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HYDROPYROLYSIS OF INSOLUBLE CARBONACEOUS MATTER IN THE
MURCHISON METEORITE

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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
(Sephton, 2002).

Much of our current understanding of meteoritic organic matter has come from
investigations of the Murchison carbonaceous chondrite, approximately 100 kg of which fell
in Australia in 1969. Over the last three decades Murchison has been the focus of intensive
research using the most modern techniques and, consequently, the Murchison organic
inventory has become a valuable reference to which all other meteoritic organic matter may
be compared. The major organic component in Murchison is a solvent-insoluble, high
molecular weight macromolecular material that constitutes at least 70% of the total organic
content in the meteorite. As the dominant organic entity, this component is key to
understanding the origin of meteoritic organic matter. The macromolecular material consists
of an aromatic framework linked and surrounded by short functional groups.

Analytical pyrolysis is often used to thermally decompose macromolecular organic matter
in an inert atmosphere into lower molecular weight fragments that are more amenable to
conventional organic analytical techniques. Hydropyrolysis refers to pyrolysis assisted by
continuous flow high hydrogen gas pressures and a dispersed sulphided molybdenum
catalyst. This method retains structures and stereochemistries. Hydropyrolysis of the
Murchison macromolecular material successfully releases significant amounts of high
molecular weight PAH (Fig. 1). The majority of the carbon in the Murchison hydropyrolysate
appears to be present as three- to seven-ring polyaromatic hydrocarbons (PAH) including
phenanthrene, fluoranthene, pyrene, chrysene, perylene, benzoperylene and coronene units
with varying degrees of alklyation. The absence of long-chain alkyl substituents indicates that
these moieties exist within or around the aromatic network as hydroaromatic rings and short
alkyl substituents or bridging groups. The higher molecular weight PAH within the
pyrolysable macromolecular material extend up to coronene. Carbazole is a dominant
nitrogen heterocyclic compound in the hydropyrolysate.

Although hydropyrolysis liberates substantial amounts of organic matter from the
macromolecular material, over 50% of macromolecular carbon remains unconverted. Hence,
the meteoritic organic network contains both labile (pyrolysable) and refractory (non-
pyrolysable) fractions. Comparisons with experimental yields from bituminous coals (over
85%) indicate that this refractory residue probably consists of a network dominated by at least five- or six-ring PAH moieties cross-linked together.

Current work is extending the data set to include the hydropyrolysates of several carbonaceous chondrites that have been subjected to different levels of alteration on their parent body to assess if there is any discernible macromolecular record of secondary processing.

![Total ion chromatogram (TIC) of the hydropyrolysate from the Murchison meteorite. (S) elemental sulphur](image)

**Figure 1.** Total ion chromatogram (TIC) of the hydropyrolysate from the Murchison meteorite. (S) elemental sulphur

**REFERENCES**