GUSEV-MERIDIANI-TYPE SOIL COMPONENT DISSOLVED IN SOME SHOCK GLASSES IN SHERGOTTITES. D. K. Ross[1,3], M. N. Rao[2], L. E. Nyquist[3], C.-Y. Shih[1,3], S. Sutton[5], D. H.Garrison[6,3], [1]Jacobs Technology-JETS, 2224 Bay Area Blvd. TX. 77058 (daniel.ross@nasa.gov); [2]SCI, Johnson Space Center, Houston. TX. 77058; [3]EISD, NASA, Johnson Space Center, Houston. TX. 77058. [5]Dept. of Geophys. Sci. & CARS Univ. of Chicago. Chicago. IL. 60439. [6]Barrios Technology-JETS. 16441 Space Center Blvd. Houston Tx 77058.

Introduction: Modal analysis, based on APXS, MiniTES and Mossbauer results obtained at Gusev and Meridiani sites on Mars, indicates that Martian soils consist predominantly of igneous minerals such as olivine, pyroxene and feldspar (~ 70 – 80%), with the balance consisting of alteration minerals such as sulfates, silica and chlorides [1,2]. These studies also showed that soil alteration did not occur in-situ and igneous and alteration components are derived from different sources.

Below, we analyse the chemical abundance data obtained from shock glasses in shergottites using mass balance mixing models. In these models, the two main end members used are (a) host rock chemical composition [3] and (b) the GM soils average composition [1] as the second component. Here, we consider the S-bearing phases as indicators of added alteration phases in the shock glasses and GM soils. Although the S-bearing phase in shock glasses occurs as micron sized sulfide blebs, we showed in earlier abstracts that sulfur was originally present as sulfate in impact glass-precursor materials and was subsequently reduced to sulfide during shock melting [4-6]. This conclusion is based on results obtained from S-K XANES studies, Fe/S atomic ratios in sulfide blebs and $^{34}S/^{32}S$ isotopic measurements in these sulfide blebs [4-6]. Additionally, sulfur in several EET79001 Lith. A glasses is found to correlate positively with Al_2O_3 and CaO (and negatively with FeO and MgO), suggesting the presence of Al- and Ca- sulfate-bearing phases. The distribution of the $^{87}Sr/^{86}Sr$ isotopic ratios determined in Lith. A glasses (,27 & ,188 and ,54) indicate that Martian soil gypsum and host rock material were mixed with each other in the glass precursors [7]. In some vugs in Lith A glass ,27 [8] detected gypsum laths. Furthermore, the Martian regolith-derived component (where sulfur typically occurs as sulfate) is identified in these glasses by determining neutron produced isotopic excesses/deficits in ^{80}Kr and ^{149}Sm isotopes [9]. Moreover, the suggestion that the large amount of sulfur found in ,507 was sourced from pyrrhotite in the host rock, would require that excessive quantities of host rock would need to be stripped of sulfur to make this sulfide-rich glass. These results provide ample evidence that S occurred as sulfate and was added to glass precursor materials prior to impact shock.

Results and Discussion: In Figs. 1 and 2, we plot the SO_3 abundance (S calculated as SO3) against FeO and MgO determined in shock glasses from Tissint, Shergotty and EET79001, Lith. A and Lith. B on a semi-log plot. We also show end member compositions of host rocks and GM soils. Host rock data and the GM soils compositions are connected by tie lines and mixing proportions of these components are tic-marked. The Shergotty sample DBS (#4) was studied by us, and Shergotty samples #1, and #3 data are taken from [10].

In Fig.1, (FeO vs SO_3), EET79001,507 shock melt plots within the field of GM soils, suggesting that the S-bearing component in this glass could be similar to that present in GM soils. Shergotty #3 plots near the GM soils suggesting that this glass also contains large proportions of soil components. However, the data points for EET79001,506 and Tissint plot distant from the GM soils, indicating that the host rock component dominates in these glasses. Other glasses plot between these two extremes. In Fig. 2 (MgO vs SO_3), EET79001,507 plots well below the GM soils suggesting the presence of a major diluting mineral phase in this glass. Based on Al_2O_3 vs SiO_2 and CaO vs SiO_2 correlation plots (not shown here) for this glass, it appears that the diluting material is plagioclase, which was mixed with the glass precursors in addition to the plag. already present in host rock and GM soils. However, Tissint and 79001,506 glasses seem to be simple mixtures of host rock and a GM soil-like component, with host rock being dominant.

Using a simple mass balance (GENMIX) program, we calculate proportions of host rock and GM soils in these glasses such that the calculated composition matches the measured composition. In some cases, to achieve a match, we needed to include other components, such as plagioclase, jarosite or whitlockite (when necessary) into the mass balance routine. Obtaining agreement between major elements in the calculated and observed compositions is the main goal of mass balance calculations (with lesser emphasis on minor elements). The results of mass balance calculations are reported in Table 1. These shock glasses contain varying proportions of the mixing components. In some glasses (EET79001,506 and Tissint), the host rock component (~85 – 90%) dominates with only ~5 – 15 % of GM soil contribution. However, in other shock glasses (EET79001,507 and Shergotty 3), GM soil contribution dominates. In 79001,507, large quantities of plagioclase and jarosite are also required to match the observed composition. In some glasses (Shergotty), both these components occur in significant amounts. In other glasses (,507 and Shergotty DBS), large amounts of plagioclase seem to have been mixed into the impact melt in addition to the igneous plag. already present in the host rock and GM soils. Note that in EET79001,507 glass, large amounts (~14%) of jarosite are needed to match the observed SO_3. The rationale behind jarosite addition in this glass is provided by independent evidence where FeO and SO_3 show strong correlation (r^2 = ~0.85) (figure not given) with SO_3 ranging from 0.2 to ~18% in this glass. Here, the data points plot on the line joining the host rock and jarosite but not on the line joining host rock and pyrrhotite. Furthermore, the plag addition in 507 and Shergotty DBS glasses is supported by large enrichments of Al_2O_3 relative to the host rock found in the Al_2O_3 – SiO_2 correlation plots (not given here) in these glasses.

