**Making In Situ Resource Utilization (ISRU) a Reality on the Moon with the International Lunar Resource Prospecting Campaign (ILRPC): Prospecting, Science, and Planetary Protection.** C.R. Neal[1], A. Abbud-Madrid[2], J.D. Carpenter[3], C. Espejel[4], K. Hadler[5], K.A. Hibbitts[6], A. Salmeri[7].
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**Introduction:** Being able to live off the land through in situ resource utilization (ISRU) is enabling for sustained human Solar System exploration. To hone the skills and technologies needed to do this, Earth has been blessed with its nearby Moon that contains important and potentially enabling resources. Estimating and understanding the reserve potential of lunar resources requires extensive exploration work, which begins with a prospecting campaign. This process demands significant coordination, effort, and financial and technical capabilities. Fortunately, the Moon is very popular as there are ongoing active missions from 4 countries and ~30 missions planned between now and the end of the decade.

**The ILRPC:** At the 2024 Space Resources Roundtable (SRR) meeting, the idea of an International Lunar Resources Prospecting Campaign was discussed with the ISRU and SRR communities [1]. During that meeting a governance structure was formulated and this has been developed over the last year.

The ILRPC has started to coordinate active and proposed lunar missions to obtain much needed datasets that increase the probability of finding elevated concentrations of water ice at multiple locations. This requires integration of orbital datasets that provide targets for surface ground-truth missions. Initial ideas are described in Neal et al. [2]. Since then, specific locations at the lunar south pole have been identified for detailed investigation of polar water ice. These are not the large permanently shadowed regions (PSRs) because these are often deep and difficult to access, requiring 10+km round-trip traverses [3] in 20-60K temperatures to access the water ice. Smaller PSRs are targeted that show potential for buried and surface water based on obtained data, as these should be accessible. It is important to understand the nature of these deposits beyond accessibility, such as form, extractability (geotechnical properties), distribution, composition, to assess reserve potential [2]. For polar water ice there is only one point of ground truth - the LCROSS mission to Cabeus crater. What LCROSS demonstrated was that Cabeus ice is impure and refining capabilities would be needed. But is the Cabeus data representative of ice from other PSRs?

The ILRPC intends to initially integrate orbital datasets to highlight optimal locations for surface assets to be deployed, and to initiate preliminary reserve potential estimations. Data from the surface assets will be used to refine the integrated orbital data so it can be a better predictive model as exploration proceeds. This approach can enable the participation of new space-faring nations to contribute to this prospecting campaign (in addition to demonstrating new national capabilities), and can be used to propsect for other lunar resources.

**Environmentalism:** There are many issues that need to be resolved regarding lunar resource utilization, and one of those is what we term "environmentalism". On this planet, protecting the environment is synonymous with protecting life and ecosystems. For the Moon, that does not work. However, protecting the science contained within the lunar environment is a concern. This has been raised in the peer-reviewed literature with regard to the radio-quite far side and astronomical investigations that could be undertaken there [4,5,6]. In addition, there have been calls for developing a governance framework for lunar resources [7] and protecting scientific practice on the lunar surface, especially at the poles [8,9,10]. Particularly pertinent to the ILRPC is the National Academies report in 2020 on the Study of Lunar Volatiles [11]. Finding 6 states "*A clear articulation of prioritized science objectives to frame a strategy for exploration of the lunar PSRs does not exist and is required for an effective planetary protection policy for the Moon*." With the initial endeavors of the ILRPC focused on small PSRs, it is important to not only understand the unique features on the Moon, but also to document the pristine lunar environment. This is required in order to maximize the science ***and*** exploration of lunar sites of extraordinary scientific importance (SESIs) [6]. The importance of documenting and understanding the pristine lunar environment cannot be overstated. The U.S. Exploration Roadmap [12] defines this as being of high and near-term priority. But how can lunar exploration, commerce, and science work together to achieve their seemingly disparate goals? The answer is to go to the Moon together.

**Lunar Resource Exploration Strategy**: Going to the Moon requires that we go for all human kind. This is important for making resource utilization a reality under current law [13]. Looking for, extraction, and refinement of resources should include lunar scientists in the core teams. The acts of prospecting (e.g. Fig. 1), mining, and processing can yield important and critical scientific data that will probably never be obtained if scientists waited for government-funded mission opportunities.

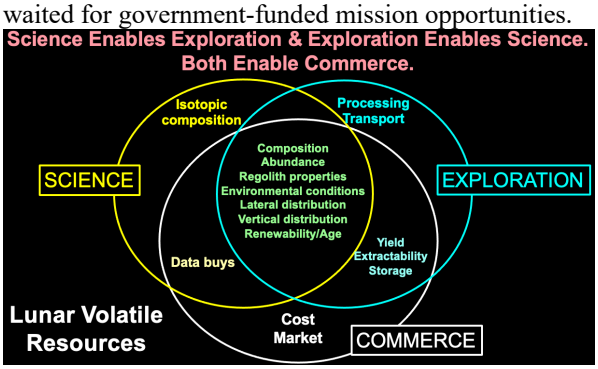


**Figure 1**. Most of the data (in green) acquired for prosepcting (exploration & commerce) informs science.

The ILRPC believes that by interating lunar scientists into exploration and commercial teams to investigate lunar resources, everybody wins. But how *exactly* do we preserve the knowledge of the pristine lunar environment during mineral extraction? This is where we can learn from archeology and European construction policies. If an archeological site is uncovered during excavation, construction stops and the site is documented (i.e., science gets done!). Lunar scientists need to be critical members of the prospecting, site characterization, and mineral extraction teams. Once mining begins, progress is monitored and if new discoveries are made mining stops in that area and the discovery is documented, sampled, and the knowledge preserved. **NOTE**: it is apparent that such discoveries alluded to above *would not be made without mining activities*, and we believe adoption of this policy is the way to advance not only science, exploration and commerce, but also advance ISRU into the critical path for human exploration of the Moon (and beyond).

**Moving the ILRPC into the Future**: What other resources could the ILRPC focus on? It is evident that in situ use of lunar resources will be an initial requirement IF a permanent human presence on the Moon is to be achieved, as stated in the U.S. Space Policy [14]. However, there are countries [15,16] and companies [17] looking at exporting Helium-3 from the Moon to Earth for clean energy and revenue, respectively.

At this Roundtable, lunar rare earth metals in the Procellarum KREEP Terrane are examined for solving a critical mineral shortage in the United States [18]. Understanding the extent of lava tubes in the maria for potential non-polar habitat locations (e.g., [19]) is another resource. And sites for locating far side radio observatories to explore the Dark Ages of our universe is an issue that could make major scientific breakthroughs and bring together scientists, engineers, and commercial partners to get the science by going to the Moon together. These are the types of activites the international lunar resource prospecting campaign could deliver.

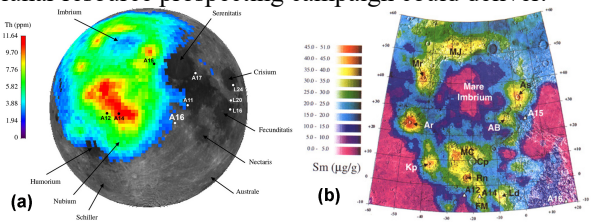


**Figure 2**: Fig. 2.1. Procellarum KREEP Terrane (PKT). (a) The PKT defined by Th abundance (Joy et al. 2020); (b) Mare Imbrium Sm (μg/g) (Elphic et al. 2000).

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