TRAVERSE PLANNING WITHIN SCHRÖDINGER BASIN IN SUPPORT OF A CANADIAN CONTRIBUTION TO THE PROPOSED HERACLES MISSION. Z. R. Morse[1,2], G. R. Osinski[1,2], M. Bourassa[1,2,3], L. L. Tornabene[1,2], E. Pilles[1,2], P. J. A. Hill[1,2], M. Cross[2,3], D. King[1,2], G. Tolometti[1,2], and M. Zanetti[1,2], [1]Department of Earth Sciences, University of Western Ontario, London, ON, Canada. [2]Centre for Planetary Science and Exploration (CPSX), University of Western Ontario, London, ON, Canada. [3]Department of Electrical and Computer Engineering, University of Western Ontario, London, ON, Canada. (zmorse@uwo.ca)

Introduction: Future robotic exploration of the Moon is necessary as a precursor for human exploration not only for testing critical technologies required for a long-term human presence on the Moon, but also for performing a reconnaissance mission to gain a better understanding of the area of investigation before humans return to the surface. The Human Enabled Robotic Architecture and Capability for Lunar Exploration and Science (HERACLES) is an international mission concept that includes the potential contribution of a Canadian Precursor to Human and Scientific Rover (PHASR) for a human-assisted lunar sample return mission [1,2]. In 2017, the Canadian Space Agency (CSA) awarded a contract to a team at the University of Western Ontario (PI: Osinski) to perform a science maturation study to mature and validate the preliminary science requirements of a PHASR for the HERACLES concept and develop a preliminary science scenario.

Mission Concept: The PHASR study focused on a proposed HERACLES destination of Schrödinger Basin near the lunar south pole. The primary goal of this mission would be to analyze the local lunar surface using onboard instruments and cache samples over a 70-day period [2]. The samples would then be returned to an ascent vehicle which would rendezvous with the Deep Space Gateway and eventually return to Earth. After the proposed sample return ascent vehicle would leave the lunar surface, the rover would continue to explore Schrödinger Basin for up to another year, performing follow-up science.

PHASR Science Goals: The science goals for PHASR have been divided into four themes: (1) Lunar Chronology, (2) Impact Cratering, (3) Lunar Volcanism [e.g. 3], and (4) Prepare for Human Return to the Moon. For additional details on these science objectives see Osinski et al. [2].

Proposed Traverse Plan: In order to best address the science goals for the PHASR mission concept, a proposed traverse plan has been created which covers ~85 km across the basin floor (Fig. 1). This proposed traverse is situated between the prominent pyroclastic vent and the interior wall of the Schrödinger peak ring (Fig. 1). The main target of this sample traverse is the pyroclastic deposit on the basin floor. This material was determined to be the highest priority target for a mission to Schrödinger due to the potential inclusion of lunar mantle materials and possible presence of volatile-rich materials.

Proposed Landing Site. This example traverse begins with a 100 m diameter landing ellipse, centered at (140.071° E, -75.235° N). This is shown as a blue circle on the basin floor morphologic overview and inset maps (Fig. 1). Additionally, a 1 km diameter threshold landing region is denoted as a white circle. Based on remote sensing data analysis, this entire region appears to be flat-lying and relatively boulder-free, making it safe for landing. This 1 km zone around the proposed landing ellipse also represents a region which could be affected by the landers descent thrusters on approach to the lunar surface. This means that any sampling of lunar material should take place outside this zone to avoid sampling materials that are contaminated or altered by the decent vehicle during the landing process.

Threshold Traverse. The proposed traverse begins with a northward drive toward the rim of a small well-preserved unnamed 0.9 km diameter crater located nearby. We have included three potential stops within the ejecta blanket of this crater, stops 1a, 1b, and 1c, where there are abundant boulders and soft regolith for sampling. The rocks here were protected from the effects of space weathering in the subsurface, until they were excavated by the 0.9 km crater. Thus these rocks represent relatively fresh material excavated from depth, providing further insight into the depth and composition of the pyroclastic deposit. After sampling and observations within the ejecta blanket are completed, the traverse path proceeds back past the landing site and continues further on toward the east. This path in and out of the ejecta blanket represents a threshold traverse distance of 5.2 km. Passing the lander enroute to the remaining stops provides an opportunity to return the samples collected thus far in the mission to the lander for return if any major problems occur that would end the mission after this initial stage.

Nominal Traverse. The nominal traverse path includes the threshold traverse into the ballistic ejecta blanket of the small 0.9 km crater and continues clockwise along the path indicated by the solid white line in Figure 1. This nominal path is a total of 85 km in length and accesses several additional units of surface materials. Stops 2, 3a, 3b, and 4 along with potential stop 1 are all associated with a large graben running across the northern end of this nominal traverse.