Furthermore, Fe/S (atomic) ratios determined in shock sulfide blebs in Tissint and EET79, 507 are always >1 (range 1.03 – 1.19 and in few cases >1.5) whereas the igneous pyrrhotite globules yield the Fe/S (atomic) ratios of ~0.89 – 0.93 in all these samples. In addition, in sulfide blebs in some glass pockets in Tissint we determined Fe/S (atomic) ratios as low as 0.52 [5]. Profiles of S- K XANES spectra of the sulfide blebs in ,507 glass are quite different from those determined in igneous pyrrhotite [4]. The sulfur based results presented above clearly show that sulfide blebs in shock melt were not generated by direct shock melting of pyrrhotite from the host rock.

Conclusions: The mass-balance calculations presented here do not provide unique solutions. However, they clearly demonstrate the requirement for external components other than host-rock to be added to shock melt and quench to form these glasses. The need for S-enriched components is unequivocal and the S-enrichments in impact melt glasses cannot be explained by host rock sulfur alone.

References: [1] H. Y. McSween et al. (2010) *JGR*, *115*, E00F12, doi: 10.1029/2010JE003582. [2] I. O. Mc Glynn et al. (2012) *JGR*,*117*, E01006, doi: 10.1029/2011JE003861. [3] C. Meyer (2012) *Mars Meteorite Compendium*, Report-27672, 1-175 pp, JSC. Houston. TX. [4] S. R. Sutton et al. (2008) *LPS XXXIX*, abs. #1961 & (2014) *LPS XXXXVI*, abs. #1524, [5] D. K. Ross et al. (2012) *LPS XXXXIV*, abs. #1715, [6] M. N. Rao et al. (2010) LPS XXXXI, abs. #1161, [7] L. E. Nyquist et al. (2012) *75th Met. Soc. Meeting*, abs. #5262; [8] J. L. Gooding and D. Muenow (1986) *GCA*, *50*, 1049. [9] M. N. Rao et al. (2011), *JGR*, *116*, E08006, doi: 10.129/2010JE003764, [10] D. Stöffler et al.(1986) *GCA*, *50*, 889. [11] A. S. Yen et al. (2006) *JGR*, *111*, E12S11, doi: 10.1029/ 2006JE002797.

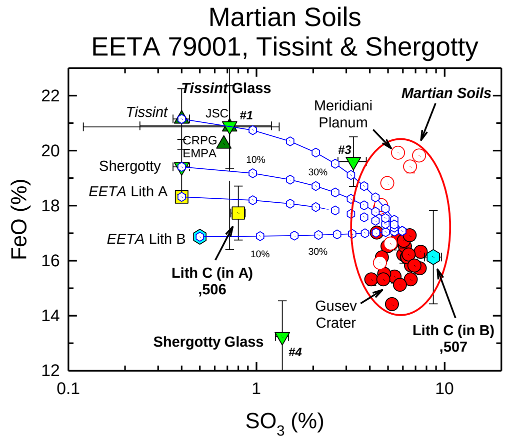

Figure.1. FeO – SO_3 plot for shergottite shock glasses. Note that the ,507 data point plots in GM soils.

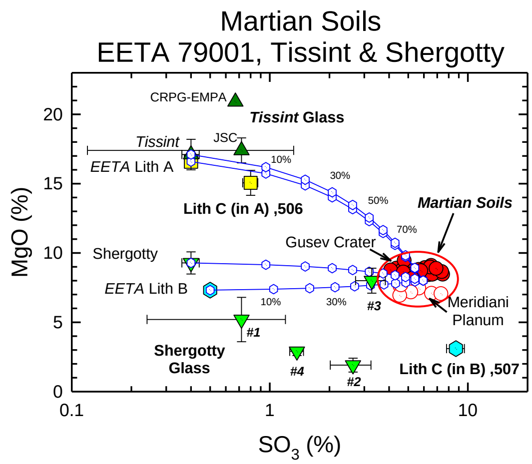

Figure.2. MgO – SO_3 plot for shergottite shock glasses. The compositions for the Gusev and Meridiani soils are taken from [11].

sample	Host rock (%)	GM soils (%)	Plagio-clase (%)	Other mineral (%)	SO_3 (%) in glass
EET79, 507	~2	~45	~39	~14 (Jaro-site)	~8.6
Sher-gotty 3	~50	~50			~3.3
Sher-gotty DBS	~50	~25	~20	~5% (whit-lockite)	~1.5
EET79, 506	~88	~12			~1.1
Tissint shock melt	~95	~5			~0.7

Table 1. Results of mass balance mixing model.