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Evidence of Microbiology in Comets

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Abstract

In this paper, we re-examine a wide range of evidence for comets as carriers and distributors of life in the cosmos. The significance of a recent probable detection of dimethyl sulphide (DMS) as a potential biomarker has been challenged on the basis of its discovery in comet 67P/CG, a comet that wrongly came to be regarded as a "dead" comet. Our own extensive studies over nearly 4 decades have consistently established a strong case for the comet 67P/CG being indeed a living rather than a dead comet, and the new discoveries simply add to the strength of this earlier assertion.

Keywords

Comets, Organic Molecules, Methyl Disulphide, Bacteria

1. Introduction

Serious scientific discussions about the possibility of comets harbouring microbial life began over 4 decades ago [1] [2] (Hoyle and Wickramasinghe 1981, 1985). The recent revival of the same idea, with discussions centred on new and relevant data, cannot be divorced from this earlier historical context. The initial discussion of cometary biology, based on a growing body of relevant facts, moved swiftly from speculation to serious science following the last perihelion passage of Comet P/Halley in 1986. The first investigation of a comet after the dawn of the Space Age (ESA's Giotto mission) marked a crucial turning point in the history of cometary science. A dark comet surface ("darker than the darkest coal") was indicated by the Giotto photometry, thus promptly overturning the long-held Whipple "dirty snowball model" of comets with a carbonaceous model quickly coming to the fore. More importantly, D.T. Wickramasinghe and D.A. Allen obtained the first 2 - 4 micrometre infrared spectrum of the dust emanating from an outburst of the same comet on 31st March 1986 [3]. This spectrum in its detailed configuration showed unequivocal evidence of C-H rotational/vibrational stretching indicating complex aromatic/aliphatic hydrocarbon structures, that were remarkably *consistent* with an absorption spectrum for bacterial dust. This correspondence shown in **Figure 1** paved the way for an avalanche of similar results all unerringly pointing in the same general direction in the years and decades that followed.

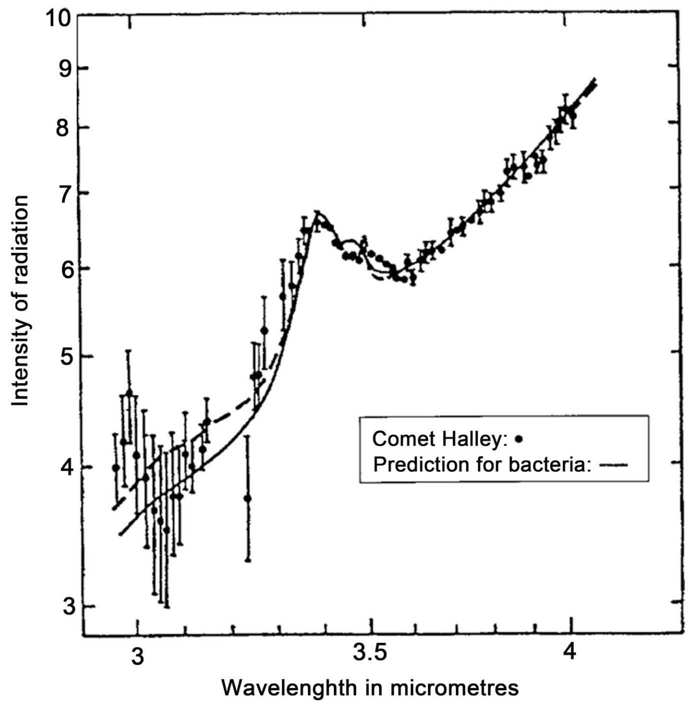

Figure 1. Infrared emission by dust coma of Comet Halley observed by D. T. Wickramasinghe and D.A. Allen on March 31, 1986 (points), compared with normalized fluxes for desiccated E-coli at an emission temperature of 320 K [3]. The solid curve is for unirradiated bacteria; the dashed curve is for X-ray irradiated bacteria.

2. The Ever-Growing Case for Biological Comets

Over the ensuing decades Fred Hoyle and one of the present authors continued to present a large body of compelling evidence in support of the contention that comets are the most natural repositories and distributors of bacterial life in the Universe [1] [2] [4]. The interior domains of comets and cometary-type bodies (e.g., carbon-rich asteroids), heated by long-lived nuclides (e.g., Al-26), and containing liquid water, were shown to be maintained over astronomical timescales extending to billions of years [1]. Such domains serve as natural repositories as well as transmitters of microbial life across the galaxy.

