

CONFIRMATION OF SOLUBLE SULFATE AT THE PHOENIX LANDING SITE: IMPLICATIONS FOR MARTIAN GEOCHEMISTRY AND HABITABILITY. S. P. Kounaves¹, M. H. Hecht², J. Kapit^{1†}, R. C. Quinn³, D. C. Catling⁴, B. C. Clark⁵, D. W. Ming⁶, K. Gospodinova^{1‡}, P. Hredzak¹, K. McElhoney¹, and J. Shusterman¹; ¹Tufts University, Medford, MA, 02155 (samuel.kounaves@tufts.edu), ²Jet Propulsion Laboratory, Pasadena, CA, ³NASA Ames Research Center, Moffett Field, CA, ⁴University of Washington, Seattle, WA, ⁵Space Science Institute, Boulder, CO, ⁶NASA Johnson Space Center, Houston, TX, [†]Present Address: Woods Hole Oceanographic Institution, Woods Hole, MA, [‡]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, $(\text{SO}_4^{2-})_T$, present in the soil by addition of Ba^{2+} as BaCl_2 . The Ba^{2+} remains relatively constant until sol 116 when a BaCl_2 crucible is added. Soon afterwards the Ba^{2+} rapidly increases, indicating that the Ba^{2+} is no longer being precipitated by the SO_4^{2-} . At that point $(\text{SO}_4^{2-})_T = \Delta\text{Cl}^-/2$. The SO_4^{2-} in solution = 5.9 (± 1.5) mM, equivalent to 1.4(± 0.5) wt % SO_4^{2-} in the soil.

Several sulfate mineral phases are plausible candi-

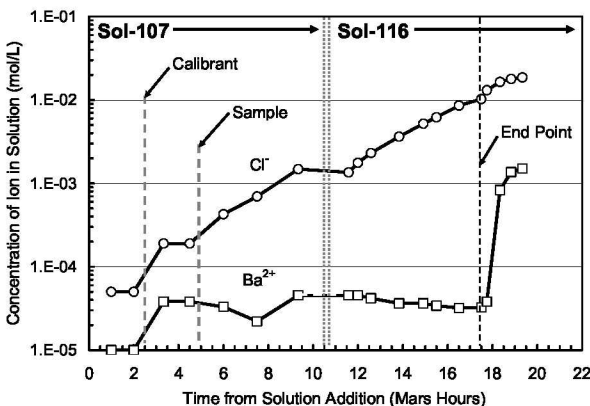


Figure 1. Titration of sulfate by addition of barium.

dates for the soluble sulfate, including K-, Na-, Fe-, Mg-, and Ca-sulfate. The Fe was eliminated by the sensor responses. The concentrations of the K and Na were too low and would account for only a minor fraction of any mineral phase. Only MgSO_4 and CaSO_4 remain as the most likely phases present in the soil.

Calculations show that addition of BaCl_2 , coupled with dissolution of SO_4^{2-} , would result in an increase of Mg^{2+} and a decrease of Ca^{2+} only if a MgSO_4 phase were added. This was observed during the sol 107 analysis [10]. The addition of soluble CaSO_4 would cause an increase in Ca^{2+} and no change in Mg^{2+} , which is not observed. This suggests the major fraction of SO_4^{2-} was added as a 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°C and partial pressures of CO_2 (P_{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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