Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.37562

Sulfur isotope anomalies in Ryugu and Bennu reveal photodissociation processes

MARGOT DEBRUYCKER[1], FRÉDÉRIC MOYNIER[2] AND JABRANE LABIDI[3]

[1]IPGP-CNRS-UPC
[2]Université Paris Cité, Institut de Physique du Globe de Paris
[3]Institut de Physique du Globe de Paris, CNRS

CI chondrites have geochemical compositions that closely match solar photosphere abundances. The origin of sulfur in those asteroids is not entirely clear, partly because CI meteorites have undergone extensive alteration and sulfide oxidation. This generates substantial mass-dependent S isotopic variations and obscures the original signatures. Here, we present results for the sulfur speciation and isotopic composition of asteroids Ryugu and Bennu. Those are CI materials that show similar alteration but lower oxidation signatures than most CI meteorites. In addition, these samples are from the surface of their parent-body, and their composition may reveal the unique features of the outermost layers of CI asteroids.

We digested 10mg of Ryugu and 47mg of Bennu material, yielding sulfur contents of 4.5 ± 0.5 wt.% S and 5.8 ± 0.5 wt.% S, respectively. These values are similar to the average bulk sulfur abundance of CI chondrites. Sulfur occurs mostly as sulfide (S^{2-}), but oxidized sulfur is present in both samples. In Ryugu, ~92 %ΣS is S^{2-}, ~8 %ΣS is elemental sulfur (S^0) and sulfate (S^{6+}) was under a limit detection of 0.06 wt. %. In Bennu, ~97 %ΣS is S^{2-}, ~2 %ΣS is S^0 and ~2% ΣS is S^{6+}.

Sulfur isotope analyses reveal no mass-independent anomalies in sulfide, with values close to CDT in $\Delta^{33}S$ and $\Delta^{36}S$. This may reflect the composition of the nebular gas present in the CI forming region. However, small but resolvable $\Delta^{33}S$ anomalies of ~ –0.030 ± 0.010 ‰, associated with near-zero $\Delta^{36}S$ values, were found in the oxidized sulfur of both Ryugu and Bennu.

This is a unique signature that has never been observed in CIs. We suggest that isotopically anomalous S^0 was produced by photochemistry and deposited on the surface of the two asteroids. Elemental sulfur likely formed either immediately after parent-body formation via photodissociation of nebular H_2S, or during late impact events that released ice-trapped H_2S from asteroid surfaces.

Our isotopic results highlight the distinct nature of asteroids Ryugu and Bennu surfaces, where photolytic components have accumulated. This will allow placing new constraints on the astrophysical context of CI asteroids formation and evolution.