The Prospects for Life Elsewhere in the Solar System

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In the later years of the 20th century, it became common in the scientific community to assume that life does not exist in the Solar System; therefore, the exploration of the Solar System by humans or unmanned devices must have other objectives than the discovery of life. This pessimism is largely the result of the initial discoveries of the US and Soviet space programs, which revealed hostile environments such as Venus and Mars.

**Mars**

Mars is currently a very cold place with an extremely thin atmosphere; at first glance, it would appear to be an inhospitable environment for life. It has been compared to Antarctica, though this is an interesting comparison, because Antarctica has many forms of microbial life within its ice and rocks, even in its most inhospitable regions. Liquid water could not exist on the surface for longer than a few minutes at a time, but there is likely to be liquid water in rock pores and cracks several kilometers underground; this may be a habitat for life.

**Viking biology experiments**

The Viking Mars landers were active on Mars from 1976-1980. They were equipped with biology experiments for analyzing Martian soil that, it was assumed, would definitively answer the question of life on Mars. An astonishing positive result was obtained with the Labeled Release (LR) experiment, but the GCMS experiment failed to detect any organic compounds in the Martian soil (Levin and Straat, 1988). A non-biological explanation was accepted for the positive result of the LR experiment; however, Levin notes that this was a change in attitudes among the scientists: “It was understood [before the Viking mission], then, that only one of the three experiments might return a positive response, were there truly life on Mars, and that such independent data would most probably be strong enough on its own merit to substantiate the detection of life” (Levin and Straat, 1988).

The LR experiment (Figure 1) used simple nutrients labeled with carbon-14 dissolved in water. To test the Martian soil, the nutrient broth was added to it, and then the radioactivity of any gas released would be measured―microbial life would presumably metabolize the nutrients and give off carbon dioxide containing carbon-14. To control for non-biological reactions that could cause this same effect, the same experiment was repeated after heating the samples to a temperature of 165⁰C, which would presumably sterilize the soil sample (Levin, 2010).

The results, which were very similar for both Viking 1 and 2 landers, indicated the presence of life: carbon-14 dioxide was produced from the soil upon addition of the nutrient broth, but with prior “sterilization,” no carbon-14 dioxide was given off. If a second addition of the nutrient broth was given to the non-sterilized soil after several days, no carbon-14 dioxide was given off. This last result was widely understood to be evidence *against* life, since microbes usually reproduce when given nutrients, so there would presumably be more microbes to produce carbon-14 dioxide when more of the nutrient broth is added. However, Antarctic soil samples containing microorganisms were found to exhibit the same behavior, because the microorganisms died before the second addition of nutrients (Levin, 2010).

The Viking Pyrolytic Release (PR) experiment was designed to measure synthesis of organic compounds using carbon dioxide from the air (this is essentially the reverse process of the LR experiment); in this experiment, a simulated Martian atmosphere containing carbon-14-labeled carbon dioxide and carbon monoxide were incubated with Martian soil for varying lengths of time and with or without simulated sunlight, then the labeled gas was purged and the soil was heated to 635⁰C to vaporize any carbon-containing compounds. This experiment gave positive results, since radioactive gases were detected (Plaxco and Gross, 2011:280). The PR experiment results cannot be interpreted as biological, however, since heating to 175⁰C does not entirely prevent the reaction, and heating to only 90⁰C does not inhibit the reaction at all; this is inconsistent with reactions mediated by biology (Klein 1978).

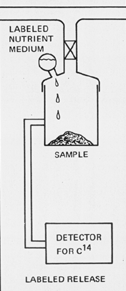
The negative GCMS results initially seemed to rule out organic matter in the Martian soil; because it is almost inconceivable that living organisms could exist without organic compounds, this implied that there were not any microorganisms in the Martian soil. The conclusion that there were no organic materials was brought into question in 1998, when the Phoenix lander detected the presence of perchlorate ions (ClO4-); this would destroy any organic material in the heating step that begins GCMS analysis (Levin, 2010).

**Martian meteorites**

Meteorites expelled from Mars by volcanism or impacts have been identified, and two of them have been reported to show evidence of biological exposure on Mars. One of these is ALH 84001. In 1996, microscopic structures in the rock that appear to be fossils of microorganisms were identified (McKay et al, 1996). In addition, there are carbonate globules that must have formed in a wet environment, and are suggestive of biological activity (McKay et al, 1996).

**Conclusion**

The evidence for life on Mars is still inconclusive, despite many attempts to determine this. The exploration of Mars has not been thorough enough to rule out life, however: there have been no sample return missions, no manned missions, and no drilling of the interior. The existing results, especially those from the Labeled Release experiment of the Viking landers, suggest that more exploration is justified.

Figure 1: Labeled Release (LR) experiment of Viking landers (artemis 2012).

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