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LIVING DIATOMS IN THE POLONNARUWA METEORITE – POSSIBLE LINK TO RED AND YELLOW RAIN

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ABSTRACT

Meteoroids belonging to a cometary meteor stream, upon entering the atmosphere, could undergo hierarchical fragmentation, and the smallest micron-sized dust might serve to nucleate rain. The larger fragments that survive passage through the atmosphere may end up as the spray of meteorites such as were collected in Sri Lanka on 29th December 2012 and 3rd January 2013. We show tentative evidence for the presence a wide range of genera and species of diatoms which are living, in addition to those discovered in SEM studies that are fossilised.

Keywords: Polonnaruwa Meteorites, Freezing nuclei, Red rain, Yellow rain, Living diatoms, Comets, Panspermia

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1. Introduction

A possible connection between meteor activity and the occurrence of freezing nuclei in the troposphere and rainfall has been noted for a few decades (Bowen, 1956). Fig. 1 shows the dates during the period 1954-1956 when concentration of freezing nuclei was found to be high in the troposphere (Bowen, 1956). The peak dates indicated here are typically 3-4 weeks *after* the Earth crossed the meteor streams – Geminids (Dec 13), Ursids (Dec 22) and the Quadrantids (Jan 3). Such meteor streams comprise particles of various sizes from millimetres to several tens of centimetres which largely burn up in the stratosphere. The occasional larger bolides burst through to the lower atmosphere, losing outer material underway if fragile due to the high pressure gradients, before exploding into a cluster of meteorites that land on the Earth or fall in the sea. This progressive fragmentation model with lateral spreading of fragments, where they break off (Ceplecha and ReVelle, 2005; Bland and Artemieva, 2006) applies to the fragile Polonnaruwa-bolide. The equipartition theory of Carpinteri Pugno (2002) with a single explosive break-up is too simplistic and does not apply in our case.

From the abundance of fragments of the Polonnaruwa-metorite over an area of scale ~1km, we can estimate an originating bolide of mass ~100-1000kg, and that the final explosive break-up occurred a few km altitude. Sightings of the fireball from a wider area (tens of km) suggest some breakup occurred at greater altitudes, with smaller fragments separating from the main fireball and dissolving into micro-fragments and gases high in the troposphere. This is consistent with the review of bolide fragmentation theory of Popova (2011) for low-density fragile rock. Only fragments below 100μm have low-enough terminal velocities to survive the frictional heating, as long as they retain coherence under the pressure gradients.

This scenario of successive breaking up during descent makes it plausible that the Polonnaruwa-bolide seeded the troposphere with micro-fragments just prior to its final fragmentation into 1-100cm meteorites. Microfragments in the stratosphere take day-weeks to fall under gravity and in this time were swept far from Sri Lanka by stratospheric winds. Micro-fragments in the troposphere are borne on turbulent air currents and would seed clouds above Sri Lanka under relatively fixed wind patterns.

To this scenario, we must add that the Polonnaruwa-bolide is likely associated with a meteor stream, of smaller mm-cm sized particles which encounter the earth over 2-3 days. These decelerate and frament at 50-80km altitude, then take days to weeks to settle through the stratosphere. The smallest particles take the longest time to fall, and serve to form freezing nuclei for ice/rain drops. The rainfall events following a meteor stream interaction are therefore spread over several weeks, as observed by Bowen (1956).

If we are looking for living organisms, that survive radiation conditions in space, we are more likely to find them within the interior of the 1-10 cm meteorite fragments. However, spores are radiation-hardy and could survive space travel and atmospheric landing within the mm to cm-sized meteor stream particles (Wallis & Wickramasinghe 2004).

With the smallest particles taking the longest time to fall, and thus serving to form freezing

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nuclei for rain, the rainfall events following a meteor stream interaction could be spread over several weeks as observed by Bowen (1956). This appears to have been the case with the Sri Lankan red/yellow rain episodes in December 2012.

