A Multi-Purpose Landing Site Near Crater Idel'son L. H. Hiesinger[1], C. H. van der Bogert[1], M. Massironi[2], F. Sauro[3], R. Pozzobon[2], S. J. Payler[4], L. Bessone[4], N. Mangold[5] and others[6]. [1]Institut für Planetologie, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany (hiesinger@uni-muenster.de), [2]Univ. of Padua, Dipartimento di Geoscienze, [3]Dept. of Biological, Geological and Environ. Sci., Ital. Inst. of Speleology, Bologna Univ., [4]Dir. of Human and Robotics Exploration, ESA, [5]Lab. of Planetology and Geodynamics, Univ. of Nantes; [6]https://uni-muenster.sciebo.de/s/cn5TrcvMudVxIHM

Introduction: Understanding the nature, volumes, and distributions of lunar volatiles is unquestionably important for many open scientific questions related to the Moon, i.e., origin, thermal evolution, and geologic history. An Artemis landing site close to the South Pole, will allow us to address many of these questions about lunar volatiles. However, a landing site within 6 degrees of the South Pole would allow many more additional questions to also be addressed. For example, proximity to the Schrödinger basin and the South Pole-Aitken basin rims will allow collection of samples from large basins for age determinations and investigations of their impact and ejecta materials.

Thus, our proposed landing site was not only selected for safety considerations, but is also geared to contribute to many scientific questions. Serving many purposes, the landing site offers additional benefits compared to a landing site that is tailored to only one scientific question. The complexity of the landing site requires astronauts who are trained in lunar geology and field work to maximize the scientific output.

Results: Here, we propose a landing site at 84.8 °S and 106.6 °E, an area close to crater Idel'son L in a few hundred meter deep, 45 x 50 km large depression on Nectarian plains (Fig. 1). A preliminary inspection of WAC/NAC images and the SLDEM indicates that the landing site appears to be fairly smooth and gently undulating. Craters larger than a few hundred meters are at least 1 km away and steep mountains are located at distances of several kilometers. The landing site offers access to an area shown to be hydrogen-rich (~0.3 wt%) by LEND [1] without having to deal with permanently shaded regions, which pose critical challenges to any human or even robotic exploration. However, thermal modelling indicates that in the general area, ice would not be stable at the immediate surface, but only at depth of at least 2.5 m [2]. Nonetheless, colder secondary craters, the mountain range NW of the landing site as well as a permanently shadowed region (PSR) at Idel'son L crater would allow access to ice much closer to the surface or even directly at the surface. Less than 15 km away, light plains deposits can be accessed, as well as pre-Nectarian mountains – presumably representing older crater or basin rim materials (Fig. 1b). Imbrian-aged crater Idel'son L and its associated PSR [3] at its southern rim are also within range, in addition to several secondary crater chains. According to the new unified geologic map [4], the ejecta blanket of Schrödinger basin is within less than 30 km from the site (Fig. 1b). Thus, the landing site allows access to several geologic units.

Studying this region could be accomplished by several traverses as indicated in Figure 1 or by a loop that connects the points of interest. The lengths of the traverses refer to one-way distances. Ideally, individual traverses could be combined in loops to cover as many scientific goals as possible while minimizing driving. Alternatively, the landing site could be moved to a TBD location along a specific traverse. Here, we outline the scientific goals for each traverse.

Traverse 1 (33 km): Along this traverse, several objectives could be accomplished. The landing site is located at the eastern margin of a hydrogen-rich area [1], which could be sampled in the immediate vicinity. H concentrations increase toward the NW of the landing site in the direction of pre-Nectarian mountains and the PSR associated with Idel'son L crater [1,3]. While ice is stable at the landing site only at depths >2.5 m [2], colder secondary craters, the mountain range, and the Idel'son L PSR [3] would allow easier access to volatiles. In addition, the ejecta blanket of Idel'son L could be studied in detail. The composition of the ejecta blanket would allow us to gain information about the structure and composition of the upper 1-2 km of the lunar crust [5].

Traverse 2 (4 km): Should mobility be restricted, the landing site still offers the possibility to reach stable ice with a vertical drill within about 2.5 m [2] as it is located in a H-rich environment [1]. Chances to get access to ice increase by visiting secondary craters that are located about 4 km from the landing site. Besides providing better access to volatiles, secondary crater investigations can provide insight into impact processes.

Traverse 3 (11 km): The destination of this traverse is the pre-Nectarian mountain range NW of the landing site, interpreted as a remnant of a crater/basin rim. Again, on the way, H-rich materials could be sampled, similar to traverses 1 and 2. An additional benefit is access to very old highland material that is missing in the Apollo/Luna sample collection.

Traverse 4 (29 km): The ultimate goal of this traverse is to reach the Schrödinger ejecta blanket. Along the traverse, H-rich materials could be sampled as well as the pre-Nectarian crater/basin rim material[1,4].

Getting access to Schrödinger materials would allow us to study the structure and composition of the lunar farside crust and would most likely also give us access to SPA materials. Provided the SPA material can be identified among the samples, their radiometric ages would provide important information on the lunar cataclysm [6] and would also provide a new calibration point for the chronology function [e.g., 7,8].

Traverse 5 (27 km): East of the landing site is a set of heavily degraded Nectarian craters, including crater Wiechert P, which contains a PSR [3]. Although the PSR is probably difficult to access, the traverse would provide insight into the structure of a 40 km diameter old crater that has been affected by many subsequent impacts, as well as the state of ancient regolith.

