MASS DELIVERY ONTO TERRESTRIAL PLANETS – INSIGHT FROM SCALING LAWS AND BASIN RECORD. S. C. Werner[1], M.-H. Zhu[2], K. Wünnemann[3], and T. Rolf[1], [1]Centre for Earth Evolution and Dynamics, University of Oslo, Norway (stephanie.werner@geo.uio.no) , [2]Space Science Institute, Macau University of Science and Technology, Taipa, Macau, [3]Museum für Naturkunde, Leibniz Institute for Evolution and Biodiversity Science, Berlin, Germany.

Introduction: A striking feature on the lunar surface is the population of impact basins of which a few dozen are cataloged. These large-scale structures have diameters of several 100 to >2000 km and their signature is clearly visible in present-day observables such as the gravity field [1]. The chronology of lunar basins is essential for understanding the age of the lunar surface and its early evolution [2]. Recently, [3] began to evaluate the challenges numerical approaches face when basin forming impacts are studied. We have expended on this attempt here and focus on the projectile-crater size scaling and potential mass delivered, while a companion abstract [4] investigates the role of basin-forming impacts on the thermal evolution of the moon.

Observations: [2] documented an offset between the basin size-frequency distribution and the 10s-100s km diameter range impact structures and the scaled observed main belt asteroid size-frequency distribution (SFD) [5] for Moon, Mars, and Mercury, Fig. 1.

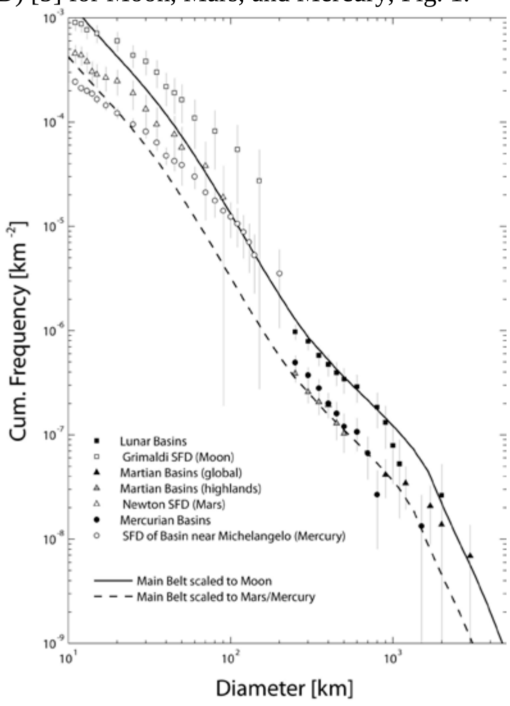

Fig. 1: Cumulative crater SFDs for Mars, Moon, and Mercury in comparison with simple scaling of the main belt asteroid size-frequency distribution [5] and one example measurement of one of the oldest surface (basin rim units) for each of the three bodies.

The main belt asteroid distribution is suggested to best represent the projectile population for the earliest bombardment phase [6]. [2] compared the total basin distribution and representative counts for the oldest surface units on the respective three bodies. From these observations it was suggested that the maximum surface age derived from the basin distribution itself and that from the crater distribution of most densely cratered surface units appears younger by about 150 million years for all bodies. Recent data, [e.g., 1] could not detect significant numbers of subdued basins to recover basins missing in number of a factor of two. For the current state of comparison only simple, continuous crater size-projectile size scaling laws were used – the impact velocity was kept constant. The preliminary results do not yet allow to unravel the discordance between crater record and main-asteroid belt.

Basin formation modelling and scaling: To obtain a scaling relationship between projectile diameter and final basin diameter, we make use of several correlations in this work: (a) [1] demonstrates that the diameter of the inner ring approximately corresponds to the diameter of the Bouguer anomaly (measured at the halfvalue width) (b) [e.g., 1] also suggest that diameter relationship between the inner ring and main ring is almost 2, and (c) by a series of iSALE basin forming simulations with varying impactor diameters we find a scaling relation between transient crater diameter and Bouguer anomaly diameter. We carried out simulations assuming different pre-impact target temperature conditions [7,8] and found that irrespective of whether we assume a hot or a cold target the results of all simulations fall on the same scaling line (Fig. 2). Finally, (d) we employed standard π-group scaling [9] to relate transient crater size with the projectile diameter – note that the effect of pre-impact target temperature is not negligible here (Fig. 3). Based on these relationships that are partly based on observations and partly on numerical models we can finally predict basin size for a given projectile diameter (Fig. 4). In a last step, we used the correlations described above to estimate the possible relationship between observed basin SFDs and the respective projectile, which formed basins of a specific size.

