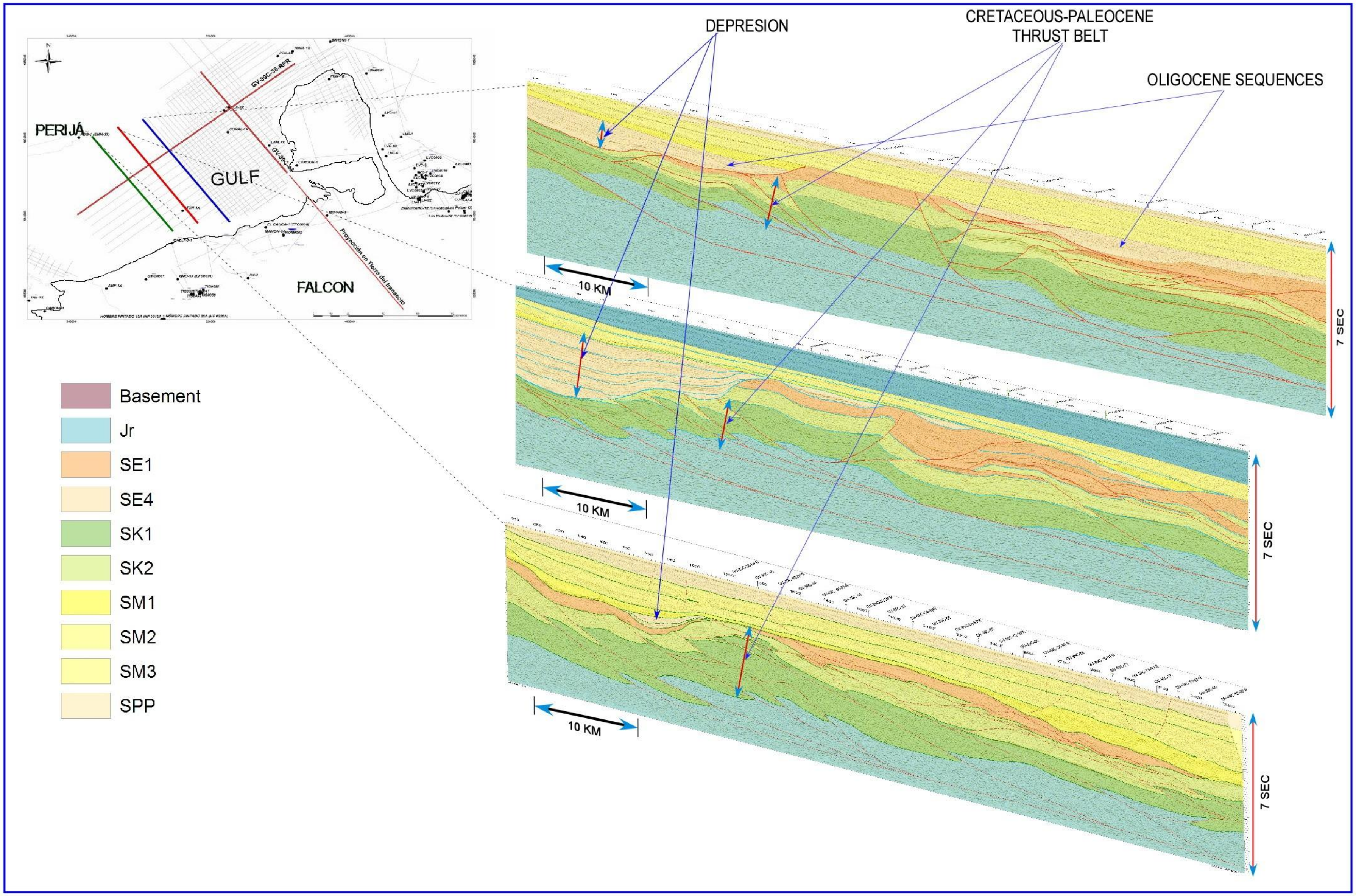

Figure 8. Parallel seismic lines. The depression in the north loses thickness in the northeast direction. The Oligocene sequences in the north and the south are separated by the Cretaceous-Paleocene Thrust Belt.

