Journal of Cosmology, 2013, Vol. 22, pp 10183-10188 (accepted August 9, 2013)

ISOLATION OF A DIATOM FRUSTULE FRAGMENT FROM THE LOWER STRATOSPHERE (22-27Km)-EVIDENCE FOR A COSMIC ORIGIN

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Abstract

Sampling of the stratosphere at heights between 22 and 27 km was carried out in the UK on 31st July 2013 using balloon-borne equipment carrying aseptically clean electron microscope stubs onto which aerosols were directly captured. The experiment revealed the presence of a diatom frustule captured from a height of >25km. On account of the very short residence time of particles of diatom size and mass at these heights, we argue for its incidence from space, with a probable origin in the watery environment of a comet.

Keywords: Stratosphere, diatoms, comets, panspermia

Introduction

There have been a number of investigations showing that viable bacteria and fungi exist in both the lower (Griffin, 2004, 2008, Smith *et al*, 2010) and the upper stratosphere over the altitude range 20km-60km (Imshenetsky *et al*,1978, Bigg, 1984; Greene *et al*, 1964; Harris et al, 2002; Wainwright *et al*, 2003,2004; Yang et al, 2008,2009; Shivaji *et al*, 2009). Since a number of different methodological approaches have been used in these studies, and a range of different microbes have been isolated from the stratosphere using a variety of approaches, there is little doubt that microbes do exist in the stratosphere. Such organisms are unlikely to grow in this "high cold biosphere" but survive instead in the dormant state as "extremodures" (Wainwright, 2008); the fact that bacteria and fungi can be grown on isolation media when returned to Earth shows however, that these stratosphere-derived microbes remain viable despite exposure to the extreme rigours of the stratosphere.

Here we report, using a relatively simple low-cost stratospheric sampling methodology, the isolation of a particle which, beyond doubt, is a fragment of a diatom frustule. We believe that this is the first-ever report of the isolation of a diatom frustule from the stratosphere and we provide arguments to support our view that this biological particle may have arrived from space.

Materials and Methods

A balloon-launched sampling device was released from Chester, NW England on 31st July 2013. The sampler included a drawer mechanism that could be opened and closed at any desired height using telemetry. The stratosphere sampler carried a video camera by which the opening and closing of the sampling draw was viewed, confirmed and recorded. The sampling apparatus was protected from downfall of particulate matter from the balloon by a cover. Prior to launch, the inside of the draw device was scrupulously cleaned, air blasted and finally swabbed with alcohol. New scanning electron microscope stubs were placed in rows inside the drawer with their top surfaces facing outwards so that when the draw was opened any particulate matter in the stratosphere would attach to them and they could later be removed for examination under the scanning electron microscope. The protective layer on the surface of the stub was peeled off just before launching under a cover to prevent any particulate contamination. After sampling, the apparatus was transported to the laboratory and opened under conditions which avoided exposure of the stubs to contaminating dust and the stubs were similarly transferred under cover to the scanning E/M. The stubs were then sputter-coated with gold for 30secs at 30mA and then examined using a SEM (JEOL 6500F).

Balloon launch: The balloon was launched from an open field near Dunham on the Hill (near Ellesmere Port, Cheshire, England) during daylight hours and traversed to just south of Wakefield in West Yorkshire (England). The sampling drawer was opened for 17 minutes as the balloon rose from 22026m to 27008m. The sampling apparatus was returned to Earth (by parachute) undamaged and completely intact.

Control flight: A separate control flight was made to the stratosphere prior to the sampling flight, when the draw was not opened, but all other sampling procedures were observed. No particulate matter was found (using the SEM) on any of the unexposed microscope studs, showing that the draw remained airtight and that none of the stubs was exposed to particles at, or near, ground-level or at any height up to the stratosphere. These results also show convincingly that no particles contaminated the stubs during any of the sample processing procedures, thereby demonstrating that the scrupulous procedures used to prevent ground level contamination proved effective and that no such contamination occurred.

