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Multi-Mbar Equation of State Data for Planetary Science: CO_2 and MgO

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The formation of terrestrial planets and planetary structure is of great interest because of recent exoplanet discoveries of super earths. MgO is a major constituent of Earth's mantle, the rocky cores of gas giants such as Jupiter, and likely constitutes the interiors of many exoplanets. Comets, which are remnants from planetesimals often involved in planetary impacts, primarily contain H_2O and CO_2 ices. Understanding the high pressure – high temperature behavior of MgO and CO_2 is important for determining planetary structure and formation. Experimental data is usually lacking in the regions of interest and the equation of state models used for simulating impact events have not been validated at extreme conditions. To better understand the behavior of CO_2 and MgO at Mbar regimes relevant in planetary impacts, we conduct plate impact experiments using Sandia National Laboratories' Z – Machine facility. In the first half of this talk, we present shock and second shock experimental data on CO_2 to pressures of 8 Mbar to validate the CO_2 equation of state models. Density functional theory (DFT) simulations provide insight into the dissociation pathway along the Hugoniot. In the second part of this talk, we examine single crystal MgO under shock compression utilizing experimental and DFT methods to determine phase transformations along the Hugoniot, which we measure to nearly 12 Mbar. The experimental results show the B1 – B2 solid – solid phase transition occurs near 4 Mbar on the Hugoniot. The solid – liquid transition is determined to be near 7 Mbar with a large region of B2-liquid coexistence. Using DFT methods, we also determine melt along the B1 and B2 solid phase boundaries as well as along the Hugoniot. The combined experimental and DFT results have determined the phase boundaries along the Hugoniot, which can be implemented into new planetary and EOS models.

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