
Paper Overview: The authors summarize results from the *in situ* analysis of three different rock samples (Adirondack, Humphrey and Mazatzal) located several hundred meters apart at the Spirit MER landing site in Gusev Crater. These rocks have “irregular vesicles and vugs, suggesting a volcanic origin ...[and] were [likely] ejected from nearby Bonneville crater by an impact event” (pg. 842). The Adirondack and Humphrey rocks are partially coated by a light material, with some interior, darker material exposed, while the Mazatzal rock is uniformly coated with light material. Data was analyzed from multiple onboard instruments including: Pancam, Mini-Thermal Emission Spectrometer (Mini-TES), Mössbauer Spectrometer, Microscope Imager and the Alpha Particle X-ray Spectrometer (APXS). The Rock Abrasion Tool (RAT) was used to expose fresher, interior material to allow for comparison with exterior coating. Results suggest the rocks are basalts primarily composed of olivine with possible components of magnetite and pyroxene. Additionally, the samples have varying degrees of dust cover and alteration rinds, which required only limited amounts of groundwater to form.

Summary of Observations

Pancam:
- Pancam spectra of the dark interior of the Adirondack and Humphrey samples (see figure to right) are “consistent with the presence of olivine, which has a broad (composite) absorption band near 1000 nm” (pg. 842). The spectrum of the dark interior of the Mazatzal sample may also correspond to the presence of olivine; however, the relationship is not as clear.
- The spectra of the dark interior material also has a weak band centered at 930 nm that likely indicates the presence of either pyroxene or ferric oxide contaminants (such as dust)

Mini-TES:
- Mini-TES spectra of the dark surface is similar to other olivine-bearing basalts observed on the surface of Mars
- An emissivity peak at ~ 450 cm\(^{-1}\) indicates olivine of an intermediate composition (Fo36-60), although obtaining modal mineralogy from unmixing is complicated by a feature at ~875 cm\(^{-1}\)
- A lack of scattering at wavelengths >1300 cm\(^{-1}\) indicates that if there is any coating on the dark surface, it is either very thin (<10 μm) or it is coherent
- Spectra for both the natural surface and the interior of the Humphrey sample appear similar, while they appear different for the Mazatzal sample. This suggests multiple coatings for the Mazatzal sample
**Microscopic Imager:**

- An oblique RAT grind into the Humphrey sample (see figure to left) shows a dusty surface and alteration rind transitioning to a fresher, largely dust free interior. The fresher interior is characterized by tiny veins filled with light material. The outer coating also has hexagonal pits inferred to be from the erosion of olivine crystals. This again suggests a competent coating due to the ability to retain a mineral cast.
- Images of the Adirondack and Mazatzal samples also revealed relatively dust free interiors, light-toned grains and fractures filled with a light-toned material.
- Cemented dust is excluded from the possibilities of fracture filling material as there is no red coloration.
- The light-toned grains are thought to be olivine phenocrysts.
- Mazatzal also shows a dark coating bounded on both sides by a light coating (possibly cemented dust). This coupled with several layers of crosscutting fractures could indicate several episodes of fluid alteration; however, alteration is not necessarily due to fluid-rock interaction.

**Mössbauer Spectrometer:**

- “Least squares fitting of Mössbauer spectra for Adirondack, Humphrey and Mazatzal indicates the presence of olivine, pyroxene and magnetite” (pg. 844).

**APXS:**

- Measured data from the natural and grinded surface were used to extrapolate composition of uncoated rocks (See Table 1 in article) by normalizing to 0.3 weight % of residual sulfur.
- Major elements for uncoated rocks are Si, Fe, Mg and Ca, with the only difference between the samples being a higher concentration of ferric iron in the Adirondack and Humphrey samples.
- Coatings of the three samples differ from the composition of the surrounding regolith, suggesting some degree of alteration.
- Major mineral constituents were also determined, with all three samples being dominated by olivine, pyroxene and plagioclase, consistent with the Mössbauer measurements.
- “The olivine-rich component [of these samples] is substantially more primitive than those of basaltic martian meteorites, Pathfinder rocks and the calculated compositions of TES surface types 1 and 2” (pg. 844). This suggests that these basalts have undergone very little fractionation and likely represent the least fractionated material observed on the surface of Mars.
- The basalts also have a relatively high aluminum content, possibly suggesting the melting of an ancient and undepleted mantle.

**Additional Observations:**

- There is no obvious source for the volcanism implied by the basaltic composition, as the nearest volcano, Apollinaris Patera, shows no apparent flows in the vicinity of Gusev crater.
- The analyzed samples are unlikely to be impact melt due to low Ni/Cr ratios, suggestive of no significant input of meteoritic material.
- “Alteration of these rocks required only limited amounts of groundwater” (pg. 845).