Results and Discussion

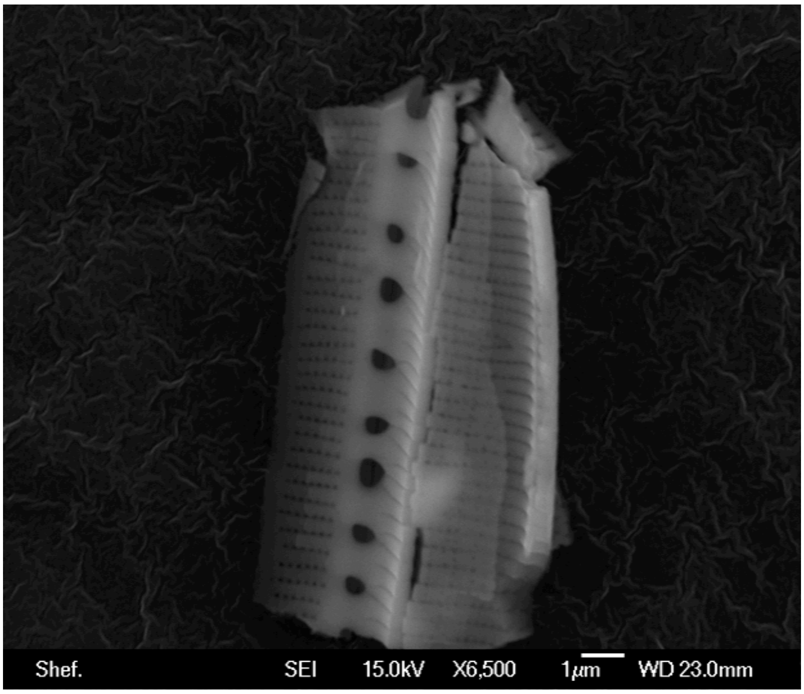

Fig. 1 SEM of a diatom frustule (possibly a *Nitzschia* species) captured on a stub from a height of 25km in the stratosphere

Figure 1 shows a scanning electron micrograph of the surface of an SEM (scanning electron microscope) stub which was exposed to the lower stratosphere (at a height of between 22-27 km) over Northern England on 31st July 2013. On one stub was discovered part of a diatom which, we assume, is clear enough for experts on diatom taxonomy to precisely identify. Similarities with a broad class of diatoms belonging to the *Nitzschia* species point to a probable tentative identification with a terrestrially known similar organism. The diatom in Fig.1 is obviously incomplete and probably does not contain a protoplast, and is therefore part of an empty frustule. It is not known if the diatom reached the stratosphere as a fragment or whether it arrived with a viable protoplast encased within an intact frustule. The frustule was associated, on the same stub, with cosmic dust particles similar to those seen during balloon sampling flights to 41km (Wainwright, 2008).

As stated in a previous section, both bacteria and fungi have been isolated from the lower as well as the upper stratosphere (Greene et al, 1964; Yang et al, 2009). Since many inorganic particles can morphologically resemble bacteria or clumps of bacteria it is often difficult without additional evidence to be absolutely certain that a bacteria-like particle found in the stratosphere is a biological entity rather than a mineral particle. This problem does not however, apply to the particle shown in Fig.1 which is clearly and unequivocally part of a diatom and not an inorganic particle. Critics have also claimed that the bacteria isolated from stratospheric sampling do not come from this region but are contaminants which originate from the balloon itself, or during later processing of the stratosphere-derived samples in the laboratory. Again this criticism emphatically does not apply to the diatom frustule shown in Fig.1 simply because diatoms do not occur on pristine balloons, in laboratory air, nor are they associated with laboratory workers. The methods used to clean the sampling apparatus would also prevent such contamination, as would the approaches used to maintain sterility before the E/M stubs were exposed to the stratosphere. It is therefore clear that the particle shown in Fig.1 is a fragment of a diatom frustule which was isolated from the stratosphere at a height of between 22 and 27km.

How did the diatom frustule reach the lower stratosphere?

There are clearly two possibilities to explain how the diatom isolated here reached the lower stratosphere; either it was lofted from Earth's surface, or it was falling to Earth from space. Occam's razor might suggest to some that the latter possibility occurred and that the diatom was in some way lofted from Earth to the stratosphere. The most obvious means by which a particle of the size and mass of the diatom fragment shown in Fig.1could be lifted from Earth's surface to, say 25 km, is by a violent volcanic eruption. However, no such eruption appears to have taken place in the months prior to the short period of our stratosphere sampling. The residence time in the stratosphere of such a relatively large and dense particle as the diatom fragment would have been very short.

