THE FIRST GLOBAL GEOLOGICAL MAP OF MERCURY. Louise. M. Prockter[1], Mallory J. Kinczyk[1], Paul K. Byrne[2], Brett W. Denevi[1], James W. Head III[3], Caleb I. Fassett[4], Jennifer L. Whitten[5], Rebecca J. Thomas[6], Debra L. Buczkowski[1], Brian M. Hynek[7], Lillian R. Ostrach[8], David T. Blewett[1], Carolyn M. Ernst[1], and the MESSENGER Mapping Group. [1]The Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723, USA. [2]North Carolina State University, Raleigh, NC 27695, USA. [3]Brown University, Providence, RI 02912, USA. [4]Mount Holyoke College, South Hadley, MA 01075, USA. [5]National Air and Space Museum, Smithsonian Institution, Washington, DC 20560, USA. [6]The Open University, Milton Keynes, MK7 6AA, UK. [7]University of Colorado, Boulder, CO 80303, USA. [8]NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA.

Introduction: The first reconnaissance of Mercury was carried out by the Mariner 10 spacecraft in the 1970s. Three flybys of the innermost planet yielded images of just under half of the globe, at a variety of viewing geometries and resolutions. These images were used as the basis for a series of Mercury quadrangle maps [1]; however, the map authors did not follow a uniform set of mapping conventions or units, making it difficult to compare the geology of different parts of the imaged hemisphere or to interpret boundaries between the maps.

The MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft orbited Mercury during 2011–15 and imaged the planet in its entirety. A global monochrome base map is now available in the Planetary Data System (PDS) at largely uniform viewing geometry and a resolution of ~250 m/pixel. This vastly improved data product forms the basis for the first global geological map of Mercury (Fig. 1), which provides standardized unit descriptions. The geological map will facilitate the comparison of units distributed discontinuously across Mercury's surface, thereby enabling the development of the first global stratigraphic column, and provides a guiding basis for future mappers.

Data: The map will be published at the 1:15M scale and is being created using standard U.S. Geological Survey mapping guidelines within a geographical information system (GIS). In addition to the monochrome PDS-archived base map and other base map products with alternate viewing geometries, ancilliary topography and color data were used where necessary to aid in the identification of specific units. Datasets from other published and ongoing local and regional mapping efforts have been incorporated wherever possible, including a global map of crater and basin rims [2], ghost craters [3], smooth plains [4], and tectonic structures [5]. The locations of features not resolvable at our map scale, such as pyroclastic vents [6] and hollows [7], will be indicated on the map to assist future analyses. We have mapped the ejecta deposits of all impact features >90 km in diameter; below this diameter, these deposits are generally too small to be resolved at our map scale.

Mapped units: We have classified all craters >40 km in diameter on Mercury with a revised version of the earlier five-age classification scheme [8, 9]. Specifically, we used the new MESSENGER dataset to reevaluate this morphology-based scheme, standardizing some of the diagnostic features for each class [10]. From this work we have been able to characterize the global distribution of different classes of impact features across the planet.

Mercury's surface consists of two major plains units, smooth and intercrater plains. Intercrater plains lie between large (i.e., several tens of kilometers) craters and basins and contain a high spatial density of small superposed craters 5–15 km in diameter [11]. They are generally of lower reflectance and shallower spectral slope than smooth plains [12]. In contrast, smooth plains are relatively sparsely cratered and postdate the intercrater plains. The spatial density of relatively small superposed craters on this unit is approximately uniform, indicating that it is nearly coeval, globally [4]. One unit included by the Mariner 10 mappers [1] that does not appear on our map is intermediate plains. A recent analysis [11] showed that areas previously mapped as intermediate plains are indistinguishable from either intercrater or smooth plains. We follow the recommendation [11] that the intermediate plains unit is not a sufficiently distinct map unit, especially at the global scale used in our map.

In addition to the globally distributed plains units, we have also included prominent units associated with larger basins. One such example is the Odin Formation, consisting of discontinuous patches of hummocky plains that extend up to 800 km beyond the rim of the Caloris basin. A second prominent unit is the Caloris interior plains, which closely resembles smooth plains material but has undergone at least two phases of intense tectonic deformation [13]. Additional basin-related units will be included on the map prior to its completion.

Two primary tectonic landforms are observed at global map scales: (1) extensional landforms, which consist of negative-relief, steep-sided depressions that are usually linear in plan view, and (2) shortening landforms, positive-relief features that are linear to arcuate in plan view, which may manifest as single scarps, arched landforms with or without a crenulated ridge, or some intermediate form. Extensional landforms are scarce and almost always found within basins that host smooth plains and are interpreted to have formed from thermal contraction [14] or intrusive radial dike emplacement

[15]. Shortening landforms are distributed across the planet and are the dominant form of tectonic deformation on Mercury, resulting from widespread global contraction [5 and references therein].

Publication: The final geological map and global stratigraphy, when published, will be accompanied by a GIS-ready digital version of the map.

