

Short communication

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Comparison of research methods and interpretation of ALH-84001 (McKay et al. 1996, Science and studies based on Science publication by Thomas-Keprta et al. 2000 GCA, Thomas-Keprta *et al.* 2001 PNAS) and ALH-77005 (Gyollai *et al.* 2019 Open Astronomy)<https://doi.org/10.1515/astro-2019-0010>

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On the occasion of publication Gyollai *et al.* (2019) in Open Astronomy, media interest aroused. The questions cannot be answered by one word, that is why our authorship offers a comparative interpretation as a response (for details see the cited papers). Let us start with the general questions:

“What is the main difference between the American 1996 study and your 2019 one?”

„Did you find different biological markers or were your method, strategy or interpretation different and more conclusive?”

Shortly we can answer: both. Also, we have to ask for attention of the other paper published in the same volume of Open Astronomy by the same authors (Gyollai *et al.* 2019) which give a more detailed methodological overview used on chondrites, and also used for Martian meteorite ALH-77005.

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Comparing the research methodology and interpretation of the two groups we find many similarities in the following aspects:

Both groups used multi-methodology on high resolution (mineralogy, chemistry, organic matter, texture, isotopes) taking into account the terrestrial analogies, the case of contamination (terrestrial and laboratory), and both groups made efforts on the complex interpretation, as US group wrote:

“None of these observations is in itself conclusive for the existence of past life. Although there are alternative explanations for each of these phenomena taken individually, when they are considered collectively, particularly in view of their spatial association, we conclude that they are evidence for primitive life on early Mars.”

This scenario, on the one hand, is somehow similar to the structural hierarchical complex interpretation, but there is a cardinal difference comparing with the one used by the Hungarian group, namely: **all observations were made NOT from the same (in situ) places, and that offer surface for “attact”, that destroy the conclusive status.**

U.S. group used both destructive and non-destructive measurements. Hungarian group used only non-destructive measurements.

U.S. group used also *in situ* analyses by optical rock microscopy (not detailed in Science), and EPMA (Science) for element composition, but used also non *in situ* investigations.

Hungarian group used only *in situ* measurements.

Differences are in the type of used methods, as Hungarian group used *in situ* non-destructive measurements by Raman spectroscopy and ATR-FTIR (Infrared) spectroscopy (These methods were probably not routinely used methods 20 years ago). We ask for attention, that even the laser excitation energy is enough to cause mineral transformation from poorly crystallized forms like ferrihydrite to more stable mineral forms like goethite or hematite. FTIR is the best from this point of view. **Hungarian group used Raman and FTIR spectroscopy, both methods determine micromineralogy (main element composition) and embedded organic matter in the given micro-texture *in situ*, in Hungarian case this micro-texture is mineralized microbially produced texture determined by optical rock microscopy. So, in this case, the dataset on different hierarchical level refers to one system. Hierarchy levels form a chain, which continuously diminishes in size range in a coherent way.**

In the U.S. case, there are data on organic matter determined on fresh broken surface, element composition, mineral composition on carbonate globules by EPMA, but in this case we miss the detailed microtextural features, for which the most adequate and sensitive method is optical rock microscopy. Hungarian group compared the same part of terrestrial microbially mediated samples by optical rock microscopy and EPMA, and it is clear that only element distribution does not give as detailed plausible microtextural picture as optical rock microscopy can.

U.S. group offer a very detailed crystallographic characterization of magnetite minerals (HRTEM) including their chemistry, and a 6 point based comparison with terrestrial microbial magnetite (magnetotactic bacterial activity), which represent one structural hierarchical level, but in extremely high resolution. The connection between the surrounding mineral assemblage and the micro-texture is not well established.

Researches of the ALH-84001 have several high-resolution instrumental investigations that take into account the parallel earth processes. What is the main difference between the current Hungarian research on ALH-77005 and that of American ALH-84001 one? Shortly: the frame of reference is different. Hungarian group used the structural hierarchy method. This requests a mutually embedding sequence of the structures found on various hierarchy levels. These hierarchy levels form an embedding sequence from the topmost structure – *i.e.* carbonate globule till the PAH molecules and down to the corresponding isotope data. Application of the structural hierarchy is a real step further because all dataset elements refer to the same system. The corresponding structural levels do not

open surface for attacking the convincing argumentation system. For example: in McKay *et al.* (1996) Science paper, even if the scanning electron microscopy found microbial scale-like forms, that microscopy was not able to determine their mineral composition, just as it was not possible to determine any mineralized organic matter. This was later attacked arguing that the microbial form alone was not conclusive evidence. Similarly, the determination of PAHs on the broken surface itself was not conclusive evidence.

The ALH-84001 researchers were able to measure all types of data at different levels of hierarchy, but they did not interpret data in the structural hierarchy. If there is no possibility to define a data type at a particular hierarchy level, which is fitting into the embedding sequence, it represents an attack surface in a convincing argumentation system.

Our frame of reference contains all essential features of the structural hierarchy method. In the system, the synchronously existing phenomena appear as embedded structures of different hierarchy levels. This requirement has not been met in all data collecting by the McKay *et al.* measurements mentioned above. However, this requirement was considered in the case of the magnetite garlands found in ALH-84001. Magnetite minerals were not only forming the size of the particles produced in the magnetotactic bacteria, but also in forming their larger units, in the nature of the garlands. Friedman *et al.* (2001) produced statistics on magnetite garlands (chains, and chain fragments) in the carbonate. Among these, the longest garland was 13 units of minerals and he found two further 11 unit lengths. The shorter the garland, the greater is their number of occurrence. In light of these statistics, the fragmentation of larger garland units could be inferred.

Our ALH-77005 tests have always provided information on minerals from a given mineral range in the texture, and on *in-situ* FTIR and Raman spectroscopy measurements on the smaller structural levels associated with them. Therefore, as the only components of a single system, which was once formed by the assistance of living microbe, it is a natural conclusion that the living system contributed to the formed texture and its corresponding subsystems.

Summary

If biosignature candidates (PAHs, magnetite, carbonate) occur "independently", the bound matrix is not evident, and this cause that these biosignature candidates "alone" can be interpreted also by abiogenic processes, or, by other words, abiogenic formation cannot be excluded. We may

call this case a ***partially coherent*** measurement system (ALH-84001 case).

If the measurements are applied in an embedding (hierarchical) sequence, we may call the case a ***continuously coherent*** measurement system: We measured all the data on the same portion of the ALH-77005 sample. (Only the delta 13 C data were taken from the literature; Douglas *et al.* 1992).

This requirement is fulfilled by Friedman *et al.* (2001), too.

We published an abstract in the structural hierarchy topics: There we propose that this embedded hierarchical systematics should be preferred in planetary science in the future (Bérczi 2017).

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