Enhancing Geomorphological Maps using Geo-spectral Maps on the Example of the Lunar Apollo Basin.
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Introduction: Commonly, maps of planetary bodies show units based on either morphological appearance or spectral data. Geomorphological maps use images in the visible range, topographic information and surface roughness to determine units of similar morphological appearance that likely formed as part of one geological process. Geo-spectral maps use images at different wavelengths to determine units with similar spectral indices giving information on the uppermost part of the surface.

In this study we present a technique to combine geo-spectral and geomorphological maps into one product, which contains more information than its constituents. Here, we present the technique on the example of the lunar Apollo basin. Synchronous work has been performed on the Rachmaninoff Basin on Mercury as a combined effort within the PLANMAP project [1].

Data: We use two existing maps of Apollo basin. The geomorphostratigraphic map by [2] and the geo-spectral map by [3]. Apollo basin is situated in the NE part of South Pole-Aitken basin on the lunar far side.

Morpho-stratigraphic map: [2] produced a morpho-stratigraphic map of the area (Fig. 1) using LROC WAC images and topographic information from the LOLA/KAGUYA merged DEM [4] to determine geomorphological units and crater size-frequency measurements for establishing a stratigraphy.

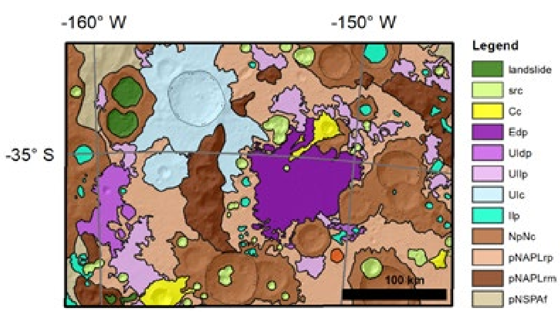

Fig. 1. *Morpho-stratigraphic map [2].*

Geo-spectral map: [3] analyzed M3/Chandrayaan-1 data [5] after performing the most up-to-date calibration, thermal removal and photometric correction [6,7]. [3] defined the Apollo Basin spectral units by using the two strong pyroxene absorption bands at 1 and 2 µm that characterize lunar spectra,considering the reflectance at 550mm and the spectral slopes between the maximum of the 1 µm shoulders. In Apollo Basin, they described 12 different spectral units (SU) (Fig. 2).

Method: As we aim to combine both maps within one, we first digitized the spectral map into a vector graphic. This simplifies the map and, while it could lead to some spectral information being lost, it is necessary so that we can compare the contact linework of both maps.

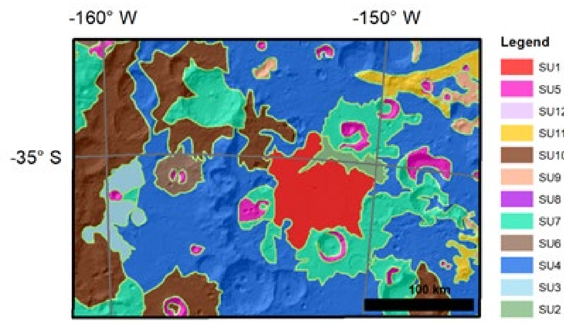

Fig. 2. *Vectorized version of the Spectral map by [3].*

We experienced two kinds of relationship between contacts:

(a) the geomorphological contacts overlap or are in very close proximity to the geo-spectral contacts, following e.g. mare extents (Fig. 3, left). In this case, we combine the spectral and geomorphological contact keeping the outline of the geomorphological contact as we aim to utilize the geo-spectral map to enhance the geomorphological one, which has a higher resolution.

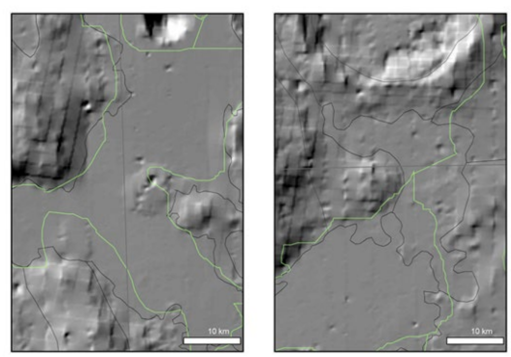

Fig. 3. *Two types of contact correlation: contacts from the geomorphological map are black, spectral contacts are green. Left: contacts closely align. Right: contacts crossing.*

(b) the geo-spectral and geomorphological contacts vary significantly and crosscut each other (Fig. 3, right). In that case we implement the geo-spectral contact as a spectromorphological contact. The spectromorphological contact follows the geo-spectral contact and divides the geomorphological units into different

