GEOLOGIC MAPPING IN THE SOUTHERN UTOPIA BASIN. H. C. Buban[1] and C. H. Okubo[2], Astrogeology Science Center, U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001, (hbuban@usgs.gov).

Introduction: The southern Utopia basin of Mars is home to landforms that are commonly referred to as pitted cones, and whose origin is currently unknown. Geologic mapping is ongoing in this area to try and understand the formation and complex geologic history of these cones. Here, we present the status of the map components and initial findings based on the map.

Background: Pitted cones are occur in large numbers in the Utopia basin and northern lowlands, but are also found in other sedimentary basins and chaotic terrains across Mars. Previous investigations have found these pitted cones to be either pingoes[1], pyroclastic cones[e.g., 2,3], or mud volcanoes [e.g., 3,4]. These cones are thought to provide insight to the complex Martian geologic history when they are believed to have formed in Late Hesperian to Early Amazonian. Regional geologic mapping in this study could lead to more certain time constraints and better understanding of the conditions on the Martian surface when these cones were created.

The study area for this mapping project is the southern Utopia basin, approximately 3000 km east of Olympus Mons. In 2016, Okubo et al. [5] identified an area of interest where multiple types of pitted cones and rifting appeared to form concurrently with the surrounding Vastitas Borealis Formation (VBF), and interpreted that the cones in this area were formed by sedimentary processes, not igneous or periglacial as has been interpreted in the past.

Data & Methods: A 1:150,000 scale geologic map is in progress. Contacts have been traced on a controlled CTX basemap with MOLA DEM and hillshade, THEMIS day/night IR, and HiRISE supplemental images. A digitizing scale of 1:30,000 with a vertex spacing of 30 m was used to create geologic contacts.

Eight geologic units have been identified in the area, the majority of which are edifice-forming. The unit with the largest area in the striated shields (Ss) and covers approximately 70% of the mapping area.

Three types of cones have been identified in the mapping area: cratered cones, pitted domes, and cratered pancakes (**Fig. 2)** Over 500 cones with a diameter greater than 500 km have been mapped in the study

area. Cones that have a diameter of 100-499 m will be indicated with a symbol in the location features key. The majority of these cones occur within the rift filling units, although some cratered coned and pitted domes are found within the striated shields.

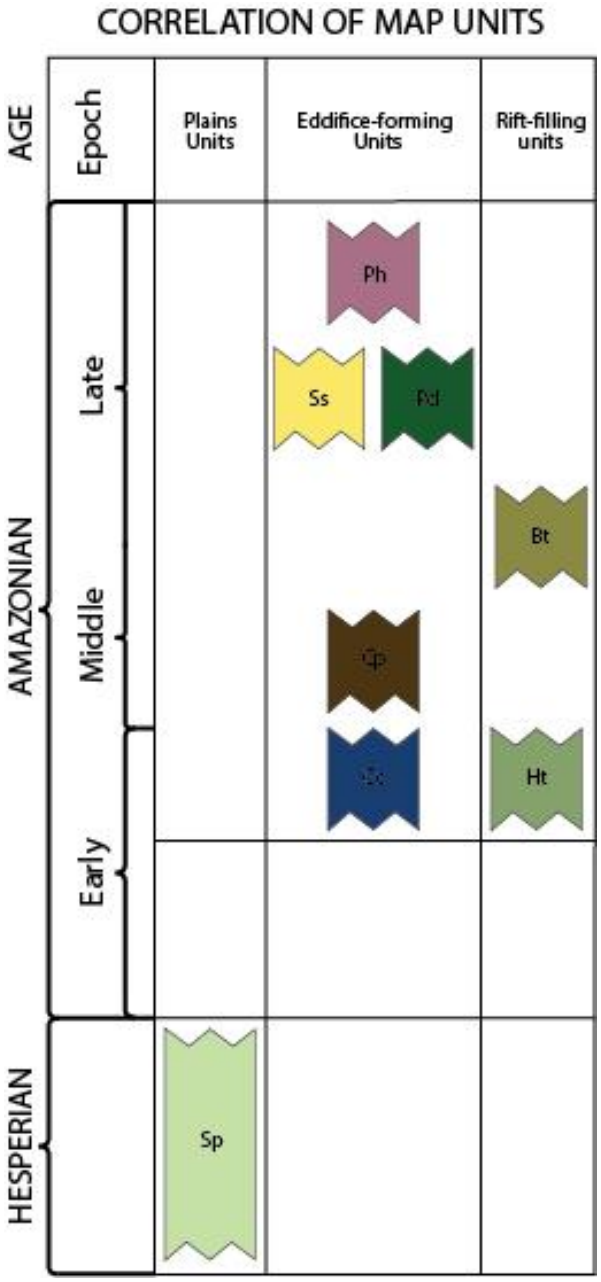

Figure 1. *Correlation of map units (COMU) for the study area.*

Following mapping guidance from the USGS Planetary Geologic Mapping (PGM) group [6], craters have been delineated at the rim (d=450-750m) or circled and included in the surface features (d>700m). The largest crater in the mapping area has a diameter of 2.11 km and has some ejecta present and a small central peak-

