



Data Article

Eu isotope data of NIST3117a standard reagent for determination of Eu isotope fractionation in geological rocks using MC-ICP-MS

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ABSTRACT

The data presented in this work summarize the results of Eu isotope ratio of NIST3117a standard reagent collected between December 2017 and July 2020, which were used standard isotope ratio for calculating delta notation of Eu isotope ratio in the geological rocks [1,2]. The Eu isotope ratio of NIST3117a using MC-ICP-MS was measured by conventional standard-sample-bracketing (SSB) and combined standard-sample bracketing and internal normalization (C-SSBIN) for comparison. Sm was used as a spike element for normalization in determining Eu isotope ratio. The purpose of data collection was to check homogeneity and stability of Eu isotope ratio for NIST3117a Eu standard reagent for determining Eu isotope fractionation in the various kinds of geological materials. The data can be used as bench mark for Eu isotope standard reagent for determining the degree of Eu isotope fractionation in the geological materials.

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Specifications Table

Subject	Chemistry, Earth and Planetary Sciences
Specific subject area	Analytical Chemistry, Isotope analysis
Type of data	Table, Figure
How data were acquired	MC-ICP-MS (Neptune plus)
Data format	Raw and analyzed data
Parameters for data collection	All the isotopic ratios are reported in delta (δ) notation relative to NIST3117a used as an in-house standard solution, where $\delta_{\frac{151}{153}Eu}(\%) = \left[\frac{(\frac{151}{153}Eu)_{sam}}{(\frac{151}{153}Eu)_{Ave, NIST3117a}} - 1 \right] \times 1,000 \quad (1)$ where $(\frac{151}{153}Eu)_{sam}$ and $(\frac{151}{153}Eu)_{Ave, NIST3117a}$ are the mass bias corrected isotope ratio of each NIST3117a and the average isotope ratio of total measured data from NIST 3117a during this study, respectively.
Description of data collection	The data are Eu isotope ratio of NIST3117a standard reagent measured between December 2017 and July 2020.
Data source location	Institution: Korea Institute of Geoscience and Mineral Resources City/Town/Region: Daejeon Country: Korea
Data accessibility	With the article
Related research article	1. S.-G. Lee, T. Tanaka, Gd matrix effects on Eu isotope fractionation in geological rocks using MC-ICP-MS: Optimizing Europium isotope ratio measurements in geological samples, <i>Int. J. Mass. Spectro.</i> 469(2021)116,668, https://doi.org/10.1016/j.ijms.2021.116668 .

Value of the data

- Eu isotope ratio of NIST3117a standard reagent was accurately and precisely measured as a reference material to compare change in Eu isotope ratio in the geological rocks.
- Eu isotope ratio was determined by multi-collector inductively coupled plasma mass spectrometry (MC-ICP-MS) using a Sm spike
- The comparison result of Eu isotope ratio determined by normalizing using different Sm spike isotope pair and MC-ICP-MS could be useful in understanding matrix effect and importance of element purification for isotope ratio determination.
- The stable Eu isotope ratio of NIST3117a standard reagent could be used as standard to study Eu isotope fractionation in the geological and planetary materials.

1. Data Description

Table 1 provides Eu isotope ratio of NIST3117a determined by conventional Standard-Sample-Bracketing (SSB) and Combined-Standard-Sample-Bracketing Internal Normalization (C-SSBIN) method using MC-ICP-MS [1,2]. The Eu isotope ratios in Table 1 were used as reference isotope ratio for calculating a standard delta notation (‰) of a geological material relative to the NIST3117a Eu standard solution [1,2]. The experiment for determining Eu isotope was performed between December 2017 and July 2020. The Sm spike isotope pairs for normalization of Eu isotope ratio are ^{147}Sm - ^{149}Sm , ^{147}Sm - ^{152}Sm , ^{147}Sm - ^{154}Sm , ^{149}Sm - ^{154}Sm and ^{150}Sm - ^{154}Sm .

2. Experimental Design, Materials and Methods

Determination of Eu isotope ratio needs a standard of reference. The NIST3117a standard solution (Lot. No. 120,705) is a homogeneous, concentrate form (10,000 $\mu\text{g/mL}$) that gives consistent Eu isotope ratios. Because it showed stable Eu isotope ratio [1], NIST3117a was used as an in-house standard solution for determining Eu isotope ratios from geochemical reference materials. An in-house Sm solution was prepared from ultrapure Sm_2O_3 produced by Alfa Aesar (99.998%

Table 1Eu isotope ratio of NIST3117a determined by MC-ICP-MS using Sm internal standard isotope pairs ($^{150}\text{Sm}/^{154}\text{Sm}$, $^{147}\text{Sm}/^{154}\text{Sm}$, $^{147}\text{Sm}/^{149}\text{Sm}$, $^{149}\text{Sm}/^{154}\text{Sm}$ and $^{147}\text{Sm}/^{152}\text{Sm}$).

