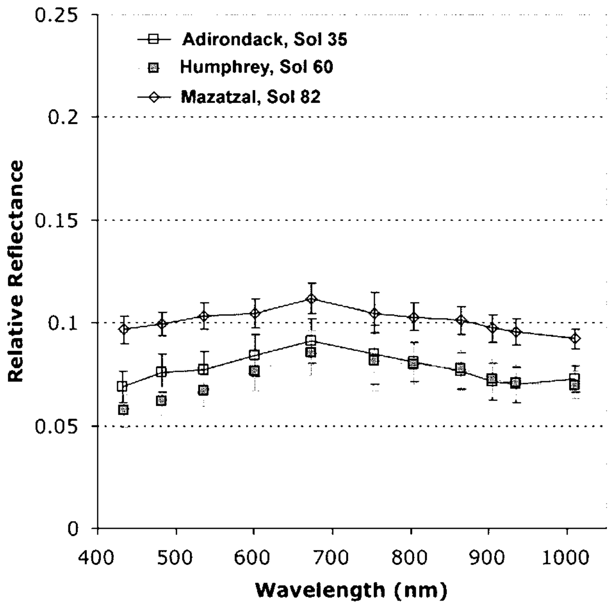

Figure 5. Pancam spectra of RAT holes ground into Adirondack (Sol 35, imaging sequence P2578), Humphrey (Sol 60, imaging sequence P2597), and Mazatzal (Sol 82, imaging sequence P2590). Errors bars represent the standard deviations of several hundred pixels within selected regions of interest.

grains, not so obvious in MI images, occur in the groundmass. None of the grains appears to be euhedral, although some subhedral outlines are apparent. Pixel counts of gray scale images may be less subjective than optical point counting on a grid, and a mode of dark grains in Humphrey determined in this way is 20 volume%. However, MI images of Adirondack and Mazatzal do not have enough contrast to permit accurate pixel counts of these crystals.

[11] Tiny, irregular veins of light-colored material crosscut all three rocks. These veins cannot be fractures filled with dust, because they are not red in Pancam images. A surface rind on Humphrey, revealed by a fortuitous oblique grind from the brushed surface into the interior of the stone [see *McSween et al.*, 2004, Figure 2; *Squyres et al.*, 2004, Plate 12], does not contain the gray megacrysts seen in the rock's interior. This observation suggests that weathering on Mars preferentially destroys olivine. Mineralogical and chemical differences between Gusev rock surfaces and interiors support this hypothesis, which is explained by the rapid dissolution of olivine under acidic conditions [*Hurowitz et al.*, 2006; C. Schröder et al., Evidence for olivine weathering in rocks at Gusev crater, manuscript in preparation, 2006 (hereinafter referred to as Schröder et al., manuscript in preparation, 2006)]. A more distinctive rind is visible on Mazatzal [*Squyres et al.*, 2004, Plate 13]. The thin, dark rind underlying the dust cover is smooth and hard, and resembles a varnish. A sliver of this rind remains in the RATed image of Mazatzal in Figure 3. A light-colored vein crosscuts the varnish and thus must be younger. This dark varnish, too, is devoid of olivine. The alteration rinds on Gusev basalts have been described and interpreted elsewhere [*Haskin et al.*, 2005] and are not the focus of this paper.

3.2. Grinding Hardness

[12] The RAT monitored the energy expended during grinding. The grinding energy, divided by the volume of rock removed, is a function of several physical properties, but especially rock hardness. Because secondary alteration minerals are usually soft, grinding hardness is probably a proxy for degree of alteration. Grinding hardness for the three rocks analyzed, expressed in J/mm^3, is approximately as follows: Adirondack - 64, Humphrey - 94, and Mazatzal - 61 [*Bartlett et al.*, 2005]. The hardness of Humphrey suggests that it is the least altered of these rocks, consistent with the MI observation that it contains the highest proportion of olivine.

4. Olivine Identification and Accompanying Mineralogy in Gusev Basalts

[13] Olivine is the only mineral identified or inferred from data by all the Athena instruments on the Spirit Rover. The synergy provided by the Pancam, Mini Thermal Emission Spectrometer (MiniTES), Mössbauer Spectrometer (MB), and Alpha Particle X-ray Spectrometer (APXS) allow documentation of the mineralogy of these rocks.

4.1. Pancam Multispectral Observations

[14] Pancam 11-wavelength (430 to 1009 nm) spectra of RAT holes ground into Adirondack, Humphrey, and Mazatzal are shown in Figure 5. These relative reflectance (radiance factor or "I/F") spectra were calibrated using near-simultaneous measurements of the Pancam calibration target [*Bell et al.*, 2006]. These are the lowest reflectivity, least red spectral units identified by Pancam at the Gusev landing site. The low reflectance and lack of a steep increase in reflectivity toward the red wavelengths indicate that the RAT holes are not contaminated with aeolian dust and imply the almost complete absence of ferric minerals within the shallow (~5–7 mm) interiors of these rocks.

[15] The reflectance maximum near 650–700 nm and the negative spectral slope from ~700 to 1000 nm are both consistent with the iron mineralogy of these rock interiors being dominated by ferrous silicate phases like olivine or pyroxene [e.g., *Adams*, 1974; *Morris et al.*, 2000; *Cloutis and Bell*, 2003]. The Pancam spectra do not reveal an unambiguous near-IR reflectivity minimum that could be used to provide a strong constraint on the specific ferrous mineralogy. However, the presence of a weak minimum between 900 and 1000 nm in the Adirondack and Humphrey spectra could be consistent with the presence of low-calcium pyroxene, and may indicate a subtle difference in mineralogy between these two rocks and Mazatzal. In addition, the decrease in reflectance toward the longer wavelengths observed in all three spectra could be the high-energy wing of a mineral absorption band centered in the near-infrared beyond Pancam's wavelength range. If so, this feature could be consistent with the presence of either olivine or high-calcium pyroxene, both of which exhibit absorptions in the 1000–1300 nm wavelength region.

[16] Further support for a ferrous mineral signature in these rock spectra comes from comparison of Pancam multispectral parameters to those derived from laboratory