

Space Studies of the Earth-Moon System, Planets, and Small Bodies of the Solar System (B)
Highlights in Planetary Science and Exploration (B0.9)

EXPLORATION OF MERCURY: THE MESSENGER MISSION

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The MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft, launched in August 2004 under NASA's Discovery Program, has been collecting orbital observations of Mercury since March 2011. Elemental remote sensing of Mercury's surface indicates that the moderately volatile elements Na, K, and S are not depleted relative to other terrestrial planets. Orbital images document widespread evidence for ancient volcanic activity ranging from effusive to explosive eruptions. High-resolution images have revealed the presence of irregular rimless depressions or "hollows" likely produced by the loss to diurnal heating or sputtering of some volatile-rich material. Polar deposits in permanently shadowed high-latitude regions are dominated by water ice on the basis of neutron spectrometry, surface reflectance, and thermal modeling with measured topography; in most locations the ice is covered by 10–30 cm of anomalously dark volatile material postulated to consist of complex organic compounds. The tectonic history of Mercury is dominated by greater planetary contraction than previously recognized; long-wavelength changes in topography postdated the emplacement of large expanses of volcanic plains. Gravity and topography measurements indicate that mascons and crustal thinning are associated with some impact basins. Mercury's internal magnetic field is that of a dipole offset from the planet's center by 0.2 Mercury radii, a geometry difficult to reconcile with existing dynamo models. Magnetospheric measurements have revealed a highly time-variable and spatially structured particle environment. Despite complex feedbacks among the exosphere, magnetosphere, and surface, the large-scale structure of the exosphere – dominated by Na, Ca, and Mg – shows seasonal variations in general agreement with those expected from variations in solar flux with Mercury true anomaly but little variation with changing solar conditions. Energetic electron events are regular features of Mercury's magnetosphere, but the causative acceleration mechanism remains a topic of study. MESSENGER is now in a second extended mission. Solar gravitational forces reduce the periapsis altitude between successive orbits. Orbit-correction maneuvers will yield four extended intervals when the periapsis altitude will be 15 to 25 km, and once the remaining propellant is consumed the spacecraft will impact the surface in late March 2015. During this low-altitude campaign, the unprecedented high-resolution views of the surface will help elucidate many of the processes that have shaped Mercury's surface. MESSENGER's low-altitude observations will also illuminate the consequences of precipitating ions and energetic electrons at Mercury, the response of the exosphere and magnetosphere to solar wind conditions during the declining phase of the solar cycle, and

short-wavelength components of the internal magnetic and gravity fields and their implications for crustal magmatism and the mechanical evolution of Mercury's lithosphere.