Impact induced compaction of chondrites and the porosity evolution of chondritic parent bodies.

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Meteorites are fragments form recent collisions in the asteroid belt as their cosmic ray exposure age is much lower than their formation age [1]. The average collision speed between two objects of the asteroid belt is determined by the eccentricity and inclination of their respective Keplerian orbits. Typical values are on the order of a few km s^{-1}. In such a collision, the smaller collision partner (the projectile) is destroyed and, depending on the mass ratio of the colliding objects, a crater on the larger body (the target) is formed or it is entirely destroyed too.

Especially, meteorites that originate from unequilibrated parent bodies (with sizes smaller than about 300 km) can provide important insights into the dynamics of chondrite formation and compaction. However, the last fragmentation process in which the meteorites are formed is extremely violent and changes the initial properties of the parent body as the deviation in porosity of carbonaceous chondrites and their parent bodies (the C-type asteroids) show [2]. These asteroids have been exposed to an abiding bombardment of smaller objects. We found that the formed craters cover the surface of the parent body several times during the age of the Solar System.

In order to quantify the effect of consolidation, we performed high-velocity impact experiments into porous chondrite parent body analogs and measured the degree of compaction as a function of depth. We found that the volume filling factor ϕ (ϕ = 1-porosity) increases with increasing impact pressure to a power of 0.082 and reaches unity for pressures higher than 1 GPa [3]. Thus, we deduced the pressure range required to compact carbonaceous chondrites to their typical volume filling factors of ϕ = 0.6 – 0.9 [4] to be between 2 and 200 MPa.

The experiments also showed that the pressure and, thus, the volume filling factor in the target decrease with increasing depth as a function of projectile size. The expected crater size depends on the size ratio of target and projectile as well as on the impact velocity [5]. From our findings, we expect the pressure wave to penetrate the parent body significantly deeper than the crater size. Thus, the volume beneath the crater would also be compacted and changes the initial condition for further impacts.

We will present our results on the consolidation of chondrite analog material in laboratory impact experiments and estimate the evolution of the parent body surface layers due to multiple impacts for parent body radii of 70 to 300 km and for different projectile sizes at collision velocities of 1 - 5 km s^{-1}.

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