RADIATIVE TRANSFER MODELING OF LUNAR HYPERSPECTRAL DATA. K. R. Stockstill-Cahill[1], J. T. S. Cahill[1], P. G. Lucey[1], and B. R. Hawke[1]; [1]University of Hawaii at Manoa, Hawaii Institute of Geophysics and Planetology, 1680 East-West Rd., POST 602B, Honolulu, HI 96822.

Introduction: One of the current goals of the Selenoligcal and Engineering Explorer "KAGUYA" (SELENE) and the Moon Mineralogy Mapper (M^3, aboard Chadrayaan-1) missions is the accurate determination of surface composition. These data are being collected with the knowledge that when light interacts with an airless body surface it is either absorbed or reflected in a way unique to each of the most common minerals on Moon (e.g., plagioclase, pyroxene, and olivine) [1]. In preparation for the release of these data sets, it is vital that we further develop modeling techniques for deriving mineralogy from hyperspectral data sets.

We have previously developed multispectral methods for deriving minerals from spectra [e.g., 2]. We are now extending these methods to continuous (hyperspectral) data. This approach is similar (but not identical) to previous efforts and exploits the abundant information contained within hyperspectral data.

Here we present an iterative modeling technique used to reproduce laboratory reflectance spectra and the known composition of lunar mare and highlands soils characterized by the Lunar Soil Characterization Consortium (LSCC) [3-5]. The spectra of nineteen lunar soil samples previously characterized by the LSCC are examined here [3-5]. Compositional data for low-Ti mare soil samples were not previously published but are presented here courtesy of the LSCC (L. A. Taylor, *pers. comm.*). Our focus is on the major lunar silicates (plagioclase, orthopyroxene, clinopyroxene, and olivine) that constitute significant portions of their overall composition.

Methods: Our fundamental approach is to use radiative transfer modeling to fit spectra. In all cases, we assume a cumulate composition including some combination of pyroxenes (low- and high-Ca varieties), plagioclase, and olivine. The process involves multiple steps, outlined below.

Model spectra are computed using radiative transfer theory developed by Hapke [6-8] using the mineral optical constant data of Lucey [9] and iron optical constant data of Paquin [10]. This model is similar to that implemented by Clark et al. [11] and explained in detail by [12]. The model uses the optical constants of minerals to calculate single scattering albedo for each component at a specified particle size, maturity, and mineral chemistry. It has been shown that the most optically dominant grain size on the Moon is approximately 15 microns [13-14]; therefore, the work presented here focuses exclusively on compositions derived for the 10-20 micron lunar soil size fraction. Single scattering albedo of each mineral component is added linearly, weighted by abundance, and are converted to reflectance.

Equilibrium is assumed for the mafic mineralogy and their chemistries are varied in the form of Mg' ranging from 20-95 in increments of 5. Mineral modes span the full plag-olivine-opx-cpx system, resulting in fifty-six initial mineral combinations evenly spread between the four mineral species.

Comparisons of the model and lunar soil spectra are made in continuum removed reflectance (i.e., spectra normalized to its continuum) using a slightly modified version of Clark et al.'s [15] shape and contrast matching algorithm. The continuum is removed by dividing each spectrum by a line tangent to the maxima on either side of the 1 micron absorption feature.

The goodness of fit of each model is fit against Mg' to select the favored Mg' and mineralogy for that spectrum. The "best fit" model can then be compared the measured quantities of Mg' and mineralogy for the LSCC soils. Refinement of this algorithm is on-going, but we are current getting about and least 20% accuracy with respect to mineralogy, with mean absolute differences varying from 6-9 volume% depending upon the mineral phase, and within 5-10 units of the Mg'-ratio (Figures 1 and 2).

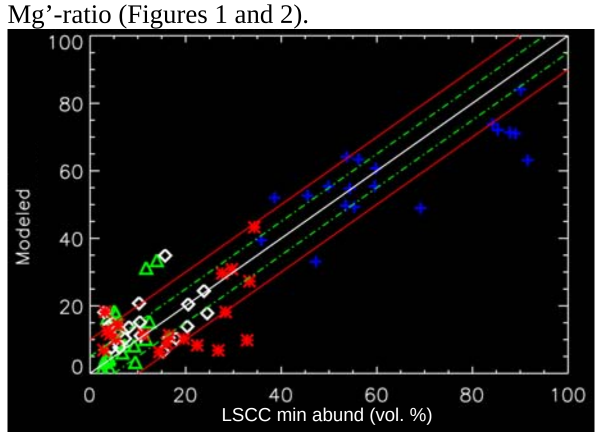

Figure 1: Plot of measured LSCC mineral abundances vs. modeled abundances along the one-to-one trend (white diagonal line). (Blue cross = plag, red asterisk = cpx, white diamond = opx and green triangle = olivine.) Note that most symbols plot within the red diagonal line, which represents 10% absolute difference. (Green dashed line = 5% absolute difference.)

