Analysis of Tagish Lake macromolecular organic material

Conference or Workshop Item

ANALYSIS OF TAGISH LAKE MACROMOLECULAR ORGANIC MATERIAL. I.Gilmour, V.K. Pearson and M.A. Sephton, Planetary and Space Sciences Research Institute, The Open University, Milton Keynes MK7 6AA, United Kingdom (I.Gilmour@open.ac.uk).

Introduction: The fall and recovery of the Tagish Lake meteorite [1] has provided a unique opportunity to study the organic composition of what is possibly a new type of carbonaceous chondrite. The bulk element abundances of Tagish Lake have led to the suggestion [1] that it is more primitive than type 1 CI chondrites. Preliminary analysis indicated that it contains around 3.6 –5.4 wt % C of which some 3.7 wt % is carbonate [1], much of the remainder being organic carbon. The majority of this organic matter occurs as a complex macromolecular material. We have undertaken a flash pyrolysis-gas chromatography-mass spectrometry study of Tagish Lake to examine the chemical composition of this macromolecular material and have compared the results with those obtained from the type 2 CM chondrite Muchison.

Experimental: Around 30 mg of whole-rock meteorite that had been kept cold since its fall (at ca. -20°C) was loaded into a pre-cleaned quartz glass tube. The sample was flash pyrolysed at 610°C using a CDS 1000 pyroprobe (CDS Analytical, Oxford, PA), within 15 s after insertion into the interface, for 15 s in a flow of helium. The heating rate of pyrolysis was 20°C ms^{-1}. The interface was held at 260°C and the GC injector maintained at 250°C. 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°Cand final isothermal hold for 8 min. The pyrolysate was analysed on an Agilent Technologies 5973 GCMS operated in fullscan electron ionization mode (50-500 Da, 1.8 scan s^{-1}, 70 eV electron energy).

Following the intial pyrolysis at 610°C, the sample was pyrolysed a second time at 1000°C, all other conditions were the same as for the first run. A similar-sized sample of whole-rock Murchison meteorite was also pyrolysed under identical conditions for comparison.

Results: The total ion chromatogram for the 610°C pyrolysis is shown in Figure 1a. In general, the pyrolysate is dominated by aromatic compounds, however, two compounds predominate: the C_{16} polyaromatic hydrocarbons fluoranthene and pyrene. Other polyaromatic hydrocarbons are also present, though in much lower quantities. Figures 1b – 1e are reconstructed ion chromatograms that show the distribution of 1-ring to 4-ring aromatic hydrocarbons.

The pyrolysate of Tagish Lake is dominated by relatively high-molecular weight aromatic compounds; small quantities of the C_{18} PAHs chrysene and benzanthracene were observed in the pyrolysate. Relatively small quatities of one and two-ring species were observed, although chromatographic resolution of one-ring aromatics was difficult due to the release of substantial quantites of sulfur which col-eluted with benzene and toluene.

Discussion: Although representing by far the major organic component in meteorites, macromolecular material has not been extensively studied. To date, studies have been laregly restricted to the Murchison meteorite so that the fall of Tagish Lake represents a unique opportunity for comparison between the macromolecular material in these two chondrites.

Several distinct differences have been observed between Tagish Lake and Murchison. Aliphatic hydrocarbon moieties are present in significant amounts within the Murchison macromolecular material. Pyrolysis studies have indicated that these entities exist within or around the aromatic network [2] while NMR studies have revealed abundant aliphatic units in the form of short, branched groups which link aromatic centers [3]. Tagish Lake macromolecular material, however, is apparently more aromatic in character – the dominant pyrolysis products are two parental PAHs, alkyl-substituted PAHs being scarce by comparison. Pyrolysis experiments of Murchison have also released several heteroatom species such as O-containing phenols, S-containing thiopphenes and benzonthiophenes and N-containing species such as benzonitrile. Small amounts of phenol were detected in Tagish Lake pyrolysates, however, the dominant S-containing moeities were small amounts of benzo-thiophenes and scarce amounts of thiophenes.

However, the major difference between the two meteorites is in the molecular weight distribution of the pyrolysis products. Murchison contains substantial quantities of alkyl-benzenes and other monoaromatic species such as indanes that are either missing or extremely scarce in the pyrolysates of Tagish Lake. This suggests that the macromolecular material in Tagish Lake has a more condensed aromatic structure with higher-molecular weight aromatic moeities predominating.

Conclusions: Pyrolysates of the Tagish Lake meteorite are dominated by two high molecular weight PAHs suggsting that the macromolecular material in Tagish Lake consists of a highly condensed aromatic network.

References: [1] Brown et al., 2000, Science 290, 320. [2] Septhon et al., 2000, GCA 64, 321. [3] Cronin et al., 1987, GCA, 51, 299.

