ENAC / PROJET DE MASTER 2021-2022
SECTION DE GÉNIE CIVIL

Frictional Properties of Volcanic Rocks From High-Enthalpy Geothermal Reservoirs

Author : Florian Jermann

Supervision: Prof. Marie Violay[1] / Dr Barnaby Fryer[1]

[1] Laboratory of Experimental Rock Mechanics (LEMR) EPFL

Introduction The increasing interest for sustainable energy has led to the development of high-enthalpy and supercritical geothermal reservoirs. Although earthquakes are a hazard in volcanic areas where such projects are often built, little is known about the frictional properties of the host rock in high-enthalpy geothermal settings. Mineralogy of these rocks depends not only on formation but on temperature, pressure and fluid conditions altering the rock after formation. To study friction and how it is influenced by alteration, friction experiments are carried out on basalts, dolerites and a breccia from Reykjanes and Krafla geothermal fields (both Iceland) and the Newberry Volcano (USA).

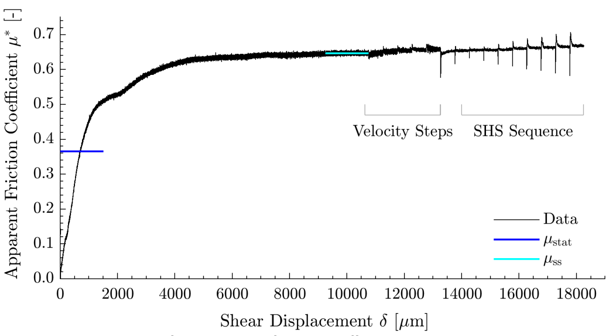

Figure 1: An example of the apparent friction coefficient against shear displacement (slip) with the static and dynamic apparent friction coefficient indicated. The plot shows the data of the basalt K708 tested at room humidity.

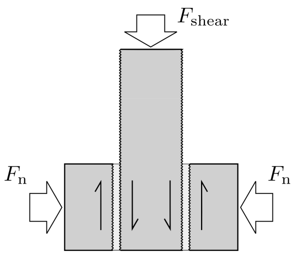

Figure 2: Illustration of the double-direct shear configuration used to test the samples.

Methods All rocks were tested as gouge to eliminate the influence of texture and structure in a double-direct shear configuration. Tests were run at 10 MPa normal stress under room-dry and saturated conditions. Following a run-in phase, we performed velocity steps from 3 to 300 μm/s and slide-hold-slide (SHS) sequences from 1 to 3000 s. A thin section of each sample was prepared for petrographical analysis.

Results The samples show various degrees of alteration, clay minerals are thus thought to be present in various quantities in the samples. The dynamic apparent friction coefficient is in Byerlee's range or slightly lower. It tends to drop when water is present. All samples experience velocity strengthening or neutral behaviour and clearly recover strength on a hold but do so at small healing rates. Healing of the samples from Krafla shows to be insensitive to the presence of water.

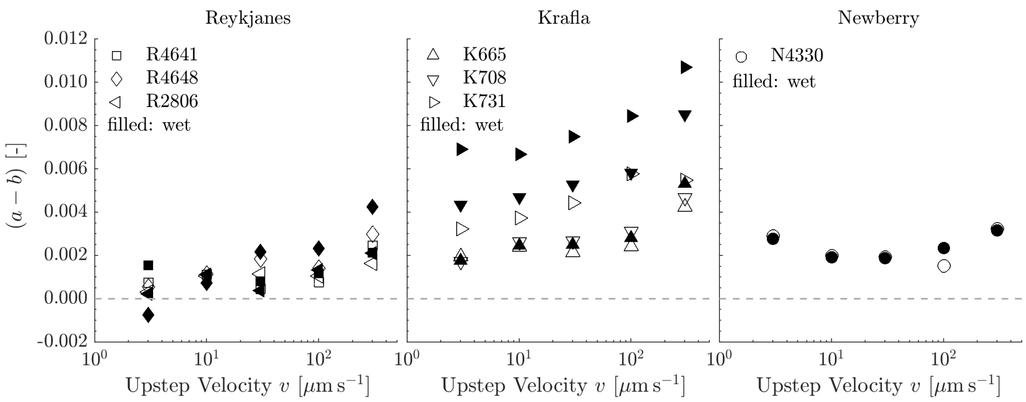

Figure 3: The (a-b)-value as determined by the slip law fit for all experiments. Note the generally small values of (a-b) and the slight tendency of (a-b) to increase with velocity

