Geophysical Research Abstracts
Vol. 21, EGU2019-9249, 2019
EGU General Assembly 2019

Predicting the chemical composition of the Ivrea geophysical body: A petrophysical and petrological analysis

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Geophysics and outcrop data collectively provide insights into properties of the Earth's lithosphere. Linking the two, however, needs up/downscaling over several orders of magnitude calling for tighter constraints connecting these and describing the actual physical and chemical architecture of the lithosphere. The Ivrea-Verbano Zone (Southern Alps, Italy) represents the most complete, time-integrated crust–upper mantle archive that acts as a petro-geophysical benchmark of the Earth's continental crust. Unserpentinized mantle peridotite slivers embedded in lower crustal rocks and large gravimetric, magnetic, and seismic anomalies of the buried Ivrea body suggest that dense, "mantle-like" rocks are possibly located as shallow as ∼3 km depth at Balmuccia location in Val Sesia [1]. However, to date, the present-day spatial geophysical resolution does not provide a precise structure and chemistry estimate of the Ivrea body. Here we present a petrophysical and petrological investigation to unravel the chemical composition of the Ivrea body using a combination of published laboratory seismic compressional wave velocities (VP) of lower crust and upper mantle rocks, Perple_X-based thermodynamic modelling, and end-member mineral physical property compilation along a theoretical 60-km 1-D vertical profile below Balmuccia location, including in situ geophysical data collected at large scales. While we have solid laboratory constraints that account for the effect of porosity on VP in the 15-km depth range, at larger depth, we present four modelled scenarios using: 1) Cr-diopside pyroxenite, 2) lherzolite, 3) dunite, and 4) harzburgite, with the latter displaying different degrees of serpentinization (1 to 35%). VP were calculated assuming 5-kbar mantle exhumation and a closure temperature of 700 °C. Along the available VP geophysical profile, ranging from 6.5-7 km/s up to 30-km depth and then to 7.5-8 km/s up to 60-km depth [2], the Ivrea body cannot be made of pure mantle-type lithologies up to 50-km depth (i.e. scenarios 1-3 above are not possible). The presence of partially serpentinized mantle rocks (scenario 4 above) better matches the VP profile [3] and magnetic anomalies up to 20-km depth [4], but may be in contrast with the presence of unserpentinized mantle peridotite slivers outcropping in the lower crustal section of the Ivrea-Verbano Zone. Other viable scenarios include cumulate sequences or interlayered gabbros/(restitic?) granulites and mantle-type rocks. This study aims to close the gap between geophysical signature and lithostratigraphic interpretation and to provide a unique quantitative model that accounts for the petrophysical and petrological heterogeneity of the Ivrea lithosphere.

References:
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