Claims of Indigenous Life Forms in Meteorites: A Short Review

Bt Arnaud Mignan

Are we alone in the Universe? The answer has eluded mankind until now. Or has it? Scientists have repeatedly claimed to have found proof of extraterrestrial life. The most recent of these claims was by Richard B. Hoover, a NASA scientist, who has supposedly found evidence for indigenous microfossils in carbonaceous meteorites[1] (Hoover, 2011). Of the many claims of alien life that have been made, the ones describing living organisms or fossils in meteorites are some of the most fascinating since they are linked to something tangible. What better way could there be to prove the existence of extraterrestrial life than by having a piece of rock that contains some kind of alien form, fossil or alive, within it.

The histogram shown in Figure 1 depicts the chronology of claims of indigenous life forms, both past and present, found in meteorites, as well as the subsequent debates, from the early age of meteoritics to the present day. The histogram's cycle-like structure is striking. Each cycle starts with one extraordinary claim: meteoritic stones and irons contain fossils of multi-cellular invertebrates (Hahn, 1880), chondrites contain living indigenous bacteria (Lipman, 1932; Geraci et al., 2001), microfossils can be found in carbonaceous meteorites (Nagy et al., 1961; Hoover, 2011) as well as in Martian meteorites (McKay et al., 1996). Other studies always follow, refuting or corroborating the initial claim. Finally, the hypothesis dies off, though some have been revitalized decades later in a new cycle. Interestingly, this structure follows the famous Thomas Kuhn's Structure of Scientific Revolutions[2] (e.g., Kuhn, 1970).

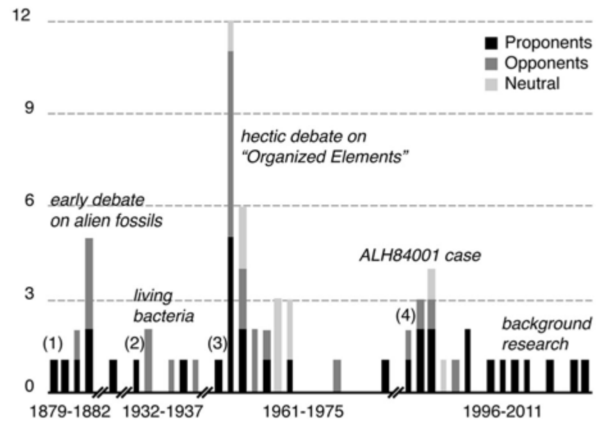

Figure 1: Chronology of claims of indigenous life forms (past or present) found in meteorites and of the subsequent debates, from the early age of Meteoritics to the present day, described by the number of publications per year. Milestones are (1) Hahn, 1879; 1880, (2) Lipman, 1932, (3) Claus & Nagy, 1961 and (4) McKay et al., 1996. Although there are hundreds of references related to the ALH84001 meteorite debate, only very few focus on the claimed observations of nanofossil shapes. The full list of publications used to generate this histogram is given in Table 1. An extended version can be found at http://www.thetricottetcollection.com/pub_met_life_suppl_Table1.html

Fossil Life Forms?

> *"La Paléontologie reste pour nous unique en son genre et dépourvue encore de terme de comparaison. Mais comme, en réalité, rien n'est unique dans la nature, sinon la nature elle-même, la seule question possible est de savoir si des termes de comparaison, qui existent certainement quoique nous les igorions, viendront ou ne viendront pas à notre connaissance"[3] – Stanislas Meunier (1871)*

In the late 19th century, Otto Hahn, not to be confused with the German chemist and Nobel laureate of the same name, claimed the presence of fossils in meteorites. He believed he had identified, in thin sections, fossils of sponges, corals and crinoids in ordinary chondrites and even in irons (Hahn, 1880). Hahn's idea was later rejected by most of his contemporaries. J. Lawrence Smith[4] stated: "Although I have probably examined more microscopic plates of (…) meteorite than any other person, still I have never discovered anything like organic remains" (Louisville Courier Journal, 1881). As can be seen in Figure 2a, the author clearly misinterpreted chondrules as being fossilized corals. This is a clear example of pareidolia, the same process that makes you see animal shapes in clouds. One other obscure

Table 1: List of publications related to the question of indigenous life forms in meteorites, from the early age of meteoritics to 2011.*

