Landing at ice exposures in the lunar polar regions

Shuai Li$^1$, Paul Lucey$^1$, and Mazarico Erwan$^2$

$^1$University of Hawaii

$^2$Goddard Space Flight Center
Introduction

• Water ice may be allowed to accumulate at PSRs on airless bodies
  – Only few mm ice can be sublimated in billion years at temperature < 110 K (Zhang and Paige, 2009).
• Direct evidence for surface exposure ice on Mercury and Ceres was found.
  – The exposed ice is relatively pure.
Introduction

• Direct evidence for the lunar surface exposed water ice in the lunar polar regions seen by the M³
  – The abundance is lower than that on Mercury and Ceres

Li et al., Submitted
Introduction

- Consistent with high LOLA albedo, LAMP band ratios, and temperature < 110 k.
- The distribution is patchy: 3.5% of the PSRs < 110 K.

Li et al., Submitted
Significance of landing at ice exposures

- Water ice is the importance in situ resources for utilization for future exploration of the Moon.

- It is critical for understanding the unique processes of deposition, transportation, and retention of ice on the Moon.
The distribution of lunar surface ice

- Associated with temperature < 110 K, but not all low temperatures show ice
The distribution of lunar surface ice

- True polar wander?
  - Ice must be very old, and rate of supply is very low

The stability depth of ice when the Moon was on its palaeo-axis

Siegler et al., 2016
The low abundance of lunar surface ice

- Slow supply of water and fast overturn of the top layer by impact?
  - The top 1 m layer will be erased by impacts every around 500 million years on the Moon, 3 billion years on Mercury (Costello et al., under review).
  - Explains the patchy distribution and low ice abundance
  - More ice could be beneath the surface, > 1m?
Possible landing sites

• Most ice exposures on the north pole are located at crater walls with very rough topography, min-max elevation > 4000 m.

South pole: Sverdrup crater

Min-Max elevation: ~250 m

Min-Max elevation: ~300 m
Possible landing sites

South pole:
Haworth-Shoemaker-Faustini

Min-Max elevation: ~270 m

Min-Max elevation: ~260 m

Min-Max elevation: ~200 m
Summary

• It will help to constrain the thickness and abundance of these deposits for future in situ resource utilization.
  – Drilling > 1 m depth is required.

• Dating the age of the ice helps to test the true polar wander hypothesis. These ice might be deposited before the polar wander (> 2-3 Ga ago?)
  – If it can be done in situ, no sample return is required.

• Measuring the rate of hydroxyl or molecular water migration.
  – The migration of molecular water (if any) should be extremely slow.
  – A mass spectrometer is required.

• Testing the hypothesis about the gardening effect. It could be more water beneath the surface but mixed with regolith and the abundance is low.
  – Drilling and in situ sampling from the deep is required.