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AN IMPACT ORIGIN FOR CHRYSE PLANITIA ON MARS? L. Pan¹, C. Quantin¹, C. Michaut¹ and S. Breton¹.
¹ Univ. Lyon, Université Claude Bernard Lyon 1, ENS de Lyon, CNRS, UMR 5276 LGL-TPE*, F-69622 Villeurbanne, France (2 rue Raphaël Dubois, Bâtiment GEODE, Villeurbanne, 69622, France. lu.pan@univ-lyon1.fr).

Introduction: Large impacts dramatically influenced planetary surfaces in the first hundreds of million years since solar system formation. On Mars, early large impacts may have created the hemispheric dichotomy [1,2], delivered additional planetary materials [3] and induced local habitable environments [4,5]. Unlike the Moon or Mercury, the lack of well-preserved record of earliest epochs on Mars due to the active resurfacing on the planet results in large uncertainties in the early impactor flux. It is found that the scarcity of large impact basins, in particular on the dichotomy boundary of the planet, is inconsistent with the expected high impactor flux in the first hundreds of million years [6]. Thus, it is crucial to evaluate the effect of active geologic and fluvial activities on the planet, which may have masked the topographic signature made by large impact basins.

Investigating Chryse Planitia: Chryse Planitia, located to the south of Acidalia Planitia, is a region of low-lying plains on the dichotomy of Mars, at the termini of major outflow channels (Figure 1a). The ringed distribution of massifs and chaotic terrains surrounding the plains led to the suggestion that the Chryse region originated from a large impact [7,8]. However, because most topographic features have been removed and the gravity anomaly is small (Figure 1b, c), the presence of an early impact basin is still under debate [6]. Here we make use of the latest Goddard Mars Model gravity data [9], as well as the global imagery and topography datasets [10,11] to revisit the origin of Chryse Planitia. Impact size-frequency distribution has been widely used to

understand the resurfacing history of planets [e.g. 12, 13]. In addition, impact crater population on planetary surfaces have predictable initial morphologies (e.g. depth, rim height), which can be modified by subsequent geologic processes, such as erosion and infill. Study of impact crater morphology and statistics may provide crucial information on the subsurface topography and resurfacing history [e.g. 14]. We build upon a global crater database [15] and investigate the morphology and distribution of impact craters to understand the subsurface topography and resurfacing history of the Chryse basin.

Impact crater populations in Chryse and adjacent regions: We mapped and classified the buried impact crater populations based on their degrees of degradation in the extent of the general Chryse and Acidalia region [16]. We highlight impact craters with clear rim structure in the imagery or topography dataset as partially and completely buried craters and exclude those with only a non-circular topographic depression and little evidence of crater rim (unclear category). We find a heterogeneous distribution of buried impact craters within Chryse Planitia. Interestingly, buried impact craters are lacking in the regions with positive Bouguer anomaly compared to adjacent regions (Figure 1c, Figure 2a). North of Chryse Planitia, only partially-filled small impacts are found in the region covered by the late Vastitas Borealis Formation. The distinct morphology of buried/degraded and pristine impact craters causes a bimodal distribution of the depth-diameter ratio in both

