Stony Brook University
The Graduate School

Doctoral Defense Announcement

Abstract

The Formation and Stability of Saline Minerals at the Martian Surface

By

Nicholas J. Tosca III

Evaporite minerals have been identified throughout the martian sedimentary record. Because evaporites can record detailed paleo-environmental information and often host fossil biosignatures on Earth, they are priority targets for future exploration. However, understanding processes that control the formation of these minerals on Mars requires an understanding of the behavior of Fe in highly concentrated evaporating fluids. In this study, a model is developed using the Pitzer ion interaction approach that accurately describes thermodynamic properties of the $Fe_2(SO4)_3$-H_2SO_4-H_2O system. Incorporating this model into a multicomponent thermodynamic database enables detailed study of evaporite mineral formation and stability on Mars. From geochemical modeling, the variation in evaporite mineralogy on Mars may be traced to volatile-anion input – a variable intimately tied to pH. Using the "chemical divide" concept, evaporites at the martian surface can be used as sensitive probes of pH, atmospheric composition, and cation proportion in solution. Applying this approach to saline assemblages in Nakhlite meteorites and in Meridiani Planum sediments reveals two geochemical systems; each characterized by different pH and anion proportion. A complicating factor however is the concomitant oxidation of soluble Fe-bearing minerals. Such a process may have contributed to complex Fe mineralogy observed at Meridiani Planum through diagenesis. Fe-oxidation experiments at high ionic strength show a progression of mineral phases that begins with the formation of schwertmannite and subsequent ageing to jarosite and nano-crystalline goethite; a process strongly controlled by pH. Low water activity and small particle size drive the ageing of goethite to hematite which provides the final step of a mechanism that is consistent with the distribution of Fe-minerals at Meridiani Planum. These results show that the instability of Fe^{2+}-sulfate minerals at the martian surface may lead to the association of Fe-oxide and Fe-hydroxysulfate minerals with evaporite salts. Indeed, such a geologic association has been observed through remote sensing techniques. Thus, as the Fe-sulfates are sensitive to pH, Fe-oxidation and relative humidity, understanding these phase relationships in greater detail will ultimately exploit the presence of these minerals as a unique set of geochemical probes.

Date: August 3, 2007
Time: 10:00 AM
Place: Earth and Space Sciences Bldg., Rm. 123

Program: Geosciences
Dissertation Advisor: Scott M. McLennan