Date	$\delta^{151/153}\text{Eu}$ (SSB)		$\delta^{151/153}\text{Eu}$ (‰, C-SSBIN)									
			Normalizing isotope pair									
	no-normalization		$^{150}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{149}\text{Sm}$		$^{149}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{152}\text{Sm}$	
	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE
Dec. 23 2017	-0.716	0.004	0.022	0.005	0.005	0.004	-0.027	0.005	0.019	0.004	-0.013	0.004
	-0.581	0.005	0.027	0.006	0.007	0.005	-0.015	0.007	0.016	0.005	-0.014	0.005
	-0.495	0.005	0.023	0.005	0.015	0.004	-0.003	0.007	0.023	0.005	-0.003	0.005
	1.500	0.005	0.029	0.006	0.026	0.006	0.002	0.008	0.024	0.005	-0.004	0.005
	1.528	0.006	0.017	0.006	0.014	0.004	-0.013	0.007	0.026	0.005	0.000	0.004
	1.554	0.005	0.025	0.006	0.008	0.005	-0.008	0.008	0.018	0.005	-0.006	0.005
	1.554	0.005	0.024	0.007	0.016	0.005	-0.004	0.011	0.028	0.006	0.008	0.005
Jan. 27 2018	1.380	0.008	0.019	0.004	0.010	0.004	-0.017	0.006	0.021	0.004	-0.004	0.004
	1.250	0.010	0.033	0.004	0.024	0.004	-0.010	0.007	0.037	0.004	0.006	0.004
	0.767	0.005	0.026	0.006	-0.032	0.005	0.027	0.008	-0.053	0.005	-0.026	0.005
	0.737	0.004	0.040	0.005	-0.029	0.005	0.029	0.006	-0.055	0.005	-0.014	0.005
	0.755	0.005	0.044	0.006	-0.022	0.005	0.037	0.007	-0.047	0.006	-0.009	0.005
	0.730	0.004	0.022	0.005	-0.038	0.005	0.006	0.007	-0.058	0.005	-0.029	0.005
	0.786	0.005	0.070	0.006	-0.012	0.005	0.052	0.008	-0.039	0.005	0.003	0.005
	0.542	0.005	0.000	0.006	-0.044	0.005	-0.017	0.007	-0.056	0.005	-0.052	0.004
	0.584	0.004	0.019	0.005	-0.047	0.004	-0.038	0.008	-0.052	0.004	-0.052	0.004
0.676	0.004	0.007	0.005	-0.042	0.005	-0.018	0.008	-0.055	0.005	-0.043	0.005	
Jan. 28 2018	0.933	0.007	0.088	0.005	0.000	0.004	0.073	0.008	-0.027	0.004	0.020	0.004
	0.853	0.005	0.058	0.005	-0.021	0.004	0.052	0.008	-0.051	0.005	-0.004	0.005
	0.826	0.005	0.086	0.006	0.002	0.004	0.092	0.008	-0.035	0.005	0.017	0.005
	0.790	0.007	0.086	0.005	0.006	0.004	0.085	0.008	-0.026	0.004	0.030	0.005
	0.766	0.005	0.099	0.005	0.010	0.004	0.073	0.008	-0.019	0.005	0.025	0.005
	0.781	0.005	0.103	0.007	0.005	0.006	0.082	0.008	-0.026	0.006	0.026	0.007
	0.763	0.005	0.089	0.008	0.001	0.006	0.096	0.008	-0.030	0.006	0.028	0.006

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Table 1 (continued)

Date	$\delta^{151/153}\text{Eu}$ (SSB)		$\delta^{151/153}\text{Eu}$ (‰, C-SSBIN)									
	no-normalization		Normalizing isotope pair									
			$^{150}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{149}\text{Sm}$		$^{149}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{152}\text{Sm}$	
	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE
Oct. 18 2018	-1.446	0.008	0.045	0.008	0.032	0.007	-0.006	0.009	0.050	0.007	0.013	0.006
	-1.726	0.008	0.049	0.008	0.028	0.007	-0.014	0.013	0.044	0.007	0.005	0.007
	-1.761	0.007	0.047	0.009	0.020	0.007	-0.030	0.012	0.040	0.008	-0.004	0.007
	-1.760	0.008	0.045	0.008	0.027	0.006	-0.012	0.011	0.045	0.006	0.011	0.006
	-1.680	0.008	0.071	0.007	0.042	0.006	0.004	0.011	0.064	0.006	0.017	0.006
	-1.813	0.006	0.048	0.008	0.014	0.005	-0.027	0.012	0.038	0.005	-0.002	0.007
	-1.776	0.007	0.051	0.008	0.019	0.007	-0.015	0.012	0.036	0.008	-0.002	0.007
	-1.812	0.006	0.052	0.008	0.019	0.006	-0.039	0.010	0.040	0.007	-0.001	0.007
Oct. 23 2018	-1.504	0.012	0.045	0.009	0.023	0.008	-0.026	0.013	0.041	0.007	0.009	0.008
	-1.572	0.003	0.031	0.002	0.015	0.000	-0.024	0.003	0.031	0.000	-0.011	0.003
	-1.504	0.009	0.029	0.008	0.016	0.007	-0.035	0.011	0.034	0.006	-0.004	0.007
	-1.572	0.000	0.038	0.000	0.023	0.000	-0.017	0.000	0.040	0.000	0.007	0.000
	-1.471	0.005	0.028	0.005	0.011	0.005	-0.025	0.005	0.029	0.005	0.000	0.005
	-1.641	0.005	0.006	0.005	-0.011	0.005	-0.036	0.005	-0.002	0.005	-0.034	0.005
	-1.572	0.006	0.033	0.006	0.010	0.006	-0.047	0.006	0.038	0.006	-0.003	0.006
	-1.562	0.006	0.041	0.006	0.018	0.006	-0.019	0.006	0.033	0.006	-0.001	0.006
	-1.633	0.008	0.032	0.008	0.017	0.008	-0.024	0.008	0.036	0.008	0.005	0.008

