A NEWLY DISCOVERED IMPACT BASIN ON MERCURY REVEALED BY MESSENGER.

Thomas R. Watters[1], **Scott L. Murchie**[2], **Mark S. Robinson**[3], **James W. Head**[4], **Clark R. Chapman**[5], **Sean C. Solomon**[6], **Brett W. Denevi**[3], **Sarah L. André**[1], **Caleb I. Fassett**[4] **and the MESSENGER Team**. [1]Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, DC 20560 (watterst@si.edu); [2]Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723; [3]School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85251; [4]Department of Geological Sciences, Brown University, Providence, RI 02912; [5]Southwest Research Institute, 1050 Walnut St., Suite 300, Boulder, CO 80302; [6]Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, DC 20015.

Introduction: Mariner 10 imaged several well defined impact basins that range in size and age. The Caloris basin, initially thought to be ~1300 km in diameter [1], is the largest, followed by Beethoven (~625 km in diameter) and Tolstoj (~510 km in diameter) [2]. The Caloris basin is the youngest of these [2] and formed before the end of the period of heavy bombardment of the inner solar system (~3.9 Ga). Many other heavily degraded and buried basins have been proposed from inferred remnants of basin rings [2]. The MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft imaged the entire Caloris basin for the first time during its January 2008 flyby, and the basin diameter was determined to be ~1500 km [3, 4, 5]. No large impact basins have yet been newly identified from images obtained during MESSENGER's first Mercury encounter.

Newly Viewed Basin: Images obtained from the second MESSENGER flyby in October 2008 covered an additional ~30% of Mercury. The approach images revealed a large, previously unrecognized impact basin in the southern hemisphere, centered near 33°S, 88°E (Fig. 1). Roughly eighty percent of this basin was illuminated during the encounter. The easternmost rim was imaged by MESSENGER during the first flyby and, although recognized to be the illuminated rim of an impact crater, the scale of the impact feature was not resolvable. The newly viewed basin has a variable main rim made up of rugged, high-relief, irregular scarps in the north and east, and smoother, lower-relief scarps in the west and south (Fig. 1), with a mean diameter of ~715 km, making this newly discovered basin the second largest well-preserved impact feature on Mercury. Preliminary crater counts of the density of large craters superimposed on the rim suggests that within the uncertainties the newly viewed basin and the Caloris basin are approximately the same age.

Major Geologic Units: Three geologic units associated with the basin can be distinguished on the basis of morphology and spectral properties; a blocky unit, a hummocky unit, and a smooth plains unit. The blocky unit, well preserved outside the northern basin rim, is interpreted to be ejecta deposits. The hummocky unit is in the interior of the basin and is comprised of knobs that rise above patches of rolling hills near the basin margin (Fig. 1). The hummocky unit is confined to the northern and part of the western margin and is analogous to the knobby ejecta material in the interior of the lunar Orientale basin (Montes Rook Formation) [6]. Smooth plains are the most broadly distributed unit occupying much of the basin interior and extend to the southern and eastern rim (Fig. 2). These smooth plains embay and bury the hummocky unit in some areas. Some basin interior impact craters exhibit sharp and distinct contacts between crater rims and the smooth plains, indicating that the plains are superposed on preexisting ejecta. Embayment relations and evidence of partially infilled impact craters suggest a volcanic origin for the smooth plains [4, 5, 7].

Tectonic Features and Stress History: Tectonic landforms in the basin reflect contraction and extension of its rim and interior. Wrinkle ridges with basin-radial and basin-concentric orientations deform the interior smooth plains (Fig. 2, 3). Basin-concentric wrinkle ridges form a ring in the interior that is ~375 km in diameter. Most of the basin-radial wrinkle ridges are located inside the ring (Fig. 3). The ring of wrinkle ridges in the basin may reflect deformation localized by a buried interior basin ring.

Linear and curvilinear troughs also form a basin-radial and basin-concentric pattern (Fig. 3). The basin radial troughs are the most common, and the majority occur interior to the ring of wrinkle ridges. Many of the radial troughs are found adjacent and parallel to basin-radial ridges (Fig. 2, 3). These troughs are interpreted to be graben, formed by extension of the interior plains. Basin-radial graben and wrinkle ridges form a "wheel spoke" pattern that is without analog in other impact basins on Mercury, the Moon, or elsewhere in the Solar System.

The rim and interior of the basin are crosscut by a large lobate scarp (Fig. 1, 3), a common tectonic landform on Mercury that is the surface expression of a thrust fault [1, 8, 9]. The lobate scarp extends nearly 400 km across the basin floor, offsetting the smooth plains material and the rims and floors of two ~60-km-diameter impact craters (Fig. 2, 3). Outside the basin, the scarp extends for almost 600 km, cutting intercrater plains and two other large impact craters (Fig. 3). This lobate scarp is the longest yet found on Mercury.

The observed crosscutting relations of the tectonic features indicate multiple episodes of contractional and extensional deformation in the newly viewed basin. Wrinkle ridges are crosscut by radial and concentric graben (Fig. 2, 3), suggesting that contractional deformation predates extensional deformation of the smooth plains. This same sequence of tectonic events is found in Caloris basin [4, 5]. Some concentric and radial wrinkle ridges crosscut graben and superpose other wrinkle ridges, suggesting that extension in the basin was followed by another episode of compression. This episode of contraction may have occurred in response to a second stage of infilling by volcanic material in the basin center. A second stage of infilling is shown by embayment relations between the more heavily deformed smooth plains inward of the ring of wrinkle ridges (plains with radial graben) and less deformed smooth plains (without radial graben) near the basin center. The large-scale lobate scarp that crosscuts the basin likely formed as part of a subsequent stage of global contraction.

