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Anomalous elastic behaviour of hydrous sanidine megacrysts from the Eifel, Germany

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Sanidine megacrystals from Volkesfeld (Riedener Kessel, East Eifel volcanic field) are well known for their fast irreversible changes of optical properties at moderately high annealing temperatures (starting from 750°C) [1]. These unique optical effects are probably related to fast changes of the Al/Si-order, the origin of which is not yet understood. Polarised infrared spectra and NMR studies indicate a relatively high amount of water (about 200 wt-ppm) in the Eifel sanidines compared to low-sanidine crystals from Madagascar ($\sim$ 1 wt-ppm) [2,3] possessing no unusual optical properties at high temperatures. In order to clarify the role of water for the observed anomalies, we investigated the elastic properties of sanidine megacrystals from four different eruptive centres (Essingen, Kerpen, Rockeskyll, Volkesfeld) of the quarternary volcanic fields of the Eifel between room temperature and 1100°C with the aid of resonant ultrasound spectroscopy (RUS). Low-sanidine from Madagascar served as a reference.

The Eifel sanidine megacrystals are all very similar in respect to their chemical and structural properties. The chemical composition $Na_xK_{1-x}AlSi_3O_8$ as obtained by EMPA varies between $x = 0.15$ (east Eifel volcanic field) and 0.27 (west Eifel volcanic field) with up to 2 at-% celsian and less than 0.02 at-% anorthite. High-resolution DSC and thermogravimetric measurements revealed an irreversible weight loss at about 950°C which corresponds to about 250 wt-ppm H_2O. Single crystal structure analyses yielded $2t_1 \approx 0.58$ for the Al-occupation of the t_1 tetrahedral position indicating nearly fully disordered high-sanidines. For comparison, the potassium-rich low-sanidines from Madagascar are characterised by $2t_1 = 0.69$.

The temperature evolution of the elastic constants of "dry" Madagascar sanidine is monotonic and fully reversible in successive runs. However, at about 890°C a small peak appears in the ultrasound attenuation above a slowly rising background. In contrast, the hydrous Eifel sanidines show an exponentially increasing ultrasound dissipation above 800°C followed by a rapid irreversible softening of all resonance frequencies by about 8% above 970°C. The observed anomalies are most likely related to the mobility of water dissolved in the crystal structure of the Eifel sanidines. On first heating the water slowly gets mobile above 800°C and leaves the crystal structure at about 970°C. The high mobility of the water molecules allow for a new, less ordered equilibrium state to be reached on the time scale of the experiment. The increase of the configurational entropy as well as the development and propagation of micro-cracks lead to an elastic softening of the macroscopic crystals.

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