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Mineral and rock composition of the Mercury and Moon surfaces

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Lunar highland anorthosites have been regarded as a suitable analogue for Mercury surface composition, since the first images were acquired by Mariner 10 in 1974 (Murray et al., 1974), and a number of studies have subsequently confirmed significant lithological similarities between the two planets. Characterization of the surface composition is one of the scientific objectives of the missions to Mercury, and is one of the keys in the investigation of the geological evolution of such an extreme planet.

Several spectroscopic observations of Mercury surface in the visible (VIS), near infrared (NIR) and mid infrared (MIR) indicated very low FeO and TiO_2 content (e.g., Sprague et al., 1994, Blewett et al., 1997; 2002). Most of the VIS Mercury spectra are characterized by a red slope and very weak or absent absorption bands, with close similarity to the lunar highlands anorthosites. Hence, an anorthositic composition was also inferred for Mercury's crust. Photometric properties of both planet surfaces suggest the presence of a regolith with various degrees of space weathering, associated with the formation of submicroscopic metallic iron (e.g., Hapke, 2001; Blewett et al., 1997). Although the two surfaces were subjected to similar processes, some differences exist. Mercury regolith is probably characterized by finer grain size fractions and by a greater maturity than the Moon (e.g., Shevchenko, 2004). Fully understanding space weathering effects on surface spectroscopic response is critical to identify regolith and outcropping rock chemical and mineral compositions.

On the Moon, both large outcrops of anorthosites and widely extended areas with basaltic composition were detected in both the near- and farside of the planet (Hawke et al., 2003a, 2005; Li and Mustard, 2003). The relationships among areas with different compositions allowed a stratigraphic profile of the lunar upper mantle-crust to be reconstructed (Hawke et al., 2003a). The areal composition variations can also be correlated with crust thickness variations (Potts and von Frese, 2003), with important implications for understanding the planet's geological evolution.

On Mercury, basalt occurrence was excluded on the basis of emission data in the microwave (6.2-0.3 cm) region (Jeanloz et al., 1995). However, the analysis of recalibrated Mariner 10 data revealed a previously undetected diversity of surface composition (Robinson and Lucey, 1997). NIR reflectance spectra showed the absorption band of ferrous iron in pyroxene (Warrel et al., 2005) and MIR emission spectra displayed absorption features attributed to minerals that are common components of intermediate and mafic rocks, including basalts (Sprague et al., 1994, 2000; Sprague and Roush, 1988).

Different mineral assemblages and different rock associations imply distinct paragenesis in well defined temperature and pressure conditions and time spans. This results in specific crust characteristics, also allowing inferences about crust formation processes. In particular, the presence of basalts, i.e., rocks directly related to upper mantle composition, sets the question of the contribution of volcanic activity to crust formation. Effusive igneous processes were recognized on the Moon, in both mare and nonmare regions, on the basis of returned sample composition, remote sensing spectroscopic data and morphological features (e.g., Pieters, 1993; Hawke et al., 2003), although the nature and chemistry of volcanism are not fully understood. Mercurian volcanism is a highly debated issue. The inferred existence of a remnant inner planet melted portion, the ambiguous nature of some plain units, and the presence of tectonic structures suggest that volcanism cannot be excluded *a priori* (Milkovich and Head, 2001: Head and Wilson, 2001). The identification of volcanic structures and rock compositions consistent with effusive processes provides the keys to answer this question.

Ongoing and planned missions to Mercury (such as Messenger and BepiColombo) address these issues. SIMBIO-SYS onboard BepiColombo will acquire images with different spectral and spatial resolutions. Integration of global coverage stereoscopic data, high spatial resolution data and hyperspectral data in the whole VIS- MIR region will contribute to the data sets relative to both surface composition diversity and morphological structure. A better identification of the composition of surface units will result in improved comprehension of the crust characteristics and history, as well as the processes at the crust-exosphere interface. And, in a wider/forward perspective, some insight into the origin of the planet can also be expected.

References

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