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Table 1 (continued)

Date	$\delta^{151/153}\text{Eu}$ (SSB)		$\delta^{151/153}\text{Eu}$ (‰, C-SSBIN)									
	no-normalization		Normalizing isotope pair									
			$^{150}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{149}\text{Sm}$		$^{149}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{152}\text{Sm}$	
(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE	
Dec. 25 2018	-0.291	0.002	0.037	0.002	0.035	0.002	0.025	0.002	0.039	0.002	0.033	0.002
	-0.337	0.005	0.046	0.005	0.038	0.005	0.022	0.005	0.048	0.005	0.032	0.005
	-0.352	0.005	0.013	0.005	0.028	0.005	-0.010	0.005	0.037	0.005	0.018	0.005
	-0.218	0.014	0.040	0.009	0.038	0.008	0.024	0.015	0.044	0.007	0.036	0.009
	-0.129	0.016	0.031	0.009	0.036	0.008	0.012	0.010	0.049	0.008	0.025	0.009
	-0.140	0.019	0.026	0.009	0.033	0.007	0.021	0.010	0.041	0.007	0.028	0.007
	-0.147	0.016	0.025	0.009	0.015	0.008	0.008	0.012	0.030	0.008	0.015	0.009
	-0.119	0.016	0.030	0.008	0.041	0.007	0.042	0.009	0.046	0.008	0.039	0.007
Dec. 26 2018	0.080	0.011	0.043	0.008	0.034	0.007	0.044	0.011	0.037	0.007	0.043	0.008
	0.280	0.017	0.049	0.006	0.034	0.006	0.025	0.011	0.042	0.006	0.034	0.006
	0.284	0.005	0.035	0.005	0.039	0.005	0.046	0.005	0.036	0.005	0.040	0.005
	0.381	0.005	0.067	0.005	0.073	0.005	0.067	0.005	0.068	0.005	0.070	0.005
	0.824	0.010	0.065	0.008	0.050	0.007	0.041	0.010	0.060	0.008	0.055	0.007
	0.901	0.011	0.057	0.009	0.054	0.008	0.060	0.011	0.059	0.009	0.052	0.008
	0.569	0.012	0.041	0.011	0.045	0.009	0.032	0.012	0.051	0.009	0.048	0.010
	-0.491	0.010	0.020	0.010	0.033	0.009	0.034	0.012	0.027	0.008	0.036	0.008
	-0.235	0.018	0.068	0.008	0.066	0.008	0.071	0.011	0.061	0.008	0.063	0.008
	-0.323	0.000	0.044	0.000	0.046	0.000	0.052	0.000	0.050	0.000	0.046	0.000
	-0.167	0.005	0.052	0.005	0.045	0.005	0.051	0.005	0.033	0.005	0.036	0.005
	-0.160	0.005	0.036	0.005	0.038	0.005	0.043	0.005	0.035	0.005	0.043	0.005
	0.104	0.005	0.038	0.005	0.043	0.005	0.043	0.005	0.040	0.005	0.043	0.005
	-0.167	0.016	0.034	0.010	0.048	0.009	0.049	0.009	0.050	0.009	0.048	0.009
	-0.160	0.014	0.045	0.010	0.046	0.008	0.039	0.011	0.041	0.008	0.042	0.009
	0.104	0.008	0.055	0.009	0.052	0.008	0.049	0.011	0.058	0.009	0.056	0.008

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Table 1 (continued)

