A LONG DURATION HUMAN-ASSISTED ROBOTIC SAMPLE RETURN MISSION TO THE SCHRÖDINGER BASIN PART 2: TRAVERSING TOWARDS THE BASIN WALL. D. J. P. Martin[1], F. E. McDonald[1], E. S. Steenstra[2], S. Paisarnsombat[3], C. S. Venturino[4], S. O'Hara[5], A. Calzada-Diaz[6], M. K. Leader[7], S. Bottoms[8], K. K. Klaus[9], D. Hurwitz-Needham[10], and D. A. Kring[11], [1]University of Manchester, (dayl.martin@manchester.ac.uk), [2]Vrije Universiteit, [3]University of New Brunswick, [4]University of Buffalo, [5]University of Illinois at Chicago, [6]Birkbeck University of London, [7]University of Texas, [8]University of Colorado, [9]The Boeing Company, [10]Goddard Space Flight Center, [11]Lunar and Planetary Institute.

Introduction: Sample return missions to the surface of the Moon are required to resolve most of the important lunar science goals identified by the National Research Council [1]. As there is currently no infrastructure for human missions to the lunar surface, it is likely that robotic exploration will be the next step forward in addressing those science goals.

Previous studies have identified locations that maximize scientific return [2], with the Schrödinger basin highlighted as one of these top priority landing sites. Based on that outcome, a short-duration (1 lunar day) human-assisted robotic mission concept was previously designed for a small region in the inner basin [3]. Here, we expand that traverse for a longer-duration human-assisted sample return mission.

Schrödinger Basin: Located on the farside of the lunar surface, Schrödinger is a ~320 km diameter peak-ring basin and the second youngest impact basin on the Moon (Figure 1) [4]. As it is situated within the South Pole-Aitken basin (the oldest basin on the Moon), returned samples may be able to provide constraints to the start and end of the basin-forming epoch and test the lunar cataclysm hypothesis (two of the highest priority science goals [1]).

HERACLES: This study builds on the short-duration mission concept by extending the mission to a 3 year traverse. The extended traverse was developed for an ESA-led study of the HERACLES concept, currently being considered by the International Space Exploration Coordination Group (ISECG) for the Global Exploration Roadmap (GER). The concept involves a tele-operated rover that is deployed on the surface and collects three sets of samples that are launched into lunar orbit by a reusable ascent vehicle. This concept involves crew in Orion and an Exploration Augmentation Module (EAM) stationed at the second Earth-Moon Lagrange Point (L2) that provides: (1) continuous communication between the rover and Earth, (2) an opportunity for astronauts to visit L2 and remotely control the rover, and (3) a docking station for a sample-return container from the lunar surface [5]. Crew in the EAM then return the samples to Earth in Orion.

Traverse Routes: Two routes were designed: one that goes from the basin center to the basin wall (described here) and another that remains in the basin center [6]. The traverse route begins where the first lander deploys a rover near the inner edge of the eastern peak ring. The rover is then driven to the central-southern inner basin and the southern basin wall (Figure 2). The length of the traverse is ~291 km and, based on a basic operations study, can be accomplished well within the 3-year timeframe of the HERACLES concept.

Landing Site/Section 1: The first section of the traverse is an anticlockwise loop from the landing site to the peak ring and back to the landing site. This section is designed to maximize scientific and exploration results with a continuous feed of *in situ* measurements and the first set of farside samples returned to Earth. The peak ring consists of pyroxene- and olivine-rich lithologies (possibly norite and troctolite, respectively) along with anorthosite [7]. The rover will collect samples of each lithology from small boulders at the foot of the peak ring that have been traced to outcrops upslope. These samples of the mid- to lower crust [8] can be used to: (1) test models of the lunar magma ocean, (2) test models of peak ring uplift, and (3) provide a critical comparison of pristine farside and nearside material. Regolith samples will also be collected along this route and, to the north of the ring, a fracture thought to be associated with the nearby pyroclastic vent will be investigated.

Section 2: The second section of the traverse is the longest and will investigate an immense pyroclastic vent (and associated deposits), freshly excavated peak ring material (due to a recent impact), a secondary crater field (mostly formed from the nearby Antoniadi impact), and material that has recently slumped from the basin wall into the inner basin. The pyroclastic vent is of great interest as it is possesses a permanently shadowed region and may contain significant amounts of usable resources suitable for *in situ* utilization on future, long term missions [9]. Multiple samples of the pyroclastic deposit will be collected in order to investigate any lateral changes in age, composition, and potential resources with lateral distance from the source vent.

A fresh crater, excavating the center of the peak ring, exposes multiple lithologies as determined by M^3 reflectance spectra from the crater walls [7]. Samples from the ejecta blanket at the foot of the peak ring will be collected to compare with peak ring lithologies from the first section of the traverse and will aid in the investigation of peak ring and basin-forming processes.

