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CHARACTERISTICS AND GEOMETRY OF IMPACT INDUCED CALCITE TWINNING

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Introduction: Calcite twinning can be used to infer stress magnitude and stress orientation, and is therefore widely applied as a palaeopiezometer in various terrestrial geological settings [1]. Also, the calcite microstructure in carbonaceous chondrite meteorites has been proven to be a useful tool for reconstructing the parent body deformation history during and/or after aqueous alteration [2]. In carbonaceous chondrites, calcite twinning is thought to be a result of deformation via impact gardening on the parent body(ies) [3, 2]. However, the characteristics and geometry of calcite twinning during impact are not well-known, as the methods for calcite twin stress analyses are generally applied to calcite that was deformed at lower strain rates during tectonism [1]. To better understand the characteristics and geometry of calcite twinning in response to impacts and to test the methods of stress analyses, we have here carried out two sets of physical impact experiments on calcite using a light-gas gun [4]. We are currently analyzing the results using SEM imaging (2D and 3D) and EBSD analyses. Calcite speleothems were chosen for the experiments, as these are composed of pure calcite and are tectonically undeformed.

Results and discussion: The first set of experiments used 1.5×1.5 mm sized cubes of calcite as projectiles, which were fired into a target of water at a speed of 1.068 km/s. These conditions gave a maximum peak pressure of ca 1 GPa [5]. SEM and EBSD analyses of the recovered calcite fragments show that they are heavily ruptured along cleavage planes, and have developed twins. The twins occur on the $\{\bar{1}018\}$ planes, and hence are calcite e-twins. This set of experiments shows that calcite twins can form by impact at shock pressures of ca 1 GPa, which are more realistic of impact gardening on asteroids than previous impact experiments on calcite at 85 GPa [6]. The second set of experiments used 0.8 mm diameter stainless steel bullets which were fired into two calcite targets at 1.068 km/s and 1.098 km/s. In the first target the projectile was fired normal to the calcite c-axes, and in the second target the projectile was fired parallel to the calcite c-axes. Craters formed in both targets with maximum diameters of 7.4 mm and 5.9 mm, and volumes of ca 11 mm^3 and 8.5 mm^3 respectively. Both craters had similar depths of about 1.6 mm. The first target produced a highly irregular circumference and internal topography, while the second target produced a more bowl shaped crater. Calcite in the interiors of the craters is highly fractured and twinned. Melting occur at the base of both craters. Preliminary EBSD analyses of the top surface of the target, immediately outside the craters, show that twinning is absent here. Future EBSD analyses will investigate the characteristics and geometry of the calcite twins in cross sections of the interiors of the craters.

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