

The north Pyrenean Front and related foreland basin along the Bay of Biscay: constraints from the MARCONI deep seismic reflection survey

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The Pyrenees form a doubly vergent mountain belt which resulted from Late Cretaceous-Cenozoic interaction between Iberian and Eurasian plates. They extend from the eastern Alps to the Atlantic Ocean NW of the Iberian peninsula displaying different characteristics along strike. Between France and Spain, the Pyrenees s.s. developed over a previous thinned continental crust and forms a continental collisional orogen with limited subduction of the continental Iberian lithospheric mantle and lower crust underneath the Eurasian plate. More to the West, in the Cantabrian Pyrenees, the oceanic crust of the Bay of Biscay became involved in the Pyrenean orogen but, unlike most oceanic lithosphere, was only moderately subducted. Instead, deformation was mainly concentrated in the previously thinned Iberian continental crust of the Bay of Biscay Iberian continental margin. Recording this structural change, in the Pyrenees s.s., the North Pyrenean front is made up by basement involved north-directed thrusts developed from the inversion of the extensional faults that bounded to the north most of the main Lower Cretaceous intracontinental basins formed during the opening of the Bay of Biscay. In contrast, in the Cantabrian Pyrenees, the North Pyrenean front has been interpreted as an accretionary prism located in the front of Cantabrian continental slope that deforms Cenozoic and Mesozoic sediments of the Bay of Biscay oceanic basin .

In September 2003, a deep seismic reflection survey (MARCONI 1), consisting of 11 seismic profiles, was carried in the eastern part of the Bay of Biscay (fig. 1) to improve the knowledge of the structure of this area and to understand the processes that governed its evolution. This survey, together with the ECORS-Bay of Biscay deep seismic profile and the industrial seismic lines, allows characterizing the change in the structural style of the North Pyrenean front and highlighting the role played by the pre-existent Mesozoic structure in the deformation pattern of this front.

The seismic profiles show that in the Bay of Biscay exist two domains with a different Pyrenean and north-foreland structure: the eastern, Basque-Parentis sector and the western, Cantabrian sector.

In the eastern sector, the North Pyrenean front is located close to the coast at the bottom of the Basque continental slope. It corresponds to a major E-W trending thrust that was controlled by the inversion of a major Early Cretaceous extensional fault bounding the Basque basin to the north. The frontal thrust sheet is thrust on top of the Cenozoic rocks of a foreland basin that, developed in the footwall of this thrust, was not deformed in the footwall of the north Pyrenean thrust system. The North Pyrenean foreland basin, in this

eastern sector, lies on the top of a continental area which includes the Parentis basin and the Landes plateau. This latter plateau was an uplifted area during the Early Cretaceous times between the Parentis basin to the north and the Basque basin to the south. In this plateau and northwards, no significant contractional deformations are observed affecting the Cenozoic sediments and the present-day structure is controlled by north and south-dipping normal faults bounding a complex system of Mesozoic half-grabens including the Parentis basin (fig. 2A). Cenozoic sediments in this area are only affected by salt walls and diapirs composed of Triassic evaporite-mudstone. The growth of these diapirs took place during the Mesozoic opening of the Bay of Biscay but also they were squeezed during the Late Cretaceous-Paleogene convergence between Iberian and European plates. This indicates that, although minor, some Pyrenean contractional structures also developed in this area.

