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Low-temperature microdiamond aggregates in the Maksyutov Metamorphic Complex, South Ural Mountains, Russia

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ABSTRACT

The Middle Paleozoic Maksyutov Complex is an important component of the Eurasian collisional orogeny. It consists of dominant mica-rich garnet schist and mica-poor quartzofeldspathic gneiss enclosing minor mafic eclogite boudins (unit no. 1). Employing Raman spectroscopy, we identified three cuboidal microdiamond inclusions (~2–3 micrometers in diameter) in garnet hosts from two different mica-poor gneissic samples. Broad spectral bands and high magnification SEM images suggest that the cuboids are fine-grained nanocrystalline diamond aggregates characterized by limited long-range ordering. Their poor crystallinity is compatible with relatively low-temperature, solid-state growth in the absence of both melt and a C-O-H-N fluid. Poor crystallinity, and small grain size suggest that such aggregates may represent the lowest temperature microdiamonds yet identified in nature. Their formation required ultrahigh-pressures (UHP) at a minimum of 3.2 GPa, and a metamorphic temperature of ~650 °C. Blocky graphite up to 10+ mm across in the matrix of mica-rich carbonaceous garnet schist may represent pseudomorphs after much larger neoblastic diamonds. Thermobarometric calculations for analyzed coexisting garnet + omphacite + phengite from six Maksyutov unit no. 1 mafic eclogites indicate retrograde physical conditions of 610–680 °C, 1.7–2.6 GPa, slightly lower-pressure conditions than the coesite stability field. Complete conversion of diamond to blocky graphite in the mica-rich schists, and recrystallization of coesite to quartz in the schists, quartzofeldspathic gneisses, and eclogite pods reflect relatively slow exhumation from ~110 km depth to upper crustal levels over 60–90 m.y. Phengite inclusions in zircon and garnet hint at modest activity of H_2O during prograde UHP metamorphism of the eclogites and mica-poor gneisses. The latter have retained rare, tiny microdiamond inclusions in garnet on decompression. Abundant white mica in the carbonaceous garnet schists probably reflects a C-O-H-N fluid-mediated, kinetically enhanced prograde production of diamond, and efficient obliteration of this phase accompanying leisurely ascent of the subduction complex. In contrast, associated mica-poor gneisses and eclogites were relatively dry during exhumation, so retained rare nanocrystalline microdiamond inclusions in garnet.