Date	$\delta^{151/153}\text{Eu}$ (SSB)		$\delta^{151/153}\text{Eu}$ (‰, C-SSBIN)									
	no-normalization		Normalizing isotope pair									
			$^{150}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{149}\text{Sm}$		$^{149}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{152}\text{Sm}$	
(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE	
Dec. 27 2018	0.339	0.006	0.069	0.006	0.062	0.006	0.055	0.006	0.065	0.006	0.061	0.006
	0.609	0.006	0.019	0.006	0.038	0.006	0.062	0.006	0.029	0.006	0.034	0.006
	0.784	0.005	0.002	0.005	0.025	0.005	0.033	0.005	0.020	0.005	0.017	0.005
	0.676	0.012	0.054	0.011	0.065	0.008	0.061	0.010	0.061	0.009	0.064	0.009
	0.596	0.013	0.030	0.012	0.038	0.011	0.048	0.014	0.037	0.011	0.040	0.010
	0.639	0.011	0.058	0.008	0.075	0.006	0.092	0.013	0.073	0.006	0.079	0.007
	0.508	0.015	0.040	0.010	0.046	0.010	0.036	0.014	0.048	0.010	0.046	0.010
	0.486	0.016	0.049	0.010	0.059	0.008	0.087	0.012	0.046	0.008	0.061	0.008
	0.686	0.005	0.065	0.005	0.054	0.005	0.041	0.005	0.066	0.005	0.051	0.005
	0.527	0.005	0.024	0.005	0.037	0.005	0.024	0.005	0.043	0.005	0.031	0.005
	0.401	0.021	0.054	0.009	0.052	0.008	0.203	0.012	0.052	0.008	0.056	0.008
	0.401	0.015	0.045	0.010	0.057	0.007	0.040	0.010	0.063	0.007	0.059	0.007
	0.526	0.015	0.017	0.009	0.031	0.008	0.054	0.013	0.033	0.008	0.032	0.009
	0.410	0.024	0.040	0.010	0.041	0.009	0.039	0.011	0.044	0.010	0.038	0.009
	0.514	0.022	0.057	0.010	0.066	0.010	0.056	0.013	0.068	0.009	0.061	0.010
	0.526	0.005	0.017	0.005	0.031	0.005	0.054	0.005	0.033	0.005	0.032	0.005
Jan. 1 2019	-3.963	0.013	0.011	0.005	0.025	0.004	0.033	0.006	0.022	0.005	0.027	0.004
	-2.760	0.007	0.036	0.006	0.024	0.006	0.006	0.008	0.027	0.006	0.015	0.005
	-2.765	0.009	0.018	0.007	0.013	0.005	-0.007	0.007	0.017	0.005	0.003	0.005
	-2.803	0.013	0.011	0.007	0.014	0.006	-0.015	0.007	0.023	0.007	0.002	0.006
	-2.778	0.008	0.007	0.005	0.009	0.004	-0.013	0.006	0.017	0.005	0.005	0.004
	-2.839	0.012	0.031	0.006	0.016	0.007	-0.016	0.009	0.034	0.006	0.004	0.007
	-2.876	0.016	0.021	0.008	0.009	0.006	-0.015	0.008	0.023	0.006	-0.002	0.006
	-2.922	0.006	0.024	0.006	0.002	0.006	-0.032	0.006	0.020	0.006	-0.005	0.006
	-2.997	0.006	0.026	0.006	0.015	0.006	-0.013	0.006	0.026	0.006	0.004	0.006
	-2.887	0.009	0.038	0.009	0.031	0.009	0.012	0.009	0.041	0.009	0.020	0.009
	-2.961	0.012	0.022	0.007	0.010	0.006	-0.020	0.009	0.028	0.006	-0.006	0.006
	-2.997	0.009	0.024	0.007	0.012	0.007	-0.014	0.009	0.027	0.007	0.004	0.007
	-2.961	0.015	0.021	0.007	0.012	0.006	-0.021	0.010	0.022	0.006	-0.005	0.007
	-2.997	0.018	0.026	0.006	0.014	0.005	-0.003	0.007	0.020	0.005	0.006	0.005

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Table 1 (continued)

