Geophysical Research Abstracts
Vol. 13, EGU2011-6035-1, 2011
EGU General Assembly 2011

In-situ pore pressure determination - application of a fibre optic sensor for the determination of rock physical properties

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To understand the behavior of rocks under changing load or temperature conditions, the determination of physical parameters like fluid pressure or temperature within the pore space is essential. One example is the Skempton coefficient B, which can be determined by the means of laboratory experiments. For a direct measurement of this parameter, a hydrostatic compression test on a jacketed rock specimen under undrained pore pressure conditions has to be performed. Pore pressure variations under changing load conditions are used to calculate the Skempton coefficient. The performance of pore pressure measurements under undrained conditions, however, is often biased due to the experimental set-up. In order to meet the requirements for an experiment under undrained conditions, the fluid volume within the tubing between the rock specimen under investigation and the shut-off valve has to be sufficiently small compared to the entire pore fluid volume within the specimen.

To overcome the problem of large tubing volumes and to allow for an in-situ pore pressure determination within a jacketed rock specimen, this study focuses on the application of a novel fibre optic pressure and temperature gauge. Due to several inherent advantages like remote operation, small size and robust construction, fibre optic sensors are especially well suited for laboratory applications. The sensor used within this study consists of a miniature all-silica fibre optic Extrinsic Fabry-Perot Interferometer (EFPI) sensor which has an embedded Fibre Bragg Grating (FBG) reference sensor element to determine temperature and pressure directly at the point of measurement.

For this experiment, the sensor is embedded in a drill-hole within the sample reducing the void volume to less than 0.1 percent of the pore fluid volume, and thus meeting undrained conditions. An isothermal hydrostatic compression test is performed at pressures ranging from 0 to 70 MPa. In-situ pore pressures could be determined with an adequate accuracy and first results are promising that this fibre sensor technique can be used to determine rock physical parameters related to pressure and temperature changes at the point of measurement.

In this paper we will present the fibre optic sensor technique used for determining the poro-elastic response of porous media as well as the implementation in an existing rock mechanical test set-up.