References: [1] Strom R.G., Trask N.J., and Guest J.E. (1975) *J. Geophys. Res.*, *80*, 2478-2507. [2] Spudis P.D. and Guest J.E. (1988) in *Mercury*, Univ. Arizona Press, Tucson, 118–164. [3] Solomon S.C. et al. (2008) *Science*, 321, 59-62. [4] Murchie S.L. et al. (2008) *Science*, 321, 73-76. [5] Watters T.R. et al. (2008) *Earth Planet Sci. Lett.*, submitted. [6] Wilhelms, D.E. (1987) U.S. Geol. Sur. Prof. Paper 1348. [7] Head J.W. et al. (2008) Science 321, 69-72. [8] Melosh H.J. and McKinnon W.B. (1988) in *Mercury*, Univ. Arizona Press, Tucson, 374-400. [9] Watters T.R., Robinson M.S., and Cook A.C. (1998) *Geology, 26,* 991-994.

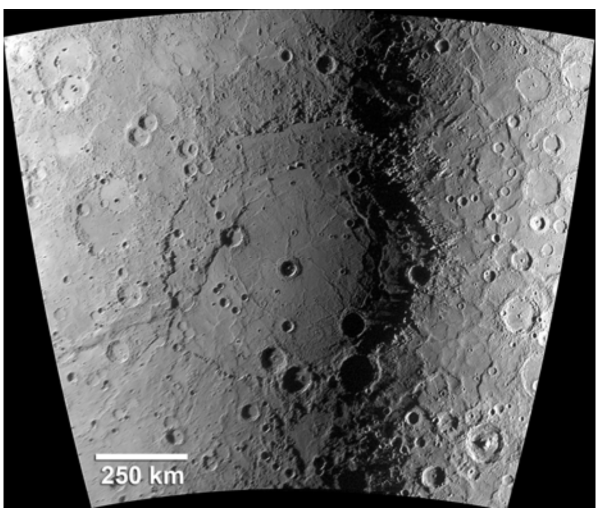

Figure 1. The newly discovered basin on Mercury. The Mercury Dual Imaging System (MDIS) narrow-angle camera (NAC) mosaic combines images obtained during MESSENGER's first and second flybys. The dark vertical band that is largely in shadow falls along the terminators of the second flyby approach hemisphere and the first flyby departure hemisphere.

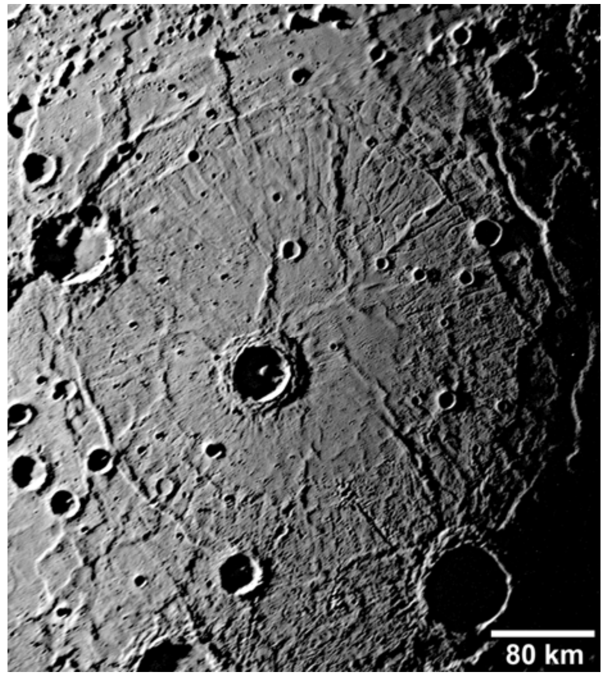

Figure 2. The interior of the newly discovered basin is dominated by smooth plains that locally embay and bury interior hummocky ejecta. These plains have been heavily deformed by contractional and extensional tectonic features. This NAC mosaic is comprised of images obtained during MESSENGER's second flyby.

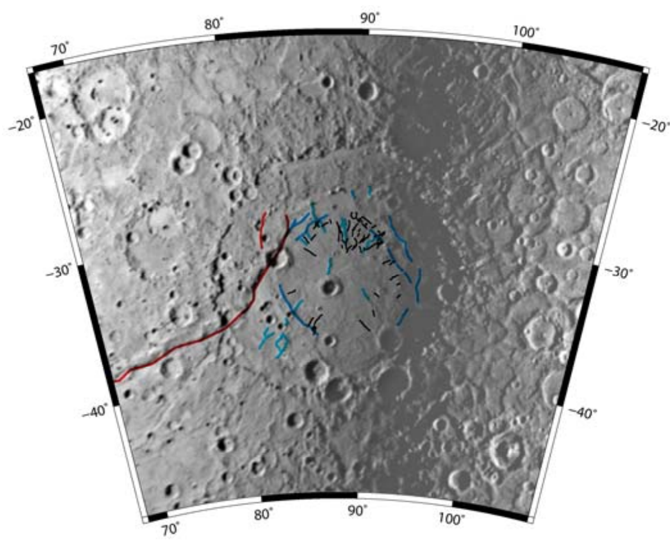

Figure 3. Map of tectonic features in the newly viewed basin. The map shows the location of wrinkle ridges (blue), troughs or graben (black), and lobate scarps (red) digitized from and overlaid on a NAC mosaic. The diameter of the basin is ~715 km.