Date	$\delta^{151/153}\text{Eu}$ (SSB)		$\delta^{151/153}\text{Eu}$ (‰, C-SSBIN)										
	no-normalization		Normalizing isotope pair										
	(‰)	2SE	$^{150}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{149}\text{Sm}$		$^{149}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{152}\text{Sm}$		
		(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE
Jan. 26 2019	-1.487	0.006	0.002	0.006	0.004	0.006	-0.012	0.006	0.010	0.006	0.001	0.006	
	-1.339	0.006	0.007	0.006	-0.009	0.006	-0.042	0.006	0.008	0.006	-0.024	0.006	
	-1.095	0.005	-0.025	0.005	-0.007	0.005	0.002	0.005	-0.009	0.005	-0.010	0.005	
	-1.026	0.015	0.012	0.006	0.005	0.004	-0.008	0.008	0.007	0.005	0.003	0.004	
	-0.758	0.024	0.023	0.006	0.012	0.005	-0.011	0.007	0.021	0.005	0.007	0.005	
	-0.904	0.017	0.010	0.006	0.000	0.004	-0.021	0.007	0.007	0.006	-0.004	0.004	
	-0.548	0.026	0.013	0.005	0.009	0.004	0.010	0.007	0.005	0.005	0.011	0.005	
	-0.532	0.028	0.018	0.006	0.018	0.005	0.005	0.009	0.024	0.006	0.013	0.005	
	-0.441	0.025	0.006	0.007	0.003	0.005	-0.007	0.009	0.010	0.006	0.004	0.006	
	-0.894	0.024	0.007	0.006	0.012	0.005	0.010	0.008	0.016	0.005	0.011	0.005	
	-1.065	0.013	0.000	0.005	0.000	0.004	-0.004	0.008	0.004	0.004	-0.001	0.004	
Jan. 27 2019	-1.547	0.007	-0.002	0.005	-0.006	0.005	-0.021	0.008	0.003	0.005	-0.015	0.005	
	-1.471	0.005	-0.013	0.006	-0.024	0.004	-0.021	0.000	-0.010	0.005	-0.032	0.004	
	-1.357	0.009	-0.003	0.007	-0.008	0.005	-0.024	0.007	-0.004	0.006	-0.015	0.005	
	-1.288	0.006	-0.016	0.006	-0.013	0.006	-0.037	0.006	-0.008	0.006	-0.021	0.006	
	-1.258	0.006	-0.009	0.006	-0.015	0.006	-0.027	0.006	-0.010	0.006	-0.020	0.006	
	-1.293	0.010	-0.014	0.010	-0.018	0.010	-0.023	0.010	-0.014	0.010	-0.026	0.010	
	-1.288	0.009	-0.019	0.006	-0.017	0.005	-0.042	0.009	-0.009	0.005	-0.021	0.006	
	-1.258	0.012	-0.021	0.006	-0.030	0.005	-0.052	0.006	-0.018	0.006	-0.039	0.005	
	-1.151	0.010	-0.003	0.005	-0.016	0.005	-0.039	0.008	-0.005	0.005	-0.024	0.005	
Apr. 2 2019	0.319	0.014	-0.046	0.007	-0.040	0.007	-0.023	0.009	-0.045	0.007	-0.046	0.007	
	1.931	0.056	-0.054	0.006	-0.028	0.006	0.016	0.010	-0.051	0.005	-0.017	0.006	
	2.453	0.050	-0.056	0.009	-0.040	0.008	-0.001	0.013	-0.055	0.007	-0.024	0.009	
	3.769	0.053	-0.052	0.009	-0.011	0.008	0.064	0.013	-0.045	0.009	0.011	0.009	
	3.986	0.047	-0.037	0.009	0.006	0.007	0.098	0.013	-0.033	0.008	0.031	0.008	
	3.863	0.042	-0.060	0.008	-0.022	0.007	0.063	0.013	-0.055	0.007	0.004	0.007	

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Table 1 (continued)

Date	$\delta^{151/153}\text{Eu}$ (SSB)		$\delta^{151/153}\text{Eu}$ (‰, C-SSBIN)									
	no-normalization		Normalizing isotope pair									
			$^{150}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{149}\text{Sm}$		$^{149}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{152}\text{Sm}$	
	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE
Apr. 6 2019	-0.292	0.014	-0.036	0.008	-0.044	0.006	-0.074	0.011	-0.033	0.007	-0.049	0.007
	1.306	0.034	-0.061	0.010	-0.049	0.008	-0.018	0.013	-0.063	0.008	-0.036	0.009
	1.826	0.020	-0.047	0.009	-0.040	0.008	-0.020	0.013	-0.052	0.008	-0.034	0.009
	1.999	0.055	-0.059	0.008	-0.052	0.007	-0.008	0.011	-0.064	0.008	-0.040	0.008
	1.433	0.019	-0.043	0.009	-0.034	0.008	-0.016	0.011	-0.043	0.009	-0.030	0.008
	2.090	0.019	-0.075	0.008	-0.046	0.007	0.004	0.010	-0.061	0.008	-0.031	0.007
	2.418	0.024	-0.085	0.007	-0.036	0.005	-0.046	0.007	-0.071	0.006	-0.028	0.005
May 29 2019	2.953	0.023	-0.027	0.006	0.018	0.006	0.035	0.007	0.012	0.006	0.036	0.006
	0.275	0.011	-0.035	0.004	0.000	0.004	0.015	0.006	-0.004	0.004	0.006	0.005
	1.265	0.020	-0.037	0.004	0.008	0.004	0.015		-0.007	0.005	0.025	0.005
								#####				
	0.335	0.011	-0.027	0.009	-0.024	0.007	-0.029	0.010	-0.024	0.008	-0.024	0.007
	0.014	0.007	-0.032	0.008	-0.041	0.007	-0.070	0.011	-0.035	0.007	-0.054	0.007
	0.239	0.009	-0.051	0.008	-0.037	0.006	-0.016	0.009	-0.051	0.006	-0.037	0.006
	-0.640	0.008	-0.041	0.006	-0.022	0.006	-0.042	0.009	-0.012	0.006	-0.006	0.006
	0.634	0.014	-0.040	0.007	-0.020	0.005	-0.009	0.007	0.011	0.008	-0.013	0.007
	1.837	0.030	-0.046	0.006	-0.011	0.005	0.031	0.008	0.009	0.008	0.009	0.006
2.750	0.035	-0.049	0.006	-0.011	0.005	0.065	0.008	0.012	0.009	-0.006	0.006	
Jun. 19 2019	-1.662	0.004	-0.025	0.003	-0.046	0.004	-0.093	0.005	-0.024	0.004	-0.059	0.004
	-1.610	0.005	-0.014	0.004	-0.032	0.004	-0.079	0.006	-0.013	0.004	-0.042	0.004
	-1.524	0.003	-0.025	0.000	-0.039	0.003	-0.083	0.005	-0.019	0.003	-0.046	0.003
	-1.515	0.005	-0.028	0.004	-0.036	0.003	-0.075	0.005	-0.020	0.003	-0.046	0.003
	-1.572	0.006	-0.026	0.003	-0.037	0.003	-0.074	0.005	-0.022	0.003	-0.044	0.003
	-1.391	0.009	-0.027	0.004	-0.035	0.003	-0.064	0.004	-0.023	0.003	-0.037	0.003
	-1.490	0.008	-0.021	0.004	-0.024	0.003	-0.057	0.005	-0.008	0.003	-0.026	0.003