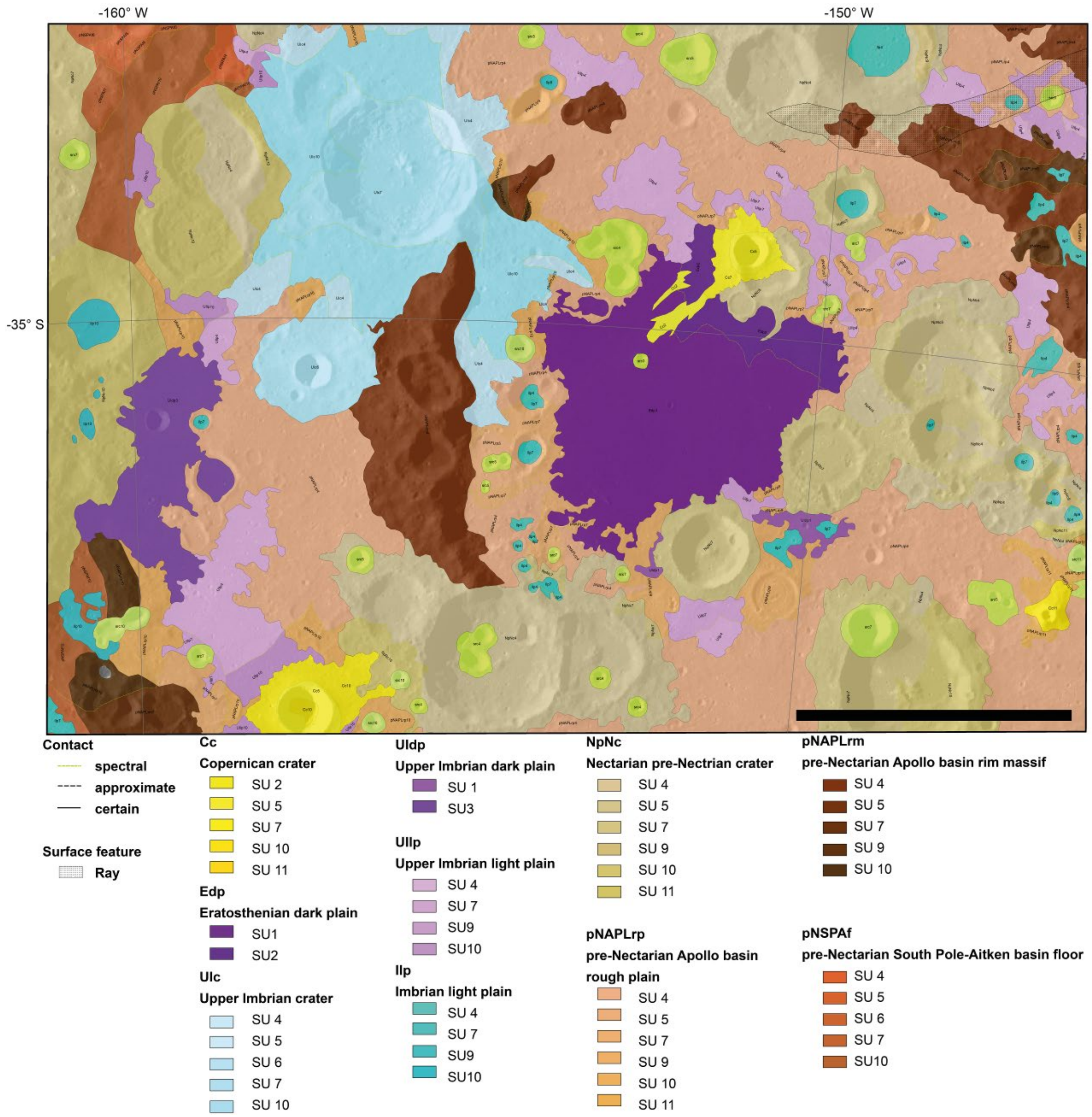

Fig. 4. *Spectomorphological map of Apollo Basin*

spectral sub units.

For displaying these different subunits we chose to stay within the same color but add saturation for expressing the different spectral units. This leads to a number of spectral subunits within each geomorphological unit.

Results: Within Apollo basin we were able to identify 10 new spectral subunits within the geomorphological units determined by [2]. While most of these can be traced back to surface variations such as ejecta from nearby craters, we were able to identify a new unit of mare material. This mare unit shares morphological appearance and absolute model age with another mare unit but is of a different spectral unit. We also discovered extensive Ray material in the NE part of the map.

Conclusion: Here, we aimed to provide a recipe on how to enhance geomorphological maps using geo-spectral maps. We showed a step by step description of our creation of a spectromophological map. Spectro-morphological maps can improve geomorphological maps as they provide additional information on a study area, which might be able to further distinguish units and complete the story of an area as shown by our example in the lunar Apollo Basin.

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