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APPLICATION OF GC×GC-TOFMS IN THE ANALYSIS OF METEORITIC ORGANIC MACROMOLECULES

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Geological processing has long-since obliterated the Earth-based record of pre-biotic chemical evolution. However, remains of the materials that were involved in the construction of the Earth are preserved in ancient asteroids, fragments of which are naturally-delivered to the Earth as meteorites. Carbonaceous chondrites are a particularly primitive class of meteorite that contain 2 to 5 wt. % carbon, most of which is present as organic matter (Gilmour, 2004).

Off-line pyrolyis and on-line pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS) has been used in the analysis of materials such as carbonaceous chondrites (e.g. Watson et al., 2004), however GC-MS systems can be easily overwhelmed by the complexity of the sample and a great deal of information can be lost by the inability to resolve these unresolved complex mixtures (UCM). Recent advances in instrument design have resulted in a major increase in sensitivity and chromatographic resolution.

A Leco Pegasus IV GC×GC-Time of Flight Mass Spectrometry system was used to analyse the organic material in a number of carbonaceous chondrites. The analyses were conducted on an Agilent 6890-5973 GC-MS as well as the GC×GC-TOFMS system which included online pyrolysis, online thermochemolysis and analysis of products released upon off-line hydropyrolysis.

The main advantages of Py-GC×GC-TOFMS include increased sensitivity of the mass spectrometer over the whole mass range, when compared to the more conventional quadrupole mass spectrometer which is partially due to narrow peaks widths (<0.15 s). Greatly increased signal to noise ratio, due to compounds being separated from the column bleed of the first column on the second GC column. The GC×GC is able to separate compounds that co-elute on a standard gas chromatograph system. Separation of analytes by volatility and polarity enables traditionally unresolved complex mixtures (UCM) to be examined in detail, and vastly increases the number of compounds identified (approximately an order of magnitude increase in resolved peaks). GCxGC is therefore able to afford a greatly enhanced picture of the structural and isomeric diversity of extraterrestrial organic

matter on considerably smaller samples and to provide analyses of samples that were previously unattainable (e.g. rare meteorites, interplanetary dust particles, micrometeorites and returned samples). An example is shown in Figure 1: a contour map of a total ion chromatogram for a pyrolysed sample of Cold Bokkeveld (CM2) macromolecular organic matter. The structural diversity observed in virtually all classes of organic compounds detected, a predominance of branched chain isomers and a decline in abundance with increasing molecular weight are common characteristics that is consistent with the production of meteoritic organic matter through a combination of different processes taking place in a wide range of extraterrestrial environments. (Gilmour, 2004).

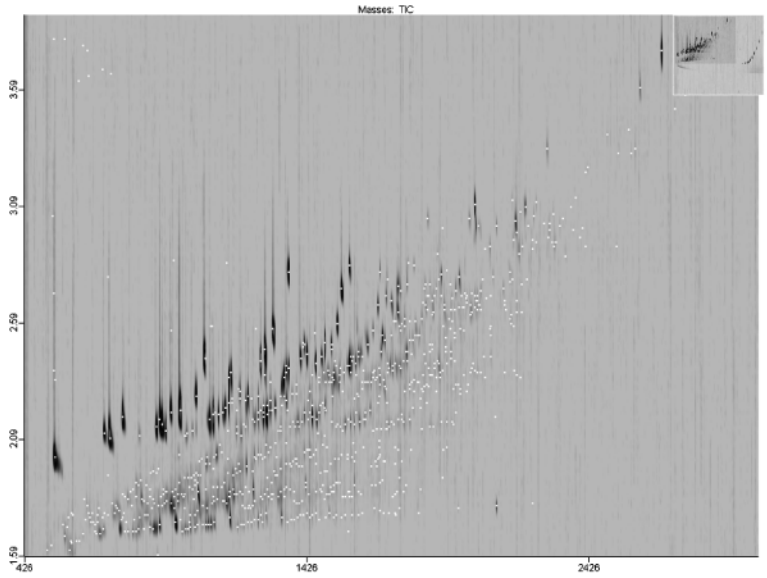

Figure 1. GC×GC total ion chromatogram for hydropyrolysis products from Cold Bokkeveld.

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