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The Kokchetav Massif: Type locality of metamorphic diamonds

[1]Schertl, H.-P., [2]Sobolev, N.V.
[1]Ruhr-University Bochum, Inst. of Geology, Mineralogy & Geophysics, Germany; hans-peter.schertl@rub.de
[2]V.S. Sobolev Institute of Geology & Mineralogy, Siberian Branch of Russian Acad. of Sci., Novosibirsk, Russia

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A geodynamical revolution in modern geosciences was initiated due to the discoveries of metamorphic coesite and diamond in mid 1980s / 1990. Such diamonds, although often only tens of microns in size, provide a valuable information on deep subduction processes. A window into a completely new field of research was established by the recent discovery of microdiamonds in ophiolitic peridotite and chromitite (e.g., from Luobusa, Southern Tibet, China and the Urals, Russia).

The contribution presented here gives an overview of the diamond-bearing UHP-metamorphic rocks from the Kokchetav Massif and summarizes the most important and far-reaching implications. The Kokchetav massif is part of an intracontinental orogenic belt between the former Laurasia and Gondwana and part of one of the largest suture zones in Central Asia, the Central Asian Orogenic Belt (CAOB). The HP and UHP rocks occur in two structurally different units, firstly the Vendian to Cambrian megamélange belt where the HP/UHP metamorphic blocks experienced different pressure conditions which correspond to 60–200 km depths and, secondly, the accretionary prism in which eclogites were metamorphosed at depths of about 60 km. Key localities are at Kumdy Kol, where an underground mining gallery was constructed which cuts diamondiferous rocks, and Barchi Kol. Important lithologies observed at Kumdy Kol are different types of gneisses, calcsilicate, garnet peridotite, and eclogite. The Barchi Kol site comprises different types of Grt-pyroxene and calcsilicate rocks, eclogite, amphibolite, gneiss and migmatite. Importantly, up to date microdiamond was never observed in any of the Kokchetav eclogites. A multitude of bulk rock geochemical analyses are available from the Kokchetav HP/UHP rocks. Most of the Kumdy Kol, Kulet, and Sulu-Tyube eclogites were interpreted to represent mafic compositions of the tholeiite series. Bt-Grt-Ky schists from Enbek-Berlyk, Bt schists from Sulu-Tube and Grt-Ms-Ky schists from Kumdy Kol contain abundant amounts of Al_2O_3 and were interpreted as former shales; mica schists higher in K_2O and SiO_2 presumably have arcosic protoliths. “Whiteschists” are suggested to be formed from basaltic protoliths by metasomatic processes; Grt peridotite from Kumdy Kol is depleted in Cr_2O_3 and enriched in TiO_2 and hence is related to the Fe–Ti type of peridotites. Trondhjemitic veins crosscutting eclogites are interpreted as partial melting to occur during the exhumation process within crustal levels. Several $\delta^{18}O$-studies were carried out to resolve the controversy on crustal sedimentary versus mantle-derived magmatic protoliths. In-situ $\delta^{18}O$ studies of a zoned garnet from a layered calcsilicate rock suggested that the initial uplift rate must have been very rapid, since the measured profile could not have survived for more than 1 Ma at peak metamorphic temperatures of 1000°C. PT-estimates yield peak metamorphic conditions of at least 43 kbar at temperatures of about 950-1000°C. Zircon separates show inherited Proterozoic cores and mantle with the peak of UHP metamorphism at about 537-530 Ma. Several Ar-Ar-ages on micas scatter around 529-528 and 521-517 Ma and reflect different stages of the exhumation history. Migmatization occurred during the exhumation stage at about 526-520 Ma. Microdiamonds which reach a grain size of 300 micrometers, contain highly potassic fluid inclusions as well as solid inclusions like carbonates, different silicates and metal sulphides which favours the idea of a diamond formation from a C-O-H bearing fluid. Nitrogen isotope data and negative $\delta^{13}C$ values of Kokchetav diamonds indicate a metasedimentary

origin. A number of unique mineralogical findings were made as K-feldspar exsolutions in clinopyroxene, coesite exsolutions in titanite, quartz-rods in clinopyroxene and the discovery of new minerals like K-tourmaline, kokchetavite, a hexagonal polymorph of K-feldspar and kumdykolite, an orthorhombic polymorph of albite.

In essence, the Kokchetav UHP rocks are of vital significance for geoscientists who are interested in the diverse properties and processes which occur under upper mantle conditions. This discovery was a trigger for an intense search of further possible diamondiferous terranes worldwide, especially for the new findings of diamond-bearing peridotites and chromitites.