

A role of carbonate sediments in subduction factory: high-pressure experiments in the system MORB-CaCO₃

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In the convergent plate margin, some carbonate sediments accrete to the continental crust, and others subduct into the upper mantle. What is the fate of the subducted carbonate in the mantle? The occurrences of marbles and carbonate-bearing eclogites in the UHP metamorphic belts (e.g. Becker and Altherr 1992) imply that abundant of sedimentary carbonates within the oceanic crusts subduct into the upper mantle at least 100 km. The several lines of evidences indicate the existence of some recycled carbon. The carbon stable isotope shows that some diamonds were formed from organic carbon (e.g. Galimov 1991), and very rare ones are formed from marine carbonate (Sobolev 1984). Some metasomatic agent is considered to have originated from recycle carbonates in the arc system (Papua New Guinea; McInnes and Cameron 1994) and in hot spot (Hauri et al. 1993). Hoernle et al. (2002) discussed that the carbonatite magma in the Cape Verde Islands originated from the subducted carbonate sediments.

Although the role of carbonate in mantle eclogite is very important, earlier experiments have been carried out below 3.5 GPa for carbonate-bearing eclogite. Yaxley and Green (1994) and Shirasaka (1998) studied high-pressure phase relations in the system MORB-CaCO₃-H₂O at 1.5-3.0 GPa and 1.0-2.5 GPa respectively. These experiments showed that calcite or dolomite coexists with silicate melt of andesite to dacitic compositions at relatively lower temperatures. Yaxley (1999) carried out experiments in the 60 wt.% eclogite + 40 wt.% CaCO₃ system at 3.0-3.5 GPa. He showed that in the partial melting of carbonated eclogite, the first melt coexisting with calcite is carbonatitic.

In order to understand the role of carbonate-bearing eclogite in the upper mantle, I determined phase relations in the system 90 wt.% MORB-10 wt.% CaCO₃ experimentally at 2.7-8.0 GPa and 800-1300 C. Clinopyroxene and garnet are present in all the runs. Coesite (quartz), rutile, carbonate and carbonatitic melt are present. The solidus temperature decreases from ca. 1200 C at 3 GPa to ca. 900 C at ca. 4.5 GPa dramatically due to the appearance of dolomite below solidus. At 3.5-4.0 GPa, calcite is stable in solidus and carbonatitic melt is produced. With increasing pressure, dolomite is stable in solidus and carbonatitic melt is produced above ca.4.5 GPa, and then, dolomite saturated solidus temperature increase up to ca. 1250 C with pressure. On the other hand, dolomite breaks down to aragonite + magneiste in the lower temperatures than dolomite field in subsolidus above 5.5 GPa. Melt has calcic-dolomite to calcitic composition and is low in SiO₂, TiO₂, Al₂O₃, Na₂O and K₂O contents. With increasing temperature and decreasing pressure, melt is enriched in the Ca# (= Ca/(Ca + Mg + Fe) x 100) and decreased in the Mg# (= Mg/(Mg + Fe) x 100).

In the subduction zone with relatively cold oceanic lithosphere with carbonate sediments, carbonate is stable at least up to 8 GPa. On the other hand, subducted hot oceanic plate may produce carbonatitic melt, which will cause metasomatism in the lithosphere overlying wedge mantle and high-pressure metamorphic rocks. Even in the cratonic lithosphere, which has the lowest geothermal gradient, carbonatitic melt could be produced within eclogite at 3.5-6.0 GPa. In the subduction zone, carbonated eclogite with or without the presence of water would melt and yield carbonatitic melt at depth due to the heat conduction from the ambient peridotitic mantle. Because solidus temperature of dolomite eclogite is 300-400 C lower than carbonated lherzolite (1330 C), partial melting of dolomite eclogite is not rare in the upper mantle and possibly account for the origin of carbonatitic magma and their common role as metasomatic agents.