REVISITING THE SURVEYOR VII LANDER: UNDERSTANDING THE EFFECTS OF EXTENDED EXPOSURE TO THE LUNAR ENVIRONMENT AND DETERMINING THE AGE OF TYCHO. N. E. Petro, NASA Goddard Space Flight Center; Planetary Geology, Geophysics, and Geochemistry Laboratory.

Introduction: The Artemis III Science Definition Team [1] report highlights the importance of understanding the effects of the deep space and lunar thermal environments on human-emplaced materials. While a long-lived Artemis program may afford the opportunity to learn from equipment deployed during Artemis, opportunities to sample equipment deployed on the Moon in the 1960s affords a unique and unprecedented opportunity to study the effects of space exposure on material in space for over 50 years. Here we discuss the value of a mission to Surveyor VII.

Landing Area(s): The Surveyor VII lander is located at −40.9812º, 348.4873º [2], in a rugged region dominated by ejecta from Tycho, with several rock fragments in the vicinity of the lander [3, 4]. The landing site contains a relatively thin regolith cover, relative to the Apollo sites, and contains the least-mature regolith of a landing site thus far.

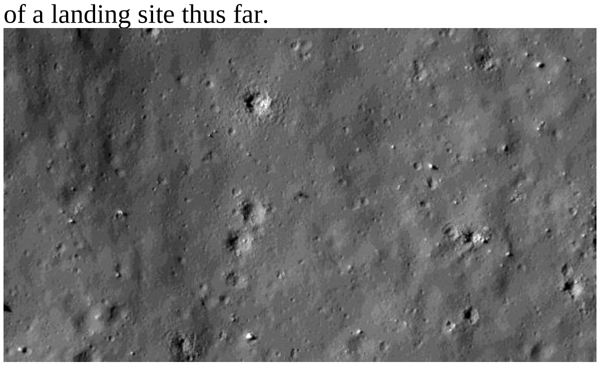

Figure 1. LROC NAC image of the Surveyor VII lander (center of image). LROC NAC image M150598504R. Small fresh crater at top center of the image is ~20 meters in diameter.

Science Objectives: A robotic mission to the Surveyor VII lander could have multiple science objectives. A lesson of the Apollo 12 mission, in addition to pin-point landing, is the value in visiting and retrieving hardware from Surveyor III [5] which provided a 31-month baseline for space exposure and the effects of landing impingement from the Apollo 12 lunar module. Like the Apollo 12 sampling of the Surveyor III lander, a visit to and collection (or high-resolution scan) of hardware from the lander would provide insight to material exposed to the lunar environment for >50 years. The materials available would be limited to optics (glass) and metal hardware for the lander and will provide valuable insight into changes to those materials, as well as any dust accumulation over the time the lander has been on the surface. Understanding how hardware reacts to the lunar environment over time Is highlighted as Goal 6k of the Artemis III Science Definition Team report [1].

In addition to understanding the Surveyor VII materials, a direct sampling/age determination of the Tycho event *via* geochronology would be valuable. Not only would such a measurement test hypothesis of what was sampled at the Apollo 17 landing site [6] and possibly collected at the lunar south pole by an Artemis mission [7]. The fact that the ejecta at this site is relatively young, any analysis of the material within the regolith would reveal insight into solar activity over the last ~100 mya. Additionally, the emplacement of geophysical hardware (heat flow, seismometer, retroreflector) should be considered at any location visited by a lander.

Required Capabilities: An adequate mission to the Surveyor VII site could take on many forms, which all depend on the quality of instruments available at the time of flight. In general, pinpoint landing is critical, but the ability to have a rover approach and interact with the Surveyor VII spacecraft if key.

A purely *in situ* version of this mission would require the rover to carry a documentation system to scan the hardware at resolution of 100's of µm's [e.g., 8]. The specifications of such a system need to be defined by those interested in the response of hardware to the lunar environment, which would likely emphasize the number of craters on the hardware. Other instrumentation to document any radiation damage to optics or other exposed materials would need to be determined. Additional capabilities for *in situ* geochronology of Tycho ejecta/melt would be value added to such a mission.

A version of this mission that returns Surveyor VII hardware and surface samples would require an arm equipped with tools to cut/pry and collect hardware, in addition to collecting any fragments or regolith for return to Earth is of course valuable and would enable far more analyses of the hardware and surface samples.

References: [1] Weber, R. C., et al., (2021) The Artemis III Science Definition Team Report, 1261. [2] Wagner, R. V., et al., (2017) *Icarus*, 283, 92-103. [3] Turkevich, A. L., et al., (1968) *Science*, 162, 117. [4] Jaffe, L. D., et al., (1970) *Icarus*, 12, 156. [5] (1972) *Analysis of Surveyor 3 material and photographs returned by Apollo 12. NASA SP-284*, [6] Schmitt, H. H., et al., (2017) *Icarus*, 298, 2-33. [7] Denevi, B. W. and M. S. Robinson, (2020), #5122. [8] Hörz, F., (1974) Photo documentation of Long-term Lunar Surface Exposure Experiment, JSC-08676, 49.