Geophysical Research Abstracts
Vol. 21, EGU2019-1993, 2019
EGU General Assembly 2019

Frictional properties of simulated fault gouges prepared from the Groningen Carboniferous: Effects of any coal present

Jinfeng Liu (1,2), Luuk Hunfeld (2), André Niemeijer (2), and Christopher Spiers (2)

(1) Guangdong Provincial Key Lab of Geodynamics and Geohazards, School of Earth Sciences and Engineering, Sun Yat-Sen University, China (liujinf5@mail.sysu.edu.cn), (2) Department of Earth Sciences, Utrecht University, The Netherlands

Induced seismicity in the Groningen gas field upon gas production is believed to be in relation to (re)activation of pre-existing faults in the reservoir and immediate under- and overburden formations. Data on the frictional properties of the constituent fault rocks is required, in attempt to better understand induced seismicity in the Groningen gas field and to better model the response of faults present in the field to changes in stress-state upon gas depletion. Recently, geophone data reports $\sim$5% of earthquake events in the Groningen gas field occurred in the Carboniferous formation, which cannot be explained by the frictional properties of the Carboniferous shale. One of the hypotheses for these events may be any presence of coal that also exists in the Carboniferous formation of the Groningen gas field. However, this remains unclear, as no available data on frictional properties of coal or Carboniferous shale with any presence of coal under reservoir conditions can be found in the literature.

Here, we document 21 dynamic friction experiments performed on simulated fault gouges prepared from the mixtures of coal and the Carboniferous shale, with the aim of investigating the effects of any coal present (0-100% in volume fraction) on the frictional properties of the Carboniferous shale substrate material collected from the Groningen gas field. The coal samples used in this study are bituminous coal collected from the Upper Silesian Basin in Poland, which is of similar age (Upper Carboniferous) and broad origin to the Groningen gas field source rocks. We performed velocity stepping, constant velocity, slide-hold-slide (SHS), load-unload-load (LUL) friction experiments, under near in-situ conditions of 100 degrees Celsius and 40 MPa effective normal stress, employing sliding velocities of 0.1-100 μm/s. The experiments demonstrated that the presence of coal in volume fractions $\geq$ 50% caused strong slip-weakening behaviour of the Carboniferous shale, and significantly lowered frictional strength from $\sim$0.47 to $\sim$0.3, regardless of the experimental conditions employed. This slip-weakening behaviour likely reflects strain localization in coal-rich shear bands, perhaps accompanied by a change in the coal molecular structure. However, reloading experiments (LUL) show that slip-weakening is limited to small initial displacements (2-3 mm), and does not occur during reactivation. From a rate and state friction point of view, almost all experiments exhibited stable, velocity strengthening behaviour of the carboniferous shale at in-situ stress, pore water pressure (15 MPa) and temperature conditions, regardless of coal content. By contrast, under dry and gas saturated (CH_4, Argon) conditions, and when saturated with water at 1 atm, 50:50 shale-coal mixtures show unstable, velocity-weakening, and even stick-slip behaviour. On the basis of our results, we conclude that reactivated fault rock material derived from the Groningen Carboniferous shale formation will behave stably at in-situ conditions even when coal-bearing, though the mechanisms controlling frictional behaviour remain unclear. At the same time, possible effects of macroscopic compositional heterogeneity on fault stability, such as coal smearing, cannot be completely eliminated.