A High-Pressure Structure of Manganese Metal at 6, 23, and 44 GPa

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The goal of this research program is to quantify the carbon contribution of the deep Earth to the global carbon cycle. In order to do this, we need to measure the free energies of formation of oxides and carbonates at high pressures and temperatures. This in turn requires knowing density and elastic properties of oxides, carbonates, and metals at high temperatures and pressures. We are investigating the 5 most abundant 1st row transition metals in the mantle, which includes manganese. Manganese is of particular interest because it is one of the most abundant transition metal geochemical tracers, it readily forms a carbonate at ambient pressure, and its high-pressure structure and equation of state parameters are relatively unknown. At ambient conditions manganese adopts a complicated BCC structure (Bradley and Thewlis, 1927) and its pressure/volume equation of state was determined to 165 GPa by Fujihisa and Takemura (1995). They determine density as a function of pressure to 165 GPa but under non-hydrostatic conditions in the diamond anvil cell. In addition, they measure a phase transformation at pressures above 165 GPa.

Here we report new data on the pressure/volume equation of state and structure of manganese metal, determined at beamline 12.2.2 at the Advanced Light Source. Three samples of manganese were loaded and pressurized to 6, 23, and 44 GPa with a CO_2 pressure medium, using the gas loading system at the ALS, and laser heated to promote reactions with the CO_2 and to release non-hydrostatic stresses. X-ray diffraction patterns were obtained before heating and after quenching. The results show manganese metal and still to be determined reaction products. The structure of manganese was determined using newly developed python-based software for extracting high resolution 2-dimensional information from X-ray diffraction images.