SPECTROSCOPY OF NEARSIDE HIGHLAND IN RELATION TO APOLLO 16 ROCK SAMPLES.

A. Yamamoto[1], T. Arai[2] H. Takeda[3], and M. Miyamoto[3], [1]Remote Sensing Technology Center of Japan, 1-9-9 Roppongi, Minato-ku, Tokyo 106-0032 (aya@restec.or.jp) , [2]Antarctic Meteorite Research Center, National Institute of Polar Research, 1-9-10 Kaga, Itabashi, Tokyo 173-8515, Japan (tomoko@nipr.ac.jp), [3]Dept. Earth & Planetary Science, the University of Tokyo, Hongo, Tokyo 113-0033, Japan.

Introduction: Understanding reflectance spectral signatures of returned soils and rock samples of the Moon are essential to interpret the remotely-sensed data obtained from orbital satellites, such as Clementine and upcoming SELENE mission. Correlations between remote-sensing data and spectral data of soils, which represent average compositions of specific landing sites, have been well studied. However, the discrepancies between remote and soil data have been also recognized, apparently due to the differences in the extent of exposure of geological units, and hence major rock component in the area sampled. The major geological units were represented and sampled at the landing site, but not necessarily in the same proportions where these units occur in the areas around the sites. Thus, variations of the reflectance spectra depending on the proportion of the multiple rock types mixed in the soils need to be understood, in order to accurately estimate rock types and mineral compositions based on the orbital data. Here, we discussed the diversity of reflectance spectra of the nearside lunar highland, based on the spectral data of various types of Apollo 16 rock samples.

Samples: Five Apollo 16 rock samples with different texture, modal abundance, and mineral composition were selected (Table 1, Fig. 1). They were provided by NASA JSC. Differences in rock textures are due to the extent of shock effect. Note that 60019 sample we studied is poikilitic clasts included in the regolith breccia [1].

Methods: Bidirectional reflectance spectra from 0.3 – 2.5 µm were measured using a UV-Visible-Near IR spectrophotometer of the University of Tokyo. Rock chips were used for the spectral measurement and Halon powder was used for the standard. Assumed interpretation based on multi-band spectral data, composite absorption features were discussed instead of decomposing into individual absorption bands. Mineralogical analyses were done by JEOL 8200 Electron Microprobe at National Institute of Polar Research.

Table 1 Rock type and modal abundance of samples stud-

sample#	rock type	modal abundance (vol%)	Ref.
60025	cataclastic anorthosite	Pl: >90 with minor Px & Ol	2
67016	Feldspathic polymict breccia	Pl: ~90 with minor Px & Ol	3
60019	Feldspathic impact-melt breccia	Pl + Px: ~70 with Ol	1
67235	Mafic impact-melt breccia	Pl: 54, Px:40, Ol:6	
67667	Feldspathic lherzolite	Pl: 20-30, Ol:20-50, Px: 30-50	4

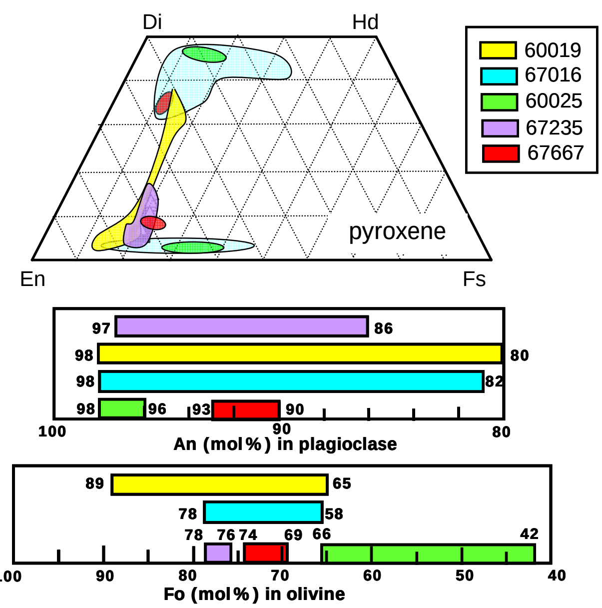

Fig. 1 Mineral compositions of samples studied.

Results and Discussions: Measured reflectance spectra of the samples are shown in Fig. 2. 67667 displays a distinct spectral feature from the rest, having strong absorption bands around 1.0 µm and 2.0 µm. This is due to the higher modal abundance of pyroxene and olivine, resulting in the extensive composite absorption signatures around 1.0 µm and 2.0 µm. The rest samples also exhibit weaker absorption signatures around 1.0 µm and 2.0 µm. For 60025 with the highest modal plagioclase, the spectral feature shows plagioclase absorption band around 1.25 µm, in addition to the pyroxene absorption bands. Olivine absorption band is not readily noticeable for all the samples. However, the pyroxene absorption band signatures around 1.0 µm tend to be slightly modified toward the longer wave length except 67667. This indicates that the absorption band of pyroxene is affected by those of plagioclase and olivine.

