Contrasting Origins of the Most Magnesian Glasses from Iceland and Hawaii

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In a melting column produced by upwelling of the mantle, the most magnesian melts are generated in the deepest part of the column at the highest temperatures. With increasing degree of melting, at lower temperatures and pressures, the primary melts become less magnesian but at the same time have higher Mg# and coexist with more forsteritic olivine. Hence, melts with high Mg# need not be generated at extremely high temperatures. The presence of volatiles also lessens the requirement for high temperatures as the solidus of mantle lherzolite is lowered 25-60ºC for each wt% H_2O in the melt and about 10ºC for each wt% CO_2 in the melt. The most magnesian volcanic glasses found in Iceland and Hawaii provide evidence for magmas generated in dissimilar parts of melting columns. The most magnesian basalt glasses from Iceland, so far published, contain up to 10.5 wt% MgO, and are found in several picrite formations on the Reykjanes Peninsula and in the northern volcanic zone. Generally, the Icelandic picrite formations appear to date back to the glacioisostatic period at the end of the last ice age. In terms af major and trace element compositions, these picrites are the most depleted volcanics found in Iceland. Furthermore, they show LREE depletion, depleted $^{143}Nd/^{144}Nd$, and low concentrations of radiogenic Pb. The associated high-MgO glasses have unusually low concentrations of K_2O and P_2O_5 (generally ≤0.05 wt%) and the TiO_2 content is generally about 1 wt% or less. When all of these characteristics are taken into consideration, it is clear that this kind of high-MgO melt cannot be parental to most of the less magnesian basaltic melts found in Iceland. Instead, we propose that the high-MgO melts are generated at the top of the melting regime under Iceland at a pressure close to 1 GPa, approximately at the low-pressure extreme of the transition from spinel to plagioclase lherzolite, after segregation of the more fusible part of the upwelling mantle column. By assuming that these melts are close to being primary products of the melting of lherzolite (or harzburgite with some clinopyroxene and spinel and/or plagioclase remaining), use of the CMASNF geothermometer yields a relatively modest temperature of up to 1280ºC. The most magnesian glasses from Hawaii, with up to 15 wt% MgO, are found in turbidite sands at the base of Puna Ridge, the submarine extension of Kilauea volcano. In contrast to the primitive Icelandic glasses, the Hawaiian picrite glasses are derived from a relatively undepleted source. For example, the most magnesian glasses contain about 0.3 wt% K_2O, 0.2 wt% P_2O_5, and 1.9 wt% TiO_2. Unlike the Icelandic high-MgO basalt glasses that lie close to the olivine-plagioclase saturation boundary, the Hawaiian picrite glasses clearly align along olivine fractionation lines. On the basis of the CMASNF geothermometer, Gudfinnsson and Presnall (2002) argued that the glasses with about 15 wt% MgO could be generated from mantle lherzolite with potential temperature of about 1420ºC at a pressure of about 2.5 GPa. Thus, we propose that the Hawaiian picrite melts are generated in the deeper levels of the melting column where only a relatively small amount of melting and melt segregation has occurred.