A FRAMEWORK FOR THE HISTORY OF THE MOON'S POLAR ICE. A. P. Jordan[1,2*], J. K. Wilson[1,2], N. A. Schwadron[1,2], H. E. Spence[1,2], W. C. de Wet[1], and N. Petro[5], [1]EOS Space Science Center, University of New Hampshire, Durham, NH, USA (*email: a.p.jordan@unh.edu), [2]Solar System Exploration Research Virtual Institute, NASA Ames Research Center, Moffett Field, CA, USA, [3]NASA Goddard Space Flight Center, Greenbelt, MD, USA.

Introduction: Despite advances in remote sensing, it has been difficult to determine the history and distribution of water ice on the Moon. Interpretations of datasets can differ on crater-scales and smaller [e.g., 1]. Furthermore, trying to resolve these differences has often caused larger-scale features to be ignored.

Yet larger scales are important, because they can reveal the ice's history. For example, neutron albedo data can be explained by a relatively recent deposit centered on the poles and an offset deposit of ancient (>3.5 Gyr old) ice emplaced when the Moon's spin axis was different [2]. These features were found by looking at the large-scale, polar ice "caps."

Polar ice framework: For interpreting ice on large scales, we have created a framework with two components: polar ice's maximum concentration and extent. Siegler et al. [2] showed the importance of the maximum, and now we show the importance of the boundary of the ice "cap." These two components will help us determine the history of the polar ice.

This framework results in two basic scenarios. For example, a recent deposit of ice should be centered about the current pole, having a maximum at the pole and a boundary symmetric about the maximum/pole (Fig. 1). If, however, the deposit is old enough (> 3.5 Gyr [2]), its maximum will be offset from the current pole and its boundary will be centered on the maximum (Fig. 1). An admixture of ancient and recent ice [e.g., 2] would superpose these two scenarios, modified by any loss.

Polar ice with depth: We can apply this framework as a function of depth. For example, Siegler et al. [2] considered hydrogen at only one depth. Yet if surficial ice is recent [e.g., 3], then it may be symmetric about the current poles, unlike the buried ice [2]. In this case, the surface "cap" may not align with the buried "cap."

We show that such analysis is possible by synthesizing a range of observations. Surface data are from the Lyman Alpha Mapping Project (LAMP) on the Lunar Reconnaissance Orbiter (LRO) and the Moon Mineralogy Mapper (M3) on Chandrayaan-1. The deepest (~50 cm) data are neutron observations from the Neutron Spectrometer on Lunar Prospector (LP-NS) and the Lunar Exploration Neutron Detector on LRO. All four datasets show polar ice extending to ~±70°, as predicted [4].

Proton albedo can probe hydrogen at depths of ~1-10 cm, linking surface to neutron measurements [5]. Data from the Cosmic Ray Telescope for the Effects of Radiation (CRaTER) on LRO show that hydrogen increases with increasing latitude, but currently cannot show whether this occurs mainly above ±70°. Consequently, we have developed new techniques [6] to help us determine whether the ~±70° boundary is also in the proton albedo. We will report on progress made in this analysis. If surficial ice is indeed more recent than buried ice, proton albedo data will help show whether ice at ~1-10 cm is related more to the surface deposits or to the deeper deposits.

References: [1] Hurley D. M. et al. (2016), white paper,<http://sservi.nasa.gov/wp-content/uploads/2016/02/Volatiles_White_Paper.pdf>. [2] Siegler M. A. et al. (2016), *Nature, 531,* 480-484. [3] Gladstone G. R. (2012), *JGR, 117*, E00H04. [4] Watson K. et al. (1961), *JGR, 66*, 3033-3045. [5] Schwadron N. A. et al. (2016), *Icarus, 273*, 25–35. [6] Schwadron N. A. et al. (2017), *Planet. Space Sci., 296,* 99–109.

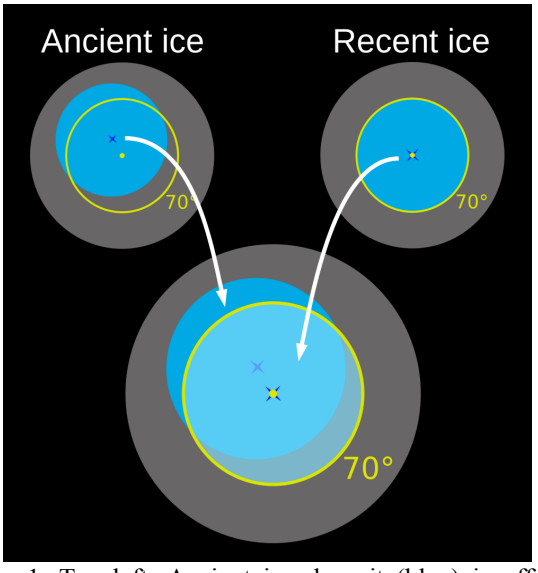

Fig. 1. Top left: Ancient ice deposit (blue) is offset from current pole (yellow dot); boundary is symmetric about maximum ("x"). Top right: Recent ice deposit is symmetric about current pole. Bottom: Admixture of two ice deposits. 70° latitude is predicted to be extent of ice [4].