Geochemical evolution of the Tarim mantle plume and the eruption of large igneous province

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Large igneous province (LIP), generally related to the mantle plume, is characterized by huge magma (>0.1 Mkm^2) erupted within a short duration, which is strongly associated with climate change and mass extinction. The early Permian Tarim LIP in NW China is mainly composed of ~250,000 km^2 intraplate basalts. The completed basalt section with a ~1,000 m sedimentary intercalation crop out in northern margin of the Tarim Basin, providing an excellent opportunity to investigate the evolution of a mantle plume.

We measured the elemental and Sr-Nd-Pb isotope compositions of basalts layer by layer. The results show that the incompatible elemental ratios (Nb/U, Ce/Pb, Ba/Th, Th/La) and radiogenic Sr-Nd-Pb isotope compositions of basalts display systematic correlations. That is, the basalts erupted earliest in both two main episodes have relatively low Nb/U, Ce/Pb, Ba/Th ratios, high Th/La ratios and enriched Sr-Nd-Pb isotopic compositions. The relationship between Sm/Nd ratios and εNd(t) together with the simulation of mass balance suggest that the effect of crust contamination is insignificant. Thus, the geochemical evolution of basalts represent the variation of mantle source. The correlations between trace element ratios and Sr-Nd-Pb isotopic compositions clearly indicate that two components (the main part of the mantle plume and fusible enriched component) were involved in the source. Because of the low Ba/Th ratios, this fusible component is most likely from the recycled oceanic crust containing sediment rather than metasomatized lithsophere. Camparing the two main eruptive episodes, it seems that the fusible component is enriched in the earliest basalts and continuously decreased with eruption. This suggests that the supply of the fusible component in the mantle plume probably be the trigger for the eruption of the Tarim LIP, then the massive eruption was interrupted with the running out of the fusible components in the plume.