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Evidence of deformation control on the P-T record in compositionally heterogeneous shear zone during subduction-exhumation cycle

Matteo Maino[1,2], Leonardo Casini[3], Stefania Corvò[1], Antonio Langone[2], Filippo Schenker[4], and Silvio Seno[1,4]
[1]Department of Earth and Environmental Sciences, University of Pavia, Pavia, Italy (matteo.maino@unipv.it)
[2]Istituto di Geoscienze e Georisorse, CNR, Pavia, Italy
[3]Department of Chemistry , University of Sassari, Sassari, Italy
[4]Institute of Earth Sciences, University of Applied Sciences and Arts of Southern Switzerland (SUPSI).

Pressure-temperature paths are a major tool for tectonic reconstruction as proxies of the burial and exhumation history of the rocks during subduction-exhumation phases. The mineral assemblages are commonly considered to reflect lithostatic pressure and near-equilibrium regional geothermal gradients. These axioms ground on the assumptions that the rock cannot support high differential stress in one place, and that heat diffusion in rocks is fast enough to defocus localized thermal anomalies, respectively.

The rare but systematic occurrence, in actual mountain ranges, of ultrahigh-pressure and/or high-temperature rocks within lower grade metamorphic rocks rise a major challenge for developing a consistent geodynamic model for exhumation of such deep seated rocks. Subduction zones are, in fact, efficient player driving material from the surface down into the Earth's mantle. However, the mechanisms to exhume part of this material (and particularly the denser oceanic rocks) back to the shallow crust are still highly debated.

In this contribution, we present new structural, petrological and thermochronometric data from an exhumed subduction zone - the Cima di Gagnone in the Central Alps– where small ultramafic inclusions (peridotite) preserving high temperature and high pressure record are enveloped within amphibolite-facies gneisses, defining a classical inclusion-in-matrix system. We found evidence of heterogeneous metamorphic and temperature records in both peridotite and felsic rocks, being the gneisses generally characterized by much lower pressure. However, we detect also in the matrix gneiss close to peridotite inclusions high-pressure and high-temperature remnants, which are structurally and temporally associated with those of ultramafic bodies.

The coexistence, at the outcrop scale, of such different conditions implies either extreme mechanical decoupling or extremely variable metamorphic equilibrium during Alpine subduction and exhumation. A possible alternative explanation is to consider part of the metamorphic record as due to mechanical deviations from lithostatic pressure and equilibrium temperature. We compare the observed metamorphic pattern with the outcome of numerical simulations obtained from elasto-visco-plastic 2D Finite Difference models. The evolution of rocks strength and viscosity is furthermore monitored to control the effectiveness of physical conditions simulated with the analytical dataset. Finally, we discuss a possible positive feedback of tectonic stress on the development of apparently incompatible metamorphic patterns.