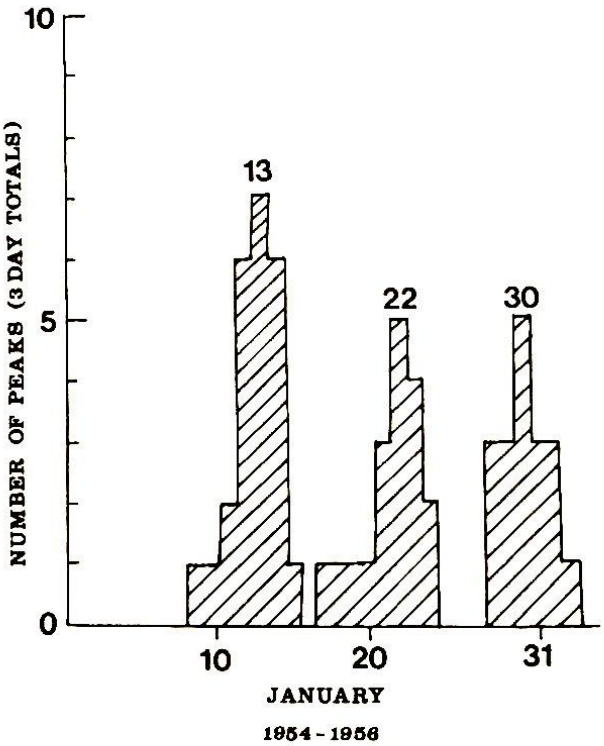

Fig.1. Histogram of the dates in January when the concentration of freezing nuclei was observed to be high in 1954, 1955, 1956 (From Bowen, 1956)

The first reported meteor activity in Sri Lanka (confirmed by radio frequency disturbances in the ionosphere) date towards the end of November 2012.

The first reports of red and yellow rain in Sri Lanka appear sporadically from mid-December 2012, approximately two weeks after the start of the Geminid meteor showers, including sightings of fireballs. Our earlier papers in the present series described the existence of diatoms in these rocks that indisputably fell from the sky over Araganwila, Polonnaruwa on 29 December 2012 and over Mahiyangama (Rakkinda village) on 3-4 January 2013 (Wickramasinghe et al, 2013a,b). The two falls appear to be similar with respect to the biological structures that were found within them, and we also shown that these stones could not be interpreted as fulgurites as some have claimed. The proximity of these events to the time at which the Ursids (debris from Comet, 8P/Tuttle) were expected to be a maximum suggests that the Earth encountered particularly large fragments in this meteoroid stream, some of which survived entry through the atmosphere, ending up as meteorites.

It is tempting to speculate that micron-sized dust (including diatoms) from the fragmenting meteoritic bolides may have seeded tropospheric rain clouds to produce episodes of red, yellow and possibly green rain as were reported during December and January in various locations in Sri Lanka.

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2. Living diatoms in the Polonnaruwa meteorite

Could there indeed be living diatoms, as opposed to fossils, in the Polonnaruwa meteorite, and could they have been dispersed in the troposphere to form freezing nuclei for rain? The question may sound outrageous, but if the answer turns out to be in the affirmative, the consequences will be profound. Ongoing panspermia in real time would then have been proved (Hoyle and Wickramasinghe, 2000), and the origin of life pushed back to a probable time of some 300,000 to 1 million years after the Big Bang (Gibson et al, 2010).

In earlier papers we reported the discovery of distinctly recognisable diatom frustules in the Polonnaruwa meteorites (Wickramasinghe, Wallis, Wallis et al, 2013a,b). These structures are intertwined with the rock matrix, and we argued that they could not be modern terrestrial contaminants. Accepting the evidence that points to the identification of these stones as meteorites – albeit defining a new class of meteorite - the existence of primitive life in their parent body appears undeniable. We provisionally identify the parent body as a cometary crust beneath which photosynthetic diatoms could have survived over millions of years.

The existence of living or viable diatoms in the meteorite was already suggested in SEM studies by the presence of what appears to be exopolysaccharide membranes surrounding some of the diatoms. We now present more direct supportive evidence from optical microscope studies carried out in Sri Lanka.

The surface of a meteoritic stone was sterilised and a sterile wide-bore hyperdermic syringe inserted into a depth of about 2-3 cm into its interior. By this means a small quantity of fine powdery material from the interior was extracted and dispersed onto a drop of sterile distilled water on a sterilised microscope slide. Examination under a light microscope showed a range of diatoms exhibiting motility as well as evidence of chlorophyll-containing chromophores.

