Beyond U-Pb: Petrochronology of the Rb-Sr and K-Ar systems

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U-Pb petrochronology owes its existence to the nearly unanimously recognized fact that Pb* diffusion is negligibly small compared to retrograde reaction rates. Attempts to interpret Pb zonations in monazite as diffusive transport [1] were proved wrong by multi-element maps [2], which show that fluid-induced patchy textures are the principal cause of Pb mobility. Natural bell-shaped Pb diffusion profiles in minerals are rare or absent.

The dearth of mathematically sound diffusion profiles equally applies to Sr and Ar in micas and feldspars. The tight link between petrology, microtextures, chemical composition and geochronology seen in U-Pb systems also pertains to Rb-Sr and K-Ar. Overdetermined multi-mineral Rb-Sr isochrons with excess scatter [3] and stepwise release ^{39}Ar-^{40}Ar results [4] demonstrate ubiquitous correspondence between relict phases and isotopic inheritance. Rb-Sr and K-Ar chronometers belong to Class II [5] just as do U-Pb chronometers: as a rule they yield formation ages, as their recrystallization/reaction rates are up to 7 orders of magnitude higher than diffusive reequilibration rates [5].

Accurate dating of monometamorphic rocks requires assessing petrologic equilibrium using multivariate thermodynamic software. Complex parageneses of polymetamorphic, unequilibrated rocks are disentangled by: (i) CL/BSE images, qualitatively identifying relicts, retrogression reactions, and chemically open systems [6]; (ii) EPMA, quantifying heterochemical disequilibrium phases and assigning them to a P-T segment; (iii) in ^{39}Ar-^{40}Ar, relating the chemical Ca/Cl/K signature of the analyzed mineral to its age. Many rock-forming minerals are highly retentive of Ar, unless they are obliterated by retrograde reactions [4]. K-Ar and Rb-Sr frequently provide a different perspective on the P-T evolution of a rock than does U-Pb, as K+Rb-rich minerals (phyllosilicates and especially feldspars) react/dissolve faster than U-rich accessory phases (zircon, monazite).

References

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