The effects of fluid and bulk composition on Ti-bearing assemblages in the Kokchetav UHP marbles

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Relationships between Ti-bearing phases, the stability of diamond and fluid compositions have been recognized in the UHP marbles from the Kokchetav Massif.

The Kokchetav UHP marbles were divided into three types: (1) diamond-bearing dolomite marble (peak assemblage: dolomite + aragonite + diopside + garnet + diamond + rutile, (2) Ti-clinohumite-bearing dolomitic marble (peak assemblage: aragonite + dolomite + garnet + diopside + forsterite + Ti-clinohumite), and (3) titanite-bearing calcite marble (peak assemblage: aragonite + diopside + K-feldspar + garnet + phengite + titanite). These UHP marbles were subjected to the same P-T conditions and the peak P and T have been estimated as at least 6 GPa and near 1000 C or a little higher. Clear contrasts have been remarked in these marbles; (1) diamond is present in dolomite marble but is absent in dolomitic and calcite marbles, and (2) each marble has a distinct Ti-bearing phase: rutile in dolomite marble, Ti-clinohumite in dolomitic marble and titanite in calcite marble.

The purpose of this study is to explain the stability relations of Ti-bearing assemblages in these three marbles by the phase relations in the model system CaO-MgO-SiO2-TiO2-CO2-H2O, together with the stability of diamond in the model system. Thermochemical calculations with dataset by Holland & Powell (1990) revealed that the six phases (calcite/aragonite, dolomite, diopside, quartz/coesite, rutile and titanite) were controlled by the following three reactions and they generate an invariant point:

(1) Dol + 2SiO2 = Di + 2CO2

(2) CaCO3 + SiO2 + Rt = Ttn + CO2

(3) Dol + 2Ttn = Di + 2 CaCO3 + 2Rt

Titanite stability was constrained by the solid-solid reaction (3). The tie-line of dolomite + titanite was unstable compared with diopside + aragonite + rutile triangle at UHP conditions. This triangle is a compositional divide in Arg-Dol-Coe-Rt tetrahedron and unstabilizes titanite in dolomite-bearing compositions. The decarbonation reaction (2) also restricts titanite stability. Titanite formation by this reaction required extremely low XCO2 conditions. Assuming that XCO2 = 0.1 in calcite marble, the minimum T of titanite formation is over 1200 C inconsistent with the peak temperature of around 1000 C by other estimations. If XCO2 was extremely low as 0.02, the occurrence of titanite in calcite marble takes place at about 1000 C. The stability of Ti-clinohumite + aragonite in dolomitic marble demands also extremely low XCO2 conditions

The phase relations in the model system CaO-MgO-SiO2-TiO2-CO2-H2O and the estimated XCO2 conditions for those marbles indicated that Ti-bearing phase relations in the Kokchetav marbles can be explained by the heterogeneity of fluid compositions under UHP conditions and the bulk compositions of the marbles.