Some outstanding geological problems in the exploration of the Moon and approaches to solve them

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The perspective provided by orbiters, landers, human and automated surface exploration, and analysis of samples returned by Apollo and Luna missions, has made the Moon a keystone in the understanding of planetary geological processes. The absolute chronology, and mineralogy, geochemistry and petrology of samples with known provenance permits us to understand the nature of fundamental processes and to extrapolate them to conditions on other planetary bodies, where information is very incomplete. Thus, it is important to focus on key problems and measurements that will enhance this planetary process and evolutionary perspective.

Impact cratering is one of the most important processes shaping planetry crusts, particularly in early history. New information is needed at all scales to understand the nature of the process in terms of the depth of excavation, role of oblique impact, modification stage, production of impact melt, ejecta emplacement dynamics, and the role of volatile emplacement and fate. Better understanding of impact cratering is also crucial to solidification of the chronologic foundation of crater size-frequency distribution ages on the Moon.

Magmatic activity (plutonism and volcanism) is the major crustal building and resurfacing process throughout the history of one-plate planets. It also records the distribution of mantle melting processes in space and time. Fundamental analysis is needed to distinguish and understand the nature of magmatic activity during heavy bombardment (intrusion, and extrusion, such as cryptomaria). For later lunar history, we are now focusing in on the detailed mare stratigraphic record, and key information on the distribution of basalt types and the distribution of melting in space and time is becoming available. Volume information is less clear, however, and is required to establish fluxes. Detailed settings for volcanic vents and their products are necessary to establish the full range of eruption styles and their petrogenetic significance.

The Moon is the type locale for tectonic activity on a one-plate planet. The origin and significance of its tectonic features (basin mountain rings, graben, wrinkle ridges and arches) can best be understood in the context of the complete lunar data set, and then extended to other planetary bodies. Outstanding problems include distinguishing magmatic and tectonic graben, establishing the three-dimensional structure of wrinkle ridges and arches, documenting the internal structure of mountain ranges, and linking these events to lunar thermal evolution.

Increased understanding of these processes and their interplay will lead to the deconvolution of the complex record of early crustal formation and evolution of the Moon and the establishment of a key planetary perspective on the first half of Solar

System history, a record that is largely missing on Earth, and incomplete on other terrestrial planetary bodies.

What information is required to address these questions? Crucial to all of these problems is higher spatial and spectral resolution information on the mineralogy, geochemistry, topography, and structure of lunar features and deposits. These data can be obtained through orbital and mobile surface exploration experiments which will also pave the way for site selection for the next phase of human exploration.