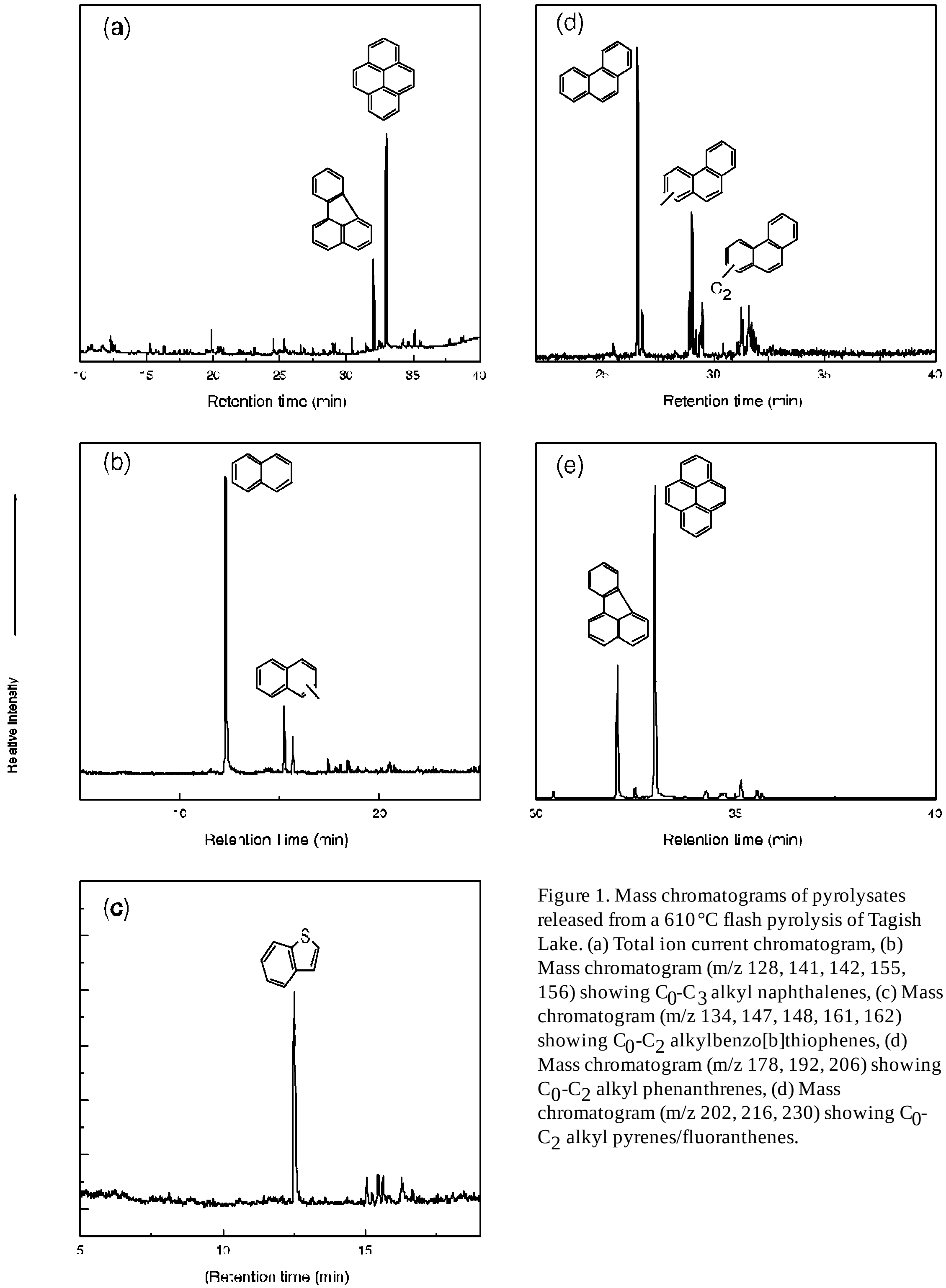

Figure 1. Mass chromatograms of pyrolysates released from a 610 °C flash pyrolysis of Tagish Lake. (a) Total ion current chromatogram, (b) Mass chromatogram (m/z 128, 141, 142, 155, 156) showing C_0-C_3 alkyl naphthalenes, (c) Mass chromatogram (m/z 134, 147, 148, 161, 162) showing C_0-C_2 alkylbenzo[b]thiophenes, (d) Mass chromatogram (m/z 178, 192, 206) showing C_0-C_2 alkyl phenanthrenes, (d) Mass chromatogram (m/z 202, 216, 230) showing C_0-C_2 alkyl pyrenes/fluoranthenes.