VIPER LANDING SITE GEOLOGIC MAPPING AS A PRECURSOR FOR ARTEMIS LANDING SITE MAPPING.

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Introduction: Geologic mapping is important for strategic decisions related to Artemis; however, many details about these maps remain uncertain. We seek to leverage geologic mapping for the NASA Volatile Investigating Polar Exploration Rover (VIPER) to learn lessons applicable for Artemis geologic mapping.

The VIPER map is focused on linking landed observations to the broader geologic history of the Moon. One application of the VIPER map is to test the hypothesis that volatile deposition in the upper meter of the regolith occurred at a few specific times in the last billion years. This is to be accomplished by mapping the expected extents (and thicknesses) of crater ejecta in the VIPER study area and using the degradation state of the craters to estimate the ages of the ejecta. By placing VIPER observations of volatiles in this spatio-temporal framework, it should be possible to determine if volatiles are associated with deposits of specific ages.

Relevance to Artemis: We suggest that several aspects of the ongoing mapping for VIPER are highly relevant for Artemis.

Map extent: One challenge the VIPER map faces is that craters from outside the map area can contribute significant ejecta. However, the minimum size of the craters that would significantly contribute to the map area increases with distance. This leads us to use a nested series of maps, with the spatial resolution decreasing with distance from the VIPER mission area.

Map units: The lunar south pole is not marked by major lithologic variations (to first order, the rocks are highlands anorthosites). Instead, the geologic history of the region is primarily a record of overlapping impacts of all sizes. This suggests that the idea of nested maps of sequentially smaller scales that focus on craters and their ejecta will be useful to capture the geologic framework of Artemis landing sites.

An open question is the degree of “lumping versus splitting” to use in grouping craters of similar age. There is non-trivial uncertainty in estimating the age of craters from their morphology, especially for the most common, moderately degraded, craters [1,2]. This leads to uncertainty in the expected superposition relationships between craters of similar age. Recent studies have relied on Monte-Carlo simulations to consider the full range of plausible superposition relationships [3,4], but this is difficult to incorporate into a geologic map. An expedient way to deal with this uncertainty is to group the ejecta from similarly-aged craters together. What is unclear at this point is how many gradations of crater age can be reliably distinguished at a given map scale. Answering this question will determine the number of discrete chronostratigraphic units that can be mapped and thus the temporal resolution the nested maps deliver.

Map scales: While a nested mapping scheme appears necessary, the required number of steps and the size of the changes in scale between steps are not known. Based on experience with context imagers for high-resolution imaging and other related work, we estimate that a five-fold step in resolution is likely to be appropriate. For VIPER, we plan to create the highest-resolution (largest scale) map at 1:5,000 scale, covering a 5x5 km area on a 1x1 m sheet. Two additional maps, at 1:25,000 and 1:125,000 scale (25x25 and 125x125 km areas), are planned. The expectation is that the smallest-scale map can be integrated into global maps and data sets. However, given that the global geological mapping has been done at 1:5,000,000 scale [5], it is possible that a dedicated South Pole map between 1:1,000,000 and 1:500,000 scale could be essential.

Mapping methodology: Having nested maps at different scales may provide an opportunity to accelerate work by having multiple parallel mapping efforts. We intend to experiment with various methods to allow multiple mappers to concurrently contribute to the overall map. This may be extremely important for Artemis if the timeline to produce maps is significantly shorter than the 3–4 years typical for traditional planetary geologic maps.

Data release: The goal is to publish the VIPER map as a digital geographical information system (GIS) package as well as a traditional 2D map. This opens the possibility to include a wide variety of additional data layers in the same GIS package. It may even be possible to update the package as new map products become available (and pass appropriate peer-review). If successful, this publication method could be a “one stop shop” for all the cartographic data needed to analyze an Artemis site for both fundamental and applied science.

References: [1] Basilevsky A. T. (1976) *Proc. LPSC, 7*, 1005-1020. [2] Fassett C. I. et al. (2022) JGR doi:10.1029/2022JE007510. [3] Cannon K. M. et al. (2020) GRL doi:10.1029/2020GL088920. [4] Christopher H. et al. (2023) *LPSC 54*, Abstract# 1828. [5] Skinner J. A. et al. (2020) *LSSW 6*, Abstract# 5128.