The Tagish Lake chondrite and the interstellar parent body hypothesis

Conference or Workshop Item

THE TAGISH LAKE CHONDRITE AND THE INTERSTELLAR PARENT BODY HYPOTHESIS. I. Gilmour, M.A. Sephton and V.K. Pearson, Planetary and Space Sciences Research Institute, The Open University, Milton Keynes MK7 6AA, United Kingdom (I.Gilmour@open.ac.uk).

Introduction: The fall of the Tagish Lake meteorite and the subsequent suggestion that it may represent a new type of chondrite that is more primitive than type 1 CI chondrites [1] provides a unqiue opportunity to reexamine ideas on the origin of extraterrestrial organic matter. To date, most studies of the organic matter in meteorites have focussed on the Murchison meteorite which fell in 1969.

We have undertaken a gas chromatography-mass spectrometry investigation of solvent extractable organic compounds in Tagish Lake. The results are used to test the interstellar parent body hypthesis for the origin of extraterrestrial organic matter proposed by [2].

Experimental: A crushed and powdered sample (ca. 450 mg) of Tagish Lake was solvent extracted using dichloromethane (3 ml, Distol grade) by sonication for 20 minutes. The extract was removed using a pasteur pipette after centrifugation and concentrated to around 50 µl under a stream of dry nitrogen. The extract (1 µl) was injected onto a GCMS (Agilent Technologies). The GC oven was operated under the following conditions: initial isothermal hold for 2 min at 50°C; temperature programmed at 5°C/min to 300°C and final isothermal hold for 8 min. Compound identifications were performed by comparison with the NIST mass spectral database.

Results: Figure 1a shows the total ion current chromatogram obtained for the extract. A wide range of organic compounds were observed including aromatic and alkyl-aromatic compounds, phenols, nitriles and aliphatic hydrocarbons.

Figure 1b is a m/z 57 reconstructed ion chromatogram (RIC) that selectively displays the distribution of aliphatic hydrocarbons. The majority of the aliphatic hydrocarbons show great structural diversity in contrast of the typical homologous series of n-alkanes associated with terrestrial contamination [3]. However, some n-alkanes were observed, the most notable of which had 15-16 carbon atoms.

Figure 1c is a RIC (m/z 105,106,119,120,134) that selectively displays the distribution of C2-C4 alkyl substituted benzenes.Toluene was not observed in this analysis due to its low molecular weight which precluded adequate separation from the solvent. Alkyl-substituted benzenes are the predominant species observed for compounds with between 6 and 10 carbon atoms and a diverse range of isomers are present. However, there is a steady decrease in relative abundance with increasing degree of alkylation.

Figure 1d is a RIC (m/z 103, 117, 131) that selectively displays the distrubtion of C0-C2 alkyl substituted benzonitriles. As with the alkyl benzenes a diverse range of isomers is observed and the relative abundance decrease with increasing degree of alkylation.

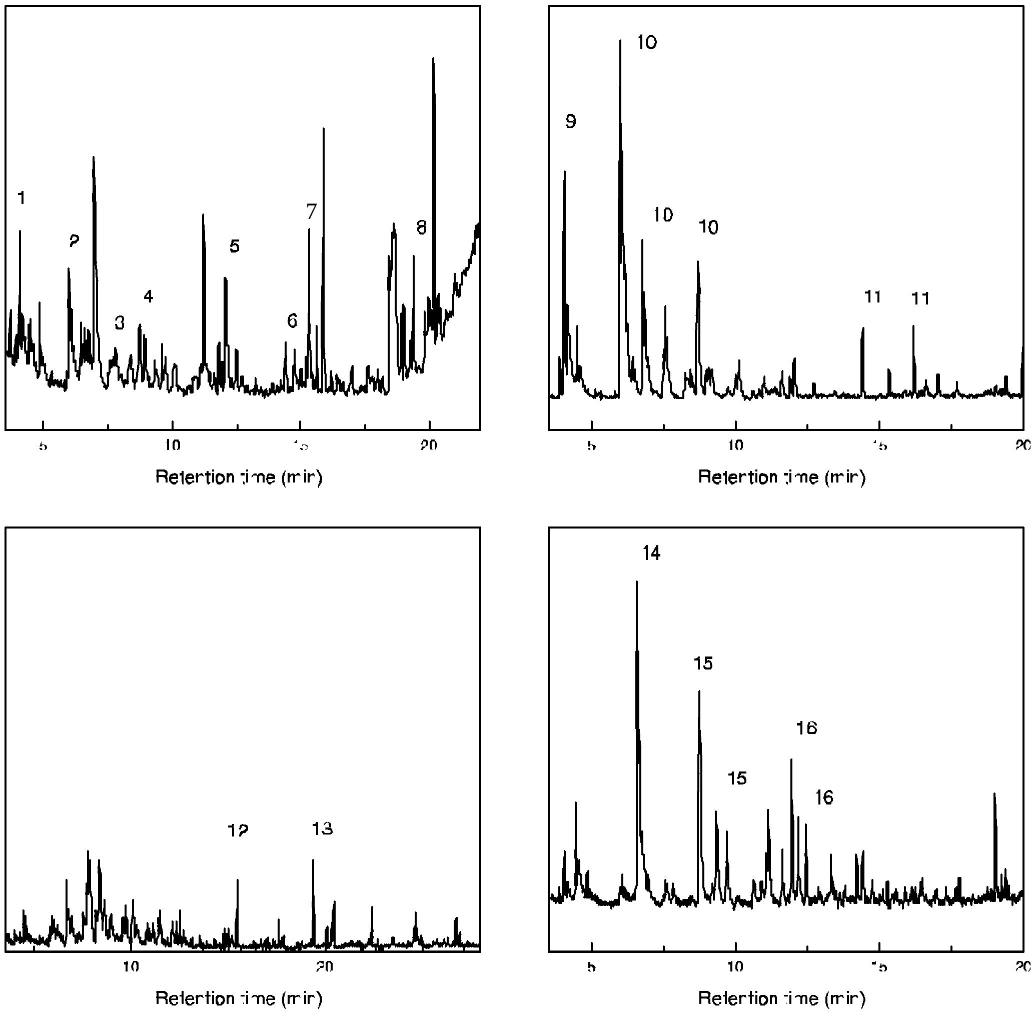
Figure 1e is a RIC (m/z 142, 153, 155) that has been used to selectively display the distribution of some higher molecular weight N-containing compounds. N-containing compounds are major components of the total ion current chromatogram suggesting that they are a significant proportion of the free organic inventory of Tagish Lake.

