NEW PROSPECTION METHODS FOR WATER ICE AND VOLATILES ON THE MOON. Pr. Pooneh Maghoul[2], Gustavo Jamanca-Lino[3], Pr. R Boudreault[1,2].
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Introduction: Some lunar regions present better conditions to store water and other volatiles inside frozen traps at high latitudes [1]. The information collected can be interpreted as 1-10% ice in the near subsurface strata, some in the form of arctic like permafrost, but these results are still controversial [2]. The principal regions of present interest are Permanently Shadowed Regions (PSR), which lie at the bottom of craters or nearby on the lunar poles, considered macrotraps cold, in which sunlight never touch the surface due to the topography and precession orbit of the Moon, keeping a temperature well below 100 K. This presentation summarizes the hints of permafrost ice on the South Pole, possible water ice texture, volatiles concentrations, and their geomechanics implications for mining activities. It further proposes a novel geophysical instruments to identify water ice deposits on the moon, Mars or beyond in the Solar System.

State of Art: Space agencies are looking for water ice on the South Pole to supply resources to the Artemis program. In addition, the VIPER mission, which carries prospecting instruments on board, is planning to land in the vicinity of the Nobile region, also at the South Pole. According to several ongoing conceptual designs and/or current NASA challenges, at least an ore grade of 4% could be found in regolith into the first 80 centimeters of the excavation. Although the texture is unknown, it seems more of the ice would be mixed with regolith at an intergranular level, with a high influence in the geomechanics properties of the icy regolith face to excavation and drilling.

Not only water is an interesting material in itself. Ice bodies on the moon host volatiles such as ammonia and methane to supply materials such as hydrazine and nitrogen tetraoxides, which can use for fuel propellants as well, offering a set of materials that can be used for long habited missions but also as exportable from the Moon. A source of ice volatiles can be used to manufacture propellants to respond to the market demand of satellites and the upper stage for GEO, also reducing the cost of future travels to Mars and the Outer Solar System [3].

Several concepts have been proposed for extraction, including sublimation in situ using passive and active methods, concentration, and excavation plus extraction. Nevertheless, the absence of representative samples and analogs environments complicates a complete evaluation of these methods on a pilot scale, reducing the concepts to laboratory experiments, where not all the variables can be assessed. Also, the texture of ice grains and their distribution in a deposit will considerably affect the selected process efficiency, so more prospection activities are mandatory before in situ pilot experiments. Following the new mining terrestrial technologies, an acceptable reserve assessment on the Moon will include concepts such as Geometallurgy, machine learning, and data mining evaluation.

Indeed, for space and terrestrial exploration, new volatile prospection technologies are nearing the maturity process. A terrestrial spin-off application of this type of technology is to measure the permafrost in regions on the Earth, for example, in Canada, to monitor the effect of climate change. Another important application is to detect hydrological features such as groundwater depth, landfills, and potential methane reservoirs [4] to supply urbanism and resources demand of new cities.

Conceptual design: The Canadian Space Mining Corporation (CSMC) is developing a geophysical prospecting and 3D imaging instrument called Temporal and Impedance Prospecting Sensor (TIPS), that advances the state-of-the-art in planetary exploration. TIPS is a novel design that combines measurements of ultrasound and electrical impedance interacting within the Time-Domain to generate non-invasive tomography. TIPS will be deployed from on-board a mobile platform such as a rover, from which electrodes will contact the surface, measure the behavior of the materials to an impedance current and ultrasonic perturbation, and process the data to deliver 3D tomography of a specific region that can be reconstructed in real-time. The concept of measuring impedance and ultrasound vibrations for imaging is not new, but 3-dimensional imaging using the time-domain signal that segments and filters the data and delimits the elemental composition is an entirely new capability.

Acknowledgments:

References:

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