The density of dry and volatile-bearing felsic magmas at lower-crustal and upper-mantle conditions (0-4 GPa, 1200-2000K)

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The physical properties magmas, and particularly their density, are key controls on the migration rate and emplacement depth of intrusions. However, because of the high viscosity of felsic liquids, density and compressibility measurements with the sink/float method and sound velocity measurements are challenging. As a result, the density and compressibility of dry and volatile-bearing granitic and phonolitic liquids is poorly constrained, particularly for the pressure-temperature conditions relevant for their formation and emplacement.

In this study, we present in situ experimental data on the density of dry and hydrous haplogranitic and haplophonolitic melts at pressure and temperature conditions relevant for the crust and the subducting slab. The experiments were performed with a panoramic Paris-Edinburgh press installed at the ID27 beamline of ESRF. The samples were contained in a cylindrical diamond capsule and pressure and temperature were determined from the X-ray diffraction patterns of hBN and platinum using the double-isochore method. The density of the melts was determined from the X-ray absorption contrast between the sample and the diamond capsule (Mo edge, 20 keV). The molten state of the sample at the condition of the density measurements was verified by X-ray diffraction. The run products were analyzed by electron microprobe and infrared spectroscopy to verify the chemical composition and volatile content of the samples.

Our results on the granite melts, combined with literature data at atmospheric pressure, provide the first experimentally derived equation of state of dry and hydrous granitic liquids at crustal and upper mantle conditions. This equations of state enables the prediction of the partial molar volume of water and granite melt density for the pressures, temperatures and water contents relevant for partial melting in the lower crust, melt migration through the middle crust and the emplacement of intrusions in the upper crust. In addition, we derived the equation of state for dry phonolitic melts.