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Impact Cratering Experiments in Rock Targets Over The Temperature Range 150 – 900 K

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Abstract

We report on laboratory experiments of hypervelocity impact cratering in rocks. Although most impact experiments are performed at room temperature (typically 291 K) this is not the norm for planets other than the Earth. On Mars for example, annual mean temperature is around 210-220 K and on Venus it is of order 740 K. It is therefore of interest to know how targets pre-heated to these temperatures behave under impact. Accordingly we make a preliminary report on hypervelocity impact experiments on three rock types (limestone, sandstone and basalt). The impact speed was ~5 km s^{-1} with 0.8 mm dia. spherical st. st. projectiles. Target temperature varied from 150 – 900 K. We found crater dimensions decreased as temperature increased, with the strongest effect in crater volume.

1. Introduction

Impacts are a ubiquitous process throughout the solar system. To understand them use is made of both computer simulations and laboratory experiments. Modelling can operate at various size scales, but the physics of the processes needs to be correctly input. In experiments we can vary individual parameters in the impacts (such as impact speed etc.) so that we can explore dependencies on specific properties. Here we use experiments in the laboratory to test the influence on impact cratering of target temperature at the moment of impact.

The temperature of rocky bodies in the solar system is not a single uniform value. Yet most experimental studies take no account of this. Impact cratering on metals has recently been reported as a function of temperature over the range 130 – 470 K [1]. Here we look at impacts on rocks over 150 K – 900 K. This builds on an earlier report of related work in our laboratory which reported on impacts in limestone, sandstone and hematite rocks over a temperature range 172 – 500 K [2].

2. Method

In the original work [2] some targets were blocks and some cylinders. In this new work all heated targets were cylinders whilst room temperature and cooled targets were rectangular. For heated work they were placed in a specially designed heating jacket with their front face exposed. Thermocouples on the jacket monitor the target temperature. The target assembly was placed in a large vacuum chamber which was then evacuated to ~0.5 mbar. For low temperature shots the targets were pre-cooled in a low temperature freezer and then placed in the target chamber. Again, target temperature was monitored by a thermocouple. The target chamber was connected to a two stage light gas gun at the Univ. of Kent [3]. In the shots here, a 0.8 mm dia. st. st. spherical projectile was used, fired at ~5 km s^{-1}. The targets were imaged during impact and an example is shown in Fig. 1.

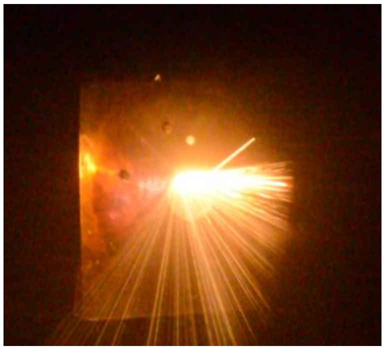

Figure 1: A sandstone target seen near face on undergoing an impact. The bright rays seen are ejecta. The target temperature at the moment of impact was 730 °C.

After each shot, the targets returned to room temperature and were examined visually. They were also imaged with false-stereo imaging to allow 3D digital reconstructions of the craters. Crater depth, diameter and volume were obtained in each case.

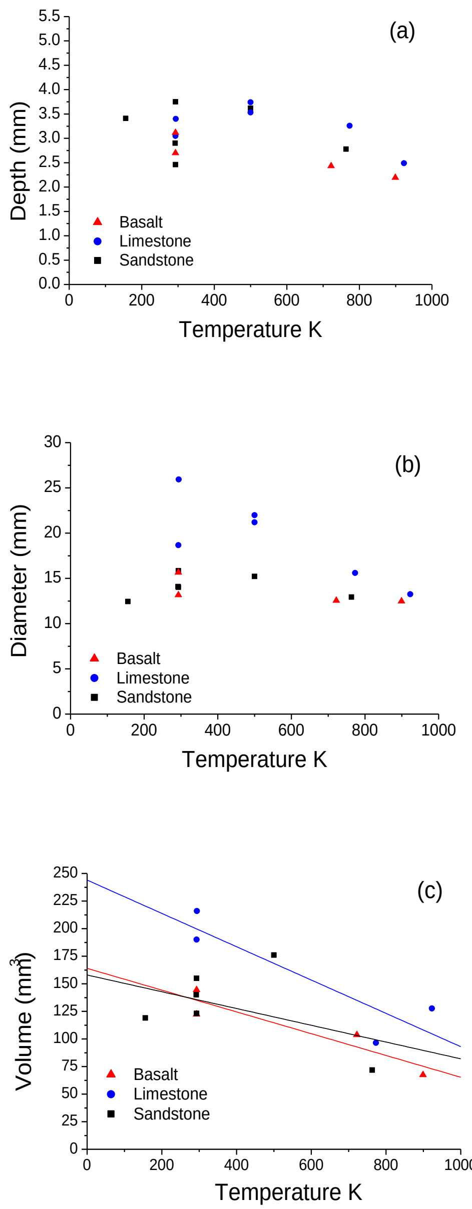

Figure 2: Results of crater dimensions vs. pre-impact target temperature. (a) Depth, (b) Diameter and (c) Volume.

3. Results

The results of the analysis of data from 14 shots are shown in Figure 2 for crater depth, diameter and volume. The crater depth (Fig. 2a) shows a slight decrease in magnitude (~10%) with increasing temperature for all samples, although the data at room temperature shows scatter of similar magnitude. For crater diameter (Fig 2b), limestone shows a strong decrease in diameter with rising temperature, whilst sandstone and basalt show only weak decreases. However, these effects are reinforced in crater volume (Fig 2c) where a strong decrease in volume is seen in all cases as temperature increases to 900 K. Based on the fits shown we find an average decrease in crater volume of 0.05% per K.

We note that there are some data points that do not follow the general trend and occasionally deviate with a large scatter from the expected results. In addition the datum for sandstone at 150 K (currently the only low temperature shot in this series) does not suggest continued growth in crater size at low temperatures. However, this is a single data point and this low temperature region needs to be investigated with more shots.

4. Summary and Conclusions

There appears to be a trend in decreasing crater size as rock targets are pre-heated before impact from room temperature to 900 K. We will investigate further by extending the data sets to low temperatures and combining the data with that in [2]. We also intend adding hydrocode simulation modeling to our work to see if the trends can be reproduced.

Acknowledgements

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References

[1] Nishida M., et al. Influence of temperature on crater and ejecta size following hypervelocity impact of aluminium spheres on thick aluminium alloy targets, International Journal of Impact Engineering, vol. 42, pp 37-47, 2013.

[2] Morris A.J.W., et al. Cratering efficiency in rocks as a function of rock temperature. 42nd LPSC Conference, abstract 1943, March 2011, Houston, 2011.

[3] Burchell M.J., et al. Hypervelocity Impact Studies Using the 2 MV Van de Graaff Dust Accelerator and Two Stage Light Gas Gun of the University of Kent at Canterbury, Meas. Sci. Tech. 10, 41-50, 1999.