Calcium Isotopic Variations in Lunar Basalts

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Lunar basalts were the direct partial melting products of lunar mantle, their chemical and isotopic compositions were genetically related to each other. In documents, the isotopic compositions of lunar basalts were investigated and averaged to represent the lunar mantle or the bulk silicate Moon (BSM), provided that the isotopic fractionations during partial melting processes were limited. This kind of assumption, for many isotopic system, could be true, but not for calcium. Mostly based on terrestrial samples, recent studies suggested that calcium isotopic fractionation during partial melting processes might be limited on current analytic scales, but still could reach up to 0.1-0.2 per mil (e.g., Kang et al., 2017; Zhu et al., 2018; Chen et al., 2019). In addition, calcium isotopic composition for lunar basalts currently yields a range 0.78-1.08‰ (e.g., Simon et al., 2010; Valdes et al., 2014; Schiller et al., 2018 and our own unpublished data), this variation is obviously bigger than that 0.1-0.2 possibly produced during partial melting and couldn't be explained by the degrees of partial melting. Thus, at least, calcium isotopic composition for BSM purposed based on average numbers of lunar basalts are questionable. And the variation in lunar basalts may provide unknown information, such as heterogeneity of the lunar mantle, contaminated lunar basalts, etc.

Our recent practices indicated that $\delta^{44/40}Ca$ of the lunar basalts positively correlated with 1/CaO, decreased with increasing Al_2O_3 content and negatively correlated with the content of the anorthosite. It seems that lunar basalts are generally mixed with different amounts of anorthosites during their upwelling processes. This should be an important factor need to be considered during constraining the compositions of lunar mantle and the BSM, and could be very helpful to understand the lunar mantle homogeneity and the lunar magma ocean processes.

This work was supported by Natural Science Foundation of China (No. 41490632, 41773062) and the Key Research Program of the Chinese Academy of Sciences (Grant No. XDPB11).