ARE K AND Rb UNIFORMLY DEPLETED IN LUNAR ROCKS?

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The Moon is depleted in moderately volatile elements (MVEs), including twin alkali elements K and Rb. The setting and extent of this depletion are still uncertain. It could have taken place in the protolunar disk in the aftermath of the giant impact, or in the fully assembled Moon by loss from the lunar magma ocean, or through more localized impact-induced escape. Establishing whether K and Rb are uniformly depleted in lunar rocks is important because some models/scenarios would favor the preservation of volatile-rich reservoirs in the Moon [*e.g.*, 1-3]. For example, Tartèse *et al*. [3] argued that the depletion in MVEs could be a nearside feature induced by a large impact responsible melting and vaporization in what is now known as the Procellarum basin (however see [4] for observational evidence against an impact origin for this feature).

Lunar Prospector data reveal no heterogeneity in K/Th ratio between the nearside and farside [5,6]. A compilation of trace element abundances in lunar rocks reveal some heterogeneity in K/U and Rb/Ba ratios (U and Ba are highly incompatible elements with similar geochemical behaviors as K and Rb). However, we find that K/U correlates with La/U, and Rb/Ba correlates with Th/Ba. Because La, U, Th, and Ba are all highly refractory elements, the variations in La/U and Th/Ba in lunar rocks cannot be due to volatilization and must reflect magmatic processes. We have modelled the behavior of K, Rb, La, U, Th, and Ba during lunar magma ocean crystallization and we find that plagioclase crystallization and flottation can explain the variations in the K/U, Rb/Ba, La/U, and Th/Ba documented in lunar rocks. We use the correlations K/U-La/U and Rb/Ba-Th/Ba to estimate the K/U and Rb/Ba at chondritic La/U and Th/Ba ratios, allowing us to estimate the composition of the bulk Moon. We also use another approach to estimate the composition of the Moon, which relies solely on samples that have near-chondritic proportions of Ba, Th, U, and La. The reason why samples would have non-chondritic proportions of these elements could be that (*i*) the concentration measurements are imprecise or (*ii*) these elements were fractionated by magmatic processes. The rationale for focusing on elements that have chondritic relative abundances of Ba, Th, U, and La is that during melting and crystallization, these elements bracket the behaviors of K and Rb. The samples that have Ba, Th, U, and La in chondritic proportions are therefore likely to have K/U and Rb/Ba ratios that are representative of the bulk Moon. Our estimates of the lunar composition with this second approach yields results that are identical to the first approach. We also examined the composition of lunar meteorites that should have sampled the lunar far side, and we find K/U ratios consistent with our other estimates. To summarize, as far as we can tell K and Rb are uniformly depleted in lunar rocks, and we are able to better constrain their depletions and the inventories of heat-producing elements in the bulk silicate Moon [7].

References: [1] Canup, R. M., Visscher, C., Salmon, J., & Fegley, B. 2015, Nature Geoscience, 8, 918. [2] Dhaliwal, J. K., Day, J. M., & Moynier, F. J. I. 2018, 300, 249. [3] Tartèse, R., Sossi, P. A., & Moynier, F. 2021, PNAS, 118, e2023023118. [4] Wieczorek, M. A., et al. 2012, Science, 1231530. [5] Lawrence, D., Feldman, W., Barraclough, B., Binder, A., Elphic, R., Maurice, S., & Thomsen, D. 1998, Science, 281, 1484. [6] Feldman, W., Barraclough, B., Maurice, S., Elphic, R., Lawrence, D., Thomsen, D., & Binder, A. 1998, Science, 281, 1489. [7] Dauphas, N., Nie, N., Blanchard, M., Zhang, Z.J., Zeng, H., Hu, J.Y., Meheut, M., Visscher, C., Canup, R., Hopp, T. 2021, PSJ, submitted.