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RESEARCH

Microspherules and Presumptive Biological Entities Found Inside the Polonnaruwa Meteorite

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A sample of the Polonnaruwa meteorite was cut in half and examined using the scanning electron microscope. Microspherules were observed which proved to be carbonaceous when examined by EDX. A number of biomorphs were also seen in an interior section, including a presumptive diatom. We conclude that the biomorphs are closely associated with, or integrated into, the meteorite and the inside of which is mineralized, showing that they are not contaminants, but instead must have originated from the meteorite's cosmic source.

Introduction

On 29 December 2012, a large meteoritic bolide disintegrated and fell in the village of Araganwila, near the city of Polonnaruwa in Sri Lanka. The meteorite was found to possess a highly porous and composite structure which is characteristic of a carbonaceous chondrite, with fine-grained mineral aggregates connected with mineral intergrowths, and the presence of a few percent carbon confirmed its provisional status as a carbonaceous meteorite (Wallis et al. 2013, Wickramasinghe et al, 2013a, b). The distribution of stable oxygen isotopes within the stones have added weight to this preliminary conclusion (Wallis et al, 2013a). The mineralogy, petrology and chemistry of these stones are currently under study, and their meteorite status might in due course be firmly established (Wallis et al, 2013b). Scanning electron microscope studies of the Polonnaruwa meteorite showed the presence of fossilized diatoms embeded in the outer surface of the meteorite (Wickramasinghe et al, 2013c). The aim of the present study was to cut a sample of the Polonnaruwa meteorite into two and examine an inner section for the presence of biological entities and other features of interest.

Materials and Methods

A portion of the Polonnaruwa meteorite was sectioned and then examined under the scanning electron microscope. Using a hot plate the sample was fixed to a polymer stub with wax which was then staged in a wire saw setup (Well 3241 Wire Saw). The wire saw uses a subtle slope to encourage the wire to gently press up against the front face of the staged sample and the gradient of this slope can be altered so as to increase or decrease the force which the wire places upon the sample. The wire used was approximately 0.17mm thick and coated with very fine diamond particles of mode size, circa 30 microns; when activated, the wire makes slow and delicate progress through the sample. After the sample was cut, one half was placed in a staging chamber with the face to be analysed flush to the base. Konductomet phenolic mounting compound (20–3375–016) was used to stage the sample. Surface grinding and then polishing of the sample surface is usually undertaken at this point however, in this case only an instantaneous grinding process was conducted. This was done to remove any build up that might be present on top of the surface to be studied and to ensure that only fresh sample material was exposed. The coarseness of pile used was 120 microns using a Bueler Automet 250 for 5 seconds with a touch force of 20N, a head speed of 50 RPM and a Platen speen of 140 RPM. Due to the relatively low conductive nature of the samples and in order to minimise charging effects and optimise image acquisition the sample was coated in gold using an Emscope gold sputter coater. The sample was coated for deposition duration of 1 minute at 15 milliamps. Before being introduced into the SEM (JEOL 6500F) the sample was placed in a vacuum chamber overnight to remove any remaining moisture.

Results and Discussion

The first particle of interest that was discovered is shown in **Fig. 1** in which can be seen a large spherical particle which is located *inside* a cavity formed within the meteorite matrix. The cavity is more clearly seen in **Fig. 1B** which also shows and EDX analysis of the sphere. The cavity when complete with its upper half would have formed a chamber in which the spherule, which is apparently not

