Petrochronology of shear zones

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In the eclogite facies shear zone of Bottarello, Monte Rosa, Western Alps [1], fault recrystallization around 600 °C gives concordant Lu-Hf (garnet) and 39Ar-40Ar (white mica, WM) 47 Ma ages; unsheared rock at the same T preserves Mesozoic inheritance. The Ar retentivity of WM is not accurately predicted by hydrothermal laboratory experiments, as the latter are plagued by dissolution artefacts [2]. Independent field observations confirm that WM only starts losing Ar in dry rocks above 600 °C [3-8], but when retrograde reactions occur, WM can recrystallize and be totally reset below 230 °C [9]. The Bottarello fault WM dates its own HP formation.

The island of Naxos (Cyclades, Greece) is the classic example of multiple, coexisting WM generations [10]: relict pre-eclogitic WM, eclogitic phengite, retrograde muscovite. Element maps demonstrate intergrowths at a scale <5 μm. Rb-Sr bulk mica ages are Eocene [11], concordant with bulk K-Ar ages. This is a paradox, as Ar diffusivity is 4 orders of magnitude higher than that of Sr [12]; this means that both chronometric systems record formation ages at 500-600 °C. WM generations can be unravelled by their Ca/Cl/K signatures; coarse and fine sieve fractions are never isomineralic, as shearing did not eliminate all relicts. The Ca/Cl/K-vs-age trends give ages of individual mica generations.

The in-sequence thrusts of the Garhwal Himalaya were long-lived. Microstructures and element maps identify three monazite generations (dated by U-Pb) and 3 WM generations: relicts in microlithons; foliation-defining mica; static coronas. As in the previous shear-zones, intergrowths are <<10 μm. Only combining Ca/Cl/K systematics with the observed in vacuo WM structure breakdown temperatures can assign the different WM ages in the same sample to chemically distinct generations [13]. WM formation ages overlap with Mnz ages and date the onset of faulting, the kinematic peak, and the post-faulting corona formation.

There is no free lunch: dating deformation is extremely labor-intensive and requires, always, establishing the context between microtextural, microchemical, petrological and multichronometric analyses. Whenever one of these four is missing, the tectonic reconstruction is invariably faulty [14].

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