#	Reference	Cat.	P/O
1	**Hahn (1879)**	**I**	**P**
2	**Hahn (1880)**	**I**	**P**
3	Birgham (1881)	I	P
4	Louisville Courier J. (1881)	I	O
5	Weinland (1882)	I	P
6	Anonymous (1882)	I	O
7	Smith (1882)	I	O
8	Vogt (1882)	I	O
9	Weinland (1882)	I	P
10	Kirkpatrick (1912)	I	P
11	**Lipman (1932)**	**II**	**P**
12	Farrell (1933)	II	O
13	Nininger (1933)	II	O
14	Roy (1935)	II	O
15	Lipman (1936)	II	P
16	Roy (1937)	II	O
17	**Claus & Nagy (1961)**	**I**	**P**
18	Anders (1962)	I	O
19	Anders & Fitch (1962)	I	O
20	Briggs & Kitto (1962)	I	-
21	Fitch et al. (1962)	I	O
22	Gregory (1962)	I	O
23	Morrison (1962)	I	P
24	Mueller (1962)	I	O
25	Nagy et al. (1962)	I	P
26	Nagy & Claus (1962)	I	P
27	Palik (1962)	I	P
28	Pearson (1962)	I	O
29	Staplin (1962)	I	P
30	Briggs & Mamikunian (1963)	I	-
31	Claus et al. (1963)	I	P
32	Fitch & Anders (1963a)	I	O
33	Fitch & Anders (1963b)	I	O
34	Mamikunian & Briggs (1963)	I	-
35	Nagy et al. (1963)	I	P
36	Anders et al. (1964)	I	O
37	Vdovykin (1964)	I	O
38	Oro & Tornabene (1965)	II	O
39	VanLandingham (1965)	I	P
40	Manten (1966)	I	-
41	Nagy (1966)	I	-
42	Urey (1966)	I	-
43	Nagy (1967)	I	-
44	VanLandingham et al. (1967)	I	P
45	Tan & VanLandingham (1967)	I	?
46	Rossignol-Strick & Barghoorn (1971)	I	O
47	Nagy (1975)	I	P
48	**McKay et al. (1996)**	**I**	**P**
49	Anders (1996)	I	O
50	Bradley et al. (1997)	I	O
51	McKay et al. (1997)	I	P
52	Zhmur et al. (1997)	I	P
53	Hoover et al. (1998a)	I	P
54	Hoover et al. (1998b)	I	P
55	Sears & Kral (1998)	I	O
56	Westall et al. (1998)	I	-
57	Westall (1999)	I	-
58	Steele et al. (2000)	II	O
59	Geraci et al. (2001)	II	P
60	Gibson et al. (2001)	I	P
61	Hoover & Rozanov (2003)	I	P
62	Hoover et al. (2004)	I	P
63	Hoover (2005)	I	P
64	Hoover (2006)	I	P
65	Hoover (2008)	I	P
66	Rozanov (2010)	I	P
67	Hoover (2011)	I	

** The claims can be separated into two categories: (I) fossil life forms and (II) living organisms. Original (extraordinary) claims of indigenous life forms in meteorites are highlighted in bold. Other publications are linked to the following debates (proponents P, opponents O). Although some references have certainly been missed, this list should still give a fair representation of the evolution of thoughts on this fringe science topic. Note that publications presenting only conjectural or indirect arguments for life in meteorites (e.g., Panspermia theory, studies on organic compounds) are not considered in the present review. For references on claimed biomarkers in carbonaceous meteorites, please refer to Hoover (2011). For hundreds of references on the debate on biomarkers in the ALH 84001 meteorite, please refer to http://curator.jsc.nasa.gov/antmet/mmc/ALHA84001ref.pdf*

but notable theory based on this trick of the mind is the Nummulosphere of Randolph Kirkpatrick (1912), according to which all rocks on Earth would have formed from the accumulation of foraminifera[5]. In his work, Kirkpatrick ironically criticizes Hahn by stating: 'Dr. Otto Hahn believed in the organic origin of meteorites, but he fails to produce any evidence in support of his theory. He mistook the chondrules of aerolites for Sponges, Corals, and Crinoids (…) Further, he considered the Widmanstatten figures of siderites to be for the most part plant-cells and not crystals.' At the same time, Kirkpatrick indicates: 'Nummulitic structure is clear enough to my practiced sight in meteorite sections containing stone and iron (…) (Meteorites) are lumps of mineralized and ore-enriched nummulitic rock (…) In my opinion, meteorites have no more to do with nebular and prenebular theories than have lumps of chalk.'

