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Deformation phases of the Furrial Producing Trend, Eastern Venezuela Thrust Belt

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The area of the "Furrial Trend" is highly complex and has been the subject of extensive seismic and geological studies (Helwig et al. 2002, Marquez et al.2003). The model presented here is the result of a full scale integration of all petroleum engineering disciplines (production seismic, geology, geochemistry and reservoir engineering).

Four major tectonic phases have been recognized in the Furrial trend

The first phase of deformation from the NW (Fig.1) is best expressed by three sets of observations. 1) low angle fault planes parallel to the present day structure in the Carito Field that are locally associated with large amount of pressure solution and quartz cement that indicate a tectonic activity while the structure was water bearing (Chatellier et al. 2001), 2) trapped water locally present in the southern part of the Furrial Trend, in the complex area of the deformation front where the replacement of the migrating oil has not succeeded to push away all of the residing water, 3) all of the major older structures located to the north have a WSW-ENE strike direction indicating a NNW-SSE stress direction.

Tear faults associated with the NW compression have been controlling the subsequent development of the three fields of the "Furrial trend": the Furrial, Carito and Santa Barbara Field and have allowed distinct deformation to take place in each of these fields.

The second phase of deformation (Fig.2) corresponds to a compression from the NE indicated by a common N220 direction of high dips seen in dipmeter and confirmed by the structural contours based on well data. It also has been identified by very large isopach jump (thousands of feet) oriented NW-SE and it has been corroborated by the geometry of various stacked compartments well expressed by the API versus depth trends (Chatellier et al. 2003). Porosity depth trends also indicates tectonic activity post oil emplacement and the geometry of the displacement corroborates the existence of the second phase of deformation (Chatellier et al.2002a). The obliquity of the second phase has induced geological anomalies such as reverse faults associated with missing sections (Chatellier et al. 2002b). Tear faults (NE-SW) have been identified from seismic and confirmed by mapping the structure.

This second phase is well expressed in the Santa Barbara Field and buried in the other two fields because of the subsequent phase 3 deformation.

The third phase of deformation (Fig.3) corresponds to an out of sequence compression involving and inverting the deep seated Pirital fault, a major structural feature located to the north of the deformation front. This phase of activity has been associated with important backthrusting, horizontal detachments and reactivation of faults. The lateral variation in tectonic response between the Furrial, Carito and Santa Barbara fields is at its maximum during this phase and is related to the distance of the Pirital thrust. Furrial, the furthest away from the fault corresponds to a simple fault bend fold. Carito is more complex, especially in its western part where thrusting and fault propagation breakthrough took place. Santa Barbara has been the most affected and exhibit strong evidences of deformation typical of triangle zones. Thus numerous horizontal detachment levels are intersecting the stratigraphy and altering the reservoir properties of the field; the best example being a tectonic klippe in the northwestern part of the field.

The extensional **fourth phase** is of limited importance for the field development and may be related to the gravity gliding of the eastern Venezuela thrust belt in the upper Pliocene to Pleistocene (Chatellier, 2003).

Note that an early North-South basin tilt seems to have taken place, the expression of which is seen in the northeastern part of the Furrial Field and in some North-South transverse features still under study.

The map of the Santa Barbara field (Fig.4) schematically summarizes the effects of the various tectonic phases that have affected the area.

