

CHEMICAL WEATHERING ON MARS: INTERACTIONS OF SULFUR DIOXIDE WITH OLIVINE AND OLIVINE THOLEIITE IN SIMULATED MARTIAN ENVIRONMENTS. M.C. Booth, E.K. Gibson, Jr., NASA/Johnson Space Center, Geochemistry Branch, Mail Code SN7, Houston, TX 77058; and R. Kotra, Lockheed, 1830 NASA Rd. 1, Houston, TX 77058.

The martian regolith examined by the Viking Landers contained an abundance of sulfur (7-9% as SO_2), probably in the form of sulfates (1). Sulfur abundance was greatest in thin "duricrusts" at the regolith surface in Chryse Planitia. Using the dry valleys of the Antarctic as a martian surface analog, Gibson et al. (2) have proposed an evaporite origin for sulfur species in the martian regolith by the upward migration of soluble ions during regolith water evaporation. As an alternative origin for this regolith sulfur, the interactions of sulfur dioxide, a probable byproduct of martian volcanism, with silicate material has now been examined by means of environmental simulation, with measurable sulfur fixation and surface crusting observed. These SO_2 studies constitute an expansion of earlier work by Clark et al. (3), with greater emphasis placed on the chemical weathering of primary igneous material rather than weathering products (carbonates, oxides, nitrates, clays).

The environmental chambers used for these studies were capable of providing the fundamental characteristics of the martian environment including diurnal cycling of soil temperatures, atmospheric pressures and compositions, and ultra-violet irradiation (> 200 nm). Powders of olivine and olivine tholeiite rock samples were used as experimental soils. Dual environmental chambers were interfaced to a nitrogen glove cabinet to enable sample preparation, including grinding and chamber loading, be accomplished without exposure of rock powders to air. The partial pressures of H_2O and O_2 were continually monitored during operations within the glove cabinet with partial pressures maintained < 50 ppm and < 250 ppm, respectively. Environmental parameters examined for their effect on SO_2 interactions with experimental rock powders during simulation experiments included total H_2O , partial pressures of H_2O and O_2 , ultraviolet irradiation, maximum surface temperature [T(max)], and the rate of diurnal cycling. The nominal martian simulation experiment involved a split powder sample of olivine-olivine tholeiite 5 mm thick and 1.75-inch diameter, was of 45-hour duration with a 6-hour diurnal cycle, sample temperature cycle of 180 to 298K, atmosphere composition of 100 mbars CO_2 , 25 mbars SO_2 , < 50 precip. $\mu\text{m H}_2\text{O cm}^{-2}$, $\text{pH}_2\text{O} \sim 1\mu\text{m}$, and had direct ultraviolet irradiation of powder samples. Water frosts formed during periods of low sample temperature sublimed upon sample warming toward T(max). Experiments were also conducted with surficial H_2O frosts being allowed to melt, rather than sublime, to determine whether changes in weathering chemistry occur with the introduction of a transitory liquid water phase.

Analysis of experimental powders was accomplished using a thermal analyzer-mass spectrometer system (4), providing information on the chemistry and abundance of the sulfur species generated during simulation. Preliminary results of TA-MS analysis of experimental olivine powders suggest the growth of at least one sulfur species in olivine which is stable to 600°C at 10^{-5} atm pressure. Results also indicate that the reaction of SO_2 with olivine is non-photochemical, involves H_2O in addition to SO_2 , occurs more readily in olivine than in olivine tholeiite, and proceeds with or without diurnal cycling. The reaction slows with decreased soil temperature, and produces a thin sulfur-rich upper crust in powder samples in addition to overall sulfur enrichment of samples.

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These results consequently support the alternative origin of martian regolith sulfur at least in part from the heterogeneous reaction of SO_2 , an out-gassing component of mafic shield volcanism with mafic silicate material on Mars, even under current environmental conditions.

REFERENCES; (1) Toulmin, P. III et al. (1977), J. Geophys. Res. 82, p. 4625-4634; (2) Gibson, E.K., Jr. et al. (1981), NASA Tech. Mem. 84211, p. 463-465; (3) Clark, B.C., et al. (1979), J. Mol. Evol. 14, p. 91-102; (4) Gibson, E.K., Jr. (1973), Thermochimica Acta 5, 243-255.