

REE abundances and ^{87}Rb – ^{87}Sr and ^{176}Lu – ^{176}Hf systematics of diogenite meteorites

T. Saito¹, H. Hidaka¹ and S.-G. Lee²

¹Department of Earth and Planetary Sciences, Nagoya University, Nagoya 464-8601, Japan

²Geological Research Division, Korea Institute of Geoscience and Mineral Resources, Daejeon 34132, Republic of Korea

HED (howardite, eucrite, and diogenite) meteorites are the most abundant subgroup of achondrites. Spectroscopic studies (e.g., Binzel and Xu, 1993) suggest that HEDs originate in the crust of the asteroid 4 Vesta. Since the igneous activity on Vesta is thought to be restricted within the early stage of solar system (e.g., Nyquist et al., 2003), the HEDs preserve the record of the differentiation process of proto-planetary crust (Vestan crust). At present, however, geochemical, mineralogical, and petrological studies of HEDs have not reached at a clear conclusion to the differentiation process of Vestan crust. Though a detailed comparison of the chronological data between eucrites and diogenites may provide a temporal relationship of their crystallization, chronological studies of diogenites are less developed than those of eucrites. In this study, Sr and Hf isotopic analyses and the determination of rare earth element (REE) abundances were performed on nine diogenites to put temporal and geochemical constraints on their differentiation process.

Three fall diogenites (Bilanga, Johnstown, and Tatahouine), three desert-find diogenites (Hamara, LMT 042, and NWA 5480), and three antarctic-find diogenites (Y-74013, Y-74097, and Y-002875) were used in this study. Each powdered sample (0.1–0.8 g) was dissolved by HF–HClO₄ mixture on a hot plate. After complete digestion, the sample solution was once evaporated to dryness, and was redissolved in 3M HCl. The fraction obtained in these procedures was defined as “whole rock” in this study. In addition to the WR sample solution, “residue” and “leachate” sample solution was prepared by the following acid-leach procedure. Each powdered sample (~ 1 g) was leached using hot 0.5M HCl (100°C) for 24 hours. After the collection of the leachate fraction, the acid residue was completely decomposed by HF–HClO₄. Finally, these solutions were once evaporated to dryness and redissolved in 3M HCl as well as WR sample. The sample solution was divided into two portions. A major portion was used for isotopic measurements of Sr and Hf by TIMS and MC-ICP-MS respectively. Remaining minor portion was used for determination of REE abundances by ICP-MS.

CI-normalized REE patterns of WR, residue and leachate samples are shown in Fig. 1. Most WR diogenite samples measured in this study show lower abundances of REE relative to chondritic value and enrichments of heavier REE (HREE) with negative Eu anomalies (Fig. 1a). These characteristics are commonly observed in typical diogenites, and are probably caused by orthopyroxene-rich monomineralic composition of diogenites (Barrat et al., 2010). Since these characteristics are much clear in the residues rather than WRs, the chemical compositions of the residues are probably closer not to those of WRs but to pure orthopyroxene, reflecting the compositions of their parental melts. Large variation of REE patterns in leachates shown in Fig. 1c suggests that these fractions are derived from multiple sources like accessory minerals and terrestrial contaminants. These minor phases are heterogeneously distributed in diogenites, and largely affect lighter REE abundances (Barrat et al., 2010). On the other hand, HREE patterns of diogenites are not largely affected by the additional phases, due to high abundances of HREE in orthopyroxene. Similar HREE patterns between WRs and residues are consistent with insignificant contribution of minor phases to HREE abundances. Therefore, HREE abundances of the residues are most likely to preserve the compositions close to pure orthopyroxene. Based on partitioning coefficients of REE in orthopyroxene, the variation of (Dy/Lu)_n values in residues of diogenites measured in this study indicates the crystallization of these diogenites from multiple parental melts.

To investigate the temporal relationship between eucrites and diogenites in detail, isotopic measurements of Sr and Hf are in progress.

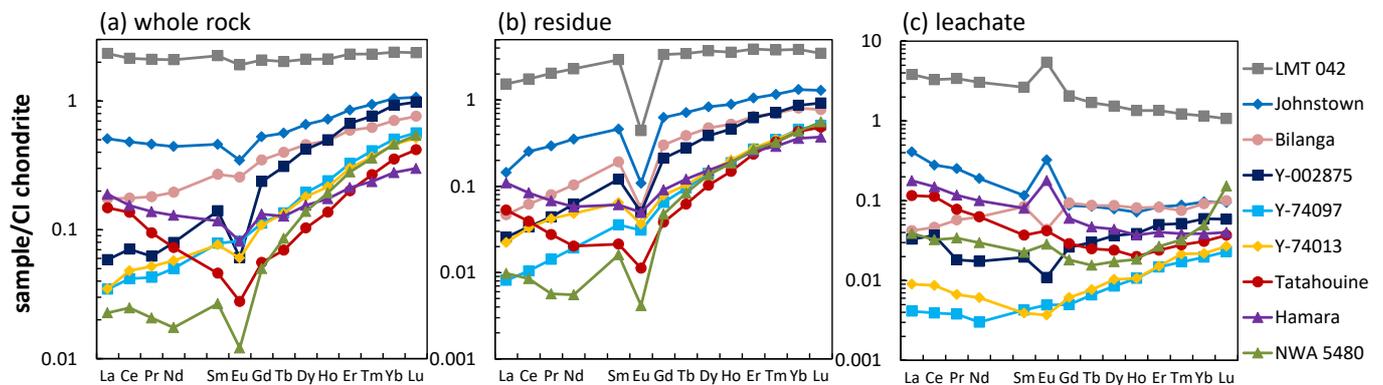


Fig. 1. REE abundances of (a) WR, (b) residue, and (c) leachate of diogenites measured in this study. CI chondrite values for normalization are from Anders and Grevesse (1989). REE abundances of residue and leachate are defined as weight of an element in each fraction per weight of powdered sample used for leaching.

References

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