Discussion: The interstellar parent body hypothesis proposed by [2] suggests that meteoritic organic matter is produced by aqueous transformation of interstellar precursors initiated by the internal heating of a volatile-rich parent body. A significant proportion of the aromatic moeties in Murchison display evidence of being the relics of interstellar grain processes [4]. The free organic inventory in Murchison has been interpreted, in part, as the products of the aqueous alteration of this interstellar precursor material on the parent body.

There are several notable differences in the free organic inventory of Tagish Lake compared to Murchison. Foremost is the relative prominence of nitrile and other cyano-aromatic species. Organic molecules with such hydrogen-poor functional groups may reflect relatively low levels of aqueous processing on the Tagish Lake parent body. One consequence of which may be a relative decrease in the abundance of hydrogen-rich niotrogen containing species such as amino acids.

Further investigations using compound specific isotope analysis may better constrain exactly where on the interstellar-parent body continuum Tagish Lake organic matter lies.

References: [1] Brown et al., 2000, Science 290, 320. [2] Cronin and Chang, 1993, Chemistry of life's origins, 209. [3] Sephton et al., 2001, Precamb. Res. 106, 45. [4] Sephton and Gilmour, 2000, Ap. J., 540, 588.



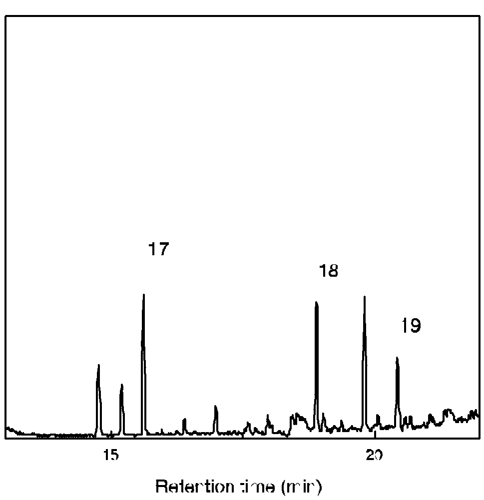


Figure 1. Mass chromatograms of a solvent extract of Tagish Lake. (a) Total ion current chromatogram, (b) Reconstructed ion chromatogram (RIC) showing aliphatic hydrocarbons, (c) RIC for alkyl-benzenes, (d) RIC for benzonitrile and alkyl-benzonitriles, (e) Partial RIC for higher molecular weight N-containing species.

Peak identites. 1. Dimethyl benzene, 2. Benzaldehyde, 3. Phenol, 4. Benzonitrile, 5. Benzene dithiol, 6. Napthalene, 7. Phthalic anhydride, 8. Phenyl pyridine, 9. Dimethyl benzenes, 10. C3-alkyl benzenes, 11, C4-alkyl benzenes, 12-13. C15, C16 normal alkanes, 14. Benzonitrile, 15. C1-alkyl benzonitrile, 16. C2-alkyl benzontrile, 17. Di-cyano substituted benzene, 18. Phenyl pyridine, 19. Iso-cyano naphthalene