SDSU Astr 310: Astrobiology **Prof. W. Welsh**

MARS (Part 2)

Today, Mars' atmosphere is too thin for liquid water to exist on the surface. Mars is too small (too little mass) to keep a thick atmosphere; also, meteor impacts and solar wind "eroded" the atmosphere (Mars has no magnetic field to shield the atmosphere from the Solar wind).

The Viking Biology Experiments

Each Viking lander performed 3 biology experiments to search for life. In each case Martian soil was exposed to radioactively labeled nutrients and gases to see if metabolic reactions would take place (can we catch the Martians eating?)

Carbon Assimilation: in sunlight, does soil absorb CO or CO_2, implying photosynthesis?
Labeled Release: add broth and see if tracers are incorporated into soil
Gas Exchange: add broth and search for gaseous by-products of metabolism

At first, it seemed that in all three experiments, the answer was yes - metabolism was taking place!! But further testing showed the answer often remained "yes" even when the soil was sterilized before the test (or done in the dark). Something was wrong…

Recall that the gas chromatograph/mass spectrometer (GC/MS) tests showed that the soil contains no organic compounds. Instead, the soil contains highly reactive peroxides.

Viking Biology Experiment Conclusion

Because the soil contains no organic compounds, the biology experiments were not detecting signatures of life: Peroxides in the soil gave a "false positive" result.
No evidence of life was found.

"Extraordinary claims require extraordinary evidence..." - Carl Sagan

Viking contained a fourth instrument capable of detecting life: cameras!
Again, no evidence of life was detected.

Does this mean Mars is dead?
No. But it is unlikely that life exists on Mars' surface. Furthermore, it does not tell us if life existed on Mars 3-4 billion years ago, when perhaps there was a lot more water.

"If Viking landed in the driest part of the Atacama and done exactly the same experiments, we would have found no signs of life. The Atacama appears to be the only place on Earth where Viking would have found nothing." - Paraphrased quote from Chris McKay (from Astrobiology Magazine)

Can Mars Harbor Life?

It is *possible* that Mars had life in the past.
There is frozen water under the surface (permafrost) which melts occasionally: could there still be life under the surface?
Some bacteria can stay "alive" for millions of years as spores in a "hibernation" state.
If there was life in the past, could these have survived??

The 2001 Mars Odyssey Mission

Three main experiments:

- search for water (gamma ray & neutron detector)
- map chemicals on surface (IR & visible cameras, gamma ray spectroscopy)
- measure the radiation environment

Major discovery:

The neutron detector indicates that there is a lot of water ice just below the surface, especially near the poles.

How do neutrons indicate water??

Cosmic rays smash into the surface, creating a mini explosion of nuclear particles (protons, neutrons, alpha particles). These particle radiate outward. Protons & alpha particles are easily stopped. Neutrons can travel long distances – even back out into space, where they are measured by Odyssey. Light nuclei (such as H) can slow and stop the neutrons, but heavy nuclei cannot. The absence of neutrons indicates the presence of light nuclei.

What light nuclei are we talking about?

Only H is abundant enough to have an effect. The most common molecule that contains H is water (H_2O), in the form of ice. {H_2 is not present on Mars.}

The Mars Exploration Rovers (MER)

Science Goals:

- Determine the geologic record at the landing sites with emphasis on the history of liquid water
- What role did water play in the formation of the rock?
- When these rocks formed, how suitable was the environment for life?

MER Science Instruments:

-Panoramic Cameras (pancam): 2 hi-res stereo cameras
-Mini-Thermal Emission Spectrometer (mini-TES): IR spectrometer for mineral composition
-Microscopic Imager (MI)
-Alpha Particle X-ray Spectrometer (APXS)
-Mossbauer Spectrometer (for Fe-bearing minerals)
-Rock Abrasion Tool (RAT): for grinding rock
-plus magnets, navigation and hazard cameras, wheels

MER *Opportunity* is off to a very good start: So far it has made the following discoveries:

- spectroscopic confirmation of hematite
- high sulfur, chlorine & bromine concentrations (up to 40%), probably in the form of sulfate salts (e.g. magnesium sulfate = epsom salts);
- these sulfates only form in water (or if rock is exposed to water for a very long time)

- "Blueberry" or "Marsberry": These spherules are probably "concretions": precipitation of minerals dissolved in water. Blueberries are made of hematite!
- ***"vugs"*** are slit-like features in rock cause by crystalline salt minerals that have since eroded away. "vugs" require a briny water environment to form.
- "crossbedding": Non-parallel strata (layers) in some rocks. Crossbedding occurs in sediments deposited in gently flowing water

These discoveries have led scientists to the conclusion that Meridini Planum was soaking wet! *Opportunity* is probably at the shoreline of a large body of salty water.

"If we're correct in our interpretation, this was a habitable environment on Mars. This was a shallow sea. These are the kinds of environments that are very suitable for life"
– Steve Squyres, Principle Investigator for the MER

Mars Reconnaissance Orbiter (MRO): high-resolution imager (30 cm resolution!)

Future Missions:

Phoenix (2007): lander investigation of water ice & organic molecules
Mars Science Laboratory (2009): next generation rover
Mars Glider(?)
Mars Sample Return Mission (2014?)