Genesis of the iron-rich alkaline large igneous province

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Large igneous province (LIP) is the product of ultra-large-scale (>0.1 Mkm^2) intraplate magmatism within a limited duration (< 1-5 Ma). Generally, the main basalts in LIP are tholeiitic, corresponding to the high degree of partial melting of the mantle. However, the early Permian Tarim LIP in NW China are characterized by iron-rich alkaline basalts. Alkaline basalt usually corresponds to a relatively low degree of partial melting (<15%) of mantle peridotite, and the iron-rich component has a high density. Both of these seem to be negative for the formation of LIP.

In order to investigate the genesis of Tarim LIP, we studied the water content and component characteristics of "primary" magma by the earliest crystalized clinopyroxene (cpx) and olivine (ol) grains. The calculated high mantle potential temperatures (1532-1563℃) suggest that the Tarim LIP is related to a mantle plume. The H_2O contents of "primary" magma estimated by H_2O of cpx and H partition coefficient between cpx and melt range from 3.8 % wt. to 5.2 % wt., markedly higher than the H_2O content of mid-ocean ridge basalts (MORB) and oceanic island basalts (OIB) and fall in the range of island arc basalts (IAB). Such a high H_2O content can effectively reduce the viscosity of the mantle material and the density of the melt, which is conducive to the rise of a plume. In addition, the earliest olivine grains have significantly higher NiO contents and Fe/Mn ratios than those of olivine from global MORB, we suggest that the low SiO_2 content of the Tarim basalts resulted from a high proportion of silica-deficient pyroxenite component in the mantle source. Melting experiments have showed that compared to the peridotite, a higher proportion of melting (up to 40%) of silica-deficient pyroxenite can still generate alkaline basalt. Thus, the high water content and high proportion of pyroxenite in the mantle source are the crucial factors in the formation of the Tarim LIP. The water-rich subducted oceanic slab would react with iron at the core-mantle boundary to produce FeO_2H_x and FeH, forming ultra-low velocity zones (ULVZ). We infer that the H_2O- and iron-rich Tarim LIP was likely source from this kind of ULVZ.