PRELIMINARY MINERALOGY AND GEOCHEMISTRY RESULTS AT THE MER-A LANDING SITE IN GUSEV.
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Introduction: MER-A (Spirit) landed within Gusev Crater, hypothesized to have been a site of intermittent fluvial [1] and possibly lacustrine [2] sedimentation. A key to documenting aqueous processes is the mineralogical and chemical compositions of sedimentary deposits. Data bearing on the mineralogy and geochemistry of rocks and soils at the landing site have been limited so far, in part because of flash memory problems that restricted rover operations for many sols.

The Spirit landing site is situated within the low albedo thermophysical unit mapped by [1] (low albedo smooth unit of [3]), the thermal inertia of which is consistent with sand-sized particles. MOC images of this unit show numerous dark (possibly dust devil) tracks and some blanketing materials. The ephemeral nature of this unit suggests that it is a deflation surface of the Plains surface unit [1] (Gusev Crater Formatiion Member 2 of [3]), a flat, high-albedo unit that dominates western Gusev and is distinguished by craters with hot ejecta in nighttime THEMIS imagery.

Rocks: The site is littered with angular, fine-grained dark rocks, some of which have pits resembling vesicles and vugs. These characteristics are consistent with mafic volcanic rocks. We speculate that the angular rocks may be ejecta from impacts into flows inside or outside the crater, or fragments of larger, somewhat rounded boulders that also occur at this site.

Visible/near-infrared Pancam spectra of the dark rocks exhibit reflectance maxima at 673 nm (shorter than the maxima for Mars Pathfinder gray rocks at 750 nm). This shorter maximum may be consistent with the presence of olivine, which has a broad (composite) absorption band. A shorter band center at 930 nm also suggests the presence of pyroxene or contamination from ferric oxides. The Gusev rock spectra resemble those of uncommon black rocks at the Pathfinder site, which have been interpreted as olivine-bearing basalts [4].

Deconvolving the mineralogy of rocks from their Mini-TES spectra is confounded by surface observation effects, and corrections are presently being formulated. These effects include "sidewelling" radiance from warm soils onto cooler rocks and "downwelling" radiance – thermal emission from the sky that may shallow out features and distort band shapes. The long wavelength region is least sensitive to these effects, and examination of those parts of the rock spectra resemble orbital MGS-TES spectra of olivine-bearing basalts seen elsewhere on Mars [5].

Significantly, all of the rocks that have been imaged by Mini-TES at the Gusev landing site appear to be spectrally similar, although a few "white" rocks seen in Pancam images might be different. However, detailed Pancam observations suggest that the white rocks are actually dark rocks mantled with high albedo dust and/or a cemented coating or weathering rind.

To date, the only dark rock studied in any detail is Adirondack, a possibly faceted (ventifact?) rock that is partly coated by high albedo material. Pancam images indicate that the coating is more pervasive toward the base of the rock. Adirondack Mini-TES spectra do not show the scattering at short thermal infrared wavelengths that is characteristic of fine particulates, so the coating is either coherent (an alteration rind or a cemented coating), or else a thin (<5-10 microns thick) veneer of unconsolidated dust. This conclusion is supported by Mini-TES thermal mapping which shows that rock temperature variations do not correlate with coating thickness.

An APXS analysis of the coated surface of Adirondack was taken in the early evening when the temperature was high but still gave acceptable results. Preliminary assessment of the measurement indicates sulfur and chlorine contents about half those of the nearby soil. Mars soils are enriched in these elements by more than a factor of ten compared to martian meteorites and the deduced composition of Mars Pathfinder rocks. The elevated sulfur and chorine abundances support the presence of a coating of dust or, if it is an alteration rind, the process must introduce sulfur and chlorine (e.g. reactions with volcanic exhalations). The bulk composition of this rock surface is basaltic.

Moessbauer spectra sample a greater depth of material than do APXS spectra. A Moessbauer spectrum of the surface of Adirondack with a long (12 hr) integration time is interpreted to indicate the presence of forsteritic olivine and magnetite. A second ferrous iron doublet may indicate pyroxene, if this spectrum reflects the composition of the rock rather than the coating material. A weak ferric doublet is also present, which may be associated with either the rock or its coating. The measured ferrous iron/total iron ratio for the surface of Adirondack is 0.8, similar to that for fresh terrestrial basalts (0.85-0.9).