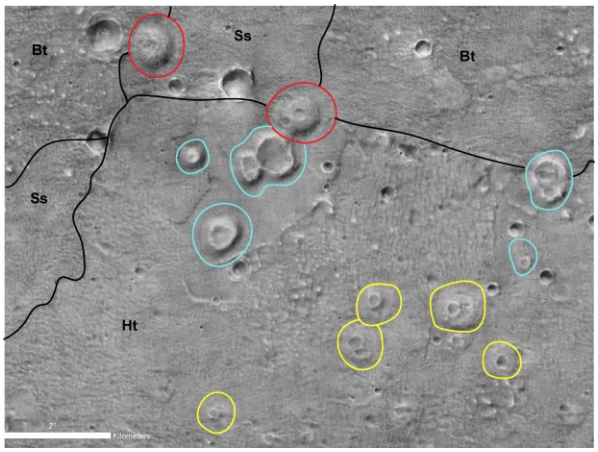

Figure 2*- Example of the tree types of cones found in mapping area: pitted domes (red), cratered cones (cyan), and cratered pancakes (yellow). Approximate geologic units not related to the cones are shown in black. The majority of the cones occur in rift-filling units-Ht in this image.*

like structure. Two old and highly modified circular features are found in the map area and are probably rims and/or ring structures from ancient craters.

Results: The map is currently undergoing minor edits before the final version is ready for submission to the USGS Planetary Geologic Mapping group. The current COMU and DOMU are shown in **Figure 1 and Table 1.** At least 3 separate rifting event have been identified in the study area occurring throughout the formation of cone features. Based on the observations from mapping, we propose that the cones, shields, and rifts are intrinsic properties of the VBF and were not caused by post-depositional, exogenic processes. This further establishes the interpretation that subsurface sediment slurries were a driving factor in the evolution of the Martian landscape during the Late Hesperian to Early Amazonian.

Summary: Mapping in this area of the Utopia basin continues to support the interpretation put forth by Okubo et al. [5] that pitted cones and rifting of materials occurred during the formation of the VBF and are not caused by external, post deposition processes. This finding can help further constrain the time of formation for similar features found in other basins across the surface of Mars.

Future work: The next steps for this project include:

- Making edits to 1:150,000-scale geologic map.
- Complete the geologic history for the COMU.
- Finalize the DOMU (**Table 1)** and identify all type localities.
- Work on map text.
- Conduct crater counting to better constrain age of units

Unit Symbol	Unit Name and Definition
	Plains Unit
Sp	**Smooth plains**—Orange-peel texture at the 1-10 m scale; Smooth at the scale of 10s-100s of meters; Meter-scale boulders present but generally not abundant
	Edifice-forming units
Ph	**Plumose hills**—Forms irregularly-shaped rises that have digitate margins and a hummocky to striated top surface; These landforms straddle portions of much longer, through-going ridges or troughs; At the meter scale, surface has scaly texture, with smooth material between adjacent scales
Ss	**Striated shields**—Forms shield-like landforms that are multiple kilometers across; Undulating texture at the scale of 10s-100s of meters, with numerous subparallel, discontinuous ridges 10-50 m wide and up to 5 km long; At the meter scale, surface has scaly texture, with smooth material between adjacent scales; Scaly texture superposed on ripples and ridges
Pd	**Pitted domes**—Forms rounded hills that are commonly circular in map view; Contains numerous small (typically <200-m-diameter), bowl-shaped depressions that are often centered on and aligned along the periphery of the landform; Surface appears rough at the meter scale; Landform has convex slopes along periphery
Cp	**Cratered pancakes**—Forms landforms consisting of a low, ovate platform (the "pancake") topped with a bowl-shaped crater.
Cc	**Cratered cones**—Forms landforms that are quasi-circular in map view and contain typically one large central depression; Landform has convex slopes along periphery; Surface appears smooth at the meter scale
	Rift-filling Units
Bt	**Bumpy terrain**—Undulating, texture at the scale of 10s-100s of meters, with numerous 10-100-m-scale rounded knobs; At the meter scale, surface has scaly texture, with smooth material between adjacent scales; Scaly texture superposed on ripples and knobs. Lobate margins
Ht	**Hummocky terrain**—Highly undulating, rippled texture at the scale of 10s-100s of meters; Scaly texture, with smooth material between adjacent scales, at the meter scale; Lobate margins

Table 1*- Description of units in mapping area.*

References: [1] de Pablo M. and Komatsu G. (2009) Icarus, 199, 49–74. [2] Brož P. and Hauber E. (2013) JGR, 118, 1656–1675. [3] Brož P. et al. (2015) JGR, 120, 1512–1527. [4] Komatsu G. et al. (2016) Icarus, 268, 56-75. [5] Okubo C. H. et al. (2016) LPS XLVII Abstract #1334. [6] Huff A. E. et al. (2020) PGMM Abstract #7046.