Effects by water on generation temperatures of komatiites

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Recent ultra high pressure experiments have shown that komatiitic melts can be produced by partial melting of hydrous mantle even at normal temperature. However, starting materials in these hydrous experiments were simplified peridotites with high water content ranging from 1 to 16 wt%. To constrain the possible conditions of the komatiite formation, melting experiments should be done using natural peridotite with reasonable H2O contents and compositions of melts may be provided with relatively small errors. Here, we report the results of melting experiments of natural peridotite KLB-1 with 0.5 and 1 wt% H2O under high pressures and temperatures conditions and we evaluate the possible conditions for the formations of Al-depleted and undepleted komatiites from wet mantle.

Melting experiments of wet KLB-1 with 0.5 and 1 wt% H2O were carried out using multi-anvil apparatus, and the phase relations and compositions of partial melts were determined at 4 to 12 GPa. Degree of partial melting of wet KLB-1 at the same P-T condition differs significantly from that of dry one at relatively lower degree such as 30 %. Effects of water on degree of partial melting decrease with increasing degree of partial melting. Although presence of small amount of water (~0.5 wt% H2O) lowers solidus temperature remarkably (~100 degrees Celsius), crystallization temperatures of garnet and clinopyroxene of wet KLB-1 under the same pressure conditions are similar to those of dry KLB-1 experiments. This means that garnet and clinopyroxene coexist with melt even at high melt fractions, and that compositions of produced melts at hydrous system, especially aluminum contents, are different from those at dry system.

Experimental results from the present and previous studies indicate that melt fraction of produced melt correlate with its Mg# [= Mg/(Mg+Fe) 100; all Fe as FeO], and this correlation has little or no dependences on the pressure at which melt produces and on their source water content and CaO/Al2O3 ratios, as far as the mantle peridotites have similar Mg#. Archean Al-depleted and Al-undepleted komatiites at primary compositions, which were estimated from the most magnesian olivine (Fo = 93.5-94.0) and a Mg-Fe partition coefficient, have relatively narrow range Mg# (=80-82), indicating that they were formed by similar degrees of partial melting of mantle peridotite (ranging from 25 to 45 % of partial melting, if Mg# of the source were ~89). Whereas, Cretaceous komatiite were formed by less than 20 % melting of anhydrous komatiite. These estimated values were consistent with those derived from geochemical data. Archean Al-undepleted komatiite can be formed from either dry or wet KLB-1, and the pressure and temperature conditions of formation from hydrous KLB-1 with 1 wt% H2O is respectively ~4 GPa and ~1650 to 1700 degrees Celsius, which is ~2.5 GPa and ~200 degrees Celsius lower than that from anhydrous KLB-1. Al-depleted komatiite can be also formed from either dry or wet mantle, but anhydrous Al-depleted komatiite requires ~12 GPa and ~2100 degrees Celsius to be formed, which is ~3 GPa and ~200 degrees Celsius higher conditions than hydrous system of 1 wt% H2O. Presence of 1 wt% H2O in the mantle decrease the potential mantle temperature for the generation of komatiites by 150 degrees Celsius.