STUDY OF THE APOLLO16 LANDING SITE: RE-VISIT AS A STANDARD SITE FOR THE SELENE MULTIBAND IMAGER. M. Ohtake[1], T. Arai[2] and H. Takeda[3], [1] Planetary Science Department, Japan Aerospace Exploration Agency (JAXA), 2-1-1 Sengen, Tsukuba, Ibaraki, 305-8505, Japan, e-mail:ohtake.makiko@jaxa.jp, [2]National Institute of Polar Research, 9-10, Kaga 1-chome, Itabashi-ku, Tokyo, 173-8515, Japan, e-mail: tomoko@nipr.ac.jp,[3]Research Inst., Chiba Inst. of Technology, 2-17-1 Tsudanuma, Narashino City, Chiba, 275-0016, Japan, e-mail: takeda@pf.it-chiba.ac.jp.

Introduction: It is our ultimate goal in our future lunar exploration mission to obtain data of modal abundances of minerals and chemical compositions of the lunar surface. Global multi-spectral data of Multiband Imager (MI) for the SELENE mission is going to deriver that information by combined with hyper-spectral data of Spectral Profiler (SP). To understand mineral abundance and mineral compositional distribution of the lunar surface from the remote sensing data using MI and SP we need precise understanding of correlation between mineral composition and spectral reflectance. One of the most important procedures for the precise correction and calibration of remote sensing data is a selection and understanding of a suitable optical standard site.

Purposes: MI will take images of the whole surface of the moon during one year SELENE mission [1] [2]. Special resolution of the MI is one order higher than the previous Clementine UV/VIS camera therefore we need to re-evaluate and select both of the suitable standard site and standard samples for MI. We are planning to take several images of the same standard area under different phase angle condition throughout the mission period. During conversion process from radiance to reflectance, accuracy of determined reflectance value for the standard site is very important because all reflectance data are derived by this process. Matured, homogeneous and low reflectance rectangle area near the Apollo 16 landing site was selected as an optical standard area for the Clementine UV/VIS camera based on the intense studies [3][4]. This area is also used in the many previous lunar observation study therefore it is important for us to use same standard area to compare MI derived data with many previous studies. However MI probably can have standard area for MI own in spite of the successful calibration of the Clementine UV/VIS camera to maximize scientific returns from the MI's hardware advantages such as high radiance and special resolution. Purpose of this study is to re-evaluate optical properties of Apollo 16 landing site and selected laboratory standard by studying correlation between their mineralogy and reflectance spectra and select a best standard area for the MI. To check capability of our spectral analyses algorithm [5] using MGM [6] [7] is also the aim of this study.

Manufacturing of the MI flight model hardware is finished and its optical property is fully tested last year. High S/N and low stray light characteristics of MI optics and electronics are going to deriver new information of the lunar surface.

Samples and Methods: We measured bidirectional reflectance spectra of five Apollo 16 regolith samples (from 400 to 2500 nm at i=30 and e=o) by MIRAI (Mineralogical Reflectance Analyses Instrument) at JAXA [8]. These 5 samples (listed in Table 1) were selected as representatives of 5 different geological units of this area, including a regolith 62231 used for Clementine standard. Obtained spectra were compared to the spectra of sampling spots pixels in the Clementine PDS mosaic data [5]. Curve fitting calculation using Modified Gaussian Model (MGM) [6] were applied to the derived sample spectra to understand the relation between the reflectance spectra and the mineralogy of the samples. Five polished thin sections (PTSs) 62231,43, 66041,129, 67601,88, 60501,121 and 63501,149 are prepared and provided by the NASA Johnson Space Center (JSC). We study modal mineralogy and mineral composition of all 5 PTSs by Electron Microprobe. Chemical compositions of minerals were studied by a JEOL 733 electron probe microanalyzer (EPMA) at the Ocean Research Institute, the University of Tokyo and JEOL 8200 electron probe microanalyzer (EPMA) at National Institute of Polar Research (Tokyo).

Table 1 Description of studied Apollo samples.

Sample No.	Description
60501	Soil at LM landing site.
62231	Soil at Station 2 Buster crater rim.
63501	Soil at Station 13 rich in North Ray crater ejecta.
67601	Soil at North Ray crater, highland component mixtures.
66041	Soil at Station 6 white ray material.

Results: All sample spectra (Figure 1-a) indicate weak pyroxene absorption signatures at around 1000 and 2000 nm. Absolute value of the obtained reflectance is higher in the order of sample 67601, 63501, 66041, 62231 and 60501. Reflectances at 750 nm are 32.0, 26.0, 20.8, 20.5 and 19.3 % (given in the order of sample numbers). Reflectance variation of 62231 between 3 different compaction and surface roughness conditions, maximum density difference of 15%, is up to 25 % of the reflectance value. And this variation is larger than that of the terrestrial olivine and pyroxene analogous samples sieved in 75 -105 um .

Our laboratory reflectance and the correspondent reflectance in the Clementine mosaic data are very consistent with each other in the order of reflectance. Scaled reflectance (Figure 1-b) indicates that sample 67601 and 63501 seem to be less matured than other samples. Real variation of reflectance on the lunar surface less than special resolution of the Clementine UV/VIS camera have not known but in the Clementine mosaic images of the Apollo 16 landing site higher reflectance area show higher reflectance variation within neighbor pixels. Variation of reflectance for each sample in the order of higher reflectance is 28.2-25.7, 23.8-22.6, 21.6-20.3, 21.5-20.8 and 20.8-20.0 % within 3×3 pixels around sampling spots.

