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Creep of rock from Barents See, monitored by Acoustic Emissions, Ultrasonic Transmissions and deformation measurements

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It is generally known that creep deformation of the rocks, occurring in the Earth under high stress level, influences the fluid flow, as well as other processes related to the strain accumulations. Strain localization across multiple scales is a complex process in any tectonic environment, and is still poorly understood. Because of some technical complications, the majority of laboratory researchers prefer to make a rock testing under deformation control mode, rather than under stress control mode. Three-day multistage loading testing of the mudstone/shale sample collected from the Barents See was conducted in Skoltech in the frame of international project. The loading of the sample was done under 20 MPa confining pressure as a series of consecutive 20 MPa axial stress-steps. After each step, the axial load was kept constant for at least 3 hours' time interval to study the creeping of the sample, while the monitoring of axial and radial strain allowed to calculate the rock viscosity.
In addition, sixteen Acoustic Emission (AE) sensors were glued to the cylindrical surface of the rock. They were used as well for localization of microcracking within the rock, as for periodical measurement of P-wave velocities along different directions. During the early stage of the rock loading, all velocities demonstrated initial increase related to the compaction of the rock. However, after application of approximately 50% of the maximal axial stress, a strong heterogeneity of P-wave velocity within the rock was recorded, and the decrease of the velocities along some traces indicated occurrence of local dilatancy of the sample. The results of these observations are well correlated with the beginning of AE clustering in the fracture nucleation zone, and both processes were detected during the secondary, steady-state stage of the creep. It was found that the location of AE nucleation zone correlates well with the position of natural crack detected in the sample before the testing by 3D CT X-Ray scanner.
Macroscopic failure of the sample occurred approximately two minutes after the application of the final stress-step equal to 280 MPa. Analysis of AE signals shows close correlation between the onset of macroscopic fault acceleration, accompanied by significant increase of AE signal amplitudes, and the beginning of tertiary creep stage, detected approximately 25 seconds before the final failure of the sample. Preexisted in the sample natural crack could be considered as healed natural fault, and during our test, we studied activation and creeping of this fault during the stressing of the sample up to the failure, causing observed changes of P-wave velocities, clustering of AE events and variations of rock viscosity.