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Entering Schrödinger's Pyroclastic Vent and PSR: A Trafficability Analysis for the next Generation of Lunar Exploration Rovers

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In situ investigation of Lunar Pyroclastic Deposits (LPDs) and Permanently Shadowed Regions (PSRs) is a milestone for the future of lunar exploration, resource utilization (ISRU), and a permanent human presence on the Moon. For analysis, ground assets such as rovers have to enter and successfully traverse these areas. One high priority target for exploration is Schrödinger Crater, in particular a prominent pyroclastic vent that hosts a PSR. Using boulder tracks, previous remote sensing based studies suggest that regolith in LPDs and PSRs features bearing capacities equal to or higher than in mare and highland regions, thus, both regions might generally be able to support exploration vehicles. Bearing capacity is a measure for the trafficability of a surface as it can be used to estimate the sinkage of a vehicle, thus, describing the fundamental ability of a surface to bear an exploration vehicle.

While trafficability in plane LPD terrain appears to be unproblematic, Schrödinger's pyroclastic vent features significant topography gradients. As slope increases, the bearing capacity of lunar regolith decreases significantly. In addition, steep slopes are challenging due to an increased risk of wheel slippage and rover overturn. Therefore, potential decline traverses into the vent need to be carefully assessed to avoid delays or failure of a mission. Other challenges for rover locomotion and operation across the vent are unfavorable illumination conditions and obstacles such as small craters and blocks.

This study investigates in detail if and how Schrödinger's pyroclastic vent can be accessed by conventional and unconventional ground vehicles, i.e. wheeled rovers, legged rovers, and hybrids. It uses previous findings concerning the general bearing capacity of LPDs and PSRs and refines them using local bearing capacity values derived from the analysis of rockfall boulder tracks within the vent itself. Other aspects of trafficability are addressed using high-resolution topography, high-resolution optical imagery, as well as illumination maps.

Advantages and disadvantages of wheeled, legged, and alternative locomotion techniques for the exploration of Schrödinger's pyroclastic vent are explored. The assessment includes large wheeled rovers such as the Lunar Electric Rover and Resource Prospector, small wheeled rovers, such as Nanokhod-, Shrimp, and SandFlea-type rovers, legged robots, such as SpaceBok- and Spot-type robots, as well as hybrids, such as RHex-type robots. The analysis results in detailed trafficability maps and traverse proposals for each considered vehicle type to support a successful exploration of Schrödinger's pyroclastic vent in the future.