Geophysical Research Abstracts
Vol. 17, EGU2015-6548, 2015
EGU General Assembly 2015

Subduction of European continental crust to 70 km depth imaged in the Western Alps

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The first conclusive evidence in support of the burial (and exhumation) of continental crust to depths larger than 90 km was provided by the discovery of coesite-bearing metamorphic rocks in the Dora Maira massif of the Western Alps (Chopin, 1984). Since then, even though similar outcrops of exhumed HP/UHP rocks have been recognized in a number of collisional belts, direct seismic evidences for subduction of continental crust in the mantle of the upper plate remain rare. In the Western Alps, the greatest depth ever recorded for the European Moho is 55 km by wide-angle seismic reflection (ECORS-CROP DSS Group, 1989). In an effort to image the European Moho at greater depth, and unravel the very complex lithospheric structure of the W-Alps, we have installed the CIFALPS temporary seismic array across the Southwestern Alps for 14 months (2012-2013). The almost linear array runs from the Rhône valley (France) to the Po plain (Italy) across the Dora Maira massif where exhumed HP/UHP metamorphic rocks of continental origin were first discovered. We used the receiver function processing technique that enhances P-to-S converted waves at velocity boundaries beneath the array. The receiver function records were migrated to depth using 4 different 1-D velocity models to account for the strongest structural changes along the profile. They were then stacked using the classical common-conversion point technique. Beneath the Southeast basin and the external zones, the obtained seismic section displays a clear converted phase on the European Moho, dipping gently to the ENE from ∼35 km at the western end of the profile, to ∼40 km beneath the Frontal Penninic thrust (FPT). The Moho dip then noticeably increases beneath the internal zones, while the amplitude of the converted phase weakens. The weak European Moho signal may be traced to 70-75 km depth beneath the eastern Dora Maira massif and the westernmost Po plain. At shallower level (20-40 km), we observe a set of strong amplitude negative-polarity converted phases (generated by downward velocity decreases) beneath the Dora Maira massif and the westernmost Po plain. Records in the Po plain display a strong but intricate converted signal from the Adria Moho between 10 and 35 km depth. We propose that the negative-polarity converted phases are generated by downward decreasing velocity between, from top to bottom, the Ivrea body of mantle origin, a thick wedge of HP/UHP metamorphic rocks and the European lower crust. Our receiver-function section thus displays the classical wedge-shaped image of the Alpine crust, but with the deepest European Moho ever recorded (70-75 km), and clear evidence of continental subduction of the European lower crust beneath the Ivrea mantle body (and possibly Adria mantle) as a negative-polarity converted phase indicative of an inverted Moho. Based on our seismic section, complemented with seismic and gravity modelling and geological arguments, we propose a new crustal-scale cross-section of the Western Alps.