

THE EFFECT OF TERRESTRIAL WEATHERING ON STABLE STRONTIUM (SR) AND BARIUM (BA) ISOTOPIC COMPOSITIONS OF ACHONDRITES

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Introduction: Strontium (Sr) and barium (Ba) are refractory lithophile element with 50% condensation temperature (T_c) of 1464 K and 1455 K [1], respectively. Their unique nature makes their stable isotope compositions unaffected by volatilization and core formation and can be used as potential tracers to better understand the precursor materials of planetary bodies [2]. Moreover, as alkali earth elements, Sr and Ba show significant fluid-mobility. Several studies have shown that terrestrial weathering will increase the Sr and Ba contents of desert-find meteorites due to the formation of secondary carbonate and sulfate. However, it is not clear whether and how weathering process will alter the Sr and Ba isotopic compositions of meteorites, which hinders the application of stable Sr and Ba stable isotopes in cosmochemistry.

To investigate the effect of terrestrial weathering on stable Sr and Ba isotopic compositions of achondrites, we conducted leaching experiments on three eucrites including Fall, Desert Find and Antarctic Find, and then measured the isotopic compositions of supernatant, residual phase, and bulk samples.

Samples and Methods: The three eucrites are NWA 13583 (Desert Find), GRV 13001 (Antarctic Find) and Qiquanhu (Fall). Leaching experiments were conducted at room temperature for 48h using 1 N HAC on rock powders. Sample powders was placed in a Teflon vessel with 6 mL 1N HAC, and then took 0.5 ml supernatant each time at different time points. The Ba and Sr content were analyzed by an Elan 6100 DRCII ICP-MS at University of Science and Technology of China (USTC), Hefei, China. All supernatants were mixed in preparing for the isotopic analysis because of the low concentration of each solution. Isotopic compositions were determined using a Neptune Plus MC-ICP-MS) at USTC. Results are reported in $\delta^{138/134}\text{Ba}$ notations ($\delta^{138/134}\text{Ba} = [(^{138}\text{Ba}/^{134}\text{Ba})_{\text{sample}} / (^{138}\text{Ba}/^{134}\text{Ba})_{\text{SRM3104a}} - 1] \times 1000$) and $\delta^{88/86}\text{Sr}$ ($\delta^{88/86}\text{Sr} = [(^{88}\text{Sr}/^{86}\text{Sr})_{\text{sample}} / (^{88}\text{Sr}/^{86}\text{Sr})_{\text{SRM987}} - 1] \times 1000$). The uncertainties were reported as two standard deviations (2SD). The results of USGS standard analyzed in the same batch with our samples show consistent results with the recommended values, proving the quality of our data.

Trace Element

Sr concentration. The Sr contents of supernatant are shown in Figure 1. All samples show increased Sr content with prolonged leaching time. However, the dissolution rates are significantly different for the three samples. The rate of Qiquanhu shows a relatively sluggish decreasing with 15.23 $\mu\text{g Sr/L/h}$ between 0-0.5h, 0.971 $\mu\text{g Sr/L/h}$ between 0.5h-6h, and 0.527 $\mu\text{g Sr/L/h}$ between 6h-48h (Fig 1a). GRV 13001 shows rates of 13.721 $\mu\text{g Sr/L/h}$ between 0-0.5h and 0.234 $\mu\text{g Sr/L/h}$ between 6h-48h, whereas decreasing to 0 $\mu\text{g Sr/L/h}$ between 24h-48h (Fig 1b). NWA 13583 shows the highest rate of 133.30 $\mu\text{g Sr/L/h}$ between 0-0.5h but its Sr content is nearly unchanged after 6h (Fig. 1c).

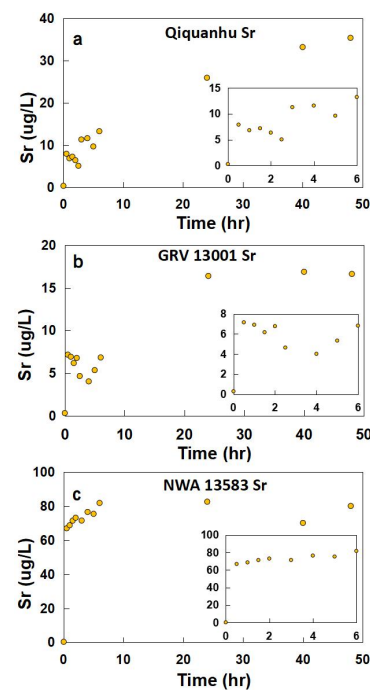


Fig.1 Sr concentrations of supernatant of achondrites.

Ba concentration. All samples show increased Ba content with prolonged leaching time. However, the dissolution rates are significantly different for the three samples. The rate of Qiquanhu shows a relatively sluggish decreasing with 0.668 $\mu\text{g Ba/L/h}$ between 0-6h, 0.134 $\mu\text{g Ba/L/h}$ between 6-48h (Fig 2a). For GRV 13001, the concentration of Ba is too low, indicating that the Ba is not be leached out. But it shows that 1N HAC will not leach out the Ba from the silicate phase for 48h (Fig.2b). NWA 13583 shows the highest rate

of 31.824 $\mu\text{g Ba/L/h}$ between 0-0.5h, 0.229 $\mu\text{g Ba/L/h}$ between 6-24h but its Sr content is nearly unchanged after 24h (Fig 2c).

