EPSC Abstracts
Vol. 8, EPSC2013-690, 2013
European Planetary Science Congress 2013

Microfossils in the Polonnaruwa meteorite - evidence for a cometary ecosystem

N Chandra Wickramasinghe (1), **Max K Wallis** (1), Nori Miyake (1), Jamie Wallis (2), D-H Wallis (1)
(1) Buckingham Centre for Astrobiology, University of Buckingham, Buckingham MK18 1EG, UK, wallismk@cf.ac.uk
(2) School of Mathematics, Cardiff University, Cardiff, UK, Jamie Wallis/smajw2/CardiffUniversity@cf.ac.uk

Abstract

The Polonnaruwa fall coincident with a fireball in the North Central Province of Sri Lanka on 29 December 2012 provided samples of an unusually low density carbonaceous chondrite [1]. Electron microscopy reveals an extraordinary complexof microfossils, which at first aroused strong scepticismbecause they would constitute convincing evidence for life in the solar system. O-isotope and chemical data show their hasty claims of contamination and terrestrial origin to be unfounded. We give here fuller details and examples, showing the Polonnaruwa meteorite is worthy of intensive study as a hugely important find in the identification of life on an extraterrestrial body.

1. Introduction

Electron microscopy (SEM/EDX) studies at Cardiff showed the Polonnaruwa meteorite fragments to be of an unusually inhomogeneous and poorly compacted carbonaceous chondrite with a uniquely-rich spread of microfossils [1,2]. As well as early mineralogy, the O-isotope data (Fig.1) prove its meteoritic origin, not a terrestrial fulgarite formed by a lightning strike as some were claiming.
The $\delta^{17}O : \delta^{18}O$ position of Pollonaruwa is close to C1 chondrites Alais, Ivuna, Orgeil and on the mixing line connecting with C1-like chondritic IDPs [2].

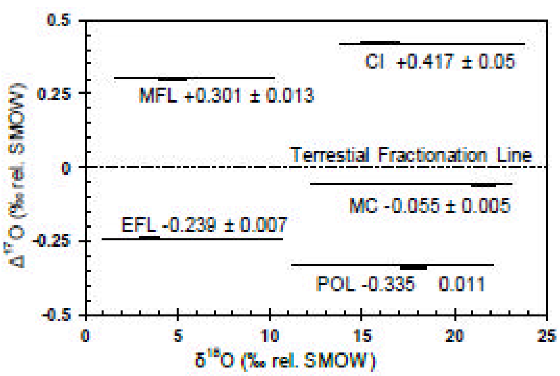


Figure 1: $\Delta^{17}O$ is -0.335 relative to SMOW, which is larger than eucrites (-0.24) and meta-C chondrites (-0.055); normal C1 chondrites are positive (+0.42)

2. Microfossils in SEM

Scanning electron microscopy has previously shown some near-complete skeletons of diatoms in interior of the meteorite, in freshly-cleaved samples [1,2]. EDX was used to identify the elemental composition, mainly Si in the case of diatom skeletons. Examples are readily found (10-20µm long), numerous broken skeletons in the largely mineral matrix (Figs. 2,3).

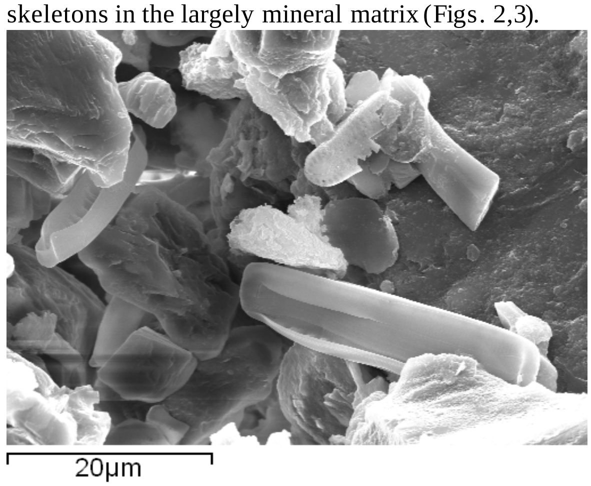


Figure 2: Two types of 'boat' diatoms (mid-left and lower right) plus a fragment (upper right) with an intricate pattern of holes (enlarged below).

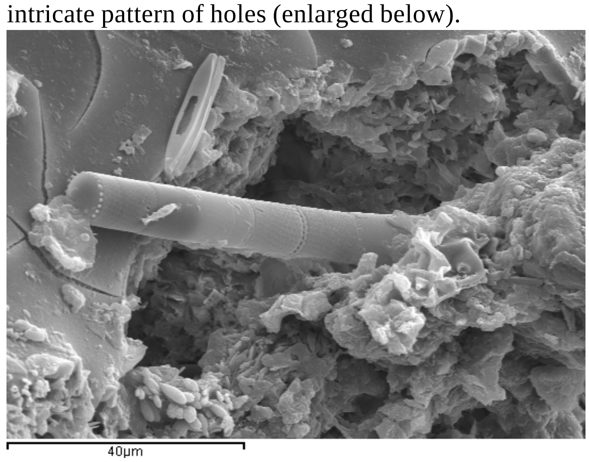


Figure 4: A well preserved cylindrical exoskeleton 10µm diameter, over 50µm long. Note above it the 25µm long double oval structure, with centre broken away. Both appear to have been lodged in place after the mineral deposits – irregular to the right and smooth to the left.

