DEVELOPMENT OF GROUND-BASED LUNAR VIS/NEAR IR SPECTRAL IMAGER. M. Matsushita[1], T. Takata[1], Y. Ikeda[3], N. Hirao[2] , M. Saito[1], Y. Chiba[1], Y. Takeyama[3], [1]Miyagi University of Education (Aoba, Sendai, 980-0845 JAPAN, *contact to* toshiko@miyakyo-u.ac.jp) , [2]Tohoku University, Dept. Mineralogy, Petrology, and Economic Geology, [3]Genesia co.

Abstract: In order to obtain 3dimentional spectral images of mare on the nearside of the moon, we have developed a ground based Lunar Spectral Imager. It focuses on the absorption band of 950 nm. The resolutions of the space and the wavelength are 9 km and 10 nm (VIS), and 20 km and 20 nm (IR).

Introduction: The spectral analysis of mare materials is essential in order to clarify the lunar resurfacing process, in particular, the relationship between the distribution of volcanic emplacements and origins of the magma [1, 2]. In order to obtain 3dimentional spectral images of mare on the nearside of the moon, we have developed a ground based Lunar Spectral Imager. The Lunar Spectral Imager focuses on the absorption band around 950 nm, and the effective wave length is between 600 and 1600nm. The band is characterized by the iron contents of mare soils, which indicate the classification of basaltic rocks of mare lava [3, 4].

Specification of Lunar Spectral Imager: Fig. 1 shows the entire system of our ground-based Lunar VIS/Near IR Spectral imager. It is consisted of a Newton telescope (F5, focal length of 150 cm, Takahashi MT-300), a spectrometer (Genesia co. grating 200 g/mm), a visible camera (SBIG ST-7E, Si area sensor), a near infrared camera (SU Inc, SU320-1.7RT-D, InGaAs area sensor), and a viewing camera (Genesia co. based on Phillips co. ToUCam-Pro).

Lights collected by the telescope focused on a slit mirror. Lights reflected by the mirror, which indicate the lunar surface except the position of spectral observation, are focused on the viewing camera. Lights passing through the slit are dispersed by the spectrometer, and then split into visible and near infrared by a dichroic mirror. The split lights are focused on the VIS camera and the near-IR camera, respectively. The visible image data can be obtained simultaneously with the infrared image data. Therefore, it is easy to correct the spectral data, including the atmospheric conditions, the phase angles of the lunar surface, and so on.

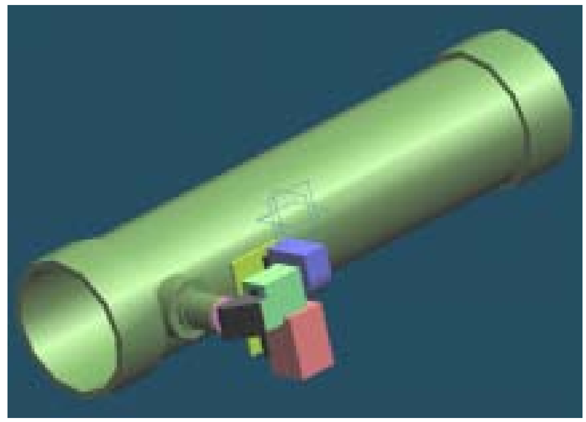

Fig.1. Entire system of the Ground-based lunar VIS/near IR spectral imager. Purple, red, and green boxes are VIS camera, IR camera, and spectrometer, respectively. Yellow green pipe is a telescope. A viewing camera is not shown.

Detailed specifications of each subsystem are summarized in table 1. The reflective mirrors of the telescope are coated by MgF_2 in order to avoid the low reflectivity of the wavelength of 900 nm. The equatorial mounting of the telescope (Takahashi EM500 Tenma PC) is controlled remotely while confirming the observed regions using images of viewing camera. PC camera is utilized for the viewing camera in order to reduce the cost and the weight (< 100 g) of the entire imager.

