

A COMPARISON OF THE MOON MINERALOGY MAPPER (M3) AND THE IMAGING INFRARED SPECTROMETER (IIRS) DATA IN FISHER CRATER. S. Bouffard¹, M. Lemelin², G. Osinski³, ¹University of Sherbrooke (samuel.bouffard2@usherbrooke.ca), ²University of Sherbrooke (Myriam.Lemelin@USherbrooke.ca), ³University Of Western Ontario (gosinski@uwo.ca)

Introduction: Minerals possess characteristic reflectance spectra in the visible and infrared wavelengths. Data acquired by hyperspectral sensors allow the study of the Moon surface, due to the information they collect in this wavelength range and in a high number of spectral bands [1]. Two imagers with hyperspectral sensors have been in lunar orbit, the Moon Mineralogy Mapper (M3) in 2009 and Imaging Infrared Spectrometer (IIRS) in 2019. The data from those missions are the only one of this kind. M3 has a spatial resolution of 140m/pixel for the entire Moon in 86 bands from visible to near-infrared (420 – 3000 nm). The bandwidth is about 10 nm [2]. In comparison, IIRS has a spatial resolution of 80m/pixel in 256 bands in the near-infrared (700 – 5000 nm) for certain regions of the lunar surface. The bandwidth is about 20 nm [3]. For IIRS, the coverage of data released is limited to within $\pm 30^\circ$ N/S (**Fig 1.**).

In this study, we want to investigate and explore the lunar surface with the recent IIRS dataset. We use a region covered by both the M3 and IIRS instruments. The region we choose is *Fisher* crater located at 8.0° N, 142.4° W, on the far side of the Moon. At geological scale, *Fisher* crater was formed in the *Lower Imbrian* epoch, between 3.85 – 3.8 Ga by an impact on the *Oriente group* [4]. The Kaguya Multiband Imager (MI) shows that the more abundant mineral present in this crater is plagioclase, far followed by orthopyroxene, olivine, FeO, and clinopyroxene [5]. This site was chosen because of the superposition of the data acquired from M3 and IIRS, so we can perform a comparison between the data. To investigate the differences between those two images, a spatial resolution comparison was shown, and an unsupervised classification was performed in ENVI.

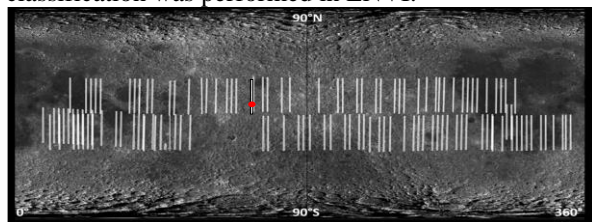


Fig 1. Spatial Coverage of the lunar surface for IIRS instrument. The maximum latitude coverage is about 30° N and 30° S. Fisher crater is indicated by the red dot with its associated bands.

Data & Method: The data was acquired on The Planetary Data System (PDS) from NASA for the M3 [6] and on the Indian Space Research Organisation

(ISRO) Science Data Archive from Indian Space Agency for IIRS [7]. The file name of the M3 image is *M3G20090528T213152_V01_RFL* and the data type is Level-2 (reflectance) on PDS. The IIRS image is *ch2_iir_nci_20191202T0639493114_d_img_d18* and the data type is on Level-1 (calibrated radiance). First, we had to calculate the reflectance (ρ) of the IIRS image in IDL from ENVI, because only Level – 1 data was accessible (**Equation 1.**) [3].

$$\rho_{ap}(\lambda) = \frac{L(\lambda)}{\cos(i) \times \frac{F_0(\lambda)}{\pi}} \times \left(\frac{1}{d_{AU}} \right)^2$$

Equation 1. Radiance to Reflectance conversion for one pixel.

Second, we export an image of *Fisher* crater for M3 and IIRS to show the spatial resolution of those two instruments. Each image was projected on the coordinate system Plate Carree. Third, we plot the spectral signature for each class of both images, to show the spectral resolution and the difference of reflectance for each class. Fourth, we perform a K-Means unsupervised classification to identify the different spectral groups in the images, because this method is mainly used for this type of classification. A spectral subset was done on M3 and IIRS images, to have the same spectral range (750 to 3000 nm). To lead this classification, we have based ourselves on [8]. They had five different types of minerals, so we took five classes in our classification.

Preliminary Results: Here are the preliminary results. First, we have the spatial resolution for both instrument M3 and IIRS for Fisher crater. The result shows that the spatial resolution of IIRS is better than that of M3. The large structure can be identified on both images, but the detail of IIRS is much higher than M3 (**Fig 2.**).

