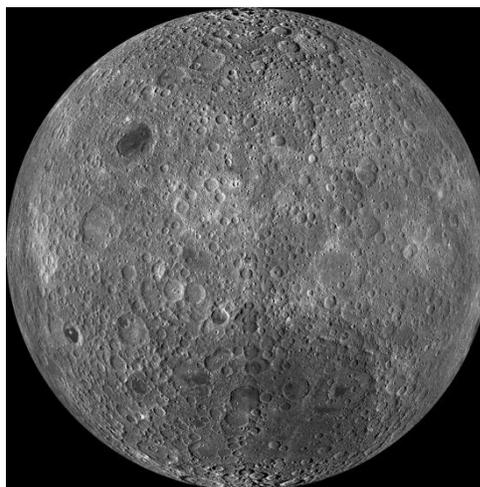


## New Views of the Moon II 2008-2018. An initiative to integrate new lunar information into our fundamental understanding of the Moon and the next stages of international lunar exploration.

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### 1. Introduction

In 1998, the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM) sponsored a long-term initiative to improve our understanding of the Moon and its history by integrating all available types of data: in situ investigations, analyses of lunar samples, telescopic observations, and spacecraft datasets. This initiative, New Views of the Moon (NVM-I), was supported by NASA's Science Mission Directorate and the Lunar and Planetary Institute and guided principally by Brad Jolliff, Charles Shearer, Mark Wieczorek, and Clive Neal. The goals of the original NVM-I initiative were (1) to summarize new insights that have been gained about the Moon as a result of recent global data sets (Clementine, Lunar Prospector), and their integration with sample and other data; (2) to define current understanding of the Moon's geologic history, resources, and potential for scientific exploration; and (3) to communicate implications of knowledge gained from research and exploration of the Moon for planetary science and exploration beyond the Moon. The NVM-I initiative ultimately involved contributions and data synthesis from over 100 individual scientists and engineers at numerous workshops and special sessions at worldwide scientific meetings. NVM-I culminated in a book "New Views of the Moon" published in 2006 as volume 60 of *Reviews in Mineralogy and Geochemistry* published by the Mineralogical Society of America. In 2012, the book was translated into Chinese. NVM-I went to press prior to analysis of the data from missions flown since 2000, and before the major discoveries from sample analyses made this century.



**Figure 1.** Mosaic of over 15,000 LRO Wide Angle Camera images showing the far side of the Moon including the South Pole-Aitken (SPA) basin.

Using new mission observations and new lunar sample measurements, incredible strides in lunar science have been made since NVM-I was published. We therefore propose to start a new international lunar science community initiative, the New Views of the Moon II (NVM-II), that will integrate these new observations and produce a richer understanding of our nearest neighbor in space, reveal new clues about the history of the Solar System as recorded on the Moon, and provide new information to define missions and investigations for a renewed exploration of the Moon with robotic and human missions.

## **2. A New Perspective from Missions**

A key goal of NVM-II is to synthesize the results from recent lunar missions to build on the results of NVM-I. Subsequent to the publication of NVM-I, data from numerous missions exploring the interior and surface of the Moon have become available. These include SMART-1 (ESA), Kaguya (Japan), Chang'e 1, 2, 3 (China), Chandrayaan-1 (India), LRO, LCROSS, ARTEMIS, GRAIL, and LADEE (USA). These new datasets (e.g., Fig. 1) have redefined our view of the Moon with regards to lunar time-stratigraphy, lunar crustal evolution, terrain formation, cratering processes, tectonic and geochemical processes, volatile reservoirs, and resource potential. During the projected three-year duration of NVM-II a variety of additional missions are possible. Potential missions include new Chang'e missions, a mission to return samples from the SPA such as MoonRise, SELENE-2, a new series of Russian Luna missions, a South Korean lunar orbiter, human missions in cislunar space using the Orion spacecraft, surface missions designed for resource exploration and utilization, and commercial missions linked to the Google X-Prize.

## **3. New Perspective from Samples**

Since 2006, using new or improved analytical approaches, sample studies have shed light on the nature, behaviour, and role of volatile reservoirs in the lunar mantle and crust, the age and evolution of the lunar highlands, age and origin of the Moon, and dynamical processes in the early Solar System. Ion microprobe studies of lunar volcanic glasses and apatite in mare basalts indicate H-bearing species are in higher abundance in the lunar interior than expected and that there are distinct endogenous volatile reservoirs in the lunar mantle. New age dates on lunar highlands rocks have identified a major lunar thermal event at approximately 4.35-4.38 Ga. Does this event represent the termination of the primordial differentiation of the Moon via the lunar magma ocean or is it a major mantle event such as the overturn of the lunar magma ocean cumulate pile? NVM-II is designed to help address this and other questions arising from recent sample studies while integrating with remotely sensed results.

## **4. A New Perspective from Engineering and Resource Utilization**

The lunar missions this century have also generated new observations that directly enable future human missions to the Moon while providing a foundation for future human activity in the Earth-Moon system and beyond enabled by the identification of lunar resources. For example, the meter-scale Digital Terrain Models produced by LRO permit terrain referenced navigation as well as morphometric assessment of lunar terrains, enabling optimized hardware decisions and increasing the chance of mission success. In another example, new illumination maps now available for the Moon characterize the distribution and nature of volatile and solar resources on the lunar surface, permitting efficient future utilization of a variety of lunar resources to sustain human exploration and commerce beyond LEO and into the Solar System.

## **5. Proposal for a New International Lunar Initiative**

The time is right to synthesize these new observations and to integrate them with our understanding of the Moon prior to 2006. NVM-II will build upon both NVM-I and the Lunar Sourcebook to produce a comprehensive new science and engineering assessment of the Moon. The initiative will consist of topical workshops, special meeting sessions, and Web-based resource collections, leading to a book product. Themes that will be included in the initiative are: Summary of 2001-2015 lunar missions and their goals, the origin of the Moon, initial differentiation and late accretion, impact chronology of the Moon, cratering processes and history, the constitution and structure of the lunar interior, lunar tectonics, lunar volatiles in the interior, volatiles on the lunar surface, exosphere and interactions with the lunar surface, lunar resources, lessons learned, and future exploration goals. NVM-II has already been presented to the Lunar Exploration Analysis Group in the Fall of 2014 and to the planetary community at the Lunar and Planetary Science Conference in the Spring of 2015. This abstract and presentation is a solicitation for input from the international lunar community.