Modelling carbonaceous chondrite survival for use as a potential lunar resource

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Abstract:
The lunar surface may provide an abundance of extractable metals [1], water [2], and potential construction materials for lunar habitats [3], but there is a lack of carbon (C) and nitrogen (N) to facilitate a sustainable human presence [4]. However, these elements have potentially been delivered to the Moon by carbonaceous chondrite (CC) meteorites [5] and using numerical modelling (iSALE-3D [6]) we determine the survival of these materials post-impact. We modelled the impact of a 1-km diameter CC-like asteroid into a single-layer, basaltic lunar surface. Porosities were included in both the projectile and target, based on average values for CC parent bodies (40%) [7] and the lunar megaregolith (10%) [8]. Multiple impact velocities and angles were tested (Table 1). Peak shock temperatures measured in the projectile were compared to vaporization temperatures for known C- and N-bearing materials in CCs, such as silicon carbide (SiC), graphite, diamond, and certain amino acids. The only scenario in which significant amounts of N-bearing compounds survive was at the lowest impact velocity and angle (orange material, Fig. 1). C-bearing compounds survive well in impacts with velocities <5 km/s, especially when highly oblique (all colours, Fig. 1). Impacts with velocities >10 km/s and angles >30° do not yield any significant amount of surviving solid material. However, particularly resilient C-compounds (e.g., SiC/graphite/diamond) may still survive. Less oblique impact angles lead to higher post-impact temperatures but concentrate the surviving projectile material within the craters. Highly oblique impacts at low velocity can lead to concentrations of material (up to 30% projectile mass) away from the crater (Fig.1).

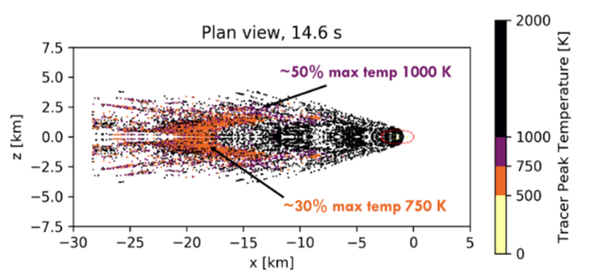

Figure 1: Temperature plot showing the location of surviving projectile material post-impact for the scenario with an impact angle 15°, vel. 5 km/s. Impact zone located at [0,0] and direction is right to left. Red dashed line shows the approximate shape and location of the transient crater.

Impact angle	Impact velocity (km/s) 5	10	15
15°	100%	75%	30%
30°	90%	0%	0%
45°	85%	0%	0%
60°	68%	0%	0%

Table 1: Combinations of impact angle and velocity modelled thus far. Percentages show projectile material that survives and remains solid post-impact.

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