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The New View of Mercury after MESSENGER's first year in orbit

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The MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft has been making measurements of the innermost planet and its environment nearly continuously since its successful insertion into orbit about Mercury in March 2011. Extensive data from orbit have enabled discoveries about Mercury's composition, geology, interior, magnetic field, and interaction with the solar wind. MESSENGER's first chemical remote sensing measurements of Mercury's surface indicate that the planet's bulk silicate fraction differs from those of the other inner planets and is richer in volatile constituents than predicted by most planetary formation models. Global image mosaics and targeted high-resolution images (to resolutions of 10 m/pixel) reveal that Mercury experienced globally extensive volcanism, including widespread examples of both flood lava and pyroclastic deposits. The tectonic history of Mercury, although dominated by global contractional deformation as first seen by Mariner 10, is more complex than first appreciated, with numerous examples of extensional deformation tied to impact crater and basin modification. Long-wavelength changes to Mercury's topography occurred after the earliest phases of the planet's geological history. Several large gravity anomalies, including one candidate mascon, are found in Mercury's northern hemisphere. Crustal thickness in this hemisphere is greater at low latitudes and lessens near the pole, and there is evidence for thinning beneath some impact basins. Measurements of Mercury's moments of inertia require either (i) a mantle density that is too high to be compatible with evidence from elemental remote sensing of Mercury's surface for low mantle abundances of Fe, Al, and Ti or (ii) a solid high-density layer between the silicate mantle and fluid outer core that may be a solidified FeS layer at the top of an Fe-S-Si core. Mercury's magnetic field is dominantly dipolar, but the field is axially symmetric and equatorially asymmetric, a geometry that poses challenges to dynamo models for field generation. Mercury's unusually dynamic solar wind interaction leads to significant variations in magnetospheric and exospheric conditions that can drive surface processes. In March 2012 MESSENGER concluded its primary mission and inaugurated a year-long extended mission designed to address a new set of scientific questions raised by the early orbital observations.