EVALUATING THE EFFECT OF SULFUR ON ALTERATION ASSEMBLAGES IN IMPACT CRATERED TERRAINS ON MARS.

S. P. Schwenzer[1,2] and D. A. Kring[1] [1]Lunar and Planetary Institute, USRA, 3600 Bay Area Blvd., Houston, TX 77058, USA; kring@lpi.usra.edu. [2]The Open University, Faculty of Science, Earth and Environmental Sciences, Walton Hall, Milton Keynes, MK7 6AA, UK; s.p.schwenzer@open.ac.uk.

Introduction: A clay, namely nontronite, was recently discovered in Noachian terrains [1]. That discovery was rapidly followed by detection of chlorite, serpentine, kaolinite, zeolites, and carbonates [2]. All of the hydrous silicates are restricted to the Noachian terrains [3]. Therefore, the alteration phases occur in the old, heavily cratered environment on Early Mars, which was most likely shaped in a very short period of time during the Late Heavy Bombardment (e.g., [4]). Thus, impact cratering was a very important process contemporaneous to the formation of hydrous silicates. This is especially important in the light of studies that have shown that impact craters are capable of hosting hydrothermal systems [5, 6] and producing alteration phases [7]. On Mars, geologic links to impact-generated formation of alteration minerals in central peaks and modification zones of Martian craters have been found [2]. Modeling the formation conditions of those phases demonstrates where and when these phases form in the post-impact hydrothermal environments on Mars.

Magmatic rocks from Mars – meteorites: We have shown earlier that those two factors (water to rock ratio (W/R) and rock chemistry) produce three distinct types of assemblages [7]: At low W/R a "metamorphic" assemblage occurs that mainly contains serpentine, chlorite and amphibole. At intermediate W/R a nontronite-hematite assemblage dominates; at low W/R the precipitate is hematite that is accompanied by some pyrite and diaspore, depending on the Al and S content of the system. Fig. 1 (left column) displays the alteration phases forming from the composition of the lherzolithic shergottite LEW 88516 [7]. If the system contained more feldspar, e.g., like the basaltic shergottite Dhofar 387, the resulting mineral assemblage will contain secondary feldspar as well as zeolites [8]. If the protolith is a dunite, a serpentine-magnetite assemblage results [8]. High amounts of CO_2 lead to carbonate formation on the expense of hydrous silicates [9].

Martian surface rocks and soils: Rocks from the surface of Mars contain more S than the Martian meteorites (Fig. 1, row 1). To determine how buried sediments with similar properties could be affected by impact-generated hydrothermal alteration, we calculated the alteration of Martian surface rocks from the outcrop "Peace" and the "Paso light" soil as measured at Gusev Crater on Mars [10]. The calculations indicate the addition of S does not have a major influence on the alteration assemblages at very high W/R, because the initial fluid dominates the precipitated assemblage (Fig. 1, row 2). At intermediate to low W/R, however, the dissolved rock compostion dominates the nature of the alteration assemblage. The most significant differences are the formation of pyrite at the expense of hematite and iron bearing hydrous silicates and the formation of anhydrite instead of Ca-bearing silicates (Fig. 1, rows 3,4). This, in turn, changes the amount of SiO_2 bound in the silicates, causing quartz or amorphous SiO_2 to precipitate. Moreover, the total amount of alteration products from the S-rich systems is smaller than from the S-poor systems. Therefore, more ions remain in solution (Fig. 1 row 5) and are available for later reaction or deposition.

Conclusions: Studies of hydrothermal systems at terrestrial and Martian craters [6, 11] have revealed that the most fractured and, thus, most "active" parts of the systems are the central uplift and the modification zone. As they evolve, the temperature declines over several thousand years with the isotherms moving inwards and downwards. Consequently, model assemblages formed at intermediate W/R and temperatures of ~150 °C are the most likely alteration products to be found. The silicates formed in that temperature and W/R range are mainly smectitic clays and chlorite, but also serpentine, zeolites, and amphibole. The clay-rich rocks are ideal astrobiological targets, because they may have provided habitable conditions. The sulfides described here can be harvested as source of energy by some microorganisms. Overall, large Noachian impact craters are important and promising places for the search for fossil habitats and their potential inhabitants.

References: [1] Bibring, J.-P. et al. (2005) *Science, 307,* 1576–1581. [2] Ehlmann, B.L. et al. (2009) *Journal of Geophysical Research, 114:* E00D08, dio: 10.1029/2009JE003339. [3] Poulet, F. et al. (2007) *Journal of Geophysical Research, 112*: E08S02, doi: 10.1029/2006JE002840. [4] Strom, R.G. et al. (2005) *Science, 309*, 1847–1849. [5] Newsom, H.E. (1980) *Icarus,* 44, 207–216. [6] Abramov, O., Kring, D.A. (2005) *JGR, 110*: doi: 10.1029/2005JE002453. [7] Schwenzer, S. P., Kring, D. A. (2009) *Geology 37 (12):* doi: 10.1130/G30340A.1. [8] Schwenzer, S.P., Kring, D.A. (2009) Lunar and Planetary Science **XL**: #1421. [9] Schwenzer, S.P., Kring, D.A. (2009) Meteoritical Society Meeting, Nancy, France, #5262. [10] Gellert, R. et al. (2006) *Journal of Geophysical Research, 111:* E02S05, doi:10.1029/2005JE002555. [11] Abramov, O., Kring, D.A. (2007) *MAPS, 42,* 93–112.

