LUNAR FIELD EXPLORATION SCENARIOS FOR A SOUTH POLE OUTPOST. P.E. Clark[1], J. Bleacher[2], S. Mest[3], N. Petro[2], and L. Leshin[2], [1]Catholic University of America (Physics Department), [2]NASA/GSFC, [3]Planetary Science Institute; all@NASA/GSFC, Greenbelt, MD 20771, Pamela.E.Clark@NASA.gov.

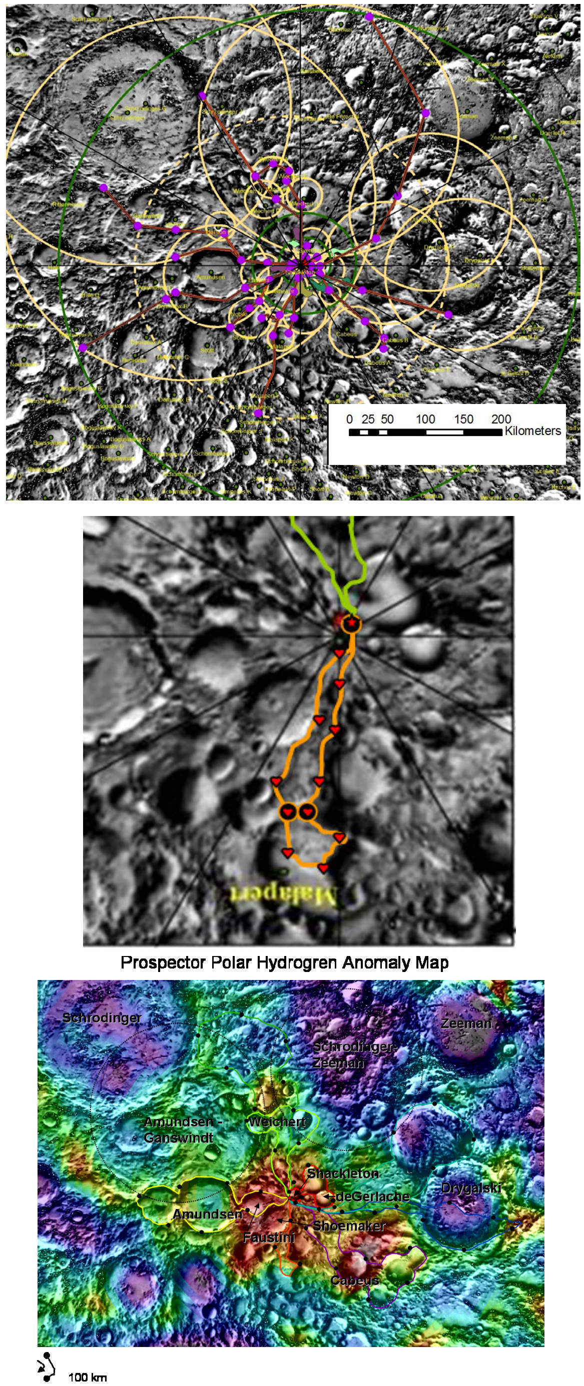
Purpose: The work reported here responds to the need to provide the Constellation Program Office Lunar Surface Systems Project with science requirements for lunar surface system architecture and metrics for lunar surface system operations, and to do so in a way that addresses lunar science goals, as most recently stated by the Lunar Exploration Working Group (LEAG) [1]. In response, the Surface Science Scenarios Working Group (chaired by Laurie Leshin) of the NASA HQ Outpost Science and Exploration Working Group (OSEWG) is attempting to develop science-driven lunar surface activity scenarios utilizing a small of lunar scientists with combined expertise for planning and executing lunar field studies on scales ranging from tens to hundreds of kilometers [2,3]. Operations groups have already begun to use mathematical models for field operations to maximize 'science return' in terms of metrics like EVA time, samples collected, and distance covered. For these such approaches to be sound, they must consider an actual connection to the geology of a given site The metric approach without that input does not maximize scientific significance of potential field excursions. Here, we are reporting contextual to regional traverse plans in South Pole Aitken Basin [2], some of them originating from the identified outpost site at Shackleton, complementary to ongoing efforts towards local scale (10 km radius) exploration planning from sortie sites using the Apollo extended J mission model.

Approach and Methodology: NASA has considered a variety of exploration strategies for the return to the Moon, ranging from an outpost model 'in the middle of nowhere' from a science standpoint, but potentially allowing for field exploration of progressively greater duration and mobility, to variable duration sorties involving landing at sites of particular scientific interest. Here, we discuss science activity scenarios and requirements for exploration at scales ranging from tens to hundreds of kilometers from the outpost, as well as hundreds of kilometer scale exploration at sites of particular interest, lying mostly well to the north of the outpost, within South Pole Aitken Basin. Local scale (Apollo J mission) sorties require careful advance planning and a degree of luck to select an optimal site to 'sample' a particular feature. Contextual to regional scale field studies significantly enhance what is learned locally, while providing flexibility and enhancing insight into major science questions using carefully selected sites.