Hahn's idea did not survive. It was, however, (kind of) resurrected in the 1960s by Bartholomew Nagy's group, who proposed the catchy term organized elements (OEs) for what they believed to resemble unicellular microfossils in carbonaceous chondrites (Claus & Nagy, 1961). Their 1961 paper led to a hectic debate published in the prestigious Nature and Science journals. The debate lasted for several years (Figure 3). In 1962, Fitch et al. refuted the claim; OEs consist in fact of mineral grains. The authors stated: “although the work of Claus and Nagy was done with much greater care and competence than the early work of Hahn, the decision whether a certain form is of biological or inorganic origin is once again purely subjective.” Nagy et al. (1962) responded that Fitch et al. had not looked at the right place and proposed four more experiments to corroborate their hypothesis. Anders & Fitch (1962) then discriminated OEs in two classes: (1) simple shapes, indigenous and inorganic and (2) complex shapes of biological origin but most likely spore contaminants. Nagy et al. (1963) verified that the complex OEs were not contaminants and Fitch & Anders (1963) that they really looked like contaminants. And the story went on… until it died off.

The Martian meteorite, ALH84001, discovered by a 1984 expedition in the Allan Hills of Antarctica, has been made famous by a team from NASA (McKay et al., 1996)

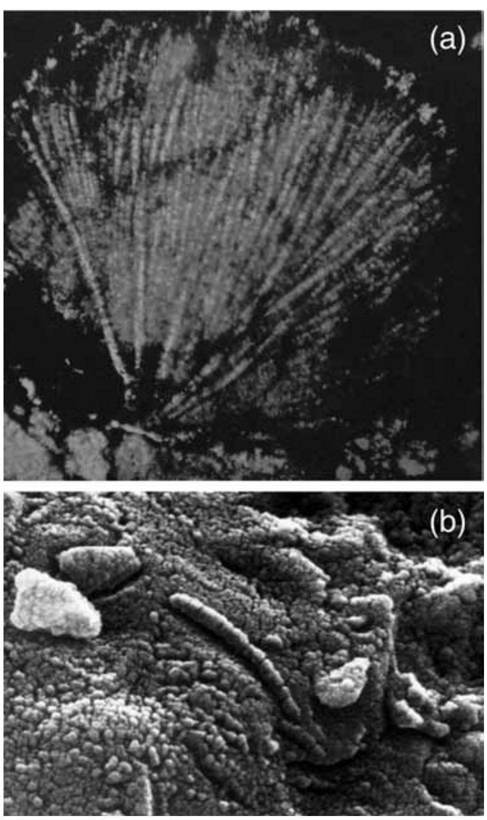

Figure 2: Rogue's gallery of claimed life forms found in meteorites: (a) Alien coral fossil? More likely a chondrule! (Source: Hahn, 1880, cover photograph – courtesy of J. Koblitz, METBASE); (b) The face of Martian life? Not likely (Source: NASA, McKay et al., 1996).

for it contains “elongate forms (that) resemble some forms of fossilized filamentous bacteria” (Figures 2b). ALH84001 is now part of the pop culture (Figure 4) in contrast with other claims. This may be due to the fact that the existence of Martians would make more sense to the layman than the existence of “Asteroidians” or “Cometians”, but it is more likely due to the frantic media attention at the time.[6] Ashley & Delaney (1999) give a simple answer to the ALH84001 enigma, in agreement with a number of previous studies: “The ultrabasic igneous rock, ALH84001, is (…) an extremely poor candidate in which to search for Martian life as it is more likely to show terrestrial contamination signatures than Martian biogenic signatures.”

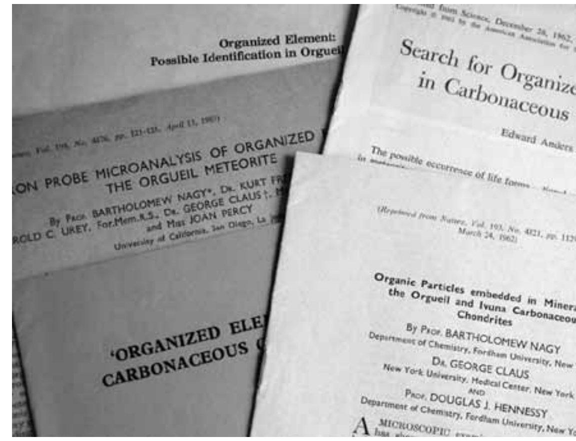

Figure 3: The 1960s “Organized Elements” saga or the hectic debate around the possible presence of microfossils in carbonaceous meteorites, hypothesis proposed by Nagy's group and refuted by Anders/Fitch's group (but recently revitalized by Hoover). Source: Library of Meteoritics of the Tricottet Collection.