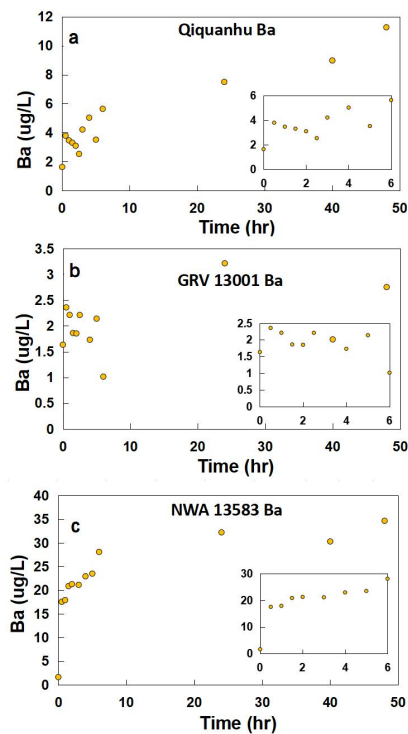


Fig.2 Ba concentrations of supernatant of achondrites.

Stable Sr and Ba Isotopic Compositions:

Qiquanhu shows consistent $\delta^{88/86}\text{Sr}$ among supernatant, residue, and bulk rock (Fig 3). Both of GRV 13001 and NWA 13583 show heavy Sr isotope compositions in supernatant.

The Ba isotope signatures are more complicated than Sr isotope. Qiquanhu show consistent $\delta^{138/134}\text{Ba}$ between residue and bulk, but the supernatant is much heavier (Fig. 4). The leaching residue of GRV 13001 shows heavier Ba isotopic composition than bulk rock and supernatant. Differently, the leaching residue and supernatant of NWA 13583 show similar $\delta^{138/134}\text{Ba}$ (Fig 4).

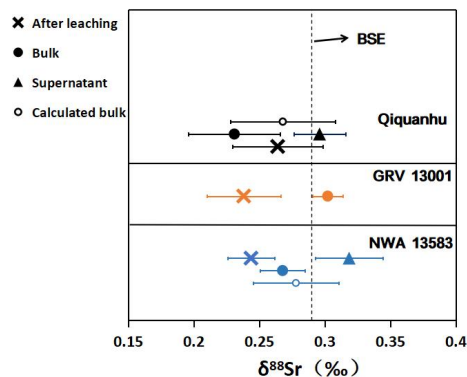


Fig.3 Strontium isotopic compositions of terrestrial contaminations of Eucrites. The vertical dashed line stands for the Bulk Silicate Earth $\delta^{88}\text{Sr}$ value (-0.29%), from [3].

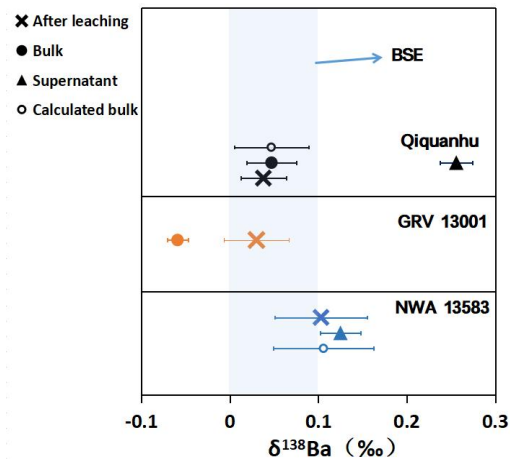


Fig.4 Barium isotopic compositions of terrestrial contaminations of Eucrites. The shaded area is the Bulk Silicate Earth $\delta^{138}\text{Ba}$ value ($0.05 \pm 0.05\%$, 2 SD, from [4]).

Discussion: Both the supernatant of GRV13001 and NWA13583 show heavier Sr isotope composition than leaching residue (Fig.3), suggesting that terrestrial weathering may shift the $\delta^{88/86}\text{Sr}$ of achondrites towards higher values (Fig.3). The Ba isotopic signature of GRV 13001 is different with NWA 13583, with one having heavier isotope composition in residue while the other show unfractionated isotope composition (Fig.4). It possibly reflects that secondary minerals formed in Antarctic weathering are different from those in hot-desert weathering. Further detailed petrography observations will be needed to confirm this.

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References:[1] Lodders, K., (2003) *ApJ*, 591, 1220-1247. [2] Moynier, F., et al. (2010) *GCA*, 74, 799–807.[3] Charlier, B.L.A., Nowell G.M, Parkinson I.J., et al. (2012) *EPSL*, 329: 31- 40. [4] Nan, X., Yu, H., Kang, J., Huang, F., et al. (2022) *JUSTC*, 2021-0276.