NEW CRATER SIZE-FREQUENCY DISTRIBUTION MEASUREMENTS OF THE SOUTH POLE-AITKEN BASIN. 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: The South Pole Aitken (SPA) basin is the largest (>2500 km in diameter) and presumably the oldest preserved impact structure on the Moon [e.g., 1]. The SPA basin is of particular interest because (1) it might have penetrated the entire lunar crust and exposed lower crustal or upper mantle material, (2) despite its deep penetration, it did not reveal KREEP-rich rocks in contrast with the Imbrium basin, and (3) its age will shed light on the plausibility of the terminal cataclysm [e.g., 2]. Such a cataclysmic late heavy bombardment was proposed to explain the large number of ~3.9 Ga impact ages documented in the Apollo and Luna sample collection [e.g., 3]. Provided the age of the SPA basin is close to 4 Ga, this would support the lunar cataclysm hypothesis [4]. Unfortunately, the age of this basin is not well constrained. Ancient lunar samples from the Apollo 16 and 17 landing sites, which clearly predate the local geology at these sites, as well as lunar farside meteorites Dhofar 489 and Yamato 86032 were interpreted to indicate the formation of the SPA basin at 4.23 Ga [5]. However, it remains unknown whether these samples were indeed emplaced by the SPA impact or by other impact(s).

New data from the Lunar Reconnaissance Orbiter (LRO) now allow us to perform detailed and systematic crater size-frequency distribution (CSFD) measurements over the entire SPA basin in order to derive 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: For our crater size-frequency distribution measurements we used a global mosaic of LRO wide-angle camera (WAC) images with a pixel scale of 100 m/pixel. The mosaic was processed with ISIS 3 and imported 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. In particular, to identify old and highly degraded impact structures, and to improve our statistics in areas with large shadows close to the pole, we used LOLA topographic data. The CSFDs were plotted with CraterStats [7]. We used the production function (PF) of [8] and the lunar chronology of [9]. As a result, we obtained absolute model ages (AMAs) for craters in the diameter interval of ~1.5 km to 300 km [9]. For a detailed description of the technique of CSFD measurements, we refer to [e.g., 9, 10-12].

Results: We mapped an area of 7.72 x 10^6 km^2 within the SPA basin on which we counted 10,144 craters. Our CSFD measurements indicate that the SPA basin is ~4.26 (±0.03) Ga old (N(1) = 3.70x10^{-1}).

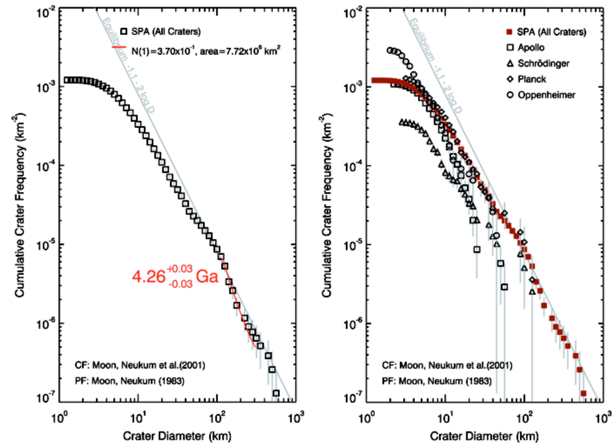

Fig.1. *Absolute model age of the SPA basin (left) and relative ages of Apollo, Schrödinger, Planck, and Oppenheimer (SPA is shown in red).*

We also find that the craters Planck and Oppenheimer formed nearly at the same time as each other, i.e., ~4.09 (+0.02/-0.03; N(1) = 1.11x10^{-1}) and ~4.04 Ga (±0.01; N(1) = 8.43x10^{-2}) ago. Schrödinger is younger and the CSFD shows an absolute model age of ~3.92 Ga (±0.02; N(1) = 3.74x10^{-2}). Both Planck and Schrödinger are characterized by 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, we could only derive a poorly constrained age of 3.91 Ga (+0.04/-0.06; N(1) = 3.46x10^{-2}). This might be due to the modification of the basin by Orientale ejecta and/or secondary craters, which disturbed the CSFD so that we only get a poor fit to a few large craters.

Discussion: The geologic maps that cover SPA indicate pre-Nectarian ages for Apollo and Planck and Nectarian ages for Schrödinger and Oppenheimer [13,14]. These ages are confirmed by our CSFDs when applying the stratigraphy of Stöffler and Ryder [15]. However, based on its fresh-looking morphology, Wilhelms [1] argued that 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]. Garrick-Bethell et al. [5] carefully reviewed work by [17-27] and concluded that the lunar samples 63503, 76535, 60025, 67955, 78155, and 78235 all show old ages of 4.11-4.27 Ga. In addition, lunar meteorites Dhofar 489 and Yamato 86032, which are believed to come from the farside also show Ar-Ar ages of 4.23 Ga [17,18]. Because 76535 originated from a depth of 40-50 km [28], and Dhofar 489 also comes from deep crustal layers, a very large impact is required to excavate these samples. This led [5] to propose that these sample ages might represent the age of the SPA basin. Our absolute model age for SPA are indeed close to these radiometric ages, thus supporting such a model.

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.

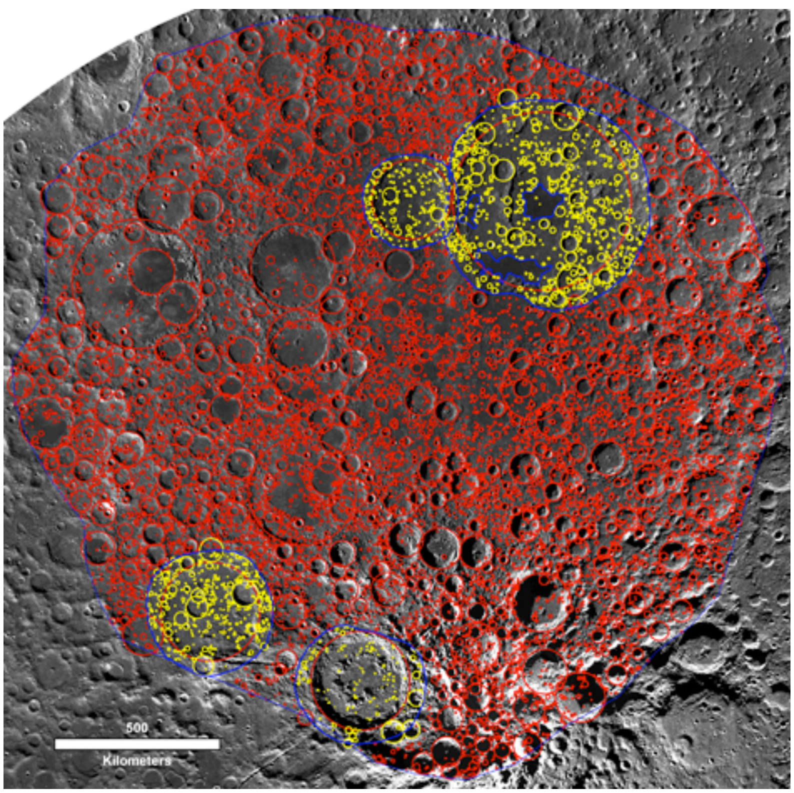

Fig. 2. *Count area (blue) and counted craters (red) within the SPA basin. Craters superposed on Planck, Oppenheimer, Schrödinger, and Apollo craters/basins are shown in yellow. Stereographic map projection with the south pole approximately at the center of the lower image margin.*