Chondrule formation by collisions between molten planetesimals with volatile materials

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Chondrule formation is one of the most important issues to be solved in planetary science. Although many models have been proposed, a consensus has not been reached. Heating by ^{26}Al causes internal melting of rocky planetesimal. When such plantesimals collide, silicate melt can splash out from inside and may lead to formation of chondrules (e.g. Asphaug et al.2011, Sanders and Scott 2012). However, the size of a droplet should be much larger than the chondrule size in this model. Here I propose a new model based on collisions between a melting rocky planetesimal associated with volatile materials. I determined a range of water content which is suitable for chondrule formation. Collision simulation is conducted to determine the efficiency of chondrule formation using iSALE hydrocode. The left panel of the figure is the snapshot of a collision between a 10km radius dunite planetesimal and a 40km radius melting planetesimal with 2km thick outer solid shell. I determined the volume above melting temperature as a function of pressure. As pressure decreases, the volatile material contained inside the volume expand quickly and will produce small sized droplets. Therefore, the important quantity is the volume of melting silicate as a function of pressure. The right panel of the figure shows the melting volume coming from target (red) and projectile (blue). The volume with a pressure less than 100MPa is shown. If the volatile (H_2O) content is one percent, water vapor starts to expand at this pressure. It can be seen that a significant amount of chondrules would be produced if the collision velocity is larger than 3km/s. Two major types of chondrites (carbonaceous, ordinary) might be explained by these two types of melting regions during a collision.

Keywords: Chondrule, Planetesimal, Collision, Volatile material