Fragments of extinct comets in the form of carbonaceous meteorites could well contain tell-tale signs of a bio-friendly past history. This seems to be clearly evident in the Polonnaruwa meteorite (Wickramasinghe, Wallis and Wallis, [5]) as well as in the highly porous fragments recently recovered from the asteroids Ryugu and Bennu [6]. In the case of the recovered fragment of Ryugu (see **Figure 2**), an extensive range and variety of microorganisms have been discovered in the porous matrix, but all these have been dismissed as most probably arising entirely from terrestrial contamination (Genge *et al.*, [6]). Whilst we cannot absolutely refute this claim, the possibility of viable microbial spores pre-existing within a loosely aggregated rock that has been derived from a once "living" cometary or asteroidal body cannot be ruled out.

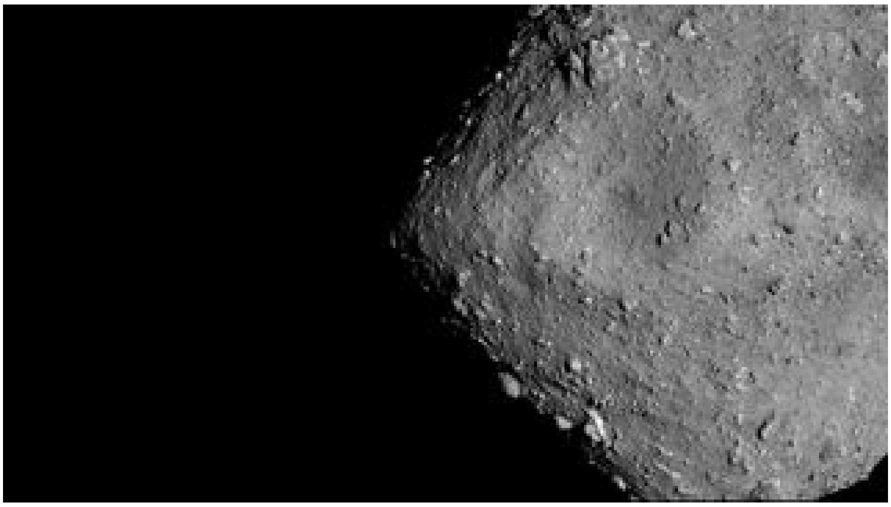

Figure 2. Image of the asteroid Ryugu from Japan's Hayabusa 2 mission. (Image credit: JAXA/University of Tokyo/Kochi University/Rikkyo University/Nagoya University/Chiba Institute of Technology/Meiji University/University of Aizu/AIST/Kobe University/Auburn University).

Although a majority of cometary scientists over the past decade have felt comfortable admitting the discovery of biologically relevant organic molecules in comets, admitting the possible evidence of alien life, no matter how strong such evidence might be, has proved difficult, mainly for cultural reasons in our view.

Historically, a highly significant correspondence with biology emerged from the Stardust Mission, which captured high-speed cometary dust in blocks of aerogel and studied the residues in the laboratory. Discovered amongst the cometary residues was the most common biological amino acid Glycine together with a mixture of other hydrocarbons [7]. As was the common trend at the time, all this was set peremptorily aside as being *merely* the discovery of *prebiotic* building blocks of life in the external universe, a discovery that posed no threat whatsoever to the prevailing dogmas in science. The same was the dismissal of evidence of aqueous activity from sulphide mineral assemblages in the samples that were returned from the Stardust Mission in 2011 [8].

3. Rosetta Mission

The Rosetta Mission to Comet 67P/C-G (2013-2016) next came in to yield a wealth of new data that satisfies all the consistency checks for biology. **Figure 3** shows the comet spewing out material including water and organic molecules in January 2015.

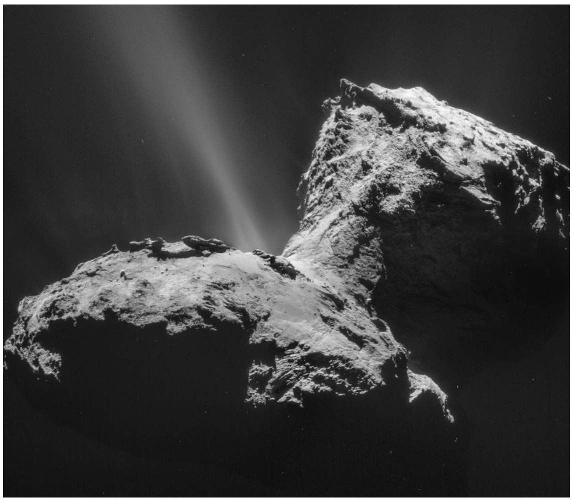

Figure 3. Comet 67P/Churyumov-Gerasimenko on Jan. 31, 2015. (Courtesy European Space Agency Rosetta team).

