MINERALOGY FROM IN SITU MEASUREMENTS AND RETURNED SAMPLES OF CHANG'E-5 YOUNG BASALTS. Xuejin Lu[1], Zongcheng Ling[1], Jian Chen[1], Haijun Cao[1], Changqing Liu[1], Shandong Provincial Key Laboratory of Optical Astronomy and Solar-Terrestrial Environment, Institute of Space Sciences, Shandong University, Weihai, 264209, China (zcling@sdu.edu.cn).

Introduction: Chang'e-5 (CE-5) mission successfully returned 1731 g lunar samples from the young mare unit (P58/Em4) in northeastern Oceanus Procellarum [1, 2]. Previous researches of remote spectroscopic investigation indicated an obvious absorption characteristic at ~1 μm and abundant olivine content in these young basalts [3, 4]. However, the mineralogical from CE-5 returned samples revealed a low proportion of olivine [5, 6]. As the youngest basalt sample to date, spectroscopy for CE-5 returned samples is expected to solve this contradiction. The relation between spectral characteristics of these young basalts with mineral mode and composition deserves further studies.

In addition, the Lunar Mineralogical Spectrometer (LMS) onboard CE-5 lander performed in situ measurements. LMS acquires hyperspectral data of pre-sampled surface, post-sampled surface and a rock surface, and multispectral maps of the scanning area, which can help us interpret mineral information and understand geological context of the CE-5 landing area.

Data and Methods: LMS has two operating modes [7]: 1) hyperspectral mode for single points (labeled quadrangles in Figure 1a); 2) multispectral mode for ~2 m×2 m region (white polygon in Figure 1a). Four spectra of pre-sampled surface, three spectra of post-sampled surface, and one spectrum of the Shi Gan Dang rock were acquired under the hyperspectral mode by LMS. The CE-5 samples contain scooped surface soils (CE5C) and drilled soils (CE5Z). Three CE-5 soil samples (CE5C0400YJFM00501, CE5C0600YJFM00301, and CE5Z0107YJFM002) are allocated to Shandong University. The fine portion (<25 μm) of CE5C0400 represents fine soil at the upper lunar regolith; the CE5C0600 (<1 mm) represents coarser soil at the subsurface; the CE5Z0107 represents samples from a depth of ~0.5 m. The reflectance spectra of soil samples were acquired by a FieldSpec 4 Hi-Res VNIR spectrometer with an incidence angle of ~30° and an emission angle of ~0°.

The spectral parameters (band center at ~1 μm and ~2 μm, BC1 and BC2) and false color composite map (red channel: reflectance ratio of 1450 nm/950 nm (Ratio1000); green channel: reflectance ratio of 1550 nm/2200 nm (Ratio2000); blue channel: reflectance at 750 nm (R750 nm)) were produced to investigate mineralogical distribution at the CE-5 landing site.

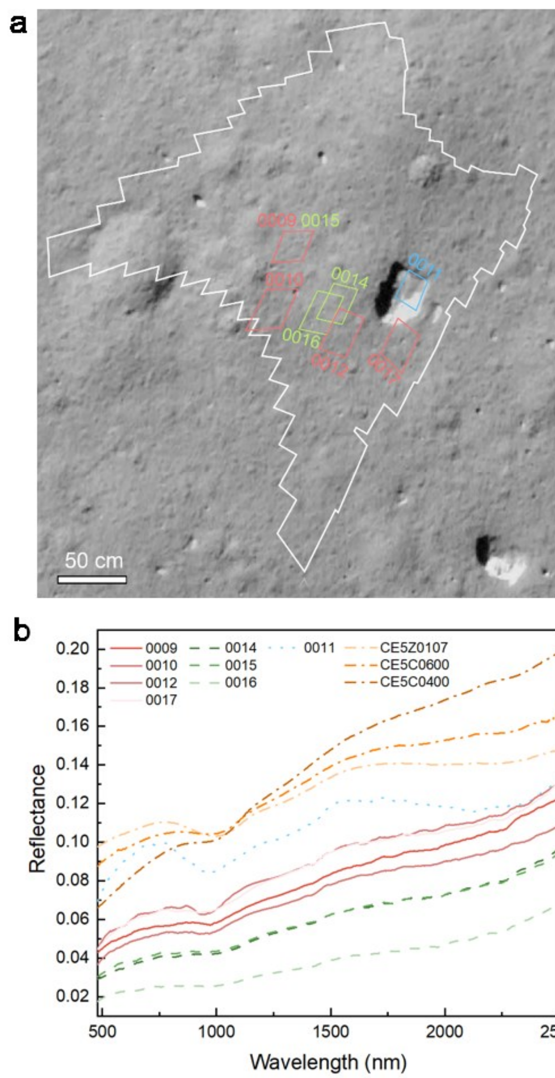

Figure 1. The image and spectra of the CE-5 landing site. (a) The ultrahigh-resolution image captured by CE-5 LCAM (frame 0410) with measured areas (the white polygon). (b) The hyper-spectra of in situ measurements and three CE-5 soil samples.

