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HOW MUCH TIME INFORMATION DO METAMORPHIC MINERALS RECORD? AGE DISCORDANCE BETWEEN „ROBUST" ISOTOPE SYSTEMS AND THEIR LINK WITH P-T-D DATA IN ALPINE HIGH-P ROCKS

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Exact knowledge of the timing of different stages related to a metamorphic PT path is indispensable for calculating reliable exhumation and/or cooling rates in metamorphic rocks. However, the evaluation of radiogenic isotope data from metamorphic minerals to establish their strict time significance needs to address, first of all, the following basic problems:

a) isotopic (dis-)equilibrium within the analyzed system;
b) the influence of (probably unequilibrated) inclusions in the "clean" mineral separates used for dating;
c) the effects of any possible post-peak perturbation (open system behaviour) of the isotopic systems, due to late active processes, such as thermally controlled diffusive loss of radiogenic isotopes, selective deformation-induced (re-)crystallization, fluid activity, or a combination thereof.

Although an apparent age scatter from samples with a common tectono-metamorphic history might well be explained in some cases by processes a) and b), age discordance, even between the so-called „robust" systems (U-Pb, Lu-Hf, Sm-Nd), can also result from heterochronous chemical processes operating at different stages of metamorphic (re-)crystallization and/or isothermal decompression and exhumation of deeply buried rocks. This means that, depending on bulk chemistry and pre-existing metamorphic history (mineralogy, microstructure) of the rocks involved as well as inhomogeneous distribution of deformation in an accretionary or exhuming wedge, different isotopic systems may be influenced by different processes.

Examples from Alpine eclogite- to amphibolite-facies-grade areas of the Austroalpine basement are used to illustrate the above discussed problematics.

In the Koralpe and Saualpe (KS) area of the SE Austroalpine units Sm-Nd ages from pyropic high-P garnets in meta-acidic lithologies (mainly metapelites) cluster within a narrow time range between 91±2 and 86±2 Ma. Sm-Nd garnet ages from the Schneeberg garnet mica schist complex in the southeastern Ötztal basement (western part of the Austroalpine unit) are roughly similar, ranging between 93–90 Ma for the final stage of garnet crystallization. All these ages are interpreted to trace final peak pressure conditions for the "high-P metamorphic belt" (THÖNI & JAGOUTZ, 1993) that characterizes considerable portions of the southern Austroalpine basement units. The data imply that exhumation of eo-Alpine high-P rocks in the Austroalpines initiated almost contemporaneously, within the rather narrow time window of c. 89±3 Ma. This date correlates in time with the oldest portion of the Gosau Group sediments in the Northern Calcareous Alps (WAGREICH & FAUPL, 1994). Together with mica cooling ages, the above age data allow the mean exhumation rates for the southern Austroalpine sheet to be constrained on a regional scale. The calculated values are 4-6 km/Ma for the time interval of roughly 89 (±3) to 78 (±3) Ma (corresponding to cooling rates of 25–40 °C/Ma, respectively) (EXNER et al., 2001).

On the other hand, mineral-mineral and mineral-whole rock ages from metabasic rocks of the KS, calculated on the basis of the Sm-Nd and Lu-Hf isotope systems, scatter more widely, yielding ages of between 109±9 and 87±5 Ma. In combination with microstructural and microchemical data, these somewhat older dates from more competent, Ca-rich lithologies may be interpreted to reflect earlier steps of the same eo-Alpine high-P evolution.

Interestingly, U-Pb SHRIMP ages for zircons from the same metabasites range among the youngest age figures (THÖNI et al., 2001). Since some of these zircons show inclusions of high-P garnet and omphacite, late-metamorphic zircon crystallization (82±4 Ma) is independently proven by microstructural criteria.

It may be inferred, therefore, that the so-called "robust" chronometers – generally thought to date peak PT conditions – may yield internally discordant, but valuable age results, being able to record basically different processes operating along a coherent subduction/exhumation path of one single continuous metamorphic evolution. The above results are also compared with "robust" isotope data from other HP-UHP areas of the Alpine chain and implications for their interpretation are discussed.

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