American Mineralogist, Volume 99, pages 170–177, 2014

Crystal structure and compressibility of lead dioxide up to 140 GPa

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Abstract

Lead dioxide is an important silica analog that has high-pressure behavior similar to what has been predicted for silica, only at lower pressures. We have measured the structural evolution and compressional behavior of different lead dioxide polymorphs up to 140 GPa in the laser-heated diamond-anvil cell using argon as a pressure medium. High-temperature heating prevents the formation of multi-phase mixtures found in a previous study conducted at room temperature using a silicone grease pressure medium. We find diffraction peaks consistent with a baddeleyite-type phase in our cold-compressed samples between 30 and 40 GPa, which was not observed in the previous measurements. Lead dioxide undergoes a phase transition to a cotunnite-type phase at 24 GPa. This phase remains stable to at least 140 GPa with a bulk modulus of 219(3) GPa for $K_0' = 4$. Decompression measurements show a pure cotunnite-type phase until 10.5 GPa, where the sample converts to a mixture of baddeleyite-type, pyrite-type, and OI-type (*Pbca*) phases. Pure α-structured lead dioxide (scrutinyite) is found after pressure release at room pressure even though our starting material was in the β-structure (plattnerite). Pressure quenching to the α-structure appears to be a common feature of all group IVa oxides that are compressed to structures with greater density than the rutile-type structure.

Keywords: Lead dioxide, phase diagram, high pressure, equation of state