The most recent claims of indigenous fossils in meteorites come from Hoover (2011). While the research has recently been considered by some media to be ‘exclusive news,’[1] his work on the topic spans for over a decade (e.g., Hoover et al., 1998). Hoover (2008) claimed: “The CI and CM carbonaceous meteorites contain a large number of complex and embedded coccoidal and filamentous forms consistent in size, shape and morphology with known species of cyanobacteria, sulfur bacteria and other morphologically convergent prokaryotes.” In regards Nagy's OEs, Hoover (2011) indicated: “(Nagy et al.) failed to recognize a pollen grain and erroneously included an image of it in their original paper. This resulted in their work being discredited.” Although the shapes observed by Hoover are likely to be indigenous, the problem with pattern recognition is always the same and the lesson should have been learned by now.

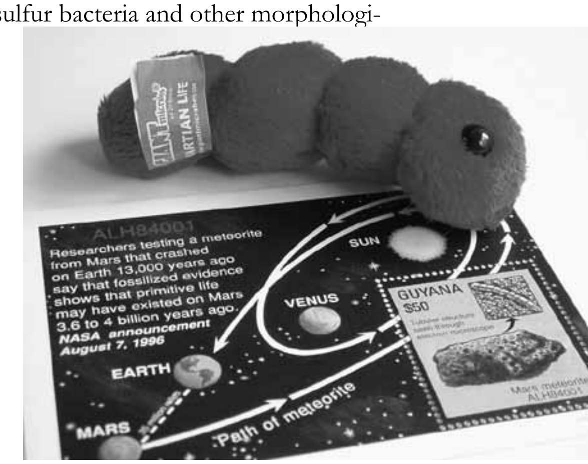

Figure 4: Pop culture associated with the ALH84001 meteorite: A souvenir stamp sheet (released in 1996 by Guyana) and a plush ALH84001 alien bacterium (Copyright Giantmicrobes, Inc.).

Living Organisms?

“I fail to find in Dr. Lipman's experiments any good

evidence of the presence of bacteria in the interior of (meteorites) (…) It is very questionable whether all contaminations from the air can be excluded" – Nininger (1933)

"(The claim of bacteria of extraterrestrial origin in meteorites was) received by the layman with philosophical interest and by geologists and bacteriologists with skepticism" – Roy (1935)

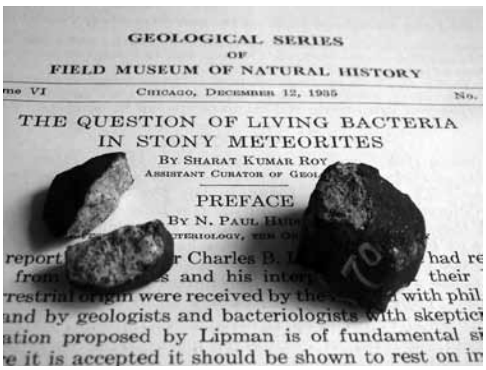

Figure 5: Cooking recipe of Lipman (1932): Wash the surface of the meteorite with soap and hot water with the help of a sterile brush. Rinse it with distilled water and dry it with a paper towel. Place in a solution of bactericide. Add some alcohol and expose to a flame until the alcohol has burned away. Crush in a mortar. Voila, wait and watch for some indigenous bacteria. Left: Holbrook meteorite fragments (Tricottet Collection #22.38). Right: Pultusk meteorite (TC27.21) – Lipman found bacteria in both of these meteorites, in fact laboratory contaminants (Roy, 1935). Background: "The question of living bacteria in stony meteorites", by Roy (1935).

Figure 6: Carbonaceous meteorites are known to contain complex organic compounds. Here is an insight into the interior of an Allende meteorite (TC26.1).