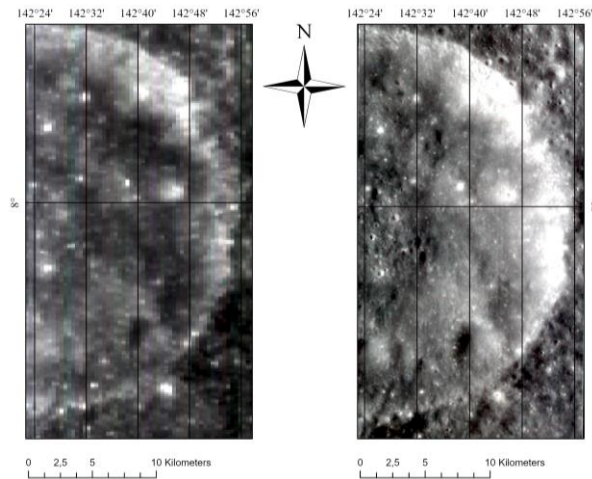


Fig 2. Spatial Resolution of M3 (left) and IIRS (right) for Fisher crater.

Second, a comparison of the spectral signature was done for each class of the unsupervised classification. A spectral subset was done between 750 – 3000 nm, to fit the two datasets. IIRS has many variations and higher reflectance than M3. Furthermore, from Class 1 to 5 the reflectance grows, and the difference in reflectance between the two spectra increases (Fig 3.). According to the ISRO, Level-2 (reflectance) is in development for IIRS data [3].

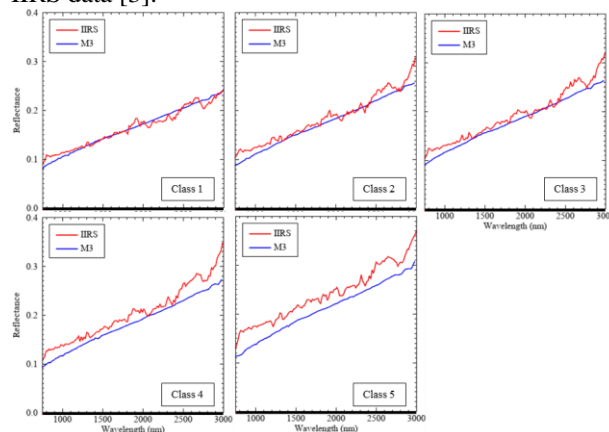


Fig 3. Comparison of IIRS and M3 spectra for each class of the unsupervised classification.

Third, the unsupervised classification shows that we can extract more detail of the lunar surface with IIRS than M3, due to its spatial resolution. We went on Quick Map to compare this classification with the mineral maps derived from the Kaguya MI data. It is possible to notice that M3 classification match with the outline of MI data especially with class No 5 associated with plagioclase [5]. IIRS seems to have a lack of precision for the match of those same outlines although the IIRS and MI data have a similar spatial resolution (80 versus 62 m/pixel) (Fig 4.).

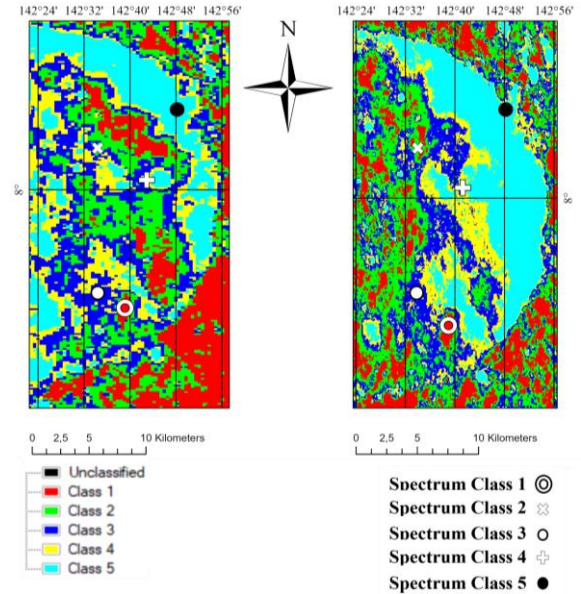


Fig 4. K-Mean unsupervised classification of M3 (left) and IIRS (right) for Fisher crater, with the location of the spectrum acquire on fig 3.

Discussion and conclusion: The M3 dataset covers almost the entire lunar surface, while the IIRS data released so far covers only a portion of the equatorial region. The IIRS data has a much higher spatial resolution than M3, but, as the current calibration stand, the M3 dataset appears to be better suited to identify the different materials at the surface. The IIRS data allows to have more spatial information, but the calibration of the data is not optimal yet. This can be verified with the Kaguya MI data and the classes associated with the unsupervised classification of M3 / IIRS images [5]. The classes shown in Fig. 4 cannot be associated with confidence with the minerals identified by the Kaguya MI. Only class No5 can be associated with greater confidence to plagioclase. This is maybe due to the low abundance of the other mineral in Fischer crater. Higher calibration levels of the IIRS data and the release of additional imagery will undoubtedly be useful in the identification of minerals on the lunar surface in the coming years.

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