BASALTIC LAVAS AT GUSEV CRATER REVISITED. A. G. Monders, E. Médard and T. L. Grove, Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge MA 02139, USA (monders@mit.edu; emedard@mit.edu; tlgrove@mit.edu).

Introduction: High pressure melting experiments on basalts analyzed near the Spirit landing site at Gusev Crater were first presented by Monders et al. [1]. After our study was completed, it was discovered that the sensor heads had been inadvertently switched at the launch site, requiring recalibration and recalculation of new compositions for Humphrey, Adirondack, and Mazatzal. High-pressure phase relations on these recalibrated Gusev basalt compositions are reported here, and we find no significant change. In addition, the results of low-pressure crystallization experiments are discussed.

The rocks described from the Spirit landing site at Gusev Crater are dark, fine-grained vesicular basalts, containing <25% olivine phenocrysts [2,3]. Alpha-Particle X-Ray Spectrometer (APXS) analyses of abraded samples indicate they are primitive basalts, with an average of 11% MgO. Orbital spectroscopy of broad areas of the surface of Mars suggests that similar olivine-rich basalts are a widespread component of the Southern Highlands crust [4, 5].

High-pressure, high-temperature liquidus experiments that were performed on the preliminary Gusev composition have been redone using the recalibrated data (Table 1) [2]. The phase relations have been investigated between 1 atm and 1.5 GPa at temperatures of 1240 to 1400 °C. One atmosphere experiments were performed using the FePt wire-loop technique at an fO_2 of QFM; high-pressure experiments were performed in a ½-inch piston cylinder, using Pt-graphite capsules.

High-pressure phase relations: The high-pressure phase relations were not changed significantly by the recalibration of the data. Olivine remains the first silicate phase to crystallize at pressures up to 1.0 GPa; above this pressure, orthopyroxene becomes the first silicate phase to crystallize. The Gusev Crater basalt composition is multiply saturated with olivine + orthopyroxene + spinel near the liquidus at 1.0 GPa and 1310 °C (Figure 1). The previous experiments had a slightly higher pressure (1.1 GPa) and somewhat higher temperature (1360 °C) at the multiple saturation point.

The conclusion that the Gusev basalt is a primary or near-primary mantle melt remains quite robust. Melts segregated at shallow depths (1.0 GPa - 85 km), placing an upper limit on the thickness of the Martian lithosphere below Gusev Crater at the time of eruption. Based on anhydrous melting experiments [6] on a primitive Martian mantle composition [7], the melt fraction necessary to produce the Gusev basalts would be about 20 percent.

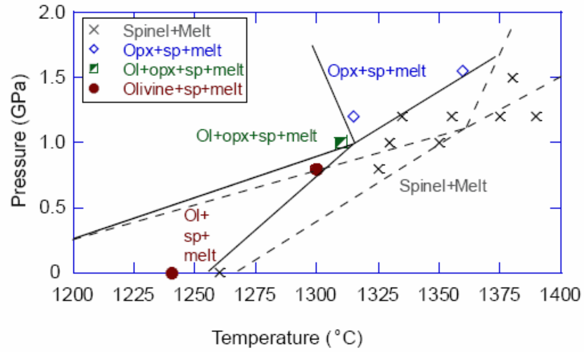

Figure 1. Experimental phase diagram for Gusev Crater basalt. An olivine + orthopyroxene + spinel multiple saturation point was found on the liquidus near 1.0 GPa and 1310 °C. Dashed lines indicate the experimental phase relations of the preliminary Gusev composition.

The 3.65 Ga age [8] and widespread distribution of Gusev-type olivine-rich basalts would suggest that they are an important part of the primitive Martian crust that forms most of the Southern Highlands. The high temperature of multiple saturation is in agreement with generation taking place early in Martian history and suggests that significant shallow mantle melting processes were still occurring at this stage of Martian history.

Oxide (wt%)	preliminary	Recalibrated
SiO_2	45.73	45.57
TiO_2	0.49	0.55
Al_2O_3	11.07	10.51
Cr_2O_3	0.58	0.63
FeO*	17.82	19.48
MnO	0.39	0.42
MgO	12.20	10.97
CaO	7.63	8.05
Na_2O	2.89	2.35
K_2O	0.06	0.08
P_2O_5	0.59	0.59
Total	99.91	99.64

Table 1.Composition used in the Gusev experiments has been averaged from the compositions reported for Adirondack, Humphrey, and Mazatzal. Preliminary compositions were reported in [3], recalibrated compositions used in the new experiments were reported in [2].

