

EXPLORATION OF THE INNER SOLAR SYSTEM WITH MESSENGER

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Since March 2011, NASA's MERcury Surface, Space ENvironment, GEOchemistry, and Ranging (MESSENGER) spacecraft has been orbiting the innermost planet and returning a wealth of data that provide new insights into its geochemistry, geology, interior structure, magnetic field, and interactions with the space environment. Compositional measurements made by means of X-ray and gamma-ray spectrometry indicate that Mercury's surface has a similar K/Th ratio, is relatively enriched in Mg and S, and is depleted in Al, Ca, Fe, and Ti, relative to the other terrestrial planets. These data rule out formation models requiring extreme heating and volatile loss and suggest that the planet formed from highly reduced precursors. The chemical data do not indicate (but do not rule out) the presence of a magma ocean early in the planet's history. Moreover, Mercury's distinct composition has important implications for the accretionary history of the inner solar system. Global image mosaics and targeted high-resolution images reveal that the surface of Mercury has been shaped by extensive volcanism and displays examples of both flood lava plains and pyroclastic deposits. Enigmatic shallow depressions or hollows, not observed on other planets, are present in many impact craters. These hollows may have formed through recent loss of volatile-rich material. Laser altimetry and imaging confirm that many polar craters for which Earth-based observations indicate the presence of interior material with high radar backscatter are in permanent shadow. MESSENGER neutron spectrometric measurements will help to answer whether the radar-bright material is water ice. Magnetometer data indicate that Mercury's magnetic field is dominantly dipolar, but the magnetic equator is offset substantially northward from the geographic equator, posing a challenge to dynamo models. Interactions of Mercury's magnetic field with the solar wind lead to a remarkably dynamic magnetosphere and the generation of the complex exosphere at least in part through ion bombardment of surface materials.

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