

THE NATURE AND ORIGIN OF AROMATIC ORGANIC MATTER IN THE TAGISH LAKE METEORITE. S. J. Clemett¹, L. P. Keller², K. Nakamura², and D. S. McKay², ¹LMSO / NASA Johnson Space Center, Mail Code C-23, Houston, TX 77058 (simon.j.clemett@jsc.nasa.gov), ²NASA Johnson Space Center, Houston, TX 77058.

Introduction: The Tagish Lake meteorite is an unusual carbonaceous chondrite that does not fit well within existing chondrite taxonomy. Bulk analyses suggest ~5 wt.% C of which ~1 wt.% is in the form of organic matter and the remainder is present as inorganic carbonate [1]. The exact nature and form of this organic component is, as is the case with the other ordinary and carbonaceous chondrites, still poorly understood. Yet its significance has far reaching implications, from contributing to the abiotic evolution of the early Earth and Mars, to providing geothermal constraints in the evolution of the Solar nebula.

Methods & Samples: Several small fragments (~100 μ m-sized) from "pristine" Tagish Lake sample #TL3B6 (carbonate poor lithology) were removed using a clean stainless steel needle and pressed directly into either Au foil or freshly cleaved KBr. Functional group analysis was performed on the KBr pressed samples using a FTIR spectrometer operating in transmission mode from selected areas (~100 x 100 μ m²). Specific molecular analysis was performed on the Au pressed samples using the new two-step laser desorption/laser ionization mass spectrometer (²L²MS) [2] recently constructed at JSC. In this instrument a line-tuned CO₂ laser (~10 μ m) focused by ZnSe optics to its diffraction limit (~30-40 μ m) is used to generate 1 μ s IR laser pulses for non-thermal desorption. A pump-amplifier frequency-quadrupled Nd:YAG laser (266 nm) is used to generate 4 ns UV laser pulses for resonance-enhanced multiphoton ionization (1+1 REMPI) of desorbed neutrals. Resultant ions are then analyzed by injection into a reflectron time-of-flight mass spectrometer.

Results: Figure 1 illustrates a typical ²L²MS spectrum of the aromatic, non-macromolecular, organic matter present in Tagish Lake. Although the spectrum appears complex it can be described by overlying alkylation series of the naphthalene, phenanthrene and dibenzofuran. Additional strong peaks associated with phenol and dimethoxybenzene are ubiquitous. Figure 2 illustrates a typical organic-rich FTIR spectrum, showing strong bands associated with aliphatic -CH₂- and -CH₃ symmetric and asymmetric stretches but no resolvable peaks associated with aryl -CH. This absence is likely explained as a consequence of the lower IR adsorption cross-section of aryl -CH along with

preferential substitution of aryl -CH by -CH₃ as opposed to -(CH₂)_nCH₃ (i.e. C₂-phenanthrene is more likely present predominately as dimethyl-phenanthrene rather than ethyl-phenanthrene). Additionally well resolved IR spectral features consistent with aliphatic thiols (R-SH) are reported for the first time.

²L²MS results were generally self consistent between samples taken from locations separated by several mm in the bulk fragment of TL3B6. However, in several analyses unidentified high-molecular weight material was observed (e.g., anomalous mass peaks at 323, 393 & 505 amu in Figure 3) hinting at a much broader sample heterogeneity. While terrestrial contamination can not be discounted, no source of potential contamination could be identified in the analysis protocol and no such peaks have been observed either previously, or subsequently, in the analysis of other cosmochemical samples.

Discussion: Previous studies have shown that organic matter in Tagish Lake is present either as: (1) unbound, relatively simple mono- and poly- functional molecular species (10-30%); or, (2) as a complex, highly cross-linked macromolecular polymer (70-90%). Results from thermal pyrolysis [3], hydrolysis [4] and solid state NMR [5] of Tagish Lake suggest the predominant subunits of the macromolecular material to be cross-linked parent 1- to 4-ring PAHs dominated by fluoranthene and pyrene, with very little alkyl substitution. In contrast the ²L²MS results reveal the non-macromolecular aromatic material in Tagish Lake to be dominated by extensively alkylated PAHs such as naphthalene, phenanthrene, and O- containing dibenzofuran. The disparity between these two components argues *against* a common origin. This is consistent with the interpretation of C and N isotope studies of chondritic acid residues in which separate solar and presolar [6] origins were ascribed to the soluble vs. insoluble organic components.

References: [1] Brown *et al.* (2000) *Science*, **290**, 320; [2] Clemett & Zare (1996) *IAU 178*, 305; [3] Gilmour *et al.* (2001) *LPSC XXXII*; [4] Sephton *et al.* (2003) *LPSC XXXIV*; [5] Cody *et al.* (2002) *LPSC XXXIII*; [6] Alexander *et al.* (1998) *MAPS* **33**, 603.

