Petrotectonics-geochronology of ultrahigh-pressure (UHP) crustal and upper mantle rocks — implications for Phanerozoic orogeny

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UHP metamorphic terranes worldwide reflect descent of continental crust to depths of ~90-140 km in now-imbricated contractional orogens. For documented UHP belts thus far recognized, formation took place in Phanerozoic time. Rocks are strongly retrogressed to low-P mineral assemblages; relict UHP phases are retained under kinetically inhibiting circumstances, mainly in tough, refractory host minerals. Many UHP complexes consist of thin, allochthonous sheets, but the two largest, in China and Norway, are ≥10 km thick. They are made up chiefly of quartzofeldspathic rocks ± serpentinites; mafic-ultramafic lithologies comprise less than 10 % of each exhumed subduction complex. Some UHP garnet peridotites and eclogites reflect crustal emplacement; others are mantle-wedge derived. SHRIMP dating of zoned zircons in gneissic and eclogitic rocks constrains the timing of protolith, peak, and retrograde recrystallization. Roundtrip P-T paths are completed in ~10-20 Myr; ascent rates to mid-crustal levels approximate descent velocities. Late-stage domical uplifts characterize some UHP complexes. Sialic crust may be carried to great depth because it is attached to a largely oceanic downgoing plate. Exhumation typically involves near-adiabatic decompression through the P-T fields of much lower P metamorphic facies. Thin-aspect-ratio, ductiley deformed nappes, generated by subduction-zone shear forces, allow heat to be conducted away as UHP complexes rise, cooling the sheets. Ascent along the subduction channel is driven chiefly by the positive buoyancy of a mainly continent-crust slab relative to the surrounding mantle. Rapid exhumation prevents establishment of a more normal geothermal regime in the subduction-zone. Return to mid-crustal levels does not require wholesale removal of the mantle wedge. Combined with vigorous erosion, late-stage underplating, contraction, tectonic aneurysms and/or lithospheric plate shallowing may elevate mid-crustal UHP décollements in domical uplifts. Where these situations are not satisfied, UHP complexes are totally transformed to low-P mineral assemblages, obliterating evidence of past profound burial.

Temporal constraints on the juxtaposition and exhumation of deep crustal domains, East Athabasca region, Western Canadian Shield

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The nature and rates of processes that juxtapose and exhume crustal domains are of central importance for understanding continental evolution. Although innumerable studies have investigated these problems in mid- and upper crustal rocks, the scarcity of orogen-scale lower crustal exposures has hindered study of these processes at deeper crustal levels. A spectacular exposure of granulites, composed of several distinct lithotectonic domains, occurs in the East Athabasca area in northern Saskatchewan. The high temperatures achieved by these granulites during ca. 1.9 Ga peak metamorphism, and their subsequent protracted cooling histories, provide a superb opportunity to reconstruct the detailed T-t paths of these rocks by exploiting the full temperature range permitted by the U/Pb (zircon, monazite, titanite, apatite, rutile), $^{40}Ar/^{39}Ar$ (hornblende, muscovite, biotite), and (U-Th)/He (zircon, apatite) isotopic systems. These data record several distinct post-1.9 Ga thermal histories that can be combined with existing thermobarometric and structural data to place constraints on domain juxtaposition and exhumation. The southern domain records cooling from peak 1.9 Ga conditions of 12-19 kbar, >800 °C to <450 °C by ca. 1.87-1.88 Ga, with biotite dates of ca. 1.8 Ga. In contrast, following peak 1.9 Ga metamorphism (10-12 kbar, >800 °C), parts of the Chipman and Northwestern domain record cooling to < 450 °C by ca. 1.83-1.86 Ga, with $^{40}Ar/^{39}Ar$ mica dates of 1.75-1.76 Ga. The cooling history of the southern domain suggests early exhumation linked to the 1.9 Ga event, and subsequent juxtaposition with the other granulite domains. The more protracted cooling histories of the Chipman and Northwestern domains may be attributable to both early ca. 1.9 Ga exhumation and subsequent regional unroofing by the ca. 1.84 Ga Legs Lake shear zone. Proterozoic (U-Th)/He dates on apatite and low U zircons are among the oldest ever reported for terrestrial rocks, and suggest the maintenance of a stable cratonic geotherm since the Proterozoic.