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ON THE COMETARY ORIGIN OF THE POLONNARUWA METEORITE

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ABSTRACT

The diatoms discovered in the Polonnaruwa meteorite are interpreted as originating in comets and the dust in interstellar space. The exceptionally porous structure of the Polonnaruwa meteorite points to it being a recently denuded cometary fragment. Microorganisms that were present in a freeze-dried state within pores and cavities may have survived entry to be added to the terrestrial biosphere.

Keywords: Meteorites, Carbonaceous chondrites, Diatoms, Comets, Panspermia

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1. Introduction

Over many years Hoyle and Wickramasinghe (2000) have argued that comets begin their lives as aggregates of interstellar grains mixed with water-ice derived from the solar nebula. The interstellar grains have been shown to be spectroscopically indistinguishable from a mixture of desiccated bacteria and diatoms with relatively minor admixtures of inorganic silicate, iron and graphite grains (Wickramasinghe, Hoyle and D.H.Wallis, 1997; Hoyle and Wickramasinghe, 1990, 2000). A small cometary fragment, <10km in radius, would have an initially melted core that remains in a liquid condition for ~ 1 million years due to heat generated by the decay of ^{26}Al and ^{60}Fe (Wickramasinghe, J.T et al, 2009; Wickramasinghe, J.T. et al, 2010). This short-lived warm episode in the history of a comet would serve to re-establish an initially dormant anaerobic microbial ecology that would later re-freeze when the radioactive heat sources run out.

Outgassing of a comet over millions of perihelion passages, during the lifetime of the solar system, would lead to the selective stripping of volatiles, leaving behind what might be identified as the parent body of a carbonaceous meteorite. Microbial material and dust enmeshed in the icy outer layers of the comet as it outgases could, on occasion, be introduced as viable living cells to the Earth. This is the essence of the panspermia theory developed by Hoyle and Wickramasinghe for the origin and evolution of terrestrial life.

Many spectral features of interstellar and cometary dust are better explained by biologically generated organics and siliceous polymers than by inorganic abiotic systems (Wickramasinghe, N.C. et al, 1997; Wickramasinghe, J.T. et al, 2010). In particular, infrared features of interstellar dust in the 8-30 μm wavelength range is explained on the basis of disordered SiO_4 tetrahedra in diatom frustules far better than by inorganically generated mineral grains (Hoover et al, 1987).

2. Diatoms and Terrestrial Silica

Biomineralisation is generally accepted as contributing to rock formation and geological processing. It is likely that diatoms play a more important role in this process than has hitherto been considered. Hoyle *et al* (1982), after assessing the fits of biological models to astronomical infrared sources, wrote thus:

"The input of cosmic microorganisms on to the Earth (in the manner we have discussed elsewhere) cannot now be thought to be limited to purely carbonaceous organisms. A considerable flux of siliceous microorganisms similar to diatoms must arrive at the Earth and at the surfaces of other planetary bodies as well. The considerably higher values of the ratio Si/Mg found in the Earth's crust (~10), Lunar material (~3), Martian material (~4) as well as in diatoms (>>10) tend to support this view. Starting from a cosmic ratio of Si/Mg ~ 1 inorganically produced silicates must be expected to have roughly equal numbers of Mg and Si atoms. The conventional explanation for anomalously high values of Si/Mg invokes geochemical processing and segregation according to differential buoyancy. Such an explanation seems to us to be far-fetched compared with our present hypothesis involving direct transport of Si-rich microorganisms."

