# IMPACT MELTING EXPERIMENTS IN A HOT BASALT TARGET.

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**Introduction:** Impact melting has been studied previously by a number of authors in all discipline of impact studies [1, 2, 3 and 4]. However, in the early year of the solar system history, the planetary bodies were internally heated by the radioactive nuclides such as $^{26}$Al [5] which provided a driving force for the internal differentiation of the planetoids forming the Fe rich cores and silicate rich mantle. During this time impacts would have been occurring between different bodies of differing temperatures and compositions. Target bodies that are internally heated could form more complex impact melts and possibly differing impact facies then that have been previously observed on Earth. One aspect of the impact into an internally heated body is mixing of target and projectile body which may have aided in shaping the chemical and mineralogical composition of the largest planetoids. Here we investigate the melting and mixing of heated targets of basalt when impacted by a metallic projectile to discover the degree of melting at the point of impact with internal temperature and the mixing of a metallic projectile with the target silicate melt.

Laboratory impact experiments were undertaken using the Light Gas Gun at the University of Kent [6]. Impacts into targets at temperatures above room temperature have been performed by heating the target in a specially designed holder. The experiments used a projectile of the Stainless Steel (stst) ball bearing fired at a range of velocities between 2 – 4 km s$^{-1}$ at a target of basaltic rock (selected as a chondritic analogue) which was held at a range of temperatures between 25- 1000 ◦C. Here we present the initial results of these experiments.

**Experimental Method:** A 1.5 mm stst projectile was placed into a sabot to be fired at a basalt target. The target was set to the required temperature using a hot target holder, to simulate targets of different formation stages from room temperature (25 °C) to approximately 1000 °C, the upper temperature limit of the equipment. To prevent degassing of the basalt during heating within the target chamber (which is under a vacuum of ~50 mbar) the basalt samples are pre-heated to the required temperature in a vented furnace, so that any degassing of the basalt to occurs within the furnace and not the evacuated target chamber.

**Results:** To date five experiments have been completed using Fe/Ni projectiles fired at velocities of approximately 2, 3 and 4 km s$^{-1}$. The target for each experiment was a basalt cylinder 60 mm in diameter and between 75 mm to 130 mm in length. For each experiment the target temperature was set to a specific temperature between 25 °C - 800 °C.

*Results: Impact at 2 km s$^{-1}$ (A):*
In an attempt to recover the projectile a velocity of 2 km s$^{-1}$ onto a room temperature (25°C) target was used. The crater produced was small and rounded with few weak radial faults spanning away from the crater. The energy from the impact did not cause spallation around the crater, the projectile was recovered post impact and had been flattered but no projectile material was observed in the crater, showing a lack of mixing between projectile and target. No products of impact melting were observed in the crater.

*Results: Impact at 3 km s$^{-1}$(B):*
At 3 km s$^{-1}$, and a target temperature of 25 ºC, the impact produced a rounded crater with three faint radial fractures extending approximately 3 cm. The projectile was recovered which had a similar distorted appearance as the projectile from shot (a). The crater dimensions produced by this velocity are similar to that produced in shot (a).

*Results: Impact at 4 km s$^{-1}$ (C, D and E):*
Each impact at this velocity caused the target to shatter on the surface at both extreme limits of the temperature range from room to 800 ºC. The ejecta and spall from each shot were collected and pieced back together in order to identify the original crater. At the centre of each crater lay areas of white powdered basalt produced at the point of impact. Upon analysis no projectile material was observed within the craters suggesting that either the projectile bounced from the target (unlikely at 4 km s$^{-1}$) or, that the projectile was carried away by the ejecta and/or partially vaporised and lost. No melt veins or glassy material have so far been observed within the craters and SEM analyses indicate little variation was present in the major elemental composition of the crater material compared to pre-impact basalt, suggesting that melting of the target body has not occurred.

The impacts onto the basalt at 4 km s$^{-1}$ produced two sets of faults. The first set of fractures are radial and extend away from the point of impact. The second set are circular and fall approximately 5 mm from the edge of the target, causing edges of the target to splay away from the middle, forming these fractures.

Variations in the craters' depth and diameter are observed with increasing temperature of the target, leading to a preliminary observation that the crater efficiency appears to increase with target temperature, which may be linked to the structural strength of the basalt (as yield strength decreases with temperature).

**Discussion:** Crater dimensions increase with the shot velocity and the temperature of the target, however the results concerning temperature are only preliminary and further experiments are required to verify this observation.

Melting of target material as a result of an impact requires precise conditions in order to prevent complete destruction of the target and allow melting and mixing of the two materials. Initial tests using a 4 km $s^{-1}$ Fe/Ni projectile caused the basalt target to shatter, even at 800 °C. At a slower velocity of 2 km $s^{-1}$, the projectile survived but did not become embedded or mixed with the basaltic target. Melting and mixing of projectile and target material within an impact crater melt pool does not detectably occur under the conditions tested so far by this study. However, it is possible that a hotter target close to silicate melting temperatures (1000 - 1200 °C) is required for this to occur. The next step is to undertake shots using velocities of 3 km $s^{-1}$ fired at a target set at a range of temperatures of 1000-1200 ºC, the maximum that can be reached, down to 200 ºC to study the change in the melt composition and volume produced. In addition to changing the velocity of the projectile, we shall also investigate the effect of reducing the projectile mass by reducing the projectile size for all temperatures investigated. The target size cannot be changed because of the constraints of the hot target holder.

This work is a continuation of the work begun by [7] and aims to continue investigating the following aspects of crater mechanics: 1. Melting induced by impact in the target; 2. Crater morphology variation with internal temperature and 3. Outcome of the projectile.

**References**

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