Sulfate minerals as targets for biomolecule detection on Mars

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A first step in the search for life on Mars must focus on the detection of specific organic molecules associated with biology as we know it. Amino acids are prime target molecules in this search strategy. Advanced fluorometric analytical techniques offer high detection sensitivities for amino acids, and amino acid chirality (handedness) can be used to distinguish biological from abiotic origins. One important consideration with respect to amino acids as target molecules is whether they are preserved over long periods of time at the cold temperatures characteristic of Mars. One way to address this issue is to investigate terrestrial mineral analogs to determine which types offer the best matrix for amino acid preservation.

Strong evidence for evaporitic sulfate minerals such as jarosite, gypsum, and anhydrite has recently been found on Mars by the Spirit and Opportunity rovers. As these minerals are deposited in terrestrial evaporitic environments, any organic molecules from extant or extinct microorganisms should be co-deposited. Thus, we have investigated concentrations of organic matter along with amino acids in natural terrestrial sulfate mineral samples. We have found that sulfate minerals contain between 0.03 to 0.69 % organic carbon as well as high ppb to low ppm abundances of amino acids and their degradation products in samples ranging from 30 million years old to contemporary.

From our data, it appears that amino acids and their amine decarboxylation products are well preserved over long geological time in the sulfate mineral matrices on Earth. This preliminary evidence indicates that sulfate minerals should be prime targets in the search for organic compounds, including those of biological origin, on Mars. Suitable *in situ* instrumentation is now available to detect amino acids at sub-ppb levels while also providing chiral resolution. We thus conclude that amino acids in sulfate mineral matrices are strong candidates in the search for organic molecules of possible biological origin on Mars.

Next-generation robotic planetary reconnaissance missions: A paradigm shift

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We introduce a fundamentally new scientific mission concept for remote planetary surface and subsurface reconnaissance that will soon replace the engineering and safety constrained mission designs of the past, allowing for optimal acquisition of geologic, paleohydrologic, paleoclimatic, and possible astrobiologic information of Mars and other extraterrestrial targets. Traditional missions have performed local ground-level reconnaissance through immobile landers and rovers, or global mapping performed by an orbiter. The former is safety and engineering constrained, affording limited detailed reconnaissance of a single site at the expense of a regional understanding, while the latter returns immense datasets, often overlooking detailed information of local and regional significance. A “tier-scalable” paradigm (Fig. 1) integrates multi-tier (orbit⇔atmosphere⇔ground) and multi-agent (orbiter⇔blimps⇔rovers) hierarchical mission architectures, not only introducing mission redundancy and safety, but enabling and optimizing intelligent, unconstrained, and distributed science-driven exploration of prime locations on Mars and elsewhere, allowing for increased science return, and paving the way towards fully autonomous robotic missions.

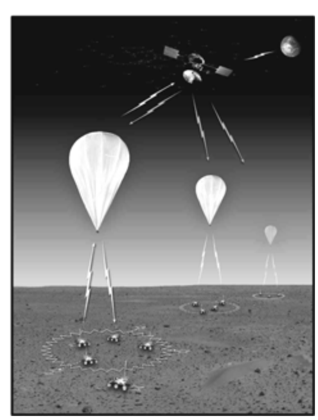

Fig. 1: Tier-scalable multi-tier and multi-agent hierarchical mission architecture

References

Fink W., Dohm J., Tarbell M., Hare T., and Baker V. (2004) “Next-Generation Robotic Planetary Reconnaissance Missions: A Paradigm Shift”, submitted to *Planetary and Space Science*