ISOTOPIC COMPOSITIONS OF FLUID INCLUSIONS IN HALITES FROM ORDINARY CHONDRITES

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Introduction: Over the past three decades we have become increasingly aware of the fundamental importance of water, and aqueous alteration, on primitive solar-system bodies. Some carbonaceous and ordinary chondrites have been altered by interactions with liquid water within the first 10 million years after formation of their parent asteroids. In fact, millimeter to centimeter-sized aggregates of purple halite containing aqueous fluid inclusions were reported in the matrix of two freshly-fallen brecciated H chondrite falls, Monahans (1998, hereafter simply "Monahans") (H5) and Zag (H3-6) [1, 2]. Nevertheless, we do not know the isotopic compositions of the aqueous fluid itself. Here we report hydrogen and oxygen isotopic compositions of the aqueous inclusion fluids by secondary ion mass spectrometry.

Methods: The samples used in this study were fluid inclusion-bearing halite crystals of 0.1 to 1 mm in size picked from fresh fracture surfaces of the chondrites. We synthesized fluid inclusions of known isotopic composition in halite crystals in order to calculate δ-values from measurement data. A Cameca ims-1270 equipped with a cryo-sample-stage of Hokkaido University was prepared for the measurements. The cryo-sample-stage (Techno. I. S. Corp.) was cooled down to c.a. −190°C using liquid nitrogen at which the aqueous fluid in inclusions was frozen into ice. We excavated the salt crystal surfaces to expose the frozen fluids by a 15 keV Cs^+ beam and measured negative secondary ions. A normal incident electron gun was applied to compensate electrostatic charging for the sputtered regions. The secondary ions from deep craters of ~10 μm in depth emitted stably but the intensities changed gradually during measurement cycles because states of charge compensation were shifted.

Results and Discussion: Reproducibility of multiple measurements of standard fluid inclusions resulted in ±90‰ (2σ) for δD, and ±29‰ (2σ) for $\delta^{18}O$. The relatively poor reproducibility is due to variable states of charge compensation on deep sputtered surface among inclusions. On the other hand, the reproducibility of $\Delta^{17}O$ is ±8‰ (2σ) because the observed variations of isotope ratios follow a mass dependent fractionation law.

Variations of δD of asteroidal fluid ranges over −330(90; 2σ) to +1200(90)‰ for Monahans and −300(96)‰ to +90(98)‰ for Zag. $\Delta^{17}O$ of asteroidal fluids range over −16(22)‰ to +18(10)‰ for Monahans and +3(10)‰ to +27(11)‰ for Zag. The variations are larger than the reproducibility of standard analyses and suggest that isotope equilibria were under way in the asteroidal fluid before trapping into halite. The mean values of δD and $\Delta^{17}O$ are +290‰ and +9‰, respectively. The mean values and the variations of the asteroidal fluids are different from the representative values of ordinary chondrites, suggesting that the origin of fluid was not indigenous to the H chondrite parent-asteroid but rather was an exogenous fluid delivered onto the asteroid from icy objects such as C, P or D asteroids, comets, or icy satellites of outer planets.

References: [1] Zolensky M. E. et al. 1999. Science, 285: 1377-1379. [2] Zolensky M. E. et al., 1999. MAPS, 34: A124.