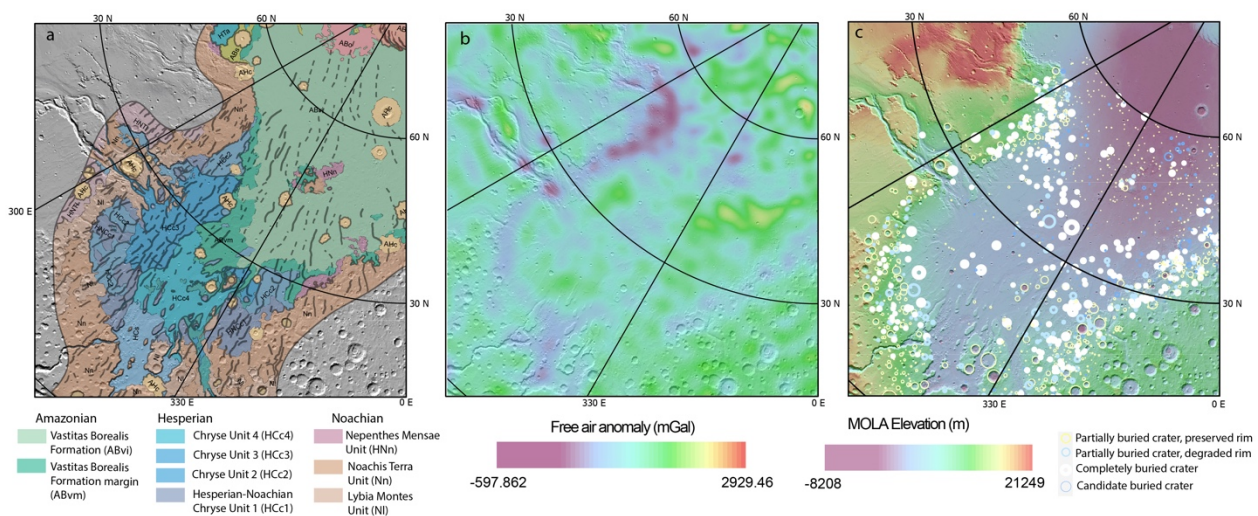


Figure 1 Map of the Chryse and Acidalia Planitia: a) Geologic map of the northern lowlands [16]. b) Goddard Mars Model 3 gravity data, Free Air anomaly. c) Topography data from Mars Orbiter Laser Altimeter (MOLA) data with the outlines of partially or completely buried impact craters. All three base maps are projected using the Mars North Polar Stereographic Projection.

the anomaly units and adjacent units (Figure 2). With only mild modification, the relative pristine population in Chryse Planitia have a distribution of depth-to-diameter ratio between 0.05-0.2, while a population of buried or heavily degraded impact craters shows a smaller depth-to-diameter ratio (<0.05). Moreover, the relative abundances of buried impact craters show an apparent discrepancy between the anomaly units and adjacent units.

Discussion: The distinct two populations of crater depth-to-diameter ratio indicate that geologic processes different from long-term degradation of crater depth have played an important role. The flat-floor morphology and well-preserved crater rim for most partially buried craters suggest that these craters probably experienced burial due to one infill event [e.g. 17]. On the other hand, the discrepancy in crater populations in the anomaly and adjacent units indicates the two types of regions experienced slightly different resurfacing processes. The adjacent units, being close to the Vastitas Borealis Formation, are more recently resurfaced than the anomaly units, evident from the number density of small craters. Therefore, the lack of buried craters in the anomaly units cannot be ascribed to recent resurfacing events. We suggest the distribution of buried impact craters in Chryse Planitia may be related to the differential resurfacing in this region, if the anomaly units correspond to an earlier topographic depression.

Summary and implications: We find a heterogeneous distribution of buried and pristine impact craters in the Chryse Planitia region that spatially correlate with positive Bouguer anomaly. The lack of buried impact craters within the anomaly unit may be due to a differential infill within a pre-existing circular depression corresponding to the Chryse anomaly unit, consistent with the origin as an impact basin. Further analyses on the

effect of topography on the impact crater statistics and the cause for gravity signature will be done to better constrain the origin and evolution of Chryse Planitia. This suggests a significant portion of the impact record on Mars may have been masked due to resurfacing. Further studies based on the evolution of cratered terrains will help reveal geological processes during this crucial time period on Mars 4 billion years ago that may have determined the fate of water and climate on the planet.

