Exploring Mercury by spacecraft: The first two MESSENGER flybys

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Abstract: The MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft, developed under NASAs Discovery Program, is the first spacecraft to visit the planet Mercury in more than 30 years. En route to insertion into orbit about Mercury in March 2011, MESSENGER flew by the innermost planet on 14 January and 6 October 2008. Objectives of the flybys included color imaging of the surface, the first high-resolution spectral reflectance measurements (from ultraviolet to near-infrared wavelengths) of surface composition, the first spacecraft altimetric measurements of surface topography, the first measurements of the abundances and compositions of plasma ions in Mercury's magnetosphere, the deepest penetrations yet into Mercury's magnetosphere, and searches for previously undetected species in Mercury's surface-based exosphere and neutral sodium tail. MESSENGERs first flyby confirmed that Mercurys internal magnetic field is primarily dipolar, documented water-group and other ions in the magnetosphere, mapped a north-south asymmetry in the Na tail and determined the Na/Ca ratio near the tail and near the dawn terminator, and detected two outbound current-sheet boundaries that may indicate a planetary ion boundary layer. The laser altimeter demonstrated that the equatorial topographic relief of Mercury is at least 5 km. MESSENGERs images provided evidence for widespread volcanism, and candidate sites for volcanic centers were identified. Also revealed were newly imaged lobate scarps and other tectonic landforms supportive of the hypothesis that Mercury contracted globally in response to interior cooling and growth of a solid inner core. Reflectance spectra show no evidence for FeO in surface silicates, and MESSENGERs neutron spectrometer yielded an upper bound of 6% on the surface Fe abundance. The reflectance and color imaging observations support earlier inferences that Mercurys surface material consists dominantly of iron-poor, calcium-magnesium silicates with an admixture of spectrally neutral opaque minerals. The October encounter revealed another 30% of the planet never before seen at close range, improved knowledge of Mercurys low-degree gravity field and its implications for the structure of the planets core, and featured targeted observations of the surface, exosphere, and tail.