Predicting martian mineral compositions *in situ*: Crystal chemical techniques

Shaunna M. Morrison,[a] Robert T. Downs,[b] David F. Blake,[c] David T. Vaniman,[d] Douglas W. Ming,[e] Allan H. Treiman,[f] Cherie N. Achilles,[g] Robert M. Hazen,[a] Albert S. Yen,[h] Richard V. Morris,[e] Elizabeth B. Rampe,[e] Thomas F. Bristow,[c] Steve J. Chipera,[i] Nicholas Castle,[f] Valerie Tu,[e] and Richard Walroth.[c]

[a]Geophysical Laboratory, Carnegie Institution, 5251 Broad Branch Rd NW, Washington, DC, 20015 USA, smorrison@carnegiescience.edu
[b]University of Arizona, 1040 E 4th St, Tucson, AZ, 85721 USA
[c]NASA Ames Research Center, Moffett Field, CA 94035, USA
[d]Planetary Science Institute, 1700 E. Fort Lowell, Tucson, AZ 85719-2395, USA
[e]NASA Johnson Space Center, Houston, TX, 77058 USA
[f]Lunar and Planetary Institute, 3600 Bay Area Blvd, Houston, TX 77058, USA
[g]NASA Goddard Space Flight Center, 8800 Greenbelt Rd, Greenbelt, MD 20771, USA
[h]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, USA
[i]Chesapeake Energy Corporation, 6100 N. Western Avenue, Oklahoma City, OK 73118, USA

The Mars Science Laboratory rover, Curiosity, is providing *in situ* analyses of rocks and soils in Gale crater. Since landing in 2012, Curiosity has analyzed the mineralogy of sediments with the CheMin instrument, the first X-ray diffractometer on another planet [1]. CheMin performs quantitative mineralogical analyses of drilled powders and scooped sediment to determine mineral abundances and unit-cell parameters of major crystalline phases with Rietveld refinement of the XRD patterns.

In order to better understand the formational conditions and geologic history of the minerals found in Gale crater, the CheMin team developed crystal-chemical methods to predict the chemical compositions of minerals observed in the CheMin samples [2,3]. The main crystalline phases identified by CheMin include plagioclase (average An_{40}), sanidine (average Or_{74}), pigeonite (average $Mg_{1.18(19)}Fe_{0.72(7)}Ca_{0.10(9)}Si_2O_6$), *C*2/*c* clinopyroxene (average $Mg_{0.96(6)}Ca_{0.73(2)}Fe_{0.31(8)}Si_2O_6$), orthopyroxene (average $Mg_{0.79(6)}Fe_{1.20(6)}Ca_{0.01(2)}Si_2O_6$), olivine (average Fo_{60}), magnetite, and alunite-jarosite group minerals [4].

The mineralogy of analyzed samples plays a key role in characterizing various 3.5 billion year old fluvio-lacustrine paleoenvironments in Gale crater. Together with findings from other instruments on Curiosity, CheMin has documented mineralogical details of the first habitable environment found on another planet [4].

[1] D.F. Blake et al. (2013) Science **341**, 1239505
[2] D.T. Vaniman et al. (2014) Science **343**, 1243840
[3] Morrison et al. (2017) Am Min, **103(6)**: 848-856
[4] Morrison et al (2017) Am Min, **103(6)**: 857-871