Melt-mantle reaction and potential metal enrichment along the subcontinental crust-mantle transition zone (Balmuccia massif, Italy)

Popular science summary

Precious metals such as gold, silver and copper belong to the group of chalcophile elements chemically affined to sulfur. Chalcophile metals are transported to the surface and entrapped by sulfides, to form strategic ore deposits. Industry demand for metals is growing dramatically causing surface reserves to shrink. To find deeper metal resources we need to search for sulfides within the lower crust and even the upper mantle. Under oceans, precious metals are known to be enriched at the boundary between the crust and the mantle which is commonly called Moho. We think that also the continental Moho is enriched in precious metals. However, the Moho exposures are rare at the Earth surface. Moho is on average ~35 km below the continental surface and cannot be easily tectonically exposed in contrast to the oceanic crust where Moho is at 7 km or less.

The recent advance in technology made Moho more tangible to become recently one of the most important topics in geoscience. After initiated and successful operations to drill through the oceanic Moho at oceans (SloMo Project started with International Ocean Discovery Program (IODP) Expedition 360) and slabs of oceanic lithosphere obducted onto a continental plate called ophiolites (International Continental Drilling Program (ICDP) Oman Drilling Project), the continental Moho became the next key target. This will be the goal of the upcoming Drilling the Ivrea-Verbano zonE project (northwest Italy) operated by the ICDP, aiming to core through a 4-km-thick section of the lowermost continental crust including crust-mantle transition zone. Drilling operations will be performed in three key sites including Premosello (1 km), Ornavasso (1 km), and the Balmuccia quarry (4 km). The Balmuccia quarry raises most scientific interest and gives the greatest opportunity for success. Many scientist are interested in revealing the nature of large-scale metal migration along the lowermost continental crust and mantle peridotites. The drilling operations will start in 4-5 years. With our PRELUDIUM project, however, we have an opportunity to get first important data earlier. The Balmuccia peridotite massif is a fragment of the subcontinental mantle exposed directly on the surface with very well-preserved contact of mantle peridotite and gabbroic rocks that may derive from the crust-mantle transition zone. The Balmuccia rocks including mantle peridotites represent exceptionally fresh lithosphere even at the surface and are exposed in large outcrops of > 100 m. This is a huge advantage in studying geological processes compared to less-defined samples from the oceanic crust-mantle boundary exposures.

In this project, we will use a combination of traditional geological techniques, such as optical microscopy, with the most sophisticated techniques such as SHRIMP Ile/MC and high-resolution sector field inductively coupled plasma-mass spectrometer (ICPMS) coupled to femtosecond laser ablation (fs-LA). Thanks to the fs-LA-ICPMS we can determine the copper, nickel, and iron isotopic composition, as well as measure the trace elements concentrations of even very rare noble metals such as platinum or gold. The laser ablation system operating in the ultrashort pulses of energy allows determining chemical or isotopic composition of a given mineral in a field of only five micrometers in diameter. The fruition of this project will help us to understand the metal enrichment at the continental crust-mantle transition zone and its implication for the metal budget of the continental lithosphere.