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PREPARING FOR ARTEMIS: THE IMPORTANCE OF FIELD GEOLOGY TRAINING IN HIGH FIDELITY IMPACT ANALOGUE SITES

Abstract

As the international community prepares to return humans to the Moon there is a growing awareness of the need for field geology training at lunar analogue sites , not just for the Artemis astronauts, but for the managers, engineers, and other personnel who will be involved in mission design and operation. The value of such training was demonstrated during the Apollo missions, in particular the later J-class missions. In advance of the first of the three J missions, Apollo 15, the astronauts conducted 18 geology field trips in the months leading up to the mission, more than triple the number for Apollo 14.

The Artemis III Science Definition Team Report specifically recommends that "astronaut geology field training will evolve for the next cohort of astronauts to be specifically tailored to Artemis program needs to maximize the value of astronaut fieldwork in the unique lunar environment." The sites being considered for Artemis III – the first lunar surface mission – and subsequent early missions are in the lunar highlands, complex terrain featuring a myriad of meteorite impact craters, superposed by, and intermixed with, ejecta from large basin-size impacts. Field geology training in impact cratering processes and products will be key for the success of these early Artemis missions.

During the Apollo missions, three meteorite impact craters were visited: Meteor Crater (Arizona), visited on several occasions; Ries (Germany) for Apollo 14; and Sudbury (Canada), for Apollo 16 and 17. All three sites are interesting for different reasons; however, there are significant limitations in terms of their appropriateness as lunar analogue sites, such as target rocks dominated by sedimentary rocks (Meteor Crater, Ries) or their age and post-impact deformation and metamorphism (Sudbury). It is proposed here that a new suite of meteorite impact craters in the Canadian Shield be considered for Artemis field geology training. Most notably among the 30 confirmed impact craters in Canada is the 28 km-diameter Mistastin Lake impact structure, Labrador. This crater is relatively young and well preserved, with well exposed impact breccias, melt rocks, and shocked materials. Critically, this crater formed in a target comprising anorthosite, the dominant rock type of the lunar highlands.

Other recommended sites include the 56 km-diameter West Clearwater Lake impact structure and the 100 km-diameter Manicouagan impact structure, which possess significant exposures of impact melt rocks and breccias. Sudbury is one of only two confirmed peak-ring impact structures on Earth – the other, Chicxulub, being buried off the Mexican coast – and the only terrestrial example of a large differentiated impact melt sheet, and should also be considered.

After taking the Artemis astronauts to Meteor Crater, a small simple impact crater that is easily accessible in northern Arizona, field expeditions to Mistastin and other Canadian impact sites are proposed. In addition to the geology training, it is noted that the remote Canadian impact sites such as Mistastin also provide unique opportunities for astronauts to hone their expeditionary skills, and are also excellent ways to engage the public in the spirit of exploration.