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The role of the extensional Mesozoic structure during the Pyrenean contractional deformation at the western Parentis basin: constraints from the MARCONI-3 deep seismic reflection profile

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Abstract: The MARCONI-3 profile shows that the western Parentis basin appears as a major half graben bounded southwards by a major N-dipping planar fault (Landes fault). It is filled by a thick sequence of Jurassic-Upper Cretaceous carbonates affected by salt domes and squeezed diapirs. Southwards of the Landes fault, the Landes High acted like a structural high until the Upper Cretaceous. The entire fill of the Parentis basin is overlied by uppermost Cretaceous to lower Miocene synorogenic deposits gently folded upon the diapirs. The features of the basin evidences that the extensional structure resulting from the Bay of Biscay opening played an important role both in the location of the north-Pyrenean front and in the features of the foreland basin. Despite of a thin crust over the Parentis basin, the lack of significant inversion structures denotes that the Landes High acted as an important buffer for the northwards propagation of the Pyrenean contractional deformation. This deformational buffer vanished during the last stages of Pyrenean orogen development when some basement faults reactivated.

Keywords: Bay of Biscay, Pyrenees, Parentis basin, seismic profile, salt tectonics.

The Parentis basin is an E-W deep depression of about 100 km length that includes about 10 km of Jurassic to Lower Cretaceous syn-rift sediments, and overlies a lowermost Jurassic to Upper Triassic evaporites and Lower Triassic-Permian detrital rocks (Mathieu, 1986) over a crust of 5-6 km thickness (Pinet *et al.*, 1987). This basin is related to the north Atlantic and Bay of Biscay opening which produced a strong crustal thinning in the region. To the west, the abyssal plain is floored by transitional or oceanic crust (Gallastegui, 2000; Sibuet *et al.*, 2004a, 2004b; Pedreira, 2004; Ruiz, 2007). In this sense, the main structures of the basin are E-striking normal faults which compartmentalise and bound it (Masse, 1997). An important number of diapirs of Upper Triassic evaporites deforms both the basin fill (Mathieu, 1986; Mediavilla, 1987) and the overlying syn-orogenic deposits (Upper Cretaceous-Cenozoic) (Curnelle and Marco, 1983; Masse, 1997). Southwards the Parentis Basin, in the Landes High, the crust becomes thicker (Pinet *et al.*, 1987). This structural high was a plateau uplifted and eroded from Early to Late Cretaceous with an uppermost Cretaceous to Cenozoic thick sedimentary succession

unconformably overlying the Variscan basement or a thin and partially eroded Triassic-Jurassic cover (Gariel *et al.*, 1997). A northwards-thinning synorogenic wedge characterized by Upper Cretaceous to Cenozoic deposits, overlie both the Parentis basin and the Landes High. Along the Basque shelf, this wedge is affected by the north-Pyrenean frontal structures (Cámara, 1997; Gómez *et al.*, 2002).

In this sense, the aim of this work is to document the structure of the upper crust of the eastern Biscay Bay using the new MARCONI-3 Deep Seismic Profile; and to establish how the Mesozoic extensional structures could affect both the location and the evolution of the contractional structures that were developed during the Pyrenean formation.

MARCONI-3 profile

The N-S MARCONI-3 profile is about 122 km long and cuts the main structures recognized in the eastern part of the Biscay Bay (Fig. 1). The acquisition configuration parameters and the processing sequence for the profile are presented on table 1 (Ferrer *et al.*, 2008).

The profile shows the eastern Bay of Biscay structure and the main features of its Alpine geodynamic evolution. Two sectors are distinguished: the Basque slope-Landes High and the western part of the Parentis basin (Fig. 2).

A thick uppermost Cretaceous to Cenozoic wedge, unconformably overlaying the Variscan basement or a thin Mesozoic cover, characterizes the Basque slope-Landes High sector (Fig. 2A). A major thrust wedge, that constitutes the north Pyrenean front, is located in the Basque slope. This structure shows a displacement about 2 km and was developed during the Late Eocene-Early Miocene. To the north, some minor normal faults disrupt the uppermost Cretaceous-Cenozoic materials.