References: [1] Schaber, G., and J.F. McCauley (1980). USGS Map I–1199; De Hon, R.A., et al. (1981), USGS Map I-1233; Guest, J.E., and R. Greeley, (1983), USGS Map I-1408; McGill, G.E., and E.A. King (1983), USGS Map I-1409; Grolier, M.J., and J.M. Boyce, USGS Map I-1660; King, J. S., and D. H. Scott, USGS Map I-2048; Trask, N.J., and D. Dzurisin, (1984), USGS Map I-1658; Spudis, P.D., and J.G. Prosser (1984), USGS Map I-1659; Strom, R.G., et al. (1990), USGS Map I-2015. [2] Fassett, C.I., et al. (2012), *J. Geophys. Res., 117,* E00L08, doi:10.1029/2012JE004154. [3] Ostrach L.R., et al. (2015), *Icarus, 250,* 602–622. [4] Denevi, B.W., et al. (2013), *J. Geophys. Res. Planet, 118,* 891–907. [5] Byrne, P.K., et al. (2014), *Nature Geosci., 7,* 301–307. [6] Thomas, R.J., et al. (2014), *J. Geophys. Res. Planets, 119,* 2239–2254. [7] Blewett, D.T., et al., (2013), *Science, 333,* 1856-1859. [8] McCauley, J.F., et al., (1981), *Icarus, 47,* 184-202. [9] Spudis, P.D., and J.E. Guest (1988), in *Mercury*, U. Ariz. Press, 118-164. [10] Kinczyk, M.J., et al. (2016), *LPS, 47,* submitted. [11] Whitten, J.L., et al. (2014), *Icarus, 241,* 97–113. [12] Denevi, B.W., et al. (2009), *Science*, *324*, 613–618. [13] Murchie, S.L., et al. (2008), *Science*, 321, 73-76. [14] Blair, D.M., et al., (2013), *J. Geophys. Res. Planets, 118,* 47-58. [15] Basilevsky, A.T., et al. (2011), *Solar System Res., 45*, 471-497.

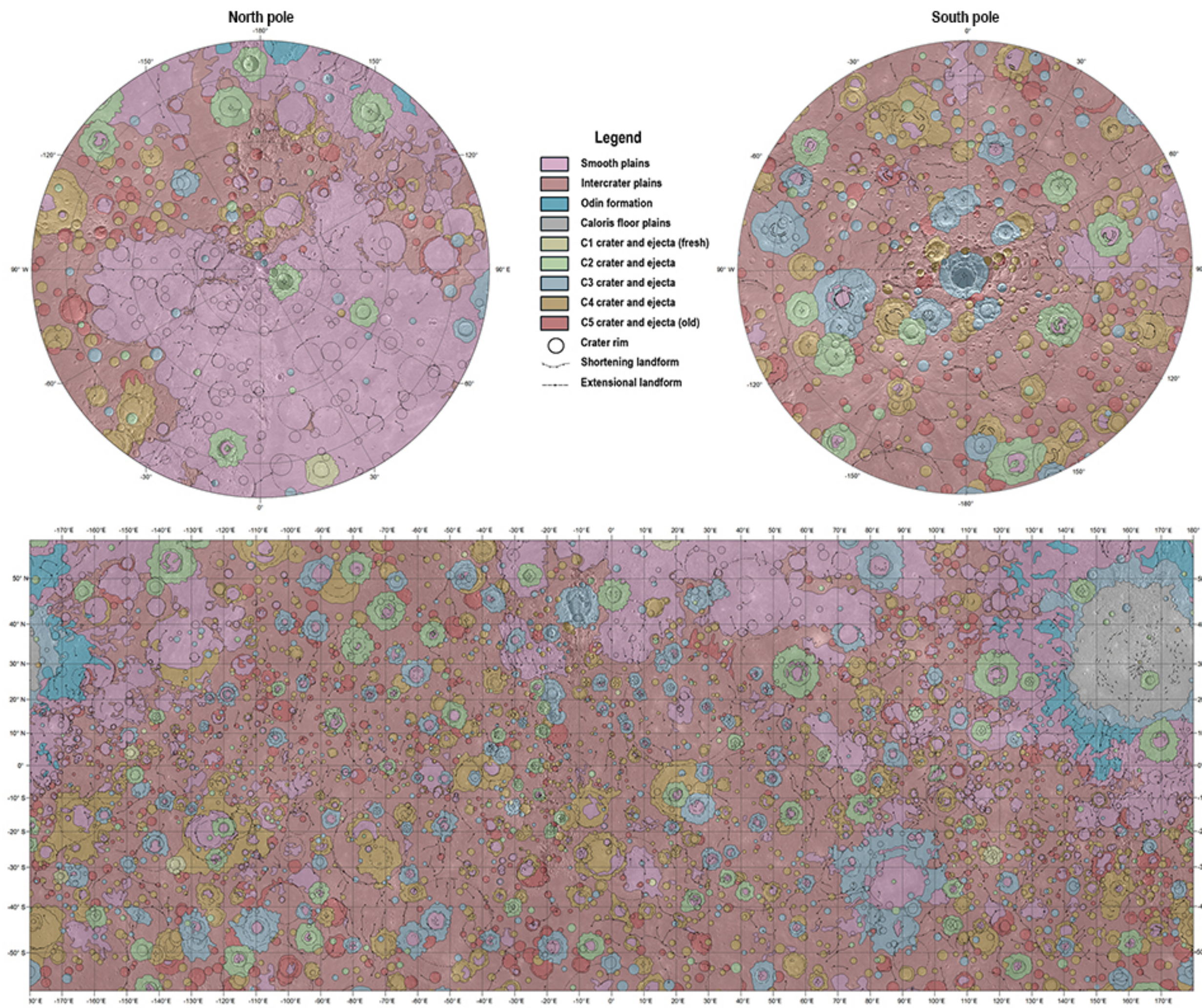

Figure 1. Draft version of the global geological map of Mercury at 1:15M scale, showing major plains units and classified craters >40 km in diameter. Colors are based on Mariner 10 maps [1] and are not final.