Age constraints on metamorphism in the Bündnerschiefer of the North Pennine Alps: Approach and first results.

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The Swiss Central Alps are marked by Barrovian metamorphism, which increases in grade from North to South, reaching upper most amphibolite facies near the Insubric Line. For some fifty years, geochronologists have aimed to determine the age of this metamorphism, applying various techniques, such as K-Ar, Rb-Sr on micas and amphibole or, more recently, U-Th-Pb on REE minerals and Sm-Nd or Lu-Hf on garnet. There is general agreement that the data reflect the metamorphic peak in the central and southern parts of the Lepontine, but interpretations are problematic in the northern part of the belt. Isotopic inheritance in polymetamorphic (Variscan, Alpine) relics in the crystalline cores of the Pennine nappes is responsible for much of the variation encountered in age determinations.

In this study, the approach is to determine ages on lower amphibolite grade samples, which experienced one metamorphic cycle only. Ideally, we elect to date well-equilibrated samples, for which TWQ thermobarometry indicates no retrogression. In the northern Central Alps, suitable units include Bündnerschiefer and the Triassic trilogy. The main method used is Ar-Ar stepwise heating on "white mica" (see below) and biotite from micaschists and calcschists. Other systems, such as U-Th-Pb on monazite and allanite, will be added in the future. Geochronological results obtained by this approach promise to yield interpretable ages, provided the phase equilibria involving the minerals dated can be quantitatively related to P, T and deformation.

First age results closely linked to paragenetic PT estimates are here presented for six samples situated on an ENE-WSW profile, from Campo Blenio (Ticino, Switzerland) to the Alpe Devero (Italy). These samples yield PT results from 610°C / 8.3kbar, for Alpe Devero to 550°C / 6.3kbar, for Campo Blenio. Intermediate PT-values are estimated for samples from the Nufenenpass, Alpe Piora and Lucomagno regions.

The conventional interpretation (Purdy & Jäger 1976) assumes that mica ages are "cooling ages", reflecting cooling to below 300-350 °C. Our data in combination with published ages indicate that this approach cannot be applied to the Central Alps.

Firstly, U-Pb ages follow a trend opposite to that predicted by conventional "thermochronology". Instead of being all 38 Ma old, or younging southward, U-Pb chronometers record oldest peak metamorphic ages of 29-24 Ma in the high-grade South and become younger (20-15 Ma) towards the North. Mica ages follow the same trend, which is antithetic to a supposed "slow cooling".

Secondly, many samples we analysed petrographically contain multiple mica generations, including relics. However, samples chosen for dating contain only muscovite (±paragonite and/or margarite), without relics of phengite, and TWQ thermobarometry indicated equilibrium assemblages. The ages of polymineralic mixtures dated can be unravelled using the Ca/Cl/K and age-chemistry correlation diagrams. Using this technique, we interpret the dates obtained as equilibration ages: between 13 Ma at Alpe Devero and 20 Ma at Campo Blenio.

Thirdly, the well-established low diffusivities of Ar in white mica, independently confirmed by all investigations of the past decade, require that all white micas retain Ar well above 550 °C. The conventional "thermochronology" based on cooling ages, would require that all Bündnerschiefer slivers would have undergone a burst of rapid exhumation, at different absolute times, but all precisely between the "muscovite closure isotherm" (> 550 °C) and the "biotite closure isotherm" (supposedly 300 °C). As our biotite-muscovite pairs give indistinguishable ages, very localized episodes of infinitely fast cooling would have occurred at 15, and at 18, and at 20 Ma. We prefer a more realistic explanation, according to which biotite (for which there are so far no reliable diffusivity determinations) also dates the metamorphic reaction producing it. Concordance of the biotite and muscovite ages is expected if the two micas are cogenetic (rather than diachronic, as they are in the more frequent case of greenschist-facies retrogression).

Multiple white mica generations give formation ages that allow dating the metamorphic mica-forming reactions at 13-14 Ma (Alpe Devero), 17-18 Ma (Piora), 20 Ma (Campo Blenio). Substoichiometric K concentrations reflect variable amounts of chlorite formation in a chemically open system.

Purdy, J. & Jäger, E. 1976: K-Ar ages on rock-forming minerals from the Central Alps. Mem. Instituti Geol. Mineral. Uni. Padova 30, 31 pp.

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