

Polonnaruwa meteorite – microfossil evidence for a cometary ecosystem

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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 complex of microfossils, which at first aroused strong scepticism because they would constitute convincing evidence for life in the solar system. O-isotope and mineral data show the quick dismissal as contamination or 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]. It was first claimed as terrestrial fulgurite formed by a lightning strike, but local geologists now say it's unlike any rock on the island of Sri Lanka. Subsequent O-isotope data rank the $\delta^{17}\text{O} : \delta^{18}\text{O}$ ratio of Polonnaruwa close to C1 chondrites Alais, Ivuna, Orgeil and on the mixing line connecting with C1-like chondritic IDPs [2]. The iridium abundances in the 4 samples analysed with ICP-OES [3] exceed 1000x terrestrial, of the same order as carbonaceous and even iron meteorites. Its meteoritic origin is now well-established.

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 (10-20 μm long), numerous broken skeletons in the largely mineral matrix (Figs. 1,2).

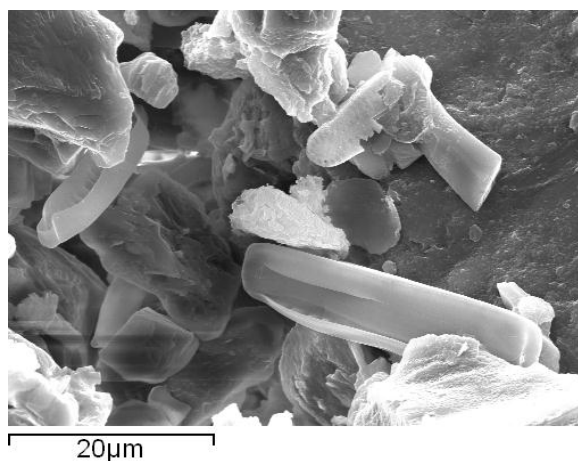


Figure 1: Two types of pennate diatoms (mid-left and lower right) plus a fragment (upper right) with an intricate pattern of holes (see example of Fig 2).

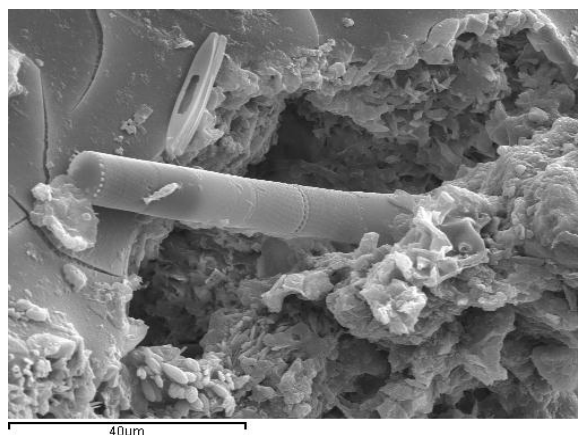


Figure 2: A well preserved cylindrical exoskeleton 10 μm diameter, over 50 μm long. The girdle and other detail establishes it as *Aulacoseria ambigua*. Note above it the 25 μm long double oval structure, identified as the polar marine diatom *Rhabdonema minutum*. Both appear to have been lodged in place after the mineral deposits – irregular to the right and smooth (hydrothermally altered) to the left.



Figure 3: One of several spiny 'hedgehog' diatoms. The matrix within 2-300 μm contains other examples and many spines broken off similar specimens.

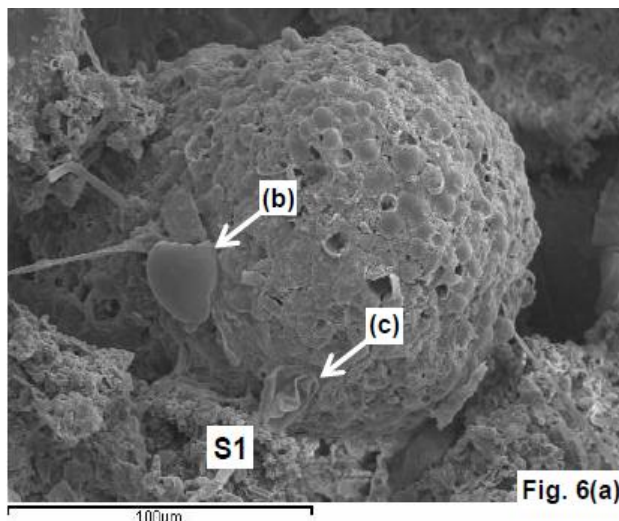
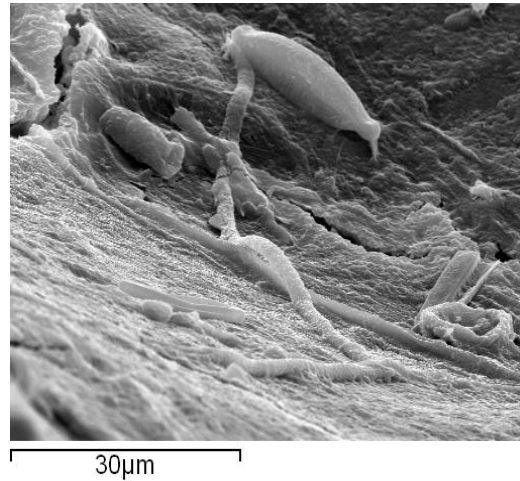


Figure 4: This 100 μm thick-walled hystrichosphere has several intact flagellae, ~100 μm -long spikes, implying a low gravity / low pressure environment. Details of the 'foot' (c) of one flagellum, show it pivots so might be used for swimming. EDX spectra taken at positions S1 and (b) show high carbon, but otherwise the body has mineralised. The anomalous C:O ratio (similar to bitumen) with no N excludes a modern biological contaminant.

Highly carbonaceous strands and other micro-structures (Fig. 5) are evidence of blue-green algae; low nitrogen shows they are ancient fossils [2]. 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 5 (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 Polonnaruwa 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 [4].

The uniquely rich find of carbonaceous and siliceous microfossils in Polonnaruwa is hugely important in the identification of life on an extraterrestrial body.

References

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