FLUID LAVA FLOWS IN GUSEV CRATER, MARS. R. Greeley[1], D. A. Williams[1], G. Neukum[2], S. C. Werner[2], T. Zegers[3], B. H. Foing[3], M. van Kan[3], P. D. Lanagan[4], P. Pinet[5], and The Mars Express HRSC Team, Department of Geological Sciences, Arizona State University, Box 871404, Tempe AZ 85287-1404, greeley@asu.edu, [2]Freie Universitat Berlin, Department of Eath Sciences, Malteserstr. 74-100 Building D, D-12249 Berlin Germany, gneukum@zedat.fu-berline.de, [3]European Space Agency (ESA), European Space & Technology Centre (ESTEC), P.O.Box 299, 2200 AG Noordwijk, The Netherlands, t.zegers@rssd.esa.int, [4]Department of Planetary Sciences, Lunar and Planetary Laboratory, University of Arizona, 1629 E. University Blvd., Tucson AZ 85721-0092, planagan@lpl.arizona.edu, [5]UMR 5562 / CNRS / GRGS, Observatoire midi-Pyrénées, Toulouse, France, Patrick.Pinet@cnes.fr.

Summary: Rocks on the floor of Gusev crater are basaltic in composition, as determined from measurements by the Mars Exploration Rover, *Spirit*. Based on compositional data, models of the basaltic lavas at the time of their emplacement suggest viscosities of 2.3 to 50 Pa•s, somewhat similar to lunar mare lavas. Morphological data and crater counts derived from the High Resolution Stereo Camera on Mars Express suggest that the lavas flooded Gusev crater at about 3.65 by, thus post-dating older floor materials, such as putative sediments emplaced by Ma'adim Vallis.

Introduction and Background: Gusev crater was selected as the landing site for the Mars Exploration Rover, *Spirit,* as part of the "follow the water" theme, based on the assumption that floor materials would include putative sediments deposited from Ma'adim Vallis [1]. However, it was recognized that materials of other origins might also be present [2], [3], [4]. Rocks analyzed by the Athena payload on *Spirit* during its traverse to the Columbia Hills are best characterized as picritic basalts [5], suggesting that the origin of the upper materials on the surface of Gusev crater (excluding windblown deposits) needs to be reassessed.

Volcanic origins of Gusev floor materials: We used the compositional data from *Spirit* to model the viscosities of the analyzed basalts at the time of their eruption and compared the results to modeled viscosities for lunar mare lavas and various terrestrial lavas (Table 1). Results suggest that the basalts in Gusev crater had viscosities of 2.3 to 50 Pa•s, depending on the amount of crystals and vesicles present during eruption and emplacement. These values for the Gusev lavas indicate that they were more fluid than tholeiitic basalts on Earth, and are more comparable to modeled viscosities of lunar lavas and hi-Mg Archean basalts on Earth.

Table 1. Compositions and inferred properties of basalt in Gusev crater compared with lunar and terrestrial lavas. Liquidus temperatures (T_{liq}) were calculated using the program MELTS [12]. Lava density (ρ) was calculated using the method of [13] and the parameters of [14]; lava viscosity (μ) was calculated using the method of [15]; and specific heat (c) was calculated from the heat capacity data of [16].

Component/ parameter	Mars: HumphreyRAT-abraded	Moon: Synthetic mare basalt	Moon: Low-TiO_2 Mare Basalt	Earth: Kambalda komatiite	Earth: Katinniq komatiitic basalt	Earth: Tholeiitic Basalt
SiO_2	46.1	43.0	43.6	45.0	46.9	50.9
TiO_2	0.52	11.0	2.6	0.3	0.6	1.7
Al_2O_3	10.6	7.7	7.9	5.6	9.8	14.6
Fe_2O_3	2.99	-	-	1.4	-	-
FeO	15.3	21.0	21.7	9.2	14.4	14.6
MnO	0.39	0.26	0.3	0.2	0.3	-
MgO	12.2	6.5	14.9	32.0	18.9	4.8
CaO	7.70	9.0	8.3	5.3	8.6	8.7
Na_2O	2.59	0.4	0.2	0.6	0.3	3.1
K_2O	0.06	0.21	0.05	0.03	0.05	0.8
T_{liq} (°C)	1270	1215*	1336	1638	1419	1160
ρ at T_{liq} (kg/m^3)	2820	2980	2900	2770	2800	2750
c (J/kg·°C)	1560	1460	1570	1790	1640	1480
μ at T_{liq} (Pa·s)	2.8	0.45	0.40	0.08	0.74	86
Composition Location	Gusev Crater, Mars [5]	SLS, based on Apollo 11 basalt [17]	Apollo 12 Sample 12002 [18]	Western Australia *Adapted from* [19]	Cape Smith Belt, Canada [20]	Columbia River Basalt, Washington [21]

*[17] inferred that the liquidus temperature of the synthetic mare basalts to be between 1380-1300°C, based on observations of crystallization experiments.
ND: Not Determined.

