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Evidence for Deep Carbon Cycle: UHPM carbonates, microdiamonds, aqueous fluid and mantle metasomatism

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In calculated P-T grids for dolomite-bearing carbonate system, CaO-MgO-SiO2-CO2-H2O (Ogasawara et al. 1995), a large "no-reaction" P-T space (excepting phase transitions) exists at high-P and low-T side, and its extent is affected by fluid conditions as XCO2. This suggests that along P-T path of cold subduction the chance of "no reaction" in subducted carbonate rocks is high and carbonate rocks can survive up to great depths in the mantle. Deep carbonate subduction process can play as an important carrier of CO2 as carbonates from Earth's surface to the mantle. The potential of CO2 influx could be affected by aqueous fluid infiltrated in subducted materials. Such speculation based on the thermodynamic results was a trigger of my study on Ultrahigh-Pressure (UHP) metamorphic carbonate rocks and microdiamonds.

UHPM carbonate rocks have preserved variable information about not only P-T conditions, but chemical systems and related reactions within deeply subducted continental materials, and are the direct evidence for deep carbon cycle from Earth's surface to deep upper mantle. The occurrences of those precious materials including metamorphic diamonds are very rare in world UHPM terranes; the representative example is a diamond-bearing dolomite marble in the Kokchetav Massif, northern Kazakhstan. The Kokchetav microdiamonds are concentrated in a carbonate rock, impure dolomite marble; the highest diamond concentration domain in garnet showed about 2700 carat/ton. Microdiamonds in this marble formed at two different stages and the second stage diamond could formed from a multicomponent aqueous fluid (not from graphite). Garnet-biotite gneiss is the second highest diamond concentration. Protolith of this diamond-bearing dolomite marble is late-Proterozoic platform sediments (impure dolostone) on the basis of the local geology and the stable isotope data on the carbonates. This indicates that limestones and dolostones can subduct into the great depths at least to the low-P limit of diamond stability field. A similar UHP carbonate rock, Ti-clinohumite-bearing dolomitic marble whose assemblage aragonite-dolomite-Ti-clinohumite was stable at extremely low XCO2, occurs at the same area, but diamond was unstable in this marble. Such strong contrast between two dolomite-bearing UHP carbonate rocks can be explained by the H2O-rich fluid condition and its heterogeneity under UHP metamorphism. Another important evidence is exsolved coesite from supersilicic titanite discovered in titanite-bearing calcite (after aragonite) marble. Reintegrated precursor composition showed that excess Si in octahedral site, 0.145 gave corresponding minimum-P as 6 GPa; this impure limestone subducted to the depths over 200 km. Exsolved coesite in titanite also discovered in "skarn-like" garnet-clinopyroxene rock that suggests strong metasomatism at UHP conditions. These two exsolved-coesite-bearing rocks lack diamond except for a thin diopside-rich layer in the calcite marble (only 61 grains and no second stage growth).

Such features of the Kokchetav UHPM carbonate rocks strongly suggest that entire decomposition of carbonates is difficult during deep continental subduction and carbonate can survive at depths over 200 km although the metasomatism within subducted materials by H2O-rich fluid ("Intraslab UHP Metasomatism") occurs at great depths. Abundant carbonate could be stored in the mantle than we expected before. Deep carbonate subduction is the most important carbon carrier into the mantle and makes strong compositional heterogeneity of the mantle. To clarify the fate of deeply subducted carbonates could be an important next step for Deep Carbon Cycle project.

Keywords: UHP Metamorphism, deep carbonate subduction, metamorphic diamond, dolomite, exsolved coesite from supersilicic titanite, Intraslab UHP Metasomatism