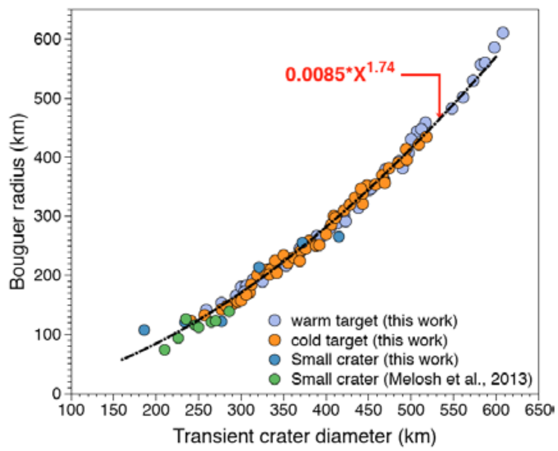

Fig. 2: The scaling relationship between the transient crater diameter and the radius of the Bouguer anomaly (measured at half-value width) based on numerical modeling using iSALE.

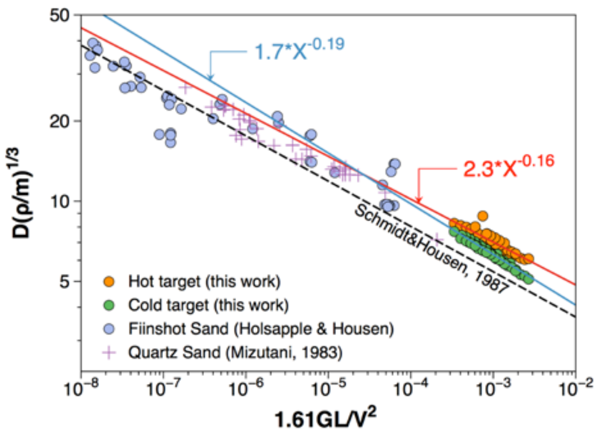

Fig. 3: The scaling relationship between $\pi_2 = 1.61GL/U^2$ and $\pi_D = D(\rho/m)^{1/3}$ *for cold and hot target. The datasets from sand experiments are given for reference [10,11,12].*

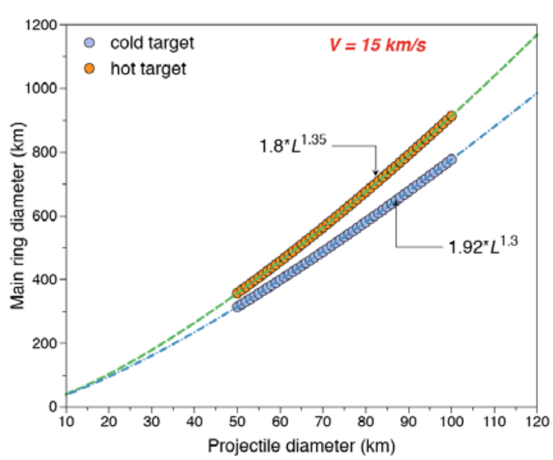

Fig. 4: The scaling relationship between projectile diameter and basin diameter for cold and hot target.

Preliminary Conclusion: Currently, we are facing the challenge, that all relationships are described by smooth functions, while the observed basin and crater SFD records a kink at about 200 km impact structure diameter. Thus, mass estimates and age determination inconsistence cannot yet be treated. We will elaborate on and refine the determination of the final impact structure diameter at the transition between basin-scale and complex craters, which for the later may currently underestimate the final diameter.

Outlook: This relationship shall be tested also for Mars and Mercury.

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