

**PYROLYSIS TYPING OF METEORITIC ORGANIC MATTER:** M.A. Sephton, C.T. Pillinger and I. Gilmour, Planetary Sciences Unit, Dept. of Earth Sciences, The Open University, Milton Keynes, MK7 6AA.

The complex organic macromolecule that constitutes the bulk of the organic matter in CM chondrites is a heterogeneous material that contains evidence of both a solar nebula and pre-solar origin; the latter indicated by an enrichment in D [1, 2]. It is structurally composed of condensed aromatic, hetroaromatic and hydroaromatic ring systems and as such is similar to the more aromatic (so called type III) terrestrial kerogens [3, 4]. However, the polycyclic aromatic hydrocarbons solvent extractable from the meteorites are apparently not the precursors of the macromolecule as their isotopic compositions are relatively enriched in  $^{13}\text{C}$  [5].

Various degradative methods have been used to study meteoritic macromolecular carbon [4, 6] including pyrolysis and chemical oxidation; on-line pyrolysis-gas chromatography-mass spectrometry (Py-GCMS) a technique long used for the chemical characterisation of terrestrial kerogens (eg.[7]; and refs therein) has not been used on meteorites to any extent. We have applied this latter technique combined with off line hydrous and anhydrous pyrolysis in an attempt to characterise further the chemical structure of the macromolecule, to examine the effects of aqueous and thermal processing, to develop a method to produce fragment compounds suitable for isotopic analysis by isotope ratio monitoring-GCMS, and ultimately to provide a relatively quick means of comparison between the macromolecular material in primitive chondrites of different class.

Table 1. Relative abundances (%) of pyrolysis fragments.

Compound	Murchison Whole (W)	Murchison Residue (R)	Anhydrous Pyrolysis (A)	Hydrous Pyrolysis (H)
Naphthalene	41	33	31.5	27.5
Methyl-naphthalene	17	20	4	19
Phenol	5	7	4	21.5
Methyl-phenol	17	16	13	20
Benzaldehyde	17	18	27	0
Benzonitrile	3	6	16	12
Benzoic acid	0	0	4.5	0

A powdered, whole-rock sample of Murchison that had previously been solvent extracted [5] and a Murchison HF/HCl residue (also solvent extracted) were used for trial experiments. Anhydrous pyrolysis was carried out at 310°C for 24 hours in pyrex vessels sealed under  $\text{N}_2$  on samples of 200 mg of HF/HCl residue. Hydrous pyrolysis experiments were undertaken using a stainless steel high pressure bomb (Parr 4740, 71ml); samples of 200 mg of residue together with 30 ml of high purity water were loaded into the bomb in a pyrex tube, the bomb sealed under nitrogen, and heated at 310°C for 24 hours. Bulk meteorite and the residues resulting from the pyrolysis were pyrolysed on-line to a GCMS as dry pellets (typically 1mg) using a pyrojector at 500°C (S.G.E, Ltd); GCMS conditions were as in [5].

The major compounds released on pyrolysis are listed in Table 1 as are their relative abundances compared to that of the bulk untreated meteorite. Little difference was observed in the on-line 500°C pyrolysis of whole-rock meteorite compared with that of an unpyrolysed HF/HCl residue implying that the mineral matrix is having a negligible effect on the pyrolysis products.

Figure 1 shows the relative abundances of benzonitrile, phenol, benzaldehyde and naphthalene plotted on a ternary diagram. It is evident that hydrous pyrolysis results in a marked increase in the relative abundance of phenol presumably due to a partial hydroxylation of the macromolecule. Interestingly, thermal processing alone produces markedly different results with a relative increase in the abundance of both benzaldehyde and benzonitrile. Perhaps the most obvious bivariate indicator of thermal history is the benzaldehyde/phenol ratio which increases and decreases markedly when heated under anhydrous and hydrous conditions (5.7 and 0.9 respectively, compared to 3.5 when unheated). The increase in alkyl-naphthalenes together with a decrease in the abundance of alkyl phenols seen in the hydrously pyrolysed sample mirrors changes that have been observed during the diagenesis of bituminous coals [8]. The trivariate analysis (Fig. 1) illustrates the potential of the technique as samples with common thermal histories can be seen to group together. The success of this kind of molecular "typing" relies on the different thermal stabilities of the chosen compound's precursors and has been used successfully for many years on terrestrial kerogens [7].

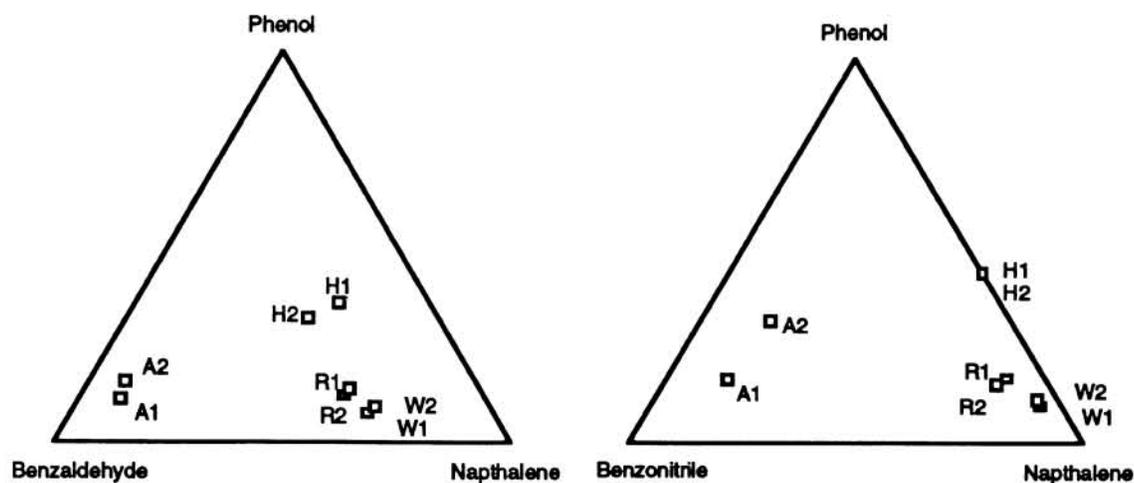


Fig1. Relative abundances from 500°C pyrograms. W1, W2: whole Murchison; R1, R2: Murchison residue; A1, A2: Anhydrously pyrolysed samples; H1, H2: Hydrous pyrolysis.

#### References

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