From morpho-stratigraphic to geo(spectro)-stratigraphic units: the PLANMAP contribution.

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Introduction: From the Apollo era onward, planetary 'geologic' mapping has been carried out using a photo-interpretative approach mainly on panchromatic and monochromatic images. This limits the definition of geological units to morpho-stratigraphic considerations so that units have been mainly defined by their stratigraphic position, surface textures and morphology, and attribution to general emplacement processes (a few related to magmatism, some broad sedimentary environments, some diverse impact domains, and all with uncertainties of interpretation). On the other hand, geological units on Earth are defined by several parameters besides the stratigraphic ones, such as rock textures, lithology, composition, and numerous environmental conditions of their origin (diverse magmatic, volcanic, metamorphic and sedimentary environments). Hence, traditional morpho-stratigraphic maps of planets and geological maps on the Earth are still separated by an important conceptual and effective gap. This makes the traditional planetary morpho-stratigraphic maps unable to fully satisfy the needs of modern planetary exploration, i.e. an optimized product to define mission strategy in terms of target selection, exploration traverse definition and resource evaluation. PLANMAP and GMAP are attempting to fill in this gap by integrating spectral and color information into morpho-stratigraphic maps, thus generating geo(spectro)-stratigraphic maps. The integration can be achieved following two different interpretative strategies (although up to date applied only on limited regions), namely the "in series" and the "contextual" approach.

In series interpretation: The more linear approach for creating a Geo(spectro)-stratigraphic map is to improve the morpho-stratigraphic one by integrating it with spectral and color information. The final result is a map where the former morphostratigraphic units boundaries can be slightly modified whereas they are internally subdivided into into several spectro-stratigraphic sub-units. At the end of the process, the two maps appear similar at a first glance, but the spectro-stratigraphic one is much more informative. This approach has been effectively carried out on the Moon and Mercury by using color basemap derived by spectral indexes and multispectral image classification.

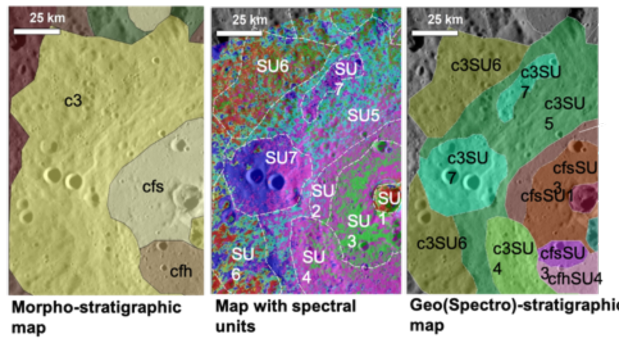

Figure 1: in-series interpretation from Giacomini et al. EGU 2021-15052

Contextual interpretation: Geo(spectro)-stratigraphic maps can be also produced directly from a contextual work on black and white images and RGB color compositions either using Principal Component (PC) analysis (see Mercury examples in Semenzato et al., 2020) and/or Spectral Indexes (see Moon and Mars examples in Zambon et al., 2021). Often the contextual work is easier using pansharpening processes. In this case, the map might consistently diverge from the morphostratigraphic one since geologic contacts are interpreted following boundaries highlighted by color variations of compositional units, which do not always coincide with the morphological ones. However besides the geo-stratigraphic units, identified by color variations can be also applied classical morphostratigraphic distinctions such as the crater degradation classes here hilighted with different stippled patterns. Given the local complexity of Martian stratigraphy and the high spectral and geometrical resolution of Martian data, the contextual approach seems the only one really feasible on Mars for integrating colors and spectra with morpho-stratigraphy

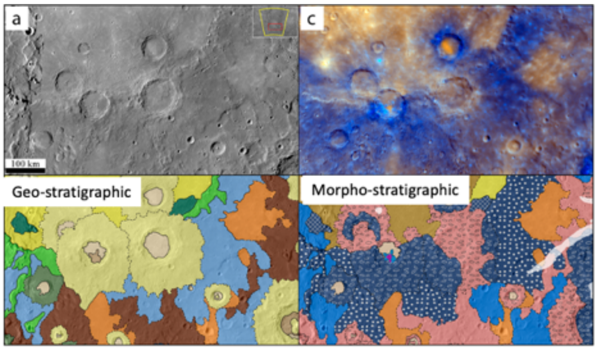

Figure 2: contextual interpretation on Rembrandt basin on Mercury by Senenzato et al., 2020

Conclusion: The integration of morphostratigraphic information and spectral ones on a single geological map can be achieved in different ways giving more emphasis to the morphostratigraphy (in series approach) or on the spectral(color) variations (contextual approach). In both cases the resulting planetary geological map is much more informative than the traditional one, but the applicability on wide regions such as entire quadrangles is still to be evaluated.

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