**MODAL ANALYSES OF APOLLO 16 SOILS BY X-RAY DIFFRACTION.** G. Jeffrey Taylor[1], Linda M.V. Martel[1], Paul G. Lucey[1], Sarah Crites[1], and D.F. Blake[2], [1]Hawai'i Institute of Geophys. & Planetology, 1680 East-West Rd., Honolulu, HI 96822, gjtaylor@higp.hawaii.edu, [2]NASA Ames Research Center, Moffett Field, CA.

**Introduction:** We have launched a project to determine the modal mineralogy of over 100 soils from all Apollo sites. The goal is to use this quantitative mineralogy in comparison with reflectance spectra of the same soils and with remote sensing data of the sampling stations to improve our ability to extract quantitative mineralogy from remote sensing observations. We report here our initial results from analysis of the <150 μm fraction of 30 Apollo 16 soils. We also analyzed 90–150, 45–90, 25–45, and <25 μm fractions from Apollos 12, 14, and 16 for comparison with previous data [1-3]. A bonus of analyzing numerous soils from one site is that it allows us to test ideas for the petrologic character of geologic terrains at the Apollo 16 site, specifically the Descartes Mountains and the Cayley Plains.

**Methods:** Samples were dry-sieved to obtain >150 and <150 μm fractions. Samples were analyzed in a Terra XRD instrument using sample sizes of ~35 mg; we did replicate analyses of each sample and averaged them. We reduced the data using Reitveld refinement as implemented by the Jade program. Glass abundances were determined by choosing a linear background and fitting a broad Gaussian to the scattering hump above background. We calibrated the instrument by using mineral mixtures and results from the Lunar Sample Characterization Consortium (LSCC [1–3]). A comparison of our data for three soil samples (25–45 μm fraction) and data from the LSCC are shown in Fig. 1. The dashed line is simply a 1:1 line; a line fitting to the data has a slope of 0.97. The standard deviation of the dataset is 2.8 wt%, which is acceptable for improving remote sensing data, and we expect it to decrease as we analyze more samples that were also studied by the LSCC.

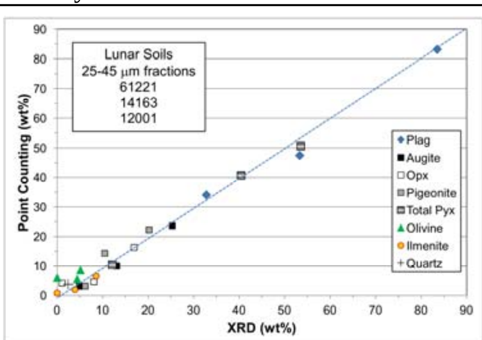


Fig. 1. Our XRD modes vs LSCC results [1–3].

**Results:** The most difficult challenge in determining quantitative modal abundances by XRD is extracting the abundance of amorphous material (mostly assorted impact glasses in lunar samples). Thus, we emphasize here modal mineralogy on a glass-free basis. Nevertheless, relative glass abundances are reasonable, as shown by the correlation (Fig. 2) of total glass abundance with $I_S$/FeO [4].

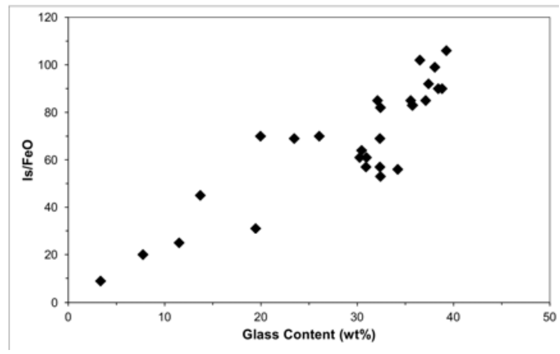


Fig. 2. Modal glass content vs $I_S$/FeO [4].

On a glass-free basis, plagioclase ranges from 78 to 94 wt%, with the sites on the Descartes Mountains (Stations 4, 11, and 13) tending to contain more plagioclase (Fig. 3). This is consistent with previous conclusions that the Descartes highlands are more feldspathic than the Cayley Plains [e.g., 5]. The relative abundance among pyroxenes and between pyroxene and olivine varies throughout the site, with little correlation with sampling location (Figs. 3–5).

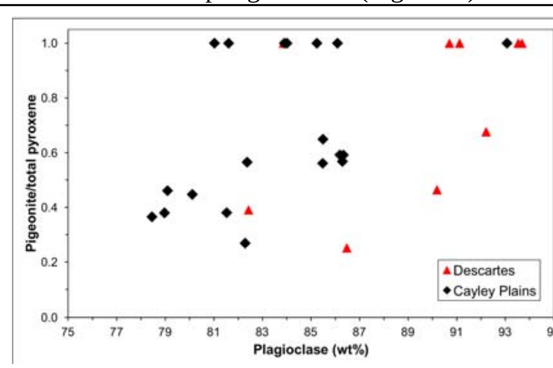


Fig. 3. Normative plagioclase (glass-free basis) vs the ratio of pigeonite to total pyroxene. Note that in general the Descartes sites are richer in plagioclase.

