CAVE ICE: A TALE OF TWO ANALOG CAVES. T. N. Titus[1], K. E. Williams[1] and A. L. Gullikson[1], [1]U.S. Geological Survey Astrogeology Science Center, 2255 N. Gemini Dr., Flagstaff, AZ 86001.

Introduction: The possibility for cave ice on Mars has both astrobiological [1] and exploration implications [2]. Cave ice could provide a record of climate, habitability, and possibly habitation. Cave ice could also serve as a resource for human explorers as a source of liquid water, which could also be separated into hydrogen (for rocket fuel) and oxygen.

The presence of cave ice requires two conditions: (1) a source of water and (2) temperatures at or below freezing. On Earth, the water source can be from percolation through the cave overburden originating from the surface, from condensation of humid air onto cold interior surfaces, or from rain or snow blown in at the cave entrance. The ice deposition deep inside terrestrial cave interiors is typically attributed to percolation of surface water and transport of humid outside air.

Modern Mars is expected to have caves where ice is likely stable [3], and the water source is likely the active circulation of humid air into the cave. Percolation is not a viable process because liquid water is not stable on the Martian surface, or even the shallow subsurface.

At higher obliquities, percolation from snowmelt becomes plausible if the cave overburden is heavily fractured [4, 5].

Analog Sites: We have started monitoring cave ice at two locations within Coconino County, AZ. These two sites are Lava River Cave (LRC) and Sunset Crater Ice Cave (SCIC). LRC, located west of Flagstaff in the Coconino National Forest, has seasonal ice. SCIC, located northeast of Flagstaff in the Sunset Crater National Monument, has perennial ice. These two caves have different structures; LRC is a lava tube that extends over a km; SCIC is a “rubble pile” that likely formed as a fissure. The major water source for both caves appears to be percolation (Fig. 1), but SCIC also shows evidence of direct surface condensation from humid air (Fig. 2).

Methods: We are monitoring the surface and interior climate conditions of both caves to constrain ice stability. The measurements include temperature, humidity, and pressure. We are also identifying where and when ice forms and dissipates. (e.g. Figs. 1-3).

Summary: Instrumentation was deployed only a few months ago. However, at the time of the Terrestrial Analog Workshop, we will have ~6 months of data which may provide preliminary results for ice stability. When complete, the monitoring program will acquire one full year of data. The comparison of ice formation and stability within these two caves will provide insights into the presence and stability of cave ice on Mars.

Figure 1: Ice formations indicative of percolation. Credit: (Left) LRC. K.E. Williams. (Right) SCIC. A.L. Gullikson.

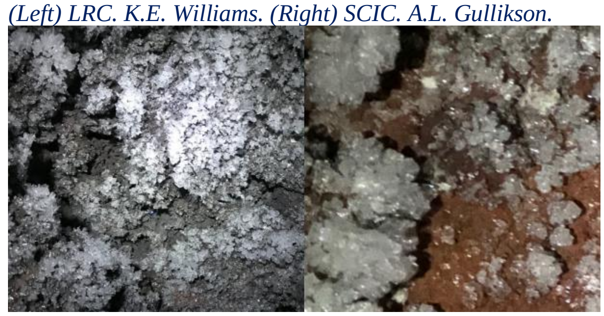

Figure 2: SCIC hoar frost, which is indicative of direct condensation of humid air on the cave interior wall. Credit: (Left) K.E. Williams. (Right) A.L. Gullikson.

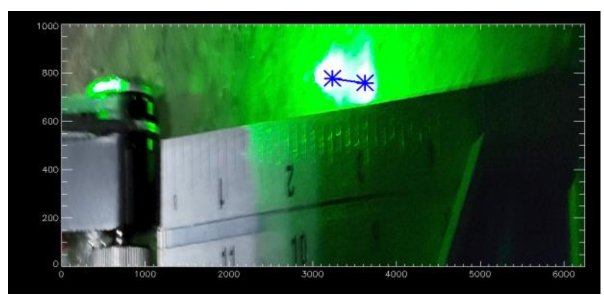

Figure 3: Example of using a laser pointer, protractor, and ruler to estimate ice thickness. Correcting for the index of refraction and the incidence angle; the horizontal distance of 1.2 cm converts to an ice thickness of 1.2 cm.

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References: [1] Carrier B. L. et al. (2020) *Astrobiol, 20(6)*, 785-814. [2] Boston, P., et al. (2004) *Gravit. & Space Biol. Bulletin*, 16(2), 121–131. [3] Williams, K., et al. (2010), *Icarus*, 209, 358. [4] Williams, K., et al. (2008) *Icarus*, 196, 565. [5] Williams, K., et al. (2009) *Icarus*, 200, 418.