Operational Testing and Analysis of Field Portable Instrument Datasets During the 2022 RISE2 Analog Lunar EVAs. Z. R. Morse[1,2], P. Whelley[3,2], C. Achilles[2], D. Rogers[4], J. M. Hurtado, Jr.[5], B. Feist[6,7], J. Richardson[2], and E. Bell[3,2], N. McCall[2], L. Wike[3], K. E. Young[2], C. L. Kostak[8,7], D. Welsh[8,7], D. Coan[7]. [1]Howard University, Washington DC, 20059, [2]NASA GSFC, Greenbelt, MD, 20771, [3]University of Maryland, College Park, MD, 20742, [4]Stonybrook University, Stony Brook, NY, 11794, [5]University of Texas at El Paso, El Paso, TX, 79968, [6]Jacobs, Houston, TX, 77058, [7]NASA Johnson Space Center, Houston, TX, 77058, [8]Wyle Services, Houston, TX, 77058.

Introduction: The Remote, In Situ, and Synchrotron Studies for Science and Exploration 2 (RISE2) team is a NASA Solar System Exploration Research Virtual Institute (SSERVI) node. Theme 2 of RISE2 is focused on the development of deployment strategies related to handheld and astronaut-deployable geologic instruments in lunar analog environments. In April 2022, the RISE2 team continued a series of field deployments to the Potrillo Volcanic Field in southern New Mexico. The team visited two field sites at Kilbourne Hole and Hunts Hole volcanic maar craters (Fig. 1). The goal of the 2022 deployment was to conduct a series of analog Extra-Vehicular Activity (EVA) scenarios to assess how astronauts might use a suite of handheld or portable geologic field instruments in different situations. These EVAs all followed a set path and provided participants a set of options at each station. The EVA would progress in different ways depending on the choices made. A strong emphasis was placed on observing the decision-making process undertaken by the astronauts in each EVA scenario to help assess which datasets contributed to completing specific scientific and operational goals.

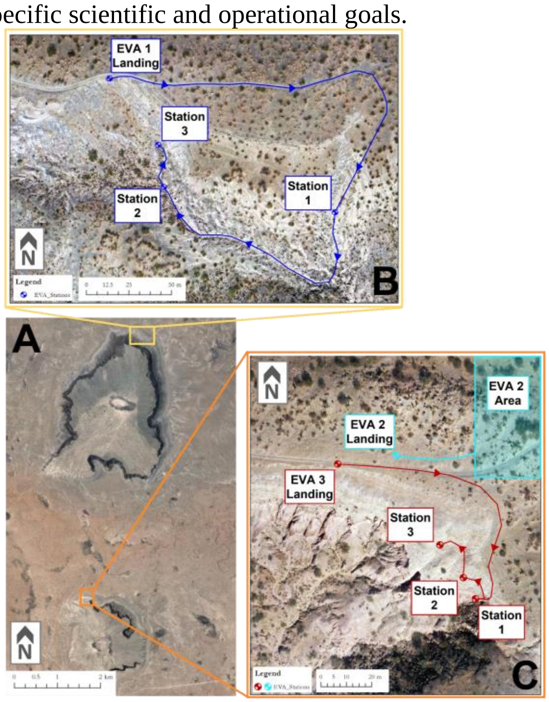

Fig. 1. – (A) Map of Kilbourne Hole and Hunts Hole field sites. (B) EVA 1 traverse path and stations. (C) EVA 2 and EVA 3 traverse paths and stations.

Three EVA Scenarios: EVA 1 was conducted at Kilbourne Hole and EVAs 2 and 3 were conducted at Hunts Hole (Fig. 1). Each EVA scenario was designed to include two analog astronauts and be completed in 60 to 90 minutes. All three scenarios were run multiple times with different participants to generate data on the decision-making process. Each EVA was facilitated by an in-person handler who walked with the astronauts and guided the EVA from a script. The EVAs involved traversing between a landing site and a series of predetermined stations. The pair of astronauts were guided between each station to remove navigation and path-finding variables from the test. Upon arriving at each station, the astronaut pair was asked to make initial observations about the geologic setting and identify features of interest related to the specific EVA goals. Participants were then given a limited amount of precollected field instrument data and asked to make *in-situ* interpretations based on the provided information. The EVA scripts would then guide the participants to a multiple-choice decision point, giving the participants options to (a) collect additional data, (b) collect a geologic sample, or (c) move on to the next EVA station. The selected option would then then determine the next portion of the EVA script. Each decision was carefully recorded by the EVA handler and captured via video and audio recordings to determine what factors contributed to the collection of additional data or samples in each situation. Additional pre-recorded data was made available if the astronauts chose to collect additional data at any of the EVA stations. Data collected by experts during previous field deployments [1, 2, 3] was used in this test to eliminate variables related to instrument use in the field and ensure that high-quality data was used in the decision-making process. These datasets were provided during the EVA as paper printouts of images, graphs, or tables (Fig. 2).