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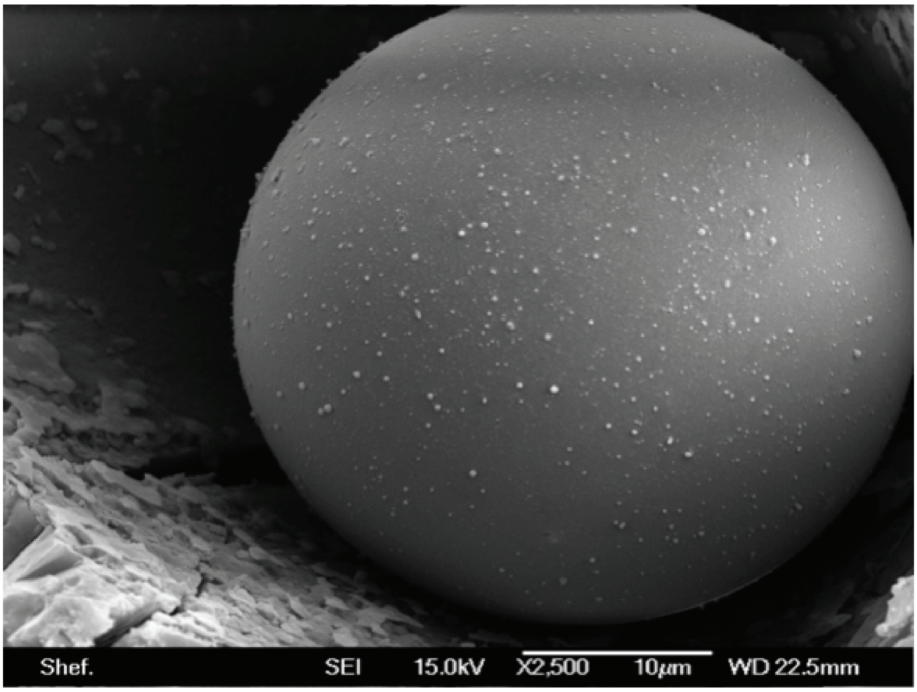

Fig. 1: A microspherule inside the Polonnaruwa meteorite.

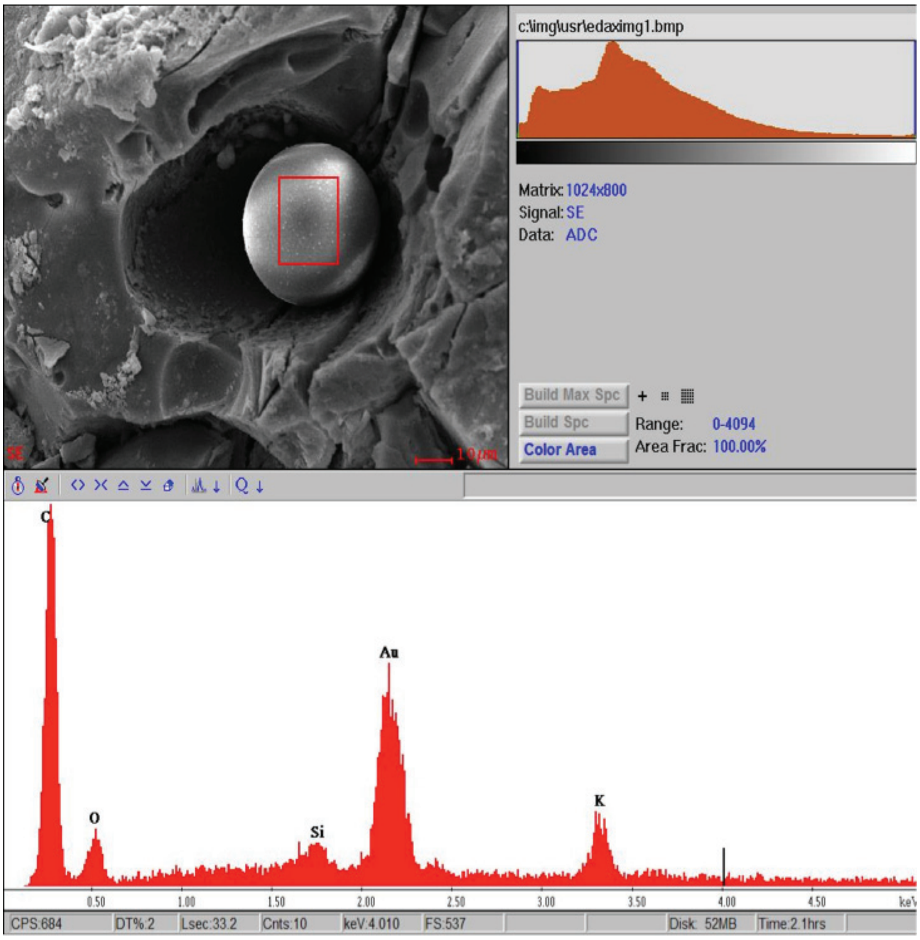

Fig. 2: Microspherule held in a cavity within the Polonnaruwa meteorite together with EDX showing analysis showing its carbonaceous composition.

fixed, would be able to move around. The particle is seen to contain C, O and K and is therefore a carbonaceous microspherule. It is noteworthy that the particle is an almost perfect sphere, and that it possesses no obvious signs of any biological morphology, as a result we consider it to be a carbonaceous, non-biological entity.

