Iron isotopic compositions of Luna 16, 20, 24 soils

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Iron is one of the most abundant elements in the Moon. The Fe exhibits not only siderophile property but also lithophile and chalcophile properties, thus, it is included in most of the minerals and rocks that compose the Moon. Therefore, Fe isotopic composition of the Moon potentially record the fractionation process that occurred during the formation of the Moon and the differentiation or alteration after the Moon formation. Previous works on Fe isotopic analyses of lunar samples suggested that the observed Fe isotopic compositions record fractionation during evaporation of Fe related to giant impact [1], differentiation of lunar magma ocean [2]–[4], and space weathering [5]–[7].

At present, there are no lunar meteorites collected as fall, thus, returned samples of the Moon are important for lunar Fe isotopic studies. In this study, we have measured Fe isotopic ratios of soil samples from the Soviet Luna missions, Luna 16, 20, and 24, using MC-ICP-MS. A highly matured sample from Luna 16 shows clearly distinguished Fe isotopic compositions between the fine-grain and coarse-grain fractions, while such Fe isotopic discrepancies among different size fractions were much smaller in submature (Luna 20) and immature (Luna 24) samples. The Fe isotopic ratios of separated grains show that agglutinates have higher δ^{57}Fe values than the bulk and monomineralic grains, indicating the abundant np-Fe^0s in agglutinates and the partial evaporation of Fe during its melting.

The δ^{57}Fe value for the coarsest grain fraction of very low-Ti basalt from Luna 24 was found to be 0.08 ± 0.04‰, which is the first Fe isotopic composition reported for very low-Ti mare basalts. This value is clearly lower than previously reported δ^{57}Fe values for high-Ti and low-Ti basalts, and is nearly identical to those of Mg-suites. This observation is consistent with the Fe isotopic evolution model during differentiation of lunar magma ocean [3]. Furthermore, the Fe isotopic ratio of the very low-Ti basalt is indistinguishable from that of the Earth’ s mantle, thus, the bulk silicate Earth and Moon are considered to possess an identical or very close Fe isotopic composition.

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