Was the red planet once blue? Meteoritic evidence for historical biosignatures

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Introduction

- In the 1970s, the *Viking* collected soil samples "spiked" with organic nutrients like amino acids, approximately akin to what we would expect were there to be life present on the surface of Mars. Eventually, the scientific majority argued chemically reactive components present in the soil that reacted with terrestrial contaminants of the Earth to produce organic by-products. [1]
- However, discoveries from the *Curiosity* using evolved gas analysis and chromatography-spectrometry, the first evidence of native organic matter on Mars was recorded. [2]
- Meteorites like Allan Hills 77005 (ALH77005) and 84001 (ALH84001) Martian meteorites discovered in Antarctica in 1977 and 1984 respectively (shown in Figure 3) are chondritic meteorites that represent pearls of the primitive Solar System in contrast to the differentiated iron meteorites as well as a rich source of speculation for the existence of organic lifeforms in ancient Mars.

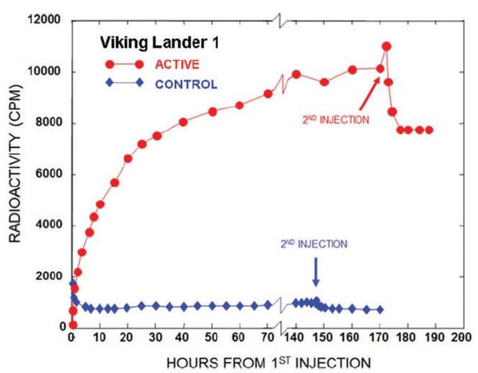

Figure 1: *Viking* labeled release experiment using radioactivity to detect microorganism metabolites in soil samples [6]

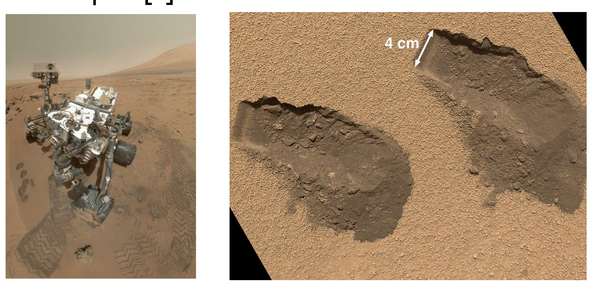

Figure 2: *Curiosity* rover soil sampling venture (left) and samples (right) [7, 8]

Meteoritic Evidence

- The ALH77005 meteorite was the first meteorite identified to come from Mars and contained bacterial signatures of life. [3] While arguments of contamination exist, optical microscopy and infrared technology along with isotope tests have revealed carbon and minerals containing biomaterial that is difficult to pinpoint origin, if not native. Scientists observed bacteria that survive by eating iron rust in the pockets of the meteorite and proposed the existence of microbes on Mars.
- The ALH84001 meteorite has not only carbon, but also nitrogen-based molecules 4-billion-years-old [4]. As we know, nitrogen is another crucial element that is of utmost importance for life on Earth, making up both our biology and geology. So, regardless of whether the nitrogen came from other carbon-containing meteorites, or it originally formed on Mars, Mars had organic nitrogen before it became the inhabitable red planet it is now.
- Meteoritic evidence now documents the partial melting and onset of differentiation. The discovery and characterization of UH154-11 have revealed the magma-based activities of a carbonaceous asteroid on the interim of differentiating. [5]

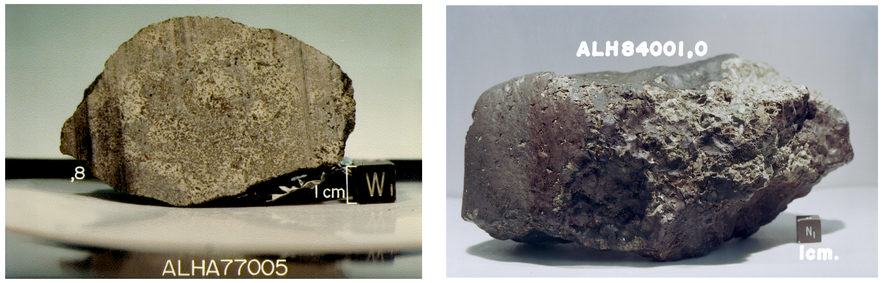

Figure 3: Fragments of ALHA77005 (left) discovered in 1977 and ALH84001 (right) discovered in 1984

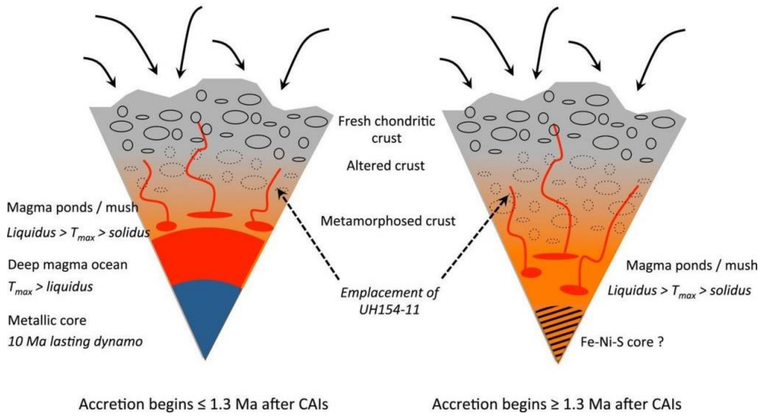

Figure 4: Evidence for Partial Differentiation of Carbonaceous Chondrite Meteorites

Limitations

- Chemical evidence does not necessarily indicate compounds produced by microbial life; they also could have been made by non-biological, mundane processes.
- The scientific majority remain skeptical of the Alan Halls meteoritic findings and refrain that more research is required before making sweeping claims of life on Mars
- While magnetic and isotope data suggest connections between the primitive Solar System and differentiated bodies structurally akin to Earth-like planets, it is difficult to make sense of this data based on our current understandings which have no frame of reference.

Conclusions

- While there is skepticism and doubts, the meteoritic evidence from Alan Hills and the asteroid differentiation from icy comets to iron meteorites appear to both corroborate the existence of organic material on Mars

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Acknowledgments

#RISINGYOUTH community service grants
TakingITGlobal INSPIRE INFORM INVOLVE INSPIRER INFORMER ENGAGER
Funded by the Government of Canada
Financé par le gouvernement du Canada
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