GEOLOGICAL MAPPING OF LARGE BASINS ON THE TERRESTRIAL PLANETS IN THE SCOPE OF PLANMAP. C. M. Poehler[1], W. Iqbal[1], C. H. van der Bogert[1], H. Hiesinger[1], A. M. Lewang[1], C. Rueckert[1], J. H. Pasckert[1], M. A. Ivanov[2], M. Massironi[3], and the PLANMAP Team. [1]Institut für Planetologie, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Str. 10, 48149, Münster, Germany, c.poehler@uni-muenster.de, [2]Vernadsky Inst., RAS, Russia, [3]Dipartimento di Geoscienze, Università degli Studi di Padova, Padua, Italy.

Introduction: The PLANetary MAPping project (www.planmap.eu) is an European Union Horizon2020-COMPET4 project, aiming to develop a European network for geological mapping. This network is will generate geological maps specifically dedicated to planetary exploration at different levels (orbital, robotic, and human) by integrating data from different sources (e.g., images, DTMs, spectral-cubes, chemical data, radar sounding products, in situ observations). By exploiting new data sets, PLANMAP aims to provide new products complementary to the existing ones, starting with the three main bodies of interest for Europe in the next decade: the Moon, Mercury, and Mars [1]. Our work for the project involves producing morpho-stratigraphic maps using crater size-frequency distribution (CSFD) measurements to help fix the absolute ages of the geomorphological units. We have chosen to examine three basins in the inner Solar System: (1) South Pole-Aitken (SPA) basin, Moon; (2) Beethoven basin, Mercury; and (3) Argyre basin, Mars; because the resulting maps and interpretations not only will support exploration goals, but also aid in understanding the history and evolution of these large basins.

Background: The SPA basin, situated on the lunar farside and centered at 53°S 169°W, is the largest [2-6] and oldest basin [7,8] on the Moon. Due to its morphological appearance it is argued that the SPA basin formed within an already solidified lunar crust [2]. Therefore, the time of SPA formation gives valuable information on the evolution of the lunar crust. The large scale of the impact led to the hypothesis of it penetrating the crust and potentially exposing lunar mantle material within the SPA [e.g., 9]. Thus, it might be possible to observe lunar mantle material or lower crustal material excavated by the impact event [e.g., 10]. Recently, the SPA has been the focus of several ongoing and upcoming missions [11-14]. On January 2, 2019, Chang'e 4 performed the first ever soft-landing on the farside of the Moon in Von Kármán crater (175.9° E and 44.8° S) [12]. Sites in SPA are also being examined as possible landing sites for ESA's HERACLES mission study [15-17].

The Beethoven basin (20°S 124°W, 630 km diameter) is one of the largest confirmed basins on Mercury [18]. Like Caloris, the Beethoven basin is significantly shallower than comparable sized basins on the Moon. giving indications for the thickness of the crust and the mechanics of basin formation on Mercury [19]. The Beethoven basin shows extensive smooth plains in its interior. Mapping the extend of smooth plains and analyzing their occurrence gives insights into the formation of smooth plains [20]. Our ongoing work mapping this basin fits into a larger planetary mapping project with the goal of producing a 1:3M map of the entire planet [21]. In preparation for new high spectral and geometric resolutions, as well as to correctly interpret new compositional measurements, detailed geological maps of Mercury's surface are needed. Such maps will also help to define the best observational strategies and target prioritization.

Mars has been targeted by several missions and is still a high interest target. The Argyre basin is one of the largest and best preserved impact basins on Mars [22]. Its complex history has led to several models including volcanic, glacial, fluvial/lacustrine/eolian and mudflows for its geological evolution [23-29]. For example, it has been proposed that meltwater from the south polar region completely filled the basin until it spilled over toward the north, forming the longest drainage system in the Solar System [30]. However, Hiesinger and Head [31] questioned this because they could not find conclusive evidence for a complete fill of the basin. To get more information on the history of this basin a detailed new map is needed.

Data: *Lunar:* We are using modern Lunar Reconnaissance Orbiter (LRO) Wide-Angle Camera (WAC) (100 m/pixel), Narrow-Angle Camera (NAC) (0.5m/pixel) [32] and Kaguya data (10 m/pixel) data with different incident angels. We are also using the hybrid spectral mapping technique using Clementine [33], M3 [34] and Kaguya MI [35] data. The topographic features are mostly mapped using Lunar Orbiter Laser Altimeter (LOLA) Digital elevation models and most recently produced LOLA/Kaguya merged digital elevation model (DEM) that has the resolution of 59 m/pixel [36]. For detailed geological mapping, LRO NAC stereo pairs DTM are used.

Mercurian: The Mercury Dual Imaging System (MDIS) data with a mean spatial resolution of ~200 m/pixel [37] is used for the geomorphological mapping of the basins on Mercury. The maps are produced on MDR (MDIS 8-color) base map and Digital Elevation Model (DEM).

Martian: The mapping of the units on Mars uses mid-infrared data from the Thermal Emission Imaging System (THEMIS) aboard Mars Odyssey. The THEMIS-IR Daytime global mosaic (100 m/px) [38] is used as a base map of the maps. THEMISIR were used to identify the thermophysical properties of the surface. In addition, we are using mid- to high-resolution visible image data from two Mars Reconnaissance Orbiter (MRO) instruments, the Context Camera (CTX; ~6 m/px) [39] and the High Resolution Imaging Science Experiment (HiRISE; 25-50 cm/px) [40,41], as well as Mars Orbiter Narrow Angle Camera (MOCNA; 1.4 - ~3 m/px) data [42] aboard Mars Global Surveyor (MGS). For structural mapping we use stereographic digital terrain models (DTMs; 50 m/px) [43] based on HRSC images and Mars Orbiter Laser Altimeter (MOLA) with a horizontal resolution of 463 m/px [44]. For small scale structural mapping we use MOLA Precision Experiment Data Records (PEDR) with an along-track spacing of 330 m and a vertical resolution of ~1 m [45].

Furthermore, we analyze data from the Gamma Ray Spectrometer (GRS, ~7 km/px) [46] and Thermal Emission Spectrometer (TES; ~3 km/px) [47] on MGS. Previous investigations based on hyperspectral data by both, the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM; 16-20 m/px) on MRO) [48,49], as well as the Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité (OMEGA) on MEx) [50-52] for the confirmation of the units.

Methods: We use the standards of [53] for planetary mapping and the used nomenclature is consistent with [54], in addition to project specific recommendations for presentation of nonstandard data sets and mapping products [55].

In addition to relative dating for stratigraphic analysis, we perform crater size-frequency distribution measurements (CSFD) and from that determined absolute model ages using the production and chronology functions of [56]. CSFD measurements are made using Crater Tool [57] in ArcGIS, and we use Craterstats to determine corresponding AMAs [58]. Detailed descriptions of the CSFD measurement technique are given by [56, 59, 60].

Ongoing work: We are working on several mapping projects on the Moon, Mercury and Mars. On the Moon we are extending the geologic map of [13], which covers the northeastern part of SPA. We are also working on a detailed study of the Von Kármán crater to provide a detailed map of the area. Furthermore, we work on new maps of the Apollo landing sites [61, 62] that give constraints on the lunar chronology functions [56].

On Mercury we are involved in the ongoing work of creating a global 1:3M map of the planet [21]. For this we are compiling a geological map of Beethoven [18] basin using the fresh multi-source data available from MESSENGER spacecraft to prepare for the BepiColombo Mission.

The final component of our PLANMAP project involves mapping Argyre basin and Western Arabia Terra. These maps will follow work done by [63] on the Hellas basin.

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