Wavelengths selection for LED-illuminated multispectral imaging on PROSPECT for Luna-27. N. Schmitz[1] and K. L. Donaldson Hanna[2], [1]DLR, Institute of Planetary Research, Berlin, Germany, Nicole.Schmitz@dlr.de, [2]Atmospheric, Oceanic and Planetary Physics, University of Oxford, Oxford, UK (Kerri.DonaldsonHanna@physics.ox.ac.uk).

Introduction: The Package for Resource Observation and in-Situ Prospecting for Exploration, Commercial exploitation and Transportation (PROSPECT) is in development by ESA for application at the lunar surface as part of international lunar exploration missions in the coming decade, including the Russian Luna-27 mission planned for 2021. PROSPECT will search for and characterize volatiles in the lunar polar regions to answer science questions and investigate the viability of these volatiles as resources. PROSPECT will drill into the surface to depths of more than 1m and extract samples. An important supporting data set will be images of the drilling and sample extraction process. Whilst these images are primarily required for operational reasons they also offer an opportuntity for science.

Imaging on PROSPECT: A supporting camera shall be deployed in order to observe the drilling, sample extraction and transfer operations. Images will primarily be used to inform selection of the point at which contact was made between the drill and the ground. Images will also be used to monitor and inform the drilling operations, the accumulation of cuttings brought up to the surface and the sample extraction and transfer. The camera will be accommodated on the box structure in which the drill mechanical unit is accommodated. It will be required to operate while samples are not illuminated and so will require a light source. Whilst this camera is not considered to be a scientific instrument, it is foreseen that the images produced will be used to inform science operations and scientific interpretation of the data produced by PROSPECT. Hence, the camera shall be equipped to provide the geological context, mineralogy and physical properties (e.g. rock and regolith particle size distributions) of the lunar surface in front of the Luna-27 lander, including the PROSPECT drill's working space.

Candidate cameras under consideration are monochrome imagers without filters. In order to enhance the capability of the camera to characterize the mineralogical diversity of the surface, the addition of an LED illuminator is envisaged. Active illumination with a panel of LEDs in different wavelengths in order to enable color imaging and multispectral science imaging was already successfully demonstrated, e.g. on Phoenix for the Robotic Arm Imager RAC [1], on Rosetta for the Rosetta Lander Imaging System ROLIS [2], and on MASCOT/Hayabusa-2 for the MasCam [3]. In addition to enabling multispectral imaging, the same illuminator would also satisfy the requirement for a light source for the camera, and extend the imaging coverage to include areas of the drill workspace and the spacecraft that may be shadowed from direct sunlight by terrain, rocks, and/or the spacecraft itself.

Selection of bandpasses: Spectral measurements at visible to near infrared (VNIR) wavelengths identify Fe-bearing minerals such as plagioclase, pyroxene and olivine by using broad absorptions at characteristic wavelengths caused by electronic transitions of Fe2+ in specific crystal structures (Figure 1). While the VNIR spectra of plagioclase, pyroxene, and olivin have diagnostic absorption bands near 1 and 2 μm, the strength of these bands can be weakened by at least two known surface processes: (1) space weathering and (2) shock metamorphism (e.g. [4], [5], [6]). These processes result in well-developed mature soils with VNIR spectra nearly devoid of their initially observed absorption features (Figure 1).

The PROSPECT camera's central bandpasses shall be selected to provide information on the spectral characteristics and variations of the lunar surface material in the camera's FoV. Furthermore, the selected wavelengths must lie within the spectral range of the used imaging detector (typically ~400-1000nm). For comparison and discrimination of data between missions, the bandpasses should correspond to available orbiter multispectral datasets, eg Clementine, Chandrayaan-1 Moon Mineralogy Mapper (M^3), and lunar Reconnaissance Orbiter Camera Wide Angle Camera (LROC WAC). Because a monochrome imaging detector is used, three bandpasses shall be selected as broadband RGB „filters" in order to enable true color imaging. A maximum of 6 different wavelengths shall be employed, in order to limit the size and volume of the illuminator.

As a starting point, we examined the bandpasses of visible cameras on previous lunar missions, eg the Clementine UV-VIS and LROC WAC cameras (e.g. [7], [8]). From these examples, we selected the following central wavelengths as a first proposal: 415, 600, 675, 750, 825, 900 and 950 nm. Bandpasses (FWHM) intended for RGB true color imaging were proposed to be broadband (50 nm), the others were proposed to be more narrow band (eg 20 nm or 30 nm). In order to test the utility of the proposed bandpasses for discriminating between materials found within the lunar regolith, we re-sampled RELAB reflectance spectra of (1) pure minerals separated from Apollo mare basalts collected at the Apollo 15 landing site [9] and (2) a suite of well-characterized Apollo bulk soils with a range of maturities to a set of nominal band passes.