Three calculated parameters, wavelength, depth and width of absorption peak center, of MGM analyses show that 67601 has largest absorption peak depth while 62231, 66041, 63501 and 60501 have similar smaller depth both in the absorption peak around 1000 nm and 2000 nm. This correlation shows consistency with the modal (vol. %) abundances of mafic minerals (pyroxene+olivine) analyzed in the PTS and also less matured features of reflectance spectra in 67061.

There is variation of absorption peak center among samples as indication of mineral composition of samples. Variation of the wavelength of the calculated peak center around 2000 nm is about 60 nm among 5 samples. Representative pyroxene compositions measured by EPMA are listed in Table 2. Because of the co-existing high-Ca and low-Ca pyroxene within each samples correlation between calculated absorption peak center and the measured mineral composition within 5 PTSs are complicated in 1000 nm area. In the other hand center of absorption peak around 2000 nm show clear two pyroxene components. Therefore further MGM analyses are required to distinguish absorption peak around 1000 nm and to understand the correlation between their mineralogy and reflectance spectra for this aspect. Consideration of the maturity effect in the MGM analyses is also required for further study.

Discussion: From our result that 62231 is not the lowest reflectance samples and also there are samples of similar degree of maturity with the fact that higher reflectance area in Clementine images indicate larger reflectance variation we consider there can be better laboratory standard for MI. For example, sampling spot of 60501 has homogeneous property and also it has similar degree of maturity therefore this sample could be the reflectance standard for MI same as sample 62231.

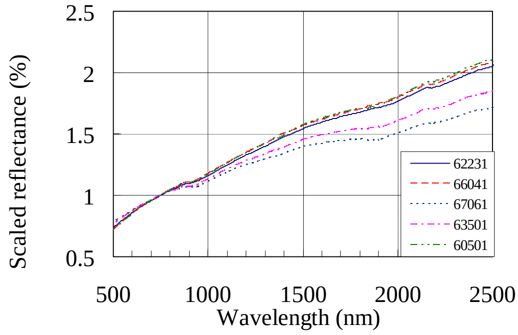

Figure 1. Scaled reflectance at 750 nm under the condition of i=30 and e=0 degree. Individual spectrum shows averaged value of several measurements. Sample 62231, 66041 and 60501 show lower and "redder" reflectance.

Table 2. Mineral compositions of representative pyroxenefragments.

	Pyroxene (co-existing high-Ca & low-Ca pyroxene)
66231	Fe#=23, Wo42 Fs13 En44 (high-Ca) Fe#=29, Wo 3 Fs29 En69 (low-Ca)
66041	Fe#=14, Wo45 Fs 7 En47 (high-Ca) Fe#=18, Wo 24 Fs13 En62 (low-Ca)
67601	Fe#=26, Wo43 Fs15 En42 (high-Ca px1) Fe#=36, Wo 3 Fs35 En62 (low-Ca px1) Fe#=23, Wo39 Fs14 En47 (high-Ca px2) Fe#=26, Wo 4 Fs24 En71 (low-Ca px2)
63501	Fe# = 27-29, Wo42Fs16En42- Wo44Fs16En40 (exsolved high-Ca px1) Fe# = 38-39, Wo2Fs38En60- Wo4Fs37En59(host low-Ca px1) Fe# = 36, Wo43Fs20En37 (high-Ca px2) Fe# = 48, Wo2Fs47En51(low-Ca px2)
60501	Fe# = 20, Wo1Fs20En79 (exsolved high-Ca px1) Fe# = 14-15, Wo44Fs8En48(host low-Ca px1) Fe# = 20, Wo40Fs12En48 (high-Ca px2) Fe# = 24, Wo4Fs23En73(low-Ca px2)

An=Ca/(Ca+Na), Fe#=Fe/(Fe+Mg), Wo=Ca/(Ca+Fe+Mg), Fs=Fe/(Ca+Fe+Mg), En=Mg/(Ca+Fe+Mg)

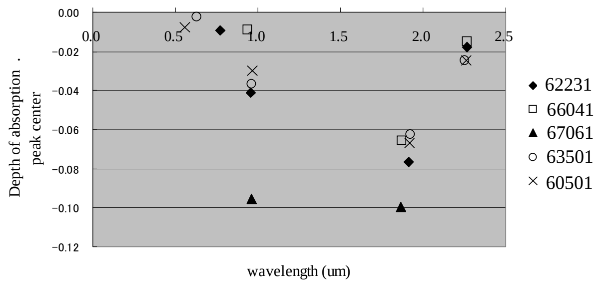

Figure 2. Results of MGM analyses of 5 Apollo samples. Correlation between calculated absorption peak center and its depth are shown. 67601 have largest absorption peak depth while 62231, 66041, 63501 and 60501 have similar smaller depth.

We thank NASA for the Apollo samples.

References: [1]Ohtake M. *et al.* (2002) *LPS XXXIII*, #1528. [2] Ohtake M. *et al.* (2002) *ISTS*, k-27p. [3] Pieters C. M. *et al.* (1992) *LPS XXIII*, 1069-1070. [4] Pieters C. M. (1999) *New Views of the Moon*, 8025-8026. [5] Ohtake M. *et al.* (2001) *LPS XXXII*, #1512. [6] McEwen (1996) *LPS XXVII*, # 841. [7] Sunshine J. *et al.* (1990) *J.Geophys. Res.*, 95, B5, 6955-6966. [8] Ohtake M *et al.* (2004) *LPS XXXV*, #2104.