New insights into lunar basalt sources from Ti isotope variations

S. KOMMESCHER[1]*, R. O. C. FONSECA[1], F. KURZWEIL[1], L. J. A. MÜLLER[1], C. MÜNKER[1], M. M. THIEMENS[2], P. SPRUNG[3]

[1]University of Cologne, Germany, ([*]s.kommescher@uni-koeln.de)
[2]Université Libre de Bruxelles
[3]Paul Scherrer Institut, Villingen, Switzerland

During the final crystallization of the lunar magma ocean (LMO), Fe-Ti rich oxides sink whereas incompatible elements are strongly enriched in the KREEP-rich components [1]. Late-stage ilmenite bearing cumulates (IBC) are an inferred source region for high-Ti basalts with complementary lighter $\delta^{49/47}$Ti values compared to the KREEP component [2,3]. This source-specific isotope signature may be preserved in lunar mare basalts or KREEP rich samples. Previous studies indicated resolvable variations in the Ti isotope compositions of mare basalts as well as source-characteristic Nd/Hf isotope patterns [1,2,4].

We analysed the $\delta^{49/47}$Ti of 24 lunar samples using the double-spike method (12 low-Ti, eight high-Ti, four KREEP-rich lunar rocks). All values are relative to Origins Lab Ti reference material (OL-Ti) [1]. Repeated analyses of the reference materials JB-2 (n=38) and BCR-2 (n=10) give an external reproducibility for $\delta^{49/47}$Ti of ± 0.046‰ and 0.050‰ (2 s.d.), respectively. Quartz-normative low-Ti mare basalts vary in $\delta^{49/47}$Ti from -0.030 to +0.011 ‰. Ilmenite basalts (low- and high-Ti) show higher $\delta^{49/47}$Ti values between -0.013 and +0.115‰. The highest $\delta^{49/47}$Ti values are observed for KREEP-rich samples ranging from +0.117 and +0.296‰.

Low-Ti quartz-normative basalts record the $\delta^{49/47}$Ti of the ambient lunar mantle. The higher $\delta^{49/47}$Ti of ilmenite basalts reflects the presence of IBC in their source region, providing further constraints on ilmenite basalt sources and late stage LMO crystallization [5]. Our analysed samples agree with models and previous studies. They exhibit wider variations than previously reported, providing further insights into lunar basalt sources [1,2]. Combining the $\delta^{49/47}$Ti and HFSE ratios of KREEP-rich samples enable the estimation of the $\delta^{49/47}$Ti of the KREEP component (0.323 ± 0.029). This KREEP estimate combined with LMO crystallization models may allow to constrain the extent of the IBC crystallization and its Ti isotope composition.

[1] Millet *et al.* (2016), *EPSL* **449**, 197-205. [2] Greber *et al.* (2017), *GCA*, **213**, 534-552 [3] Zhang *et al.* (2019), *EPSL* **511**, 1-11 [4] Sprung *et al.* (2013), *EPSL* **308**, 77-87. [5] Beard *et al.* (1998), *GCA*, **62**, 525-544