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FLUID INCLUSIONS IN EXTRATERRESTRIAL SAMPLES: FAILURES, SUCCESSES, POSSIBILITIES, AND A NOTE OF CAUTION

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Over the past half century the search for life in the solar system and beyond has become a major research focus, with much effort devoted to finding evidence for liquid H_2O and reduced carbon-bearing (organic) species in extraterrestrial samples. The most direct and convincing evidence for the presence of water and organic molecules is provided by fluid inclusions (FI) trapped in minerals that formed on the parent bodies.

Beginning in the 1970s, reports of FI in extraterrestrial samples generated much enthusiasm within the planetary sciences community. However, many of the reported FI were determined to be artifacts of sample preparation, or incomplete characterization of features that appear to be FI, or were inconsistent with the inferred PT history of the meteorite sample. An early report of aqueous (and hydrocarbon-bearing) FI in stony meteorites and the subsequent follow-up study that showed that most or all of the “FI” contained water used during cutting and polishing of the samples led to a general unwillingness to believe later reports of FI in meteorites. One of the first confirmed occurrences of extraterrestrial aqueous (liquid) fluid inclusions in a meteorite was reported by Zolensky et al. (1999; Science), who described aqueous inclusions in halite in the Monahans and later the Zag meteorites. These meteorite falls were collected shortly after landing on earth and were prepared without using water or other fluids that could introduce artifacts. The oxygen and hydrogen isotopic composition of water in FI in these same samples was later measured, showing that the fluids represent various degrees of water-rock interaction on the parent body.

In more recent years, careful studies of FI trapped in extraterrestrial samples combining synchrotron X-ray computed tomography to locate FI in samples followed by cryo-TOF-SIMS analysis of the FI have identified the presence of molecular fragments suggesting the presence of H_2O and various organic molecules in the fluids.

Challenges associated with studying FI in extraterrestrial samples include the limited abundance of potential host phases for FI, such as carbonates and phosphates, the often poor optical quality of the host phases, and the small size of the FI, with few as large as 5 microns and most less than 1-2 microns in maximum dimension.

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