Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.34748

Tracing the effects of large impacts using metal isotopes

HENG-CI TIAN, WEI YANG, XIAN-HUA LI AND FU-YUAN WU

Institute of Geology and Geophysics, Chinese Academy of Sciences

Meteorite impacts are a key geological force shaping the early surfaces and deep structures of terrestrial planets, a process ubiquitous throughout the evolutionary history of the solar system. Impact events generate extreme transient high-temperature and high-pressure conditions, inducing melting, volatile loss, and elemental differentiation in the target celestial body's rocks. These effects are "recorded" in the chemical and isotopic compositions of the rocks. Volatile metal stable isotope systems (such as those of potassium, zinc, and magnesium), due to their high sensitivity to processes like high-temperature volatilization and melting fractionation, have become powerful geochemical proxies for tracing impact temperatures, energy scales, and material sources.

Recently, we conducted a high-precision potassium isotopic study on basalts collected by the Chang'e-6 mission from the South Pole-Aitken (SPA) basin on the lunar far side—one of the largest and oldest impact basins in the solar system. The analytical results show that the potassium isotopic composition of the Chang'e-6 basalts is significantly heavier than that of samples from the lunar nearside. This anomalous characteristic cannot be explained by magmatic differentiation or subsequent processes. Ultimately, we attribute this to the impact event that formed the SPA basin, which caused volatile loss in the mantle source region of the basalts. Specifically, the impact led to the preferential loss of light potassium isotopes, enriching the residual source region in heavy potassium isotopes, which later underwent partial melting to form the Chang'e-6 basalts.

This discovery confirms that giant impacts can penetrate the lunar crust and permanently alter the chemical composition of the underlying lunar mantle. It provides the first direct isotopic evidence for "impact-driven modification of planetary deep interior materials." Furthermore, this finding offers new insights into understanding the role of impact processes in the formation and evolution of Earth and other terrestrial planets. In this conference, in addition to presenting our findings on potassium isotopes, we will also report new results on other isotopic systems, such as Fe and Ti.