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Table 1 (continued)

Date	$\delta^{151/153}\text{Eu}$ (SSB)		$\delta^{151/153}\text{Eu}$ (‰, C-SSBIN)									
	no-normalization		Normalizing isotope pair									
			$^{150}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{149}\text{Sm}$		$^{149}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{152}\text{Sm}$	
	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE
Jul. 25 2019	-0.968	0.005	-0.017	0.006	-0.018	0.005	-0.036	0.007	-0.011	0.005	-0.028	0.005
	-0.580	0.008	-0.015	0.006	-0.006	0.006	-0.019	0.008	-0.003	0.006	-0.011	0.006
	-0.636	0.008	-0.015	0.005	0.001	0.004	-0.013	0.007	0.002	0.004	-0.001	0.004
Jul. 26 2019	-0.373	0.005	0.015	0.005	0.019	0.004	0.031	0.009	0.013	0.005	0.027	0.005
	-0.183	0.012	-0.019	0.006	0.002	0.005	0.006	0.008	-0.005	0.006	0.009	0.005
	-0.332	0.008	-0.013	0.007	0.004	0.006	0.008	0.007	0.004	0.006	0.007	0.006
	-0.113	0.012	0.010	0.006	0.026	0.005	0.032	0.007	0.024	0.006	0.031	0.006
	-0.274	0.008	0.008	0.006	0.010	0.006	0.012	0.008	0.012	0.006	0.016	0.006
	0.132	0.013	-0.021	0.006	0.001	0.005	0.027	0.009	-0.009	0.005	0.013	0.005
Nov. 24 2019	-0.411	0.009	-0.006	0.006	0.014	0.005	0.014	0.008	0.011	0.006	0.018	0.006
	-0.134	0.009	-0.037	0.007	-0.036	0.005	-0.046	0.007	-0.028	0.005	-0.039	0.005
Nov. 25 2019	0.236	0.009	-0.066	0.007	-0.061	0.006	-0.064	0.010	-0.062	0.006	-0.051	0.007
	0.651	0.011	-0.062	0.004	-0.058	0.004	-0.058	0.006	-0.056	0.004	-0.053	0.004
	-0.294	0.012	-0.052	0.004	-0.056	0.004	-0.086	0.005	-0.043	0.004	-0.063	0.004
	-0.152	0.010	-0.064	0.004	-0.059	0.004	-0.069	0.005	-0.054	0.004	-0.059	0.004
	-0.125	0.012	-0.050	0.004	-0.047	0.004	-0.049	0.006	-0.038	0.004	-0.041	0.004
	-0.157	0.007	-0.037	0.005	-0.042	0.004	-0.055	0.006	-0.034	0.004	-0.041	0.004
	-0.261	0.009	-0.043	0.005	-0.042	0.003	-0.053	0.006	-0.037	0.003	-0.043	0.003
Dec. 11 2019	-0.255	0.008	-0.046	0.005	-0.043	0.004	-0.063	0.005	-0.032	0.004	-0.042	0.004
	-0.102	0.011	-0.051	0.007	-0.031	0.006	-0.045	0.008	-0.023	0.006	-0.031	0.006
	0.145	0.018	-0.058	0.006	-0.040	0.006	-0.034	0.008	-0.039	0.005	-0.037	0.006
	0.140	0.012	-0.052	0.006	-0.015	0.006	-0.003	0.009	-0.019	0.006	-0.012	0.007
	-0.242	0.017	-0.023	0.006	-0.008	0.007	-0.019	0.007	-0.019	0.006	-0.013	0.006
	-0.126	0.014	-0.037	0.006	-0.018	0.005	-0.029	0.006	-0.012	0.006	-0.015	0.005
	0.409	0.014	-0.047	0.008	-0.017	0.007	0.002	0.010	-0.044	0.008	0.006	0.008
	2.636	0.016	-0.078	0.007	-0.019	0.007	0.047	0.010	-0.044	0.007	0.006	0.007

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Table 1 (continued)

