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Synrock: Synthetic Mineral Synthesis with the Piston Cylinder Apparatus

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Grain boundary structure and nanoscale porosity exert a fundamental control on mass transport, reaction kinetics, and vibrational properties in many geological systems. Fluid confinement at grain boundaries, particularly at nanometer length scales, is expected to influence vibrational modes and fluid–solid interactions, yet processes such as grain growth and transport in such confined environments remains poorly understood. The first step to investigating how fluid behave in these environments is to obtain monomineralic materials in which the pore volume is dominated by such boundaries. To do so, quartz aggregates were synthesized in a piston–cylinder apparatus at 850–1300 °C and 1–3 GPa using four starting materials: anhydrous fumed silica, hydrated fumed silica, natural agate, and hydrated agate for varying times and quench rates. These starting materials differ in initial surface area, crystallinity, and water content, allowing evaluation of how these variables control grain growth and pore evolution within the α-quartz stability field. The porosities of recovered samples were analyzed at the 12-ID-E (U)SAXS/WAXS beamline at the Advanced Photon Source, Argonne National Laboratory to characterize the phase assemblage, pore size distribution, and pore volume across nano- to microscale length scales. Differences reflect the reaction conditions and starting materials, but also the quenching rates. Constraining these relationships establishes a framework for later investigations of confinement effects on vibrational behavior in silica systems.