Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.35579

Sulfur geochemical evidence for a high-energy impact lunar origin

DR. HAIRUO FU, PHD AND **JAMES W DOTTIN III**
Brown University

The chemical behavior of sulfur (S) provides a sensitive record of the high-temperature processes that shaped the early Earth–Moon system. Recent attempts in constraining the lunar sulfur content and primitive sulfur isotopic composition ($\delta^{34}S$) [e.g., 1–3] motivate a reassessment of the implications for Moon formation. Here, we model the coupled evolution of lunar sulfur abundance and isotopic composition across a range of giant-impact scenarios, incorporating disk composition, condensation and vaporization, metal–silicate partitioning, and late accretion. We find that the canonical Moon-forming impact, which involves re-equilibration between metal and silicate in the post-impact disk, predicts excess sulfur and likely fractionated $\delta^{34}S$ values in the Moon—both inconsistent with lunar compositions. In contrast, a high-energy giant-impact scenario (e.g., a synestia), involving metal exsolution from cooling silicate fluids, yields a sulfur-depleted Moon with $\delta^{34}S$ values that more closely match current constraints. These results require metal–silicate equilibration at 2,600–3,900 K, supporting a high-temperature origin of the Earth-Moon system. Our findings further suggest that a substantial metal phase may not be required or allowed in the initial lunar disk to explain the Moon's core, thereby relaxing a key constraint embedded in prior giant-impact models.

References:

[1] Saal, A.E. & Hauri, E.H. (2021). Large sulfur isotope fractionation in lunar volcanic glasses reveals the magmatic differentiation and degassing of the Moon. *Sci. Adv.* 7, abe4641.

[2] Li, Y., Wang, Z., Zhang, W., Zong, K., She, Z., He, Q., Zheng, J., Li, T., Pan, F., Chen, X., Crnobrnja, K., Xiao, L., Hu, Z., Wu, X., Liu, Y., Siebert, J., & Moynier, F. (2025). Sulfur isotopes from the lunar farside reveal global volatile loss following the giant impact. *Nat. Commun.* 16, 5780.

[3] Hoyos, S., Ni, P., Matsuda, N., Liu, Y., & Warren, P. H. (2026). Insignificant sulfur isotope fractionation during lunar fire fountain eruptions. *57th Lunar and Planetary Science Conference*, Abstract #1960.