Experimental study of viscoelastoplastic deformation of sedimentary rocks

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Motivation

Viscoelastoplastic deformation of rock mass:

- affects long-term stability of underground structures,
- leads to reservoir subsidence,
- affects stress distribution and compartmentalization in sedimentary basins,
- leads to development of focused fluid flow.
Experimental details

- Artificial and limestone samples were subject to preliminary freezing/melting, heating/cooling, or pre-loading cycles.
- Cylindrical samples were cored to a diameter of 30 mm and cut to a length of 60 mm.

- New experimental procedure with 4 alternating stages of creep and stress relaxation is performed in laboratory triaxial experiments.
- Volumetric and shear response to triaxial loading was recorded.
Creep in Dry Artificial Samples

- All samples exhibit transition from compaction to dilatancy with increasing stress
- Prolonged decompaction stages were observed before development of macroscopic fracture
- Preliminary heating/cooling, freezing/melting and pre-loading affect mechanical strength and creep behavior of samples
Creep in Dry Limestone Samples

- All samples exhibit transition from compaction to dilatancy with increasing stress
- Prolonged decompaction stages were observed before development of macroscopic fracture
- Preliminary heating/cooling, freezing/melting and pre-loading have minor effect on mechanical strength and creep
Effective Bulk Viscosity in Artificial Samples

**Effective mean stress**

\[ \varepsilon_{kk}^{v} = \frac{\sigma_m - \sigma_0}{\eta} \]

Volumetric strain rate

**Compaction/dilation transition stress**

Bulk viscosity, \( \eta \), is calculated after modelling fit of volumetric stress-strain-time response.
Conclusions

- During the multistage triaxial creep experiments, samples showed considerable volumetric and shear creep deformation on the laboratory time scale.

- Given that stress level did not significantly exceed the dilation-point sample withstood several cycles of loading/unloading during which a significant decompaction was achieved without forming a macroscopic fracture or shear band.

- Volumetric and shear strain rates are nonlinearly dependent on the mean stress. Bulk viscosity was calculated from the stress relaxation and creep curves in compacting and dilating regimes.

- Onset of dilatancy reduces bulk viscosity by several orders of magnitude. Obtained values of viscosities vary between $10^5$ and $10^{10}$ MPa*sec for artificial and limestone samples.

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