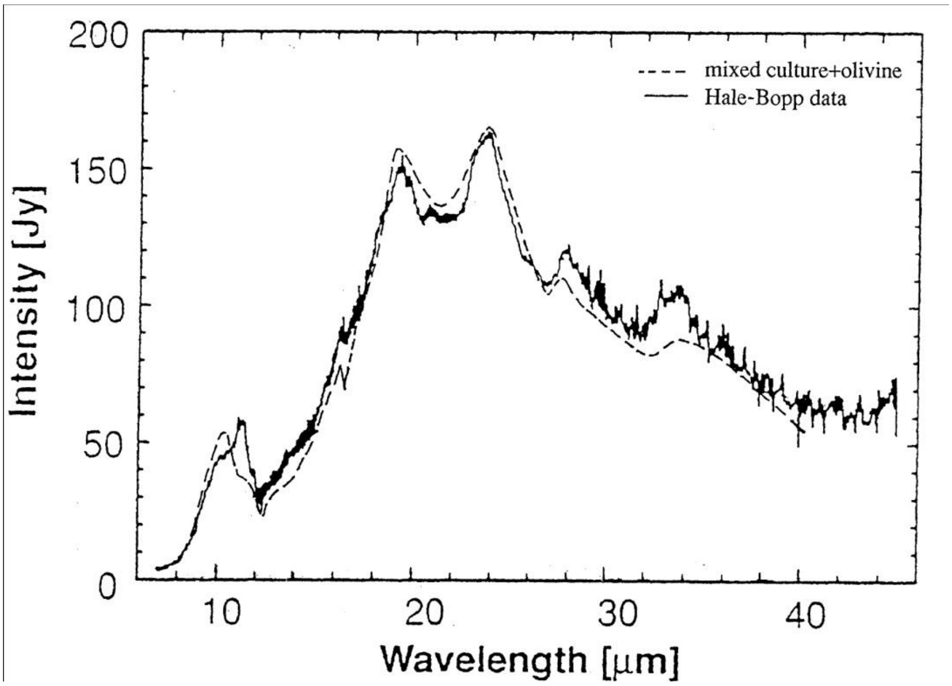

Fig.1 Solid curve is the infrared radiation from Comet Hale-Bopp when it was at a heliocentric distance of 2.9AU. The dashed curve is for a mixture of a bioculture containing 20% by mass in the form of diatoms, and less than 10% inorganic olivine (Wickramasinghe et al, 1997).

After a full three decades, these comments, written in 1982, still remain profoundly relevant. The processes of biomineralisation have come to the fore for a variety of reasons, not least of all the possibility of identifying past life on Mars from geological and geochemical studies (Bazylinski and Frankel. 2003; Blanco, et al, 2006).

The infrared spectrum of dust from comet Hale-Bopp obtained when it was at a heliocentric distance of 2.9AU is remarkably consistent with the behaviour of a mixed culture of microorganisms with a 20% contribution from diatoms, and less than a 10% contribution from inorganically generated silicates (Wickramasinghe, et al, 1997). The most striking evidence for the presence of diatoms in comets, however, has come from SEM studies of the remarkable carbonaceous meteorite that fell in Araganwila in Polonnaruwa Sri Lanka on December 29th 2012 (Wickramasinghe, Wallis, J., Wallis, D. and Samaranayake, 2013). Interior samples from this meteorite revealed a vast abundance of diatoms of various shapes and form which we have discussed in our earlier communication.

3. Structure and Classification

The Polonnaruwa meteorite was provisionally identified by us as "an unusual CM meteorite, with an exceptionally high degree of porosity". This latter proviso merits further comment and qualification, however. The lowest value of average density measured for the most porous known CM chondrite is close to 2 g cm^{-3}. With an average olivine density of 3 g cm^{-3}, this gives a vacuum volume fraction for the most porous known CM chondrites of ~ 25%. From an inspection of the SEM scans of the Polonnaruwa sample, as seen in Fig.2, we estimate a volume filling fraction in this case of nearer 50%.