The western Parentis basin shows a half graben geometry characterized by a central ridge (Txipiroi

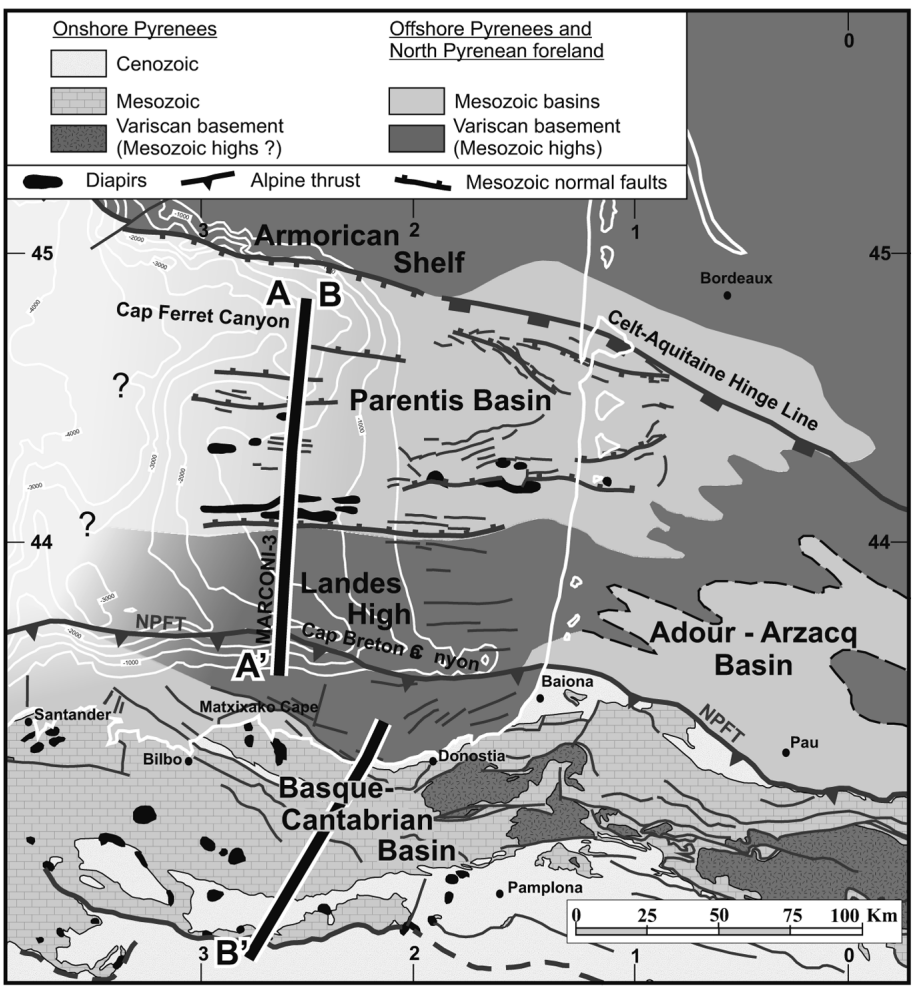

Figure 1. Simplified structural map of the Western Pyrenees combined with an uppermost Cretaceous subcrop map of the adjoining north-foreland (modified from Mathieu, 1986). The map displays the distribution of the main Jurassic-Lower Cretaceous basins and highs developed during the opening of the Biscay Bay. Thick black lines show the location of figures 2 (A-A') and 3 (B-B').

Acquisition paremeters	
Sample rate (ms)	4
Record length (s)	18
Seismic source	Gun array
Source depth (m)	8
Shot interval (s)	40
Number of channels	96
Channel depth	10
Hydrophone interval (m)	25
Processing sequence	
Trace editing	
Deconvolution	
Ban-pass filtering	
Time-variant filtering	
FK multiple removal	
CDP gather	
NMO	
Stack	
Kirchoff Time Migration	

Table 1. Acquisition configuration parameters and processing sequence for the MARCONI-3 deep seismic profile.

ridge) with Keuper salt and shales in its core and, is bounded southwards by a N-dipping master fault (Landes fault) (Fig. 2B). From a structural point of view the Jurassic-Lower Cretaceous basin fill is affected by minor folds and extensional faults that generated a system of horsts-and-grabens. Some diapirs which pierce the Mesozoic overburden, growth in relation to these extensional faults near the south boundary of the basin. Growth strata associated with these diapirs date the active growth of these structures and the partial rise of Txipiroi ridge as Albian-Late Cretaceous.

