EPSC Abstracts
Vol. 7 EPSC2012-832 2012
European Planetary Science Congress 2012
© Author(s) 2012

# South Pole-Aitken Basin: Crater Size-Frequency Distribution Measurements

H. Hiesinger[1], C. H. van der Bogert[1], J. H. Pasckert[1], N. Schmedemann[2], M.S. Robinson[3], B. Jolliff[4], and N. Petro[5]; [1]Institut für Planetologie (IfP), WWU Münster, Wilhelm-Klemm-Straße 10, 48149 Münster, Germany (hiesinger@uni-muenster.de/ +49-251-8339057), [2]Institute of Geosciences, Freie Universität Berlin, Germany, [3]Arizona State University, Tempe, USA, [4]Dept. of Earth and Planet. Sci. Washington Univ., St. Louis, USA, [5]Goddard Spaceflight Center, Greenbelt, USA.

## Introduction

Being the largest basin (>2500 km in diameter) and presumably the oldest preserved impact structure on the Moon [e.g., 1], the South Pole-Aitken (SPA) basin is of particular interest. SPA might have penetrated the entire lunar crust and exposed lower crustal or upper mantle material, but despite its deep penetration, it did not reveal KREEP-rich rocks in contrast with the Imbrium basin. In addition, its age should shed light on the plausibility of the terminal cataclysm [e.g., 2]. To explain the large number of ~3.9 Ga impact ages documented in the Apollo and Luna sample collection, such a cataclysmic late heavy bombardment was proposed, for example, by [3]. Should the age of the SPA basin be close to 4 Ga, this might support the lunar cataclysm hypothesis [4]. However, the age of this basin is currently not well constrained. While we have some ancient lunar samples from the Apollo 16 and 17 landing sites in addition to the lunar meteorites Dhofar 489 and Yamato 86032, it is unclear whether these samples are really related to the SPA event or to some other impacts. The Apollo samples which clearly predate the local geology at these sites and the lunar farside meteorites have been interpreted to possibly indicate the formation of the SPA basin at 4.23 Ga [5].

Using new data from the Lunar Reconnaissance Orbiter (LRO) we performed detailed and systematic crater size-frequency distribution (CSFD) measurements of the entire SPA basin in order to derive relative and absolute model ages of the basin itself as well as several superposed impact structures, including the Planck, Oppenheimer, Schrödinger, and Apollo craters/basins.

## Data and Methods

We counted craters on a global mosaic of LRO wide-angle camera (WAC) images with a pixel scale of 100 m/pixel. We used ISIS 3 to process the mosaic and imported it into ArcGIS. Within ArcGIS, we used CraterTools [6] to perform our crater counts. The count area was defined on the basis of morphology and topography derived from the LROC WAC mosaic and LOLA. LOLA topography was also used to identify old and highly degraded impact structures and to improve our statistics in areas with large shadows close to the pole. The CSFDs were plotted with CraterStats [7], applying the lunar chronology (CF) of [8] and the production function (PF) of [9]. From this we derived absolute model ages (AMAs) for craters between ~1.5 km and 300 km in diameter [9]. More details on the technique of CSFD measurements can be found in [e.g., 9, 10-12].

## Results

Within the SPA basin, we mapped an area of $7.72 \times 10^6$ km$^2$ and counted 10,144 craters. Our CSFD measurements indicate that the SPA basin is ~4.26 (±0.03) Ga old ($N(1) = 3.70 \times 10^{-1}$). However, our counts also demonstrate that the crater size distribution is close to equilibrium (Fig. 1), so SPA could be even older.

Planck and Oppenheimer formed nearly at the same time, i.e., ~4.09 (+0.02/-0.03; $N(1) = 1.11 \times 10^{-1}$) and ~4.04 Ga (±0.01; $N(1) = 8.43 \times 10^{-2}$) ago. Schrödinger is younger and our crater counts indicate an absolute model age of ~3.92 Ga (±0.02; N(1) =

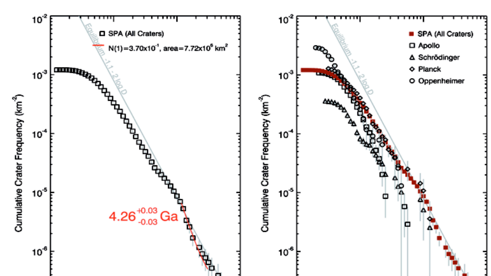


***Fig.1.*** *Absolute model age of the SPA basin (left) and relative ages of Apollo, Schrödinger, Planck, and Oppenheimer (SPA is shown in red).*

3.74x10$^{-2}$). Both Planck and Schrödinger exhibit underlying older ages of 4.26 (+0.07/-0.18; N(1) = 3.70x10$^{-1}$) Ga and 4.19 Ga (+0.08/-0.24; N(1) = 2.26x10$^{-1}$), thus being close to the age of SPA. For Apollo, only a poorly constrained age of 3.91 Ga (+0.04/-0.06; N(1) = 3.46x10$^{-2}$) could be derived, possibly because of modification of the basin by Orientale ejecta and/or secondary craters, which disturbed the CSFD such that we only get a poor fit to a few large craters.