Figure 4 shows the strikingly close correspondence between the surface reflectivity properties of this comet at mid-infrared wavelengths and the spectrum of a desiccated bacterial sample [9].

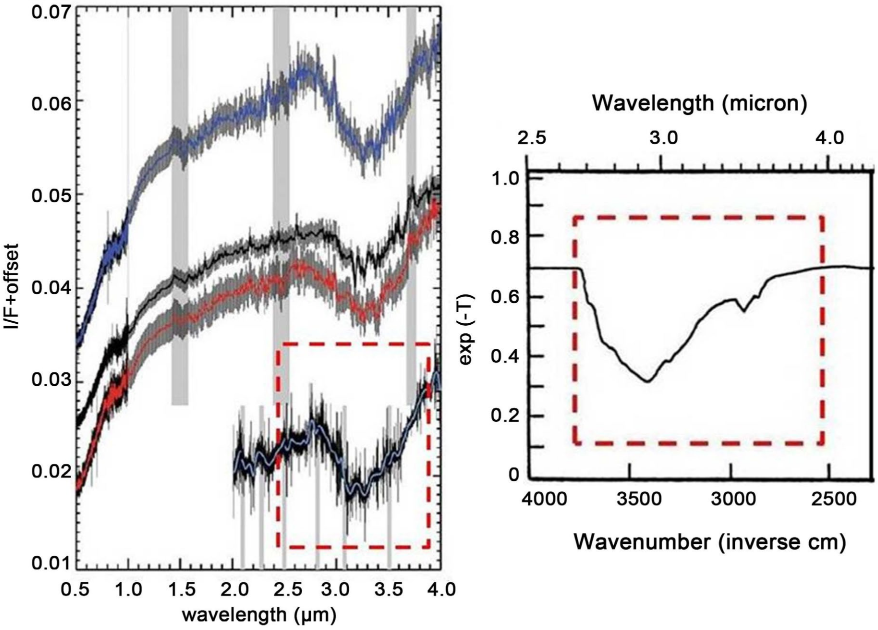

Figure 4. The surface reflectivity spectra of comet 67P/C-G (left panel) compared with the transmittance curve measured for E-coli (right panel) [9].

The Rosetta Mission's Philae lander also provided novel information about the comet 67P/C-G that, when properly interpreted, appears to be in serious conflict with the idea of a non-biological comet [5] [10]. Jets of water and organics issuing from ruptures and vents in the frozen surface, as seen in **Figure 3**, are consistent with biological activity occurring within sub-surface liquid pools.

Although there is a tendency in mainstream astrobiology to devalue the correspondences seen in **Figure 1** and **Figure 4** as coincidences arising from simple chemical functional units, weighted in a unique way that matches the spectrum of biomaterial, positing such a precise coincidence to operate on a galactic scale stretches credibility to its utmost limit. As Sherlock Holmes once declared in relation to such astounding coincidences: "the Universe is rarely so lazy"—implying that such precise and complex coincidences must always have a deeper meaning.

The report of O_2, along with confirmatory evidence for the occurrence of water and organics, provides further evidence of ongoing biological activity. Such a mixture of gases cannot be produced non-biologically under thermodynamic conditions, because organics would be readily destroyed in an oxidizing environment.

The freezing of an initial mixture of compounds, including O_2, not in thermochemical equilibrium, has been proposed. However, there is no evidence whatsoever to support such a claim. On the other hand, the oxygen/water/organic outflow from the comet can be readily explained on the basis of subsurface microbiology. Photosynthetic microorganisms operating at low light levels near the surface at perihelion could naturally produce O_2 along with organics. Many species of fermenting bacteria can also produce ethanol from sugars, so the recent discovery that Comet Lovejoy emits ethyl alcohol equivalent to 500 bottles of wine per second, may well be an indication that such a microbial process is operating [11] (Biver *et al.*, 2015).

Next, we turn to the discovery of the amino acid glycine, as well as a high abundance of the element phosphorus, in the coma of comet 67P/CG [12] (Altwegg *et al.*, 2016). Very high ratios of $P/C \approx 10^{-2}$ were observed and are difficult to reconcile on the basis of the volatilization of condensed material of solar composition with a $P/C \approx 10^{-3}$, particularly when we might expect inorganic phosphorus to be mostly fixed in refractory minerals. On the other hand, the P/C ratio of biomaterial is close to that implied by the cometary data and would be readily explained if the material in the coma started off as biomaterial—virions and bacteria.

With the presence of complex organic molecules, including the building blocks of life, independently confirmed to be present in comets, it is now reasonable to defend the thesis that there is indeed fully-fledged microbial life in comets, and moreover that these celestial objects are the repositories and the most probable conveyers of biology on a cosmic scale. The consensus view, however, that still dies hard is that although life-related chemicals, including prebiotic molecules, are permitted to exist in comets, fully-fledged life cannot.

