Geology of the Fall 2021 TREX SSERVI Autonomous Rover Field Sites. N.C. Pearson[1], G.P. Kramer[1], S. Wright[1], G. Holsclaw[2], M.E. Borrelli[3], A. Hendrix[1], E.Z Noe Dobrea[1] and the rest of of the TREX team. [1]Planetary Science Institute (1700 E. Fort Lowel Rd, Ste 106, Tucson, AZ--npearson@psi.edu), [2]Laboratory for Atmospheric and Space Physics, U. Colorado, Boulder, CO. [3]ASU School of Earth and Space Exploration, Tempe, AZ.

Introduction: In November of 2021 the NASA SSERVI Toolbox for Research and Exploration (TREX) team tested an autonomous rover system (Abstract 1674, this Session [1]. To do so, two field sites in Northern Arizona were selected. As part of the test for the autonomous rover system and remote science team, a field geologist and group of field instrument operators studied the geology on site to give site descriptions that we detail here along with the background geology.

Background and Location:
Field Site 1 was located 55km North-Northeast of Flagstaff, AZ and will be referred to as Black Mesa in this abstract. Field Site 2 was located East-Northeast of Tuba City, AZ and will be referred to as Blue Canyon. These locations are shown in Figure 1 below. Both of these field sites are located on the Colorado Plateau, a region of generally flat lying Paleozoic and Mesozoic sedimentary rocks that has been locally deformed in areas through folding and faulting. Areas of the Colorado Plateau including one of our field sites has been intruded by generally basaltic volcanism, forming flows and cinder cones ranging in age from 20MA to 1KA [2].

Figure 1: Field Site locations shown in relation to Flagstaff, AZ. Yellow bar at the bottom is 50Km long

Site 1: Black Mesa
Black Mesa was characterized by 4 major geologic units. The lowest and youngest was a generally flat lying light tan limestone to dolostone that was fossiliferous and contained silica nodules, identified as the Harrisburg Member of the Kaibab Formation (Lower Permian [3]). It was tilted at varying strikes and dips in the southwest portion of the field area indicating faulting or folding had occurred as shown in Figure 2. Above this was a fine grained red sandstone to siltstone with ripple marks, identified as the Wupatki Member of the Moenkopi Formation (Lower Triassic [3]). It was seen as generally flat lying, forming hummocky hills and had at least one sinkhole identified in the field area. Further up the section was a medium to coarse grained red sandstone identified as the Shnabkaib Member of the Moenkopi Formation (Lower Triassic [3]). It was generally characterized as a discontinuous cliff forming unit with cross stratified beds. At the top of the sections was a dark generally vesicular basalt flow. The basalt flow varied in thickness from 0.5-3m and formed a resistant capping unit. Phenocrysts from 1mm to 5cm of calcium-sodium plagioclase were common, and rare phenocrysts of olivine 1-2mm in size were identified as well. This unit is identified as the Black Point Basalt Flow and is Pliocene in age [2].

Figure 2: Tilted dolomite beds in the Black Mesa field area.

Site 2: Blue Canyon Blue Canyon was characterized by 2 major units. The lowest was a white medium grained sandstone that turned into shale and coal beds further up in section, identified as Dakota Sandstone (Upper and Lower Cretaceous [4]). The sandstone contained cross bedding in areas, was shown to have kaolinite cementation, and included large amounts of iron concretions ranging in size from 1 to 10cm. This white sandstone graded into beds of siltstone to fine sandstone with some beds of carbon rich siltstone and lignite coal. The siltstone layers contained ripples, shell fossils and fossilized wood. Exposed portions of the coal bedding had caught on fire and had locally altered shale areas to produce natural impure glass-slag. Areas where unignited coal beds had been exposed exhibited weathering to jarosite, alunite and gypsum (mineralogy confirmed with VNIR spectroscopy) likely due to weathering of sulfides in the coal and geochemical interactions with carbonate beds. This unit dominated the western edge of the field area and formed a monocline with varying dip and generally striking North. Toward the central and eastern side of the field site the dip of bedding shallowed with more of the siltstones and coal layers preserved and eventually capped by the younger second unit. This younger second unit was identified as the Mancos Shale (Upper Cretaceous [4]) and was mainly characterized by dark grey expansive clays with thin beds of fossiliferous carbonate and salts. Highly broken fossils of *Gryphaea,* ammonites, coral and shark teeth were some of the fossils found in these layers, shown in Figure 3. The highly broken nature of these fossils and fine grain sediments surrounding them suggests this unit was deposited in the deeper ocean with shell fragments transported and deposited during storm events.

Figure 3: Shell fragment bed with salts and dark grey clay in the Mancos Shale.

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References:

[1] Noe Dobrea et al. (2022) LPSC LIII Abstract #1674. [2]Fillmore (2011). [3]Billingsley, G.H. et al. 2007. [4] Haynes, D.D. and Hackman, R. J. (1977)