Correlation between modal plagioclase and composite absorption band around 1.0 µm among the samples is shown in Fig. 3. Other than 67016, a positive correlation is present where samples with higher plagioclase mode tend to show the band center position at the longer wavelength. This trend is consistent with the expectation that the increased modal plagioclase results in the composite band position of pyroxene and plagioclase more extensively

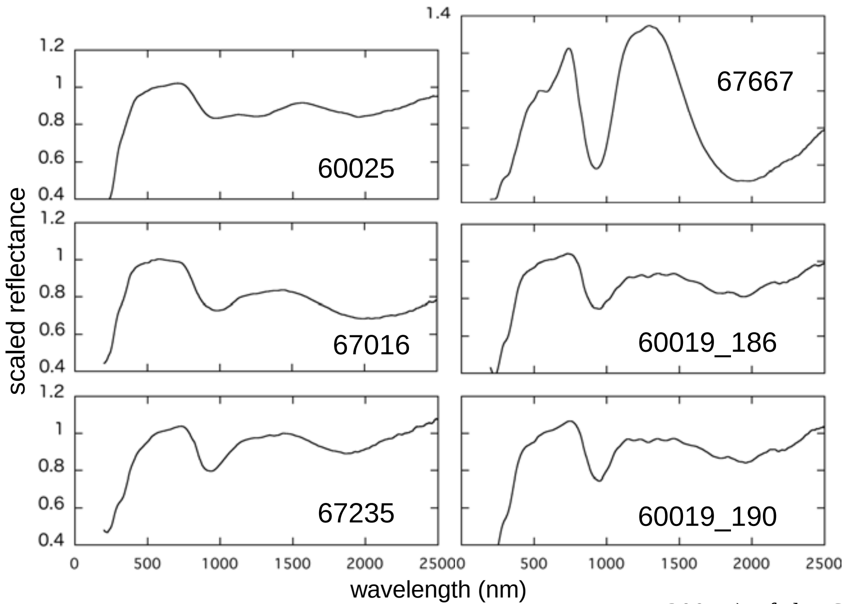

Fig. 2 Measured reflectance spectra.

moved toward the plagioclase absorption band at 1.25 µm. The reason why 67016 does not follow this correlation is that the plagioclase mode of the measured chip might be distinct from that of the reference [3], possibly because of heterogeneous nature of polymict breccia.

Fig. 4 shows a correlation between the band center position of the composite band around 1.0 µm and 2.0 µm, in relation to the average Mg/(Mg + Fe) ratio (=Mg#) of pyroxene. The arrow indicates the Mg# of the samples becomes higher from upper right to lower left. Except 67667, the linear correlation where the sample with the higher Mg# tends to show the band shifts to the shorter wavelength. This is consistent with the known correlation [5]. The composite band of ferroan anorthosite 60025 is located at the longest wave length, reflecting the most Fe-rich pyroxene composition. 67667 with intermediate pyroxene Mg# falls off the trend, having the shortest wavelength for the absorption band around 1.0 µm, but not for that around 2.0 µm. The cause needs to be further investigated. Average olivine Mg# of samples roughly shows a linear correlation with the band position around 1.0 µm, as well as pyroxene Mg#.

Among five samples, 60025 and 67667 are monomict breccias, thus best represent the original rock signature (mineral composition and texture). In the sense of modal abundance and mineral composition, the two serve as end-member rock types (nearly pure anorthosite vs. lherzolite) in Apollo 16 site. Polymict breccia 67016 is a mixture of these two plus some evolved rock type. Impact-melt breccias 60019 and 67235 are recrystallized materials from the impact melts whose compositions are mixtures of the above two end members, plus mare basalt (67235). These five roughly cover the compositional and textural range of rock types in Apollo 16 site. Remote-sensing data of the nearside crust around Apollo 16 site might be explained by the combination of spectral signature of the five samples to variable extent.

Though sampling sites of 60××× and 67××× are ~4.3 km distant from each other, no systematic difference is found at least among the five samples. Since 60025/60019 and 67016/67235/67667 are respectively located within a single pixel (100 – 300 m) of the Clementine spectral images [6], the orbital spectral data of the each sampling site of 60××× and 67××× might reflect the spectral discrepancy due to the above compositional and textural varieties.

References: [1] Takeda H. et al. (1988) *PLPSC* 18th, 33-43. [2] Walker D. et al. (1973) *EPSL*, 20,325-336. [3] Takeda H. et al. (1990). *PLPSC* 20th, 91-100. [4] Warren P. H. and Wasson J. T. (1979) *PLPSC* 10th, 583-610. [5] Burns et al. (1971) *Conf. on Lunar Geophysics, Lunar Sci. Inst.* [6] Nozette et al. (1994) *Science*, 266, 1835-1839

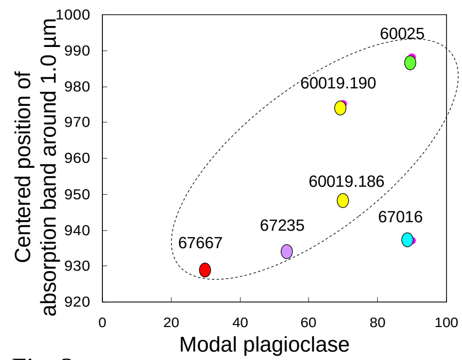

Fig. 3 Correlation between modal plagioclase and composite absorption band position around 1.0 µm.

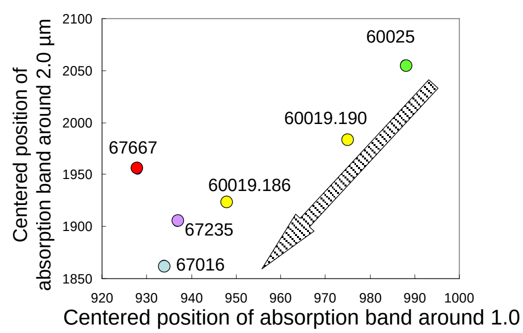

Fig. 4 Correlation between composite absorption band position around 1.0 µm and 2.0 µm with pyroxene Mg#.