RELAB reflectance spectra were re-sampled to the candidate camera LED bands: 415, 600, 675, 750, 825, 900 and 950 nm with band passes (FWHM) of 20 nm, 30 nm, and 50 nm, and other sets within this range.

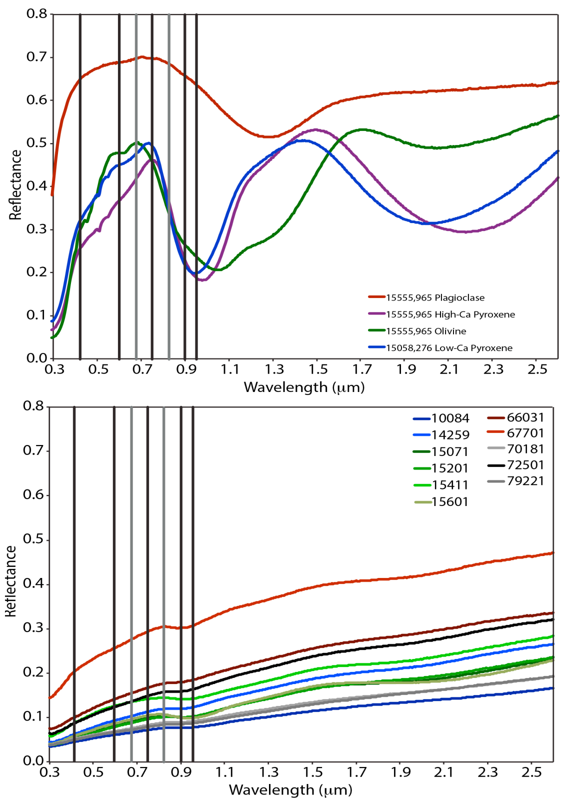

Figure 1. (Top) RELAB reflectance spectra of common lunar minerals and **(Bottom)** a suite of lunar soils of varying maturities.

After evaluating different sets of bands, we selected a set of band passes centered at 415, 675, 750, 825, 900, and 950 nm. For the soils, one important result is that accurately measuring the albedo will be critical. Figures 1 and 2 show the re-sampled spectra for (1) pure minerals and (2) Apollo soils at 20 nm.

Future plans and test programme: In order to confirm the utility of the proposed bandpasses, a test campaign, including a blind test, is under preparation at DLR. A breadboard illuminator will be designed and manufactured, and together with a PROSPECT- representative camera, used to image a set of regolith simulants, test minerals and/or analogue materials (representative of the lunar case). Reflectance spectra will be created from the data and used in order to demonstrate the utility of the proposed bandpasses for discriminating between the materials.

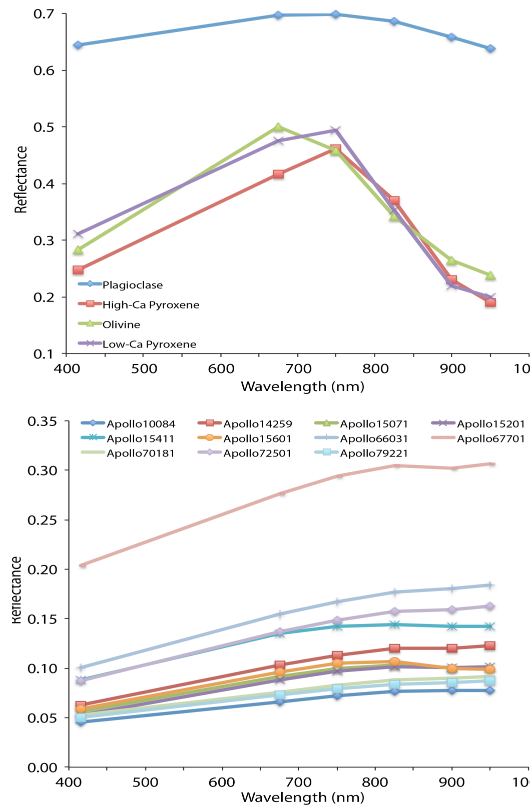

Figure 2. (Top) Re-sampled RELAB reflectance spectra of pure minerals and **(Bottom)** a suite of Apollo soils.

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References

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