Traverse 6 (13 km): SW of the landing site is an extremely flat area that has been mapped as light plains [4]. The origin of light plains deposits is still debated. Possible hypotheses include (1) volcanic deposits, (2) ejecta deposits from the Orientale or Imbrium basins or (3) ejecta deposits from local craters [e.g., 9]. Samples taken from this traverse could shed light on the origin of light plains and could be compared to those of the Apollo 16 landing site.

Conclusions: We propose a landing site that appears safe for landing and is geologically complex and heterogeneous. Such a site allows us to address a multitude of scientific goals, but also requires well-trained astronauts on the surface to fully leverage the rich geology. The Apollo program has demonstrated how valuable proper geologic training of the astronauts is and many samples and insights would not have been gained without such training. Indeed, field geology training, such as the current and future development of the Geoscience Training Program for astronauts by NASA and the ESA PANGEA program, will allow the astronauts to achieve the multiple scientific objectives of the planetary science community.

References: [1] Sanin et al. (2017), Icarus 283; [2] Siegler et al. (2016), Nature 231; [3] Speyerer and Robinson (2013), Icarus 222; [4] Fortezzo et al. (2020), LPSC 51; [5] Pike (1977), LPSC 3; [6] Hiesinger et al. (2012), LPSC 43; [7] Neukum (1983), Habil. Thesis, U. of Munich; [8] Hiesinger et al. (2020) ; LPSC 51; [9] Hiesinger et al. (2013), LPSC 44; [10] Barker et al. (2015), Icarus 273; [11] Mazarico et al. (2011), Icarus 211.

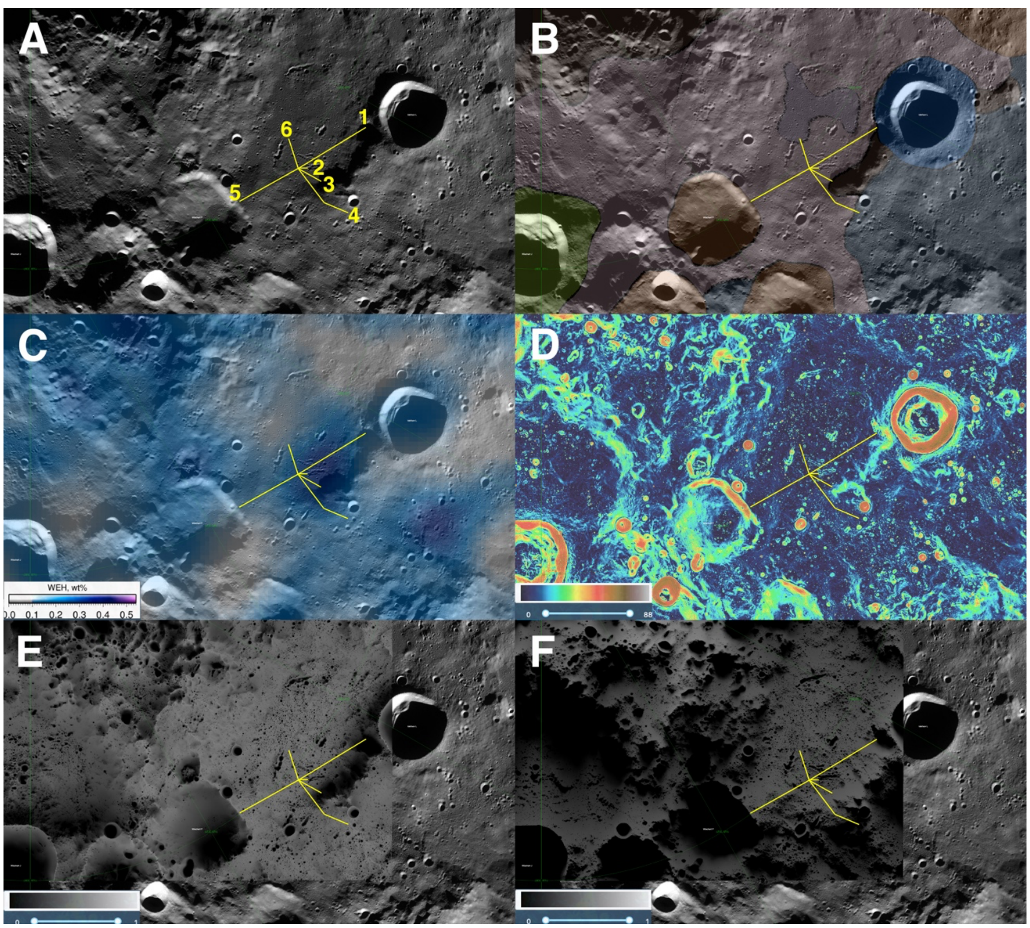

Figure 1. *(A) WAC/NAC mosaic of landing site; (B) Unified geologic map [4], (C) Water equivalent hydrogen map (0-0.5 wt%) [1]; (D) SLDEM2015 slope map (0-88 degrees) [10]; (E) Sun visibility (0= not visible, 1=always visible) [11]; (F) Earth visibility (0= not visible, 1=always visible) [11]. Potential traverses (1-6) are superposed on all images. See text for details. South Pole is beyond the upper left corner.*