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Experimental study of the effect of stress on $\alpha \rightarrow \beta$ quartz transformation at lower continental crust pressure and temperature

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Several polymorphic phase transformations are known to occur in the Earth's lithosphere and the aim of this study is to investigate the role of stress, and in particular of deviatoric stress, on the equilibrium of phase transitions. Indeed, a number of studies have been performed in order to understand whether the mean or principal stresses may trigger polymorphic phase change, the case is still not completely clear. Amongst the most common polymorphic transitions, the $\alpha \rightarrow \beta$ quartz transition has a particular importance in the lower continental crust, specially for its effect on the seismic properties of continental crust lithologies. The $\alpha \rightarrow \beta$ quartz transition is a thus good experimental case both because of the significant changes in physical properties associated to it, as well as because of its displacive quasi-instantaneous nature. To study the effect of stress on this transition, we performed a series of experiments within the GRAAL apparatus, a new high pressure Griggs-type apparatus equipped with ultrasonic monitoring installed at the Laboratoire de Géologie of ENS Paris. During these experiments, solid rock cylinders (4.5mm diameter, 10mm long) of translucent Arkansas Novaculite (grain size 3-10μm) were subjected to pressure and temperature conditions at which the metamorphic reaction should occur, i.e. pressures and temperature in the range of 0.5 - 1.5GPa and 700 - 900°C respectively. In some experiments, a deviatoric stress $\Delta\sigma$ in the range of 0.5 - 1.5GPa was also imposed on the rock specimen. In consequence, the mean stress σ_m was either equal (hydrostatic conditions) or higher (deviatoric conditions) than the confining pressure P in all experiments. The temperature was ramped across the transition under fixed $\Delta\sigma$-σ_m -P conditions. An ultrasonic transducer (Olympus V156, Shear wave, 5MHz) located below the sample assembly was used in pulse-echo to enable an active acoustic monitoring of the transition during each experiment. With this method, the transition is directly observed by a time-shift of the acoustic signal, which travelled back and forth through the specimen. Further signal processing is needed to extract the travel times in the sample. Travel times are then used to calculate the variation of both P and S elastic wave velocities in the sample at in-situ conditions. Preliminary results of our experiments show that the phase transformation is controlled by mean stress and the variation of elastic velocities that we observed are in agreement with thermodynamic models of elastic properties at P-T conditions of rocks.