An Upper Cretaceous-Cenozoic cover with a northwards-thinning wedge shape overlay unconformably the Parentis basin (Fig. 2B). This package is gently structured by some folds and faults over the diapiric structures and with tilted reflectors over the Txipiroi ridge. Middle Miocene deposits recorded the end stages of contractional deformation (Txipiroi ridge uplift and fault inversion and pop-up formation related to the diapirs conjugate normal faults). Upper Miocene-Holocene deposits are undeformed.

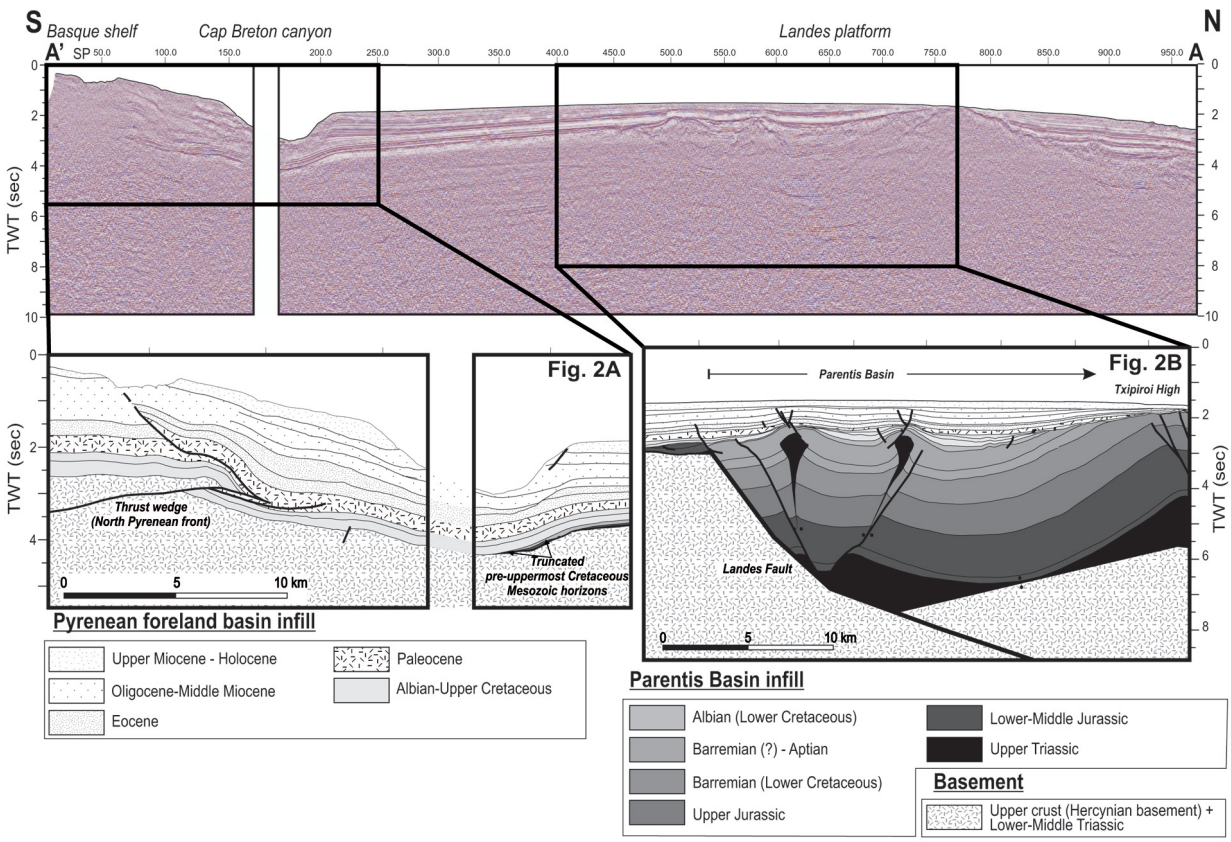

Figure 2. MARCONI-3 deep seismic profile and two details of the interpreted two-way travel time line-drawings showing the main geological features of the uppermost Cretaceous-Cenozoic sediments in the Basque shelf and Cap Breton Canyon (2A) and the structure of the southern part of the Parentis basin as well as inferred diapirs and fault geometries (2B). See figure 1 for location.

