A MICROCHONDRULE-BEARING MICROMETEORITE.

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Introduction: The Earth receives a continuous flux of cosmic dust derived from young disrupted asteroids and sublimating short period comets [1,2]. Occasionally unique micrometeorites with distinct petrographies are reported [3]. These samples expand the inventory of asteroid parent bodies and provide further clues to the formation and evolution of the solar system. In this study we report the discovery of an unusual dehydroxylated fine-grained micrometeorite containing a devitrified microchondrule droplet. This spherule contains a volatile-rich composition indicating formation in an energetic high density plume.

Methods: A single micrometeorite, recovered from the Cap Prudhomme blue-ice micrometeorite collection [4] was analysed by SEM-EMPA, BSE, X-ray element mapping and mid-IR spectroscopy.

Results: Particle CP94-050-182 (78x108µm) is a fine-grained micrometeorite, surrounded by a partial magnetite rim. A single spherical object (<10µm diameter) composed of devitrified glass is located near the micrometeorite's perimeter and contains a non-chondritic volatile-rich composition. Relative to Ivuna, Na, K and Cl concentrations are elevated an order of magnitude above chondritic values at 7.8, 19.8 and 9.4 times, while refractory Al and Ca show approximately chondritic abundances. The internal mineralogy is a heterogeneous mix of anhydrous silicates suspended in a fine-grained, porous, nanocrystalline groundmass. Anhydrous silicates are present either as low-Fe (<3wt%), Ca-rich (12-15wt%) pyroxene or high-Fe (~18wt%), Ca-poor (<0.5wt%) olivine. Pyroxene grains contain moderate Mn (0.8-1.7wt%), Cr (~1.4wt%) and Al (~2.0wt%) concentrations, while olivines contain minimal trace element contamination (Mn,Cr,Al<0.8wt%). Both anhydrous phases appear as anhedral clusters or isolated grains, intergrown with, or mantled by, a coarse non-stoichiometric Fe-rich phase. The surrounding groundmass contains randomly orientated dehydration cracks and rounded submicron vesicles. Dispersed micron-scale Mn-bearing chromite spinels ($MnCr_2O_4$) are also abundant within the matrix.

Discussion: A magnetite rim and a chondritic bulk composition confirm this grain is a micrometeorite. As with all micrometeorites atmospheric entry heating has resulted in a partial overprint of the grain's pre-atmospheric signature. Dehydration cracks imply the former presence of matrix phyllosilicates and therefore a hydrated CM or CI-like precursor, while a global mid-IR spectrum indicates that the fine-grained groundmass has completely recrystallized as olivine [5]. The coarse-grained Fe-rich phase is interpreted as clusters of intergrown serpentine and tochilinite [6] that thermally decomposed during entry, resulting in an amorphous glass.

Conversely, the anhydrous silicates remain unaffected by entry heating, and preserve primitive compositions, similar to the low-Fe-Cr-enriched (LICE) and low-Fe-Mn-enriched (LIME) silicates found in cometary IDPs, Stardust mission samples and some carbonaceous chondrites [7]. These anhydrous silicates form by condensation (at ~1200K) under reducing conditions from a gas of solar composition [7]. However, the condensation of Cr-rich silicates is expected to supress the simultaneous growth of Cr-bearing spinels [8] that are also found within the groundmass. As a result, the refractory phases in this micrometeorite are incompatible with a simplistic condensation scenario and instead require accretion of materials from 2 geochemically distinct reservoirs in the protoplanetary disk and therefore imply a period of accretion by radial mixing [9].

The small spherule inclusion is interpreted as a glassy microchondrule on the basis of the highly spherical morphology and a chemical composition similar to the droplet microchondrules, previously reported from the LL3.4 chondrite Manych [10]. This composition is distinct from the refractory (Al-rich, Al_2O_5>10wt%) chondrule glasses and olivine glass inclusions reported from the LL3.0 chondrite Semarkona [11] and from various carbonaceous chondrites [12]. Instead, the high abundance of volatiles requires high dust densities in order to retain volatile components [13, 14], high peak temperatures to destroy crystal nuclei and quench cooling to prevent crystallization. These properties, combined with the small particle size may indicate formation in an impact event. Finally, devitrification of the host glass most likely occurred during atmospheric entry heating.

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