Modal plagioclase is systematically greater than normative plagioclase (Fig. 6). A difference between modes and norms is not unusual, but this substantial difference indicates that the glass in the Apollo 16 regolith is more mafic than the crystalline material. This is consistent with the average composition of impact glass in Apollo 16 samples compared to bulk soils [3]. For example, bulk regolith contains 26–30 wt% $Al_2O_3$ [literature values], whereas impact glasses on average contain 23–27 wt% [3,6].

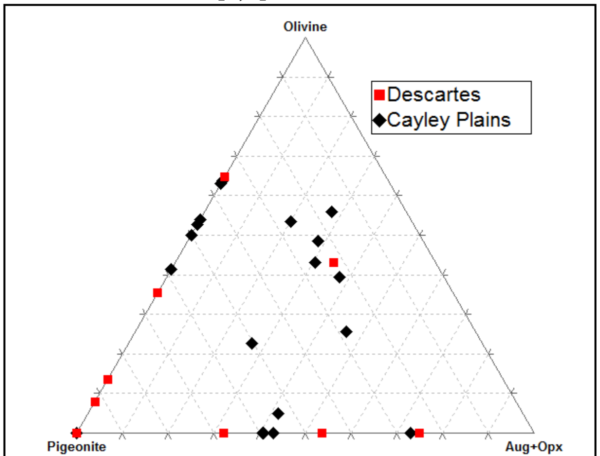


Fig. 4. Relative abundance of mafic silicates in Apollo 16 soils. Although the Descartes sites are richer in plagioclase (Fig. 3), mafic mineralogy is variable.

**Discussion:** Our results are consistent with previous studies that concluded that the Descartes highlands, as represented particularly by ejecta from North Ray Crater, are more feldspathic than the Cayley Plains [5–9]. The Cayley Plains are more mafic, probably because of addition from Imbrium [6,10] and other basin [11] ejecta. Additional mafic components may have been added to the site from mare sources [3].

This work re-emphasizes the difference in chemistry between the minerals and glass components of the soils recognized by [1-3]. This has important implications for using these data for calibration of remote sensing data. Spectroscopic methods, for example applied to M3 data, may emphasize the mineral fraction to a greater degree (agglutinate glasses incorporating abundant contrast-sapping nanophase iron for example), whereas laboratory measurements show that thermal infrared multispectral data (collected by the Diviner instrument on LRO) should not be affected by the degree of vitrification. Methods must be developed to decide how ground truth measurements such as being developed here are to be applied to remote data.

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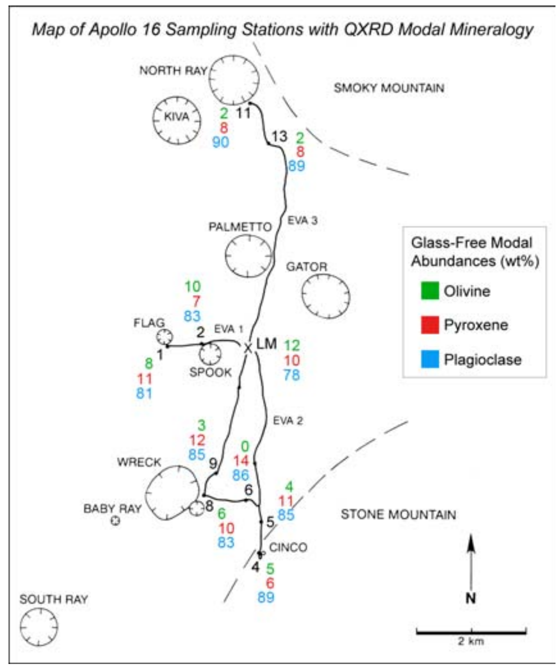


Fig. 5. Modal mineralogy of soils at the Apollo 16 site. Sites at North Ray Crater on Smoky Mountain (stations 11 and 13) and at Stone Mountain (station 4) are distinctly richer in plagioclase than sites on the Cayley Plains.

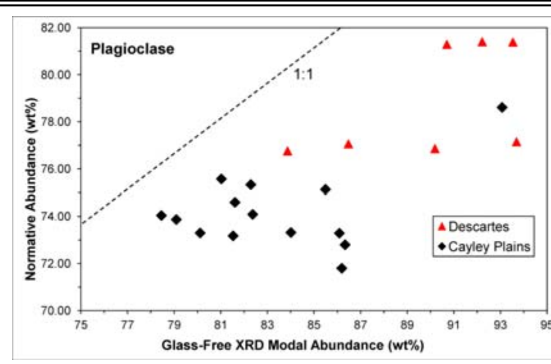


Fig. 6. Modal plagioclase of Apollo 16 soils is greater than normative mineralogy, indicating that the glass component is systematically less feldspathic than is the crystalline component.