INTRODUCTION TO NEW MARTIAN CHEMISTRY WORKSHOP: "FOLLOW THE CHEMISTRY"

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In the post-Viking era, Mars was defined largely in terms of geomorphology and the planet-wide cycles of water, dust, and CO_2. In the 21st century, we have increasingly come to understand Mars in terms of chemical processes. Soil chemistry has become a key to understanding geological, astrobiological, and even atmospheric processes. What the future holds for our understanding of Mars will be determined by NASA's Decadal Survey and similar European strategic planning endeavors. It is suggested here that a high priority for future exploration should be assigned to *in situ* and orbital studies of the chemical diversity of present-day martian soil and, where stratigraphy allows, the historical record of that chemistry.

The **mineralogy** story unfolded largely from orbit. In 2002, for example, data from the Gamma Ray Spectrometer suite was interpreted to be indicative of reservoirs of hydrated minerals at low latitudes [1]. Hints of hematite from the THEMIS instrument [2] ultimately led to the *in situ* discovery of "blueberries," putative aqueous concretions captured by MER's microscopic imager [3]. In 2006, drawing from measurements by the OMEGA instrument, Bibring et al [4] suggested that the martian epochs previously defined morphologically as Noachian, Hesperian, and Amazonian might more suggestively be defined as the ages of clays (Phyllosian), sulfates (Theiikian), and anhydrous ferric oxides (Siderikian), referring to the products of nonacidic aqueous alteration, acidic aqueous alteration, and aqueous-free oxidation respectively.

The **soil science** story is currently emerging, with the Phoenix mission providing notable contributions. Martian soil from one (subpolar) site has proven to be near-neutral in pH, buffered by calcium and possibly magnesium carbonates; laced with highly oxidized chlorine in the form of perchlorate; and may contain a modest fraction of sulfates, probably in the form of calcium sulfate [5,6]. The presence of perchlorate, in particular, suggests that photochemistry plays an important role in soil chemistry, and also implies that low temperature aqueous processes may be occurring in brines even today. The microscopic particle size distribution determined by the Microscopy, Electrochemistry, and Conductivity Analyzer (MECA) on Phoenix argues against extensive chemical modification of the soil, while atmospheric humidity measurements, when compared to soil temperature measurements, suggest that the "breathing" of salts in the soil may actually regulate the atmospheric water content.

Astrobiology and chemistry are linked both through models of possible biological evolution on Mars and through strategies for seeking evidence of such life. The Viking biology experiments inspired speculations that oxidizing soil chemistry may be inimical to the survival of the simplest prebiotic molecules [7,8]. Tosca et al. [9] extended that idea, suggesting that mineralogical evidence implied an early, aqueous Mars too acidic and saline to support the development of microbial life as we know it. From the perspective of searching for life, Capone et al [10] recently suggested that "follow the carbon" may not be the best strategy. While the carbon cycle may dominate biology, the reverse is not true. The nitrogen cycle, on the other hand (and particularly the denitrification process) is strongly influenced by biology, and the lack of nitrogen in the martian atmosphere may in and of itself contra-indicate life. In light of Phoenix findings, it might similarly be argued that dechlorification is predominantly a biological process, and the presence of large quantities of perchlorate may therefore contra-indicate extant biology.

On a predominantly dry planet, the influence of **atmospheric chemistry** is relatively important. To the long-standing discussions about photochemical oxidant formation, Phoenix has added questions about atmospheric perchlorate formation. Most recently, localized release and eventual decomposition of methane has been detected in the martian atmosphere [11]. Lacking any evidence of current volcanism on Mars, the source of such releases seem limited to sublimation of existing clathrates or biogenic sources. Confirming this observation and determining the genesis of the methane is clearly a high exploration priority.

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