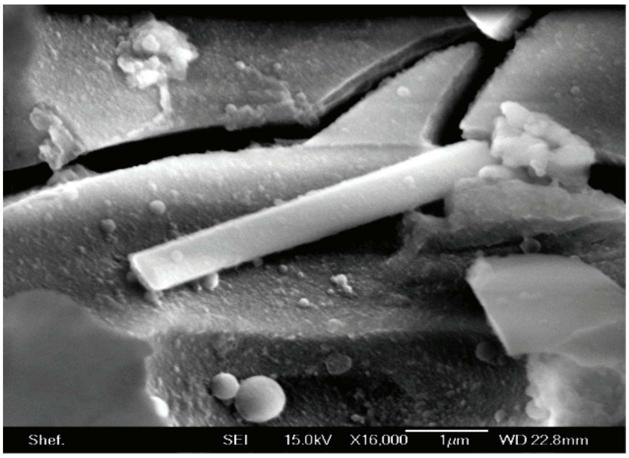

Fig. 3: Image showing interior of Polonnaruwa meteorite showing presumptive biological entities.

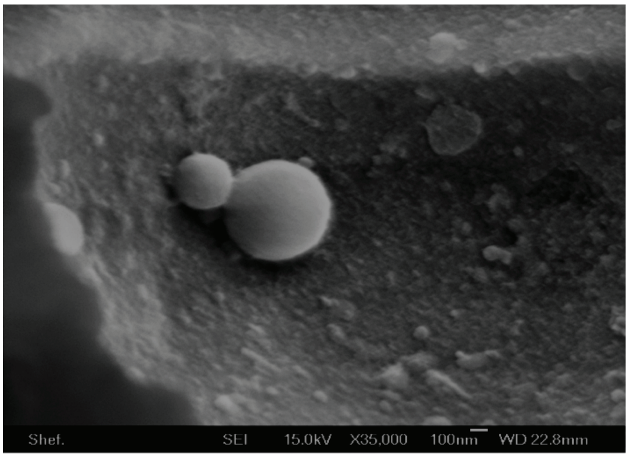

Fig. 4: Detail of the bacteria-like biomorph.

In contrast, entities exhibiting obvious biological morphology can be seen in **Figs. 3–4**. The particles of interest in **Fig. 3** are a) the long one in the centre and b) the two joined spheres at bottom left-centre of the image and c) the clumps of "cells" in the top left hand corner which has a filament originating at its base, which goes straight down and then diverts left. The long particle in the centre of **Fig. 3** appears to be a non-ornamented diatom frustule. Although diatoms often exhibit ornamentation, this apparent frustule is smooth and is similar to that frustule produced by diatoms such as *Bacillaria paxillius;*a similar diatom-like particle was found by Miyake et al (2010) in space dust collected at an altitude of 41km in the stratosphere. On close examination, this frustule shows signs of flattening, indicating that it is tube-like, rather than being a solid particle, a feature consistent with it being a diatom. Note also that the right side end of this diatom like particle is locked into the matrix of the meteorite and is overlain with meteorite debris, showing that it is part of the matrix and has not landed on the cut meteorite surface during processing and handling.

At the lower left of **Fig. 3** can clearly be seen another putative biological entity which is shown in detail in **Fig. 4**. This particle is made up of two spheres, one larger than the other, which are clearly attached, so that the smaller particle appears to be "budding" out of the larger one. This entity is similar to a budding yeast or a dividing coccoid-shaped bacteria; based on size criteria however, it would appear to be a bacterium. This particle also shows signs of being attached to the matrix and is not extraneous to the meteorite. A final apparent biological entity is shown in **Fig. 5**. This consists of a large oval-shaped particle with a pitted upper surface and whose lower surface is contoured to fit the meteorite matrix,suggesting that it was at one time a malleable,cellular orgainsm and not a rigid inorganic particle (**Fig. 5A**). A second version of the biomorph found close to the first is shown in **Fig. 5B** where the presumtive cell appears to be undergoing replication to produce a daughter cell. Note this presumptive biological entity is also integrated into the meteorite matrix and could not have contaminated the sample. Unfortunately, we are unable to allocate this biomorph to any group of known organisms.