Date	$\delta^{151/153}\text{Eu}$ (SSB)		$\delta^{151/153}\text{Eu}$ (‰, C-SSBIN)									
	no-normalization		Normalizing isotope pair									
	(‰)	2SE	$^{150}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{149}\text{Sm}$		$^{149}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{152}\text{Sm}$	
			(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE
Dec. 14 2019	0.802	0.014	-0.019	0.006	-0.006	0.004	-0.002	0.008	-0.008	0.005	0.007	0.006
	0.746	0.020	-0.029	0.006	0.000	0.005	0.018	0.008	-0.008	0.005	0.014	0.006
	1.164	0.020	-0.027	0.007	0.003	0.006	0.023	0.009	-0.005	0.006	0.018	0.006
	1.075	0.022	-0.028	0.008	0.005	0.006	0.029	0.008	-0.008	0.006	0.024	0.006
	0.678	0.027	-0.022	0.007	0.005	0.005	0.019	0.008	0.000	0.005	0.021	0.006
	1.003	0.021	-0.023	0.006	0.011	0.005	0.052	0.008	-0.008	0.005	0.027	0.006
Dec. 17 2019	0.973	0.011	-0.025	0.006	-0.011	0.005	0.000	0.007	-0.017	0.005	0.001	0.006
	1.650	0.011	-0.023	0.006	-0.007	0.005	0.025	0.008	-0.018	0.005	0.014	0.005
Dec. 18 2019	2.266	0.009	-0.046	0.006	-0.014	0.005	0.015	0.009	-0.028	0.006	0.005	0.006
	2.735	0.009	-0.038	0.007	-0.017	0.006	0.032	0.009	-0.036	0.006	0.011	0.007
	2.318	0.009	-0.034	0.008	-0.008	0.006	0.015	0.010	-0.020	0.006	0.012	0.006
	2.250	0.010	-0.043	0.007	-0.014	0.005	0.009	0.009	-0.021	0.006	0.007	0.005
Dec. 19 2019	1.651	0.009	-0.088	0.007	-0.020	0.006	-0.086	0.008	-0.077	0.006	-0.070	0.007
	1.524	0.009	-0.084	0.008	-0.020	0.006	-0.092	0.009	-0.082	0.007	-0.082	0.007
	1.408	0.009	-0.085	0.007	-0.020	0.006	-0.075	0.009	-0.067	0.006	-0.063	0.006
	0.685	0.009	-0.015	0.007	-0.020	0.006	-0.033	0.010	-0.012	0.006	-0.017	0.006
	0.699	0.010	-0.019	0.007	-0.021	0.006	-0.029	0.009	-0.021	0.006	-0.026	0.007
Jan. 22 2020	0.402	0.011	-0.064	0.005	-0.053	0.004	-0.065	0.007	-0.047	0.004	-0.056	0.004
	0.291	0.003	-0.050	0.002	-0.054	0.000	-0.073	0.003	-0.043	0.000	-0.057	0.003
Mar 4 2020	0.950	0.009	-0.033	0.011	-0.021	0.009	-0.030	0.011	-0.018	0.010	-0.014	0.009
	0.933	0.009	-0.051	0.010	-0.041	0.009	-0.060	0.013	-0.034	0.009	-0.029	0.010
	0.928	0.009	-0.046	0.011	-0.035	0.009	-0.014	0.013	-0.041	0.010	-0.030	0.009
	0.940	0.008	-0.023	0.011	-0.020	0.008	-0.025	0.010	-0.017	0.009	-0.008	0.008
	0.919	0.009	-0.054	0.011	-0.047	0.010	-0.063	0.014	-0.039	0.011	-0.043	0.010

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Table 1 (continued)

