Core Samples Recollection of Ice-Bearing Regolith in the PSR´s of the Moon South Pole

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Introduction

The presence of water in the Moon poles has been suspected since an early stage of space exploration (Watson, 1961), due to temperatures being low enough to preserve volatiles. To this day it is not entirely clear the composition, abundance and distribution of these materials, so addressing those uncertainties is a priority in the lunar exploration roadmap of the Lunar Exploration Analysis Group (LEAG, 2017). Having a good understanding of ice reservoirs in the moon is crucial to future phases of the Artemis program, water is an important resource as it can be used as propellant, in life support systems and in different industrial processes (Casanova et al., 2020), so the possibility of extracting it from the moon itself is appealing.

Water ice distribution

It is unlikely that water is stored in ice beds as in Mercury, radar measurements have not discovered large ice fragments in the near surface (Campbell, Campbell, Carter, Margot, & Stacy, 2006), this hinders the detection and utilization of this ice, as no direct outcrops may be available to harvest. However, various authors have argued the possibility that ice is tightly mixed with lunar regolith, which may indicate that at a large scale the quantity of water may be considerable. Direct evidence of this relationship was recorded by the LCROSS mission, where water was detected in the plume of an induced impact in a Permanently Shadowed Region (PSR) of the south pole (Strycker et al., 2013); further analysis of the plume suggests that the original concentration of water in the sediments could be up to 8.5% wt (Luchsinger, Chanover, & Strycker, 2021), which is not a neglectable percentage.

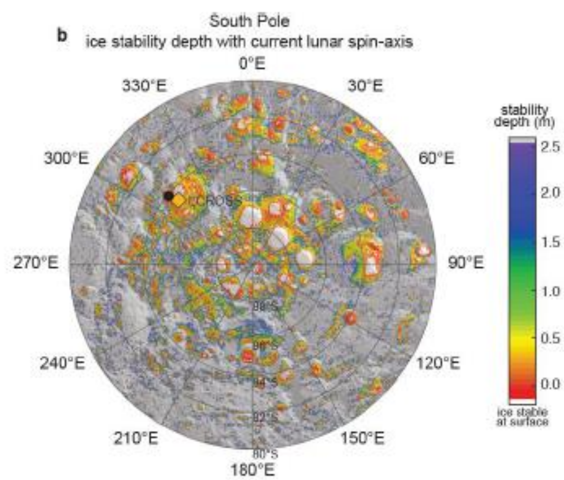

Figure 1: Water ice stability zones in the lunar south pole (Siegler, Keane, & Paige, 2018).

Added to that example, remote sensing data has also pointed to suitable geologic configurations for water in the PSR zones of the south pole and the subsurface. With the use of ultraviolet spectra from LRO, Hayne et al., 2015 discovered potential zones with water ice in the PSR´s. Further support in this direction comes from modeling lunar subsurface, water from comet impacts can easily get entrapped in the near subsurface as lunar dust covers them, which may extend the volatile life expectancy in the order of billions of years (Schorghofer & Taylor, 2007). Some calculations of ice stability suggest that large areas could be reservoirs as close as 1 meter inside the lunar subsurface (Siegler et al., 2018). These calculations point out that in depth, the moon could have an immense amount of water.

Sample recollection

Those studies leave an interesting scenario for the scientific objectives of Artemis III. First, the scientific sight has been focused on the lunar south pole and, although the landing site is not yet established, it will be within six degrees of the south pole, an area that looks promising for exploration at any longitude, as seen in **Figure 1**.

Second and focus of this proposal is the apparent relationship between regolith and water ice, the mix state of both components is clear, but the exact distribution, composition and sedimentology of those parts is still a mystery. From previous works is clear that ice exist in the surface at PSR´s and there are potential reservoirs in the near subsurface, we think that even with the limited possibilities of the two astronauts that will be in extravehicular activities (EVA)(ISECG, 2020) it is possible to gather shallow core samples of potential PSR areas, in order to improve our calculations of the water budget of the moon. Core samples information will also be valuable to understand the stratigraphy of these deposits, to know the layering and textural properties of the regolith will give us a good idea of water formation and possible ways of extraction.

Figure 1 also shows that ice stability deep ranges between 0 and 2 meters, with most of the zones between 0,5 and 1,5 meters. We think that at this shallow subsurface it is possible to retrieve cores with important information in several places, a grid sampling every hundred meters of a promising PSR may be enough to characterize the deposit. The physical and instrumental requirement for the astronauts for this task would not be that high with the help of the unpressurised rover (ISECG, 2020). This early recovery of information would facilitate the next steps of exploration, helping to enhance prospection techniques (Casanova et al., 2020; Hoshino, Wakabayashi, Ohtake, & Karouji, 2020), and to guide Artemis Base Camp location.

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