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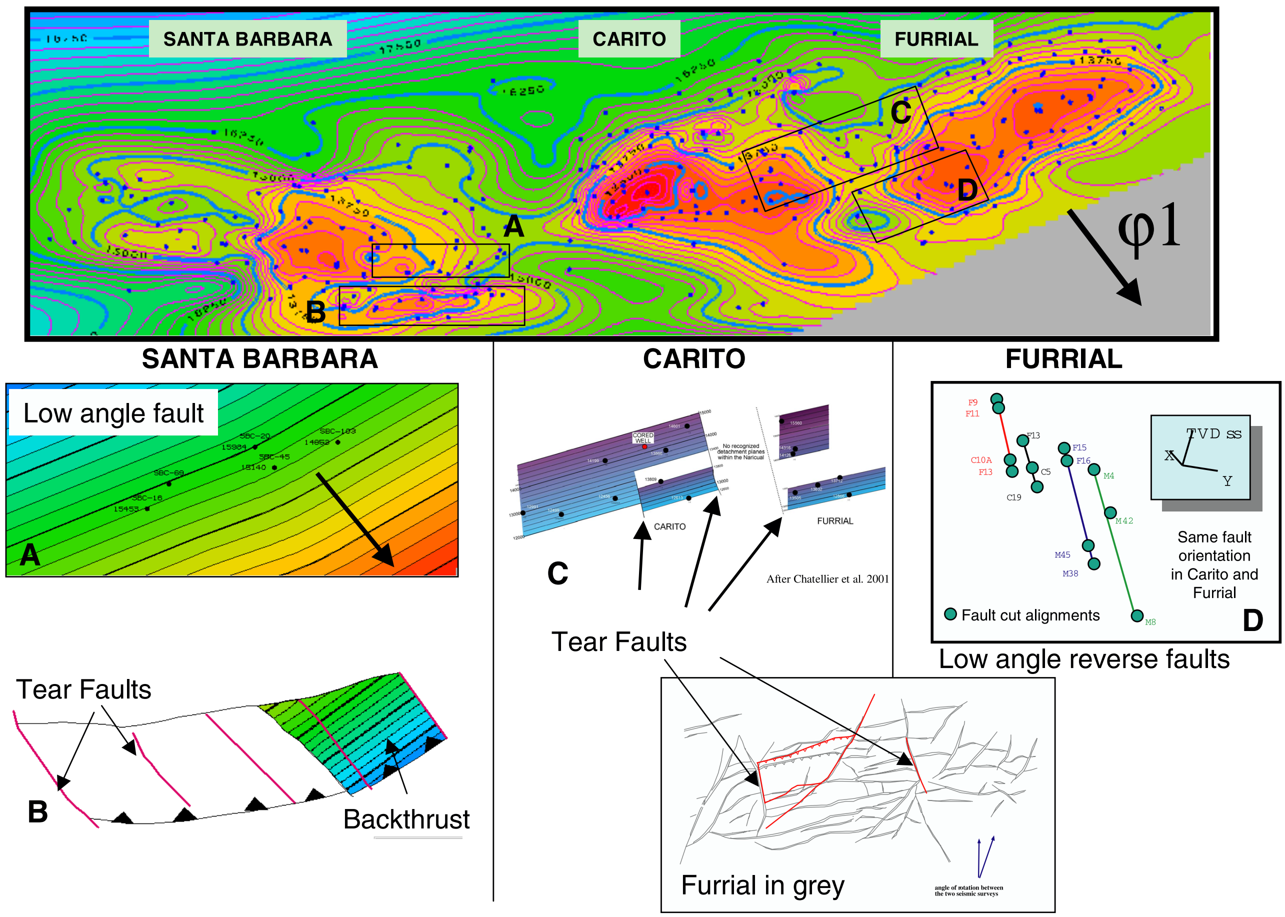