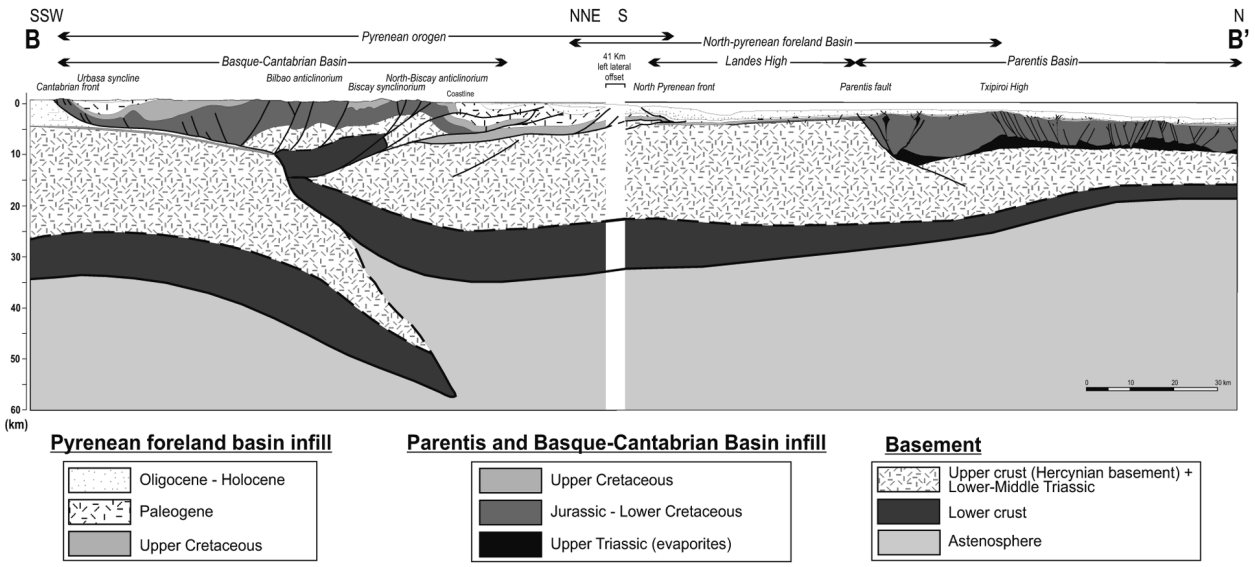

Figure 3. Upper crustal transect through the eastern Biscay Bay and adjoining northern part of the Basque Pyrenees based on MARCONI-3 profile interpretation (Ferrer *et al.*, 2008) and the cross-section made by Pedreira (2004) immediately southwards. See location in figure 2.

Discussion and conclusions

Two well-differentiated deformational stages have been identified from the MARCONI-3 interpretation (Ferrer *et al.*, 2008). The first one, coeval to the north Atlantic and Biscay Bay opening, is clearly extensional. On the contrary, the second one is related to the Pyrenean orogen building and is, therefore, compressive.

The extensional stage is divided into a syn-rift episode (Late Jurassic-Early Albian) in which the normal motion of the Landes fault formed the Parentis basin; and a post-rift episode (Late Albian-Early-Late Cretaceous) in which diapirs of Triassic evaporites were developed close to this major fault.

The compressive stage can be divided into two minor episodes. A first episode (Late Eocene-Early Miocene) in which a basement-involving thrust wedge were formed in the Basque-Cantabrian shelf coeval to the diapirs squeezing in the Parentis basin. In the second episode (Middle Miocene) besides the growth of the Txipiroi salt ridge, takes place the formation of a pop-up close to the Landes fault as a result of the conjugate normal faults inversion.