Spectral data and spatial data are recorded in each line and column of area sensors of VIS and IR cameras, respectively. Using viewing camera and remote control systems of the telescope, the imaging positions are shifted and then, 2dimentional spatial images and spectral data of each position can be obtained. CCD cameras can be on the markets and less expensive than the originally developed ones. Moreover, the total weight except the telescope and control PCs is within 4 kg. Thus, our imager is designed for the case of limited weight and cost.

SUBSYSTEM	Products	Specification	
Visible camera	SBIG ST7	Sensor	Si area
		No. pixel	765x510
		Pixel size	9 x 9 um
IR camera	SUInc.	Sensor	InGaAs area
	SU320	No. pixel	320x240
	-1.7RT	Pitch size	40 x 40 um
Spectrometer	Genesia	wave length	600-1600 nm
	GE1156-1	magnification	1
		slit	0.08 x 4 mm
		Grating grv fq.	200 g/mm
Telescope	Takahashi	F	5(extend 5.5)
	MT300	D	300 mm
Viewing-Camera	Genesia	F	reduced 3.3
	GE1156-3	Sensor	Si area
		No. pixel	659x494
		Pixel size	5.6x 5.6 um
Equatorial mounting	Takahashi EM500		

Table 1. Specification of each subsystem.

The resolution of the Lunar VIS/near IR imager is shown in table 2. The ratio of the pixel size of the IR sensor relative to the one of the visible sensor is 4.4. Thus, the spatial resolutions of VIS and IR differ as shown in table 2. Taking into consideration of the dispersion efficiency, resolutions of wavelength of the visible and the IR cameras are 10 nm and 20 nm, respectively. Thus, binning of 4 x 4 pixels in the visible region (600-1000 nm) and that of 2 x 2 pixels in the IR region are required. The Signal to Noise Ratio (SN) taking into consider the atmospheric absorption, binning of VIS/IR images, and the composite of 10 IR images is shown in fig. 2. In order to distinguish the 950 nm absorption band, SN more than 200 is required. The exposure time of the IR video camera is restricted within 16 msec and a single IR image is not enough to obtain the enough SN. It is possible for IR video camera to take 30 frame images per a second. Therefore, the positioning error can be minimized.

The correction of the wavelength is conducted by using emission lines of Ar, Kr, and Hg lamps. These can be lighted in front of the telescope and wavelength correction is performed.

Wavelength	VIS	10 nm	(2.3 nm/pix)
	IR	20 nm	(10 nm/pix)
Space	VIS	4.48"	(1.12" /pix)
		9.0 km	(2.25 km /pix)
	IR	10"	(5.0" /pix)
		20 km	(10 km /pix)

Table 2. Resolution of the Lunar VIS/near IR imager. The range of wavelength of VIS and Near-IR are 600-1000 nm and 1000 -1600 nm, respectively.

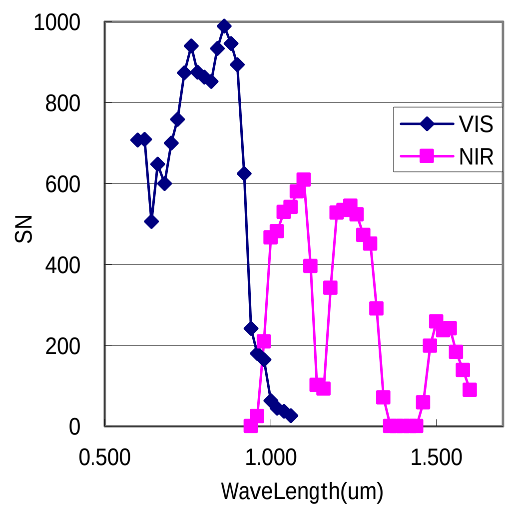

Fig.2. Signal to Noise Ratio of each pixel of the Lunar VIS/near IR imager. SN is calculated taking into account of the atmospheric absorption.

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