
The initial hydrogen isotopic composition of the solar system recorded at the μm -scale in a meteoritic Ca-Al-rich inclusion

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Résumé

In spite of numerous studies aiming at understanding the origin of water in solar system bodies, its initial hydrogen isotopic composition in the solar system has never been determined before. Meteoritic calcium, aluminum-rich inclusions (CAIs) are the oldest rocks formed in the solar system and are widely used as benchmarks for the initial composition of solar system materials. Because they are made of nominally anhydrous minerals (NAMs) formed at high temperature and very low pressure, their H isotopic composition is analytically challenging to measure. We therefore developed a novel approach for the analysis of H isotopes in NAMs using H isotopic imaging by NanoSIMS on thin sections prepared by focused ion beam (Lévy et al. 2019) and studied the petrology (Lévy et al. 2022) and H isotopic composition (Aléon et al. 2022) of E101.1, a compound CAI from the Efremovka reduced CV3 chondrite. Primary minerals have extremely low D/H ratios, with dD values down to -850‰, recording the trapping of solar/nebular hydrogen. Secondary FeO-rich minerals from a xenolithic inclusion have dD values up to +1000‰, which is attributed to diffusive H loss during capture of the fragments by the partially molten host. Hence they formed before capture with elevated water content, in a nebular environment where the oxygen fugacity was significantly higher than that of the solar gas. The H isotopic composition of this oxidizing reservoir was within 20% of that of the terrestrial oceans. H isotopes further

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correlate with oxygen and nitrogen isotopes. This indicates that inner solar system volatiles including water already had a planetary isotopic composition when CAI formed, i.e. during collapse of the protosolar cloud core, within the first 200,000 years of the solar system. A potential mechanism to produce this composition ubiquitous in planetary bodies is evaporation of excess interstellar ice infalling directly in the inner solar system at the onset of protoplanetary disk building.