SCIENCE ENABLED BY GETTING TO A SWIRL. G. Y. Kramer[1], [1]Lunar and Planetary Institute, 3600 Bay Area Blvd, Houston, TX 77058 (kramer@lpi.usra.edu).

Introduction: The bright, optically immature, curvilinear surface features known as lunar swirls should be the target of the next lunar mission. The swirls are not only a fascinating feature of the Moon, they are a laboratory to study the solar wind, space weathering, and complex electromagnetic interactions in space. A robotic or human mission to a swirl will help answer questions of interest to planetary science as well as the broader scientific community.

Lunar Magnetic Fields. Every swirl is associated with a magnetic anomaly. In addition, it has been shown that the optically brightest part of a swirl or group of swirls correlates with the location of peak magnetic field intensity [3, 4]. Models of the distributions of the magnetic source material, when constrained by the observed albedo patterns produce fields that are consistent with magnetometer measurements [5]. Specifically, strongly horizontal surface fields generate the bright swirls, while vertical surface fields result in off-swirl features called dark lanes. The more intricate swirl morphologies could be used to infer small-scale structure in the near-surface magnetic field as well as the depth and orientation of the magnetic source material.

Space Weathering. The optical properties of the on-swirls surfaces compared with off-swirl (adjacent or between swirls) and non-swirl surfaces (locations not associated with magnomalies) demonstrate the specific ways the surface material is altered by solar wind ions versus micrometeorite impacts [2, 6] - the two agents of space weathering. Not only is space weathering on-swirl retarded, the dark lanes mature much faster than a non-swirl surface [2].

Since the swirls are weathered almost exclusively by micrometeorites, in situ analysis and returned samples can be used to study their isolated effect on the maturation process. This would also benefit asteroids studies. Retardation of the weathering process on-swirl indicates that the solar wind is the dominant form of weathering at the Earth-Moon distance. However, at the Asteroid Belt it may be micrometeorites that dominate due to the decreased solar wind flux. Spectroscopic differences between asteroid and lunar surfaces due to composition and proximity to the Sun have kept this controversial [7].

Sampling Fresh Material. Since space weathering is retarded on-swirl, while normal (and possibly accelerated) space weathering rates are occurring off-swirl, even a lander or rover of limited mobility could sample materials of the same *absolute* age, but different *apparent* age (maturity) and vice versa. In a small area one can sample material formed at the same time (e.g., by volcanism, by impact), and/or exposed by impact gardening at the same time, while also sampling fresh material and its weathered counterpart.

Lunar water. Moon Mineralogy Mapper data show that the optically bright swirls are depleted in OH/H_2O relative to their surroundings [6] - consistent with the solar wind deflection model for the swirls [1]. The creation of OH and H_2O is spatially controlled by the magnetic anomalies, making swirls ideal places to study the surface hydration phenomenon and potentially providing locations for extracting this resource.

Electrical potential. Models and spacecraft data show [e.g., 10, 11, 12] that in a plasma wake, such as on the nightside of a planetary body or the shadowed side of a crater bowl, there is a dearth of positive ions to counteract the buildup of negative static electricity on an astronaut's suit or robotic equipment, and thus pose a danger to sensitive instrumentation. However, such a phenomenon may be controlled by the geometry of the magnetic anomalies in useful ways; either through protection and/or as an energy resource. The strength of such an electric field is not dependent on the overall size of the magnetic anomaly, but is related to the local gradient in the magnetic field strength. Locations where the gradient is steep, identified by a sharp bright swirl/dark lane interface, may be a small, but still viable voltage potential to exploit for surface operations.

Plasma physics. The swirls are a place to observe charged particle interactions with a magnetic field involving complex geometries. In particular, the swirls provide a laboratory for studying these interactions in a vacuum on a unique scale, larger than a vacuum chamber [13], yet smaller than a global magnetic field.

Heliophysics. How effective the magnetic anomalies are at deflecting the bulk solar plasma can be studied for both light and heavy ions and for a range of particle fluxes (from the change in incident solar wind angles with latitude) with instruments placed at lunar swirls. Variations in the magnetic field intensities, even at regional magnetic anomaly locations, provide an opportunity to determine whether there are conditions in which only electrons are deflected or other specific controls on particle mass [2, 14]. If the magnetic anomalies formed at an early age and have been protecting the surfaces from the solar wind ever since, the swirls may be a great location to sample the ancient solar wind.

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