THE SILFELA MISSION TO THE ARISTARCHUS PLATEAU, MOON. L. S. Sollitt[1], R. C. Anderson[2], R. A. Beyer[1], D. Buczkowski[3], K. B. Chin[2], A. Colaprete[1], S. Dibb[1], J. M. Dohm[4], R. C. Elphic[1], E. Fritzler[1], I. R. King[5], D. S. S. Lim[1], J. M. Long-Fox[6], Z. Mirmalek[1], D. Y. Wyrick[7], R. A. Yingst[8] and K. Zacny[5], [1]NASA/Ames Research Center, Moffett Field, CA, [2]NASA/Jet Propulsion Laboratory, [3]JHU/Applied Physics Laboratory, [4]Exploration Institute, [5]Honeybee Robotics, [6]University of Central Florida, [7]Southwest Research Institute, [8]Planetary Science Institute, luke.s.sollitt@nasa.gov.

Introduction: Silfela is a low-cost lunar PRISM mission concept designed to study the regolith properties of the Aristarchus Plateau on the Moon (Fig. 1). The mission will make use of the PRISM mobility capability (rover) to assess regoliths in different geological units. The instrument suite consists of the SPARTA regolith sampling toolkit [1,2], the NIRVSS imager/spectrometer [3], the NSS neutron spectrometer [4], context cameras, and a high-resolution hand-lens imager. “Silfela” is a word from the fictional Qenya language which means “small lunar excavation.”

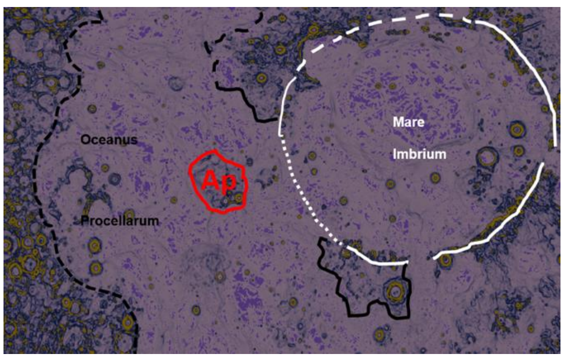

Fig. 1. Aristarchus plateau (AP), near the western margin of Mare Imbrium impact crater (white solid and dashed line) within Oceanus Procellarum (basin between the solid black lines), likely includes remnant rim material of Mare Imbrium.

Background: Regolith properties foundationally inform on wide-ranging planetary science topics, including surface evolution through impact gardening; erosional processes; the delivery and distribution of water in the inner solar system; the distribution of potential habitable zones; and thermal histories of planetary bodies. Silfela will introduce a standardized set of geomechanical measurements for the bulk and shear strength, water content, and thermal properties of the near-surface lunar regolith (< 1m depth). These measurements address several goals and questions in the NRC 2007 report [5] and in the 2022 Decadal Survey [6]. Specifically, Silfela will address needs for studies of crustal composition, heat production, and origin of crustal dichotomies (if any) on the Moon by in situ geochemical, mineralogical and heat flow measurements [6: Q5.2]; regolith heterogeneity [5: Goals 4d, 7a-d; 6: Q5.5]; and geophysical parameters that control past and present material fluxes in rocky subsurfaces, such as porosity, permeability, heat flux [6: Q10.6].

The geotechnical measurements pioneered by the Silfela mission will also serve engineering functions, not only at the Moon but on other rocky bodies as well. Future exploration of planetary bodies such as the Moon (e.g., NASA’s Artemis program) will require an understanding of regolith strengths for landing site suitability, vehicle mobility and traversability, ISRU development, or even for construction. Past planetary missions have failed or have had difficulties because planners did not understand basic surface properties such as regolith shear strength (Apollo 15 drill, Philae harpoon), triboelectric charging (Phoenix sample handling system, Curiosity sample handling system), or regolith bulk strength in a reduced-gravity environment (InSight’s Mole Drill). Silfela represents a development toward a standardized payload to address these objectives and build a basic understanding of planetary regoliths throughout the Solar System.

