Characterization of the Organic Carbon in the Tagish Lake Meteorite by Infrared Spectroscopy

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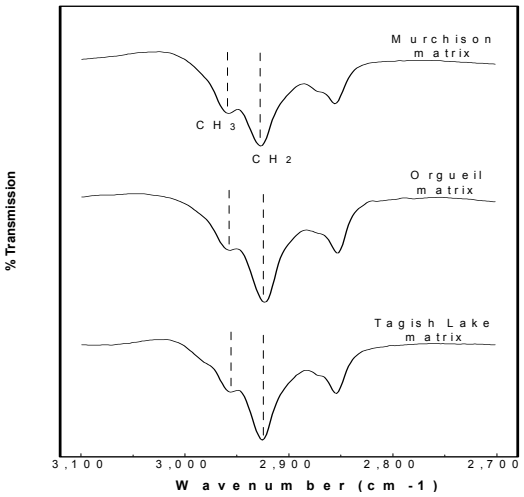
Abstract No. Flyn3498
Beamline(s): **U10B**

Introduction: The CI carbonaceous chondrite meteorites have a solar-like chemical abundance pattern, suggesting that these meteorites have not experienced chemical fractionation since the formation of the Solar System. The carbonaceous chondrite meteorites contain organic carbon, and the study of this organic matter helps to constrain the origin of organic matter in our Solar System and provides clues to the types and abundances of pre-biotic organic matter available for the origin of life on Earth.



The Tagish Lake meteorite, which fell in British Columbia in January 2000, appears to be a new type of carbonaceous chondrite, classified as a CI2 meteorite (Brown *et al*., 2000). This distinguishes Tagish Lake from all other CI carbonaceous chondrites, which are classified as CI1 meteorites, in that Tagish Lake has experienced less aqueous alteration than the other CI chondrites. Thus the Tagish Lake meteorite may provide the opportunity to study organic matter that has experienced less severe aqueous alteration than that in the other CI carbonaceous chondrites. Preliminary characterization of small fragments of Tagish Lake indicate that it contains 5.4 wt% carbon, mostly present as carbonate (3.7 wt%) but also including a significant amount of organic carbon (Brown et al., 2000).

Methods and Materials: We employed Fourier Transform Infrared Spectroscopy (FTIR), using the Continuum FTIR microscope at Beamline U10B, to characterize the organic carbon in ~10 to 30 micrometer chips taken from an ~30 mg fragment of the Tagish Lake meteorite. We previously measured the trace element content of another chip from this ~30 mg fragment using the X-Ray microprobe at X26A, and found no evidence for elemental contamination of this Tagish Lake sample (Flynn et al., 2000).

We obtained high-quality infrared absorption spectra over the 4000 to 650 cm^{-1} spectral range. The Tagish Lake meteorite is dominated by olivine, hydrated silicates, sulfides and carbonate. These minerals, which have strong absorptions over most of the spectral range we analyzed, interfere with detection of organic features over much of the infrared spectrum. However in the region from 2700 to 3100 cm^{-1}, where the C-H stretching vibrations occur, the major minerals exhibit only a broad water feature, and the sharper C-H stretching features can be easily identified.

Results: The Tagish Lake samples all exhibit three sharp absorptions features, at ~2950, 2926 and 2854 cm^{-1}, and a much weaker feature near 2870 cm^{-1}. The pair of features at 2926 and 2854 cm^{-1} correspond to the asymmetrical and symmetrical stretching vibrations of CH_2 in an aliphatic hydrocarbon, while the pair of features at 2960 and 2870 cm^{-1} correspond to the asymmetrical and symmetrical stretching vibrations of CH_3 in an aliphatic hydrocarbon. Some Tagish Lake samples also show a weak absorption at 2985 cm^{-1}. We detected no features in the 3000 to 3050 cm^{-1} region, where the CH stretching vibrations of aromatic hydrocarbons occur.

We also obtained spectra of two other carbonaceous meteorites, the CM2 meteorite Murchison and the CI1 meteorite Orgueil, for comparison with Tagish Lake. Murchison, which fell in Australia in 1969, has been well characterized, and the nature of its organic matter is well documented. Orgueil is a CI1 chondrite, but it fell in 1864 and it is difficult to insure that the small samples we have are free of terrestrial contamination.

Conclusions: The detection of the C-H stretching vibrations demonstrates that the Tagish Lake meteorite contains a significant abundance of aliphatic carbon. The difference between the CH_3 to CH_2 absorption strengths in Tagish Lake and Murchison indicates that either the aliphatic molecules in Tagish Lake are longer chains than in Murchison or that more of the aliphatic chains in Tagish Lake are terminated by functional groups other than CH_3 than is the case in Murchison. There are hints that the strength of the CH_3 absorption may decrease systematically with the degree of aqueous alteration from the CM2 meteorite Murchison, to the CI2 meteorite Tagish Lake, and then to the CI1 meteorite Orgueil, although we cannot insure that the Orgueil sample is pristine. The absence of aromatic C-H absorption features in Tagish Lake and in Murchison, which is known to contain aromatic hydrocarbons, suggests that few of the aromatic rings have hydrogen directly attached to them.

Acknowledgments: This work was supported by NASA Exobiology Grant NAG5-469101, the JSC Astrobiology Institute Grant NAG9-1109, and NASA RTOP 344-31-40-06.

References: P. G. Brown *et al*., The Fall, Recovery, Orbit, and Composition of the Tagish Lake Meteorite: A New Type of Carbonaceous Chondrite, Science, 290, 320-325, 2000. G. J. Flynn *et al*., Chemical Composition of a Unique Carbonaceous Chondrite Meteorite -- Tagish Lake, NSLS Annual Activity Report, 2000.