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Slab rollback and continental break-up in a convergent setting – seismic structure of passive continental margins in the Western Mediterranean Sea

I. Grevemeyer (1), C.R. Ranero (2), D. Pesquer (1), and J. Gallart (3)

(1) GEOMAR, Marine Geodynamics, Kiel, Germany, (2) ICREA at Instituto de Ciencias del Mar, CSIC, Barcelona, Spain, (3) Instituto de Ciencies de la Terra J. Almera, CSIC, Barcelona, Spain

The Western Mediterranean Sea is a natural laboratory to study the processes of continental extension and rifting in a convergent setting. Gravitational collapse due to tectonic thickening of continental lithosphere and the roll-back of a subducting oceanic slab during the latest phases of consumption of the Tethys ocean have led to rapid Neogene extension in an area characterized by a constant convergence of the African and European Plates since Cretaceous time, rifting Spain/Balearic Islands from Algeria, causing passive continental margins on both sides of the Western Mediterranean Basin. However, little is known about the crustal and upper mantle structure of much of the area, including the Algerian-Balearic Basin and the Spanish/Balearic margin. Here we present results from three onshore/offshore seismic refraction and wide-angle lines surveying the Spanish passive continental margin to the south of the town of Alicante and the southern margin of the Balearic promontory. The data were acquired with the German research vessel METEOR in September of 2006 and most ocean-bottom and land stations provided seismic offsets of 40 to 80 km, including wide-angle reflections from the crust/mantle boundary zone (seismic Moho). Profile P03 surveyed the southeastern margin of Spain near the town of Alicante. Profile P04 and P05 approached the Balearic promontory from the south at Ibiza and Mallorca, respectively. All lines extend roughly 100 km into the Algerian-Balearic basin, yielding for the first time constraints on the nature of the crust forming the seafloor between Spain and Algeria. Crust in the centre of the Algerian-Balearic basin is 5-6 km thick and the seismic velocity structure mimics normal oceanic crust, though velocities in the lower crust tended being 0.2-0.4 km/s lower than in typical Atlantic or Pacific crust. Seismic Moho in the Algerian basin occurs at $\sim$11 km below sea level, reaching >24 km under SE Spain and Mallorca. The continent-ocean transition (COT) seems to be rather sharp and we did not find any evidence for velocities intermediate between lower crustal and upper mantle rocks, representing magmatic under plating or lower crustal intrusions as typical for volcanic margins. Further, we did not find any evidence for exposed and serpentinized mantle in the transition zone. Stretching, however, affected a much broader area at the Ibiza segment, while off Alicante and off Mallorca seismic data support a narrow zone affected by stretching. A profound feature in the data is that the earliest crust formed after break-up is 2-4 km thicker with lower crustal velocities 0.2-0.4 km/s lower than near the centre of the Algerian basin. This feature is similar to crust formed in the southern Lau Basin and is believed to be caused by the entrainment of hydrous melts from the adjacent arc during back-arc spreading.