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カザフスタン共和国コクチェタフ変成帯に産する二種類の超高圧ザクロ石単斜輝石岩
Petrology of garnet-clinopyroxene rocks from the Kokchetav Massif, northern Kazakhstan

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In the Kumdy-Kol area of the Kokchetav Massif, two types of garnet-clinopyroxene rocks occur: one is diamond-bearing and one diamond-free. Sobolev and Shatsky (1990) described diamond-bearing garnet-clinopyroxene rock as one of the diamond-bearing rocky types in their first report on the metamorphic diamond. Recent study reports the other type, diamond-free garnet-clinopyroxene rock, from the same area (Sakamaki and Ogasawara, 2014). Both diamond-bearing and diamond-free garnet clinopyroxene rocks are mainly composed of garnet, Na-free clinopyroxene with minor amount of calcite, quartz, similar to the mineral assemblage like “skarn” , and have evidence of UHP conditions; the latter has coesite exsolution in titanite. Diamond-bearing garnet-clinopyroxene rock is composed of garnet layers and clinopyroxene layers, and contains rutile and coarse-grained microdiamond. Microdiamond occurs as inclusion of garnet and clinopyroxene, and as an intergranular phase. The morphologies are cubic form (up to 200 μm), ball-shaped form (covered with graphite) (up to 150 μm), and fine-grained (ca. 10 μm) which was discovered recently (Takabe et al., 2014). Diamond-free garnet-clinopyroxene shows granoblastic texture and consists of garnet, clinopyroxene, calcite, quartz, titanite with minor amount of K-feldspar. Titanite contains exsolved coesite needles and plates in the core, which indicate excess Si incorporated in six coordinated site; pressure-drop stage was still in coesite stability field (>2.5 GPa). Clinopyroxene in both garnet-clinopyroxene rocks contain K-bearing exsolved phases, K-feldspar and phengite, which indicates K-rich compositions of original clinopyroxene prior to exsolution. Reintegrated K_2O contents in precursor clinopyroxene were estimated at 0.60-1.04 wt.% in diamond-bearing rock, and up to 1.14 wt.% in diamond-free rock.

The bulk composition of each garnet-clinopyroxene rock was estimated on the basis of volume fractions and chemical compositions of rock-forming minerals. Diamond-bearing garnet-clinopyroxene rock is characterized by relatively high SiO_2 of ca. 50 wt.% while diamond-free rock contains significant amounts of CaO (33 wt.%) and CO_2 (12 wt.%) indicating calcite-rich modal composition.

Garnet and clinopyroxene can contain significant amounts of OH at UHP conditions and record fluid environments during the UHP metamorphism (Sakamaki and Ogasawara, 2014). We conducted micro-FTIR spectroscopy of garnet and clinopyroxene and identified significant amounts of structural OH and non-structural molecular H_2O suggesting submicron fluid inclusions in garnet;

(Dia-free, no. XX16), OH: 360+ H_2O: 20 to OH: 1655+ H_2O: 1203 ppm (wt. H_2O)
(Dia-bearing, no. 25018) OH: 391+ H_2O: 294 to OH: 1165+ H_2O: 1218 ppm
(Dia-bearing, no. 24997) 0 to OH: 1727+ H_2O: 1592 ppm.

IR spectra of clinopyroxene show complex absorption bands of structural OH in clinopyroxene host and exsolved minerals, and nonstructural molecular H_2O. Bulk water (OH and H_2O) contents in clinopyroxene were conveniently estimated at (Dia-free) 1657 to 8215 ppm and (Dia-bearing) 700 to 4384 ppm, respectively. Such high concentrations of water in garnet and clinopyroxene suggest that diamond-bearing and diamond-free garnet-clinopyroxene rocks were formed in H_2O-rich environment at UHP conditions.

These two types of garnet-clinopyroxene rocks have similar appearances like skarn but have different carbonate modal compositions, diamond occurrences, and Ti-phase stability. The difference in carbonate modal compositions reflects the difference of bulk chemical composition of protoliths and the difference of diamond occurrences and Ti-phase stability in garnet-clinopyroxene rocks were perhaps controlled by bulk compositions of protoliths and fluid environments during the metasomatism stage.

Keywords: the Kokchetav Massif, UHP metamorphism, diamond, supersilicic titanite, nominally anhydrous minerals, micro-FTIR specroscopy