Ceres Revealed in a Grain of Salt

M.E. ZOLENSKY[1*], R.J. BODNAR[2], M. FRIES[1], Q.H.-S. CHAN[1], Y. KEBUKAWA[3], T. MIKOUCHI[4], K. HAGIYA[5], M. KOMATSU[6], K. OHSUMI[7], A. STEELE[8]

[1]ARES, NASA JSC, Houston, TX 77058, USA (*correspondence: michael.e.zolensky@nasa.gov)
[2]Virginia Tech, Blacksburg, VA, 24061, USA
[3]Yokohama National University, Yokohama, Japan;
[4]University of Tokyo, Hongo, Tokyo 113-0033, Japan
[5]Graduate School of Life Sci., Hyogo University, Japan
[6]SOKENDAI, Grad. Univ. for Advanced Studies, Japan
[7]JASRI, Hyogo 679-5198, Japan
[8]Carnegie Geophysical Lab, Washington, DC, USA

Introduction

Zag and Monahans (1998) are H chondrite regolith breccias containing 4.5 GY old halite crystals which contain abundant inclusions of aqueous fluids, solids and organics [1-5]. These all originated on a cryovolcanically-active C class asteroid, probably 1 Ceres [3, 4]; the halite was transported to the regolith of the H chondrite parent asteroid, potentially 6 Hebe. Detailed analysis of these solids will thus potentially reveal the mineralogy of Ceres.

Mineralogy of Solids in the Monahans Halite

Solid grains are present in the halites, which were entrained within the mother brines during eruption, including material from the interior and surface of the erupting body. The solids include abundant, widely variable organics [6] that could not have been significantly heated (which would have resulted in the loss of fluids from the halite). Our analyses by Raman microprobe, SEM/EDX, synchrotron X-ray diffraction, UPLC-FD/QToF-MS, C-XANES and TEM reveal that these trapped grains include macromolecular carbon (MMC) similar in structure to CV3 chondrite matrix carbon, aliphatic carbon compounds, olivine (Fo99-59), high- and low-Ca pyroxene, feldspars, phyllosilicates, magnetite, sulfides, metal, carbonates, diamond, apatite and zeolites.

Conclusions

The halite in Monahans and Zag derive from a water and carbon-rich object that was cryovolcanically active in the early solar system, probably Ceres [3]. The Dawn spacecraft found that Ceres includes C chondrite materials. Our samples include both protolith and aqueously-altered samples of the body, permitting understanding of alteration conditions. Whatever the halite parent body, it was rich in a wide variety of organics and warm, liquid water at the solar system's dawn.

References: [1] Zolensky et al. (1999) *Science* **285**, 1377-9; [2] Rubin et al. (2002) *MAPS* **37**, 125-142; [3] Fries et al. (2013) *MAPS* **48**, A80; [4] Zolensky et al. (2013) *MAPS* **48**, A394; [5] Zolensky et al. (2003) *66th MetSoc Meeting*; [6] Fries et al. (2011) *MAPS* **46**, A70.