Date	$\delta^{151/153}\text{Eu}$ (SSB)		$\delta^{151/153}\text{Eu}$ (‰, C-SSBIN)									
	no-normalization		Normalizing isotope pair									
			$^{150}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{149}\text{Sm}$		$^{149}\text{Sm}/^{154}\text{Sm}$		$^{147}\text{Sm}/^{152}\text{Sm}$	
	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE	(‰)	2SE
May 3 2020	1.450	0.007	-0.049	0.010	-0.009	0.007	0.023	0.009	-0.019	0.008	0.003	0.007
	1.450	0.008	-0.023	0.008	0.003	0.007	0.016	0.010	-0.004	0.007	0.012	0.008
	1.572	0.011	-0.036	0.006	-0.017	0.006	0.011	0.012	-0.020	0.006	-0.004	0.007
	1.497	0.007	-0.013	0.007	0.009	0.005	0.023	0.009	0.002	0.005	0.023	0.007
May 12 2020	2.076	0.011	-0.009	0.009	0.013	0.008	0.038	0.012	-0.004	0.008	0.032	0.008
	1.940	0.008	-0.008	0.007	0.026	0.007	0.079	0.012	0.002	0.006	0.041	0.007
	1.735	0.010	-0.038	0.008	0.008	0.007	0.054	0.012	-0.016	0.007	0.021	0.007
May 15 2020	1.701	0.007	-0.039	0.007	-0.011	0.007	0.007	0.011	-0.019	0.007	0.009	0.007
	1.899	0.008	-0.018	0.008	-0.001	0.007	0.017	0.010	-0.013	0.006	0.012	0.007
	1.805	0.008	-0.028	0.008	-0.013	0.007	0.028	0.011	-0.024	0.007	0.004	0.008
	1.727	0.006	-0.040	0.007	-0.010	0.007	0.026	0.010	-0.015	0.007	0.012	0.007
Jun. 5 2020	-1.187	0.007	-0.029	0.008	-0.035	0.007	-0.056	0.009	-0.031	0.007	-0.037	0.007
	-0.566	0.010	-0.032	0.007	-0.035	0.007	-0.051	0.008	-0.024	0.007	-0.042	0.007
Jun. 10 2020	-0.906	0.008	-0.031	0.009	-0.038	0.008	-0.049	0.009	-0.035	0.008	-0.044	0.008
	-0.471	0.013	-0.022	0.008	-0.023	0.007	-0.016	0.009	-0.024	0.007	-0.017	0.008
	-0.328	0.017	-0.030	0.008	-0.028	0.007	-0.019	0.009	-0.028	0.008	-0.020	0.008
Jun. 11 2020	-0.660	0.006	-0.042	0.007	-0.045	0.006	-0.073	0.010	-0.031	0.006	-0.046	0.006
	-0.744	0.007	-0.016	0.007	-0.033	0.007	-0.056	0.009	-0.027	0.007	-0.035	0.007
	-0.815	0.007	-0.042	0.008	-0.047	0.007	-0.062	0.010	-0.037	0.007	-0.051	0.008
Jul. 15 2020	-1.255	0.009	-0.015	0.008	-0.011	0.007	-0.011	0.008	-0.008	0.007	-0.004	0.007
	-0.751	0.019	-0.029	0.008	-0.002	0.008	-0.013	0.012	0.002	0.007	0.003	0.008
	-0.454	0.015	-0.011	0.008	-0.011	0.006	-0.012	0.009	-0.010	0.007	0.002	0.007
	-0.442	0.012	-0.030	0.008	-0.024	0.008	-0.035	0.010	-0.023	0.008	-0.016	0.008

Table 2

Cup configuration on the Neptune Plus MC-ICP-MS for the measurement of Eu isotope ratios and Sm spike pair isotopes.

Cup	L4	L3	L2	L1	C	H1	H2	H3	H4
Mass	147	149	150	151	152	153	154	155	157
Element	Sm	Sm	Sm	Eu	Sm	Eu	Sm	Gd	Gd

purity, Lot no. P4362) [1]. Natural abundance of ^{151}Eu and ^{153}Eu is 47.81% and 52.19%, respectively. And natural abundance of ^{147}Sm , ^{148}Sm , ^{149}Sm , ^{150}Sm , ^{152}Sm , ^{154}Sm are 14.99%, 11.24%, 13.82%, 7.38%, 26.75% and 22.75%, respectively. Lee and Tanaka [1] suggested that optimal Sm spike concentration needed to equal or exceed Eu concentration. In order to obtain similar intensity of Eu and Sm isotopes, the concentration ratio of Eu and Sm was 1 to 2. And each sample had a ^{153}Eu signal intensity of 90–110 mV/ppb.

Experimental design for these data are described in Lee and Tanaka [1,2]. Eu isotopic measurements were performed on a Neptune Plus MC-ICP-MS (Thermo Fisher Scientific Ltd.) with nine Faraday cups and operated under wet plasma conditions at the Korea Institute of Geoscience and Mineral Resources (KIGAM), Daejeon, Korea. The typical sample aspiration rate was 80–100 $\mu\text{L}/\text{min}$. The gain on each Faraday cup was monitored on a daily basis to ensure normalization of its efficiency. Each sample was subjected to 50 cycles (50 cycles/block) with a 4.19 s integration interval. Blanks were analyzed before and after each unknown sample measurement. The cup configuration for determining Eu and Sm isotopes is given in Table 2. Sample solutions for Eu isotopic measurements by MC-ICP-MS consisted of 2% HNO_3 prepared from 60% ultrapure HNO_3 (Merck, Darmstadt, Germany) and deionized water (Milli-Q system, Millipore, Milford, USA).

Eu isotope ratios are reported in standard delta notation (‰) relative to the NIST3117a Eu standard solution:

$$\delta_{\frac{151}{153}\text{Eu}}(\text{‰}) = \left[\frac{(\frac{151}{153}\text{Eu})_{\text{sam}}}{(\frac{151}{153}\text{Eu})_{\text{ave. NIST3117a}}} - 1 \right] \times 1,000 \quad (1)$$

where $(\frac{151}{153}\text{Eu})_{\text{sam}}$ and $(\frac{151}{153}\text{Eu})_{\text{ave. NIST3117a}}$ are the mass bias corrected ratios of the sample (NIST3117a) and average value of NIST 3117a measured during December 2017 to July 2020, respectively.

Ethics Statement

The authors followed generally expected standards of ethical behavior in scientific publishing throughout article construction.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have or could be perceived to have influenced the work reported in this article.

CRediT Author Statement

Seung-Gu Lee: Conceptualization, Methodology, Validation, Formal analysis, Writing – original draft; **Tsuyoshi Tanaka:** Writing – review & editing, Conceptualization.

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