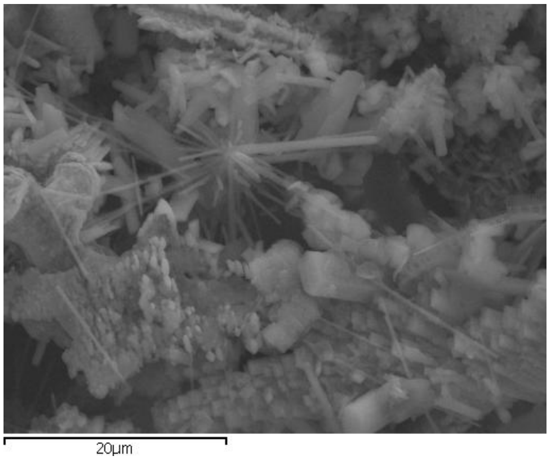


Figure 4: One of several spiney 'hedgehog' diatoms. The matrix within 2-300 µm contains other examples and many spines broken off similar specimens.

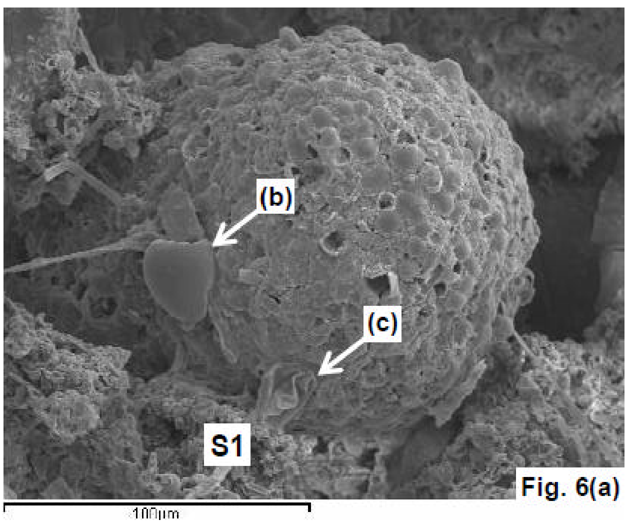
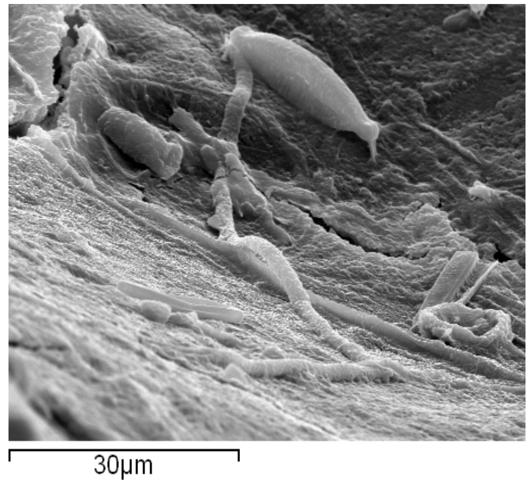


Figure 5: This 100µm thick-walled hystrichosphere has several intact flagellae, ~100µm-long spikes, implying a low gravity and low pressure enviroment. Details of the 'foot' (c) of one flagellum, show it pivots so might be used for swimming. EDX spectra taken at positions S1 and (b) show high carbon, but the rest mineral. The anomalous C:O ratio (similar to bitumen) with no N excludes a modern biological contaminant.

Highly carbonaceous strands and other micro-structures (Fig. 6) are evidence of blue-green algae; low nitrogen shows they are ancient fossils. The whole complex is suggestive of an extinct photosynthesising ecosystem, as needed to support diatoms because they are dependent on a source of carbonaceous molecules of photosynthetic origin.

Figure 6 (below): Field with algal stands plus other fossil bodies, all found to be high in C. Such fossils are also shown by EDX to be low in N (<0.1%), so cannot be kyr-old terrestrial contaminants



3. Summary and Conclusions

The oxygen-isotope data establishes the Polonnauwa stones as meteorites, independent of fireball identification. Contamination by terrestrial organisms is excluded by the abundance of broken and near-whole diatom skeletons, and by the low-N indicating an age of Myrs (if terrestrial). Carbonaceous strands are evidence of blue-green algae; other carbonaceous micro-structures await identification. As diatoms need a nitrogen source, the accompanying algal strands are consistent with a photosynthesis-based ecosystem on the originating body. We hypothesise that the Polonnaruwa chondritic meteorite most likely originated on a comet that supported a primitive ecosystem, as in the subsurface ponds or lakes possible in comets with perihelia around 1AU or smaller [3].
The uniquely rich find of carbonaceous and siliceous microfossils in Polonnaruwa is hugely important in the identification of life on an extraterrestrial body.

References

[1] Wickramasinghe, N.C., Wallis J., Wallis D.H., Samaranayake, A.: Fossil diatoms in a new carbonaceous meteorite", J. Cosmology, 21, 37, 2013
[2] Wallis J. et al: 2013 The Polonnaruwa meteorite: oxygen isotope, crystalline & biological composition, J.Cosmology, 22(2), 2013, arXiv 1303:1845
[3] Wickramasinghe, J.T., Wickramasinghe, N.C., Wallis, M.K.: Liquid water and organics in Comets, Int. J. Astrobiol, 8, pp. 281-290, 2009.