Life detection with minimal assumptions – Setting an abiological background for Mars. A. Steele[1]. [1]Carnegie Institution of Washington, Geophysical Laboratory, 5251 Broad Branch Rd, Washington DC, 20015. asteele@carnegiescience.edu

Life detection with minimal assumptions

The simplest form of extraterrestrial life detection with minimal assumptions on the nature of the organism or a potential "alien biochemistry" to be detected, is to understand the possible abiotic organic chemical reactions given the context of the samples and look for perturbations to that signal. More precisely, life chooses only a few of the many known organic chemicals produced by abiotic processes. Therefore anomalous deviations from predicted abiological yields of organic chemicals under given conditions may be the easiest life detection protocol. The assumptions are minimal; life is carbon based and it chooses only a subset of possible abiotic chemicals available. An example would be the organic chemistry responsible for the inventory of organics in the Murchison meteorite and abiotic processes such as the Miller-Urey reaction and Fischer –Tropsch (FTT) synthesis. In the case of the Murchison meteorite, it appears that all possible isomers of a particular carbon number or compound are present but only a very limited subset of these molecules used by terrestrial biology (Schmidt-Koplin 2010). In the case of FTT as chain length increases, yield decreases and although analysis of the products this is subject to analytical problems, mainly volatile loss, the kinetics of this reaction are very well understood and predictable. Life on the other hand tends to use ~ C17 to C31 alkanes and produce an odd even preference that is not present in FTT products (Donnelly, 1989). A final and perhaps extreme example of this philosophy is that if terrestrial life uses A,T,C,G and U for information storage a Martian organism may use L.M.N.O and P. Again the probability is that life will choose only a few of the possible choices of, in this case, purine and pyrimidine isomers. Therefore, knowing the abiotic reactions are possible in a certain context provides a baseline value from which any anomalous concentrations of organics that may be a 'biosignature' can be detected.

This strategy depends on several key points for implementation.

1) An understanding of possible abiotic chemistry undertaken in Mars environments (including meteoritic infall) and the preservation / diagensis of that signal with time.
2) A clear understanding of the geological context in which measurements are made.
3) A multidisciplinary and multi-measurement approach with convergent data sets from each measurement.
4) Commitment to a null hypothesis that all observations are treated as non-life signatures until a wealth of evidence exists to falsify this hypothesis.
5) Clear operating guidelines and peer review of results and data. It is after all the community and not a single investigator or measurement that will ultimately define a positive "Life Detected" result.

While apparently biased towards the detection of molecular biosignatures, the invocation of a null hypothesis demands similar rigorous examination of data from the detection of possible mineral, isotopic or morphological biosignatures.

Mars meteorites – Setting an abiotic background.

Care has to be taken in the interpretation of organic compounds in Martian meteorites due to terrestrial microbial and organic contamination (Steele et al., 2000, Toporski and Steele 2007). The challenge is then to distinguish between the terrestrial organic material (and organisms) and possible indigenous Martian organics. For many years to come these Martian meteorites will remain the only material available for analyses in terrestrial laboartories. Therefore, the wealth of information they contain, which should not be summarily dismissed simply because they may be contaminated, is essential for setting a background that give context to in-situ or returned sample measurements on Martian samples. The microbial contamination in these meteorites provides us with the best model we have for testing life detection instrumentation and rationales on a truly Martian substrate before the possibility of receiving return samples from this planet. The characterization of these organisms and their metabolic/diagenetic products will also be crucial in the search for biogenic activity in other extraterrestrial samples. These meteorites do show evidence of Martian abiotic chemistry in the form of graphitic carbon, macromolecular carbon, polycyclic aromatic hydrocarbons and nitrogen containing aromatic molecules (Steele et al., 2016, 2013, 2012a, b 2007, Wright et al., 1989, 1992). Steele et al., (2016) reviews these types of organic molecules and there potential synthesis mechanisms which can be summarized as follows; 1) impact generated graphite in Tissint, 2) secondary hydrothermal gener- ated graphite in ALH 84001, 3) primary igneous reduced carbon in 12 Martian meteorites associated with spinels 4) primary hydrothermally formed organic carbon / nitrogen containing species in the Tissint meteorite. These studies show that Mars has produced reduced carbon / organic carbon via several mechanisms and reveal that the building blocks of life, if not life itself, are present on Mars and have been manufactured over much of its history. The context of these organics in terms of the life detection strategy outlined earlier is extremely valuable allowing the beginnings of setting t non-life background from which to work from.

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