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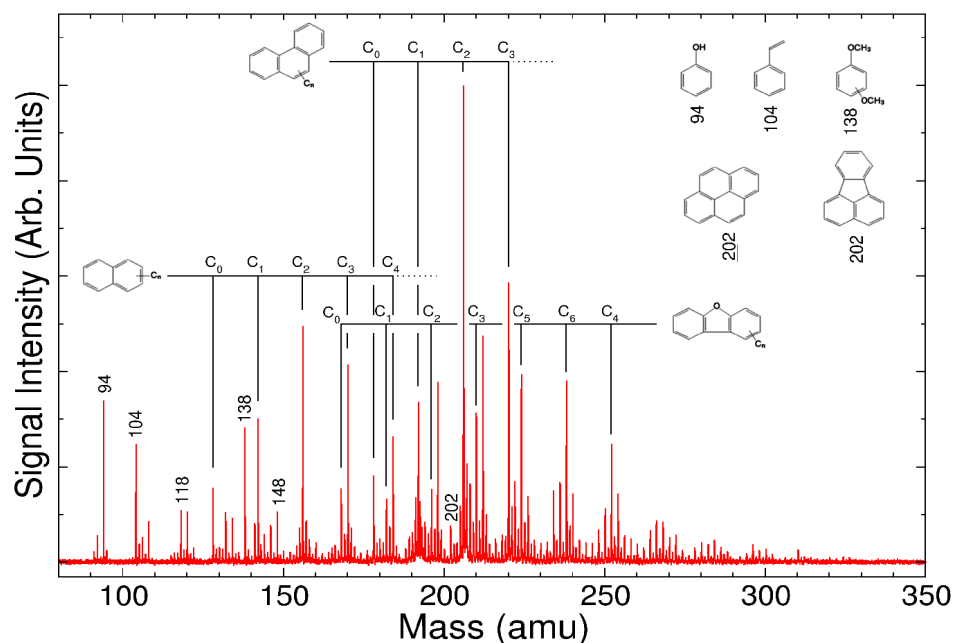


Figure 1: Representative L^2MS spectrum of Tagish Lake illustrating the three primary, overlapping, alkylation series for naphthalene (128, 142, 156 ... amu), dibenzofuran (168, 182, 196 ... amu) and phenanthrene (178, 192, 206 ... amu)

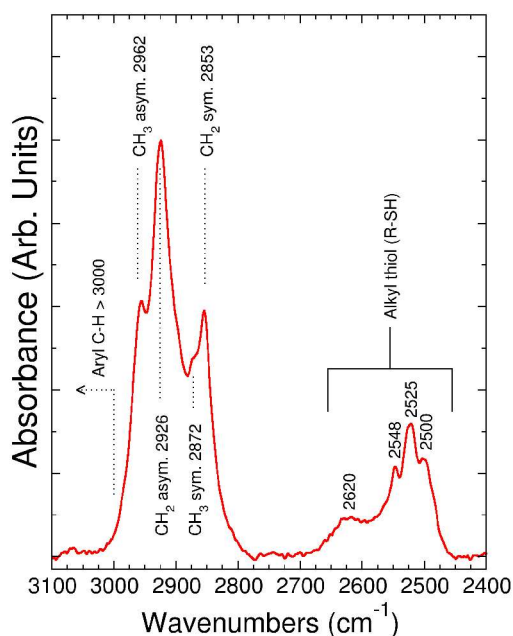


Figure 2: FTIR spectrum of Tagish Lake showing abundant aliphatic material along with S heteroatom substitution in the form of aliphatic thiols.

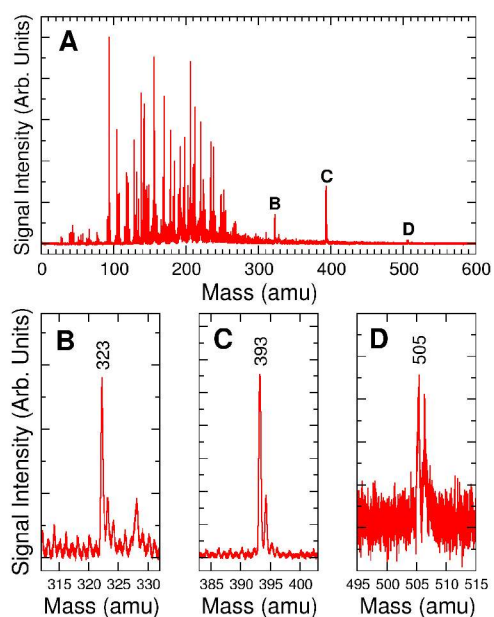


Figure 3: Unidentified high molecular weight species heterogeneously distributed in some samples of Tagish Lake.