The new HPHT triaxial apparatus at IPG Strasbourg (France)

Michael Heap, Patrick Baud, Alexandra Kushnir, Thierry Reuschlé, Frédéric Dauny, Jamie Farquharson, Luke Griffiths, Jean Schmittbuhl.

Institut de Physique de Globe de Strasbourg (UMR 7516 CNRS, Université de Strasbourg/EOST), 5 rue René Descartes, 67084 Strasbourg cedex, France

heap@unistra.fr

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ABSTRACT

Understanding the *in-situ* mechanical behaviour and physical properties of geothermal reservoir rock is of paramount importance in the optimisation of geothermal resources. The acquisition of such data requires a state-of-the-art, high-pressure, high-temperature triaxial deformation apparatus. We have recently purchased such a device—built by Sanchez Technologies (France)—using funding provided by the Université de Strasbourg (Initiative d'Excellence (IDEX) "Attractivité" grant) and LABEX grant ANR-11-LABX-0050_G-EAU-THERMIE-PROFONDE (state funding managed by the Agence National de la Recherche (ANR) as part of the "Investissements d'avenir" program). We plan to use our device to measure strength, elastic wave velocities, elastic moduli, porosity, and permeability of rock samples in a geothermal context under *in-situ* conditions.

1. INTRODUCTION

High-pressure, high-temperature experiments probing the *in-situ* mechanical behaviour and physical properties of geothermal reservoir rock are key in the successful management of a geothermal resource. Although rock deformation experiments have been performed under high-pressure and high-temperature in the context of crustal deformation (continental and oceanic) (e.g., Griggs, 1960; Mackwell et al., 1998; Violay et al., 2012; 2015), experiments of a geothermal context and/or focussed on geothermal reservoir rocks (i.e., borehole samples) are rare. For example, triaxial experiments have recently been performed on core from the Rotokawa Geothermal Field of New Zealand (Siratovich et al., 2016). The study of Siratovich et al. (2016) showed that hydrothermal alteration modifies the mechanical behaviour and strength of the Rotokawa Andesite (Figure 1). These experiments were however performed at room temperature. It is clear that future studies should focus on the mechanical behaviour of reservoir core material at *in-situ* pressure and temperature. To this end we have purchased a new HPHT machine to explore the *in-situ* mechanical behaviour, failure mode, and physical properties of geothermal reservoir rock.

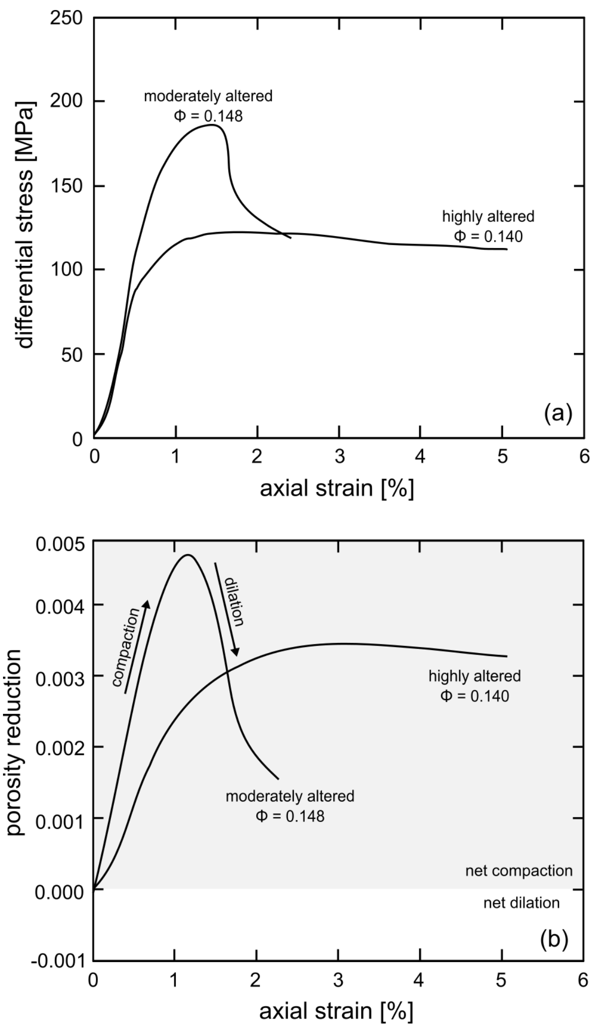

Figure 1: Mechanical data from triaxial experiments performed on variably altered (moderately- and highly-altered) core from the Rotokawa Geothermal Field (New Zealand). (a) Stress-strain curves. (b) Porosity reduction curves. Taken from Siratovich et al. (2016).

2. PRESENTATION OF THE MACHINE

The new HPHT machine at IPG Strasbourg was designed and built by Sanchez Technologies (Figure 2). It can reach a maximum confining pressure of 400 MPa (corresponding to a depth of about 15 km) and a maximum temperature of 500 °C (corresponding to a depth of about 20 km, assuming an average geothermal gradient of 25 °C/km). The confining pressure (argon gas) is applied via a gas booster and two syringe pumps. Pore pressure is controlled by a Quizix QX Series pump. Measurements and/or deformation experiments can be made on cylindrical samples 20 mm in diameter and nominally 40 mm in length. For this sample size the device can impose a maximum axial stress of 2000 MPa (measured by a load cell); we can therefore break samples in the brittle regime under high confining pressures. Axial displacement is measured using a linear variable differential transducer located on the upper piston (i.e., outside the pressure vessel). Measurements of stress, strain, porosity, permeability, acoustic emissions, and elastic wave velocity (P- or S-wave; using piezoelectric transducers embedded into the endcaps) can be made under hydrostatic conditions, during hydrostatic or differential loading, or during heating/cooling. The machine is very versatile as a result.

Figure 2: Drawing of the HPHT triaxial deformation apparatus at IPG Strasbourg (France).

3. OUTLOOK

Our immediate experimental objectives are twofold. First, we plan to assess the mechanical behaviour of geothermal reservoir rock from the Soultz-sous-Forêts geothermal site (Alsace, France). We plan to deform samples of granite (the main reservoir rock, or an analogue thereof) and Buntsandstein (the sedimentary cover) under *in-situ* pressure and temperature conditions (in conjunction with ANR grant CANTARE "Caractérisation de la zone de transition entre le socle et la couverture des bassins sédimentaires profonds pour l'exploitation géothermiques en Alsace"). Second, we plan to measure changes in permeability of the aforementioned rocks (to both water and brines) under hydrostatic conditions and during deformation at the *in-situ* pressure and temperature conditions (in conjunction with DESTRESS "Demonstration of soft stimulation treatments of geothermal reservoirs", a grant funded by the European Commission). We anticipate that the results of these experiments will improve our ability to model, manage, and optimise geothermal resources worldwide.

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