CRYSTAL-CHEMICAL ANALYSIS OF SOIL AT ROCKNEST, GALE CRATER. S.M. Morrison[1], R.T. Downs[1], D.F. Blake[2], D.L. Bish[3], D.W. Ming[4], R.V. Morris[4], A.S. Yen[5], S.J. Chipera[6], A.H. Treiman[7], D.T. Vaniman[8], R. Gellert[9], C.N. Achilles[4], E.B. Rampe[4], T.F. Bristow[2], J.A. Crisp[5], P.C. Sarrazin[10], J.D. Farmer[11], D.J. Des Marais[2], E.M. Stolper[12], J.M. Morookian[5], M.A. Wilson[2], N. Spanovich[5], R.C. Anderson[5] and the MSL team. [1]U. of Arizona (1040 E 4th St. Tucson, AZ 85721; shaunnamm@email.arizona.edu), [2]NASA ARC, [3]Indiana U., [4]NASA JSC, [5]JPL-Caltech, [6]CHK Energy, [7]LPI, [8]PSI, [9]U. Guelph, [10]in-Xitu, [12]Arizona State U., [13]Caltech.

Introduction: The CheMin instrument on the Mars Science Laboratory rover Curiosity performed X-ray diffraction analysis on Martian soil [1] at Rocknest in Gale Crater. In particular, crystalline phases from scoop 5 were identified and analyzed with the Rietveld method [2]. Refined unit-cell parameters are reported in Table 1. Comparing these unit-cell parameters with those in the literature provides an estimate of the chemical composition of the crystalline phases. For instance, Fig. 1 shows the Mg-content of Fa-Fo olivine as a function of the *b* unit-cell parameter using literature data. Our refined *b* parameter is indicated by the black triangle.

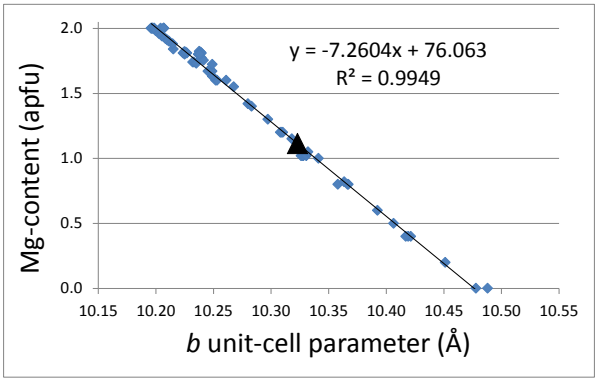

Figure 1. Mg-content of Fa-Fo olivine as a function of *b* unit-cell parameter, indicating Fo56 for the composition of the Rocknest olivine with an error of 3%.

Composition as a Function of Unit-Cell Parameters: Unit-cell parameters and chemistry were obtained from the literature for the target minerals, and relationships similar to Fig. 1 were observed. Some relationships, like that for olivine, are very well defined, whereas others, such as that for plagioclase in Fig. 2, reflect a larger range of solid solution. In the case of plagioclase, this range is a consequence of variation in Al-Si ordering and possibly of small amounts of K, not accounted for in this analysis. Augite and pigeonite were constrained to the Ca-Fe-Mg system. A simple binary plot, as shown in Fig. 1 and 2, did not fully describe the variations. Therefore, in both cases, Mg-content was estimated from the *b* unit-cell parameter because it forms a linear trend (Fig. 3a). Ca and Fe were discriminated by the β angle for augite (Fig. 3b) and by unit-cell volume for pigeonite (not shown).

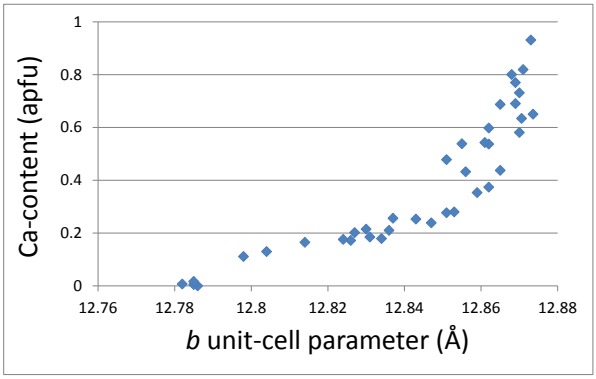

Figure 2. Ca content of K-free plagioclase as a function of the *b* unit-cell parameter. The large scatter of data results in an error of 12%.

Chemical Composition of the Major Phases: The following chemical compositions were obtained from the regressions illustrated in Fig.1-3:

olivine: $(Mg_{0.56(3)}Fe_{0.44})_2SiO_4$
andesine: $(Ca_{0.52(12)}Na_{0.48})(Al_{1.53}Si_{2.48})O_8$
augite: $[Ca_{0.77(4)}Mg_{0.67(10)}Fe_{0.56}]Si_2O_6$
pigeonite: $[Mg_{1.40(9)}Fe_{0.22(10)}Ca_{0.38}]Si_2O_6$

Table 1. Refined unit-cell parameters of the crystalline components from the Rocknest scoop 5 soil.

