White Paper Submitted To
NASA Artemis Science Definition White Paper Call

EVA H_2O Release: Need for Measurements and Monitoring During Human Exploration of the Lunar Polar Regions

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Artemis astronauts are expected to conduct multiple EVAs (Extra-Vehicular Activity) to explore the south polar regions of the Moon. A key scientific draw to the lunar polar regions is the presence of volatiles in the lunar regolith's shallow subsurface, and also of exposed ices in some Permanently Shadowed Regions (PSRs) (e.g., Gladstone et al. 2012, Hayne et al. 2015, Fisher et al. 2017, Li et al. 2018). While the scientific investigation of these volatile concentrations and their assessment as potential resources will obviously be a high priority for Artemis astronauts, it will be important to not contaminate the volatiles occurring naturally on the Moon by volatiles brought in and released by human EVAs, and if some contamination were to occur, to understand in detail how any such contamination could affect naturally occurring volatile concentrations.

Among the volatiles of concern, H_2O is the most significant in terms of the magnitude of the potential contamination. Current EVA suit systems, such as the EMU (Extravehicular Mobility Unit), and presumably the xEMU to be used on Artemis, vent H_2O at a rate of ~0.5 kg/hr. The release of this H_2O is from the following three sources, listed indecreasing order of significance: 1) the Spacesuit Water Membrane Evaporator (SWME) system, 2) the Rapid Cycle Amine (RCA) system, and 3) distributed suit leakage.

This large amount of H_2O venting is of significant concern for the integrity of the volatile-related science to be conducted. To put things in perspective, orbital neutron spectrometry indicates that the lunar polar regions commonly contain water equivalent hydrogen (WEH) at a concentration of a few percent within the top ~1 m of the regolith. Consistent with this estimate, the LCROSS impact experiment has yielded an H_2O concentration of ~5% by mass within the topmost regolith at Cabeus Crater (Colaprete et al. 2010). Considering an average regolith density of ~1.5 g/cm^3, the uppermost 1 cm of lunar polar regolith could thus contain, at <5% H_2O by mass, <0.75 kg of H_2O per m^2. Thus, each spacesuit releasing ~0.5 kg/hr is a critical factor to measure, understand, and monitor (Rosenthal et al. 2020).

We propose and recommend to NASA that Artemis astronauts include as part of their early scientific investigation of the lunar south polar region, a plan to investigate their own potential environmental impact on lunar surface and near-surface volatile concentrations, in particular their own release of H2O during EVAs, including an assessment of the fate of any H2O released in proximity to, and within, PSRs.

The following investigations are recommended:

Pre Artemis III Launch:

A) Measure, model, and understand in a controlled, laboratory setting, the release of H_2O and other volatiles (e.g., CO_2) by lunar EVA spacesuits, e.g., the xEMU.

   Note that understanding H_2O and other volatile release from other surface systems, such as spacecraft and landed habitats, is also important, but given that EVAs will likely bring astronauts in close proximity to PSRs, and possibly within them, H_2O release from EVA suits is of the highest priority.

B) Define and adopt initial H_2O and other volatile contamination mitigation strategy.

During Artemis III Mission at Lunar South Pole:

C) Monitor H_2O and other volatile releases during EVAs on the Moon.

D) Carry out control experiments in small PSRs on the Moon, to investigate the fate of H_2O and other volatiles (CO2).

   For instance, do we observe real-time cold-trapping of EVA-vented H_2O onto permanently shadowed regolith or boulder surfaces?

E) Refine and Adjust H_2O and other volatile contamination mitigation strategies for future lunar polar missions.

References

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