^{176}LU–^{176}HF AND ^{87}RB–^{87}SR SYSTEMATICS AND RARE EARTH ELEMENT ABUNDANCES OF DIOGENITES: EVIDENCE FOR THEIR CRYSTALLIZATION FROM PARTIAL MELTS OF THE VESTAN MANTLE.

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Introduction: The asteroid 4 Vesta is one of the differentiated rocky bodies in the solar system. Vesta is a distinctively informative object for investigating the scale dependence of the evolution of rocky planets. Furthermore, since Vesta is probably a remnant protoplanet [1], its physical property and internal structure possibly provide fundamental and unique information about the accretion processes in the early solar system. Howardite–eucrite–diogenite (HED) meteorites, which are believed to be surface materials from Vesta [2], offer clues for the differentiation processes of the Vestan crust. However, despite geochemical, mineralogical, and petrological studies of HED meteorites over several decades, the differentiation processes of the Vestan crust are still controversial. In this study, we focus on the relationship between crystallization timings of eucrites and diogenites, which are geochemically and petrologically distinct subgroups of HED meteorites. Although this relationship may put strong constraints on the differentiation processes of HED meteorites, it is still in debate mainly due to lack of chronological data of diogenites. On the one hand, the pioneering study on the ^{87}Rb–^{87}Sr systematics and the recent study on the short-lived ^{26}Al–^{26}Mg chronometry of diogenites suggested the later crystallization of diogenites than that of eucrites [3,4]. On the other hand, some other studies found that ^{53}Mn–^{53}Cr and ^{60}Fe–^{60}Ni isotopic data of diogenites define isochron regressions together with the eucrite data [5–7], suggesting approximately synchronous crystallization of these two meteorite classes. Although, at present, the reason for the discrepancy among these diogenite chronologies is not obvious, thermal disturbances associated with the heavy bombardment on Vesta [8] might contributed to it. Furthermore, since the previous studies mentioned above analyzed only two or three diogenite samples, their results are not necessarily representative to all diogenites. Here, we present the ^{176}Lu–^{176}Hf systematics of nine diogenites, which is characterized by considerably high closure temperature [9], together with the ^{87}Rb–^{87}Sr systematics and the rare earth element (REE) abundances and discuss about their differentiation processes.

Samples and Experiments: Three fall diogenites (Bilanga, Johnstown, and Tatahouine), one desert-find diogenite (NWA 5480), three Antarctic diogenites (Y-74013, Y-74097, and Y-002875), and two provisional diogenites were used in this study. After an acid-leaching treatment using 5 mL of hot (100°C) 0.5 M HCl to remove the terrestrial contaminants, the acid-residue of each powdered sample (~1 g) was completely digested by concentrated HF–$HClO_4$ mixture. A minor portion (~10% of the total) of the sample solution was used for the determination of elemental abundances by ICP-MS (Agilent 7700x), while the major portion (~90%) was used for the isotopic a work. Sr and Hf were purified from the sample solution through a two-step column chemistry using Ln-spec and Sr-spec resin respectively. Isotopic analyses were performed by TIMS (VG Sector 54-30) for Sr and MC-ICP-MS (Neptune Plus) for Hf.

Results and Discussion: The ^{176}Lu–^{176}Hf age of 4.40 ± 0.38 Ga with the initial ^{176}Hf/^{177}Hf ratio of 0.2820 ± 0.0013 are calculated from the ^{176}Lu–^{176}Hf data set of the nine diogenites. This initial ^{176}Hf/^{177}Hf ratio is significantly higher than the reference eucrite value (0.27977 ± 0.00008 [10]), while the ^{176}Lu–^{176}Hf age is identical to that of eucrites (4.59 ± 0.15 Ga [10]) within the error range. The high initial ^{176}Hf/^{177}Hf ratio of the diogenites indicates their differentiation from the source material characterized by superchondritic Lu/Hf ratio. An olivine-rich mantle crystallized from a planetary-scale magma ocean on Vesta [11] is probably the source material of diogenites, because it should be extremely enriched in Lu relative to Hf based on experimentally obtained olivine/melt partitioning coefficients [12]. The heavier REE abundances of the diogenites show significant variation, indicating their crystallization from compositionally diverse parental melts. A combination of the ^{176}Lu–^{176}Hf and REE data of the diogenites suggests their crystallization from partial melts of the Vestan mantle. The variation of the REE abundances can be explained by the variation of the degree of partial melting. In contrast to the ^{176}Lu–^{176}Hf systematics, the ^{87}Rb–^{87}Sr systematics of the diogenites are totally disturbed probably due to intense impacts on the Vestan surface.

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