THE CARBON COLD TRAP IN AMUNDSEN CRATER. N. Schorghofer[1], J.-P. Williams[2], J. Martinez-Camacho[3], D. A. Paige[2], M. A. Siegler[1,3], [1]Planetary Science Institute, Tucson, AZ (norbert@psi.edu), [2]University of California, Los Angeles, CA, [3]Southern Methodist University, Dallas, TX, USA.

Introduction: Water ice is expected to be trapped in permanently cold regions near the lunar poles. Other ices ("super-volatiles" or "hypervolatiles") are trapped at lower temperatures, close to the lowest temperatures measured within the lunar Permanently Shadowed Regions (PSRs). Cold-trapped CO_2 would be valuable for the production of fuel and biological materials [1]. Moreover, the interaction of carbon with galactic cosmic rays can produce organic compounds [2]. The thermal stability of solid carbon dioxide in the south polar region is determined by analysis of 11 years of temperature measurements by Diviner [3,4], a radiometer onboard the Lunar Reconnaissance Orbiter (LRO) [5].

Methods: CO_2 cold traps have previously been mapped based on model temperatures [6] or measured peak temperatures [7,8,1]. Cold traps are areas where the time-integrated sublimation loss is below a threshold value. Since peak temperatures prevail only during a fraction of the draconic year, lunar CO_2 cold traps are mapped based on time-integrated sublimation rates [5].

Diviner Reduced Data Records (RDR) from 5 Jul 2009 to 15 Dec 2020 were compiled into 6 ecliptic longitude bins and 24 subsolar longitude bins, for a total of 144 bins. The calibrated radiance measurements from Diviner channels 3–9 covering wavelengths from 7.55 to 400 μm were map projected onto a polar stereographic grid from 80°S to 90°S and converted to bolometric brightness temperatures [3,9]. Signal to noise ratios can be increased by spatial or temporal averaging of multiple individual measurements. The size of pixels was chosen as 500 m square at the pole.

To further validate the reliability of Diviner radiance measurements below 60 K, thermal model calculations were carried out for Cabeus Crater [5], which yield similarly low temperatures as inferred from the Diviner data.

Results: Spatially contiguous CO_2 cold traps exist in the craters Haworth, de Gerlache, and especially Amundsen (Fig. 1). Considering a threshold (delivery rate) of 10 kg $m^{-2}Gyr^{-1}$, the total CO_2 cold trap area in the south polar region is 204 km^2. Amundsen Crater hosts 82 km^2 of cold trap area, roughly 40% of the total CO_2 cold trapping area in the south polar region; a single contiguous patch of 65 km^2 resides on the floor of the crater. Other volatiles are also thought to be trapped on the floor of Amundsen Crater [10].

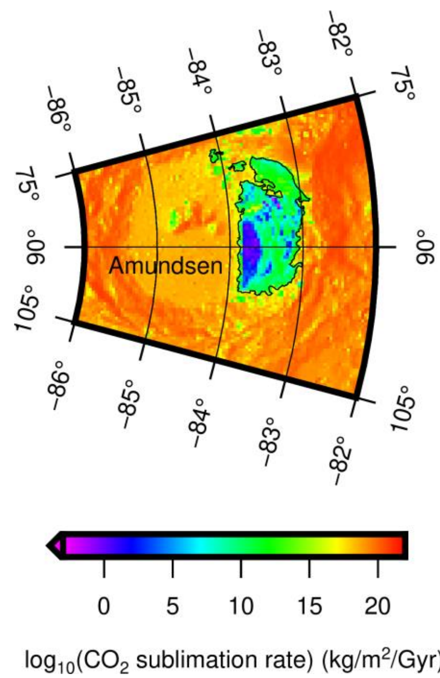

Figure 1: Potential sublimation rate of solid CO_2 in Amundsen Crater. The black contour shows the extent of the H_2O cold trap. Figure from Ref. [5].

Discussion: For in-situ resource utilization (ISRU) CO_2 can serve as a source of carbon for the production of steel, hydrocarbons (especially rocket fuel), and biological materials [1]. The fact that this resource is highly concentrated geographically has implications for the governance of the lunar surface [11]. Exploration of a large permanently dark area continuously at temperatures of 30–60 K will present significant technological challenges.

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