THEME 3:
Volatiles of the Earth

Session 3.2:
Macromolecular organic matter: discerning biological and non-biological origins

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Macromolecular organic matter (MOM) abounds on Earth and beyond. It is an important component of the modern ocean and sediments throughout geological time. In meteorites and in other extraterrestrial materials, it carries information about interstellar carbon chemistry. In Archean sediments, it constitutes one of the potentially important pieces of evidence for the antiquity of life on Earth although much controversy surrounds efforts to demonstrate biogenicity. In the Phanerozoic, macromolecular organic materisl is the ultimate supply for much of our energy needs and, through its presence in soils and its ability to take up and retain inorganic components, it indirectly supports agriculture. This session focuses on the innate qualities of macromolecular organic matter and techniques that are used to determine its structure and origins. We are especially soliciting contributions on novel properties of MOM, characterization techniques and potential tools for identifying and distinguishing MOM from biological, non-biological and extraterrestrial sources.

3.2.11

Carbonaceous microfossils in Early Archaean cherts

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Microfossils in 3.3-3.5 Ga cherts from the Pilbara and Barberton Greenstone Belts contain carbon that can be mapped by light element EDX, that has a mature signature in Raman spectroscopy, and a semi-organised ultrastructure in TEM, results that are consistent with the age and low metamorphic grade of the material. The mats were formed by small microfossils (generally <1 µm) that have no cyanobacterial affinities at the surfaces of volcani-clastic sediments deposited in shallow water basins and the littoral environment, [1-2]. The carbonaceous matter associated with the mats appears as dark brown, finely crinkly layers in thin section. Although larger microbial filaments (~2 µm diameter) appear as dark threads in the colourless quartz matrix, the smaller microfossils appear as dark pinpricks that cannot be further resolved except using high resolution SEM methods. The carbon in the microfossils can be revealed by spot analysis and carbon mapping with light element EDX. *In situ* Raman spectroscopy of specific microbial mat layers reveals two broad bands, one reflecting the E_{2g} of graphite and the other due to various defects, thus corresponding well with spectra produced by the disordered structure of matured kerogen. However, no signature related to a particular macromolecule can be distinguished. The organic matter from specific layers of chert containing previously identified microbial mats was obtained for TEM study by acid digestion. High resolution TEM investigation of the atomic structure of the organic matter showed that it was not amorphous, but consisted of stacks of few, short, nanometric, wrinkled sheets with relatively wide interspacing, indicating a moderate stage of maturity. The degree of maturity shown by the Raman spectra and the HR-TEM observations is consistent with the metamorphic grade of the matrix rock (prehnite/pumpellyite). Thus, the organic matter probably formed at the same time as the sediment deposit and does not represent younger contamination. These results support the field and microscope observations that show that the mats and their microfossils are definitely coeval with the formation of the sedimentary deposits.

References

[1] Westall et al., 2001. *Precambrian Res.*, **106**, 93-116;
[2] Westall, 2003. *Palevol - Comptes Rendus Acad. Sci. Paris*, **2**, 485-502.