SHACKLETON - DE GERLACHE RIDGE: A STRONG CANDIDATE FOR IMPORTANT LUNAR SCIENCE, SCIENCE OPEARTIONS, AND POLAR VOLATILES.

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Introduction: The National Aeronautics and Space Administration (NASA) has been tasked by the National Space Council to land humans near the lunar south pole by 2024. This landing would mark the beginning of "the return of humans to the Moon for long-term exploration and utilization", as called for by Space Policy Directive 1 [1]. Though the lunar south pole has never been visited by robotic or human missions, the possibility of utilizing water ice (detected from orbital measurements in permanently shadowed regions (PSRs), or just below the surface) as rocket propellants and life-support consumables could result in sustainable surface operations at a lunar field station [2-4].

To enable long-term exploration and utilization, any location must provide the opportunity to address compelling scientific questions, must have illumination and terrain that allows for the scientific exploration, and must have available resources to support working and living on the lunar surface in a sustainable way. The irregular ridge line that connects Shackleton, De Gerlache, and Sverdrup craters is such a location. Gläser et al. [5] refer to this ridge line as "the connecting ridge", and it was first described by Spudis et al. [6] as a possible location for a lunar field station.

Lunar Science: Of the eight prioritized lunar science concepts described in the National Research Council's The Scientific Context for the Exploration of the Moon (NRC SCEM) report [7], seven can be addressed directly at or near the connecting ridge: bombardment history, lunar interior, crustal diversity, polar volatiles, impact process, regolith processes, and the atmosphere and dust environment. A recent geologic map of the lunar south pole created by Spudis et al. [8] identifies a critically important feature at the connecting ridge location (though obscured by the Shackleton, De Gerlache, and Sverdrup impacts), a massif interpreted as a pre-Nectarian inner ring segment of the South Pole-Aitken (SPA) basin (Fig. 1). If this interpretation is correct, these craters have excavated materials of the SPA basin-forming impact, and the ejecta materials scattered on the surface of the connecting ridge could allow for reconstruction of the age and effects of the formation of the SPA basin. Pressurized mobile assets at a more mature field station could venture to Malapert peak and Leibniz β plateau to sample SPA rim materials.

The connecting ridge location also provides the ability to sample the feldspathic highlands crustal materials, to better understand the formation and differentiation of the Moon, particularly the ancient crust of buoyant plagioclase-rich rocks. The lunar interior could be studied by the emplacement of a seismic station, which would be one node in a global network of such stations [9,10]. Shallower-sensing geophone networks could be used to understand the depth and nature of the local regolith and mega-regolith.

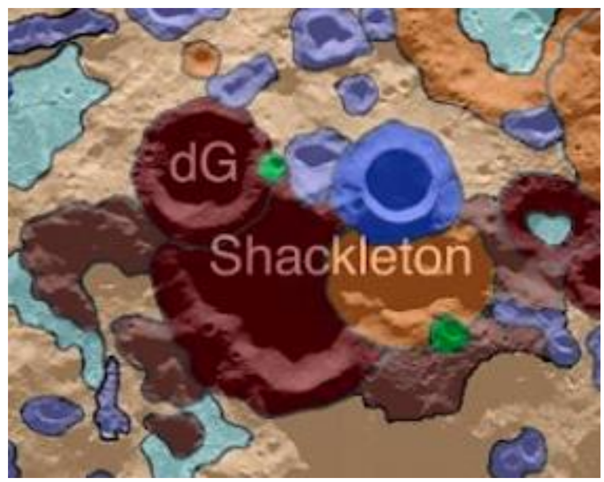

Figure 1. Geologic map of the Shackleton (in blue)-De Gerlache (dG)-Sverdrup (in red-brown) region of the Lunar South Pole (from Spudis et al., 2008).

Science Operations: In order to conduct the scientific exploration of the south pole, sufficient power will need to be generated to support field exploration vehicles, remote science stations, and laboratory studies. The connecting ridge is the most illuminated location at the south pole [5], with a maximum average illumination of 88% at two meters above the ground (Fig. 2). Solar arrays could be used early on to generate the required power, with a mature field station eventually evolving to the use of nuclear power.

