SEEKING OUT LIFE ON MARS: PHYSICS AND CHEMISTRY VS. PALEONTOLOGY

D. A. Paige[1]
[1]Dept. Of Earth, Planetary and Space Sciences, University of California, Los Angeles, 90095 dap@mars.ucla.edu

Introduction: Searching for evidence of life on Mars is an exciting endeavor that will have profound implications regardless of the outcome. The search began with telescopic observations that were initially interpreted to be evidence for surface water or vegetation. Unfortunately, the prospects for abundant life on Mars were dashed by the results of the Mariner 4 flyby, which revealed that Mars has a thin atmosphere and a generally lunar-like landscape. The lifeless nature of Mars was reinforced by the results of the Viking landers, which searched unsuccessfully for evidence of Martian life in surface soil samples at two locations.

The Paleontology Strategy: Today, the search for life on Mars continues, but rather than searching for present-day life on Mars, most effort is now focused on searching for life in Mars' past. This shift to a paleontological strategy has been motivated by both scientific and practical factors. On the scientific side, we now have a wide range of orbital and in-situ data have been interpreted as strong evidence that Mars once had long-lived environments that have supported the presence of abundant surface liquid water. On Earth, these environments represent prime habitats for life as well as geologic preservation zones for paleontological evidence for past life. If life ever had arisen on Mars, we would expect that it would have left analogous fossil traces of its existence in these locations. On the practical side, searching for past "habitability" or "signs of past life" appears to be accomplishable within our current technological budgetary framework, and it can be accomplished within agreed upon guidelines for planetary protection.

Paleontology Strategy Issues: There are two key issues with the current paleontological life search strategy. The first and most obvious is the issue of preservation. Earth has been literally crawling with life for billions of years, but on Earth, preserved evidence for life, especially non-multicellular life, is rare. Trained terrestrial paleontologists can use geological clues to identify potentially promising sites to look for signs of life, but actually finding signs of life more often turns out to be a hit-or-miss proposition. Because of the rarity of preservation, and the cumulative effects of subsequent biologic, atmospheric, and geologic processes that tend to destroy evidence that may have initially been preserved, terrestrial paleontologists never conclude that a given paleoenvironment was uninhabited. This is because we know from observing the Earth today that life has colonized all habitable niches, and there is no reason to assume that the same wasn't true in the past. Therefore, if we never find any evidence for past life on Mars, we still won't be able to prove that it was never there. The second issue has to do with the interpretability of paleontological evidence. Preserved remains of analogs to present-day organisms is the gold standard for terrestrial paleontology, and it is unlikely that question of past life on Mars will be settled conclusively without the same. The debate regarding ALH84001 meteorite demonstrates if anything that a very heavy burden of proof is required for any claim regarding past Martian life. Given this situation, the probability that such evidence would be produced by one Mars sample return mission, or even a dozen Mars sample return missions, would seem to be very small indeed.

The Physics and Chemistry Strategy: If we have learned anything about life on Earth since Viking, it is that life is amazingly adaptable. Life doesn't just die out. As long as there are habitable environments, life finds a way to survive. While the present-day Mars surface environment is known to be generally hostile to terrestrial life, the notion that Mars is currently uninhabitable is simply not correct. If we adopt the "one drop of water" definition for habitability that is accepted by most astrobiologists, then there are broad near-surface and subsurface regions on Mars today definitely habitable. These permanent or ephemeral water rich environments on Mars today are the most likely places to find evidence for present-day life on Mars, as well as "signs of life" due to their comparative youth. Using observations in conjunction with physical and chemical models, we can identify currently or recently habitable regions on Mars with much greater reliability than paleontologists can identify billion-year-old habitable regions with preserved signs of life. Once identified, the process of exploration of Mar's habitable environments can proceed at whatever pace we can afford. The initial stages could be accomplished by low-cost and "safe" geophysical and remote sensing techniques (to be described in my talk) that have been well-proven on Earth. A key advantage of the physics and chemistry strategy is that it has the potential to leapfrog the question of past life on Mars, since if we find evidence for present-day life on Mars, the question of past-life on Mars is answered automatically. Furthermore, the potential scientific payoffs for successfully finding evidence for present-day life on Mars would dwarf those for successfully finding evidence for past life.