Science Objectives. The primary target of the mission is a distinct geological contact along the southeast margin of the putative 48 km-diameter, Herodotus-E impact crater at the north-central margin of the Aristarchus plateau (Fig. 2). The contact, well-defined in a terrain-slope map and photomosaic map base (Fig. 2D,F), delineates Aristarchus silicic plateau materials (Fig. 2E) from Imbrian Mare basalt, mapped and interpreted respectively as map units Elp (Eratosthenian Imbrian Plateau material including silicic-rich pyroclastics interpreted here) and lm2 (Imbrian Mare, Upper plains-forming basaltic lavas) by [7] (Fig. 2A).

The Aristarchus plateau is of exploration interest because it contains a rich diversity of features resulting from magmatic activity, including varied igneous materials such as basaltic lava flows, extensive pyroclastic deposits, and evolved intrusive and extrusive, Th-rich silicic igneous materials [8]. Features also include rilles such as the Moon’s deepest and widest (i.e., Vallis Schröteri; Fig. 1A), dome and vent structures such as the head of Vallis Schröteri (informally "Cobra Head”), and wrinkle ridges, collapse depressions, faults, and fractures.

The primary science objective of the Silfela mission is to explore the surface and near-surface (depths to ~10 centimeters) environmental conditions at Aristarchus plateau, with particular foci on the geomechanical properties and water content of the noted two map units, along with relatively pristine impact ejecta from ray craters interpreted here to comprise exposed plateau materials (Fig. 2). Assessing the indicated water variation by the Moon Mineralogy Mapper 3-micron band data (Fig. 2B) includes determining whether there is a lithologic variation between the units, and whether one or all contain water, and if so, in what form (e.g., does it occur in the form of ice within the pore space?)

Concept of Operations: The Silfela concept is envisioned as a payload for a CLPS rover in a PRISM-style mission. As such, the payload concept will be developed to be provider-agnostic, needing only physical, power and data interface requirements. As such, the payload concept will be developed to be provider-agnostic, needing only physical, power and data interface requirements. It will likely be mounted on the front of the rover, with SPARTA fixed to a linear stage on the rover body, with the hand lens, NSS, and NIRVSS mounted in the same area on a rover deck. Depending on rover capabilities, a mast will accommodate two context cameras that will provide stereo imaging for traverse planning and 3-D site modeling using the Ames Stereo Pipeline [9]. Operations would last at least during a one lunar day cycle, with optimal deployment lasting at least two with stay-alive power during the night period.

References: [1] Anderson R.C. et al. (2022) *LPSC 2022*, abs. #2398. [2] Wyrick D.Y. et al. (2023) *LPSC 2023* [3] Roush T.L. et al. (2021) *LPSC 2021*, Abs. #2548. [4] P. N. Peplowski, R. C. Elphic, E. L. Fritzler, and J. T. Wilson (2023), *Nuclear Inst. and Methods in Physics Research, A* (in review). [5] National Research Council (2007) doi: 10.17226/11954 [6] National Academies of Sciences, Engineering, and Medicine (2022). doi: 10.17226/26522. [7] Fortezzo C.M. et al. (2020) https://astrogeology.usgs.gov/search/map/-Moon/Geology/Unified_Geologic_Map_of_the_Moon_GIS_v2. [8] Glotch TD et al. (2021) *Planet. Sci. J.. 2*, doi: 10.3847/PSJ/abfec6. [9] Beyer, R. A., O. Alexandrov, and S. McMichael (2018), *Earth and Space Science*, 5, 537– 548.

