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Nickel and samarium isotopic evidence for the impact and genesis of regolith at the Chang'e 5 landing site

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The flux and the nature of the impactors of the Earth-Moon system in the past 1 Ga are intensively studied due to their importance to the habitability of the Earth. The Chang'e 5 (CE 5) mission landed on a young terrain with a surface age of 1.6-1.7 Ga, providing a great opportunity to investigate the impacting history of the Moon in the Copernican. The sampling site of CE 5 soil exhibits an estimated thickness of <2 m and is enriched in impact glasses, aging from 4-2000 Ma, highlighting the importance of the impacting process on regolith genesis. However, the main source of the regolith and the impactors remain unknown. As a siderophile element, Ni is sensitive to the addition of exogenous materials owing to its depletion in lunar igneous rocks, e.g., a high Ni content has been reported in the CE 5 regolith, indicating the mixing of materials from the impactor. Meanwhile, the abundance of ^{149}Sm has been served as a useful tool for probing the cosmic-ray-exposure (CRE) history of the lunar regolith. Thus, the Ni and Sm isotopic compositions of the CE 5 regoliths could help constrain the source of the exogenous materials and the genesis of the regoliths.

Here, we performed high-precision analyses of mass-dependent Ni and mass-independent Sm isotopic compositions for one shoveled surface and three drilled CE 5 soils. The Ni isotopic compositions of the surface and drill-core samples are significantly heavier (0.6-0.9‰) than those of the Earth, Moon, and chondrites (0.1-0.3‰) accompanied with elevated Ni contents compared to CE 5 basalts. The heavy Ni isotopic compositions have only been observed from kamacite in iron meteorites. Meanwhile, the ε^{149}Sm values for the soils from the surface and drill core are of a limited variation (ranging from -14 to -15), indicating a relatively recent severe mixing during the formation of the regolith layer. The CRE age roughly calculated from the Sm isotopes indicating a ~160 Ma exposure of the CE5 regolith. More details on the possible impacting history of CE5 soil will be discussed in the paper.