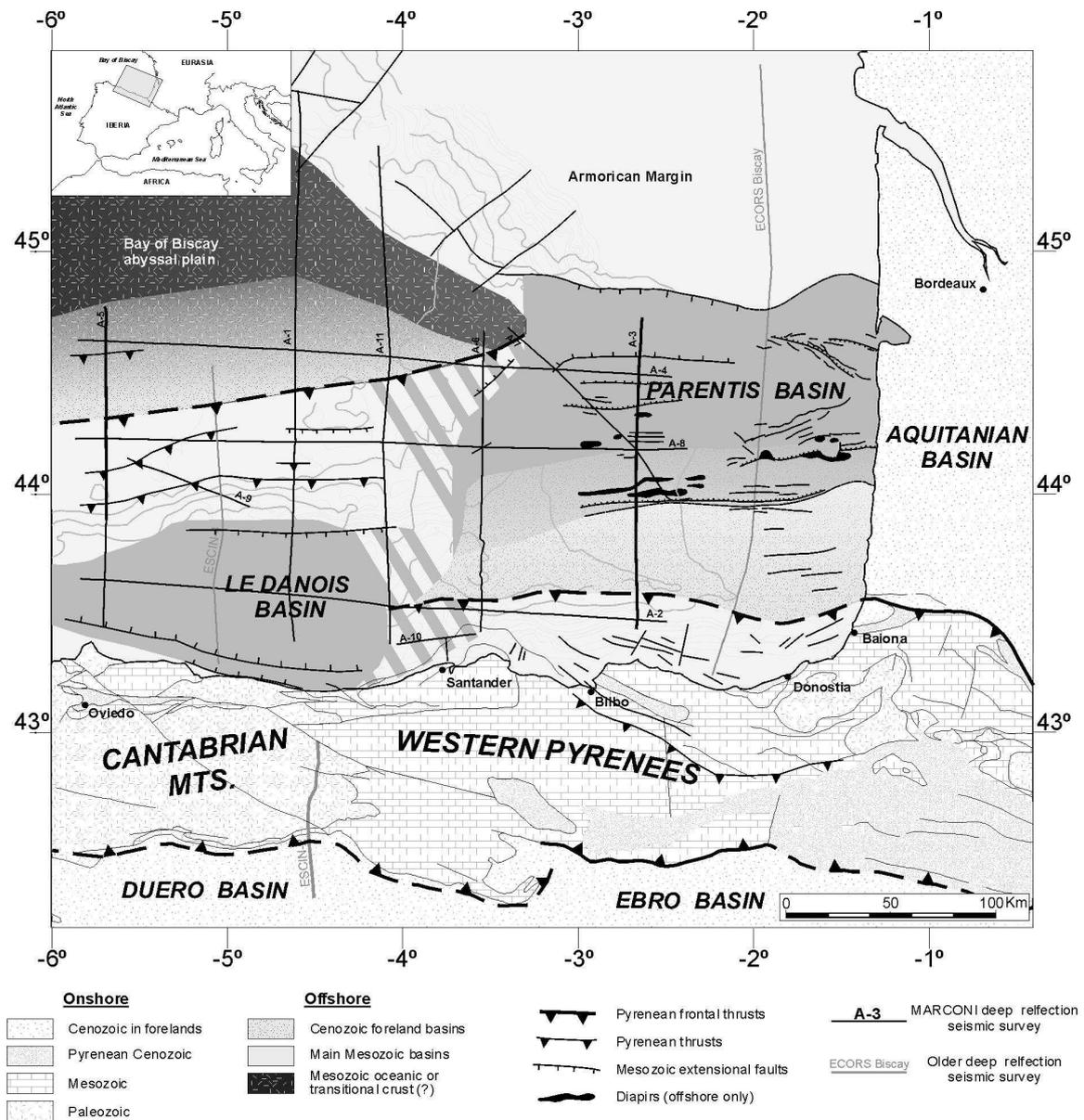


Figure 1: Simplified tectonic map of northwest Iberia with the location of the MARCONI deep seismic profiles.

In the western, Cantabrian, sector, the North Pyrenean front is shifted to the north and its geometry clearly differs from that to the east. It is a 60 km wide northward-directed blind thrust imbricate stack that previous studies have interpreted as an accretionary prism (fig. 2B). This thrust system deforms a Mesozoic cover and the Cenozoic sediments of the northern Pyrenean foreland basin which, located in front of the Cantabrian continental slope, is also shifted to the north in relation to the one developed in the eastern sector. Unlike the eastern sector, here, the North Pyrenean foreland basin lies on the top of the crust of the Bay of Biscay abyssal plain which has been interpreted as oceanic or transitional.

The transition between these two well differentiated sectors of the north Pyrenean structure corresponds to a soft transfer zone trending NNE-SSW located north of Santander (fig. 1). In this 50 km wide zone, the continental crust between the Cantabrian and the Basque north Pyrenean front is affected by major north-dipping NE-SW to E-W Early Cretaceous extensional faults. The coincidence of this transfer zone with the eastern end of the Bay of Biscay oceanic crust denotes that the different characteristics along strike of the north Pyrenean structure in the Bay of Biscay are related to a dramatic change in the nature of the subducted crust from continental to the east to oceanic or transitional westwards, being continental to the east and oceanic or transitional to the west. Therefore the rift system developed between Iberia and Eurasia during the Early Cretaceous appears as a major factor controlling not only the location and features of most of the Pyrenean thrust sheets but also the overall structure of the chain.

