EPSC Abstracts
Vol. 5, EPSC2010-573, 2010
European Planetary Science Congress 2010

The Lunar Crater Aristarchus: Morphologic Observations of Impact Melt Features and Absolute Model Age Determination.

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Abstract

Aristarchus Crater is a large (~40 km diameter), Copernican age, well-preserved impact crater, located within Oceanus Procellarum on the near side of the Moon (centered at 23.6°N; 47.5°W). Aristarchus is found in one of the most geologically diverse and intensely studied regions of the Moon. The crater is remarkable because it straddles the geologic boundary between the Aristarchus Plateau and surrounding mare flood basalts, and has presumably excavated material from both regions. Here, we report on our observations of the morphology and stratigraphy of Aristarchus using high resolution Lunar Reconnaissance Orbiter – Narrow Angle Camera (LROC-NAC) images. In addition, we have derived absolute model ages (AMAs) using crater counts on the proximal ejecta blanket, crater floor, melt pools, and flow features to constrain the age of formation of the crater. These counts are also useful for investigating the effect of target material properties on the production of small craters.

1. Introduction

The stratigraphy of the Aristarchus ejecta blanket, and the effects of target material by the Aristarchus impact were previously been explored using Lunar Orbiter V images [e.g. 1, 2]. Our work aims to use new high-resolution (better than 1 meter/pixel) LROC-NAC images to make more detailed maps of the location and amount of impact melt produced by the impact, the distribution and properties of enigmatic flow features, and further characterize the crater at high resolution. To do this, we have produced a detailed geomorphologic map based on the current coverage of LROC images.

1.1 Flow Features

Many of the enigmatic features emanating from the rim of Aristarchus are suggested to be volcanic features [3]. This debate raged throughout the 1960's and 1970's, but most modern interpretations of flow features associated with Copernican-aged impact craters are attributed to impact-generated melt rock. Aristarchus contains interesting examples of sinuous channels, which appear to have fed large flow fronts extending away from the crater [e.g. 1-3]. The higher resolution of LROC data allows these features to be studied in greater detail. Clear evidence of melt flow occurring subsequent to the formation of the crater rim is observed, and superimposed craters have also been deformed by the flow. Flow tongues are observed to cross bright ray material, indicating the melt was molten for some time after the main excavation stage [see Fig 1].

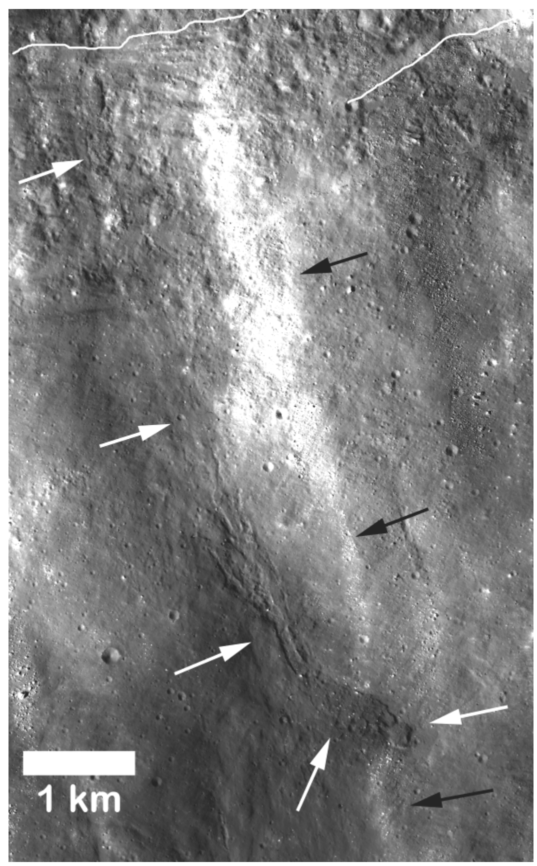

Figure 1: South-eastern portion of the Aristarchus Crater. Impact melt (white arrows) has flowed over a ray of bright blocky ejecta material (black arrows). The flow has channelized and has a lobate terminus. Crater rim (white line) is at the top of the image (LROC-NAC M104826302L [NASA/GSFC/Arizona State University]).

