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Evaluating the extent of aqueous alteration among the fine-grained micrometeorite flux

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Abstract
The degree of aqueous alteration affecting the fine-grained micrometeorite population is investigated using criteria originally developed for CM chondrites [1]. We analyse >50 micrometeorites derived from the Transantarctic Mountain (TAM) and Cap Prud'homme collections, revealing that most unmelted fine-grained particles are intensely altered, with petrographic grades equivalent to <CM2.3.

By analysing a large population of micrometeorites, spanning a range of different collection sites (and, therefore, different terrestrial accumulation windows) as well as including a range of particle sizes ([50-800μm] providing a more representative sample of the micrometeorite flux) we demonstrate that a significant fraction of the cosmic dust reaching Earth over the last 1Ma is derived from intensely altered C-type asteroids.

This implies that the young Veritas family and Beagle sub-cluster of the Themis family, that reside in the outer main asteroid belt – and which are currently considered the most probable source bodies of the fine-grained micrometeorite flux [2] – are intensely altered, water-rich, phyllosilicate-bearing bodies.

1. Introduction
The alteration of primary minerals and amorphous condensates by liquid water is a fundamental process of the early solar system and has been thoroughly investigated within the hydrated carbonaceous chondrite group.
The CM chondrites show significant variability in their degree of aqueous alteration. This has been extensively investigated using textural features [3], elemental ratios [1], modal mineralogy [4], spectroscopy [5] and isotopic signatures [6]. Almost all CM chondrites now have a petrographic grade that quantifies the degree of aqueous alteration in that sample. This numerical classification ranges between CM2.0 to CM2.7 (and theoretically up to an entirely unaltered CM3.0). In this scale, lower subtypes represent meteorites which are more intensely altered by fluid interaction.

2. Evidence of alteration
Textural evidence of aqueous alteration in fine-grained micrometeorites include: hydrated CAIs, sulphates, pseudomorphic chondrules and complex intergrown and cross-cut assemblages of phyllosilicate (Fig.1.). In many instances, extensive alteration has resulted in the near-complete replacement of anhydrous components with secondary minerals. Geochemical evidence of alteration includes decreasing Fe/Mg ratios, a loss of sulfides and metal and progressively higher abundances of oxides such as magnetite and ferrihydrite.

3. Assigning petrographic grades
In the classification scheme of Rubin et al., [1], 8 criteria are used to evaluate petrographic grade. We use an adapted version of this method, with the following metrics: (1) the percentage of metallic FeNi [varying between <0.02%-1% by vol], (2) the degree of replacement affecting anhydrous silicates [0-100%], (3) The abundance of large phyllosilicate clumps [varying between 2-40%vol] and (4) the elemental FeO/SiO_2 ratio of phyllosilicate [varying between 1.0-3.3].
These criteria are suitable for the analysis of micrometeorites, because they focus on major mineralogy and/or their heat-resistant phases. Conversely, the remaining metrics consider accessory phases, such as sulfides or carbonates that are rarely preserved in micrometeorites, owing to atmospheric entry heating.

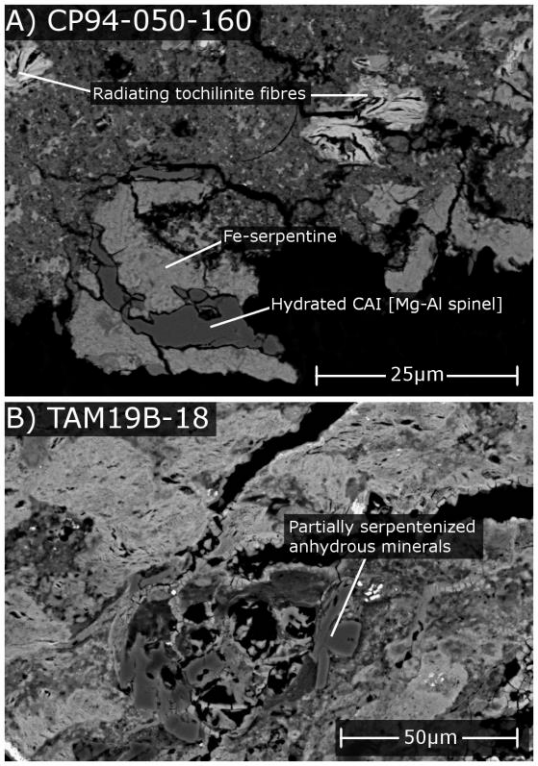

Figure.1. Alteration textures in fine-grained micrometeorites, attesting to significant interaction with liquid water.

4. Results

4.1 Cap Prud'homme micrometeorites

We analysed 30 particles from the Cap Prud'homme population (<100µm in size). The modal petrographic grade is CM2.2, representing 43% of the particles studied. Seven particles (23%) are classified as CM2.1 and 7 particles also have CM2.3 grades. However, completely altered CM2.0 particles are not recognised.

4.2. TAM micrometeorites

Among the TAM particles (250-800µm) unaltered chondrules are not recognised, while anhydrous mafic silicates commonly have skeletal morphologies and thick phyllosilicate overgrowths. Although we have analysed only 7 of these particles to date. Further analysis of the TAM micrometeorites will continue, and an updated set of statistics provided at the congress.

5. Summary and Conclusions

A large population of CM-like fine-grained micrometeorites, representing >4mm^2 of matrix, are analysed. They demonstrate that the flux of micrometeorites contains a significant fraction of hydrated, intensely altered, chondrule-poor material related to the <CM.2.2 chondrites.

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