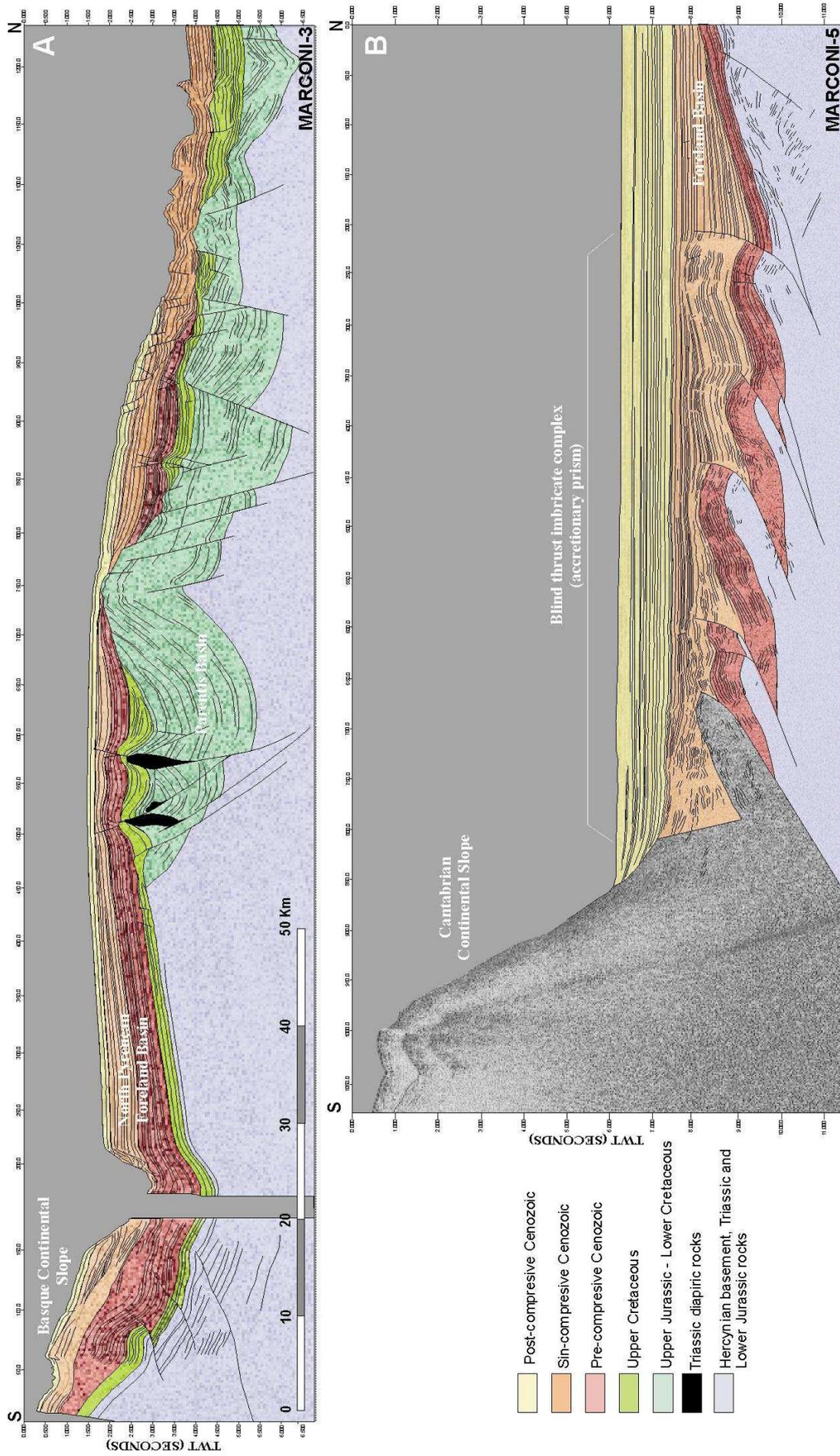


Figure 2: A. Seismic line and interpreted two-way travel time line-drawing of the MARCONI-3 deep seismic reflection profile showing the main features of the eastern part of the Bay of Biscay. B. Seismic line and interpreted two-way travel time line-drawing of the MARCONI-5 deep seismic reflection profile showing the main features of the North Pyrenean front in the western part of the Bay of Biscay.