ADDRESSING A COMMUNITY NEED: RECOMMENDED STANDARDS FOR THE CORRELATION OF MAP UNITS MAP COMPONENT. S. R. Black[1], J. A. Skinner, Jr. [1], and H. C. Buban[1], [1]USGS Astrogeology Science Center, 2255 N. Gemini Drive, Flagstaff, Arizona 86001 (sblack@usgs.gov).

Background: Planetary geologic maps are powerful tools and are frequently used to inform and guide planetary exploration before, during, and after mission operations. Therefore, as the number of missions continues to rise, it is vital that geologic maps are clear and easy to use by a broad audience. The Correlation of Map Units (COMU) is a graphical representation of the age relationships between mapped geologic units, and a required component of all geologic maps published through the USGS. Although the COMU is a fundamental part of planetary geologic maps, no standard formatting guidelines currently exist to which map authors may refer when creating this impactful map component. This lack of standardization can result in ambiguity and confusion for both map authors and map readers and may result in misinterpretation of the final map product.

One primary goal of the Planetary Geologic Mapping Group (herein referred to as the PGM Group) is to provide support and guidance for the planetary mapping community. Feedback gathered through a 2018 survey of community needs [1] highlighted a desire for clear guidance for map authors with respect to formatting standards and conventions. The PGM Group is addressing both the need for clear and broadly usable map products and formatting guidance by creating guidelines for each of the individual map components, including the COMU. Preparatory standards will supplement the existing mapping guidelines already described in the Planetary Mapping Protocols document [2]. Herein, we describe findings from an assessment of COMU published in USGS planetary geologic maps. We anticipate publication of this assessment, its findings, and revised COMU guidelines by the end of 2022. Community input is valued and encouraged.

Evolution of the COMU: The earliest planetary geologic maps targeted the Moon and were completed by terrestrial geologists, many with extensive field training. Thus, the formatting of early COMUs was similar to those in terrestrial geologic maps, and often contained additional details such as symbols showing unit characteristics and complex relationships between units (Fig. 1). Originally, the COMU contained a written Description of Map Units (DOMU); however, since 1972 [4] these two map components have been separated.

Another COMU feature that has undergone significant change is the unit box. Early planetary COMUs represented geologic units as uniformly sized

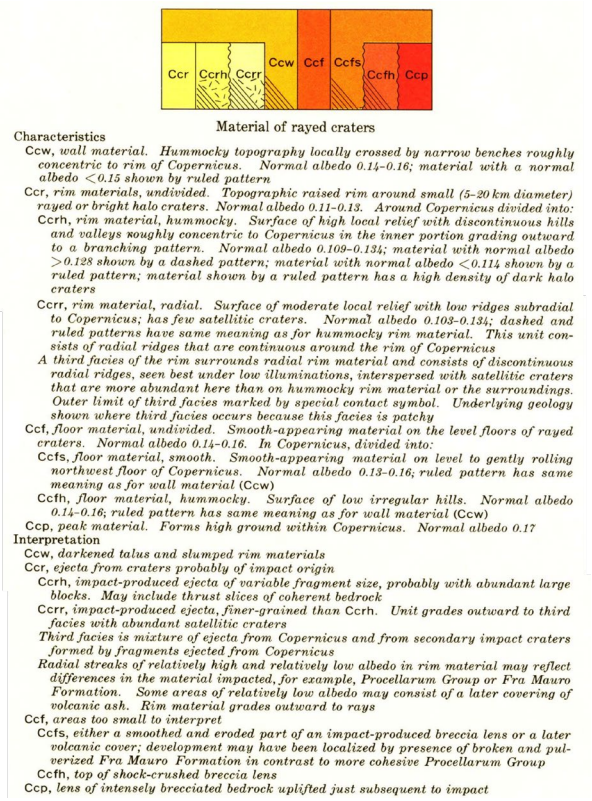

Figure 1 – Excerpt of COMU from the 1967 Geologic Map of the Copernicus Quadrangle of the Moon [3]. Early COMU formatting was similar in style to terrestrial geologic maps and included more detail than is often used in modern COMUs (Fig. 2). Based on recommendation by [4], unit correlations were separated from descriptions. Early COMUs also used hachure patterns to represent albedo differences, overtopping unit boxes, and different vertical lines.

boxes drawn with flat tops and bottoms. Beginning in 1967 [3], map authors began varying the length of unit boxes (Fig. 2), however, the intention of the lengthened unit box was often not explicitly noted. The first map of Mercury, completed in 1980, introduced the use of a sawtooth (jagged) pattern on the box tops and bottoms [5]. However, no specific explanation of what the sawtooth format was intended to convey, other than "uncertain age relations due to insufficient resolution" was included [5]. In that same year, the sawtooth approach also appeared on a Martian map [6] and persists throughout the mapping community to the present day, often with little to no explanation given for its meaning.