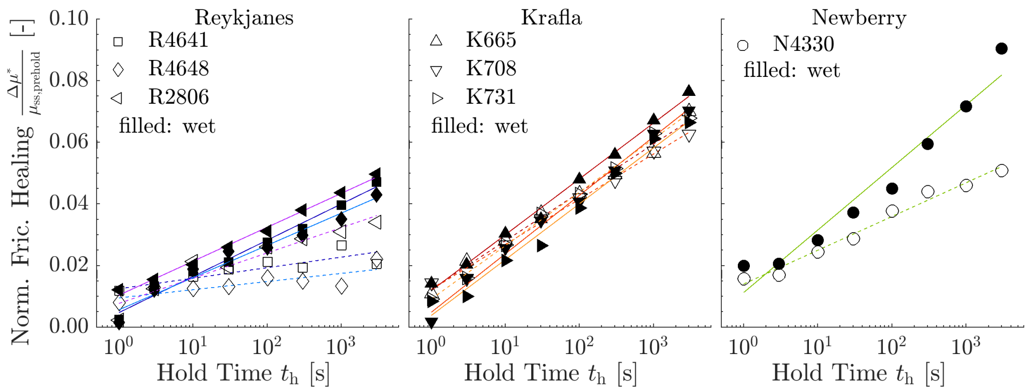

Figure 4: Frictional healing normalised by the prehold steady state value of the apparent friction coefficient with hold time. Note the similar behaviour of the dolerites R4641 and R4648 and the insensitivity of the samples from Krafla to the presence of water.

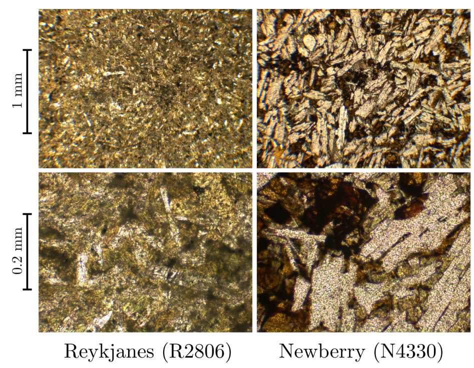

Figure 5: Thin section photographs of basalts from Reykjanes Penisula and Newberry Volcano. The high degree of impurities in the grains and the poorly defined grain boundaries indicate significant alteration.

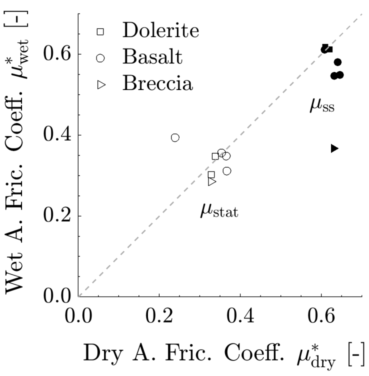

Figure 6: Wet and dry static and dynamic apparent friction coefficient for all gouges. The large scatter of the static apparent friction coefficient reflects the difficulties in picking the value.

Conclusion At the single normal stress tested, frictional strength is in good agreement with Byerlee's law. The presence of water generally decreases frictional strength. Given the low healing rates, the samples may not be regarded as frictionally strong although *(a-b)* is positive. The data from rate-and-state friction and frictional healing are surprisingly uniform. Further tests such as X-ray powder diffraction are ongoing to complete the present study and to allow for in-depth interpretation of the results presented here.