Morphologies of surface features on the floor of Gusev crater were analyzed using *High Resolution Stereo Camera* data from *Mars Express* and other orbiter images. The presence of "wrinkle" ridges similar to mare ridges on the Moon (Fig. 1), the outlines of possibly buried craters, and the remnants of benches along the margins of the floor unit at the boundary with the crater wall all suggest that the putative basalts were emplaced as thick cooling units, probably erupted in styles comparable to flood lavas on the Moon and Earth [6], [7], [8], [9], and similar to processes proposed elsewhere on Mars [10].

Crater size-frequency distributions were obtained for the primary unit on the floor of Gusev crater in which the ridges occur. Using the algorithm of [11] the estimated crystallization age of the putative lavas is 3.65 by. Similar crater counts on the southern flank of the volcano Apollinaris Patera, located just north of Gusev crater, indicate ages of about 3.76 by, suggesting that regional volcanism might have been occurring in this general period.

Conclusions: We suggest that following the impact that formed Gusev, the floor "basement" consisted of impact breccias, melts, and "fall-back" deposits. Subsequently, materials were deposited from flooding by Ma'adim Vallis, presumably by fluvial processes. The proposed fluid basaltic lava flows, indicated by the Spirit compositional data and morphologies seen in orbiter images, thus post date the primary deposits from Ma'adim Vallis and represent the younger materials on the floor, excluding surficial materials such as windblown sands and mass-wasting debris.

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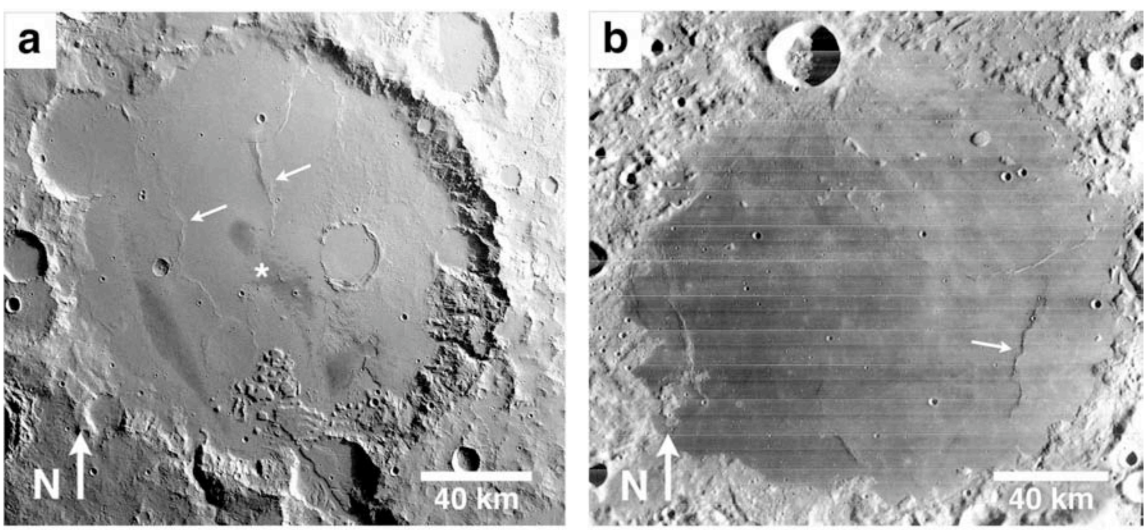

Figure 1. (a) The floor of Gusev crater imaged by HRSC showing mare-type "wrinkle" ridges (arrows) and the location images b, c, d in Figure 2; star indicates the location of the Spirit landing (HRSC image h0648_0000.nd3); (b) Grimaldi crater on the Moon, which is partly filled with basaltic lavas that have deformed into mare ridges (arrows) (Lunar Orbiter IV frame M-161).