Unravelling polytectonism using *in situ* Th-Pb dating of monazite

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Despite the high U and low common Pb contents of monazite, interpretation of conventional U-Pb monazite ages is complicated by problems including inheritance, isotopic disequilibrium, recrystallization, and other open system behaviors. These problems can be circumvented by Th-Pb dating of monazite using an *in situ* method which provides two capabilities with unique potential to assess polymetamorphism: prograde thermochronometry and continuous thermal histories. Monazite is unstable in most pelitic rocks at low grades but reappears in prograde terranes of normal Ca and/or Al contents at the aluminosilicate isograd permitting direct dating of the isograd. Although recent experimental results indicate that diffusive loss of Pb* is unlikely under amphibolites conditions, the Th-Pb system can be reset in matrix monazites by dissolution/reprecipitation reactions. However, neoformed monazites included in garnet immediately following growth are shielded from fluid alteration. By using an *in situ* analysis method, one can recognize the various misbehaviors described above and identify domains that have escaped post-crystallization exchange. We have evaluated this approach in a number of deeply exhumed settings within the Indo-Asian collision zone (e.g., Main Central Thrust zone, Red River Shear Zone, Kongur Shan detachment fault, South Tibetan Detachment, Nyainqentanglha Shan) and found it, in conjunction with thermobarometry, to be a powerful strategy with which to obtain *P-T-t* histories of crustal scale fault systems. The approach, however, can be problematic where protoliths have previously attained amphibolite grade. Ion microprobe depth profiling permits measurable gradients of Pb/Th to be observed over sub-μm length scales in separated monazites. Where these gradients can be shown to be due to diffusive Pb loss, they contain continuous *T-t* information that can be used to constrain numerical models of heat flow adjacent a fault ramp from which quantitative slip histories can be obtained. Routine application of this approach is limited by uncertainty in extrapolation of experimental diffusion data but results from geologically well-constrained environments are being used to 'anchor' the empirical results in geological time.

Geochronology of the Western Gneiss Region UHP terrane

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Geochronology and petrology of new UHP and HP eclogites define three discrete UHP domains within the Western Gneiss Region of Norway that are separated by HP rocks. $^{40}Ar/^{39}Ar$ muscovite ages show that these UHP domains are gentle antiforms that are younger than 375 Ma. The UHP antiforms range in size from ~2500 km^2 to >100 km^2 and are overlain by a HP veneer that extends over more than 60,000 km^2. If continuous at depth, the UHP terrane underlies at least 11,000 km^2. Eclogite U/Pb and Sm/Nd ages, combined with characteristic thermal diffusion distance, imply that the northern UHP domain and the two southern domains are separate crustal blocks that experienced and were exhumed from UHP conditions at different times.

Petrologic studies show that the UHP rocks underwent isothermal decompression to 0.5 GPa in ~5 Myr; this implies adiabatic exhumation of a UHP body 20–30 km in diameter or thickness. Discrepancies in anticipated and observed flattening magnitude and sinking magnitude suggest that either the UHP terrane was more viscous when it ponded at the Moho or that it did not pond at the Moho. The combined geochronologic, structural, and petrological dataset suggest that the UHP slab rose coherently from mantle to crustal depths and was exhumed through the crust progressively from east to west between 400 and 390 Ma.