Alternative Artemis III EVA Opportunities near de Gerlache Crater

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Introduction. A topographic high point on the nearside rim of de Gerlache crater (Fig. 1) has an average solar illumination of 84% [1]. The point, site 011 of [1] and *NASA's Plan for Sustainable Lunar Exploration and Development* is an attractive site to establish a solar power station if a distribution system can be developed.

If that site is selected to be a long-term power station, then it may be important to avoid fouling or cluttering the location with a descent vehicle and deployed instruments until after a preliminary set of measurements has been made within the area. Thus, it may be interesting to consider other locations in the vicinity of site 011 for an Artemis III landing.

Landing site and EVA options. To illustrate the types of options available, we provide a few details for an alternative area near the rim of de Gerlache crater (Fig. 1). The area occurs on an Earth-facing slope at an intersection created by the rim of de Gerlache crater and the rims of secondary craters that are mapped as the products of the Orientale basin-forming impact that occurred on the western limb of the Moon [2]. The area has a relatively smooth surface, but also contains a few small craters that may harbor small permanently shadowed regions (PSRs). One of the craters is fresh (Fig. 1, bottom panel).

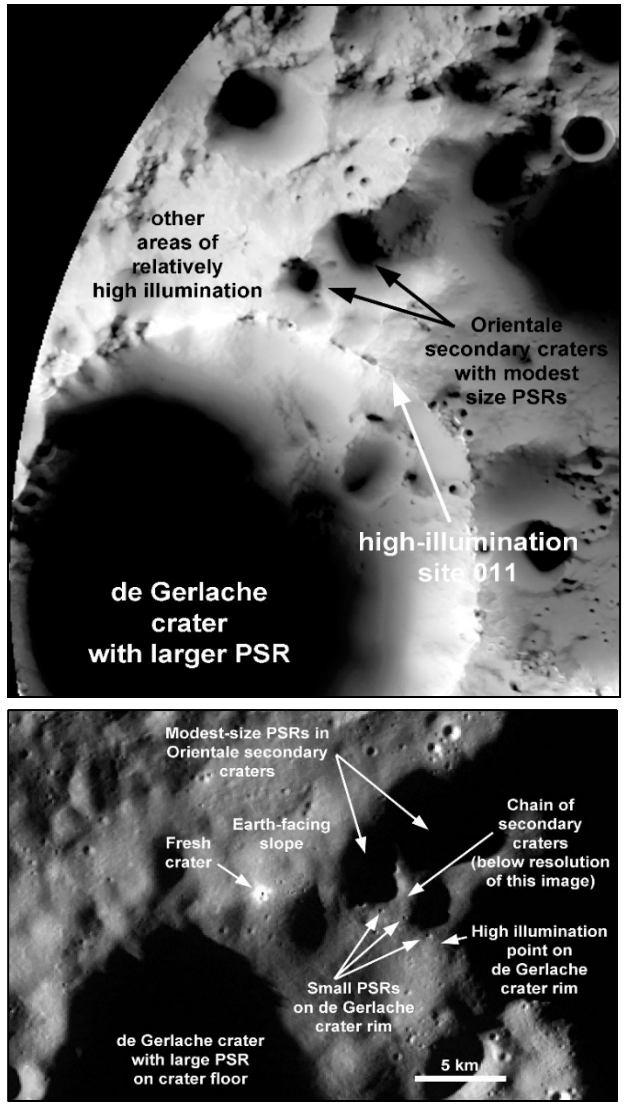

Figure 1. (top) Time-weighted LROC-WAC illumination map produced at a scale of 100 m/pixel. (bottom) LROC-WAC image of the nearside portion of the de Gerlache crater rim. The region hosts a large PSR within de Gerlache, modest-size PSRs in secondary craters produced by the Orientale impact event, and smaller PSRs produced by small, relatively recent, sporadic impact cratering events. 5 km scale bar.

If a rover is not available for the Artemis III crew, astronauts on walking EVAs may be limited to distances of about 2 km. At that scale of exploration, several targets are still available (Fig. 2). Small PSRs produced by small craters and boulders ejected from craters may provide the Artemis III crew an opportunity to sample regolith in those areas and capture any volatiles in them, similar to the sampling done by Apollo 16 and 17 crews (e.g., at Shadow Rock). A comparison could then be made between the Apollo samples (63320, 72320, and 76240) and Artemis samples to determine if volatiles are more abundant in small polar PSRs than in equatorial PSRs. Trenching and/or coring of the regolith will be important to evaluate the distribution of volatiles and regolith physical properties as a function of depth. If the capability does not exist to return to Earth a core of potentially ice-bearing regolith, then perhaps the core can be extracted on site and logged with imaging techniques and selectively analyzed with analytical techniques. Thermal and geophysical logging tools could, in parallel, be lowered into the borehole to provide critical data needed for resource model assessments.

