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Strain partitioning in a transtensional setting at the termination of an oceanic basin: the example of the Bay of Biscay-Western Pyrenees

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How is strain partitioned in a transtensional setting in front of a propagating ocean? This question is at present studied in many young oceanic basins, such as the Golf of California, the Woodlark basin or the northern Red Sea. Another example is the ancient Bay of Biscay-western Pyrenees. Plate kinematic reconstructions ask for at least 300 km of lateral strike-slip movement between the Iberian and European plates. In classical interpretations, the observed Lower Cretaceous basins were interpreted to have formed as pull-apart basins along wrench faults. The lower crustal and mantle rocks observed along the belt were interpreted by many authors to have been emplaced during the subsequent collision. The aim of our project is to understand the processes, timing and kinematics of extreme crustal thinning and locale mantle exhumation observed in the Parentis and Mauléon basins in the Bay of Biscay-western Pyrenees.

The Parentis basin lies in the termination of the Bay of Biscay. Geophysical surveys and well data show evidence for extreme crustal thinning, an important asymmetry of the basin and only little evidence for normal faulting. To the north the basin is characterized by a sag geometry whereas a detachment structure with extensional allochthons is observed in the southern part of the basin. The Mauleon basin, in contrast, is exposed onshore in the western Pyrenees, and was partly reactivated during the Pyrenean compression, which has the advantage that deeper parts of the basin are exposed and can be mapped. Our field investigations show that the base of this basin was formed by mantle peridotites and lower crustal rocks that were exhumed, reworked and overlain either by extensional allochthons, today preserved in “chaînons Bearnais”, or upper Aptian to Albian sediments. The stratigraphic record of extreme crustal thinning is documented by up to 900 m of Albian conglomerates reworking Paleozoic metasediments, indicating rapid subsidence in the basin simultaneous with uplift of the southern basin margin forming today the Axial zone. Structures that document the exhumation are exposed in the Labourd massif. In this area mylonitic shear zones are observed in lower crustal granulites that are overprinted by brittle fault zones and infiltrated by sediments, clearly supporting the existence of top-basement detachment faults. As for Parentis basin, the occurrence of detachment structures and extensional allochthons in the Mauleon basin contrasts with the simple sag geometry in its northern part, i.e. the Arzacq basin. The Parentis and Mauleon basins are bounded by SW-NE trending lower Cretaceous syn-sedimentary transform faults, the Pamplona and Mauleon faults. These structures clearly show a complex 3D structuration of the basins and question the former interpretation that these basins formed along major E-W directed strike slip faults. Based on these and other more regional observations, we suggest that a significant part of the left lateral strike slip movement predate Early Cretaceous transtension and is Late Jurassic in age. The strong pre-stucturation may have controlled the Early Cretaceous transtension and is interpreted to explain the different evolution of the southern and northern parts of these basins that evolved independently form each other. In the northern parts, the sag geometry may result from the thermal subsidence associated with the Later Jurassic event, whereas in the southern part Early Cretaceous detachment faults interacted with SW-NE directed strike slip faults resulting in a complex basin geometry observed in front of the propagating ocean.