2. Absolute Model Age

While Aristarchus has been intensely studied due to its unique geologic environment, the age of the crater is poorly constrained. Early estimates for the continuous ejecta blanket vary from ~1 Ga [e.g. 3, 4], to ~ 450 Ma [5]. These ages are based on relative crater densities, and the Hartmann [4] estimation is based on the data from Strom and Fielder [3], so it is not surprising that a similar age was found. An absolute model age for Aristarchus was determined by König et al. (1977) which suggested an age of between 130 and 180 Ma [6, 7].

We have performed crater counts on the proximal ejecta blanket at various homogeneous appearing surfaces around Aristarchus, as well as on the floor of the crater, and impact melt pools inside and outside of the crater. Craters were counted using a new program CraterTools [8] developed for ESRI ArcGIS and the data were plotted and fit using the statistics program CraterStats [9]. Absolute model ages were derived using the chronology and production functions from Neukum et al. 2001 [10]. This chronology is valid for fitting AMAs to craters between 10 m and 100 m in diameter. Because of the high resolution of LROC, we are able to count craters as small as 2 meters. Our counts have covered ~33km² of the ejecta blanket; with more than 20,000 craters with diameters ranging from 230 m to 2 m. Populations of obvious secondary craters were carefully avoided.

Our counts on the proximal ejecta blanket reveal an age of ~175 Ma, which are in excellent agreement with the previous counts of König et al. 1977 [7]. Counts were also performed on areas of the crater floor, melt pools on the terrace walls, and melt pools on the ejecta blanket. The floor of Aristarchus is presumably composed principally of impact melt, and has a ridged and ropy texture, containing many open fractures. This texture makes discerning impact craters, and determining accurate diameters difficult, resulting in a modeled age of ~40 Ma, which is probably not representative of the true age of the crater. Counts performed on impact melt found inside and outside of the crater yield ages of ~70 Ma. These areas give significantly younger AMAs, which may result from differences between the material properties of the melt and ejecta blanket, which influences the crater size-frequency distribution of these units [11]. These age discrepancies have also been noted in crater counts performed at Jackson, Tycho and Copernicus craters [11, 12, 13]. The disagreement in ages of the melt pools and ejecta blanket needs to be investigated further, and counts on the floor and other impact melt pools are ongoing. However, if the properties of target material influence the crater size-frequency distributions, a volcanic interpretation for these features is not necessary, as suggested by [3].

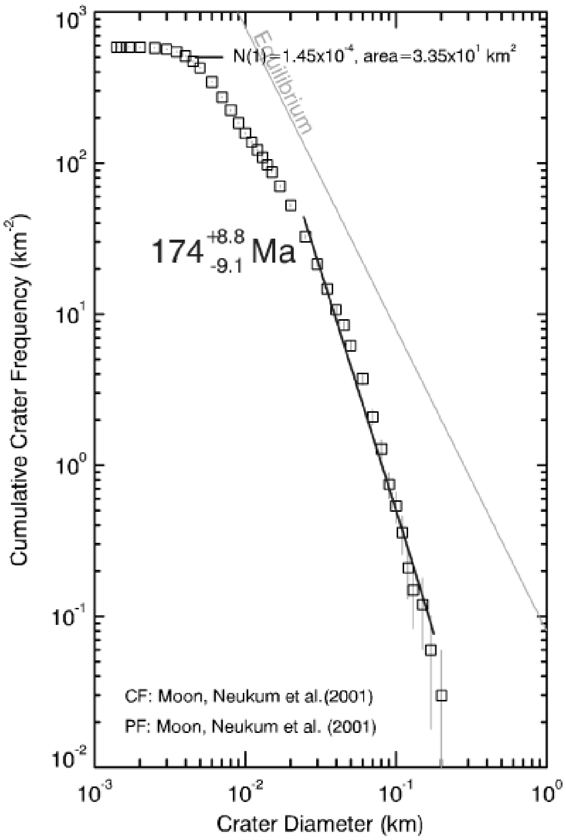

Figure 2: Combined crater size-frequency distribution for homogenous areas of the proximal ejecta blanket of Aristarchus Crater. Absolute model ages suggest the impact occurred approximately 170 Myr.

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