The terrain at the connecting ridge is also conducive to scientific exploration, with slopes along the ridge mostly <10° and slopes down the ridge mostly <20° [11].

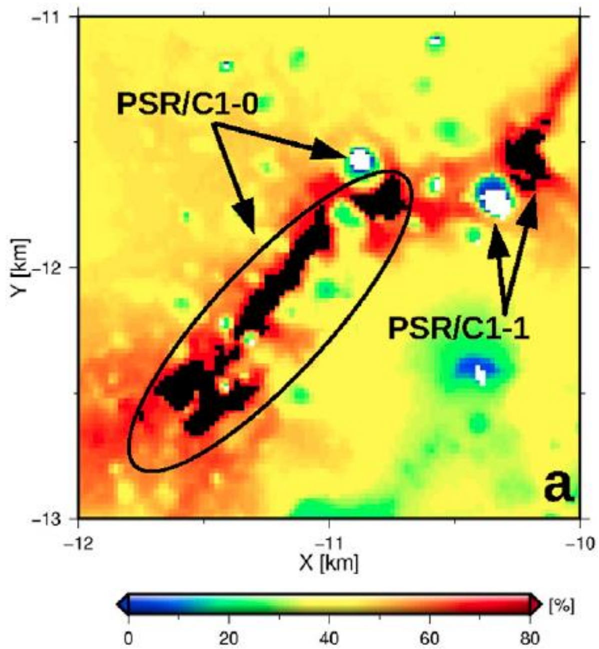

Figure 2. Average illumination conditions on the connecting ridge at 2 meters above ground over a 20-year period. Black pixels have >70% average illumination (from Gläser et al., 2018).

Polar Volatiles: Water ice on the Moon has been identified as a priority resource by the International Space Exploration Coordination Group (ISECG) [12], which now consists of 22 national space agencies. Determining the compositional state (elemental, isotopic, mineralogic) and compositional distribution (lateral and depth) of the volatile component in lunar polar regions is also the fourth highest-priority lunar science goal according to the NRC SCEM report [7]. Thus, the ability to access many locations with variable lighting and temperature environments, both surface and subsurface, is critical to the development of models that better describe the distribution of polar volatiles, which will then guide future exploration and utilization in the south pole region. The connecting ridge (Fig. 3) is within 10 km of multiple small PSRs (100s of meters to a couple of km in diameter), and 15 km from a large PSR [13]. Several of these small PSRs have maximum summer temperatures that are low enough to retain water ice at the surface [14].

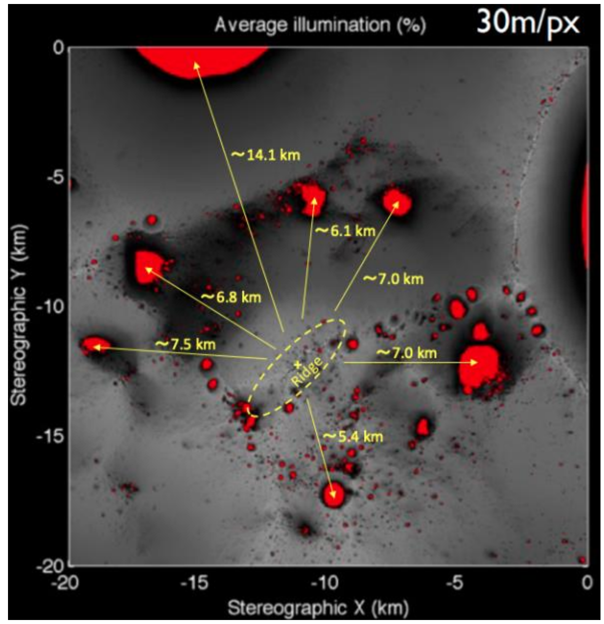

Figure 3. Point-to-point distances from a location on the connecting ridge to small PSRs, in red. (from Mazarico, 2013).

Conclusion: The connecting ridge that runs between Shackleton and De Gerlache craters is a strong candidate for the location of a lunar field station that will enable long-term exploration and utilization of the Moon. While much is unknown about the extent of polar water ice, there is no doubt that important lunar science objectives can be addressed at this site.

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