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References: [1] Marinova M. M., O. Aharonson, and E. Asphaug. (2008) *Nature* 453.7199, 1216. [2] Andrews-Hanna J. C., M. T. Zuber, and W. B. Banerdt. (2008) *Nature* 453.7199 1212. [3] Dale, Christopher W., et al. (2012) *Science* 336.6077 72-75. [4] Abramov, O. & Kring, D. A. (2005) *J. Geophys. Res. Planets* 110, 1–19. [5] Schwenzer, S. P. & Kring, D. A. (2009) *Geology* 37, 1091–1094. [6] Bottke, W. F. & Andrews-Hanna, J. C. (2017) *Nat. Geosci.* 10, 344–348. [7] Schultz, P. H., Schultz, R. A. & Rogers (1982), *J. J. Geophys. Res.* 87, 9803–9820. [8] Frey, H. V. & Schultz (1998), *R. Geophys. Res. Lett.* 15, 229–232. [9] Genova, A. et al. (2016) *Icarus* 272, 228–245 (2016). [10] Edwards, C. S. et al. (2011) *J. Geophys. Res. Planets* 116, 1–21 (2011). [11] Zuber, M. T. et al. (1994) *Science* (80-). 266, 1839–1843. [12] Hartmann, W. K. (1971). *Icarus* 15, 410–428. [13] Chapman, C. R. & Jones, K. L. (1977). *Annu. Rev. Earth Planet. Sci.* 5, 515–40 (1977). [14] Platz, T., Michael, G. G. & Neukum, G. (2010) *Earth Planet. Sci. Lett.* 293, 388–395. [15] Robbins, S. J. & Hynes, B. M. (2012) *J. Geophys. Res. Planets* 117, 1–18. [16] Tanaka, K. L., Skinner Jr., J. A. & Hare, T. M. (2005) *US Geol. Surv.* 80225 (2005). [17] Head, J. W., Kreslavsky, M. A. & Pratt, S. (2012) *J. Geophys. Res.* 107, 5003.

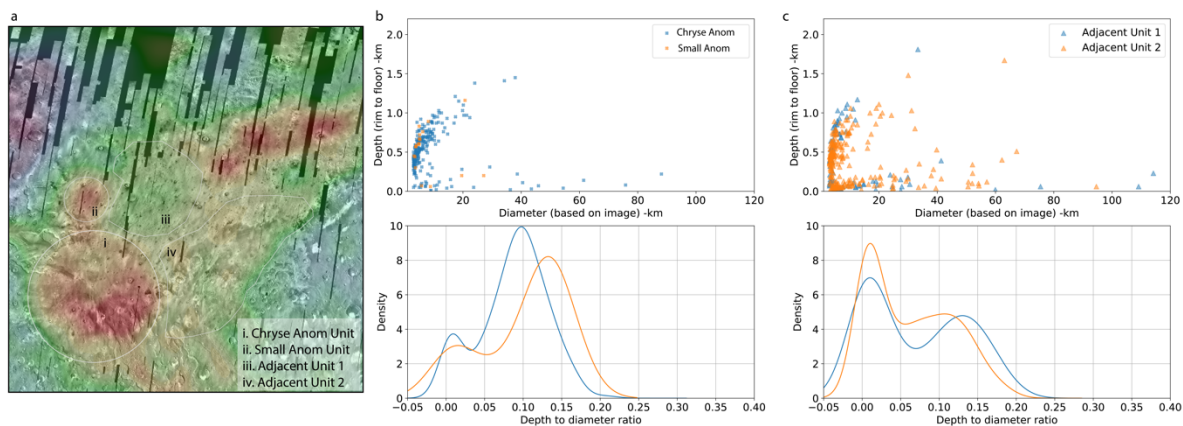


Figure 2: Depth-to-diameter ratio distribution in different units within the Chryse Planitia. a): Bouguer gravity map of the Chryse and Acidalia Planitia overlain on the THEMIS day-time Infrared data. Thin white lines outline the boundary of four units where impact crater depth and diameter are analyzed. b-c): The depth-diameter scatter plot and kernel density distribution of depth/diameter ratio for b) the Chryse anomaly unit and small anomaly unit; c) The adjacent units 1 and 2.