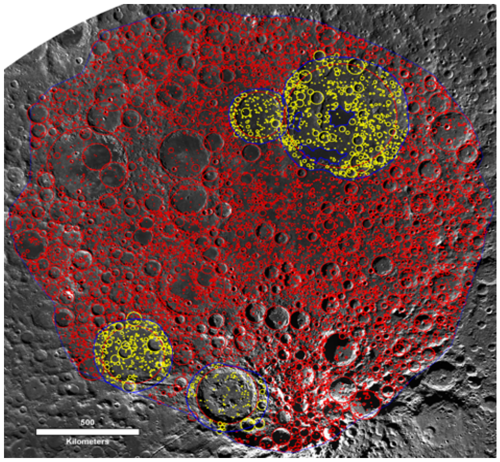


***Fig. 2.*** *Count area (blue) and counted craters (red) within the SPA basin. Craters superposed on Planck, Oppenheimer, Schrödinger, and Apollo craters/basins are shown in yellow. Stereographic map projection with the south pole approximately at the center of the lower image margin*

## Discussion

Our CSFDs confirm pre-Nectarian ages for Apollo and Planck and Nectarian ages for Schrödinger and Oppenheimer as indicated in the geologic maps of SPA [13,14] if we apply the stratigraphy of Stöffler and Ryder [15]. However, Wilhelms [1] argued that based on its fresh-looking morphology, Schrödinger could also be of Imbrian age. Our AMA of 3.92 Ga would correspond to the Nectarian/Imbrian boundary in the stratigraphy of [15], but would be Imbrian in age in the stratigraphy of [16].

After a careful review of work by [17-27], Garrick-Bethell et al. [5] concluded that the lunar samples 63503, 76535, 60025, 67955, 78155, and 78235 all show old ages of 4.11-4.27 Ga. The lunar meteorites Dhofar 489 and Yamato 86032, believed to come from the farside, also show Ar-Ar ages of 4.23 Ga [17,18]. On the basis of petrographic textures [28] proposed that 76535 originated from a depth of 40-50 km. Because Dhofar 489 also comes from deep crustal layers, a very large impact is required to excavate these samples. Consequently, [5] argued that these sample ages might represent the age of the SPA basin. While our absolute model age for SPA is indeed close to these radiometric ages, thus supporting such a model, the provenance of these samples are still highly debated.

## Conclusions

On the basis of our investigation we conclude that (1) SPA is significantly older than 4 Ga; (2) this age is consistent with radiometric ages of Apollo 16 and 17 samples, as well as lunar meteorite samples possibly excavated from the lunar farside; (3) the absolute model age of SPA is likely too old to be consistent with some models for lunar cataclysm; (4) some of the superposed craters such as Schrödinger and Planck only incompletely resurfaced the SPA basin as they exhibit underlying older ages that are similar to the age of SPA; (5) to unambiguously determine the age of SPA and excavation depth of material exposed at the surface a dedicated sample return mission is required.

## References

[1] Wilhelms, (1987) USGS Prof. Paper 1348. [2] Duke, (2003) Adv. Space Res. 31. [3] Tera and Wasserburg, (1974) LPS V. [4] Jolliff et al., (2010) LPS XLI. [5] Garrick-Bethell et al., (2008) Early Solar System Impact Bombardment. [6] Kneissl T., et al., (2010) LPS XLI. [7] hrscview.fu-berlin.de/craterstats.html. [8] Neukum G., et al., (2001) Space Sci. Rev. 96. [9] Neukum G., (1983) Habilitation Univ. München. [10] Hiesinger H., et al., (2000) J. Geophys. Res. 105. [11] Hartmann W. K., (1966) Icarus 5, 406-418. [12] Crater Analysis Working Group, (1979) Icarus 37, 467-474. [13] Stuart-Alexander, (1978), USGS I-1047. [14] Wilhelms et al., (1979 USGS I-1162. [15] Stöffler and Ryder, (2001 Space sci. rev. 96. [16] Neukum and Ivanov, (1994) Hazards due to comets and asteroids. [17] Takeda et al., (2006) EPSL 247. [18] Nyquist et al., (2006) GCA 70. [19] Lugmair et al., (1976) PLSC 7. [20] Premo and Tatsumoto, (1992) LPSC 22. [21] Huneke and Wasserburg, (1975) LPI VI. [22] Schaeffer and Husain, (1974) PLSC. [23] Norman et al., (2007) LPSC 38. [24] Turner and Cadogan, (1975) LPSC 6. [25] Oberli et al., (1979) LPI X. [26] Aeschlimann et al., (1982) LPI 13. [27] Nyquist et al., (1982) PLSC 12. [28] McCallum et al., (2006) GCA 70.

## Acknowledgements

This research has been supported by the German Space Agency (DLR). We would like to thank the LROC Operations Team for their successful planning and acquisition of high-quality LROC data.