GEOLOGY OF ANTONIADI CRATER, SOUTH POLE AITKEN BASIN, MOON. Erin Dominov[1] and S.C. Mest[2,3], [1]Geosciences Department at University of Massachusetts Amherst 611 N Pleasant St, Amherst, MA 01003 (Edominov@yahoo.com), [2]S.C. Mest, Planetary Science Institute, 1700 E. Ft. Lowell Road, Suite 106, Tucson, AZ 85719-2395, [3]Planetary Geodynamics Laboratory, Code 698, NASA GSFC, Greenbelt, MD 20771.

Introduction: Antoniadi crater (diameter = 150 km; depth = 4-4.5 km) is located at 69.5°S and 172.0°W within the South Pole-Aitken (SPA) Basin, and is situated between two older craters, Numerov and Minneart. Antoniadi is unique for several reasons. First, Antoniadi contains a central peak and inner ring of peaks, which puts it morphologically between the category of craters and multi-ring basins [1]. Second, the floor of Antoniadi contains geologic materials from the deepest part of SPA, and the Moon (-8 to -8.5 km); there is a great possibility that the impact that formed Antoniadi excavated materials from the lower crust/upper mantle. Third, Antoniadi displays a large number of secondary craters on its ejecta blanket. Most secondaries likely resulted from the Antoniadi impact event; however, it is possible that secondary craters generated from other impact events are superposed on Antoniadi's ejecta blanket.

The purpose of investigating Antoniadi is to gain a better understanding, through the latest images, of the crater, its ejecta and its geologic history with respect to the history of the SPA. This is done by generating a geologic map in ArcGIS showing the units within and surrounding Antoniadi. Unit ages are determined by calculating Antoniadi's crater size-frequency distribution statistics. These results suggest that Antoniadi formed during the Upper Imbrian period.

Background: The South Pole-Aitken basin is the largest (~2500 km) and oldest (pre-Nectarian) basin that has been documented on the moon [1-5]. SPA was formally recognized as a depression caused by an impact in Zond imagery and Apollo laser altimetry [6]. Galileo spectral data showed the interior of the SPA basin, from the $1\mu m$ absorption band, to be mafic in composition resulting from the overturn of the lower crust/mantle material and/or emplacement of cryptomare following the SPA impact event [6].

Previous geologic mapping of the entire lunar South Pole area was last done by Wilhelms et al. (1979) from Lunar Orbiter images. Since then, mapping projects of various locations near the lunar South Pole have been published, such as Schrödinger basin [7-10] and Shackleton crater [11].

In terms of lunar stratigraphy, it is assumed that older surfaces will retain more craters, and in terms of crater size, smaller craters are more frequent compared to larger craters. The lunar stratigraphic system [e.g., [1,2,12-16]. uses the ejecta blankets of several large impact basins and craters, such as SPA, Orientale, Eratosthenes, Copernicus, Imbrium and Nectaris, to serve as stratigraphic markers [17].

Methodology: Geologic mapping of Antoniadi crater was done using ArcGIS (v 9.2) and (v 9.3). The Clementine UV-VIS 750-nm image mosaic (~100 m/pixel) was used as the primary basemap. Other basemaps used include the Lunar Orbiter Global Mosaic and Clementine NIR mosaic. These images were used to assist in the identification of surface textures, contacts, and impact craters greater than 2 km in diameter. The main purpose of utilizing ArcGIS is to generate multiple layers (e.g., units, contacts, structures, etc) that can be georeferenced to the basemaps.

The area covered by the map (**Figure 1**) is approximately 885 km in diameter centered on Antoniadi crater. The most obvious features recognized in the Clementine image data are crater rims and the small secondary craters from Antoniadi, which were among the first features to be mapped. From the geologic map of the South Pole [1], it was indicated that Zeeman crater formed during the Nectarian period and Antoniadi during the Upper Imbrian period, which served as an underlying basis of this geologic map.

The Wilhelms et al [1979] geologic map provides an overview of this map area and displays numerous units, but the area of Antoniadi and its ejecta blanket contained few details. It should be noted that this work was based solely on Lunar Orbiter images and lacked spectral data. Impact craters superposed on the surface of Antoniadi were identified and used to calculate crater size-frequency distribution statistics by using the equation $\log[(n \pm (n)^{1/2})/A]$, [18]. The crater size frequency distribution charts from the Antoniadi crater ejecta blanket are shown in Figure **2a** and **2b**.

Craters were classified as primary or secondary by their morphology. The morphological differences between secondary and primary craters were determined by moderately degraded impact events (secondary) while primary craters are much more pristine in terms of well-defined crater rims and ejecta blankets, as well as displaying more of a bowl-shaped morphology than secondaries. Secondary craters form by the impact of secondary materials from nearby impact events. There has been a long-standing controversy about the relative abundance of primaries and secondaries on the Moon. It has been hypothesized that a very large population of secondaries may be present and a large enough population of them would skew the statistics. Additionally, because secondary craters are generated within the gravitational field of a primary body and are therefore densely clustered occurrences, they carry a caveat: two surfaces of equal age may differ in density significantly enough to invalidate assumptions about age [9].