Results: The spectral characteristics of CE-5 lunar samples and lunar surface before and after sampling and false-color map of the sampling region have been investigated to acquire the mineralogical information at the CE-5 landing site.

Spectral parameter analysis. The space weathering effects are clearly shown in the spectra of three CE-5 soil samples. The least weathered soil sample

(CE5Z0107) exhibits gentle spectral slope and obvious diagnostic absorption of the mafic minerals, mainly high-Ca pyroxene. All the spectral parameters from CE-5 samples and in situ measurements are close to the high-Ca pyroxene region. Thus, the high-Ca pyroxene is the dominated mafic minerals at CE-5 landing site. The post-sampled surface exhibit a BC1 at longer wavelength than pre-sampled surface, which indicates that subsurface soils contain more high-Ca pyroxene.

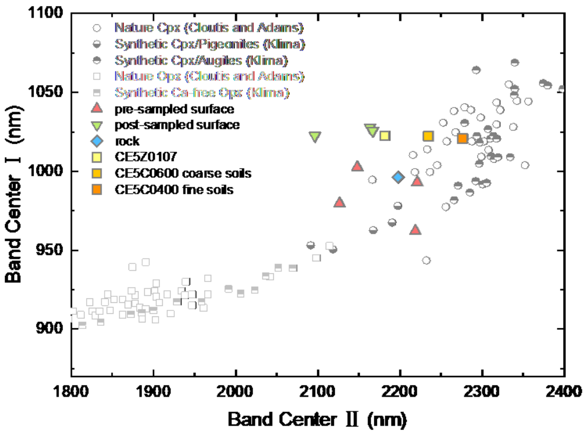

Figure 2. The spectral parameters of lunar surface at the CE-5 landing site and CE-5 returned samples (CE5Z0107, CE5C0600, and CE5C0400).

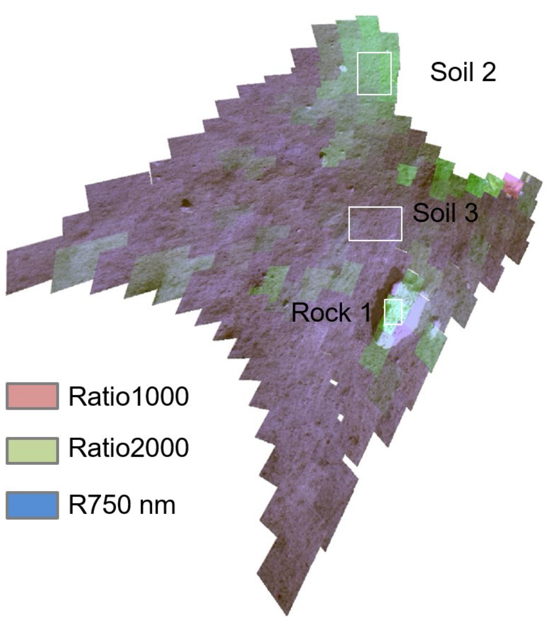

Figure 3. The mineralogical false-color map at the CE-5 landing site. Three regions exhibit different colors (white rectangles).

Mineralogical false-color map. The multi-spectral images measured by LMS are further used for analysis of mineralogy at the CE-5 landing site. There was no significant heterogeneity of mineralogy at the scanning area of ~2 m×2 m, except for the rock (Rock 1 in Figure 3) and the area near the lander (Soil 2 in Figure 3). The dominant reddish color indicates obvious absorption at ~1 μm while weak characteristic at ~2 μm. The Shi Gan Dang rock exhibits fresh and obvious absorption characteristics at ~1 μm and ~2 μm compared with surrounding mature soils (Table 1).

Table 1. The average spectral parameter of three selected region in Figure 3.

Spectral parameter	Rock 1	Soil 2	Soil 3
Ratio1000	1.368622	1.155509	1.201235
Ratio2000	1.133696	1.120801	1.002049
R750 nm	0.090205	0.060647	0.052950

The obvious and broad absorption at ~1 μm of Fe-rich clinopyroxene can be easily confused with olivine spectral characteristics. This will lead to misinterpretation of mineral content from reflectance spectra. Thus, the spectral parameters estimated from in situ measurements and returned sample in this study are useful to further understand mineralogy of lunar late-stage mare basalts.

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References: [1] Hiesinger et al. (2000) *JGR* 105, 29239–29275. [2] Qian et al. (2018) *JGR* 123, 1407-1430. [3] Staid et al. (2011) *JGR* 116, E6. [4] Varatharajan et al. (2014) *Icarus* 236, 56–71. [5] Li et al. (2022) *Natl. Sci. Rev.* 9, nwab188. [6] Cao et al. (2022) *Geophys. Res. Lett.* 49, e2022GL099282. [7] Xu et al., *Space Sci. Rev.* 218, 1–22.