Fig. 1 Various expressions of the 1st tectonic phase in the Furrial Trend

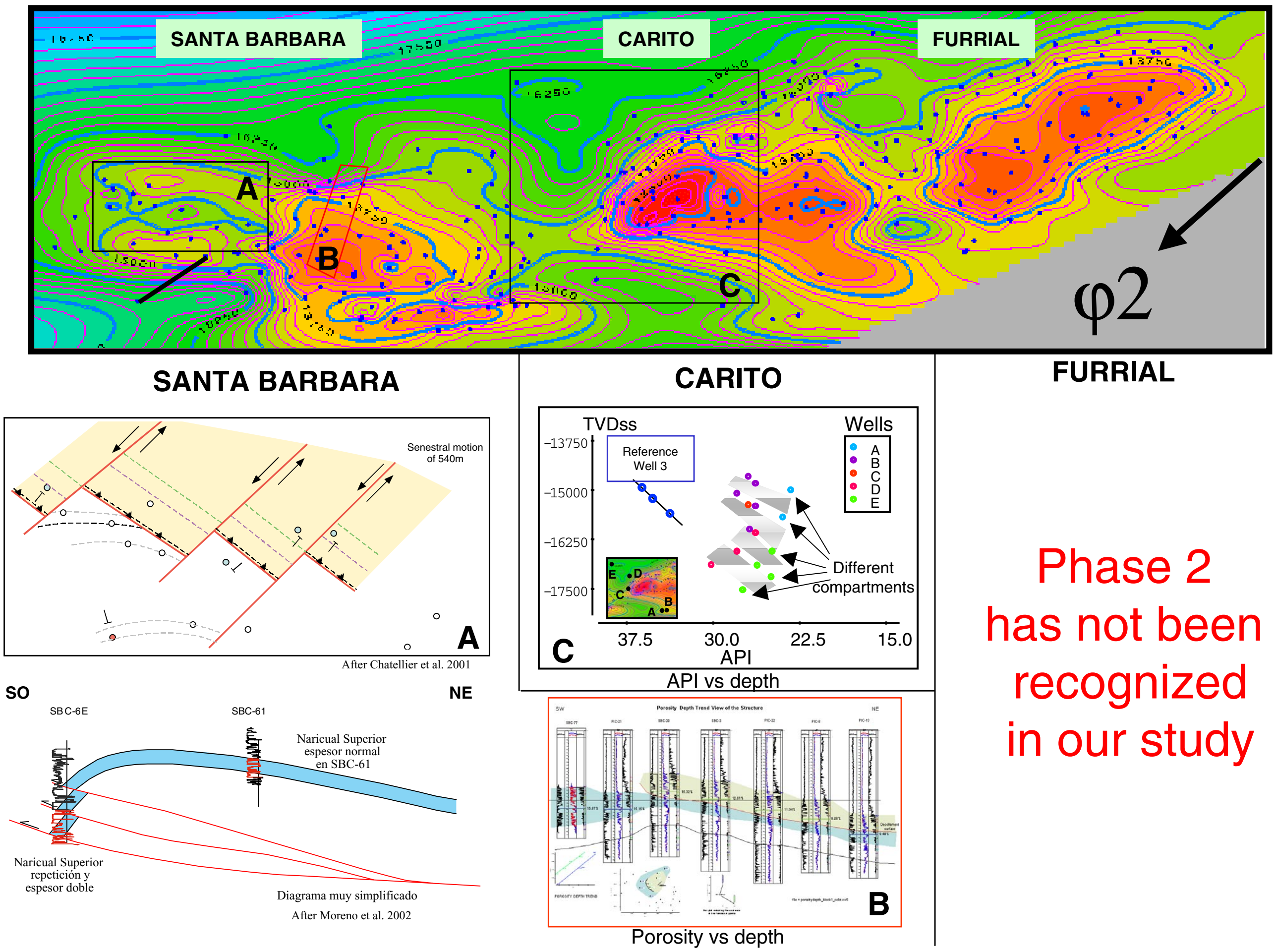

Fig.2 Various expressions of the 2nd tectonic phase in the Furrial Trend

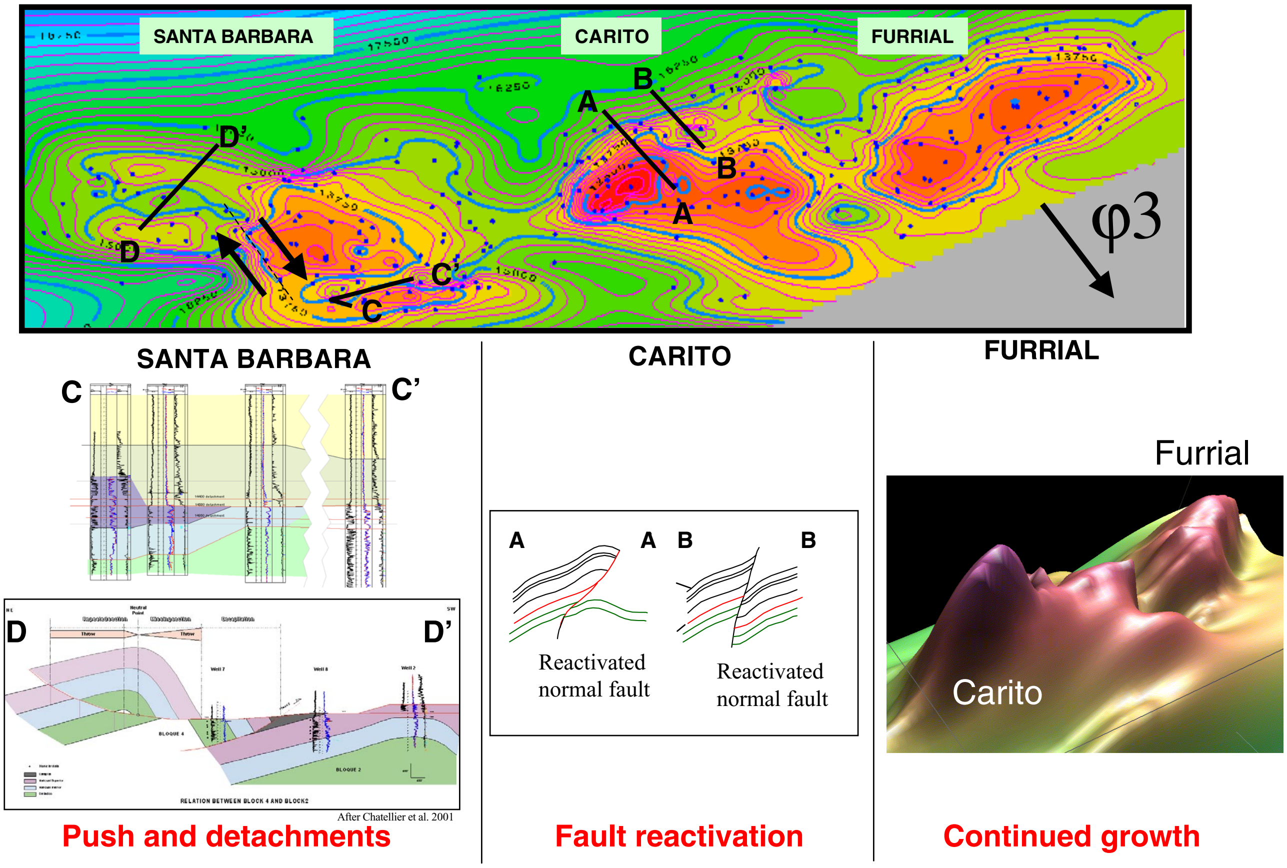

