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Slow crack propagation in glass and creep prediction

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The context of our study is the observation of the time-dependent deformation of cracked glass. The aim of our study is to observe the slow crack propagation, to quantify it and to predict finally the creep behavior.

We performed creep experiments in compaction conditions in a triaxial cell, on cracked boro-silicate glass samples. The chemical composition of the investigated glass is very close to the composition of waste vitrified packages. The matrix of the original glass (OG) is perfectly amorphous, without porosity. A few isolated air bubbles are trapped during the glass flow. Cracks are introduced in the OG through thermal shocks. Strain and acoustic emission (AE) are recorded. Several experiments are performed at different confining pressures (15 or 25 MPa), different pore fluid conditions (with argon gas, considered as the dry case, with tap water saturated porosity, or with distilled water) and different temperatures (ambiant temperature, $50^{o}C$ or $80^{o}C$).

Linear increase of the volumetric strain is first observed. A dilatancy increase is recorded. Note that dilatancy does not appear in constant strain rate tests. Constant stress tests show that dilatancy develops during a time interval that depends on the stress level. In addition AE rate are recorded. A non zero AE rate is an evidence of crack propagation.

We use a micro-mechanical model that gives the stress intensity factor at the crack tips. This factor depends on stress and geometrical parameters (all known). An exponential law describe the rate of crack propagation, as a function of temperature, environment and applied stresses. This model allows us to predict the creep rate in glass. Assuming a constant crack aspect ratio, crack length and volumetric strain are related. The volumetric strain rate is calculated from model and compared to the data.