EVA 1 – Identifying Xenoliths: The traverse path for EVA 1 was located among volcanic ash bed deposits and blocks of a basaltic lava flow at the north rim of Kilbourne Hole. The traverse path included three separate stations at varying topographic elevations. The operational goal for EVA 1 was to collect at least one rock sample at each of the three stations. The scientific goal for EVA 1 was to collect a diverse suite of samples to test planetary differentiation hypotheses, and specifically to collect samples containing clinopyroxene, quartz, and olivine. Data provided during this EVA included: (a) compositional data from a field portable handheld X-Ray Fluorescence (XRF) instrument displayed numerically as weight % tables and graphically in a ternary diagram; (b) colorized compositional data from a portable Hyperspectral Imager (HSI) presented as a series of color images; and (c) LiDAR reflectance data provided as color images. Uncrewed Aerial Vehicle (UAV) images of the traversed area and Kilbourne Hole were also provided at the start of the EVA. This scenario was completed by 8 analog astronaut pairs during the 2022 field deployment.

EVA 2 – Geophysical Survey: EVA 2 simulated the deployment of multiple geophone lines for active seismic surveys at the north rim of Hunts Hole. The operational goals for this scenario were: 1) Deploy 2 to 3 linear geophone arrays and simulate a series of active seismic sources, and 2) Determine a location with a specific depth to a basalt layer. The scientific goals for this scenario were: 1) Understand the surface and subsurface geology at the rim of a maar crater, and 2) Determine the optimal location with volatiles at a specific depth. Data provided during this scenario included simulated seismographs and seismic velocity layer models, based on previously collected seismic data at this site. UAV data was also provided for context. This scenario was completed by 6 astronaut pairs during the field deployment.

EVA 3 – Surge Bed Analysis: The third EVA scenario consisted of three stations at progressively higher stratigraphic exposures of surge bed deposits at Hunts Hole. Operational objectives for this EVA included: (1) collecting *in-situ* compositional data at each station; and (2) collecting at least one sample at Station 2 and one sample at Station 3. The science objective for this EVA was to collect data and make observations to help understand the history of the layers present at Hunts Hole. Data provided during this scenario included (a) the numerical and graphical XRF composition data; (b) the colorized HSI mineral maps; and (c) colorized LiDAR reflectance data for the layers of the surge bed deposits. This EVA scenario was completed by 9 astronaut pairs during the 2022 field deployment.

Post-EVA Surveys & Data Recording: A brief survey was conducted with the astronauts after each EVA in order to gather qualitative input from the participants on the usefulness of each dataset in select instances during the EVA. During each EVA, at least one astronaut wore a chest-mounted GoPro camera that recorded video and audio of the entire EVA. Both the written notes and video recordings were used after the field deployment to analyze the decisions made during each EVA. Additionally, transcripts of the dialogue captured in the video recordings were generated using speech to text software. These transcripts allow for simple text analysis of conversations that occurred during the EVAs, including the identification of keywords common to tasks of data or sample collection.

Fig. 2 – (Bottom) EVA participants study provided HSI data. (Top) HSI colorized mineral map showing quartz (red), olivine (green), and clinopyroxene (blue).

Results & Major Take-Aways: Participants in all EVAs were able to successfully meet the objectives with the data provided. Analysis of the syn-EVA observations and post-EVA surveys shows that image-based data (e.g., the HSI mineral maps) or graphical data (e.g., the XRF ternary diagrams) were preferred to data displayed as longer alphanumeric lists or tables. Analysis of astronaut decisions during EVAs 1 and 3 shows that participants tasked with identifying samples to collect tended to start with data that covers a wider geographic area before collecting additional focused data to confirm morphology or composition of geologic features. Analysis of EVA2 shows that subsurface datasets can effectively guide astronauts in collecting data or placing instrument packages. Additionally, we believe that expanded instrument training would result in more efficient use of datasets during EVA scenarios. Finally, we found that adding additional constraints to the analog scenarios – such as a sample mass limit, operational time limit, or time limits for specific field actions – would serve to increase the fidelity of the test and drive more realistic usage of the datasets.

Future Work: The lessons learned from the 2022 field deployment will shape the upcoming 2023 RISE2 EVA tests. We plan to increase the amount of pre-test hands-on training and to include real-time data collection to increase the fidelity of the planned analog EVAs. Real-time data collection will allow a more dynamic data-driven exploration experience and place more accurate time constraints on field operations.

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References:[1] Knudson, C. A. et al., (2023) LPSC (this conference), [2] Rogers, A. D. et al., (2022) LPSC #1977 [3] Whelley, P. et al., (2022) LSPC #2882