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SPECIAL COLLECTION: ADVANCES IN ULTRAHIGH-PRESSURE METAMORPHISM

Contrasting *P-T* paths within the Barchi-Kol UHP terrain (Kokchetav Complex): Implications for subduction and exhumation of continental crust

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Abstract

The Barchi-Kol terrain is a classic locality of ultrahigh-pressure (UHP) metamorphism within the Kokchetav metamorphic belt. We provide a detailed and systematic characterization of four metasedimentary samples using dominant mineral assemblages, mineral inclusions in zircon and monazite, garnet zonation with respect to major and trace elements, and Zr-in-rutile and Ti-in-zircon temperatures. A typical diamond-bearing gneiss records peak conditions of 49 ± 4 kbar and 950–1000 °C. Near isothermal decompression of this rock resulted in the breakdown of phengite associated with a pervasive recrystallization of the rock. The same terrain also contains mica schists that experienced peak conditions close to those of the diamond-bearing rocks, but they were exhumed along a cooler path where phengite remained stable. In these rocks, major and trace element zoning in garnet has been completely equilibrated. A layered gneiss was metamorphosed at UHP conditions in the coesite field, but did not reach diamond-facies conditions (peak conditions: 30 kbar and 800–900 °C). In this sample, garnet records retrograde zonation in major elements and also retains prograde zoning in trace elements. A garnet-kyanite-micaschist that reached significantly lower pressures (24 ± 2 kbar, 710 ± 20 °C) contains garnet with major and trace element zoning. The diverse garnet zoning in samples that experienced different metamorphic conditions allows to establish that diffusional equilibration of rare earth element in garnet likely occurs at ~900–950 °C. Different metamorphic conditions in the four investigated samples are also documented in zircon trace element zonation and mineral inclusions in zircon and monazite.

U-Pb geochronology of metamorphic zircon and monazite domains demonstrates that prograde (528–521 Ma), peak (528–522 Ma), and peak to retrograde metamorphism (503–532 Ma) occurred over a relatively short time interval that is indistinguishable from metamorphism of other UHP rocks within the Kokchetav metamorphic belt. Therefore, the assembly of rocks with contrasting *P-T* trajectories must have occurred in a single subduction-exhumation cycle, providing a snapshot of the thermal structure of a subducted continental margin prior to collision. The rocks were initially buried along a low geothermal gradient. At 20–25 kbar they underwent near isobaric heating of 200 °C, which was followed by continued burial along a low geothermal gradient. Such a step-wise geotherm is in good agreement with predictions from subduction zone thermal models.

Keywords: UHP, accessory minerals, REE, metamorphic path, subduction, Invited Centennial article