LABORATORY CRATERS AND THEIR COMPARISON WITH CRATERS FROM GT-115225 GLOBAL CATALOGUE OF MARTIAN IMPACT CRATERS. M. Vojković[1], L. Karbonini[2,1], D. Vinković[3,1], G. Salamunićcar[4,5] and S. Lončarić[5], [1]Physics Department, Faculty of Natural Sciences and Mathematics, University of Split, Nikole Tesle 12, HR-21000 Split, Croatia, marvoj@pmfst.hr, [2]luckar@pmfst.hr, [3]vinkovic@pmfst.hr, [4]AVL-AST d.o.o., Av. Dubrovnik 10/II, HR-10020 Zagreb-Novi Zagreb, Croatia, gsc@ieee.org, [5]Faculty of Electrical Engineering and Computing, University of Zagreb, Unska 3, HR-10000 Zagreb, Croatia, sven.loncaric@fer.hr.

Summary: We present the results of comparison between explosion-induced laboratory craters in stone powder surfaces and the newly available GT-115225 catalogue of Martian impact craters. Laboratory craters are centimeters in size and fit into the gravity regime of simple craters thanks to a negligible material strength of the powder. We show that these craters follow the same depth/diameter relationship as the young Martian simple craters smaller than ~10km in diameter.

Introduction: The main objectives of this work was to develop a simple method for making laboratory craters that could be used as a proxy for real impact craters on Mars. In order to achieve this, we performed measurements of craters produced in a laboratory and compared the results with measurements for Martian craters. Laboratory craters were produced in stone powder using silver acetylide (Ag_2C_2) as the explosive. Data for Mars are taken from the new GT-115225 catalogue [1], which is an extended version of the previous GT-57633 catalogue of Martian impact craters [2]. The new extended version contains 57592 previously uncatalogued craters identified using the new method for crater detection from MOLA data. The automated topographic-cross-profile and depth/diameter measurements [3] were applied on the Martian craters. We also included the data on depth and diameter of small fresh Martian craters identified in a recent work on the distribution of mid-latitude ground ice on Mars [4].

The theory of simple impact craters distinguishes between the strength regime and the gravity regime of cratering [5]. The strength regime is applied when the strength of a soil surface is large compared to the gravitational pressures within the ground surface at depths comparable to the impactor size. In this regime the crater shape is dictated by the soil properties. The gravity regime is applicable when the soil strength is much smaller then the gravity pressure. The crater properties are then dictated by the impactor's size and velocity for a given planet surface gravity. This happens for about kilometer-sized impactors, but laboratory experiments showed that craters on soils of negligible strength, such as a dry sand, can extend this regime to much smaller impactor sizes [5]. The simple explosion-induced craters under the gravity regime are geometrically similar for various planetary gravities and explosion energies. This yields a relationship between their depth and diameter [6]

$$d = 0.204 \cdot D \qquad (1)$$

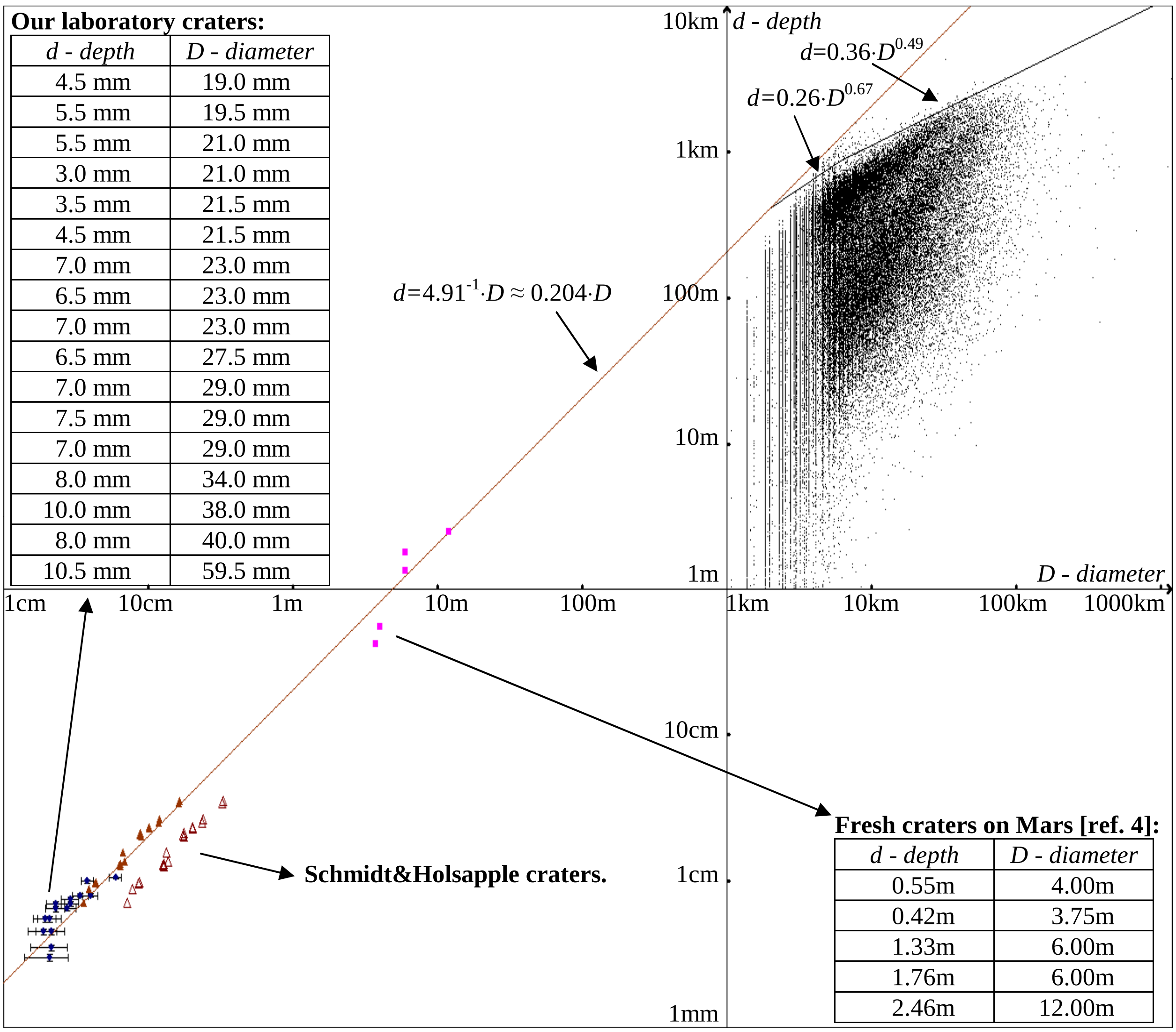
The factor 0.204 is derived from equations for crater radius at ground surface, depth of crater floor below rim and height of rim above original surface [6]. If we measure depth/diameter from the crater rim then this factor becomes 0.20 [6]. We explore if our experimental method produces laboratory craters that fit into this simple depth/diameter description together with the latest data on Mars craters.