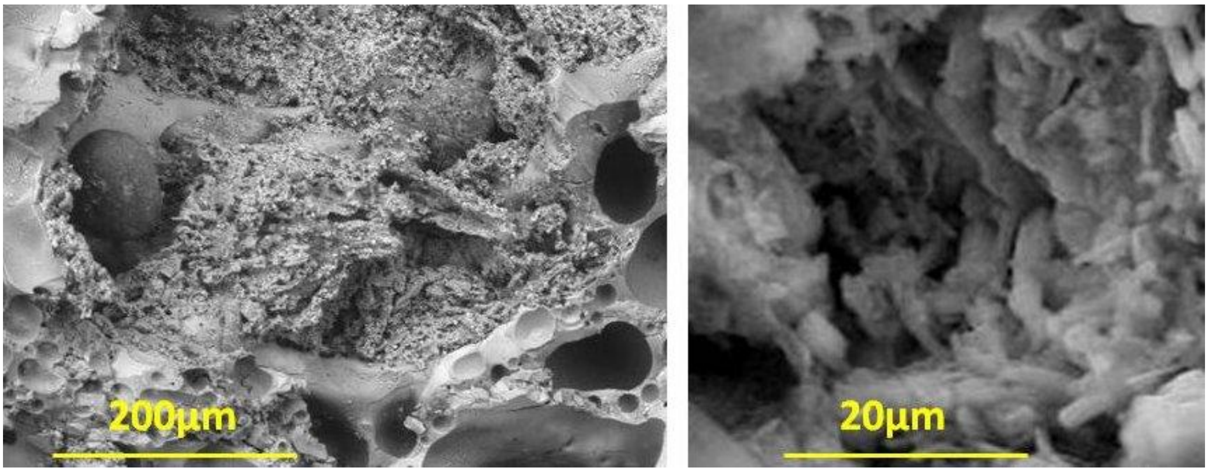

Fig.2 Fields of SEM of the meteorite on different scales

The exceedingly low average bulk density that is implied, $\rho < 1$ g cm^{-3} , and the presence of individual large cavities point to a relatively recent denudation of a cometary fragment. It is also worth noting that average porosity and the composite structure of the Polonnaruwa meteorite is not unlike a "macro" version of the general class of carbonaceous micrometeorites known as Brownlee particles. A comparison is shown in Fig.3.

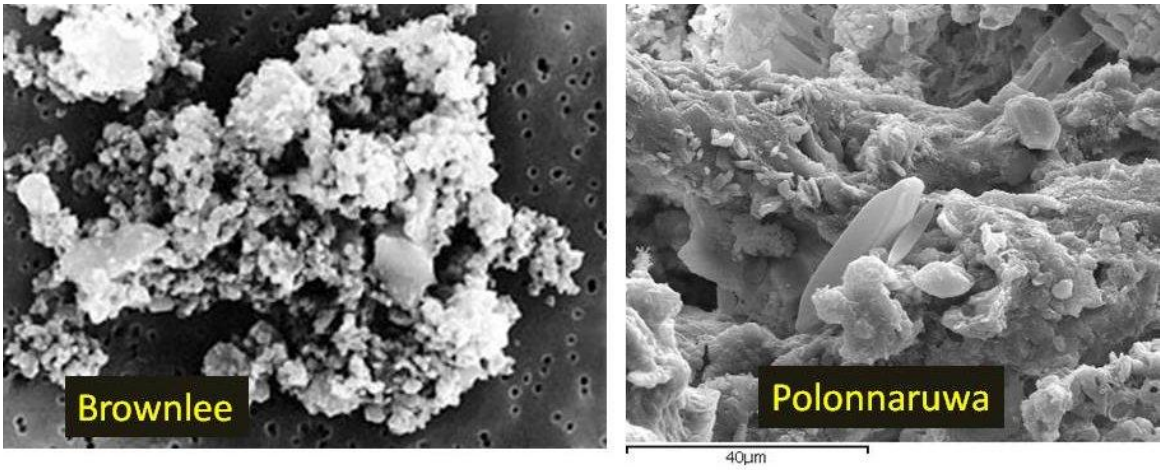

Fig. 3 Comparison of Brownlee micrometeorite and Polonnaruwa meteorite structure

From reports of strong odours and fumes that accompanied the falling stones we may infer that a large fraction of the empty cavities in the meteorite were filled with frozen volatile material, including organics, that volatilised in the atmosphere. If living cells including diatoms resided in a freeze-dried state within the pores, these too could have been added to the terrestrial biosphere. Some of the cells may have served to seed tropospheric rain clouds thus leading to red, yellow, green rain that was experienced in the same region a few days after the fireball event.

We conclude by reporting that an extract from the interior of a Polonnaruwa meteorite sample, studied under a light microscope at the Medical Research Institute in Colombo, was found to contain living diatoms (See Fig.4). If this result is confirmed in future studies and contamination is excluded, the meteorite would have been shown to contain both fossil as well as living microbes, and panspermia thus demonstrated in real time.

Fig.4 Living diatom extracted from the Polonnaruwa meteorite

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