SCARPONI Matteo (2021): Combining gravimetry, passive seismology and rock physical properties to constrain intra-crustal structures : the Ivrea Geophysical Body and the Gotthard Base Tunnel

Abstract

The structure of the Alpine orogen is complex, and many areas present an imaging gap between regional geophysical and local geological information. In the frame of this thesis, I have performed joint investigations, collecting new gravity and passive seismic data and combining them with surface geological observations and rock sample laboratory analysis, to provide higher-resolution images and models of an intra-crustal and a shallow Alpine structure. I targeted the Ivrea Geophysical Body (IGB) and the Gotthard Base Tunnel (GBT), as they provide ideal areas for testing the resolution limits of passive geophysical investigations and addressing pending structural questions as well. The IGB, considered as a sliver of Adriatic lower lithosphere, located at unusually shallow depths along the inner arc of theWestern Alps, is associated with well-known density and seismic velocity anomalies. Aiming at refining the IGB structure and its relationship with the geological Ivrea-Verbano Zone (IVZ) outcropping at the surface, I collected 207 new relative gravity data and I installed 10 broadband seismic stations which operated for 27months. In a first, 3D gravity study, I compiled a surface rockdensity map and used it to define a density-corrected gravity anomaly named Niggli anomaly. Modelling the Niggli anomaly allowed to address more properly the IGB structure at depth, the latter being modelled as a 3D, single density-contrast interface beneath the entire IVZ. From this, I obtained 400 § 100 *kg* ¢*m*¡3 as optimal density contrast, and a » 20 km-wide protruding structure reaching as shallow as 1 § 1 km depth below sea level. Petrological considerations allow to suggest ultramafic and mantle peridotite rocks as most likely components for the IGB. In a second, refined 2D study, the seismic data was also included to constrain the IGB model along the Val Sesia cross-section. A joint inversion was designed, exploiting seismic receiver functions and gravity anomalies, following an iterative inversion scheme to constrain the geometry and physical properties of the IGB. An optimal density contrast between 200 and 400 *kg* ¢*m*¡3 was obtained, with shallow segments 1-3 km depth below sea level, and in agreement with rock physical properties indicated by previous studies. For the final study, along the GBT, I acquired 80 new relative gravity data points at the surface and used 77 points measured in the tunnel to test and constrain the geological model established during tunnel construction. To this end, I developed an iterative scheme with fully 3D, density-dependent gravity terrain-adaptation corrections, to then consistently compare the observations with the synthetics from the 2D geology-based density model. Density data models for various lithologies were compiled fromthe SAPHYR rock physics database. The results show that in situ rock densities provide a better fit to the observed gravity data, and that the geological structure of GBT proposed earlier can be reasonably fit with surface and tunnel geophysical data.