

# High Pressure Phase Transitions Constrain Shock Conditions in Meteorite Parent Bodies

Oliver Tschauner

*High Pressure Center and Department of Physics,  
University of Nevada, Las Vegas*

Meteorites are fragments of planetesimals which formed and collided during early stages of the solar system. Characteristic deformation features, structural disorder phenomena such as formation of diaplectic glasses, shock-melt veins, and the occurrence of high pressure silicate phases in meteorites document the various degrees of shock-metamorphism during such collision events and allow for distinguishing six classes of shock metamorphism by increasing peak pressure and temperature.

The duration of the shock state depends on the travel time of the shock front through target and impactor, which are in the present case, the two planetesimals. Given impactor velocity and planetesimal densities between 2.5 and 3.5 g/cm<sup>3</sup> the size of planetesimals may be estimated based on shock duration if corrections for the non-planarity of the shock front and reverberation are applied. Such estimates of planetesimal size are extremely valuable input into models of the early solar system. It has almost been a dogma of planetary science that the high level shock events yielding high pressure silicate polymorphs must always have lasted for milliseconds to minutes (corresponding to 0.1 to 100 km planetesimal diameters), in part because there is no record of synthesis of such polymorphs in any lab shock experiment (time scale < 5 $\mu$ s).

We show that high pressure silicates do form on a  $\mu$ s time scale in shock experiments based on non-diffusive shock-specific ultra-fast growth mechanisms on the scale of sample particle velocities (km/s). This results puts much tighter constraints on planetesimal sizes and implies that high grade shock-metamorphic record in meteorites needs a re-evaluation.

Recently cosmochemistry, astrobiology, and planetary science put particular emphasis on the earliest condensates of the solar nebula (CAS) and also on organic material, which both are found in carbonaceous chondrites. Most carbonaceous chondrites did not experience strong shock metamorphism, however, the interest in rather fragile organic matter and in noble-gas and oxygen isotope distribution in CAS' makes a better determination of the shock metamorphism in these meteorites desirable.

At CHESS station B2 we found a new mineral phase in the important Murchison carbonaceous chondrite. Subsequent static high pressure experiments in diamond anvil cells revealed this phase to form at high pressure and, thus to constrain the shock peak pressure for Murchison much tighter than before. Based on this finding, we can for the first time identify post-shock alteration processes in Murchison by the gases of the solar nebula.