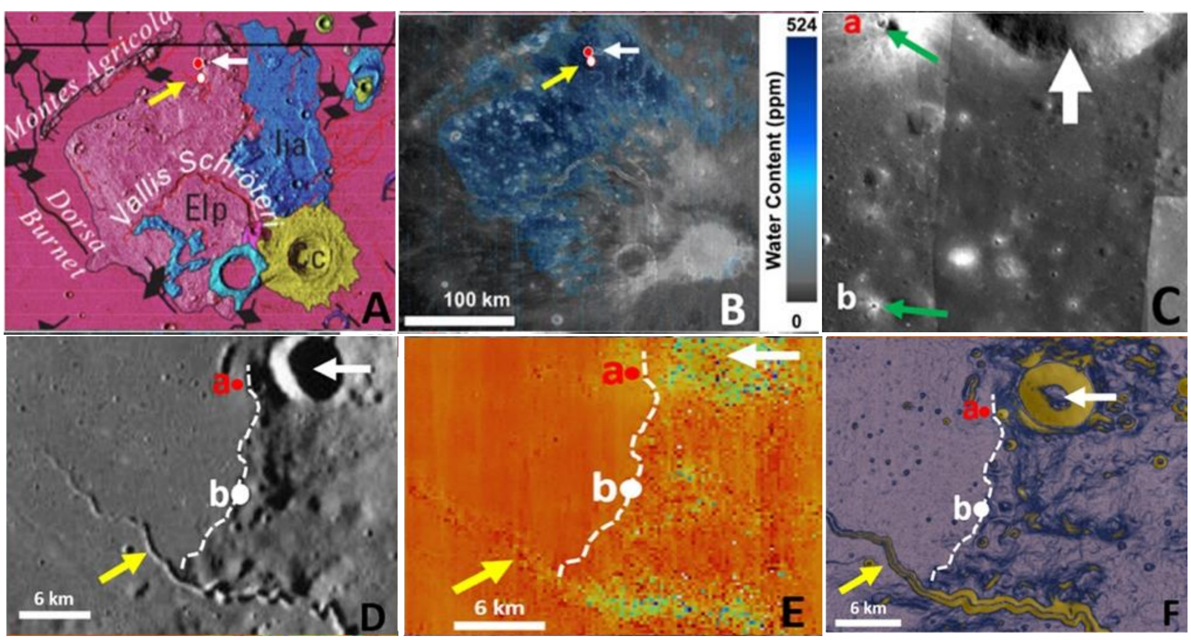

Fig. 2. The Silfela landing area and two proposed sites along the eastern of the Herodotus-E Crater, north-central margin of the Aristarchus Plateau. Panels A-F show the candidate Silfela sites a (red dot and/or letter) and b (white) along the geologic contact (white dashed lines) along the margin of Herodotus-E, Wollaston R impact crater (white arrows), and unnamed rille (yellow arrows). Panels include: (A) geological map of [7] including geologic contact that delineates interpreted lunar maria basalt (dark pink) from silicic Aristarchus plateau materials (light pink unit Elp; compare to E) and 40 km-diameter Aristarchus impact crater (yellow polygon); (B) modified from [8], water content derived from Moon Mineralogy Mapper 3-micron band data with relatively high and moderate water contents approximated by the geologic contact (D-F); (C) Lunar Reconnaissance Orbiter Camera (LROC), wide-angle camera (WAC) mosaic highlighting impact craters with light albedo ray systems (green arrows); (D) LRO image showing distinct terrain along the geologic contact; (E) part of the global silicate map based from the LRO Diviner instrument with silicic plateau materials distinct from the lunar maria basalt (compare to A,D,F); and (F) terrain slope map showing a distinct break in slope along the geologic contact, as well as rover-traversable topography (i.e. violet-colored slopes < 10° yellow-colored) at sites a and b. Sites a and b are candidates for landing and traverses up to 1.5 km away from a lander with relay communications. Both sites are dominated by slopes less than 10 degrees, as can be seen in Fig. 2F, where areas of larger slopes are rendered in yellow. Each site should have materials on either side of the geologic contact accessible within the required 1.5 km radius.