Investigations of the Oligocene-Miocene opening of the Ligurian Basin using amphibious refraction seismic data

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The Ligurian Basin is located north-west of Corsica at the transition from the western Alpine orogen to the Apennine system. The Back-arc basin was generated by the southeast trench retreat of the Apennines-Calabrian-Maghrebides subduction zone. The opening took place from late Oligocene to Miocene. While the extension led to extreme continental thinning and un-roofing of mantle material little is known about the style of back-arc rifting.

To shed light on the present day crustal and lithospheric architecture of the Ligurian Basin, active seismic data have been recorded on short period ocean bottom seismometers in the framework of SPP2017 4D-MB, the German component of AlpArray. Two refraction seismic profiles were shot across and along the centre of the Ligurian Basin. P01 was shot in an E-W direction from the Gulf of Lion to Corsica. The profile extends onshore Corsica to image the necking zone of continental thinning. P02 is a transect along the basin in NE-SW direction extending a previous shot seismic profile reaching to the Italian cost near Genua. The majority of the ocean bottom seismometer data show sedimentary and crustal phases of good quality and weaker in amplitude mantle phases to offsets up to 70 km. The arrivals of seismic phases were picked and inverted in a travel time tomography.

The results for p01 show a crust-mantle boundary in the central basin at ~12 km depth below sea surface. The crust-mantle boundary deepens from ~12 km to ~18 km within 25 - 30 km towards Corsica. The results do not map an axial valley as expected for oceanic spreading. However, an extremely thinned continental crust indicates a long-lasting rifting process that possibly did not initiate oceanic spreading before the opening of the Ligurian Basin stopped. This is in good agreement with recent kinematic modelling performed in the second phase of the SPP2017 4D-MB. The modelling results of p01 indicate that continental crust can be stretched over several million years when the opening rate is low, i.e. <2 mm/year, and syn-rift sedimentation rate is high. Subduction initiation could occur in ultra-thinned continental crust as basin inversion has been observed at the northern Ligurian margin as a result of the African-European convergence. Additionally, the observations from the Ligurian Basin might be transferred to the evolution of the Piemont-Liguro Ocean. So far oceanic crust was assumed as initial conditions for the subduction of the Piemont-Liguro Ocean. An ultra-thin continental crust as initial condition would explain the observed thin subducted Piemont-Liguro plate which seemed to be thinner than 6-7 km oceanic crust. Further, a dry continental crust could explain why no back-arc volcanism was observed. The along-basin profile p02 shows a deepening crust-mantle boundary from 11 to 13 km. Based on the retrieved velocity model, gravity modelling and further results from surrounding studies we conclude that the continental crust is thinning from the northeast to the southwest which is related to the increase of extension away from the rotation pole of the anticlockwise rotation of the Corsica-Sardinia block. It remains unclear if at the southern end of the profile the mantle is overlain directly by sediments or by extremely thinned continental crust of up to 2.5 km thickness. The results however document, that seafloor spreading and the formation of mantle-derived oceanic crust was not initiated during the extension of the Ligurian Basin.