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Transformative Lunar Science: 2024 and Beyond

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Abstract

This summer we celebrate the first steps a human made on the surface of the Moon 50 years ago. The bold Apollo and Luna programs of that era inspired generations of young scientists and set humanity on a course to invest in science and technology and to explore all corners of the solar system in which we live. With the recent journey past Pluto and into the Kuiper Belt, we've done just that….so now what? Aahhh, we have just begun!

Expanding Knowledge from 1 AU

A renaissance of robotic lunar exploration over the last 15 years has provided humanity a deeper and more intimate view of the Moon. The international array of lunar orbiting missions [SELENE, Chandrayaan-1, Changé 1-4, Lunar Reconnaissance Orbiter, LADEE, and GRAIL] have provided a global picture of this complex, but accessible differentiated cousin of Earth which together share the same 4.5 Ga of tumultuous history at 1 AU. This recent pulse of new lunar data also allowed us to glimpse the enormous opportunity for accomplishing truly *Transformative Lunar Science* [1]. These are some of the next major breakthroughs in understanding the origin and early habitability of our Earth-Moon system as well as fundamental constraints on events that control the evolution of our Solar System.

Briefly, a few examples of Transformative Lunar Science that are accessible in the years ahead include: a) Establish the period of early giant planet migration and its effects on the structure and evolution of our Solar System, b) Provide an absolute chronology for Solar System events over 4 billion years by dating specific surfaces and documenting the flux of solar system debris with time, c) Understand (and utilize) the recently recognized water cycle of the Moon and other airless bodies, d) Characterize the Moon's interior to reveal how this differentiated planetary cousin of Earth formed and evolved in the first billion years of solar system history, e) Use the quiet but accessible vantage from the lunar farside to view the universe unencumbered, f) Evaluate the extended record of space weather and fundamental on-going processes of plasma interactions with solar system surfaces.

The Moon has become recognized by the space faring nations of Earth as an 'eighth continent', with riches that have barely been recognized or tapped. It is to become the way-station to the rest of the Solar System. Like previous unexplored continents, it will take decades, perhaps generations, before the Moon becomes more than unknown territory or an object of mystery in the night sky. To move *forward to the Moon* to stay, the immediate tasks ahead include:

- Establish a robust global lunar infrastructure.
- Achieve leadership in lunar exploration across international partners.
- Optimize commercial involvement.
- Coordinate planning and implementation of human/robotic partnership.

References

[1] Pieters, C, R. Canup, D. Kring. J. W. Head, and D. R. Scott (2018) *Transformative Lunar Science,* https://sservi.nasa.gov/wp-content/uploads/2018/02/TransformativeLunarScience.pdf