ARTEMIS III GEOLOGY PRIORITIES AND SCIENCE PLANNING PROGRESS. B. W. Denevi[1], L. A. Edgar[2], C. I. Fassett[1], J. Gross[3], T. Hayden[4], J. L. Heldmann[5], J. Hostrawser[4], D. M. Hurley[1], J. M. Hurtado, Jr.[6], K. Izquierdo[1], B. L. Jolliff[7], K. H. Joy[8], Y. Liu[9], A. Madera[3,10], C. Moye[7], G. R. Osinski[4], L. M. Saper[9], A. Sonke[11], E. Speyerer[12], A. Srivastava[4], T. Sweeney[6], B. A. Cohen[13], C. Evans[3], R. Ewing[3], T. Graff[3,14], S. J. Lawrence[3], M. Miller[3,14], A. W. Needham[13], N. E. Petro[13], R. Weber[15], and K. E. Young[13]. [1]Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA, [2]USGS Astrogeology Science Center, Flagstaff, AZ, USA, [3]NASA Johnson Space Center, Houston, TX, USA, [4]University of Western Ontario, London, ON, Canada, [5]NASA Ames Research Center, Mountain View, CA, USA, [6]The University of Texas at El Paso, El Paso, TX, USA, [7]Washington University in St. Louis, St. Louis, MO, USA, [8]The University of Manchester, Manchester, UK, [9]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA, [10]Rutgers University, Piscataway, NJ, USA, [11]Arizona State University, Tempe, AZ, USA, [12]Intuitive Machines, Houston, TX, USA, [13]NASA Goddard Space Flight Center, Greenbelt, MD, USA, [14]Amentum, Houston, TX, USA. [15]NASA Marshall Space Flight Center, Huntsville, AL, USA.

Introduction: Planning for the Artemis III geology investigation is ongoing. We have refined and prioritized the geology science objectives and developed a site-agnostic investigation strategy (e.g., sampling, *in situ* investigations, observations, and documentation) to guide extravehicular activity (EVA) planning, determined the landing site characteristics most likely to result in the successful accomplishment of the geology objectives, and have been testing these science plans and training the team. Here we provide an update on these plans, priorities, and tests.

Prioritization of Science Objectives: The Artemis III Geology Team defined four science goals (Table 1) [1] that align with recommendations from the Planetary Science and Astrobiology Decadal Survey [2] and NASA's Moon-to-Mars Objectives [3]. Three objectives now support each goal; Goal A was modified to incorporate a previously separate objective (A4; origin of the Moon) into the three revised objectives to simplify planning without sacrificing progress.

Prioritization of the science objectives (in ranked order as opposed to binned priority level) provides both a reference during planning to ensure we best allocate resources and a tool to facilitate quick decision-making during operations, consistent with findings from recent analog tests [e.g., 4–6]. We considered two axes when ranking the Artemis III geology objectives: 1) the overall importance of the objective to planetary science (i.e., does the outcome have broad implications, or would conclusions have a more limited impact on the state of planetary science), and 2) the likelihood that transformative progress can be made with Artemis III toward accomplishing the objective (vs. incremental progress or inconclusive results). Each objective was evaluated along these two axes (Fig. 1) and an overall priority assigned (Table 1).

Geology Investigation: NASA has indicated that multiple potential landing sites within the Artemis III candidate landing regions

Table 1. Geology Goals and Objectives for Artemis III. Objective priority is given in parentheses.

Science Goal	Science Objective
A. Understand the Origin and Early Evolution of the Moon as a Model for Rocky Planet Evolution	**A1**. Evaluate lunar magma ocean (LMO) models for the timing and processes that led to the formation of the crust (3)
	A2. Constrain the composition and diversity of the lunar mantle and lower crust to test LMO models and post-LMO magmatic processes (6)
	A3. Establish the abundance and isotopic record of endogenic volatiles in the lunar interior to test the giant impact hypothesis for the origin of the Earth–Moon system (5)
B. Determine the Lunar Record of Inner Solar System Impact History	**B1**. Anchor the early Earth–Moon impact flux by determining the age of the South Pole–Aitken (SPA) Basin (1)
	B2. Test the Cataclysm Hypothesis by determining the post-SPA impact chronology (2)
	B3. Determine how impacts redistribute materials, the impact stratigraphy at the landing site, and the provenance of samples (7)
C. Determine how the Environment Controls Regolith Processes on Airless Bodies	**C1**. Ascertain polar regolith's physical, chemical, and geotechnical properties, and the variation in regolith evolution as a function of environment (9)
	C2. Explore the mechanisms for space weathering in polar regions as a function of local environment (10)
	C3. Characterize meteoritic material, including terrestrial debris, found in the lunar regolith as a record of past lunar impactors (11)
D. Reveal the Age, Origin, and Evolution of Solar System Volatiles	**D1**. Characterize the nature, origin, age and abundance of persistent volatiles in cold environments (4)
	D2. Characterize the nature, origin, age, abundance, and transport processes for transient volatiles (8)
	D3. Determine how exploration activities modify the record of volatiles at the lunar surface (12)

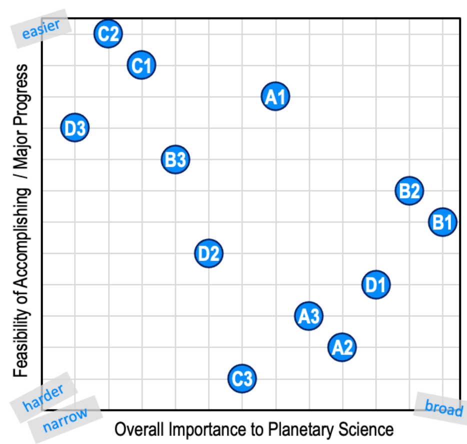

Fig. 1. Consideration of factors relevant to prioritizing Artemis III geology objectives (refer to Table 1).

will remain in consideration to maximize launch date availability. The prioritized geology objectives guide the science evaluation of landing sites in these regions, which provide a range of scientific opportunities [7]. Accordingly, we have outlined a geology investigation that maintains flexibility to the specifics of a final landing site, but provides the detail needed to determine imaging requirements [8], estimate required sample mass and the number and types of sample containers, and range of EVA time needed.

