CONFIRMATION OF SOLUBLE SULFATE AT THE PHOENIX LANDING SITE: IMPLICATIONS FOR MARTIAN GEOCHEMISTRY AND HABITABILITY. S. P. Kounaves\textsuperscript{1}, M. H. Hecht\textsuperscript{2}, J. Kapit\textsuperscript{1}, R. C. Quinn\textsuperscript{3}, D. C. Catling\textsuperscript{3}, B. C. Clark\textsuperscript{4}, D. W. Ming\textsuperscript{5}, K. Gospodinova\textsuperscript{6}, P. Hredzak\textsuperscript{1}, K. McElhenny\textsuperscript{1}, and J. Shusterman\textsuperscript{1}; \textsuperscript{1}Tufts University, Medford, MA, 02155 (samuel.kounaves@tufts.edu), \textsuperscript{2}Jet Propulsion Laboratory, Pasadena, CA, \textsuperscript{3}NASA Ames Research Center, Moffett Field, CA, \textsuperscript{4}University of Washington, Seattle, WA, \textsuperscript{5}Space Science Institute, Boulder, CO, \textsuperscript{6}NASA Johnson Space Center, Houston, TX, \textsuperscript{1}Present Address: Woods Hole Oceanographic Institution, Woods Hole, MA, \textsuperscript{2}Present Address: Massachusetts Institute of Technology, Cambridge, MA.

Over the past several decades, elemental sulfur in martian soils and rocks has been detected by a number of missions using X-ray spectroscopy [1-3]. Optical spectroscopy has also provided evidence for widespread sulfates on Mars [4,5]. The ubiquitous presence of sulfur in soils has been interpreted as a widely distributed sulfate mineralogy [6]. However, direct confirmation as to the identity and solubility of the sulfur species in martian soil has never been obtained.

One goal of the Wet Chemistry Laboratory (WCL) [7] on board the 2007 Phoenix Mars Lander [8] was to determine soluble sulfate in the martian soil. The WCL received three primary samples. Each sample was added to 25 mL of leaching solution and analysed for solvated ionic species, pH, and conductivity [9,10]. The analysis also showed a discrepancy between charge balance, ionic strength, and conductivity, suggesting unidentified anionic species.

Figure 1 shows the data for WCL cell-2 on sols 107 and 116 that, along with a blank, was one of two cells used to determine total soluble sulfate, \((\text{SO}_4^{2-})\), present in the soil by addition of \(\text{Ba}^{2+}\) as \(\text{BaCl}_2\). The \(\text{Ba}^{2+}\) remains relatively constant until sol 116 when a \(\text{BaCl}_2\) crucible is added. Soon afterwards the \(\text{Ba}^{2+}\) rapidly increases, indicating that the \(\text{Ba}^{2+}\) is no longer being precipitated by the \(\text{SO}_4^{2-}\). At that point \((\text{SO}_4^{2-})_\text{T} = \Delta\text{Cl}/2\). The \(\text{SO}_4^{2-}\) in solution = \(5.9 \pm 1.5\) mM, equivalent to \(1.4\pm0.5\) wt \% \(\text{SO}_4^{2-}\) in the soil.

Several sulfate mineral phases are plausible candidates for the soluble sulfate, including \(\text{K-}, \text{Na-}, \text{Fe-}, \text{Mg-}, \text{and Ca-sulfate}\). The \(\text{Fe}\) was eliminated by the sensor responses. The concentrations of the \(\text{K}\) and \(\text{Na}\) were too low and would account for only a minor fraction of any mineral phase. Only \(\text{MgSO}_4\) and \(\text{CaSO}_4\) remain as the most likely phases present in the soil.

Calculations show that addition of \(\text{BaCl}_2\), coupled with dissolution of \(\text{SO}_4^{2-}\), would result in an increase of \(\text{Mg}^{2+}\) and a decrease of \(\text{Ca}^{2+}\) only if a \(\text{MgSO}_4\) phase were added. This was observed during the sol 107 analysis [10]. The addition of soluble \(\text{CaSO}_4\) would cause an increase in \(\text{Ca}^{2+}\) and no change in \(\text{Mg}^{2+}\), which is not observed. This suggests the major fraction of \(\text{SO}_4^{2-}\) was added as a \(\text{MgSO}_4\) phase. If the soil was once wet, then salts from evaporating the WCL solution could also act a guide to minerals present in the soil. Such models, run over temperature ranges of 0-25\(^\circ\)C and partial pressures of \(\text{CO}_2\) (\(P_{\text{CO}_2}\)) of 0.004-1 atm, show that epsomite exceeds gypsum precipitation by 3 times to 3 orders of magnitude.

The level of dominant salts also has a direct bearing on the question of whether, under appropriate conditions, water activity on Mars could have been sufficient to support life. Using newly derived WCL solution ion concentrations and evaporation models, suggests that if a small portion of the landing site's ice had been converted to liquid water in the past, brine pockets with the WCL derived salt speciation would have had a water activity consistent with habitability.

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