

Active seismic surveys to site the Drilling the Ivrea zone (DIVE) drill-holes, Val Sesia and Val d'Ossola, Italy

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The Ivrea-Verbano Zone in the Italian Alps represents one of the most complete and best-studied cross-sections of the continental crust. Here, geological and geophysical observations indicate the presence of the Moho transition zone at shallow depth, notably as shallow as 3 km in the location of Balmuccia in Val Sesia. Correspondingly, the Ivrea-Verbano Zone is a primary target for assembling data on the deep continental crust as well as for testing several hypotheses regarding its formation and evolution.

Within the context of a project submitted to the International Continental Scientific Drilling Program (ICDP), the Drilling the Ivrea-Verbano zone (DIVE) team proposes to establish three drill holes across pertinent structures within the Ivrea-Verbano Zone. Two of the planned drill holes, each with a length of ~1000 m, are within Val d'Ossola and target the Pre-Permian lower and upper section of the lower crust. The third proposed drill hole, with a length of ~4000 m, is targeting the lower most crust of the Permian magmatic system of the Ivrea-Verbano Zone in the Val Sesia, close to the Insubric Line. Combined, the three drill holes will compose a complete section of the lower crust and the Moho transition zone and will reveal the associated structural and composition characteristics at different scales.

To bridge across a range of spatial scales and to support the drilling proposal, we have carried out active seismic surveys at the planned drilling locations. In 2017, a preliminary high-resolution reflection seismic survey was conducted across the Insubric Line mylonites at the contact between the gneisses of the Sesia Zone and the Ivrea-Verbano Zone, where a remarkably complete cross-section of the lowermost continental crust (granulitic gabbros, pyroxenite, and peridotite) is exposed. Selective stacking of forward and reverse offsets confirmed that reflection events are predominantly dipping to the west and corroborate characteristic changes observed in the migrated seismic image. These results are in agreement with the near-vertical structural dips seen in outcrop-based geological mapping, which, in turn, points to the continuity of the pervasive structural fabric at depth. More recently, in the late summer of 2019, seismic surveys were conducted using an EnviroVibe source to aid siting of the two drill holes planned in Val d'Ossola. The very high acoustic impedance contrast of the Quaternary valley infill sediments with respect to the predominant metapelitic and gabbroic lower crustal rocks, as well as the high attenuative nature of the sediments, were both beneficial and problematic. The former enables mapping of the valley structure, while the latter largely prevents the detection of low-amplitude reflections from within the underlying lower crustal rocks.

Here, we present the latest results of these seismic reflection surveys and discuss the observations with respect to the prevailing structure and the planning of the drilling operations. Beyond the specific objectives pursued in this study, our results have important implications with regard to the acquisition and processing of high-resolution seismic reflection data in crystalline terranes and their capacity for resolving complex, steeply dipping structures.