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The regolith will contain components excavated by de Gerlache crater and, thus, material excavated from pre-Nectarian units that represent the most ancient crust known on the Moon. We have few remote sensing hints of the compositions of those units in this region, but outcrops in Shackleton crater suggest anorthosite may be present [3-5] as well as debris ejected by the South Pole-Aitken basin. This material may be found in scoop and rake samples of the regolith. An opportunity to sample boulders of de Gerlache ejecta freshly exposed occurs around a small crater in the region. That ejecta may contain samples of impact melt generated by the de Gerlache impact. That impact occurred in the midst of what has been termed the lunar cataclysm, based on an age of $3.9^{+0.01}_{-0.01}$ Ga, which is estimated from a crater size frequency analysis using orbital images [6]. It will be useful to verify that age by recovering impact melt from the regolith and returning it to Earth.

If, instead, a mission is focused entirely on volatiles that may exist in PSRs, then finding a means to access a modest-size PSR in a secondary crater may be interesting (Fig. 2). If this PSR can be accessed, then a comparison between the volatiles in small (young) and modest-size (older) PSRs can be made. Crew will not be able to directly access the modest-size PSR, which is twice as wide as Meteor Crater in northern Arizona and bounded by steep crater walls. However, if astronauts can deploy a tethered instrument, then they may be able to lower the instrument into the PSR. Alternatively, once deployed, the tethered instrument can be teleoperated by crew on the Gateway or by mission control in Houston, either during the mission or after crew ascent, to make the measurements *in situ*.

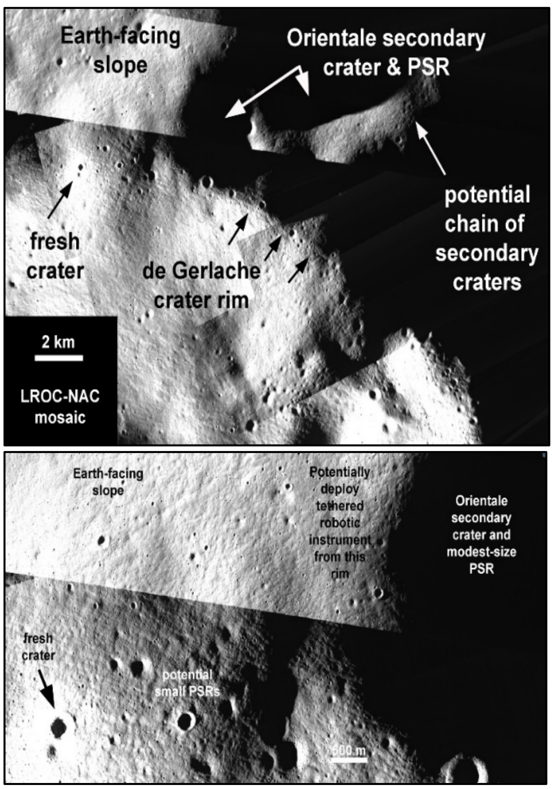

Figure 2. (top) Nearside rim of de Gerlache crater as seen in a NAC mosaic with 2 km scale bar. (bottom) A close-up view of a site within that area with a 500 m scale bar. Use the "fresh crater" to correlate the top and bottom images. Although not shown, 100 km-wide areas with slope <5° occur along the rim of de Gerlache and the northern margin of the Orientale secondary crater. Kilometer-size areas with slopes between 5 and 15° also occur in this area.

Summary. These figures illustrate a single example of an alternative to site 011 in the vicinity of de Gerlache's crater rim that would allow site 011 to remain free of mission debris, while allowing the crater rim and polar regolith to be characterized in sufficient detail to enhance preparations for the installation of long-term infrastructure needed for a sustainable exploration and development program (e.g., as described in *NASA's Plan for Sustainable Lunar Exploration and Development*). Other locations exist throughout the region. More detailed analyses, utilizing half-meter resolution NAC imagery, are needed for a comprehensive trade study to identify the best options available for an initial series of Artemis missions to the lunar surface.

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