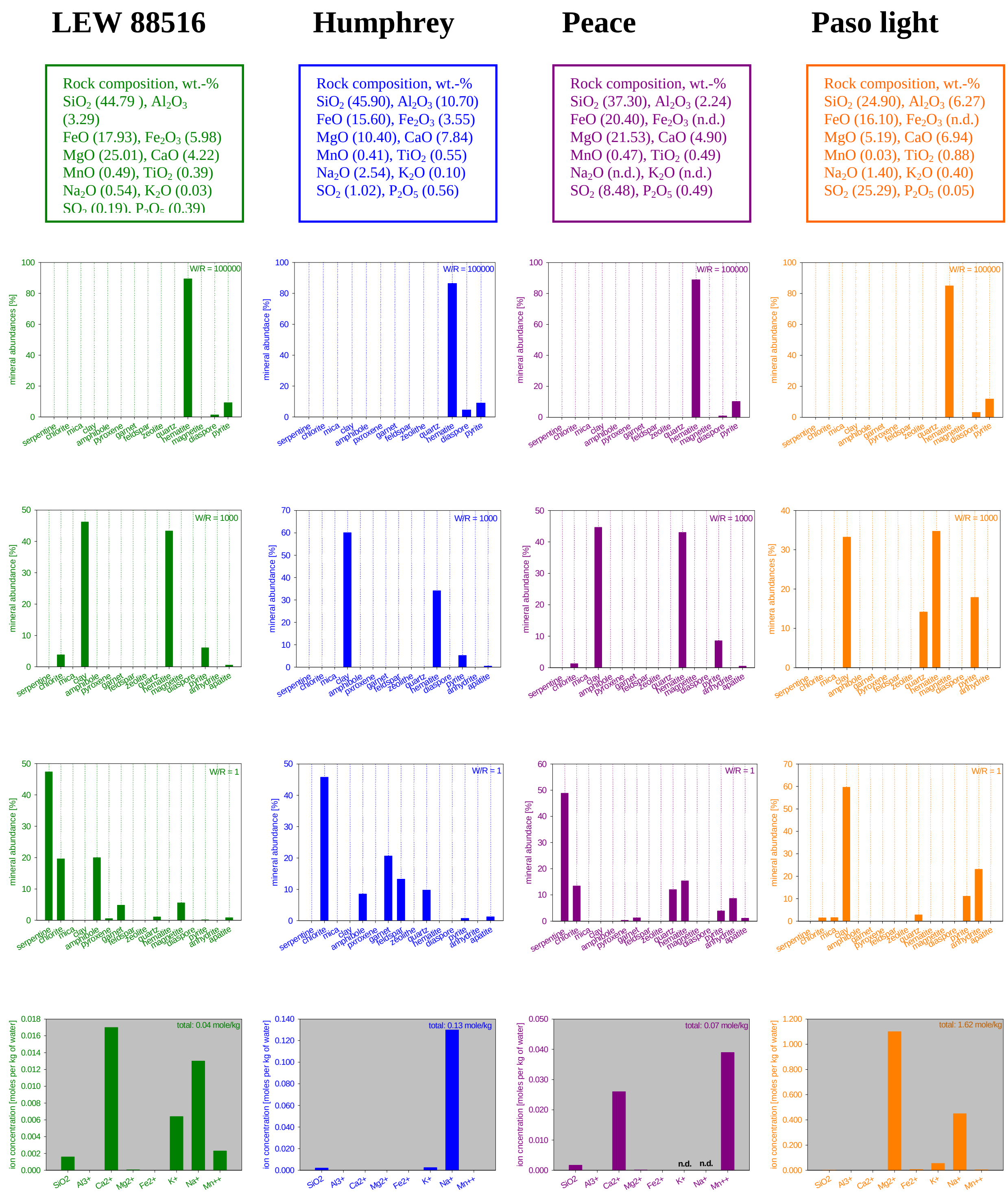

Fig. 1. Starting compositions of four rocks are displayed in row one (LEW 88516 as in [7], Humphrey, Peace and Paso from [10]). The next three rows display the resulting mineralogy for alteration phases formed at 150 °C and water to rock ratios (W/R) of 100,000, 1000, and 1, respectively. The last row displays the ions in solution in equilibrium with the assemblage at W/R of 1. Note, that this solution can leave the system and cause reactions, alteration and precipitation elsewhere.