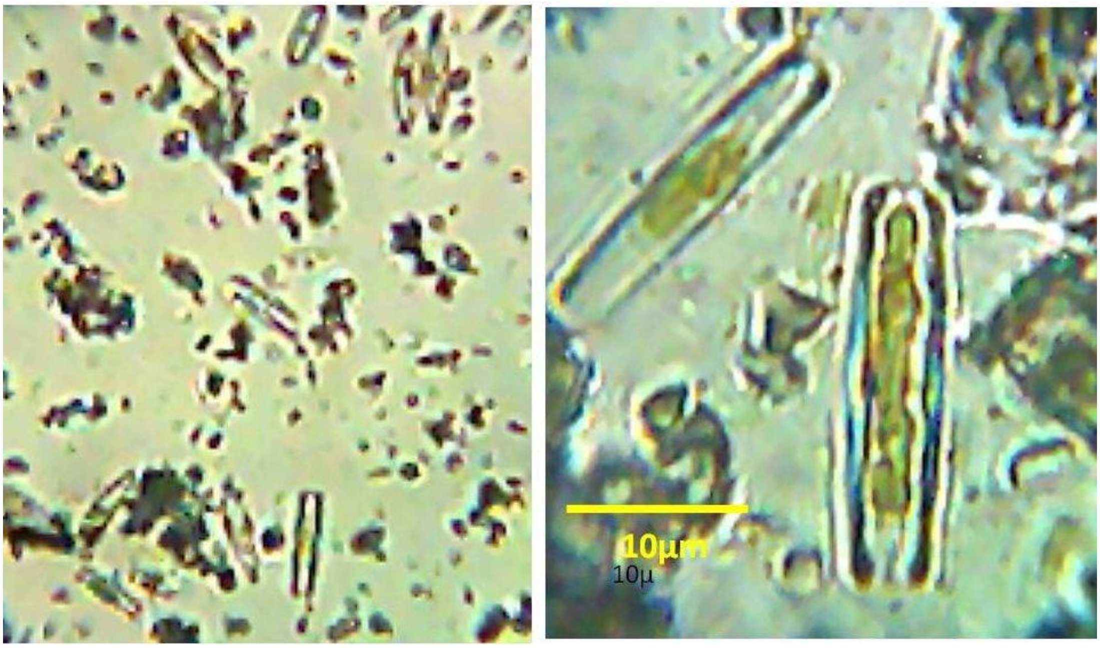

Fig.2. Living diatoms from the interior of the Polonnaruwa meteorite

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The right panel of Fig. 2 shows individual diatoms. The left panel of Fig. 2 shows a microscope field with a large and diverse collection of well recognisable diatoms, that can be presumed living by their distinctly visible interior chromatophores imparting the colours seen here. To rule out contamination as the explanation of the results in Fig. 2 we have subjected the soil 10 cm below the collection site to the same SEM and optical microscope examination. The negative results obtained so far in this control experiment gives us confidence to conclude that the living diatoms are indigenous to the meteorite and were not introduced from the surrounding soil.

3. Living biological cells in the red and yellow rain

The presence of living cells of an unidentified kind in the red rain of Kerala has been discussed elsewhere (Louis and Kumar, 2006) and similar cells are found in the Sri Lankan red rain as illustrated in the optical microscope image in Fig.3.

