

IRON AND SULFUR MINERALOGY OF GALE CRATER SEDIMENTS SIGNALS CHANGES IN HABITABLE CONDITIONS DURING DIAGENESIS. Jack Farmer¹, D. L. Bish², D. F. Blake³, D. W. Ming⁴, R. V. Morris⁴, D. T. Vaniman⁵, C. N. Achilles², R. C. Anderson⁶, T. F. Bristow³, P. D. Cavanagh², S. J. Chipera⁷, J. A. Crisp⁶, R. T. Downs⁸, D. J. Des Marais³, K. V. Fendrich⁸, J. Grotzinger⁹, J. M. Morookian⁶, S. M. Morrison⁸, E. B. Rampe⁴, A. H. Treiman¹⁰, P. C. Sarrazin¹¹, N. Spanovich⁶, E. M. Stolper⁹, and A. S. Yen⁶. ¹Arizona State University, School of Earth and Space Exploration, PO Box 871404, Tempe, AZ. 85287, jfarmer@asu.edu. ²Geological Sciences, Indiana University, Bloomington, ³NASA Ames Research Center, Mountain View CA, ⁴NASA-JSC, Houston TX, ⁵Planetary Science Institute, ⁶JPL-Caltech, Pasadena CA ⁷Chesapeake Energy Company Oklahoma City, OK, ⁸University of Arizona, Tucson, ⁹California Institute of Technology, Pasadena, ¹⁰Lunar Planetary Institute, Houston, ¹¹SETI Institute, Mountain View CA.

Introduction: Small amounts of the iron sulfide mineral, pyrrhotite ($\text{Fe}(1-x)\text{S}$) and one of its common oxidation products, akaganeite (beta- $\text{FeO}(\text{OH},\text{Cl})$), were detected at low abundances in powdered core samples using the Curiosity rover's CheMin X-ray Diffraction instrument [1]. Samples were obtained in Yellowknife Bay (John Klein and Cumberland) and at Kimberley (Windjana). Subsequently, jarosite, $(\text{K},\text{Na},\text{H}_3\text{O})\text{Fe}_3(\text{SO}_4)_2(\text{OH})_6$ was discovered in drill cores from two targets at Pahrump (Confidence Hills and Mojave2). The detection of these minor abundance alteration phases holds important implications for the history of Gale Crater sediments at these locations and the implied evolution of ancient habitable environments during diagenesis.

Fe-S Mineralogy and Diagenesis: Akaganeite typically forms by the oxidation of Fe-sulfides (e.g. Pyrrhotite) through interactions with acidic, chloride brines [2, 3]. Similarly, jarosite may also form by sulfate oxidation under an acidic pH and elevated chlorine. The high salinity/low pH conditions required for the precipitation of these minerals is in marked contrast to the primary depositional conditions of low salinity and circum-neutral pH inferred from context sedimentology and clay mineralogy at Yellowknife Bay [4, 5]. The dominance of primary basaltic minerals in Gale Crater sediments analyzed to date indicates limited aqueous weathering during transport, or following deposition. This suggests a post-depositional history dominated by low water/rock conditions

Pyrrhotite is a common magnetic mineral that occurs primarily as an exsolved phase in mafic and ultramafic igneous rocks. Pyrrhotite also occurs as a common, low abundance component of heavy mineral concentrates in igneous-derived sedimentary rocks. The low abundance of pyrrhotite in the Gale Crater sediments sampled is consistent with a detrital origin, and incomplete oxidation of pyrrhotite during brief intervals of low W/R interaction. Alteration may have been localized within zones of higher permeability where cementation was patchy.

Implications for Habitability: While akaganeite and jarosite may be correctly considered minor alteration phases of the rocks comprising the samples analyzed, they nonetheless hold important implications for the evolution of habitability in the Gale Crater sedimentary system. It seems clear that dramatic changes in pH, salinity, and water activity occurred at the microscale during the diagenesis of the sediments discussed here. If life were present, these changes would have necessitated a biotic transition from mesophilic forms, to endosedimentary microbial communities dominated by halotolerant acidophiles. While the implied environmental shifts would have been dramatic, they are likely to have remained within known environmental limits for terrestrial extremophiles [6]. In addition, Fe-sulfide oxidation pathways involved in the formation of these alteration phases could have provided potentially important energy sources for chemolithoautotrophic microbes, thereby meeting an important secondary requirement for habitability.

References: [1] Blake et al. (2012) *Space Sci. Rev.* 170, p. 341-399. [2] Bibi et al. (2011) *Geochim. Cosmochim. Acta* 75, 6429-6438. [3] Fox et al. (2015). *LPS XLVI* Abstract #1199. [4] Grotzinger et al. (2013) *Science* Vol. 343 no. 6169. [5] Vaniman et al. (2013). *Science*, Vol. 343 no. 6169. [6] Amils, et al. (2007) *Planet. Space Sci.*, 55, 370-38