ULTRA POROUS LITHOLOGY, A FOSSIL ASTEROIDAL ICE, IN CARBONACEOUS CHONDRITE ACFER 094: IMPLICATIONS FOR PARENT BODY FORMATION BY ICY DUST AGGLOMERATION.

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Introduction: It has been believed that dust grains, including ice, accreted to form planetesimals in the solar nebula, and subsequent collisions and coalescing of planetesimals resulted in the formation of large planets. The pristine dust no longer exist in its original form in the present Solar System, but its derivatives are found in primitive extraterrestrial materials. For the last few dicades, a few primitive carbonaceous chondrites have been recognized to have escaped significant aqueous alteration and thermal metamorphism [e.g., 1,2]. In order to uncover evidence of primordial ice and pristine planetary materials, we examined one of these meteorites, Acfer 094 [e.g., 1], in detail using a novel analysis protocol systematically combining various nanoanalytical techniques: FE-SEM, FIB micro-sampling, synchrotron-radiation-based X-ray computed nanotomography (SR-XCT), STEM-EDS, and NanoSIMS.

Results and Discussions: We examined two polished Acfer 094 sections containing abundant fine-grained matrix (~ 60 vol.%). In FE-SEM observations, we found a lot of small regions (~11 µm in diameter), which show ultra-porous textures, distributed throughout the matrix. Hereafter we call the regions as ultra-porous lithologies (UPLs). In SR-XCT, we found some UPLs located below the polished sample surfaces ensuring that they were originally present in the Acfer 094 meteorite. TEM observations revealed that UPLs consist mainly of fine-grained Fe–Mg-rich amorphous silicates, forsterite, enstatite, Fe–Ni sulfides, organics and contain abundant pores among the constituents (porosity ~40 %). The amorphous silicates occur at scales of several hundreds of nm to 1 µm and contain variable quantities of Fe–Ni sulfide microcrystals as inclusions. These characteristics and their O-isotopic compositions are similar to those of pristine amorphous silicates, known as glass with embedded metals and sulfides (GEMS) [e.g., 3], in cometary dust, but without the Fe–Ni metal inclusions common in GEMS. The surrounding matrix consists of essentially the same materials as UPLs. We found enstatite wiskers with *a*-axis elongation, which are thought to be primitive condensates from nebula gass [e.g., 4], both in UPLs and the matrix. All these suggest that UPLs and the matrix are highly pristine lithology preserving pristine dust materials.

UPLs with abundant pores are flagile, nevertheless, they show no evidence of pore compaction, which could have occurred during accretion. This strongly suggests that the pores in UPLs are used to be filled with some solid material(s). Ice is one of the major components of cometary nuceli and should be present in the pores of cometary dust. Therefore, it is reasonable that some ice was the original solid material, subsequently lost by evaporation and/or melting. In this study, we found that the amorphous silicates in UPLs and the matrix have been hydrated (H_2O contents: 3–18 wt.%). We infer that the hydration may have been caused by the ice melting. However, the volume of UPLs (i.e. ice) (~0.2 vol.%) is not sufficient to justify the water contens in the amorphous silicates, suggesting that the distribution of ice in Acfer 094 parent body was heterogeneous and that ice was much more abundant elsewhere in the parent body.

Based on recent astrophysical models [e.g., 5–7], we assume Acfer 094 parent body formation by fluffy dust agglomeration during its radial migration from the outer to inner regions of the solar nebula. As the source dust, we assume fluffy silicates dust with and without ice, which originally present in the outer and inner regions of the H_2O snow line, respectively. Recent simulations have shown that the fluffy icy-dust suffered sintering around the H_2O snow line and formed solid aggregates of silicate grains embedded in ice [e.g., 8]. The aggregates may correspond to ice-bearing UPLs. We infer that Acfer 094 parent body growth during the radial migration across the H_2O snow line would produce a radial variation of ice abundance in the parent body and be consistent with the presence of UPLs. The meteorite's major source of water was the ice-rich core of the parent body. This is the first practical model to provide new insight to asteroid formation by dust agglomeration, combining both analytical results and theoretical studies.

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