LUNAR SCOUT MISSIONS: GALILEO ENCOUNTER RESULTS AND APPLICATION TO SCIENTIFIC PROBLEMS AND EXPLORATION REQUIREMENTS: J. W. Head[1], M. Belton[2], R. Greeley[3], C. Pieters[1], A. McEwen[4], G. Neukum[5], T. McCord[6]. [1]Brown Univ., Providence RI; [2]Kitt Peak National Observatory, Tucson AZ; [3]Ariz. State Univ., Tempe AZ; [4]USGS, Flagstaff AZ; [5]DLR, Berlin, Germany; [6]Univ. Hawaii, Honolulu, HI.

On the basis of US and Soviet orbital and surface exploration and results from Earth-based observations, we have a first-order understanding of the major stages in the formation and evolution of the Moon[1]. The Moon is known to have formed an initial lunar highland primary crust[2], and a secondary basaltic crust due to mantle partial melting. Impact craters at all scales have modified the crust and the largest basins may have excavated through the crust into the mantle. Exploration of Mercury and Mars has shown many similarities to the Moon, indicating that the Moon is a key to the understanding of the evolution of one-plate planets[3]. The Moon may have formed from the impact of a Mars-sized object into a proto-Earth[4]. These factors indicate that the Moon is a baseline and a cornerstone in planetary exploration in reference to such fundamental questions as planetary origin, the impact record, and the formation and evolution of primary and secondary planetary crusts. In addition, some of our most fundamental information about the Moon was collected during the Apollo human exploration expeditions and many questions and issues will only be resolved by future long visits and extended exploration traverses.

Although Apollo sites are known in relative detail, and we have important Apollo orbital geochemical data for about 20% of the Moon, we lack significant geochemical and mineralogic information for much of the rest of the Moon, particularly the farside. Ironically, there is better systematic image coverage for Mars and Venus than for the Moon, the topography of Venus is better known than that of the Moon, and the majority of lunar exploration was completed more than two decades ago with old technology. Prior to the Galileo encounters, the only spacecraft digital image data for the Moon[5] was obtained by Mariner 10 on its way to Mercury in 1974!

The Lunar Scout Missions (payload: x-ray fluorescence spectrometer, high-resolution stereo camera, neutron spectrometer, gamma-ray spectrometer, imaging spectrometer, gravity experiment) will provide a global data set for the chemistry, mineralogy, geology, topography, and gravity of the Moon. These data will in turn provide an important baseline for the further scientific exploration of the Moon by all-purpose landers and micro-rovers, and sample return missions from sites shown to be of primary interest from the global orbital data. These data would clearly provide the basis for intelligent selection of sites for the establishment of lunar base sites for long-term scientific and resource exploration and engineering studies.

The two recent Galileo encounters with the Moon (December, 1990 and December, 1992) illustrate how modern technology (e.g., instruments such as the Galileo SSI-Solid State Imaging System, M. Belton, PI, with high spatial resolution and relatively low spectral resolution, and the Galileo NIMS-Near-Infrared Mapping Spectrometer, R. Carlson, PI, with high spectral resolution and relatively low spatial resolution) can be applied to significant lunar problems. Here we emphasize the regional results of the Galileo SSI to show the promise of geologic unit definition and characterization as an example of what can be done with the global coverage to be obtained by the Lunar Scout Missions.

