The past geochemical environment of Meridiani Planum, Mars, and its implications for astrobiology

BRIAN HYNEK AND TOM MCCOLLOM

Laboratory for Atmospheric and Space Physics, Univ. of Colorado [hynek@lasp.colorado.edu]

Motivation

The recent chemical and inferred mineralogical data returned from the Mars Exploration Rover Opportunity are unlike anything previously seen or anticipated on Mars. The data, combined with textural information and geologic context, suggest deposition in a shallow body of water and subsequent chemical weathering [1-2]. Aqueous geochemical modeling offers a way to explore the conditions required for emplacement and alteration of the mineral assemblages. This is crucial for assessing the potential habitability for life in the paleoenvironment. Our approach has been to use the known alteration products at the Opportunity site to evaluate potential geochemical pathways and range of environmental conditions that can produce the observed chemistry and mineralogy. From the likely chemical pathways we can calculate the energy yield available for chemosynthetic organisms and place constraints on duration of the fluid-rock interactions as well as assess habitability.

Example Results:

One typical simulation, run in *Eq3/6*, involves the reaction of "Martian" groundwater (pure water equilibrated with the current Mars atmosphere) with iron-bearing sediments in the form of pyrite (FeS_2). Pyrite is a common product from the hydrothermal alteration of basalt as seen from terrestrial examples.

As the fluid reacts with pyrite the pH drops rapidly through the production of sulfuric acid from oxidation of sulfide from pyrite, and dissolved Fe increases also. As a result, the fluid becomes saturated with hematite and jarosite and these minerals precipitate (the amount of jarosite precipitated is largely controlled by the assumed concentration of K^+ in the initial fluid). The model suggests it is feasible that known minerals at the Opportunity site (namely hematite and jarosite) could arise from interaction of pyrite-bearing sediments with an aqueous fluid in contact with a moderately oxidizing atmosphere like that currently on Mars. Using typical assumptions, a microbe could potentially obtain 10 kJ of energy from each gram of pyrite reacted under such conditions.

This is just one pathway we are exploring to understand the probable geochemical history of Meridiani Planum. Additional pathways will be presented as well as chemical energy yields and their implications for the suitability for the development of Martian life.

References

[1] Squyres S. W. et al. (2004), *Science,* 306, 1709-1714.
[2] Squyres S. W. et al., (2004), *Science*, *306,* 1698-1703.

Distribution of some elemental abundances on Mars: Results from the Mars 2001 Odyssey gamma ray spectrometer

DANIEL M. JANES[1], WILLIAM V. BOYNTON[1] AND THE MARS 2001 GAMMA-RAY SPECTROMETER SCIENCE TEAM

[1]Lunar & Planetary Laboratury, Univ. of Arizona, djanes@lpl.arizona.edu

The 2001 Mars Odyssey Spacecraft has recently completed its first martian year in orbit. Data collection with full boom deployment began in June, 2002 and has continued to the present with only short interruptions due to Solar Particle Events, instrument annealings and related activities. Gamma rays produced by individual elements can be the result of any of three processes: inelastic scatter, capture of thermal neutrons, or radioactive decay, each of which requires a separate method of processing and normalization. Our data collection rate for individual gamma rays is measured in counts per thousand seconds. Nevertheless, sufficient data has now been gathered to begin to examine some elemental distributions for the mid-latitudes on Mars.

While we continue to analyze the data and determine the exact normalization procedures to use for each process leading to the observed gamma rays, we can now map out relative abundances for several elements. These elements include hydrogen (mapped as its water equivalent), chlorine, iron, silicon, potassium and thorium. The elements that we have been able to map to date show modest global differences in their distribution and these variations in elemental distribution are clearly associated with previously mapped geologic and morphologic regions on Mars.

Silicon has limited variability (less than a factor of 2) over the planet but shows a modest enrichment in the northern lowlands and a significant decrease over the Tharsis region. Iron varies by a factor of 2 globally and also shows enrichment over the northern lowlands. (It should be noted that all of the in situ measurements to date have come from landers in the northern lowlands.) Chlorine shows a larger variation, on the order of a factor of 3, and is particularly high in the Medusae Fossae formation west of Tharsis. The range in distribution of potassium and thorium is relatively modest, especially when compared to that of the Moon.

In addition to elements whch can be mapped in the mid latitudes, other elements can be averaged over large, geologically defined regions. Comparisons and correlations of these elements will be presented along with the maps.