Exhumation histories of high-pressure rocks: New insights from Rb-Sr geochronology

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High-pressure (HP) rocks can be considered as 'flight recorders', potentially recording their individual P-T-time-deformation path through evolving orogens. Reading the flight recorder requires both deciphering of the geochronological information, and correlating it with data on pressure, temperature and tectonometamorphic processes. Isotopic signatures of minerals, like the Rb-Sr system of white mica, has long been considered as particularly sensitive to temperature. This often prompted direct translation of sets of mineral ages into cooling histories, with inference of exhumation paths from thermal histories. However, this approach is problematic because microscale spatial correlations of isotopic ages with mineral growth zonation and recrystallization fronts (Vance *et al*. 2003) indicate that factors like availability of fluids, mineral recrystallization, and the modal rock composition similarly play vital roles in determining whether an isotopic system remains closed.

As an alternative approach, assemblages which remained closed for intermineral isotope exchange can be used to generate Rb-Sr 'event ages' for specific metamorphic processes. It is shown that the Rb-Sr system of white mica in eclogite may persist unchanged even through very high temperatures (>650°C). Key requirements for this high thermal stability are a) absence of free aqueous fluids after crystallization, evidenced from absence of fluid-mediated retrogression reactions, and b) modally controlled closed system behaviour, i.e., presence of white mica in an assemblage solely of phases like garnet and omphacite which do not allow for significant diffusional Sr isotope exchange even at the highest temperatures reached. A valid Rb-Sr multimineral isochron comprising all phases of an eclogite assemblage can be interpreted as dating eclogitization (cf. Glodny *et al.* 2005), and directly linked to PT data from the same sample to constrain eclogitization conditions.

The same concept applies to assemblages formed later in a HP rocks' history. Veins, precipitated from fluids during exhumation, may be used to determine age and PT conditions of amphibolite- or greenschist facies overprints. Different event ages combine to an exhumation history, established beyond the pitfalls of closure temperature theory. Using examples from the Tauern Window (Austria) and the Bergen Arcs (Norway), the potential of this approach to precisely constrain contrasting exhumation histories is demonstrated.

References

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Topographic threshold values for the interpretation of low-temperature thermochronology

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Low-tempertature thermochronology provides the opportunity to quantify surface processes over geological time scales. Deducing exhumation rates is crucially depending on assumptions about the shape of isotherms. Here we present apatite fission track (AFT) data sampled along a horizontal structural level, allowing to reconstruct the critical paleo-isotherm. Samples have been collected along the 16 km long Gotthard road tunnel in central Switzerland and the corresponding surface line. The study was accompanied by 3D numerical thermal modelling, which was carried out incorporating thermally relevant parameters and mechanisms, e.g. topography, geology, thermal conductivities, heat production. Modelling predict a net topography-induced perturbation of the 110°C isotherm of around 250 m, whereas spatial variable heat production rates are capable to produce a perturbation of 550 m. Modelling shows that the effect on near surface isotherms due to spatial variations of thermal conductivities are small. Measured AFT-ages broadly range around 6 Ma along the tunnel. No correlation of ages with overburden and topography can be seen, demonstrating that topography induced perturbation of isotherms under given boundary conditions (topographic wavelength: 12 km, relief 1.7 km, exhumation rate: 0.45 mm/y) and physical parameters of the Gotthard transect can be neglected for the interpretation of AFT-ages. Thus in areas characterised by similar topographies, apparent exhumation rates deduced from age elevation relationship (AER) need no corrections for topography-induced perturbation of isotherms.