We plan extended routes using standard field geology methodologies. Preliminary reconnaissance is based on assessment of digital remote data and interpretive maps. Stations for study are located where the best indications of the stratigraphy (as surface or near-surface exposures), structure, and origin of a local feature (e.g., volcanic dome) or terrane (e.g., basin) are (a) along a most accessible route (in terms of overall relief) and (b) best sampled and documented in situ using the least possible number of field camps or sites. Scenarios scientific merit is considered in terms of the advancement of high priority science objectives, as identified in the latest LEAG roadmap).

Rules and Tools: We assume the mobility capabilities of the most mature version of lunar surface architecture now being considered as well as Apollo 'ground rules' for crew activities [4] (continuous EVA time (8 hours), walk back from any rover <10 km) and Apollo J mission logs to indicate reasonable mobility of a roving vehicle (average 5 to 10 km/hour, driven about half of the time during a multi-stop EVA). We also assume 2 rovers in the field, a minimum crew of 4, availability of Apollo geology/sample collection/documentation tools, plus audio/video feed to the ground and additional handheld, rover-mounted, and laboratory tools not available during the Apollo missions, ranging from simple field spectrometers to ground-penetrating radar. We also consider the deployment of one or more automated science stations (ALSEP equivalent) as part of some scenarios as appropriate.

Scenarios: The largest and oldest confirmed basin on the Moon, SPA is the most prominent farside feature and, particularly in its northern portion, gives access to volcanic basalt flows of distinctive composition and underlying farside stratigraphy, which could include deep crustal to upper mantle material. Thus, many science objectives could be addressed. Features of particular interest include (1) Olivine Hill [5], apparently rich in Mg Suite materials near Bose crater in the center of SPA near exposed basin floor, (2) Oppenheimer-area pyroclastics [6] along the northern edge of the basin, (3) Mare Ingenii, with its antipodal magnetic swirl, Th anomaly, and complex terrain, in the northwest, (4) Imbrium-age Schrödinger basin in the southwest, with its volcanic deposits, and (5) the basin structure itself including outer rings exposed on both sides of the South Pole (including Malapert). A regional scale exploration could be envisioned as a series of trips originating in northern SPA traversing



Regional SPA Science Exploration Scenarios from the outpost, including 'regional scale' routes under 500 km to Schrodinger and Malapert, from outpost (top and insert), Bombardment History Study traversing Crater continuous ejecta blankets to rims (middle) ranging from tens to hundreds of km from outpost, and trips to surrounding range of H anomalies including Faustini (75km), Amundsen (143 and 180 km), Cabeus (202 km), and Drygalski (340 km) (bottom).

north, northwest, or south/southwest (features 1-3) [7] or originating near the south pole traversing to points north (4-5).

We have also developed scenarios for three major science thrusts that could address high prioirity science objectives for field exploration from the outpost on scales ranging from tens to hundreds of kilometers: 1) Structure of SPA Basin, with Malapert and Schrodinger as principal targets and emphasis on site and subsurface structural survey and representative rock collection; 2) Bombardment History and Stratigraphy of the South Polar Highlands with emphasis on systematic surface and subsurface soil collection along traverses of ejecta blankets and rock collection representing deepest strata penetrated at crater rims, followed by extensive modeling of geochemical and geochronological data as a function depth and surface location; and 3) Volatile anomaly and inventory study, with emphasis on determining origin and nature of polar volatiles by obtaining measurements at cold traps and contextual measurements of regolith in the polar region.

Issues: Contextual (tens of km) to Regional (hundreds of km) Scale (distance covered) mobility is required for reasonable priority science from an outpost 'in the middle of nowhere' from a science standpoint. Capability for such scale increases as mobility increases at the outpost, enabling greater 'ground truth', providing regional context for samples collected and sites characterized near the outpost and thus contributes to addressing science goals. As mobility increases, more targets of interest can be combined on a given field trip. All of these scenarios can be accomplished (return to habitat) within 2 weeks of daylight, with similar equipment to local scenarios, but with additional mass for expendables (sample supply kits and life support) using a practical approach to the use of 4 crew members and SPRs that takes best advantage of their capabilities and mitigates their disadvantages. The availability of high quality topography and surface roughness data will greatly enhance the capability to plan field study scenarios. LRO will provide considerably improved data of that nature, but, for detailed route planning, such data with resolution on the scale of a meter or less will be crucial.

References: [1] LEAG; [2] Clark et al, 2008, NASA Lun Sci Conf Proc, 2030.pdf; [3] Bleacher, Clark, Mest, Petro, 2009, this publication; [4] NASA History Office, Apollo Surface Journals, http://www.hq.nasa.gov/office/pao/History/alsj/frame.html, accessed December 30, 2008; [5] Pieters et al, 2001, Lun Plan Sci XXXII, 1810.pdf; [6] Rosanova et al, 1998, Lun Plan Sci XXIX, 1710.pdf; [7] Petro, Clark, Bleacher, and Mest, 2009, this publication.