

THE ORIGIN OF VOLATILES SAMPLED BY THE LCROSS MISSION IN CABEUS CRATER. K.E. Mandt¹, O. Mousis², A. Bouquet², D. Hurley¹, and A. Luspay-Kuti. ¹Johns Hopkins Applied Physics Laboratory, Laurel, MD (Kathleen.Mandt@jhuapl.edu), ²Aix Marseille Univ, CNRS, CNES, LAM, Marseille, France.

Introduction: The Moon is recognized as a cornerstone for understanding the history of the solar system. Just as the impact history of the Moon helps us to understand the impact history of the Earth and other solar system bodies, the history of volatiles on the Moon can help us to constrain how volatiles were delivered to the Earth-Moon system as well as the development and loss of secondary atmospheres through internal outgassing.

The Permanently Shaded Regions (PSRs) of the Lunar poles are known to provide an environment well suited for long-term preservation of volatiles [1,2]. However, the exact abundance and composition of the volatiles present in the PSRs is poorly understood. The greatest insight into the composition of volatiles beyond water ice was provided by the Lunar Crater Observation and Sensing Satellite (LCROSS) mission [3,4]. This observation, and future measurements by landed missions [e.g. 5] can provide important insights into the origin and history of volatiles on the Moon and in the Earth-Moon system.

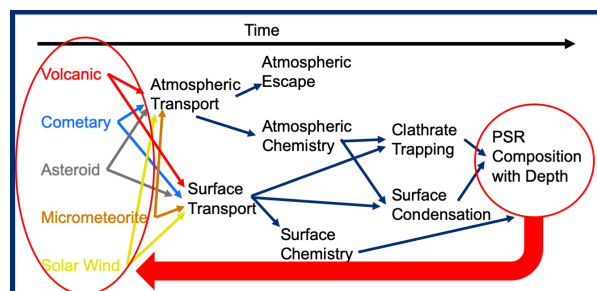


Figure 1 – Connecting the current composition of volatiles in the Lunar PSRs requires an understanding of the processes that took place between delivery of the volatiles and their sequestering.

We illustrate in Fig. 1 the processes that need to be considered in trying to connect the current composition of volatiles at the poles to the variety of possible sources. These potential sources include volcanic activity that may have been intense enough to form an atmosphere [6], impacts of comets, asteroids, and micrometeoroids occurring over the history of the Moon, and water produced by the interaction of the solar wind with the Lunar surface.

The purpose of this study is to look at the elemental composition of volatiles sampled in the LCROSS plume and determine the likely origin of the volatiles sampled

depending on whether they were trapped through clathrate formation or surface condensation.

Composition: The LCROSS mission impacted the Cabeus crater PSR, and determined the abundance of several species in the resulting plume, including H₂O, OH, CO₂, C₂H₄, CH₄, CH₃OH, NH₃, H₂S, and SO₂, based on near ultraviolet, visible, and near infrared measurements performed by the LCROSS spacecraft [3]. Far ultraviolet measurements of CO and several other species were also made, but at a different time than the LCROSS measurements [4] requiring additional work to compare the two sets of observations.

Interpreting the plume composition requires understanding how the volatiles are stored in the regolith. If they are stored as condensed material, the volume of regolith from which any constituent was volatilized by the LCROSS impact depends on the volatility of the constituent. This means that the amount of highly volatile species in the plume, such as CO, may be inflated because they would be volatilized from a larger volume than the water. However, if the volatiles are stored in clathrates the plume composition would represent the composition of the volatiles in the regolith because their release into the plume would happen through destabilization of the clathrates.

Although molecular composition is useful in trying to understand the origin of volatiles on the Moon, the processes that take place between the source and storage (see Fig. 1) complicate interpretation of the LCROSS observations. For this reason, comparing elemental composition and elemental abundance with total water abundance is the best approach for untangling the origin of the volatiles. The molecular composition of source materials provides important insight. In the comae of comets, H₂O is the most abundant molecule, with large abundances CO and CO₂ and trace amounts of C₂H₄, CH₄, CH₃OH, NH₃, H₂S, and SO₂ [7]. Volcanic gases tend to have large amounts of CO with some CO₂, H₂O, H₂S, and SO₂ [6,8,9,10]. The bulk elemental composition of each of these sources will be very different and will influence the composition of volatiles retained in the regolith either as condensed material or as clathrates.

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