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The Geology of Mercury as Revealed by MESSENGER

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More than thirty years after Mariner 10 visited Mercury, the MESSENGER spacecraft flew by the planet three times, returning a wealth of data that included, for the first time, images of nearly the entire surface of Mercury. Data from the flybys show that Mercury has a complex and heterogeneous crust that has been modified over billions of years by numerous volcanic flows, impact cratering events, and tectonic deformation [1]. Spectral data provide new clues to the composition of the surface, allow the identification of several material units with distinct reflectance and color characteristics [2], and suggest that material excavated by impacts sample units broadly similar to those at the surface from depths of several to several tens of kilometres [3]. The spectral characteristics of surface and excavated materials are consistent with a variable contribution from a low-reflectance, spectrally neutral component, possibly iron- and titanium-bearing oxides [3].

The question of whether Mercury's smooth plains were formed by volcanic or impact processes, unresolved for more than three decades, has finally been answered. MESSENGER images show impact craters and basins flooded and embayed by plains material displaying differences in color (Fig. 1) and crater retention age from their associated impact structure, thereby firmly establishing volcanism as a major process in Mercury's evolution [4]. Irregular scalloped depressions similar to volcanic vents have been documented, notably around the margins of the Caloris basin. These depressions are surrounded by bright, diffuse material, interpreted to be volcanic deposits, including some from explosive eruptions [4, 5].

Two peak-ring basins, Raditladi and Rachmaninoff (265 km and 290 km in diameter, respectively) imaged on MESSENGER's second and third flybys appear to be among the youngest impact basins on the planet [6, 7]. Despite the basin's relative youth, Rachmaninoff's inner floor contains plains that are interpreted to be volcanic in origin [8] (Fig. 1), and both basins have unusual concentric patterns of extensional faults within their peak rings. An irregular depression surrounded by bright, diffuse deposits northeast of Rachmaninoff marks a candidate explosive volcanic vent nearly twice as large as any previously identified on Mercury [8] (Fig. 1).

Lobate scarps are widespread across Mercury's surface, indicating that contraction was global, most likely as the result of interior cooling [1, 9]. The Caloris basin, imaged in its entirety for the first time, is 1550 km in diameter, 250 km larger than previously thought [10]. The Rembrandt basin, discovered during the second flyby and half the size of the Caloris basin at 715 km in diameter, has a floor that bears witness to a complex history of volcanic flows and tectonic deformation [11].

Volcanism and associated deformation on Mercury spanned a considerable time interval, perhaps extending well into the second half of Solar System history. MESSENGER will continue its exploration of Mercury once it enters orbit around the planet on 18 March 2011.

References

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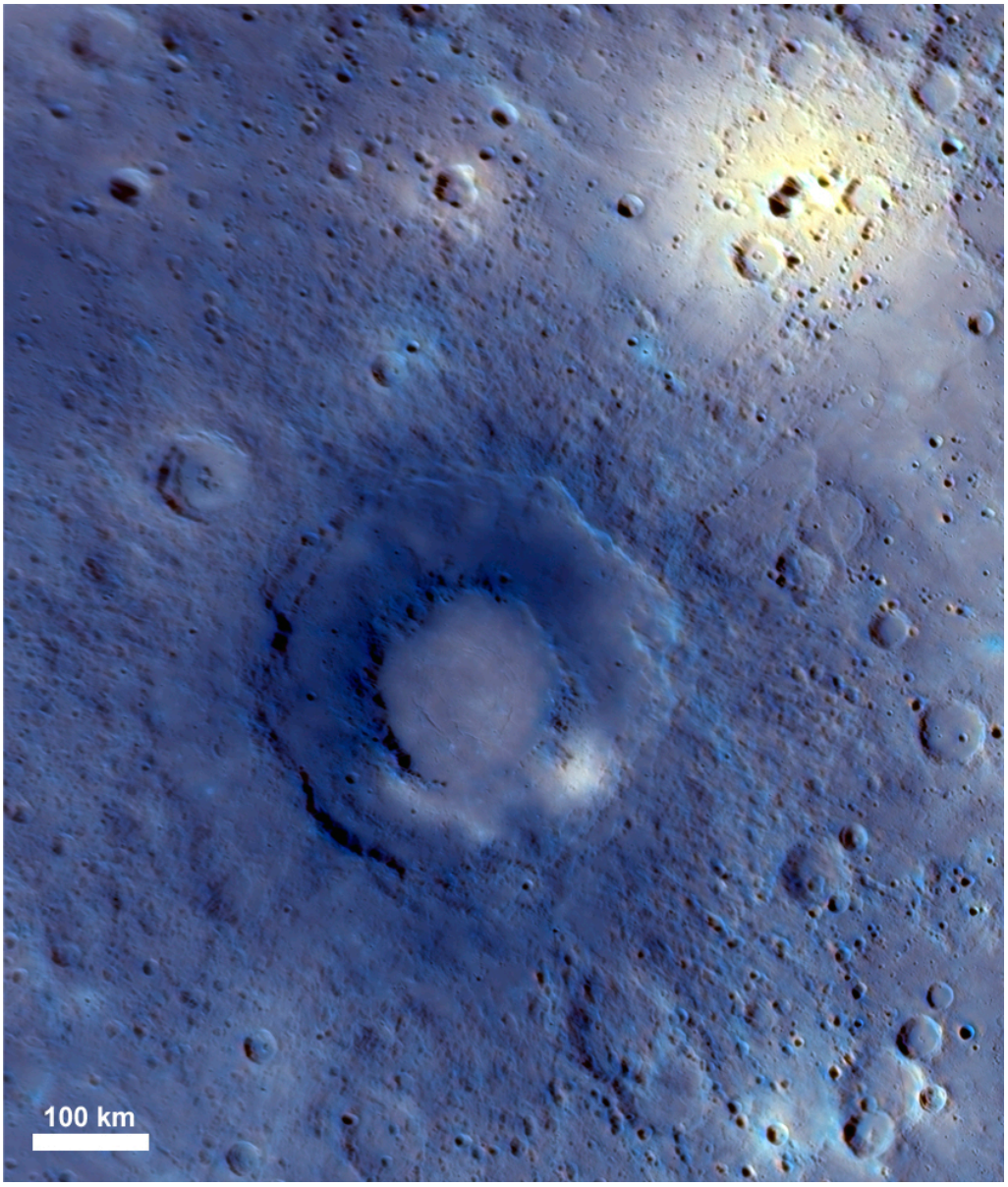

Figure 1. Enhanced-color view (second and first principal component and 430-nm/1000-nm ratio in red, green, and blue, respectively) of the Rachmaninoff basin observed during MESSENGER's third Mercury flyby. Lower-resolution wide-angle camera observations (5 km/pixel) were merged with a higher-resolution narrow-angle camera mosaic (430 m/pixel) to display color variations with geologic terrain. The center of the basin is filled with bright, comparatively red material that appears to have flowed over the southern peak ring and is interpreted as volcanic in origin. To the northeast of the basin is a scalloped depression surrounded by bright, diffuse material. The depression is interpreted to be a candidate volcanic vent and the diffuse material to be pyroclastic debris.