

# “Hydrous-Carbonaceous” Micrometeorites on the Early Earth, Moon and Mars

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Unmelted large micrometeorites with sizes of about 50-500  $\mu\text{m}$  were recovered from the Antarctica and Greenland ice sheets. Their capture in such “space collectors” made of very clean ices, where they got both shielded from most terrestrial contaminants and preserved by deep freeze, allowed for the first time the investigation of their carbon chemistry. Mass flux measurements in both ice sheets indicate that micrometeorites in this size range represent by far the dominant extraterrestrial material that survive upon impact with the Earth. Mineralogical, chemical and isotopic compositions show that they are mainly related to the relatively rare group of the CM-type hydrous-carbonaceous chondrites (<2% of the meteorite falls) and not to the most abundant meteorites (1). But marked differences between these two classes of objects indicate that the parent bodies of micrometeorites represent a new population of solar system objects, strongly depleted in both differentiated objects and chondrules, and which probably originated in the outer solar system. This conclusion is further supported by a recent comparison between the silicate mineralogy of micrometeorites and that of the coma of the Hale-Bopp comet (2), both showing pyroxene to olivine ratios at least 10 times larger than those measured in carbonaceous chondrites (with the exception of the CR chondrites).

The fine-grained matrix of micrometeorites contains a complex carbonaceous material in contact with potential catalysts. Micrometeorites can be considered as microscopic chemical “chondritic” reactors. They probably initiate a specific “shooting star” chemistry with gases and waters in planetary environments equipped with a residual atmosphere where they can slow down, such as the Earth and Mars. Investigations of foreign clasts of materials found in meteorites and even in the lunar regolith (3) suggest that the present day composition of the micrometeorite flux might have been roughly invariant with time, back to at least 4 Ga ago. Thus, the microscopic chemical reactors that we collect and investigate today could have contributed to the delivery and/or synthesis of prebiotic organic molecules on the early Earth and Mars, when their flux was much more enhanced. Moreover, the D/H distribution measured for the constituent water of the hydrous minerals of micrometeorites gives the best fit to the distribution measured for the terrestrial oceans, with regard to those of other sources of extraterrestrial water. This would suggest that a CM-type carbonaceous material depleted in chondrules was involved in the formation of the oceans at an even earlier time, thus preparing the stage for the functioning of a late veneer of chondritic chemical reactors.

Our most immediate challenges are to:

- check the potential of electrospray and/or field emission techniques coupled to high resolution mass spectrometry to detect complex organics in micrometeorites;
- ascertain the role of ferrihydrite as both a host phase of such organics, and an efficient natural cosmochromatograph/catalyst;
- collect particles from comet Tempel-Tuttle, now trapped in central Greenland (and Antarctica ?), which were delivered during the Leonids meteor storms of 1833 and 1966;
- identify possible synergetic effects between hydrothermal sources and micrometeorites in the formation of prebiotic molecules on the early Earth (and early Mars?);
- develop the consequences of a plausible important micrometeorite contamination of Martian regolith (4) to assess the possibility that the synthesis of prebiotic organic molecules (and consequently the birth of ancestral micro-organisms issued from it) was more efficient on early Mars than on Earth.

## References

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