Hf isotopic constraints on the genesis of Al-depleted (Barberton-type) komatiites

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Komatiite is divided into two groups with their chemical compositions. One is non Al-depleted, Munro-type, and another is Al-depleted group, Barberton type. The two different types are thought to result from the fractionation of garnet. The two models exits on the timing of the garnet fractionation. One is that fractionation took place during the formation of komatiitic magma, while another is that garnet layer in the mantle formed in magma ocean played important role in the genesis of the Al-depleted group.

We applied Hf isotopic tracer to put constraints on the timing of the garnet fractionation. The distribution coefficient of Lu in garnet is much higher than that for Hf, resulting in large fractionation of parent daughter elements of the Lu-Hf decay system. If garnet fractionation took place long time before komatiite eruption, low 176Hf/177Hf ratios are expected for the Al-depleted komatiite. Toft and Arndt (1999) worked on this problem with Hf isotopic tracer, however, their data were mostly on basaltic komatiites, probably due to analytical difficulty.

We analyzed 15 komatiites from Barberton greenstone belt, South Africa. Major and trace elements determined by XRF and ICP-MS revealed that both Al-depleted and Al-undepleted type komatiite are present in limited area. Hf isotopic ratios were analyzed by a MC-ICP-MS, Micromass IsoProbe. With a micro-concentric nebulizer, we can obtain precise Hf isotopic ratios with 15 ng of Hf, which enabled komatiite analysis. Initial eHf values were calculated using Hf isotopic ratios and Lu/Hf abundance ratios obtained in this study and assuming that the formation age of the komatiite was 3.48Ga. The initial eHf values thus calculated were similar for the both types. The Al-depleted type has +2 - +7, while Al-undepleted group has 0 - +10. The average values were around +4 for the both types. The results were consistent with the previous report by Toft and Arndt (1999).

The results rules out the possibility that the Al-depleted type komatiites originated from garnet depleted layer in the mantle formed by magma ocean. The positive initial eHf values indicate the derivation of the komatiites from mantle whose Lu/Hf ratios had been larger than that of chondrite (depleted mantle).