Sampling Plan: For Goal A, crystalline samples large enough to perform multiple coordinated techniques [e.g., 9,10] are key to resolving current lunar origin and magma ocean controversies. Rarer lower crustal or upper mantle components are most likely to be found as regolith fragments or within impactites. Thus, rock samples (boulder chip samples and hand-sample sized rocks) and regolith rake samples (which concentrate fragments >1 cm) are prioritized; bulk regolith samples will provide context for the measurements made on larger samples. These same types of samples (rock and raked regolith) are prioritized for Goal B, though impact melt rocks and melt-bearing breccias are the targets. The nature of ballistic sedimentation and the heavily gardened highland regolith provide a degree of chance to finding key lithic or impact melt samples for Goals A and B. We thus plan for sampling the diversity of the exploration zone by targeting areas of low slope that likely have ancient regolith, areas on slopes where material is more recently exposed, and the ejecta of larger impact craters that have exposed material from beneath the most heavily gardened regolith (which could yield samples most relevant to Goal A or B, depending on the local substrate). For Goal A, we require pristine crystalline materials, likely to be rare; for Goal B, we need robust sample statistics due to the complex impact chronology we will encounter. Both of these factors drive a desire for a large mass of returned rock samples.

Distinct environments near the south pole will be targets for studying regolith evolution processes (Goal C), including regions in permanent shadow, regions with limited (<20%) illumination, ejecta near fresh craters, the disturbed area near the lander, and undisturbed well-mixed terrain. Samples of bulk regolith will yield grain size and other physical properties, as well as insight into space weathering. Rates of polar space weathering can be constrained by sampling ejecta of fresh and degraded impact craters, particularly if accompanied by samples that date crater formation (e.g., via cosmic ray exposure age determination). Rates of regolith production due to rock breakdown can be assessed from fine-grained regolith atop boulders and by sampling material derived from boulder fillets. Additional geotechnical information will come from stereo imaging of disturbed and undisturbed regolith, trenching, and crew observations, such as the difficulty of drive tube insertion.

Goal D relies on vacuum-sealed samples to assess volatiles [see 11]. Samples collected from the coldest accessible environment and an illuminated "control" region are planned to include three separately sealed components to evaluate first-order stratigraphy of volatiles with depth: 1) surficial (upper ~cm) regolith 2) upper portion of double drive tube (~35 cm) and 3) lower portion of double drive tube (~35–70 cm). The final landing site will be a determining factor for whether regions where near-surface volatiles are predicted to be stable can be sampled. Sealed shallow surficial regolith samples can provide a means to assess transient volatiles (comparisons between pre-dawn and post-dawn locations that have temperatures incompatible with long-term sequestration of volatiles) and the distribution of volatiles deposited by the lander (varying distances from the lander in regions that remained in shadow since landing).

Testing and Training: Opportunities to test the implementation of the geology investigation are critical, and a recent (Nov. 2024) exercise included the planning and simulated execution (using virtual reality, VR) of an Artemis-III-like mission at a lunar site. The planning process led to additional ideas on how to operationalize the science traceability matrix and geologic mapping in ways that can be applied to planning for any site in the Artemis candidate landing regions, as well as areas for consolidation and simplification of imaging and sampling plans needed to meet the Artemis III geology objectives. Similar to analog field tests [e.g., 6,12], the VR-executed simulated mission was instructive for learning to adapt to discoveries or deviations from nominal timelines or operations in real time. Field exercises in the El Paso area (Feb. 2025) led by the geology team will provide additional team training, including working with the geology sampling tools (government reference design), the type of camera to be used on Artemis III, and comparisons of geologic understanding based on remote sensing observations, telemetered field observations, and in-person exploration.

References: [1] Denevi B.W. et al. (2024) *LPSC 55*, Abs. 1980. [2] National Academies of Sciences, Engineering, and Medicine (2022) *Origins, Worlds, and Life: A Decadal Strategy for Planetary Science and Astrobiology 2023-2032*. [3] NASA Headquarters (2023) *NASA's Moon to Mars Strategy and Objectives Development*. [4] Nawotniak S.E.K. et al. (2023) *LPSC 54*, Abs. 2490. [5] Achilles C.N. et al. (2024) *LPSC 55*, Abs. 2434. [6] Edgar L.A. et al. (2025) this mtg. [7] Fassett C.I. et al. (2025) this mtg. [8] Hurtado J.M. et al. (2025) this mtg. [9] Borg L. et al. (1999) *GCA*, *63*, 2679–2691. [10] Borg L.E. et al. (2020) *GCA*, *290*, 312–332. [11] Heldmann J.L. et al. (2025) this mtg. [12] Young K.E. et al. (2023) *LPSC 54*, Abs. 2179.