If meteorites could contain relics of past life on their parent bodies, why not living organisms? Following the panspermia hypothesis, meteorites are potential vectors of life (e.g., Wickramasinghe et al., 2003). The subject goes beyond the scope of the present paper since most arguments are only conjectural. Evidence of living organisms in meteorites has been, nevertheless, claimed in a few studies that are worth mentioning. Lipman (1932) stated having found living bacteria in ordinary chondrites (Figure 5). His work was immediately refuted, the most plausible origin for the bacteria being laboratory contamination (e.g., Nininger, 1933; Roy, 1935).

A more recent work is by Geraci et al. (2001), whose experiment protocol was basically similar to the one used by Lipman 70 years before. The authors indicate: "A (…) search for the presence of microbes in meteorites shows that (they) are rich in microorganisms, indicating that these already existed in early Earth formation stages (… and these are) found to be not essentially different from present day organisms." Really? How interesting!

Biogenic Organic Compounds?

"The intense controversy which once surrounded the origin of (CI chondrite) organic matter has subsided. Most authors now agree that this material represents primitive pre-biotic matter, not vestiges of extraterrestrial life" – Anders et al. (1973)

"The complex polymer-like organic matter similar to kerogen in the carbonaceous meteorites (…) constitutes an important biomarker" – Hoover (2011)

While microphotographs of pretended life forms appear as dramatic pieces of evidence (Figure 2), conclusions based on morphology alone are insufficient. Carbonaceous meteorites (Figure 6) are known to contain a multitude of complex organic compounds, the building blocks of proteins and of DNA (e.g., Anders et al., 1973). Some proponents of life in meteorites have cited these organic compounds as biomarkers to support the validity of their biomorphic findings (Hoover, 2011 and references therein). Mainstream scientists agree, however, that they are synthesized through non-biological processes, as proven by the Miller-Urey and Fischer-Tropsch experiments (e.g., Anders et al., 1973).

The Martian life scenario is different. To prove their case, McKay et al. (1996) described, in addition to their nanobacterial pseudomorphs, other finds such as Polycyclic Aromatic Hydrocarbons (PAHs), carbonates, and magnetite crystals. However, they conclude: "None of these observations is in itself conclusive (…) When they are considered collectively (…), we conclude that they are evidence for primitive life on early Mars." Again, not the most elegant scientific result we might expect.

Conclusions

"Extraordinary claims require extraordinary evidence"
– Carl Sagan

Following Occam's razor, if two hypotheses lead to the same result, the simplest one is always to be preferred. Thus complex shapes observed in meteorites, whether they are from asteroids, comets or from the planet Mars, are likely to be mineral concretions of random forms or terrestrial contaminants. However, the study of the strange and the unknown clearly has some appeal and research will continue. Although the claim of life in meteorites can be considered at the present time as fringe science, this might change in the future. So, for now, let's wait for a sedimentary Martian meteorite[7] to fall on Earth. Maybe, finally, we'll find some undeniable proof of alien life, past or present[8].

Acknowledgements
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Footnotes

1. "Exclusive: NASA Scientist Claims Evidence of Alien Life on Meteorite," Fox News, published online March 5, 2011.
2. Kuhn's structure of scientific revolutions consists of three phases: (1) the 'pre-paradigm' phase, characterized by several incompatible and incomplete theories, (2) 'normal science' in which observations are explained by a consensus and (3) 'revolutionary science' if some difficulties emerge and new assumptions are required.
3. "Paleontology remains unique and free of comparison. But since, in reality, nothing is unique in Nature, except Nature itself, the only possible question is to know whether terms of comparison, which probably exist but that we are unaware of, will come to our knowledge or not".
4. Smith's private meteorite collection was one of the largest in the world and he was regarded in his time as one of the highest authorities in the field of Meteoritics (Mignan, 2011).
5. Kirkpatrick looked at thin slides of a variety of rocks and observed shapes that reminded him of 2-D sections of Foraminifera.
6. President Clinton Statement Regarding Mars Meteorite Discovery: "(…) Today, rock 84001 speaks to us across all those billions of years and millions of miles. It speaks of the possibility of life (…)", at http://www2.jpl.nasa.gov/snc/clinton.html
7. If a meteorite of Martian sandstone hit you on the head would you recognize it? by Ashley & Delaney (1999).
8. NASA spacecraft data suggest water flowing on Mars at http://www.nasa.gov/mission_pages/MRO/news/mro20110804.html

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