CONSTRAINING MODELS OF WATER MIGRATION IN THE LUNAR SUBSURFACE Luís F. A. Teodoro[1], Richard C. Elphic[2], Vincent R. Eke[3], Matthew Siegler[4], Norbert Schörghofer[5], [1]BAER Inst., NASA Ames Research Center, Moffett Field, CA 94035-1000, USA; luis@astro.gla.ac.uk; [2]NASA Ames Research Center, Moffett Field, CA 94035-1000, USA, [3]Department of Physics, Durham University, Science Laboratories, South Road, Durham DH1 3LE, UK, [4]Department of Earth and Space Sciences, UCLA, Los Angeles, CA 90095-1567, USA, [5] Institute of Astronomy, University of Hawaii at Manoa, Honolulu, Hawaii 96822, USA

The main aim of this research is to constrain models of the ice distribution with state-of-art lunar data and to gain a better understanding of water ice dynamics in the lunar sub-surface throughout the lunar history. Although controversial in its physical form (e.g., crystalline as opposed to amorphous), there is increasing evidence of water ice at the lunar poles "cold traps". Such locations plausibly hold not only water ice but also other volatiles of economic and scientific value. Future missions may include rovers with the ability to sample materials from the top metre of the surface. This requires the identification of regions to explore and sample with the highest likelihood of finding water ice. Cold traps, including those a few cm below the surface, are the most plausible candidates.

To understand the current distribution of water ice in the polar neighbourhoods, one needs to study the dynamics of water in the top layer of regolith throughout lunar history. In a seminal paper, [1] investigated the migration of H_2O molecules in the lunar regolith by random hops within the pores. In the current study, we propose to apply a more realistic diffusion model than the ones used in [1] to regions of the lunar surface where the measured temperatures (from LRO/Diviner) and the hydrogen maps (from Lunar Prospector) suggest that the water ice has been stable over the last few billion years.

Subsurface water ice migration and stability revisited: Water molecules move through the interstices in a porous regolith. In the Knudsen diffusion regime, the molecules do not interact with one another, but move in straight lines between points on the pore channel surface. Upon collision with the surface, a molecule adsorbs for some time, the residence time, that depends on the local temperature. An irregular surface can be considered as a perturbation on the top of a pore with a smooth surface. Along the pore, there are a large number of voids with a power law size distribution within the fractal range that describes the regolith at the Apollo sites [2]. In order to produce more realistic water ice distributions the effects of a fractal grain surface specifications are included in our novel analysis. We also study the implications of considering that the water molecules deposition and sublimation rates on the surface of a regolith grain to be the same [1]. This is justifiable if the water vapor is in equilibrium with the ice mono-layers on the grain surface. However, at locations where the density of water molecules in the vapor phase is larger (smaller) than the equilibrium vapor density [1] one expects deposition (sublimation) at a rate larger than the one predicted by equilibrium.

An accurate understanding of the temperature profile in the sub-surface is central to the modelling of the water ice distribution with depth since the molecules' mobility is controlled not only by the pore size and geometry but also by the residence time. We use temperature maps constrained by the latest LRO Diviner measurements [3]. However, besides the physical conditions for ice stability one needs also to consider the places where there had been a delivery of volatiles over the last two and half billion years. The best candidates are the regions that present the highest hydrogen concentrations as seen by the joint analysis of Lunar Prospector Neutron Spectrometer and topography data-sets [4]. Currently, we are considering including weathering and/or gardening in our models [5].

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