VOLATILES IN CHONDRITES AND ACHONDRITES

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The abundance and distribution of volatiles in Solar System objects are vital for understanding planet formation and evolution. The presence of water and organic molecules is critical for the emergence of life and the habitability of planetary environments. Although some information on volatiles can be obtained from analysis of meteorites, they are prone to alteration and exchange in Earth's environment. Additionally, lack of context, i.e., which specific asteroid body, sampling location within the asteroid etc. results in an incomplete understanding. Returning samples allows for the use of state-of-the-art laboratory analyses, providing extremely high-precision, high-sensitivity, and high-resolution. More importantly, returned samples can be placed into geologic context and provide complementary information with other studies of the parent object.

A successful sample return mission from asteroid Itokawa by JAXA's Hayabusa spacecraft led to our excellent understanding about the parent bodies of ordinary chondrite meteorites. Minute details of the asteroid's history was gleaned through thorough and detailed laboratory investigations including compositions, mineralogy, and chronology. One such investigation led to the measurement of hydrogen isotopes and water in tiny Itokawa particles, which show that the silicate minerals can contain between 400-800 ppm of water and translated to up to 0.5 Earth's oceans to be delivered to proto-Earth by S-type asteroids[1]. On the other hand, the proportions of various chondritic materials accreted to form Mars are distinct from those for Earth. Recent accretion models for terrestrial planets using chondritic components suggests that S-type asteroids (specifically, H chondrites) would have contributed up to 50% the mass of proto-Mars[2]. Based on analysis of recent confirmed falls, Chelyabinsk and Benenitra, we ascertained that only about ½ of water contained within the martian mantle can be explained by accretion of S-type asteroids; We speculate that pebble accretion may have played a significant role in forming Mars[3].

Asteroids Bennu and Ryugu are the targets of ongoing sample return missions from C-type asteroids. The spectral features are similar to those of aqueously altered CM-type carbonaceous chondrites (CCs). Murchison and Aguas Zarcas are CM2 chondrite falls and potential meteorite analogs for Bennu and Ryugu. We studied these two CCs and their components to constrain the evolution of hydrogen in C-type asteroids[4]. In addition, we studies stones from Ureilites and Brachinites[5], primitive achondrites that are likely better planet forming starting materials because of their early accretion ages. I will discuss the data, and discuss how both chondrites and achondrites that formed in the inner solar system could be the source of volatiles during the early accretion stages of terrestrial planets.

References.

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