Titanium stable isotope fractionation on the Moon: Evidence for inter-mineral isotopic fractionation

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Terrestrial magmatic processes produce mass-dependent isotope fractionation of the refractory element Ti [1-3]. Recent data suggest that lunar high and low Ti basalts display a slight difference in their Ti isotope composition [3]. Furthermore, a KREEP enriched impact breccia is enriched in heavy Ti isotopes compared to mare basalts [4]. The Ti variations were linked to the formation of ilmenite, enriched in isotopically light Ti [3]. Here, new Ti isotope data are reported for lunar bulk rocks and mineral separates to further constrain the origin of the potential differences between lunar low- and high Ti basalts and the processes responsible for the observed Ti isotope variations.

A 3-stage anion-exchange procedure was used to purify Ti from the sample matrix [1,5]. Titanium isotope data were obtained on a Neptune Plus MC-ICPMS employing a Ti double spike for mass bias correction [1,2] to obtain $\delta^{49/47}$Ti data (deviations in ^{49}Ti/^{47}Ti relative to the Alfa Aesar wire standard, [1]). The reproduciblitly of $\delta^{49/47}$Ti based on repeat measurements of BHVO-2 (n=144) is 0.023 (2SD). Unspiked Ti isotope data are normalised to ^{49}Ti/^{47}Ti = 0.749766 [6].

Titanium isotope variations on the Moon are also produced by cosmogenic effects [7]. Thus, unspiked Ti isotope data were obtained for selected samples. This data show that the contribution of cosmogenic effects on the here obtained $\delta^{49/47}$Ti are insignificant. The new $\delta^{49/47}$Ti data of both low- and high-Ti lunar basalts fall within the range of terrestrial basalts. The Mg-suites samples display enrichments in heavy Ti isotopes relative to the lunar basalts, confirming Ti isotope fractionation during magmatic processes on the Moon. Olivine, pyroxene, plagioclase and ilmenite mineral separates of lunar basalts display an overall variation of ~0.25 ‰ in $\delta^{49/47}$Ti, demonstrating significant inter-mineral Ti isotope fractionation. Ilmenite is generally enriched in light Ti isotopes compared to the bulk of the investigated basalts, in agreement with hypotheses by [2-4].

[1] Williams et al. (2014) *LPSC*, 45, 2183. [2] Mandl *et al*. (2016) *Goldschmidt Abstract,* 1960. [3] Millet *et al*. (2016) *EPSL*, 449, 197-205. [4] Greber *et al*. (2017) *GCA*, 213, 534-552. [5] Schönbächler et al. (2004) *Analyst,* 129, 32-37. [6] Niederer et al. (1981) *GCA* 45, 1017-1031. [7] Zhang et al. (2012) *Nature Geosci*., 5, 251-255.