Low-pressure crystallization: At 1 atm, the first phase to crystallize is Cr-rich spinel, immediately followed by olivine. Olivine and Cr-rich spinel co-crystallize until about 25 weight percent (about 20 volume %) olivine is formed, then plagioclase and pigeonite join the crystallizing assemblage. Experimental results thus suggest that low-pressure crystallization will lead to early crystallization of about 20 volume % of olivine phenocrysts before crystallization of a pyroxene + plagioclase + olivine groundmass. Point-counting on microscopic images of the least altered of Gusev crater basalts (Humphrey) indicates the presence of ~25 vol. % olivine megacrysts and pixels counts of grayscale images indicate ~20 volume % olivine megacrysts in a groundmass formed of pyroxene, plagioclase, chromite and phosphates [2]. This is in agreement with experimental results and supports the idea that olivine crystals in Gusev crater basalts are actual phenocrysts, rather than xenocrysts. This idea is also supported by the similar composition of the three analyzed rocks, despite their wide range of megacrysts contents (9-25%). Furthermore, the composition of the olivine crystals at the point where pyroxene and plagioclase join the crystallizing assemblage is Fo_{63}, close to the Fo_{60} suggested by Mössbauer spectroscopy of Gusev crater basalts [9].

Experimental liquids obtained by low-pressure crystallization of Gusev basalts follow a tholeiitic differenttiation trend (Figure 2) similar to that observed in Iceland or the Galapagos [10]. When compared to spectroscopically determined compositions of the Martian surface (Surface Types 1 and 2), differentiated Gusev basalts have lower silica contents and show a characteristic iron enrichment. This suggests that, under anhydrous conditions, Gusev-type basalts are not the parental magmas of basaltic-andesitic and andesitic Type 1 and 2 surface compositions.

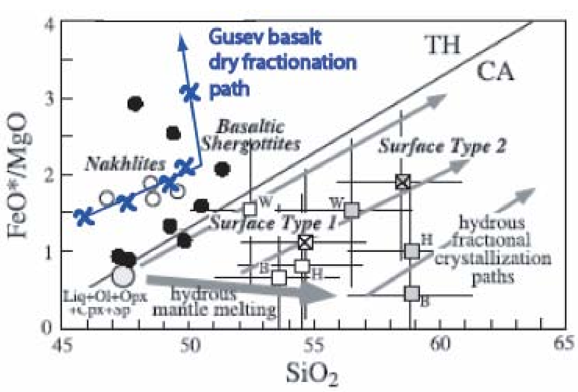

Figure 2. Low pressure experiments on the preliminary Gusev composition are indicated by X's. Gusev basalts will not produce Suface Type 1 or Surface Type 2 liquids by any low temperature fractional crystallization path. Diagram modified from [11].

When compared to shergottites, Gusev Crater basalts are enriched in Al_2O_3 and Na_2O, and have low Ca/Al ratios. Low-pressure crystallization of the Gusev Crater basalts slightly modifies the Al_2O_3 content, but the residual liquids still do not evolve to the compositions of shergottites (Figure 3). This indicates that shergottites are probably not related to the Gusev basalt by fractional crystallization, suggesting a different mantle source and/or different genetic processes.

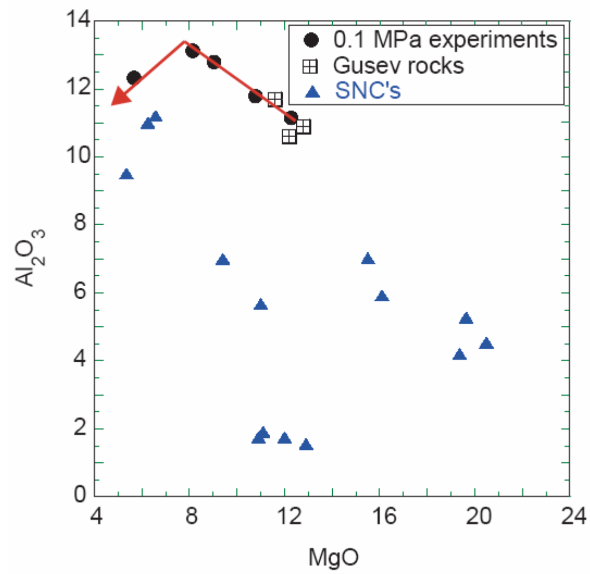

Figure 3. Low-pressure fractional crystallization of the Gusev composition (arrow) does not produce residual liquids similar to Shergottites (triangles).

References [1] Monders A. G. et. al. (2005) *LPS XXXVI*, Abstract #2069. [2] McSween H. Y. et al. (2006) *JGR*, *111*, E02S10. [3] McSween H. Y. et al. (2004) *Science*, *305*, 842-845 [4] Hoefen T. M. et al. (2003) *Science*, *302*, 627-630 [5] Hamilton V. E. and Christensen P. R. (2005) *Geology*, *33*, 433-436. [6] Bertka C. M. and Holloway J. R. (1994) *CMP*, *115*, 323-338. [7] Dreibus G. and Wänke H. (1985) *Meteoritics*, *20*, 367-381. [8] Greeley R. et al. (2005) *JGR*, *110*, E05008. [9] Morris R. V. et al. (2004) *Science*, *305*, 833-836. [10] Juster T. C. et al. (1989) *JGR*, *94*, 9251-9274. [11] McSween H. Y. et al. (2003) *JGR*, *108*, E5135.