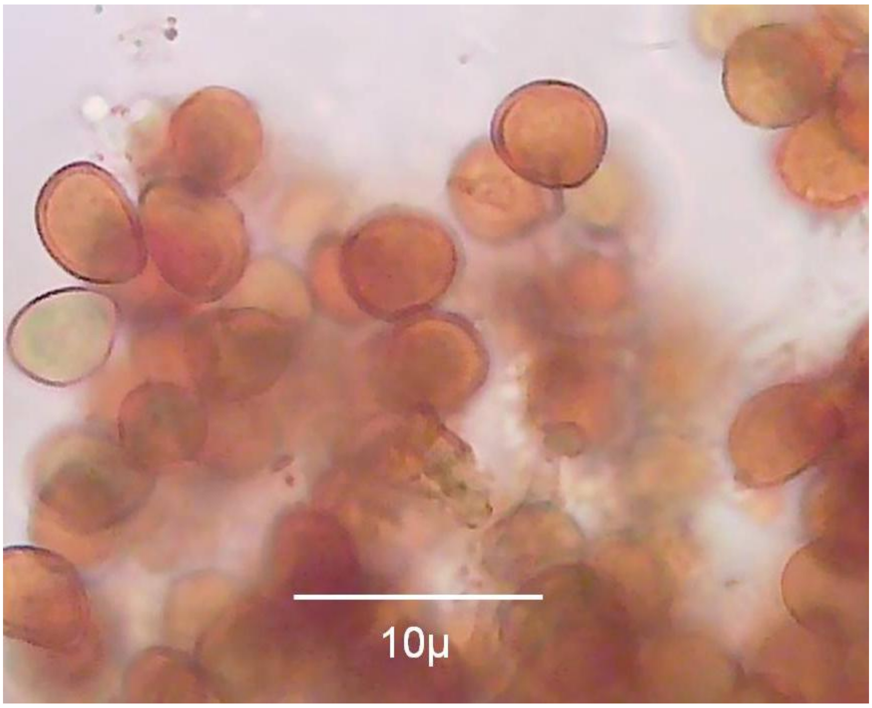

Fig.3 Red rain cells in the red rain of Sri Lanka

A hint of the presence of similar red rain-type cells in the Polonnaruwa meteorite material was already discussed in an earlier paper (Wickramasinghe, Walllis, et al, 2013a), and further work on detecting such cells is in progress.

Optical microscope images of the yellow rain have revealed the presence of several unidentified microorganisms including an abundance of diatoms that may have imparted an yellow/green colour to the rain. An example is shown in Fig.4

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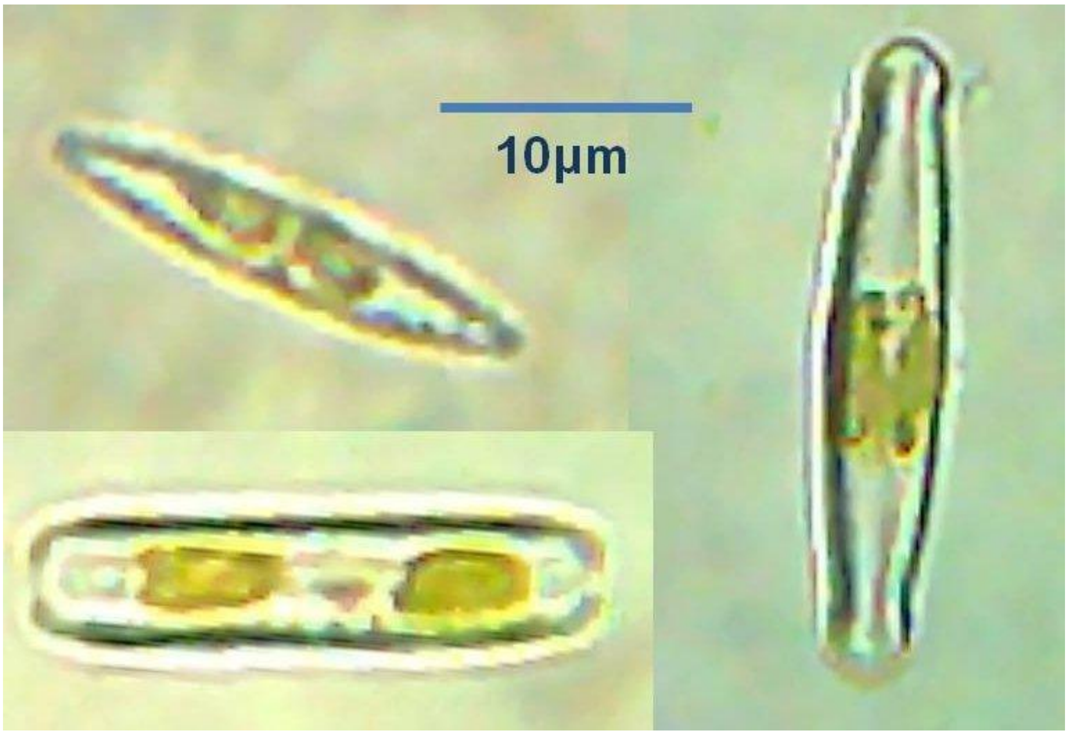

Fig.4 Living diatoms in a microscope field of the yellow rain

If the observed diatoms are not terrestrial contaminants we must conclude that diatoms, along with other microorganisms, are gaining ingress to Earth at the present time. This would be consistent with earlier studies that have shown the presence of microorganisms at 41km altitude in the stratosphere (Wainwright et al, 2003; Shivaji et al, 2009), and in the still unidentified microorganisms present in the red rain of Kerala in 2001 (Gangappa et al, 2010) and in the Sri Lankan red rain in 2012.

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