Stops 6 through 9 are all located along the interior base of the uplifted peak ring of Schrödinger. These stops all provide an opportunity to examine and sample the peak ring material from boulder falls, several of which have distinct boulder trails indicating where the material originated. These stops are the best opportunity to gain insight into deep crustal lunar materials that were uplifted during basin formation. Finally stops 10 through 15 all visit fresh impacts into the regolith on the basin floor exposing both boulders and subsurface materials.

At stop 12, approximately halfway through the nominal traverse path, we have mapped an optional return path to the lander due to relative proximity of the rover and lander at this point in the traverse and favorable terrain between the two (see white dashed line in Figure 1). At this point in the traverse the rover will have examined and sampled a majority of the types of materials necessary to fulfill the four main science objectives of the mission. At this point in the mission, if minimal sample space remains or if any mechanical issues arise with the functioning of rover platform, the rover can head directly back to the landing site and deposit all collected samples into the return capsule. This shorter traverse path would be ~54 km in total distance. If there are no operational issues and ample sample space remains, the rover would continue along the remainder of the nominal traverse route.

The final leg of the proposed traverse brings the rover across nearly the entire width of the pyroclastic deposit. This portion of the path has been designed to enable multiple samples of pyroclastic material to be collected at varying distances from the main vent. These samples would enable compositional comparison and potentially identify the thickness of the pyroclastic layer across the entirety of the deposit. This portion of the traverse is strategically positioned at the end of the primary mission traverse, allowing for the remaining sample space to be filled with these pyroclastic regolith samples. The final stops of the nominal traverse path bring the rover close to the rim of the pyroclastic vent in order to obtain imagery of the vent interior. After observing the vent interior, the rover returns to the initial landing site and transfers all collected samples to the ascent vehicle.

Stops 19 and 20 serve dual purposes as navigational assessment points in order to assess whether the rover is able to cross the large fissure to the north of the pyroclastic vent. These stops are included with the expectation that following the primary mission traverse and sample collection, the rover platform would continue on across the basin floor toward the mare deposits where an extended traverse would allow for additional sample collection and surface analysis.

Conclusions: The results of this science maturation study will aid Canada in its future contributions to the HERACLES mission concept as part of an international effort to return humans to the lunar surface.

Acknowledgements: The authors are very grateful to the CSA team, Vicky H., Tim. H., Martin P., and James D., among others for their support of the science maturation contract..

References: [1] Hiesinger et al. (2019) LPSC *L* (This Conference). [2] Osinski et al. (2019) LPSC *L* (This Conference). [3] Hiesinger and Head, (2006) New Views of the Moon, 60, Min. Soc. of America, p. 1-81.

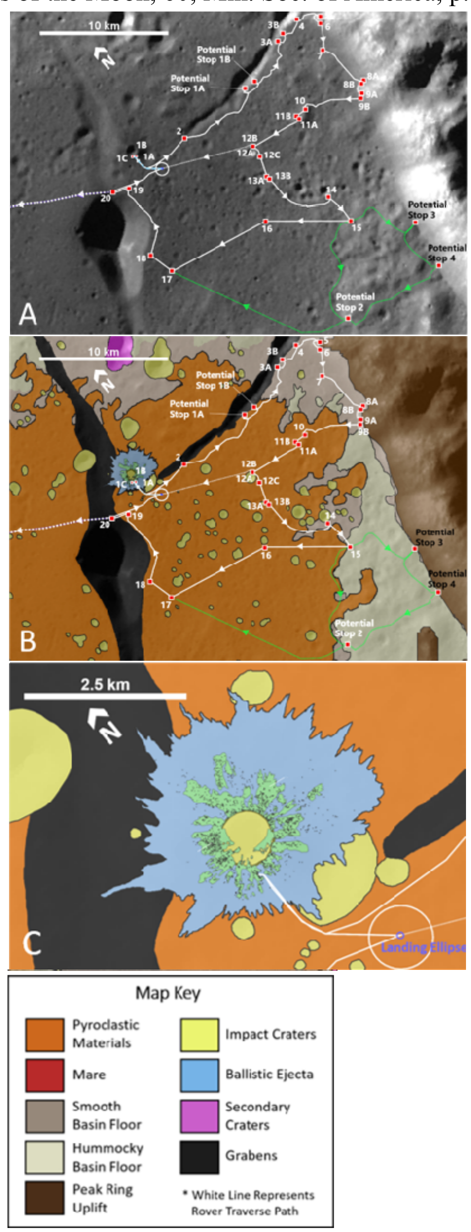

Figure 1 - Proposed rover traverse within Schrödinger Basin.