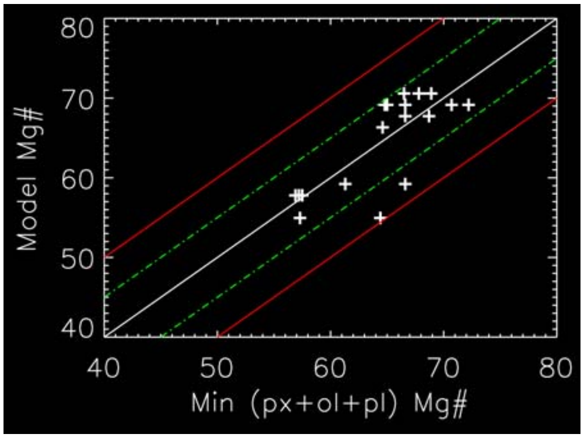

Figure 2: Plot of measured LSCC Mg# vs. modeled Mg# along the one-to-one trend (white diagonal line) for 19 LSCC soils. Note that most symbols plot within the green dashed diagonal line, which represents 5% absolute difference. (Red line = 5% absolute difference.)

Results: Analysis of telescopic hyperspectral data has been performed for a variety of locations on the Moon. Here we present results for Aristarchus plateau to illustrate this method. The main cluster of derived Aristarchus compositions is similar but not identical to the few known gabbronorites. Outlier compositions include anorthositic material, with Mg-ratios consistent with ferroan anorthosite and an ultramafic exposure (Figure 3). The main cluster of derived Aristarchus compositions appear depleted in orthopyroxene relative to known gabbronorites and possibly somewhat depleted in olivine. Additional nearside spectra are also being analyzed with this algorithm and will be presented.

Conclusions: New quantitative analysis of mineralogy and mineral chemistry, coupled with Lunar Prospector gamma-ray measurements appears to confirm that Mg-rich rocks are present in very large exposures on the lunar surface. Previous suggestions that Aristarchus exposes material similar to known gabbronorites as previously suggested. However, the mean composition of the Aristarchus exposure is less orthopyroxene-rich (or conversely more plagioclase- and clinopyroxene-rich) than known gabbronorites. The diversity revealed among these locations in close proximity, diversity that exceeds our estimated uncertainty by at least a factor of two, may indicate that high diversity is inherent in these kinds of Mg-rich rocks, and may not exclude the formation of the known gabbronorites in a single body. The compositional relationships do not indicate a clear differentiation relationship, but no quantitative modeling has been conducted.

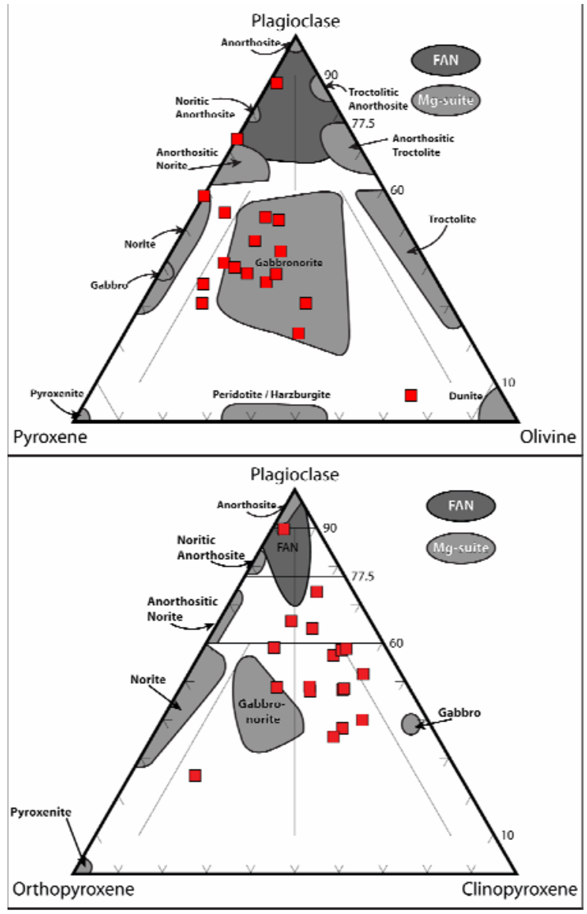

Figure 3: Plag-Pyx-Ol and Plag-Opx-Cpx classification diagrams showing fields of FAN and Mg-suite rocks (dark gray and light gray fields, respectively) with Aristarchus data plotted on top (red squares).

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