The combined COMU/DOMU format of early planetary maps often resulted in unit boxes that did not

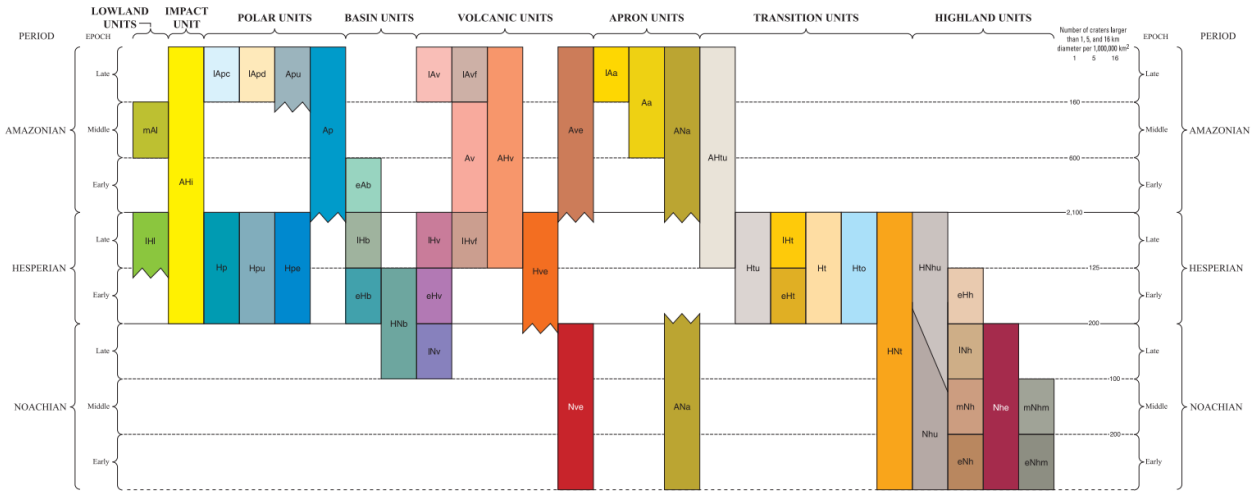

Figure 2 - COMU from the 2014 global geologic map of Mars [7]. Modern COMUs tend to rely heavily on box length, sawtooth boundaries, and vertical and horizontal spacing. However, a key issue is the lack of standard definition for each of these, resulting in varied application and, thus, interpretation.

touch horizontally or vertically. With the removal of the DOMU text from the COMU [4], map authors began to group units more closely, often with unit boxes touching horizontally and/or vertically (Fig. 2) and no clear explanation for the meaning of the spatial relationship.

The problem: The planetary geologic mapping process has evolved significantly through the decades since the initial lunar maps of the 1960s. As a result, formatting and representation of geologic units in the COMU have become confusing for map authors and map readers alike. COMU styles have changed significantly and now contain variation often without an appropriate level of explanation. This undercuts the impact and value of the COMU as a key map component. The mapping community can benefit from consolidating styles and clearly defining formatting conventions. This will result in more impactful and broadly usable map products for the future planetary science community.

COMU assessment and next steps: To create the recommended COMU formatting standards, we assessed all planetary maps published through the USGS to date (n=244), which cover Mercury (n=9; 4%), Venus (n=33; 14%), the Moon (n=75; 31%), Mars (n=106; 43%), Io (n=6; 2%), Ganymede (n=11; 5%), and Callisto (n=1; <1%). Our approach was intended to observe the variety and breadth of COMU formatting styles across all targeted bodies of interest, identify when and why (if possible) changes occurred, assess effectiveness of preparatory styles, and determine standards moving forward. COMU features that have evolved and need to be more clearly defined moving forward include the shape, fill, and relative placement of unit boxes, how unconformities and time-transgressive relationships are indicated, and inclusion of additional symbols, a geologic events column, or a COMU-specific key.

Initial observations from the assessment show three major points of confusion with the COMU over the past several decades:

- Meaning of variable unit box length
- Meaning of sawtooth boundaries
- Vertical and horizontal contiguity

The use of these characteristics is highly variable throughout the planetary mapping community, amplified by the fact that these characteristics are often not clarified for map readers.

Based on our assessment, we are compiling the most effective COMU features and formats into new standards and will describe these in a future publication. Prior to publication, we will gather community input through the annual Planetary Geologic Mappers Meeting and feedback and approval from the Mapping and Planetary Spatial Infrastructure Team (MAPSIT). Results and recommended standards will be published as a USGS Open File Report or Techniques & Methods paper.

References: [1] Skinner et al., 2019. *USGS OFR 2019-1012*; [2] Skinner et al., 2018. Planetary Geologic Mapping Protocol. *USGS Report*; [3] Schmitt et al., 1967. *USGS Numbered Series i515*; [4] Wilhelms, D. E., 1972. *Interagency Report: Astrogeology 55*; [5] Schaber and McCauley, 1980. *USGS Numbered Series i1199*; [6] Moore, 1980. *USGS Numbered Series i1196*; [7] Tanaka et al., 2014. *USGS Scientific Investigations Map #3292.*