The gentle development of significant inversion structures in the Parentis basin, despite that it belongs to a severely thinned crustal area before the Alpine compression, allows deducing that the northwards propagation of the Pyrenean contractional deformation during Late Cretaceous and, especially between Eocene and Early Miocene, was stopped by the Landes High. The role as a buffer during this time is evidenced by the fact that the basement-involving Pyrenean contractional deformation was only present south of the Landes High and mainly concentrated along the northern margin of the Basque-Cantabrian Basin (Fig. 3) (Gómez *et al.*, 2002). This fact was probably related to a difference of crustal thickness between the Landes High, in which was much thicker and stronger, and their adjacent basins (Fig. 3).

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References

CÁMARA, P. (1997): The Basque-Cantabrian basin's Mesozoic tectono-sedimentary evolution. *Mém. Soc. Géol. France.*, 171: 187-191.

CURNELLE, R. and MARCO, R. (1983): Reflection profiles across the Aquitaine basin. In: A. W. BALLY (ed): *A Picture and work atlas. Seismic expression of structural styles*. AAPG Studies in Geology, 2.3.2.-11 – 2.3.2.-17.

FERRER, O., ROCA, E., BENJUMEA, B., MUÑOZ, J. A., ELLOUZ, N. and MARCONI TEAM (2008): The deep seismic reflection MARCONI-3 profile: Role of extensional Mesozoic structure during the Pyrenean contractional deformation at the Eastern part of the Bay of Biscay. *Mar. Petrol. Geol.*, 25: 714-730.

GALLASTEGUI, J. (2000): Estructura cortical de la Cordillera y Margen Continental Cantábricos: Perfiles ESCI-N. *Trabajos de Geología,* 22: 9-234.

GARIEL, O., BOIS, C., CURNELLE, R., LEFORT, J. P. and ROLET, J. (1997): The ECORS Bay of Biscay deep seismic survey. Geological framework and overall presentation of the work. In: *Deep seismic study of the Earth's crust. ECORS Bay of Biscay survey. Mém. Soc. Géol. France*, 171: 7-19.

GÓMEZ, M., VERGÉS, J. and RIAZA, C. (2002): Inversion tectonics of the northern margin of the Basque Cantabrian Basin. *B. Soc. Géol. Fr.*, 173: 449-460.

MASSE, P. (1997): The early Cretaceous Parentis Basin (France). A basin associated with a wrench fault. In: *Deep seismic study of the Earth's crust. ECORS Bay of Biscay survey. Mém. Soc. Géol. France*, 171: 177-185.

MATHIEU, C. (1986): Histoire géologique du sous-bassin de Parentis. *B. Cent. Rech. Explor. Prod. Elf-Aquitaine,* 10, 1: 22-47.

MEDIAVILLA, F. (1987): La tectonique salifère d'Aquitaine. Le Bassin de Parentis. *Pet. Tech.*, 335: 35-37.

PEDREIRA, D. (2004): *Estructura cortical de la zona de transición entre los Pirineos y la Cordillera Cantábrica*. PhD Thesis, Universidad de Oviedo, 343 pp.

PINET, B., MONTADERT, L., CURNELLE, R., CAZES, M., MARILLIER, F., ROLET, J., TOMASSINO, A., GALDEANO, A., PATRIAT, P., BRUNET, M. F., OLIVET, J. L., SHANING, M., LEFORT, J. P., ARRIETA, A. and RIAZA, C. (1987): Crustal thinning on the Aquitaine Shelf, Bay of Biscay, from deep seismic data. *Nature,* 325: 513-516.

RUIZ, M. (2007): *Caracterització estructural i sismotectònica de la litosfera en el Domini Pirenaico- Cantàbric a partir de mètodes de sísmica activa i passiva*. PhD Thesis, Universitat de Barcelona, 354 pp.

SIBUET, J. C., MONTI, S., LOUBRIEU, B., MAZÉ, J. P. and SRIVASTAVA, S. (2004): Carte bathymétrique de l'Atlantique nord-est et du Golfe de Gascogne. *B. Soc. Géol. Fr.*, 175: 429-442.

SIBUET, J. C., SRIVASTAVA, S. P. and SPAKMAN, W. (2004): Pyrenean orogeny and plate kinematics. *J. Geophys. Res-Sol. Ea.*, 109, B8.