Fig.3 Various expressions of the 3rd tectonic phase in the Furrial Trend

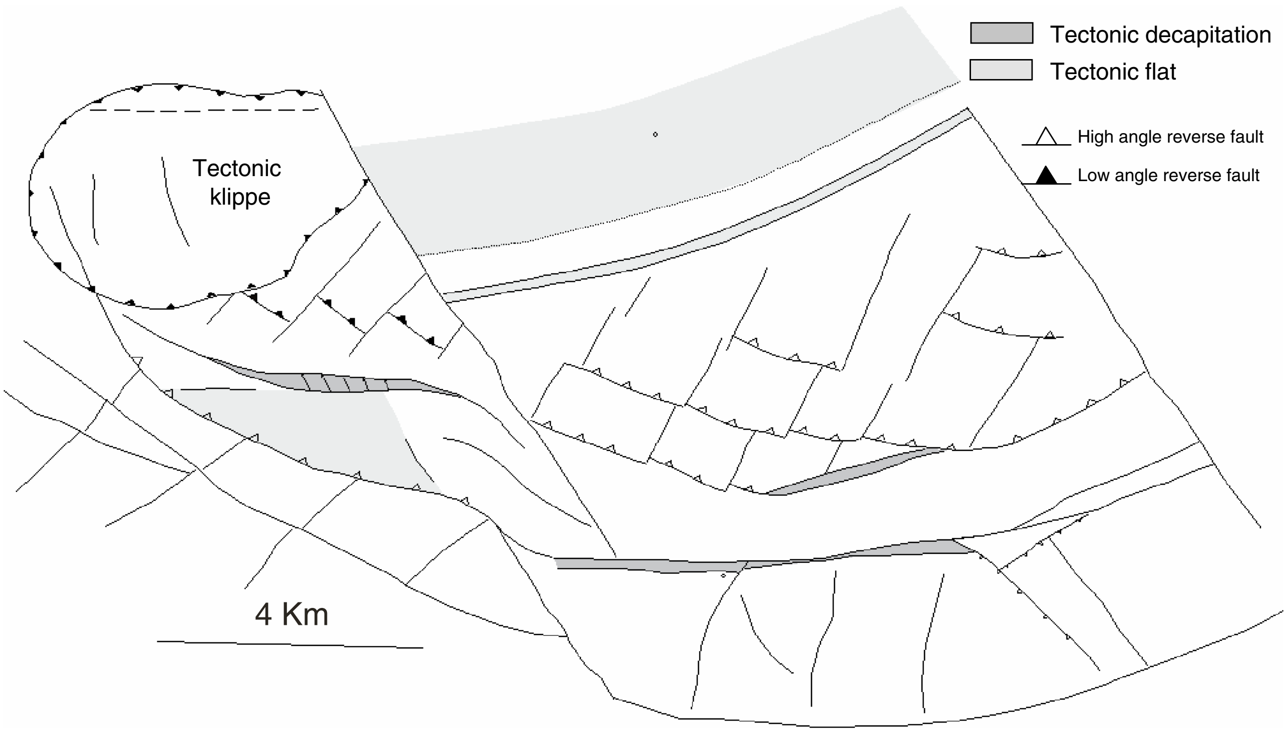

Fig.4 Major structural elements of the Santa Barbara Field, Norte de Monagas