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# Heated enstatite chondrites and aubrites likely played minor roles in producing Earth's hydrogen budget

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Hydrogen (H) is critical to the habitability of our planet, yet our understanding of its origins on Earth is unclear. Due to their widespread nucleosynthetic isotopic similarity to Earth, enstatite chondrites (ECs) are regarded as the meteorite group that best represents Earth's building blocks [1,2]. Until recently, these meteorites were considered to contain very low H concentrations, and so contributed negligibly during the initial formation of our planet to its present-day H and water budgets [3]. However, recent measurements challenge this by suggesting that ECs potentially contain significant bulk hydrogen in the form of H-S [4-6], enough to possibly explain all the H found throughout Earth today. However, these measurements focused mostly on weakly heated EH3 chondrites, meaning they may not represent the bulk of Earth's accreting material. As such, the ability of these building blocks to supply appreciable concentrations of H to the proto-Earth is uncertain.

Here, we explore the presence and speciation of H in heated ECs and aubrites using sulfur X-ray absorption near edge structure (S-XANES) spectroscopy. We find that intermediate heating experienced by EET 96341 (EH4/5, ~650 – 750 ˚C; [7]) almost entirely removed the H-S bond from this meteorite, as well as it's carrier phase, pyrrhotite. However, small pockets in this meteorite at the edge of recrystallised chondrule mesostasis do retain the H-S bond, indicating this form of H could have been stable in certain limited environments. We also find that the high temperatures experienced by NWA 16890 and associated melting experienced by Norton Country completely removed the H-S bond, arguing that there is no remaining H-S in EH6 chondrites and aubrites, respectively. These findings suggest that previous measurements of the bulk H concentrations of EH4-6 chondrites and aubrites include hydrogen in a form other than H-S. This form could be either pre-terrestrial or terrestrial in origin.

[1] Dauphas (2017) Nature [2] Javoy et al. (2010) EPSL [3] Morbidelli et al. (2000) Meteorit. Planet. Sci [4] Piani et al. (2020) Science [5] Thomassin et al. (2023) EPSL [6] Barrett et al. (2025) Icarus [7] Huss et al. (2006) Meteorites and the Early Solar System II