3D Tomography across the Balmuccia Peridotite, Ivrea Zone, Italy - Project DIVE, phase two

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The Ivrea Verbano Zone (IVZ) is one of the most complete crust upper-mantle geological references in the world, an area that the Drilling the Ivrea-Verbano zone project (DIVE) aims to study. Associated with the IVZ, the Ivrea Geophysical Body (IGB) is of particular interest, as it is a structure beneath the IVZ characterized by high seismic velocities and a strong gravity anomaly. Recent studies across the IGB indicate that dense mantle rocks are located at depths as shallow as ca. 3 km. Several geological, geochemical and geophysical studies are planned, including the drilling of a 4 km deep borehole that will cross the crust–mantle transition zone, and provide, for the first time, geophysical in situ measurements of the IGB.

In preparation for the drilling campaign, a seismic survey was performed in October 2020 in collaboration with GFZ Potsdam, Université de Lausanne, and Montanuniversität Leoben. In this study, we present results from a shallow seismic survey across the Blamuccia Peridotite, where the prospective drill site is planned. The survey was carried out with a fixed spread of 200 vertical geophones and 160 3C-sensors, spaced at 11 m along three sub-parallel lines 50-80 m apart. Vibroseis source points were at 22 m stations along a 2.2 km line utilizing a 12-140 Hz 10 s linear sweep with 3 s listening time.

Through the application of 3D traveltime tomography, a shallow velocity model was obtained. The model shows a good correlation with the surface geology and can outline the east and west boundaries of the peridotite body; however, it is not deep enough to interpret its relationship with the mantle. Velocity analyses performed through the tomography process show that the peridotite body must have a P-wave velocity at least greater than 7.3 km/s, which is consistent with the high velocities measured in several laboratory studies from samples throughout the area.

Seismic data show a lack of reflectors from the peridotite body, which could be interpreted in two ways: The peridotite body is attached to the mantle, or its structure is such that reflections from its boundaries cannot be detected by our seismic survey due to its limited aperture. However, a deep reflector was observed in some shot gathers, originating from a depth between 2-3 km from sea level. This corresponds well to the depth of the crust-mantle transition estimated from gravity and receiver function surveys. The shallow 3D velocity was used for the application of refraction statics and the development of a deeper velocity model to perform 3D pre-stack depth migration. Extreme topography, high P-wave velocities, and vertical geological structures present a challenge for the imaging process.