A perennial problem with attempting to study presumptive biological entities in meteorites is that many inorganic particles simulate, and can be confused with, bacteria, algae and other organisms. The morphology of the particles shown in **Figs. 3–5** is however, sufficiently distinct from inorganic meteorite material to putatively regard them as biological entities. The next question which arises is –from where did these presumed biological entities originate? The whole of the inside of the meteorite is, as expected, mineralized, as are the putative biological entities - a fact which clearly suggests that they are not contaminants. Additionally, the meteorite sample used here was cut and handled under very clean conditions, thereby excluding the possibility that the biological entities contaminated the inside of the meteorite. In the case of the diatom fragment shown in **Fig. 3**, its position relative to the meteorite matrix shows that it did not merely land on the cut surface from the laboratory air (a very unlikely proposition since diatoms do not occur in the environment of a general engineering laboratory) but is an integral part of the meteorite. We therefore conclude, with a high degree of certainty, that the putative biological entities found inside the Polonnaruwa meteorite are not Earth contaminants. As was mentioned previously, sculptured diatom fragments have been found embedded in the surface matrix of the Polonnaruwa meteorite (Wickramasinghe et al 2013c). Critics have claimed that these are contaminants, although they do not explain how they became embedded in the inorganic surface matrix of the meteorite. The present discovery of a fragment of an apparent diatom frustule deep inside the meteorite weakens this criticism, however. Together with the association of the other putative biological entities found here within the body of the Polonnaruwa meteorite, we conclude that there is further evidence that life exists elsewhere in the cosmos.

Acknowledgement

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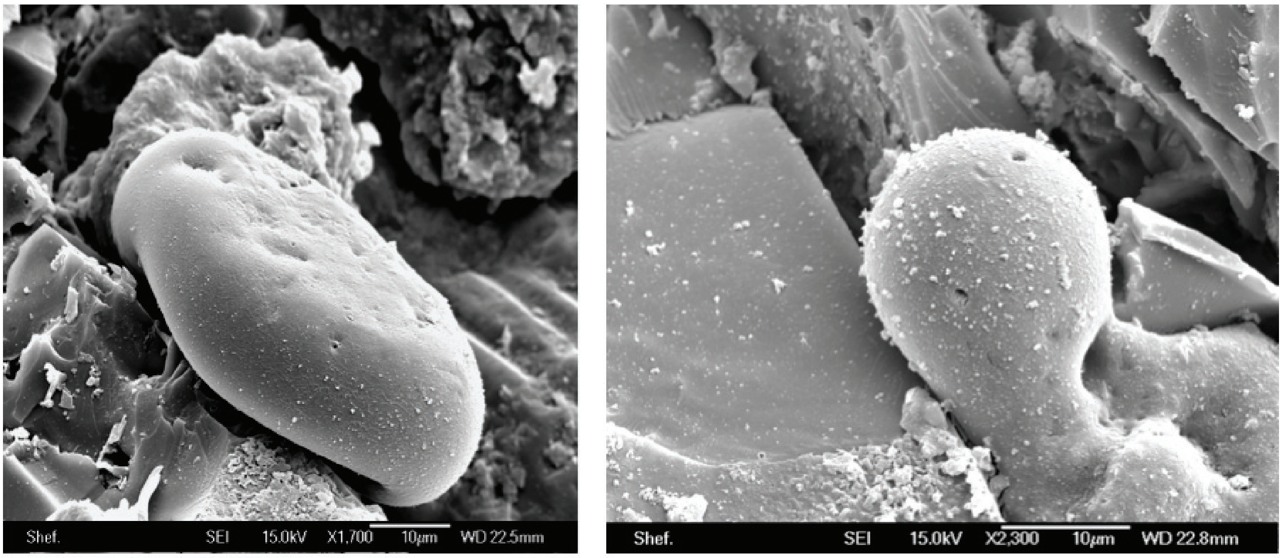

A B

Fig. 5: A) An unusual bimorph seen inside the Polonnaruwa meteorite, and **B)** another particle of the same biomorph undergoing what looks like daughter cell generation.

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