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Fossil diatoms imply common cometary origin of space-dust and the Polonnaruwa meteorite

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Abstract

IDPs collected in 2001 at 40km altitude by cryosamplers studied via scanning electron microscopy and EDX were found to contain siliceous fibres and whiskers, some isolated but often embedded in a mineral matrix. The newly-arrived Polonnaruwa meteorite gives strong evidence for the hypothesis that they are fragments of diatoms agglomerating on solar system icy bodies. Diatom frustules and even whole diatom skeletons are identifiable within the meteorite. Specimens of a siliceous exoskeleton with multiple spines/whiskers have also been found, thought to be freshwater diatoms. As diatoms are dependent on a source of nitrogenous organics, the siliceous whiskers within IDPs would be an indicator of a photosynthesizing ecosystem, probably on a comet.

1. Introduction

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. Critics leapt to assert contamination and terrestrial origin on the basis of preliminary publications due to hostility to the whole idea of extraterrestrial life.

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, subsequent O-isotope data prove its meteoritic origin, not a terrestrial fulgarite formed by a lightning strike as some were claiming.
The SEM/EDX analysis of interior, freshly-cleaved samples revealed several near-complete siliceous skeletons of diatoms, partially embedded in a largely mineral matrix (eg. Figure 1). We had previously identified siliceous whiskers embedded in Cardiff's collection of IDPs [3]. The Polonnaruwa meteorite contains similar spines, but also diatom frustules and even whole diatom skeletons whose detailed patterns clearly identifies. Examples of spikey diatoms with multiple spines/whiskers have also been found, which strongly suggests they are the source of the siliceous whiskers in the interplanetary dust (IDPs).

2. Diatoms in Polonaruwa meteorite

Figure 1: A large fossil diatom (40 µm x 12 µm) buried in the rock matrix, showing a detailed pattern representative of diatom exoskeletons. At the lower right, another fragment of exoskeleton is visible.

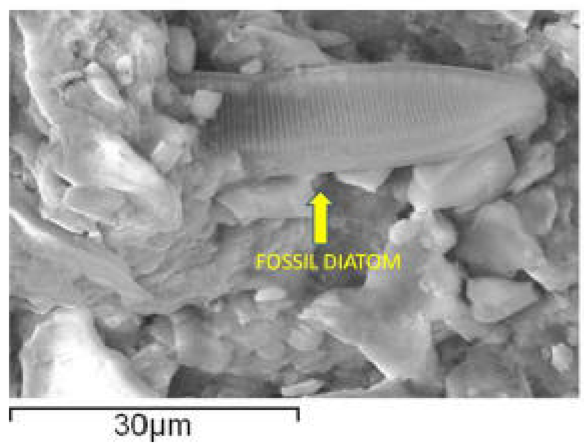

Figure 2: Field of spikey 'hedgehog' diatoms (central specimen shown in Figure 2). The large variety at bottom left has spikes ~2µm wide compared with 0.3µm of others.

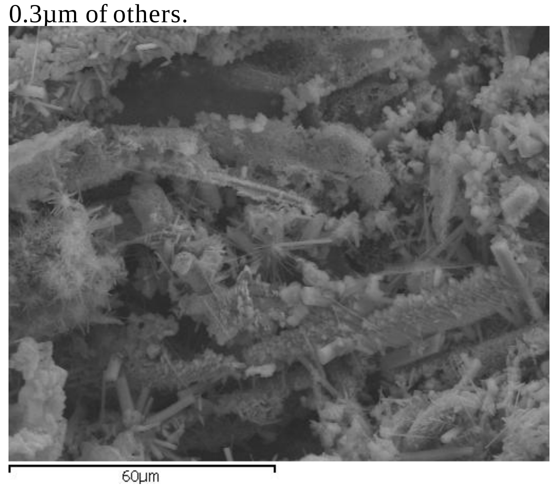

Figure 3: Higher resolution image of the 'hedgehog' shown in centre of Fig. 1. The many loose spines are likely broken off similar specimens. Note the thicker fibres ~1 µm

3. Siliceous spines in IDPs

We recently studied via SEM/EDX [3] siliceous whiskers or spines within interplanetary dust (IDPs) collected at ~40km altitude. Some were isolated but many were embedded in the mineral matrix (Fig.4).

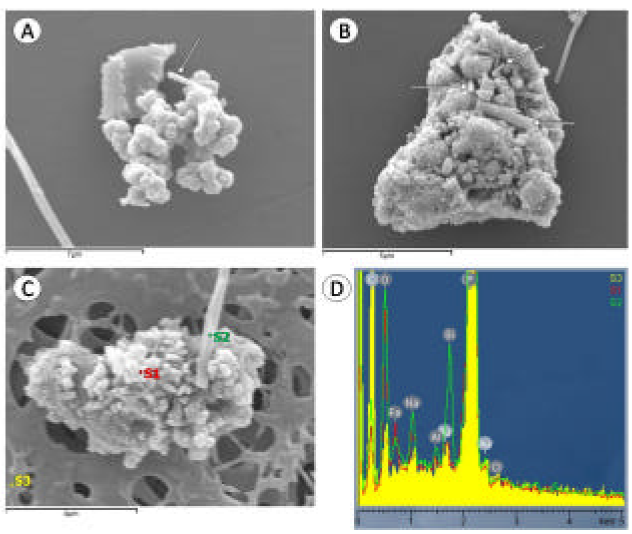

Figure 4: **[A]** SEM image of a probable carbon-rich condensate of 0.5~2.0µm aggregate with higher minerals fraction in the particles (Cr ~10.5%, Fe ~22.5%) and a 4µm x 1µm whisker (arrowed).
[B] SEM image of 5x7µm carbonaceous IDP with magnetite (C ~ 15%, Fe ~39%, O ~ 30%) and a loose submicron particle containing trace amount of Ti (~2.2%). Various sub-micron rods and whiskers are embedded (as thin as 0.1µm).

Figure 4 (caption continued):
[C] SEM image of 4 x 8µm IDP with a submicron width whisker embedded. S1 and S2 are locations of red and green lines in the EDAX spectrum (D). The yellow is the background at S3.
[D] EDX data of specimen (in Fig. C) shows the IDP's magnetite-like nature (red line; Fe ~33%, O ~30%) and the elevated Si and O in the whisker (green line - as the EDX spot size ~1µm, the Fe may be all in the underlying particle). The yellow profile is a background reading (spot-S3) of the acetate filter and gold conductive coating.

4. Summary and Conclusions

Siliceous fragments have been found in meteorites too - Orgueil and the Tagish Lake carbonaceous chondrite [3], both fragile like Polonnaruwa. The origin of the siliceous whiskers was hypothesized to be probably a comet. Other species of fossil diatoms but also non-siliceous carbonaceous fossils are found in Polonnaruwa, including probable cyanobacteria (micro-algae). We note that diatoms are dependent on a source of nitrogenous hydrocarbons of photosynthetic origin. So the accompanying carbonaceous strands and micro-structures are consistent with a photosynthesis-based ecosystem on the originating body. The origin of the Polonnaruwa chondritic meteorite – fragile and low density that is likely to degrade quickly by weathering - is most likely a comet, which would in the past have supported a primitive ecosystem, as in the subsurface ponds or lakes possible in comets with under 1AU perihelion [4].

References

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