Methods: The experiments were performed on a fine dry stone powder produced in a local limestone quarry as a by-product of stone cutting. The powder was placed in containers much larger than the finally obtained craters. The powder was compressed such that the surface density was 1.60-1.75g/cm^3. We used silver acetylide for explosive charges because it is easily accessible in small quantities as a by-product in regular chemistry classes. The charge mass varied from 10mg to 635mg. The explosive was positioned just below the surface. Its shape and bulk density varied because it was in a granular form. We compensated this uncertainty in explosive charge properties by performing multiple experiments with a similar overall mass of the charge. Since the obtained craters are very fragile for detailed measuring, we had to use a method that would harden the crater surface. Therefore, we first covered the crater with a layer of a cement powder and sprayed it with water. Once the cement hardened, we covered it with gypsum plaster. This produced the cast of the crater that we could cut and measure.

Results: The depth of our laboratory craters was 3.0-10.5mm and the diameter was 19.0-59.5mm. Their position in the depth-diameter diagram is shown in Figure 1, together with the Mars craters. We plotted the analytical prediction from Equation 1 and find that our data aligns nicely with the prediction. Moreover, recently identified small Mars craters (diameters of 4-12m) [4] are explained by the very same equation. Finally, the upper boundary on the scattered depth/diameter data from the new GT-115225 catalogue [1] is also explained by Equation 1. We also plotted literature data from explosive cratering in a dry sand under a large range of gravities simulated in a centrifuge [7]. Surprisingly, these data fit perfectly the above linear trend, but only if we use the depth/radius instead of the depth/diameter relationship. Our guess is that this difference is caused by their charge being spherical and half-buried, while our explosive charge was completely buried just below the surface. Hence, their explosive discharges were able to excavate a larger diameter of a crater.

Conclusion: The results show that our experimental cratering can be used as a proxy for simple Mars craters formed under gravity regime. The analytic relationship in Equation 1 reproduces the depth/diameter relationship for such craters and holds for 6 decades of depth (from mm sizes to kilometers) and diameter (from cm sizes to tens of kilometers).

References: [1] Salamunićcar G. and Lončarić S. (accepted) *Trans. Geosci. Remote Sens.*, (DOI: 10.1109/TGRS.2009.2037750). [2] Salamunićcar G. and Lončarić S. (2008) *Planet. and Space Sci.*, *56*, 1992-2008. [3] Salamunićcar G. and Lončarić S. (2009) *LPS XXXX*, Abstract #1085. [4] Byrne S. et al. (2009) *Science*, *325*, 1674-1676. [5] Holsapple K. A. (1993) *Annual Review of Earth and Planetary Sciences*, *21*, 333-373. [6] Holsapple K. A. (1994) *LPS XXV*, Abstract #1280. [7] Schmidt R. M. and Holsapple K. A. (1980) *J. Geophys. Res.*, *85*, 235-252.



Our laboratory craters:

d - depth	*D - diameter*
4.5 mm	19.0 mm
5.5 mm	19.5 mm
5.5 mm	21.0 mm
3.0 mm	21.0 mm
3.5 mm	21.5 mm
4.5 mm	21.5 mm
7.0 mm	23.0 mm
6.5 mm	23.0 mm
7.0 mm	23.0 mm
6.5 mm	27.5 mm
7.0 mm	29.0 mm
7.5 mm	29.0 mm
7.0 mm	29.0 mm
8.0 mm	34.0 mm
10.0 mm	38.0 mm
8.0 mm	40.0 mm
10.5 mm	59.5 mm

Fresh craters on Mars [ref. 4]:

d - depth	*D - diameter*
0.55m	4.00m
0.42m	3.75m
1.33m	6.00m
1.76m	6.00m
2.46m	12.00m

Figure 1: Depth/diameter in log/log scale for our laboratory craters (g=1G; solid dots with error bars; the upper left table), craters by Schmidt & Holsapple [7] produced in a centrifuge (g=1-463G; open triangles; the depth/radius data are shown as solid triangles); recently described small craters on Mars from [4] (g=0.38G: solid squares; the lower-right table) and all craters from the new GT-115225 catalogue (dots in top-right). Equation 1 is also shown [6].