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High-temperature deformation of volcanic materials in the presence of water

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Abstract

We describe an experimental apparatus used to perform deformation experiments relevant to the volcanological sciences. The apparatus supports low-load, high-temperature deformation experiments under dry and wet conditions on natural and synthetic samples. The experiments recover the transient rheology of complex (melt ± porosity ± solids) volcanic materials during uniaxial deformation. The key component to this apparatus is a steel cell designed for high-temperature deformation experiments under controlled water pressure. Experiments are run under constant displacement rates or constant loads; the range of accessible experimental conditions include: 25–1100 °C, load stresses 0 to 150 MPa, strain rates 10^{-6} to 10^{-2} 1/s, and fluid pressures 0–150 MPa. The apparatus is calibrated against standard values of viscosity using constant-load experiments on cores of NIST (NBS) 717a borosilicate glass. We also report results of constant-displacement rate (~10^{-6} m/s) experiments on porous (~70%) sintered cores of ash from the Rattlesnake Tuff. The cores of volcanic ash were deformed in experiments under ambient ("dry") and elevated water pressures ("wet"). Dry experiments at ~870 °C show an increase in effective viscosity ($10^{9.5}$ to $10^{10.4}$ Pa·s) with increasing strain (~30%) due to porosity reduction during compaction. Experiments under ~1–3 MPa P_{H_2O} recover lower values of apparent viscosity ($10^{9.2}$ to $10^{9.4}$ Pa·s) despite being run at lower temperatures (640–665 °C). The wet experiments also do not show a rise in viscosity with increased strain (decreasing porosity) as observed in dry experiments. Rather, the presence of an H_2O fluid phase expands the window of viscous deformation and delays the onset of strain hardening that normally accompanies porosity reduction.

Keywords: Experimental-apparatus, deformation, volcanic, rheology, high-temperature, hydrous, porosity