4. Other Relevant Comet Data

Whenever a distant astronomical body exhibits conditions that can support life, the next task is to look for evidence of molecules and/or chemistry that may be indicative of life. The model for cosmic life that is used is, of course, terrestrial carbon-based life—the only life we know of and have access to direct experimentation. One essential property of life as we know it is that it alters the composition of an environment from conditions appropriate to thermodynamic equilibrium. The combination of oxygen O_2, O_3 (oxidizing) with gases such as methane (reducing) is not permitted by thermodynamics, so their coincidence or concurrence in space may be regarded as *prima facie* evidence of biology.

Methyl chloride (CH_3Cl) is the principal source of atmospheric carbon in the terrestrial case and is mostly produced by biochemical processes [13] [14]. Emission of CH_3Cl by wood-rotting fungi contributes to some of the atmospheric complement of this molecule. The presence of significant amounts of this same molecule in space would be a possible biomarker, indicating its production in habitats similar to those found on Earth. The recent discovery of this molecule both in interstellar clouds and in Comet 67P/C-G is interesting, and so is its rejection as a biomarker, which is significant in the context of what we have discussed earlier. In another development, the discovery of cometary activity in the outermost regions of the solar system has consistently pointed to active subsurface biology analogous to a fermentation process and consequently to an independent validation of cometary panspermia [15] [16] (Wickramasinghe, Hoyle and Lloyd, 1996; Wickramasinghe, 2022).

5. Relevance of Exoplanets

The discovery of a large number of exoplanets (planets orbiting distant stars) followed the deployment of the Kepler Space Telescope in 2013, that was dedicated to this end. The number of exoplanetary systems discovered in our galaxy, some of which can support life, is reckoned to be on the scale of hundreds of millions [17]. One such exoplanet discovered in 2015 was orbiting the red dwarf star K2-18 in its habitable zone and was located about 120 light-years away from the solar system. This exoplanet, which was more massive than Earth, had its atmosphere recently analysed using archived data from NASA's Hubble Space Telescope from 2016 and 2017. An announcement was made in 2019 that there was evidence of water vapour and cloud structures in the mid-atmosphere regions of K2-18b, and that the planet had the same amount of total isolation from its host star as the Earth receives from the Sun. It was also argued that the planet had the right conditions for water vapour to condense, which explained the detected clouds [18].

Interest in the exoplanet planet K2-18b continued to grow and on September 8, 2023, astronomers from the UK and USA published a report on "Carbon-bearing Molecules in a Possible Hycean Atmosphere" describing the transmission spectrum of K2-18 b obtained with the James Webb Space Telescopes NIRISS and NIRSpec instruments in the 0.9 - 5.2 μm wavelength range [18]. By analysing such spectra, they found an abundance of CH_4 and CO_2 which, along with the non-detection of ammonia (NH_3), was inferred to be consistent with predictions for an ocean under a temperate H_2-rich atmosphere. The spectrum also suggested the detection of the biomolecule dimethyl sulfide (DMS) which was predicted by Seager [19], as a biomarker. On Earth, dimethyl sulfide is only known to be produced by photosynthesizing marine bacteria and phytoplankton, although more work is clearly needed to firmly establish this point.

6. Dimethyl Sulfide (DMS) in Comet 67P/C-G

The suggestion of possible biological activity on the planet K2-18b attracted the attention of a team of astronomers from the University of Bern in Switzerland who had earlier studied comet 67P/Churyumov-Gerasimenko with the high-resolution mass spectrometer on ESA's Rosetta spacecraft [20]. They discovered spectroscopic evidence of dimethyl sulphide (DMS) in 67P-CG's coma, a molecule believed to have only been associated with living sources on Earth, which was considered "staggering" for a comet that was previously declared to be a "cold lifeless comet". This discovery has apparently called into question the usefulness of DMS as a biosignature, which is of course not logical by any means. These new results of comet 67P/CG were presented to the 2024 European Geosciences Union in Vienna, Austria and have yet to be fully assessed. However, the assumption that comets are of necessity lifeless does not take account of other evidence such as shown in **Figure 3** and is therefore unscientific and without any foundation in our view. If due account is taken of all other relevant evidence discussed earlier, the new results on DMS in the comet further support the existence of cometary life. Nor does the new finding by the Rosetta team in any way challenge the DMS molecule's usefulness as a biosignature in the wider universe. It merely confirms it, and more generally reaffirms that life is unequivocally a cosmic phenomenon as maintained by Fred Hoyle, Chandra Wickramasinghe and their many collaborators from the early 1980's to the present day.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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