Mars, Minerals, Microbiology Oh My!

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**Abstract**

The discovery of authigenic minerals on Mars has been fundamental in the research of habitable environments across the planets. *Exploring, Mapping, and Data Management Integration of Habitable Environments in Astrobiology* discusses this discovery. These authigenic minerals hold biosignatures, which could show the presence of microbial life. As well as four important authigenic mineral systems that can indicate the potential for water environments. These systems include, iron and manganese oxides, sulfates, clays, and carbonates, each chosen because of their affinity to hold biosignatures in Earth conditions. The systematic approaches regarding these findings include a macro and a microscale system. These systems include LIDAR (Hyperspectral High Spatial Resolution Imaging), AVIRIS-C (Airborne Visible Infrared Imaging Spectrometers), IR mapping, and micro reflectance infrared spectroscopy. The future of habitable environments is still largely unknown, but advancements are still being made. The idea of a collective database is an option but has not been pursued in any great capacity.

**Introduction**

There has always been a desire to know Earth’s place in the universe, especially when it comes to life on other planets. This search for extraterrestrial life began in the nineteenth century and has evolved into the creation of numerous space programs around the world. *Exploring, Mapping, and Data Management Integration of Habitable Environments in Astrobiology,* published by Frontiers in Microbiology, dives into the idea of extraterrestrial life and also the habitability of other planet’s environments. Authigenic materials as well as biosignatures play an important role in discovering the habitability of an environment. Four main authigenic mineral systems are discussed: iron and manganese oxides, sulfates, clays, and carbonates, each indicating the potential for a water environment and the presence of microbial life.

**Recent Progress**

The discovery of authigenic minerals on Mars has been confirmed over the last two decades. Authigenic minerals are minerals that have not been transported from the spot they are discovered. It often refers to a mineral that has formed in sedimentary layers on the seafloor. On Earth, these minerals provide a substrate for microbial life. The discovery of authigenic minerals on Mars provides a possibility of life to have existed beforehand. Biosignatures are evidence of life, either in the form of minerals or elements. Chan, et al, deduces extraterrestrial life would

require habitable environments, thus leaving behind biosignatures. Detecting these biosignatures, as well as other variables, such as salinity and pH, will promote the presence of microbial life.

Mars is not the only planet discovered to contain possible habitable environments. Europa, Enceladus, and Ceres, while not planets, all present a subsurface water sources. The authigenic minerals in water are crucial in understanding extraterrestrial life and the possibility of habitable environments. Although these three moons have new discoveries of water, Chan, et al, identifies Mars as the most potentially habitable planet. The rovers, orbiters, and probes sent to Mars have provided thorough records and data. The rocks have especially provided the evidence of biosignatures. Chan, et al, focuses on “four important authigenic mineral systems that are preserved on Mars and indicate the potential for watery environments: iron and manganese oxides, sulfates, clays, and carbonates.” These four were chosen as, on Earth, biosignatures have been identified in all of these areas.

First, iron and manganese oxides, there are records of iron oxides from 3.8 billion years ago to the present in the form of rust. Manganese oxides on Mars were discovered to be “mobilized under oxidizing conditions similar to Precambrian Earth” (Chan, et al). Both oxides are tied to microbial metabolism, specifically reductive and oxidative processes.

Second, sulfates are common on Earth in aqueous low temperatures and many microbial metabolisms often do not occur in breaking down sulfate minerals. The discovery of acid sulfates on Mars suggests those aqueous environments were not hospitable, although some microbial communities can survive in acidic hypersaline environments. Also, there were biosignatures found within the sulfate minerals.

Carbonates were the third authigenic mineral system discussed in *Exploring, Mapping, and Data Management Integration of Habitable Environments in Astrobiology.* Carbonates are known for their preservation of biosignatures, specifically linked to the processing of the carbon cycle. The presence of carbonates is considered the “holy grail” according to Chan, et al. This is because its presence would suggest a CO2 rich atmosphere with a higher probability of photosynthesis occurring. Carbonates were not found in high abundance on the surface of Mars, but there were some indications of it at other subsurface locations on Mars.

The last authigenic mineral system discussed was clay. “Clays are significant indicators of surface processes forming in the presence of compressed water vapor at a temperature of several hundred degrees centigrade, to ambient water temperatures common at the Earth’s surface” (Chan, et al). Clays are generally the result of rock weathering and are the major mineral component of Earth’s soil. Clay has been documented on Mars and represents the presence of a water environment. This discovery is considered one of the most promising evidences of a habitable environment.

The last section of *Exploring, Mapping, and Data Management Integration of Habitable Environments in Astrobiology* describes the specific macro and micro scale systematic

approaches used in mapping biosignatures. Macroscales provided broad views of terrain and mineralogy while mesoscales “provide the context for the detailed observations of microscopy, mineralogy, and ecology within microscale studies of authigenic minerals” (Chan, et al). Macroscale remote sensing data provides regional context of potentially habitable areas. Remote sensing data includes several new technologies such as Hyperspectral High Spatial Resolution Imaging and Airborne Visible Infrared Imaging Spectrometers, LIDAR and AVIRIS-C respectively. These have been used to map sites of hydrothermal alteration and unique sedimentary environments. Such datasets have also been used to detect minerals generated through microbiologic activity” (Chan, et al). All these macroscale systems can then open the door to a more detailed microscale study. Microscale detection of biosignatures examine the authigenic minerals formed. IR mapping and micro reflectance infrared spectroscopy are sensitive in detecting even small traces of minerals.

**Discussion**

*Exploring, Mapping, and Data Management Integration of Habitable Environments in Astrobiology* ends with a discussion of a future potential collective data management system, Astrobiology Information System, AIS. The idea is a shared database with the ability to communicate and transfer information more effectively. As this was not considered apart of Recent Progress, it was excluded from the main section.

It is currently known that Mars is similar to Earth in many ways, from the systems to the atmosphere. The Curiosity Rover is still collecting samples and sending data from the surface of Mars. Its main mission being to find more evidence of organic materials, as discussed by Chan, et al. Curiosity has found evidence of some of the authigenic minerals discussed (Brown, et al), therefore confirming Chan, et al, article. It will be interesting to see what the future holds for the habitability of Mars.

**References**

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