Combining multi-equilibrium thermobarometry and Ar-Ar ages for micas: Results from the northern Lepontine Alps

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We use multi-equilibrium thermobarometry (TWQ; Berman, 1988) and rock-specific phase diagrams (with assemblages computed by DOMINO; de Capitani and Brown, 1987) to assess equilibria of mineral assemblages and non-equilibrium textures. Samples retaining precise PT-conditions are our best candidates for dating by Ar-Ar and, where possible, by other chronometers (monazite, allanite). Comparison of ages, PT-conditions and crystallization-deformation relations is thus a powerful tool to interpret the PTDt-history of individual samples.

The Barrovian metamorphism in the Swiss Central Alps outlines a belt of post-nappe amphibolite facies. At its northern margin, the transition from greenschist to epidote-amphibolite facies follows the Northern Steep Belt (NSB), and this zone has been reinvestigated in this study. We focus on metapelites from Mesozoic protoliths, as they reveal well preserved mineral equilibria constraining PT-conditions, and these necessarily pertain to Alpine (rather than pre-Alpine) metamorphism. Thus we avoid problems of inheritance, which have plagued many of the geochronological data obtained in the NSB over the past 50 years. Despite problems of interpretability, some of the classic K-Ar ages for micas and the U-Th-Pb for monazite may be usefully compared with new mica ages obtained in the present study.

We present here data for samples of Upper Triassic schist (“Quartenschiefer”) from two locations, for which TWQ yields tightly constrained PT-conditions and DOMINO matches the assemblages and garnet zoning observed:
- **Pizzo Molare:** Two samples of micaschist with Grt + St + Bt + Ms + Qz + Pl + Ilm (ot Rt). The matrix of sample *AMo0409* is dominated by Ms + Qz, with garnet overgrowing the schistosity, large and slightly oblique biotite flakes, and elongated laths of plagioclase. Sample *AMo0410* is comparable, except that garnet is helicitic, and Ky occurs together with St. Rt is locally present in gneissic layers, but then without Ilm. PT results reveal a minor difference in pressure: *AMo0409*: 590 ± 20 °C, 7.0 ± 0.5 kbar; *AMo0410*: 600 ± 20°C, 8.5 ± 0.5 kbar.
- **Val Antabia:** One sample of micaschist with Grt + Bt + Ms + Qz + Pl + Ilm + Rt, composed of two parts, a sheared one and a more massive part. In the massive part, garnet is overgrew the schistosity, plagioclase forms large elongated blasts, and the matrix is composed mainly of Qz + Ms, with large Bt flakes. In the sheared part, large and oblique micas disappear, all of them now being finer and aligned in the schistosity, and biotite shows minor alteration to chlorite. Mineral equilibria in the massive part indicate PT-conditions of 550±50 °C and 6.8±1.0 kbar.

On the basis of the PT-results and petrography, it is possible to characterize an equilibration stage between micas and coexisting minerals. Where Ar-ages for muscovite and biotite are identical, these are interpreted as (re)crystallization ages, pertinent to the conditions of equilibration. However, it is well established that diffusion and deformation may disturb the Ar-system. Where discrepant Ar-ages for coexisting micas are found, we interpret the age difference on the basis of the detailed petrology for the respective sample.

With Ar-data treatment still underway, we only highlight a few important results at this time. Both samples from **Pizzo Molare** yield well constrained PT-equilibria and plateau ages for muscovite at ca. 16.5 Ma. The two biotite spectra show larger variations, but average ages are similar and ~2 Ma younger than for white mica. This difference indicates a process that reset the Ar system at least in biotite. Results from the **Val Antabia** sample are of interest, as Ar-ages on both biotite and white mica from the massive part are identical (ca. 14.5 Ma). The well preserved PT-equilibria indicate a slightly lower temperature than at Pizzo Molare, and the age in this sample seems to pertain to the conditions of equilibrium (re)crystallization. By contrast, the sheared part of the sample not only shows the above-described differences in texture and petrography, but also less readily interpretable Ar data: Micas in the sheared part reveal disturbed Ar-spectra, yielding uncertain ages. Upon heating, the Ar-spectrum of white mica first shows a younger age (12-13 Ma), and the spectrum ends at ca. 14 Ma, i.e. near the age determined for the massive part. The Ar-spectrum for biotite is more disturbed yet, with ages between 11 and 17 Ma, indicating that re-crystallization and minor chloritization have affected the apparent Ar age.

REFERENCES

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