Results: Most of the units identified in this study follow the Wilhelms et al. [1979] geologic map with the exception of three units: Iaeb, Iim and Nim. Unit Iaeb is Antoniadi's ejecta blanket that covers an area of 412,000 km^2. Impact craters superposed on this unit were identified and measured and it was determined that it was emplaced during the Imbrian period, most likely Upper Imbrian, which is consistent with [1]. Unit Iim includes the materials on the floor of Antoniadi and are interpreted to be composed of mare materials because this feature consists of dark and low albedo materials. The only way to determine if the smooth dark materials in Antoniadi is impact melt or of volcanic origin is by sampling. The impact melt material may include some volcanic materials considering the floor of Antoniadi is found at the deepest point of the Moon (-8 to -8.5 km) according to the altimetry data from Clementine. In addition to the geologic mapping, a correlation chart was developed to view the relative age relationships of units that formed during geologic history in this particular area.

Crater Size-Frequency Distribution plots display crater size versus frequency over lunar geologic time; isochrons [e.g., 2] superposed on the plot assist in constraining the age of particular units. Using the SFD charts with the total crater population superposed on Antoniadi's ejecta, it is determined that Antoniadi most likely formed during the Upper Imbrian time period because of the isochrons from small diameter craters (less than 10 km) are located along the Imbrian/Eratosthenian boundary and craters greater than 10 km in diameter are located towards the Imbrian/Nectarian boundary (**Figure 2b).**

Discussion: Antoniadi's uniqueness warrants further investigation due its morphology (between craters and multi-ring basins), its ejecta blanket, the presence of dark smooth material on the crater floor, and the fact that Antoniadi is located in SPA basin and contains the deepest part of the Moon. Based on my observations and interpretations, the following conclusions can be made:

*Unit Iaeb covered a wide area (~412,000 km^2), which is most unusual for impacts of this age and contains numerous secondary craters on its surface

*There is a possibility that the impact melt on the floor of Antoniadi may contain volcanic material considering its depth of excavation.

*The SFD charts based on the Antoniadi's total, primary and secondary crater populations can provide an accurate age on the lunar geologic time scale to better estimate when Antoniadi formed, which is believed to have been in the Imbrian period.

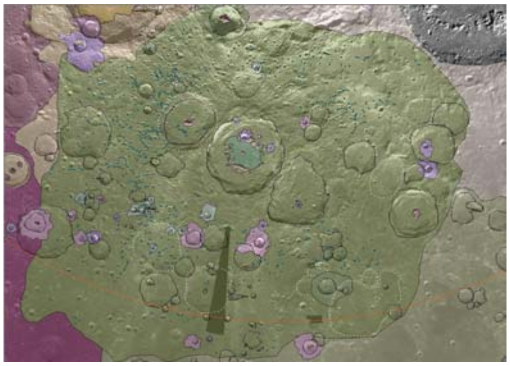

Figure 1. Geologic map of Antoniadi crater and its ejecta blanket, as well as the surrounding units identified in this study.

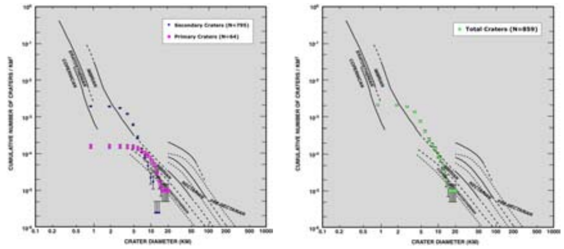

Figure 2. Crater size-frequency distribution data for craters superposed on the Antoniadi ejecta blanket. Shown are plots for primary and secondary craters (left), and the total population (primary and secondary craters) of craters (right).

References: [1] Wilhelms, D.E. et al. (1979) *Geologic Map of the South Side of the Moon*. [2] Wilhelms, D.E. (1987) The Geologic History of the Moon, 327p. [3] Spudis, P.D. (1993) The Geology of Multi-Ring Impact Basins, 263p. [4] Spudis, P.D. et al. (1994) *Science*, *266*, 1848. [5] Ryder, G. (2002) *JGR*, *107(E4)*, 6-1. [6] Pieters, C. M. et al. (2001) *J. Geophys. Res., 106* (E11), 28,001-28,022. [7] Shoemaker, E. M. et al. (1994) Science 266 (5192): 1851-1854. [8] Mest, S.C. (2007) LPSC XXXVIII, **Abs. #1842**. [9] Van Arsdall, L. E. and S. C. Mest (2008) *LPSC* **Abstract #1706**. [10] Mest, S.C., and L.E. Van Arsdall (2008) *First NLSI Lunar Science Conference, June 20-23*, **Abstract #2089**. [11] Spudis, P.D. et al. (2008) LPSC XXXIX, **Abs. #1626**. [12] Shoemaker, E.M., and Hackman, R.J. (1962), in The Moon -- Symposium no. 14 of the International Astronomical Union: London, Academic Press, p. 289-300. [13] Shoemaker, E.M. (1964) *Scientific American, v. 211*, no. 6, p. 38-47. [14] McCauley, J. F. (1967) Geologic map of the Hevelius region of the Moon: U.S. Geol. Survey Misc. Geol. Inv. Map I-491 [15] Wilhelms, D. E. (1970) Summary of Lunar Stratigraphy-Telescopic Observations: USGS Professional Paper 599-F, 47. [16] Stuart-Alexander, D. E., and Wilhelms, D. E. (1975) The Nectarian System, a new lunar time-stratigraphic unit: U.S. Geological Survey Journal of Research, v. 3, no. l, p. 53–58. [17] Hiesinger, H. and Head, J.W. (2006) *Reviews in Mineralogy and Geochemistry 60*, 1-81. [18] Arvidson, R. E. et al. (1979) *Icarus* 37, 467-474.