We decided to operate the stainless steel brush on the RAT against the rock surface without advancing the RAT far enough to engage the grinding cutter. This brushing action was intended to remove any loose dust. The APXS analysis of the brushed surface is not significantly different from the pre-brushed surface. Following that, we will use the RAT to attempt to drill through any outer coating. With this protocol, we hope to understand whether rocks at the site are partly chemically weathered or only physically coated with aeolian dust.

Soil: The regolith at the Gusev landing site is a mixture of fine-grained to sandy reddish materials and small rocks. In places, termed "hollows," finer-grained sediments appear to have accumulated, so that any small rocks are not visible. Aprons around some larger rocks also exhibit distinct soil textures and might be haloes of weathered detritus shed from the rocks. Pancam spectra show that a combination of poorly crystalline and nanophase ferric components occur in the soils. Deconvolution of Mini-TES soil spectra requires a spectral library of fine-grained minerals which is not currently available. The Mini-TES soil spectrum is virtually identical to the global average TES spectrum of fine-grained dust (possibly containing plagioclase [6] and/or zeolite [7]) that characterizes high albedo surfaces on Mars. A >1300 cm^{-1} feature in the global TES soil spectra has been interpreted to reflect the presence of small amounts (2-5%) of carbonate [6], and that same spectral feature is present in Mini-TES soil spectra.

Immediately after egress from the lander, Spirit deployed its instrument arm and analyzed the soil in front of the rover. A microscopic (MI) image of the analyzed soil appears uniformily fine-grained, although small rocks may lie below the visible surface. The soil is porous, and micro-scale topography on the soil was maintained even after being depressed by the Moessbauer contact plate. Tiny white grains, some tubular, may be orthochemical cement.

The preliminary APXS soil analysis indicates oxide concentrations that are similar to those determined by Mars Pathfinder APXS analyses [8], except for higher MgO, and lower total iron (expressed as Fe_2O_3), TiO_2, and K_2O. The higher MgO content could reflect a higher magnesium sulfate concentration or perhaps the presence of some olivine basalt particles in the analyzed volume. The correlated iron and titanium values suggest depletion of a heavy oxide phase by aeolian fractionation, as suggested for other Mars soils [9]. The potassium content of the soil appears to be somewhat lower than that for the site estimated from a global potassium concentration map constructed from orbital GRS data [10]. The inferred concentration of sulfate plus chloride in the soil is lower than the visually estimated abundance of white materials in the MI image. Measured concentrations of chromium and nickel in the soil are modest and provide no support the idea that the soil contains a significant chondritic meteorite component.

A short (<3 hr) Moessbauer integration on the soil had poor counting statistics. Based on isomer shift and quadripole splitting, the ferrous iron/total iron ratio is approximately 0.6. The spectrum shows two ferrous doublets and one ferric doublet. The most intense ferrous doublet is assigned to olivine, but mineral assignments for the other two doublets are uncertain. The finding of olivine in the soil is surprising, given that no rock fragments are visible in the MI image. The ratio of the two ferrous doublets in the soil and Adirondack are different.

Summary and Discussion: The rock population of the MER-A landing site in Gusev appears to consist primarily (only?) of olivine-bearing basalt. While most of the Gusev landing ellipse is obscured by dust, spectra from the low albedo thermophysical unit on which we landed are not obscured by dust [1]. The spectra for the TES pixel that contains the landing site (combined with several adjacent pixels that have identical spectra, to increase the signal/noise ratio) can be deconvolved to give approximately Surface Type 1 materials, generally interpreted as basalt [11]. Thus, we have fortuitously landed in the only part of the ellipse for which ground truth can be provided for compositional data derived from orbital thermal emission spectra.

The soil composition at Gusev is broadly consistent with soils at other Mars landing sites, perhaps contaminated with small amounts of basaltic rock. Thus most soils on Mars appear to be composed of deposits of a nearly uniform global dust composition, probably homogenized by winds, with small proportions of admixed local rocks and salts [12].

There is, as yet, nothing in the preliminary mineralogy and geochemistry of rocks and soils at Gusev that would support the hypothesis that Gusev once held lakes, lacustrine sediments, and evaporates, or that channels carried and deposited significant amounts of sediments into the basin. Instead, volcanic, impact, and aeolian processes appear to have dominated the geologic materials that comprise the local landscape. Further exploration focused on deciphering the underlying stratigraphy of the area, by examining the interior and ejecta blanket of a nearby crater and possibly cliffs in the distance, will be necessary to understand any possible role for water in Gusev.

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