**THE MOSCOVIENSE BASIN: INSIGHTS INTO AN ATYPICAL BASIN.** K.G. Thaisen[1], L.A. Taylor[1], J.W. Head[2], C.M. Pieters[2], P.J. Isaacson[2], J. Nettles[2], G.Y. Kramer[3], and N.E. Petro[4]. [1]Planetary Geosciences Institute, Dept. Earth and Planetary Sciences, University of Tennessee, Knoxville, TN 37996, USA (kthaisen@utk.edu), [2]Dept. of Geological Sciences, Brown University, Providence, RI 02912, USA, [3] Lunar and Planetary Institute, Houston, TX 77058, USA, [4]NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA.

**Introduction:** Several missions from different countries have recently been, or are currently, in orbit around the Moon. The capabilities of these missions range considerably, as have the products that have been released from them. But one factor that many have in common is that they have found that the Moscoviense Basin is an interesting place on the Moon. The Moon Mineralogy Mapper ($M^3$) team identified unusual mineralogical exposures [1] and other studies of the Moscoviense Basin have identified several unusual features of this farside basin. It is one of the few farside basins that has abundant mare deposits [2], is reported as having the thinnest crust on the entire Moon [3], and is reported as having an abnormally large gravity anomaly [4], for a basin of its size. We have explored these characteristics, the basin's ring configuration, re-interpreted previously identified units, and present new observations of the Moscoviense Basin.

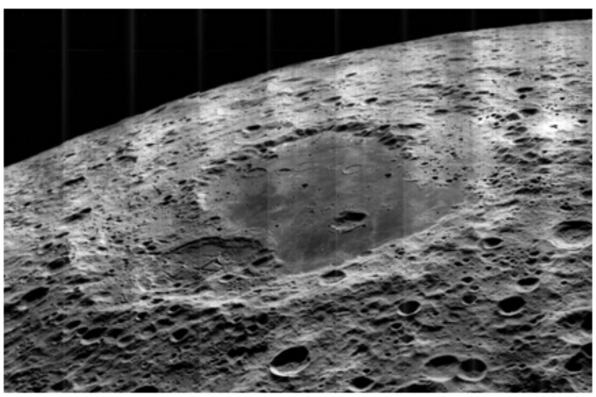

**Figure 1. Oblique Lunar Orbiter Mosaic of the Moscoviense Basin on the farside of the Moon. (Image Courtesy of NASA)**

**Physical Characteristics:** The Moscoviense Basin is a multi-ringed impact basin located in the northern hemisphere on the farside of the Moon at 27° N, 148° E (Fig. 1). The basin is classified as Nectarian in age (3.85-3.92 Ga) [5], and although its features have experienced a significant number of impacts since its initial formation, and have subsequently been degraded over time, the rings are still prominent and easily distinguished. Its three distinct rings were confirmed by [6] using LOLA topographic data; the inner peak-ring, a middle-ring, and an outer-ring are 185, 430, and 650 km in diameter, respectively. The inner peak-ring is represented by a continuous half-ring of ~185 km diameter that is open to the northeast. It is typically 20-25 km across and elevated ~2-3.5 km above the current basin floor; except at its ends, where it grades into lower massifs that become embayed by mare and are no longer exposed at the surface or are absent. The inside scarps of the existing peak-ring typically slope toward the center of the basin at angles at 10-25° and rarely exceed 35°. Surrounding the outside of the exposed inner peak-ring is a nearly continuous platform that extends slightly beyond the peak-ring to the north and east and is elevated nearly a kilometer above the mare-filled basin floor, which is about 7 km below the crest of the outer rim. Although the floor of the basin is elongated, the middle-ring is nearly circular and has a length to width ratio of 1.06:1 (NE-SW: NW-SE). Most basins have generally concentric rings that are found at ~$2^{0.5}$ x D spacings (where D = diameter of the adjacent interior ring) [7,8]. However, the geographic centers of the peak-ring and the main-ring of the Moscoviense Basin are offset along a line to the southwest, ~90 and ~60 km, respectively, relative to the center of the outer-ring. The outer-ring of the basin is a discontinuous ring that is particularly disturbed to the east-southeast. This scarp has a diameter of approximately 650 km, and when compared to the rings of the Orientale Basin as described by [2], this ring corresponds with the outer-ring that formed in the late-stages of basin formation, as the crust collapsed into the newly formed crater. The surrounding rim is generally higher to the west and south, with corresponding steeper slopes into the basin than to the north and east; where there are lower rims, typically gentler slopes, and distinct slump blocks. But how could this unusual ring configuration form?

**Impact scenarios:** The unusual off-set ring configuration and partial peak-ring in Moscoviense suggest that an oblique impact may have formed the basin. Work by Schultz [9] has identified that oblique impacts on Venus have off-set rings and partial peak-rings that are open in the down-range direction. But in an oblique impact, the force of the impact would project energy horizontally into the crust and less of a deep crustal response would be expected. Yet at this location it has been suggested by Ishihara et al. [3] that the crust is some of the thinnest on the Moon and that there is an increased gravity anomaly [4]. These features do not appear to correlate with a single oblique impact scenario. It may be that multiple impacts were involved in the formation of Moscoviense. Figure 2 illustrates a possible scenario where multiple impacts could produce a similar ring configuration as is seen here.