Mineral	Wt.%	2σ	*a* (Å)	*b* (Å)	*c* (Å)	α (°)	β (°)	γ (°)
andesine	42.9%	3.4%	8.175(5)	12.868(8)	7.117(5)	93.46(6)	116.31(2)	90.16(4)
forsterite	20.5%	2.6%	10.323(8)	6.034(4)	4.769(5)	90	90	90
augite	16.7%	3.5%	9.765(9)	8.96(1)	5.251(6)	90	106.10(6)	90
pigeonite	11.4%	3.9%	9.68(1)	8.89(1)	5.28(1)	90	108.4(1)	90

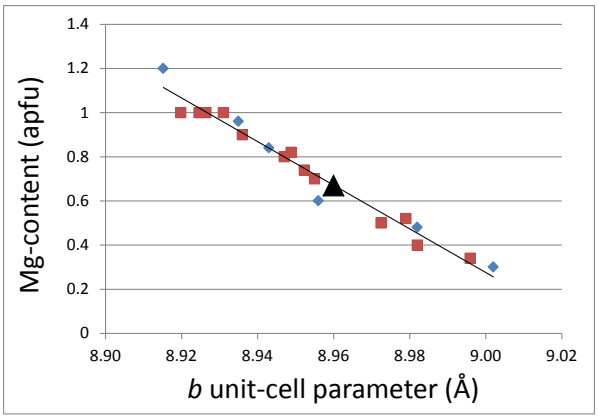

Figure 3a. Variation of Mg-content with *b* unit-cell parameter in augite obtained from literature data. The estimated Mg-content of the Rocknest augite was determined from this regression and is marked with the black triangle. Blue diamonds represent Ca = 0.8 and red squares are Ca = 1.

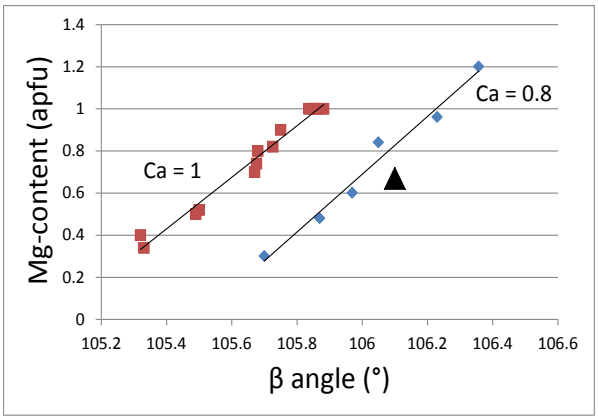

Figure 3b. The Ca-content in augite is obtained by scaling the separation between the two trends of Mg-content versus β angle at Ca = 1 (red squares) and Ca = 0.8 (blue diamonds) apfu. The black triangle represents the Mg-content from Fig. 3a at the refined β angle.

Comparison with Bulk Chemistry Measured by APXS: The bulk chemistry of the crystalline component was computed from the estimated chemical compositions weighted by abundances and is shown in Table 2. Our results agree with those estimated by [3], to a standard deviation of 0.8 weight %, providing a measure of consistency between reported chemistry of martian meteorites and CheMin results. We assumed that the crystalline component, C, plus the "amorphous" component, A, summed to the total measured by APXS [4], T, where α is a scaling factor:

$$\alpha C + (1-\alpha)A = T$$

Then $\alpha \leq 0.63$ to insure consistency with the APXS total (requires that all MgO is crystalline), implying that the amorphous component ≥ 37 % in the CheMin sample, compared with estimates of 36% [3], and 27% ± 13.5 [2]. If we assume α = 0.63 and subtract the CheMin crystalline component from the APXS total, we obtain the bulk composition of the amorphous components shown in Table 3. Our values agree with those from [3] to a standard deviation of 1.7 weight %.

Table 3. Amorphous component bulk composition (wt.%) obtained by T-αC

Component	This study	[3]
SiO_2	36.2	35.3
Fe-oxides	34.1	29.4
SO_3	13.2	13.0
Al_2O_3	4.5	3.9
TiO_2	3.7	3.5
CaO	4.0	6.3
Na_2O	2.1	1.6
MnO	1.2	0.7
K2O	1.0	1.3

Table 2. Comparison of the calculated bulk chemistry of the crystalline component with the measured bulk chemistry of the Rocknest sample in wt.%.

Component	Crystalline		Bulk
	This study	[3]	APXS
CaO	9.5	8.0	7.4
MgO	10.4	9.9	6.5
Fe-oxides	14.2	16.2	21.0
SiO_2	49.1	48.4	43.7
MnO	0.0	0.3	0.4
Na_2O	2.4	2.6	2.2
Al_2O_3	12.7	12.7	9.6
TiO_2	0.4	0.4	1.5
K_2O	0.4	0.2	0.6
SO_3	0.8	0.7	5.2

References: [1] Blake et al. (2013) *LPS XLIV*, Abstract. [2] Bish et al. (2013) *LPS XLIV*, Abstract. [3] Morris et al. (2013) *LPS XLIV*, Abstract. [4] Yen et al. (2013) *LPS XLIV*, abstract.