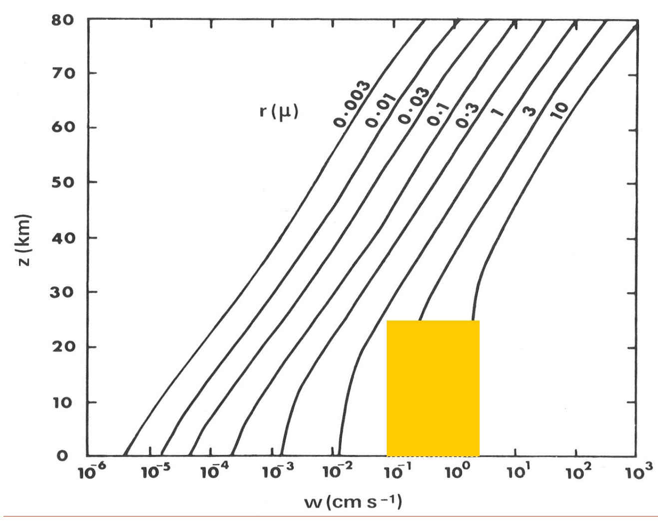

Fig. 2 The falling speed of aerosols of various radii in the atmosphere calculated by Kasten (1968). The highlighted domain corresponds to falling diatoms.

Fig.2 shows the falling speed of spherical particles of various radii (and density 1 g cm^{-3}) through the atmosphere calculated by Kasten (1968) using a standard atmosphere model. From this data we calculate that a diatom of radius in the range 3-10 micron would fall at an average of 1cm s^{-1} at a height of 20km, and that the residence time of any particle lofted to this height is about 6 hours. The conclusion is that even if a major volcanic eruption occurred a few days before the sampling event, no particles of the size of the diatom fragment resulting from it would have been retained in the stratosphere at the point of sampling. There is no record that any such eruption took place. In fact, the most recent major volcanic activity occurring close to the UK was the Evjafjallajokull volcano, which erupted on Iceland in early 2010 and caused considerable problems to commercial flights. There is certainly no way, as is often casually suggested by unthinking critics, that a particle, like the one seen in Fig.1, could simply float into the stratosphere or be carried by winds up to heights well above the tropopause. It is also unlikely that the fragment could have come from commercial aircraft, which fly below well below our stratospheric sampling height. Other possible mechanisms by which the particle could theoretically be carried into the stratosphere include gravito-electrophoresis and the involvement of blue lightning (Wainwright et al, 2004), but even these would probably only theoretically elevate particles of radii greater than 1micron to the stratosphere. It is noticeable that the diatom fragment is remarkably clean and free of soil or other solid material, thereby suggesting that it originated from a water environment, rather than being associated with volcanic debris; in relation to an Earth origin it could have resided in the oceans, while a comet could have provided a cosmic origin for the diatom fragment (Hoover et al, 1984; Wickramasinghe and Hoyle, 1999).

Concluding remarks

The diatom fragment shown in Fig.1 is a particle of relatively large size and mass and by our current understanding of the means by which such particles can be transferred from Earth to the stratosphere could not, in the absence of a violent volcanic eruption occurring within say a day of the sampling event, make such a journey. The implication of this assumption is obvious, if there is no mechanism by which the diatom fragment shown here could be elevated from Earth to the stratosphere then, when it was sampled, it must have arrived from above the stratosphere and have been incoming to Earth. Of course the standard mode of rebuttal to a space origin for the fragment is to assert that Occam's razor informs us that there *must* be a mechanism for lofting particles of this size from Earth to the stratosphere and that our findings are proof of the existence of such an *unknown* mechanism, the search for which must now begin. While an Earth–bound origin for this diatom fragment may be invoked in order to meet criteria of parsimony or conservatism, we argue that since no major violent volcanic event or other atmospheric event occurred close to the time and place of sampling, the diatom fragment shown in Fig.1 must most plausibly have come from space – thus establishing consistency with theories of cometary panspermia (Hoyle and Wickramasinghe, 2000; Gibson *et al*, 2011).

The sampling resulting in the recovery of this fragment was carried out in mid-late July 2013 during the period of the annual Perseid meteor shower. Meteorite dust in bolides has occasionally been found to be deposited into the lower stratosphere around an altitude of 20km (Jenniskens, 2006). Although no biological structures have been reported thus far in such material, it may be relevant that diatom frustules have recently been found in meteorites that fell in Sri Lanka, which are also probably from a meteor shower (the Taurids) in a rare instance of meteoroids reaching the ground (Wickramasinghe *et al*, 2013; Wallis *et al*, 2013).

To conclude we note that the results presented here provide unequivocal evidence that a diatom fragment has been found in the lower stratosphere. Further studies by us are now underway on the biology of the stratosphere with a view to finally answering the question of where the organisms found in this region originate – are they exiting from Earth, or falling in to our planet from space? For the moment we are content to claim that diatom fragment isolated during these studies has an extraterrestrial origin.

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