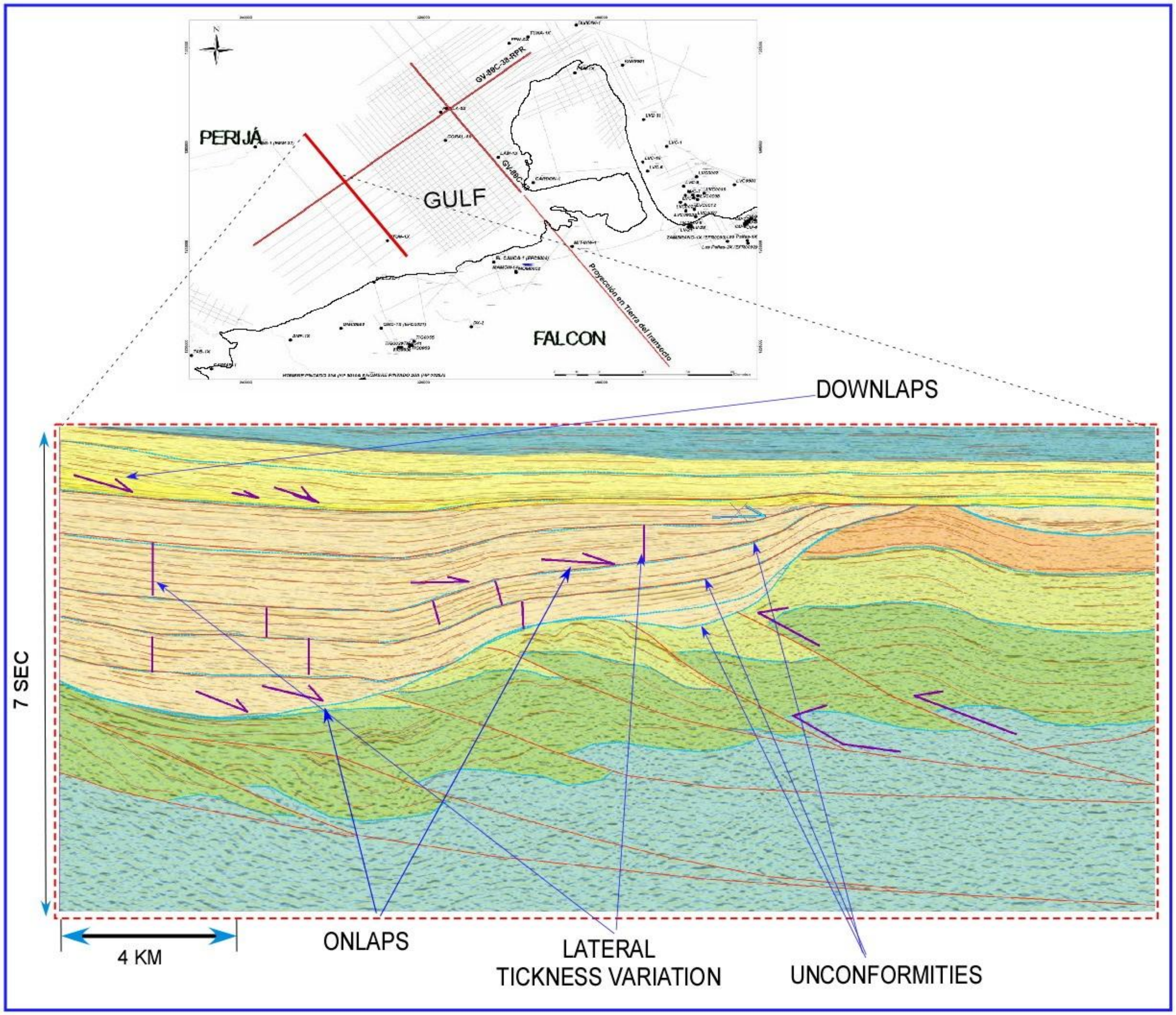

Figure 9. Depression in the north. The Oligocene sequence deposited in the depression is affected by the underlying compression. Lateral thickness variation indicates the syn-tectonic deposition of the Oligocene sequence, and the unconformities represent the different tectonic pulses of the compressive deformation. Note the downlap in the Neogene sequence which may be associated with stages of uplifting at the Perija range in the Early Miocene.