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Lu-Hf isotope systematics of 3.45Ga Barberton basalts : implications for early mantle evolution

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Lu-Hf isotope systematics of Archean rocks can provide valuable insights into early crust-mantle evolution. In particular, those of Archean mafic rocks allow us to constrain the degree of early mantle depletion. Furthermore, a combination of Lu-Hf and Sm-Nd isotope systematics provides constraints on the physical condition of the mantle differentiation. Recent studies have indicated that 3.8 Ga mafic rocks from Isua have highly positive ϵHf with nearly chondritic ϵNd, suggesting that the source mantle had differentiated under a lower mantle condition. This may reflect that the differentiation of the Earth ' s deep mantle occurred much earlier than 3.8 Ga, possibly during the solidification of a magma ocean. In this study, we report new ^{176}Lu-^{176}Hf data for 3.45 Ga basalts in the Kromberg Complex of the Barberton Greenstone Belt, South Africa. The data for all analyzed samples define an isochron age of 2801±690 Ma(MSWD=49, 2σ, N=8), whereas those for relatively pristine samples yield an age of 3890±1100 Ma (MSWD=9.6, 2σ, N=4). The latter age is consistent with the formation age. We obtained the average ϵHf value at 3.45 Ga of 2.63 ± 0.33 (2σ) for the pristine samples. This indicates that the source mantle of the basalts had been depleted in incompatible elements by 3.5 Ga, but the extent of the depletion was not as strong as that of the source mantle of 3.8 Ga Isua mafic rocks. Furthermore, we found that there is no resolvable Hf isotopic difference between Barberton basalts and komatiites. This observation suggests that Barberton komatiites and basalts share the source mantle, and their formation mechanisms resulted in their petrologic difference. By combining our results with previously reported Sm-Nd isotopic data, we propose that the source mantle of the Barberton experienced early differentiation under high pressure conditions possibly during magma ocean solidification, and subsequently the differentiated mantle had been re-homogenized by mantle mixing.

Keywords: Mantle Evolution, Basalts, Barberton, Lu-Hf, Archean, Isotopic Analysis