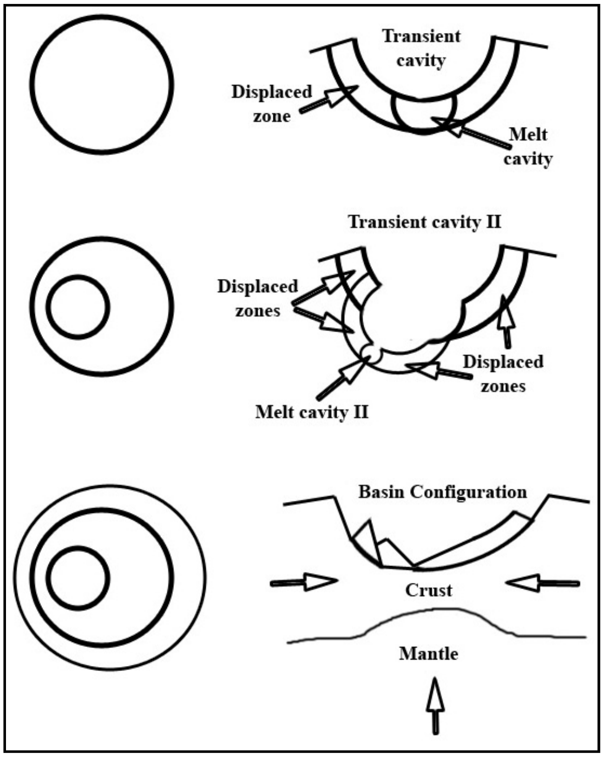


**Figure 2. Multiple impact scenario proposed by [6] as a possible scenario for the formation of the Moscoviense Basin ring structure. (Image reproduced from Thaisen et al. [6])**

**Impact melt not mare:** Three compositionally distinct mare units have been proposed within the basin. The units have been identified using the naming convention by Kramer et al. [10] as an *Imbrium-age low-Fe, low-Ti mare (Im)*, which lies primarily in the south; an *Imbrium-age low-Ti mare (Iltm)* that lies in the northwest and overlies the Im; an Imbrium-*age high-Ti mare (Ihtm)* that is located to the east (Fig. 3). However, following a re-evaluation of crater counts within the basin by Morota et al. [11], the *Ihtm* unit has been redesignated as *Ehtm*. While the *Iltm* and *Ehtm* units are obviously mare deposits, the *Im* unit is not. The *Im* unit is topographically higher than the *Iltm* and *Ehtm* units, especially in the vicinity of the peak-ring, and is exposed in crater rims and ejecta on the basin floor. The unit is highly cratered and degraded, more so than any of the other deposits on the basin floor, and has been assigned an age of 3.9 Ga by Morota et al. [11], which suggests that it, is the oldest surface unit within the basin floor and corresponds with the age of the basin itself. Spectral imagery from the Moon Mineralogy Mapper ($M^3$) onboard the Chandrayaan-1 spacecraft also indicates that the *Im* unit has an albedo more similar to the feldspathic peak-ring than the adjacent mare, and its spectra does not contain an absorption feature around 1000 nm, like a mare does. These lines of evidence suggest that the <u>*Im* unit is an impact melt</u> that formed at the time of basin formation and is not a mare deposit.

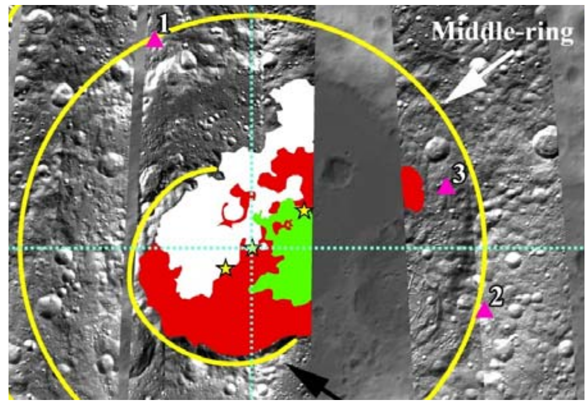


**Figure 3. Sub image from [6] showing locations of Im (red), Iltm (white), and Ehtm (green) units on the basin floor. (Image reproduced from Thaisen et al. [6])**

**Summary:** The Moscoviense Basin contains an atypical ring configuration that may be the result of an oblique impact or possibly multiple impacts. The unit *Im*, which was previously assigned as an Imbrium mare deposit, is actually an impact melt.

**References:** [1] Pieters, C. et al. (2010), *JGR.*, (In Press). [2] Head (1974) *The Moon 11 327-356.* [3] Ishihara Y. et al. (2009) *GRL, 36, L1920.* [4] Namiki, N., et al. (2008), Meteor. Planet Sci, 43(7), A114-A114. [5] Wilhelms D.E. et al. (1987) *USGS Pro. Paper 1348.* [6] Thaisen K.G., et al. *JGR*, (In Press). [7] Chadderton, L. T., et al. (1969), Nature, 223(5203), 259-263. [8] Pike, R. J., and P. D. Spudis (1987), Earth Moon Planets, 39(2), 129-194. [9] Schultz, P. H. (1992), JGR-Planet, 97(E10), 16183-16248. [10] Kramer G.Y. et al. (2008) *JGR, 113, E01002.* [11] Morota, T. et al. (2009) *LPSC XXXX, Abs. #1280.*

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