It may be possible to determine the age and composition of the Antoniadi impact and its target lithologies by collecting regolith material from the secondary crater field. An initial investigation suggests the area may contain up to 15% of material ejected from Antoniadi. As such, multiple samples of material from these secondary craters will be collected for further analysis.

Section 3: The final section of the traverse focuses on an investigation of lithologies in the basin wall in the southern region of the Schrödinger basin. The basin wall is likely composed of upper-crustal lithologies that have been exposed at the surface due to modification processes following the impact. As the Schrödinger basin is situated within the modification zone of the South Pole-Aitken basin (SPA), the upper crustal units exposed inthe basin wall of Schrödinger likely contain some portion of unmodified SPA melt-bearing ejecta [10]. As SPA is thought to be the oldest (albeit of uncertain age) and largest (>1000 km) basin on the Moon, finding pristine SPA material will allow the exact age of the SPA impact to be determined [10] and, thus, anchor the beginning of the basin-forming epoch.

Conclusion: This study identified 66 sites of interest within the Schrödinger basin to be investigated by a tele-operated rover. A total of 16 of these sites have also been targeted for sample collection of major lithologic units within the basin. The traverse begins near the inner peak ring and terminates at the southern basin wall, providing access to the peak ring (at multiple locations), a pyroclastic deposit, the melt sheet, a secondary crater field, and the basin wall (at multiple locations). The traverse provides samples that address a majority of identified science goals [1]. In contrast to another candidate traverse [6], this one does not access mare deposits, but it provides the best opportunity for retrieving samples of SPA impact melt.

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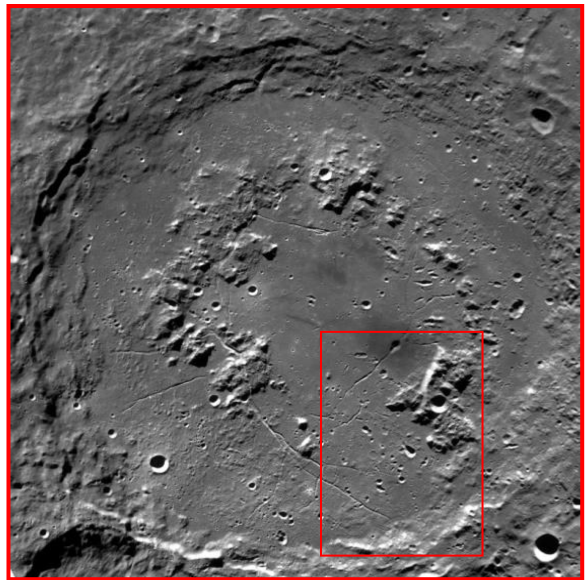

Figure 1*: A WAC image of the Schrödinger basin. The box represents the area shown in Figure 2.*

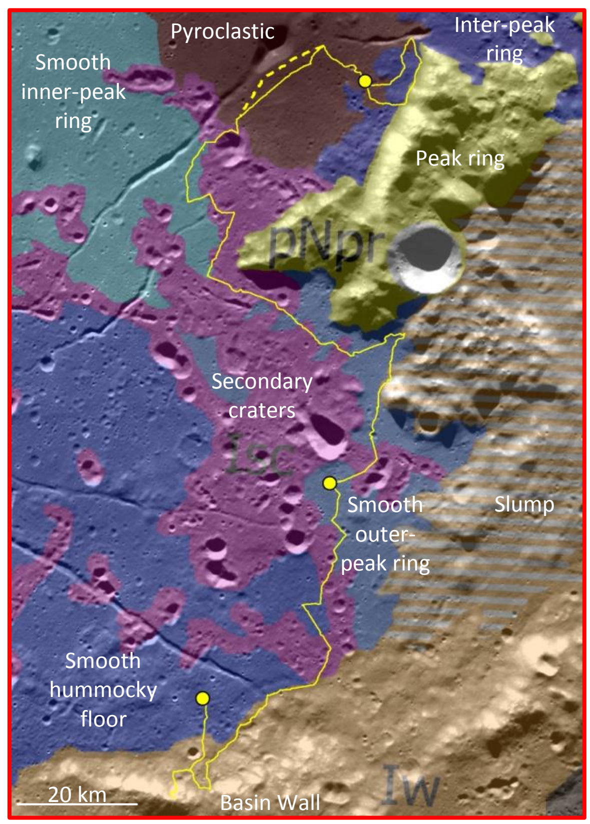

Figure 2*: The traverse route from the peak ring to the basin wall. The dashed line represents a possible route to visit the edge of the pyroclastic vent. Landing sites are represented by yellow dots. Basemap is the WAC image overlain with the geological map [7].*