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First results from the NEAREST-SEIS deep seismic cruise across the Gulf of Cadiz accretionary wedge

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The Gulf of Cadiz lies offshore of Southwest Iberia and Northwest Morocco, bounded to the West by the Azores–Gibraltar transform and to the East by the Betic-Rif mountain belt. The region is famous for the great 1755 Lisbon earthquake and tsunami. Here the plate boundary between Africa and Eurasia is complex, marked by a broad region of deformation spanning about 200 km in a north–south direction. One of the most striking structures characterizing the Gulf of Cadiz is the presence of a thick tectonically deformed sedimentary wedge, which is interpreted as an accretionary wedge formed by the W to SW migration of the Rif-Betic block. Two types of geodynamic models have been proposed to explain the recent tectonics and formation of this region: those invoking delamination of continental lithosphere beneath the Betic-Rif Alboran Sea region, and those favouring subduction of oceanic lithosphere, with associated roll-back. Numerous marine geophysical surveys were performed in the Gulf of Cadiz area during the last years, many as part of the NEAREST European project. Multi-beam bathymetry and multi-channel seismic (MCS) data were acquired, which help constrain the upper crustal structures. Deep structural maps demonstrate that sediment thicknesses in the central Gulf of Cadiz (beneath the accretionary wedge) reach a maximum of 12-13 km. Additional wide-angle seismic records acquired during the SISMAR experiment (2001) testify to the difficulty of even low-frequency waves to penetrate below this thick sedimentary body. Nevertheless, from the resulting models a 7-to-10-km thick basement is inferred beneath the western and central Gulf, which forms a roughly E-W oriented trough between the thicker (20-30 km) continental crust of SW Iberia and NW Morocco.

During the NEAREST-SEIS cruise on the B/O Hesperides (nov. 2008), two wide-angle seismic lines were acquired in the Gulf of Cadiz area using a seismic source composed of seven 1500LL Bolt airguns (4520 in3), shot at 90 s intervals. 19 ocean bottom seismometers (OBS) from Ifremer and the University of Brest and 17 OBS from UTM-CSIC, Barcelona were on board. The longer profile was shot NW-SE in the western part of the Gulf, crossing from Tagus plain to Seine abyssal plain (profile 1, 29 OBS deployments). The shorter one was a line roughly perpendicular to the South Portuguese margin (inner part of the Gulf), crossing from Portimao Canyon, the frontal portion of the accretionary wedge frontal, where the sedimentary cover is still relatively thin (profile 2, tending NNE-SSW). Here we focus on profile 2, the main purpose being to determine an accurate location of the transition between continental and oceanic crust. 15 OBS were deployed along this line with a $\tilde{7}$ nm spacing, and it was extended on land by landstations (Portuguese side). Most of the wide-angle data were of good quality, despite the rapid decrease of the amplitude arrivals with increasing offset, due to the combination of a lack of source energy and the particular nature of material constituting the accretionary wedge. The following processing was applied to all sections: deconvolution, 4–16 Hz Butterworth filter, equalization. The data generally show clear sedimentary refracted phases, deeper intracrustal phases, some arrivals refracted in the upper mantle and reflections at the boundary between the crust and the mantle (PmP).

A first modelling of the corresponding data is performed using a joint refraction/reflection traveltime tomography approach (1st arrivals and PmP phase are inverted jointly), following a Monte-Carlo type analysis to avoid the dependency on the starting model and provide velocity uncertainties. A checkerboard test is also computed to estimate the resolvability of the different parts of the resulting model. Information given by coincident MCS data (profile SWIM-01; SWIM experiment, 2006) is used to discuss and validate our velocity reconstructions. The wide-angle velocity model obtained along profile 2 images for the first time the evolution of basement structures (down to the Moho) from the South Portuguese coasts to the Northwest Morocco continental platform.