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Undrained heating and anomalous pore-fluid pressurization of a hardened cement paste

S. Ghabezloo (1), J. Sulem (2), and J. Saint-Marc (3)

(1) Université Paris-Est, UR Navier-CERMES, Ecole des Ponts ParisTech, Marne la valée, France (ghabezlo@cermes.enpc.fr),
(2) Université Paris-Est, UR Navier-CERMES, Ecole des Ponts ParisTech, Marne la valée, France (sulem@cermes.enpc.fr),
(3) TOTAL, Management of Residual Gases Project, Pau, France (jeremie.saint-marc@total.com)

Temperature increase in a fluid-saturated porous material in undrained condition leads to volume change and pore pressure increase due to the discrepancy between the thermal expansion coefficients of the pore fluid and of the pore volume. This increase of the pore fluid pressure induces a reduction of the effective mean stress, and can lead to shear failure or hydraulic fracturing. This phenomenon is important is important in environmental engineering for radioactive (exothermal) waste disposal in deep clay geological formations as well as in geophysics in the studies of rapid fault slip events when shear heating tends to increase the pore pressure and to decrease the effective compressive stress and the shearing resistance of the fault material (Sulem et al. 2007). This is also important in petroleum engineering where the reservoir rock and the well cement lining undergo sudden temperature changes for example when extracting heavy oils by steam injection methods. This rapid increase of temperature could damage cement sheath integrity of wells and lead to loss of zonal isolation. The values of the thermal pressurization coefficient, defined as the pore pressure increase due to a unit temperature increase in undrained condition, is largely dependent upon the nature of the material, the state of stress, the range of temperature change, the induced damage. The large variability of the thermal pressurization coefficient reported in the literature for different porous materials with values from 0.01MPa/°C to 1.5MPa/°C highlights the necessity of laboratory studies.

This phenomenon of thermal pressurization is studied experimentally for a fluid-saturated hardened cement paste in an undrained heating test. Careful analysis of the effect of the dead volume of the drainage system of the triaxial cell has been performed based on a simple correction method proposed by Ghabezloo and Sulem (2008, 2009). The drained and undrained thermal expansion coefficients of the hardened cement paste are also measured in the heating tests. The measured value of the thermal pressurization coefficient is found equal to 0.6MPa/°C and the test results unexpectedly show that it does not change with temperature between 20°C and 55°C. In most geomaterials, as shown experimentally by Ghabezloo and Sulem (2008), the temperature dependency of the thermal expansion of the pore fluid results in temperature dependency of the thermal pressurization coefficient. The observed anomalous thermal pressurization phenomenon is attributed to the anomalous thermal behaviour of cement paste pore fluid. The anomalous thermal behaviour of cement pore fluid is back analysed from the results of the undrained heating test and it is shown that the thermal expansion of the cement paste pore fluid is higher than the one of pure bulk water and is much less sensitive to temperature changes. This anomalous thermal behaviour is due to the confinement of the pore fluid in the very small pores of the microstructure of the cement paste, and also to the presence of dissolved ions in the pore fluid.

References:

1.Sulem J., Lazar P., Vardoulakis I. (2007) Thermo-Poro-Mechanical Properties of Clayey Gouge and Application to Rapid Fault Shearing, Int. J. Num. Anal. Meth. Geomechanics, 31(3), 523-540

2.Ghabezloo S., Sulem J. (2008) Stress dependent thermal pressurization of a fluid-saturated rock. Rock Mechanics and Rock Engineering, in press, DOI 10.1007/s00603-008-0165-z.

3.Ghabezloo S., Sulem J., Saint-Marc, J. (2009) The effect of undrained heating on a fluid-saturated hardened cement paste. Cement and Concrete Research, 39(1), 54-64.

4.Ghabezloo S., Sulem J. (2009) Evaluation of the undrained thermo-poro-elastic parameters in a conventional triaxial cell: the effect of the dead volume of the drainage system. Submitted to Int J Rock Mech Min Sci.