During the first encounter the SSI System obtained multispectral imaging data for the western part of the nearside, the western limb including the Orientale basin region, and parts of the farside including the South Pole-Aitken Basin[6]. These data, although of limited resolution (several up to about 20 km at Orientale and the farside), provided important new information on questions of the homogeneity and heterogeneity of the highland and mare crust and the depth of excavation of lunar basins. The affinity of limb and farside mare basalts to those on the nearside and at the Apollo and Luna sites is poorly known. SSI multispectral image data have permitted a census of mare deposits along the western margins of Oceanus Procellarum, in the patches along the western limb of the nearside, in the Orientale Basin, and in the farside South Pole-Aitken Basin, and the establishment of the affinities of these deposits to mare basalts on the nearside. These data show that no mare basalts with Ti abundances approaching those of the high-Ti Apollo 11 basalts or of the high-Ti regions of central Oceanus Procellarum are observed on the western limb and eastern farside; the basalts exposed there are remarkably uniform in composition, being characterized by intermediate Ti content and a relatively weak 1 µm absorption band[7]. Mare volcanism began prior to the end of heavy bombardment, in pre-Nectarian times (the period of cryptomare formation[8]). The SSI data confirmed the presence of the Schiller-Shickard cryptomare and permitted the more detailed mapping of its configuration beneath the Orientale ejecta deposit. This, together with the documentation of an additional cryptomare in the Mendel-Rydberg region, contributes to an understanding of the areal significance of mare-like volcanism in the period of basin formation[7,9]. Global assessments and stratigraphic analyses will provide additional important information on the volumetric significance of early mare volcanism. In addition, mixing models of Orientale ejecta and cryptomaria provided tests on ejecta emplacement dynamics[9], a technique that will be extremely useful globally. The compositional data on mare diversity is also providing additional insight into the existence of planet-wide mantle heterogeneity and the development of diversity and trends in single regions. Fundamental issues remain in understanding the lateral and vertical homogeneity and heterogeneity of the lunar highlands crust and its implications for models of initial crustal formation and evolution. Comparison of the deposits of major impact basins provides evidence for vertical crustal heterogeneity and depth of excavation; Galileo data show the distribution of highland and ejecta units of the 900 km diameter Orientale basin and suggest that excavation largely came from upper to middle crustal levels[9]. Data for the farside lunar crust show a major and widespread mafic anomaly primarily within the ~2000 km diameter South Pole-Aitken basin region[9,10]; the entire region has a much lower albedo than surrounding highlands. The inner, darker region has optical properties indistinguishable from low-Ti basalts, and deposits in the southern basin interior have a strong and broad ferrous 1 μm absorption, most consistent with abundant olivine. These data suggest that the South Pole-Aitken has excavated mafic-rich lower crust, and that part of its interior is characterized by cryptomaria[9,10]. Fresh impact craters show additional regional compositional diversity below the megaregolith[10] and their characteristics can be used to map the ages of craters and the impact flux[11]. Correlation of the Galileo SSI multispectral image data and Apollo x-ray spectrometer data permits the extension of Al/Si ratios over broader parts of the farside[12]. This illustrates the synergism that will be possible with complementary Lunar Scout global data sets.

The second Galileo encounter of the Moon provided higher spatial resolution SSI data (~1.1 km pixel) over the north polar and northeastern limb regions, and favorable illumination geometry for the acquisition of NIMS data, which will permit high spectral resolution characterization of broad units defined by the SSI data. Preliminary analysis of the SSI data shows that the maria (e.g., Humboldtanium, Frigoris, Crisium, eastern limb and other patches) are more diverse than those seen on the western limb and farside during EM1[13], and that several craters on basin rims have anomalous compositional characteristics relative to typical rim deposits[14]. One of the highest abundances of light plains on the Moon occurs north of Mare Frigoris[1] and SSI data suggest that some of these plains are predominantly Imbrium ejecta, while others have a cryptomare signature[13,14]. The large number of Copernican-aged craters permits further assessment of their albedo and age of emplacement[15]. Much of the highlands and plains north of Mare Frigoris are generally similar to mature highlands soils with a distinctly feldspathic composition but there are local anomalies that suggest diversity[16].

These examples of the scientific return from Galileo regional low spatial resolution coverage demonstrate that global high-resolution data from the Lunar Scout scientific payload would provide fundamental scientific return. These data in turn provide the foundation for lunar base site selection and traverse planning, as well as resource assessment (e.g., Ti, Fe, Al, soil maturity and surface correlated gases, etc.)[17]. These examples further underline the importance and synergism of global data sets (e.g., chemistry, mineralogy, geology, topography, gravity) in order to properly utilize the unique and accessible lunar laboratory and prepare for further exploration of the Moon.

References: 1) D. Wilhelms (1987) USGS. *PP1348*; 2) S. R. Taylor (1989) *Tectonophys.*, 161, 147; 3) J. Head and S. Solomon (1981) *Science*, 213, 62; 4) W. Hartmann and D. Davis (1975) *Icarus*, 24, 504; 5) M. Robinson *et al.* (1992) *JGR*, 97, 18265; 6) M. Belton *et al.* (1992) *Science*, 255, 505; 7) R. Greeley *et al.* (1992) Galileo imaging observations of lunar maria and related deposits, *JGR*, in press; 8) J. Head and L. Wilson (1992) *G&CA*, 56, 2155; 9) J. Head *et al.* (1992) Lunar impact basins: New data for the western limb and farside (Orientale and South Pole-Aitken basins) from the first Galileo flyby, *JGR*, in press; 10) C. Pieters *et al.* (1992) Crustal and mantle diverstiy of the Moon: Compositional analyses of Galileo SSI data, *JGR*, in review; 11) A. McEwen *et al.* (1992) Galileo observations of post-Imbrian lunar craters during the first Earth-Moon flyby, *JGR*, in review; 12) E. Fischer *et al.* (1992) *LPSC 23*, 361; 13) R. Greeley *et al.* (1992) this volume; 14) J. Head *et al.* (1992) this volume; 15) A. McEwen *et al.* (1992) this volume; 16) C. Pieters *et al.* (1992) this volume; 17) G. Heiken *et al.*, eds. (1991) *Lunar Sourcebook*, Cambridge, NY, 736 pp.