Experimental study of viscoelastoplastic deformation of sedimentary rocks

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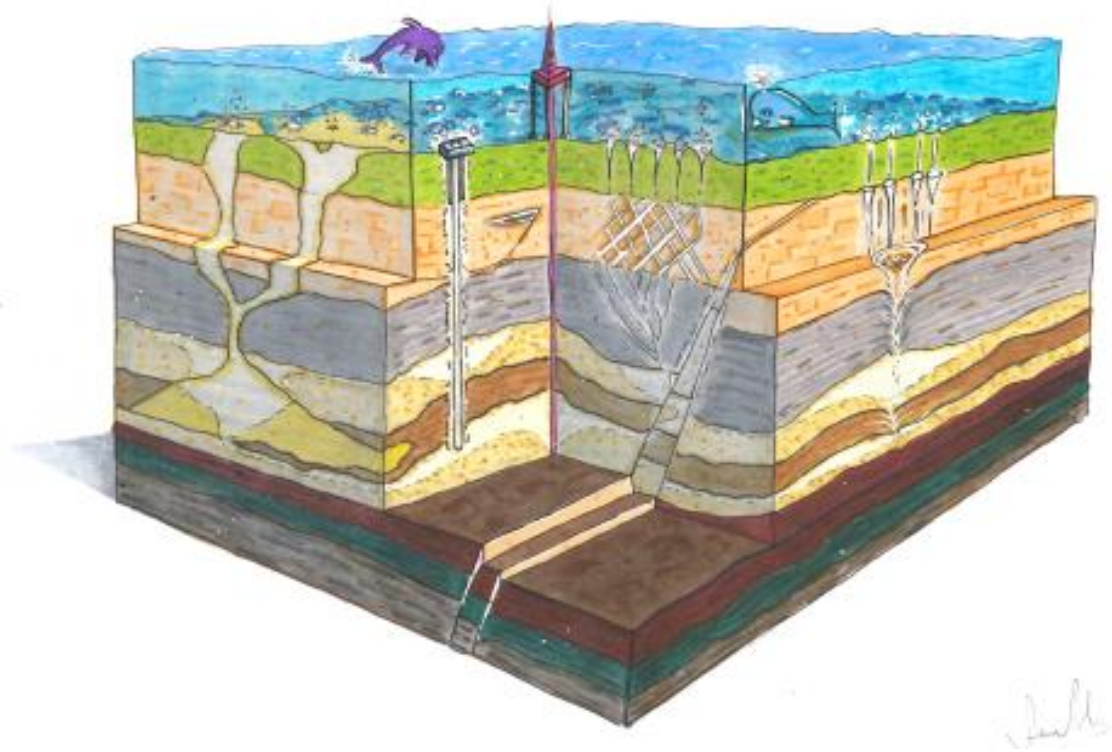
Motivation

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.

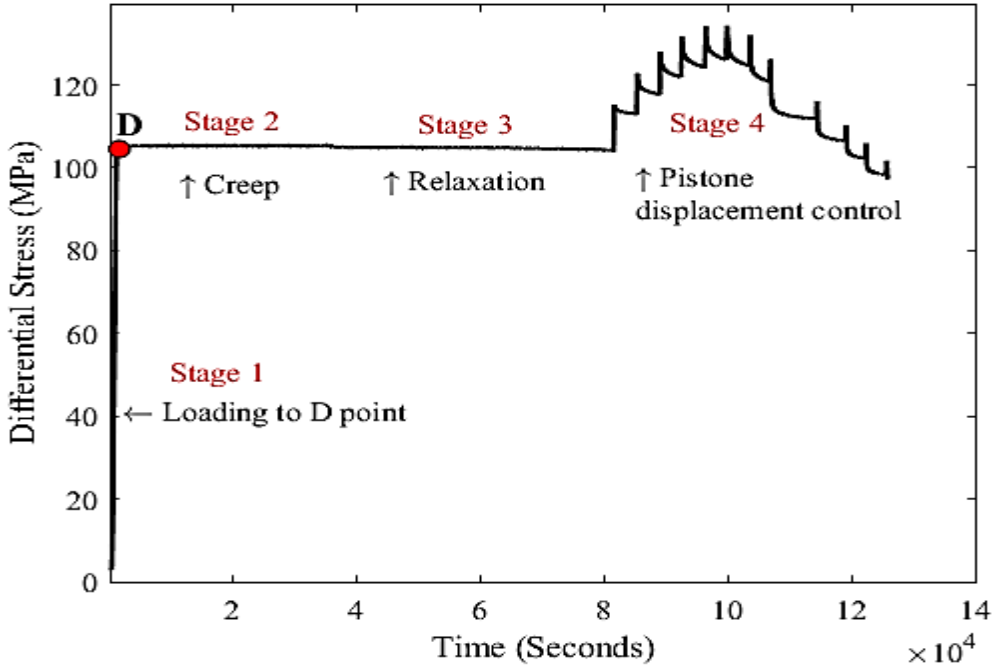


Experimental details

- 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.

Intact artificial sample

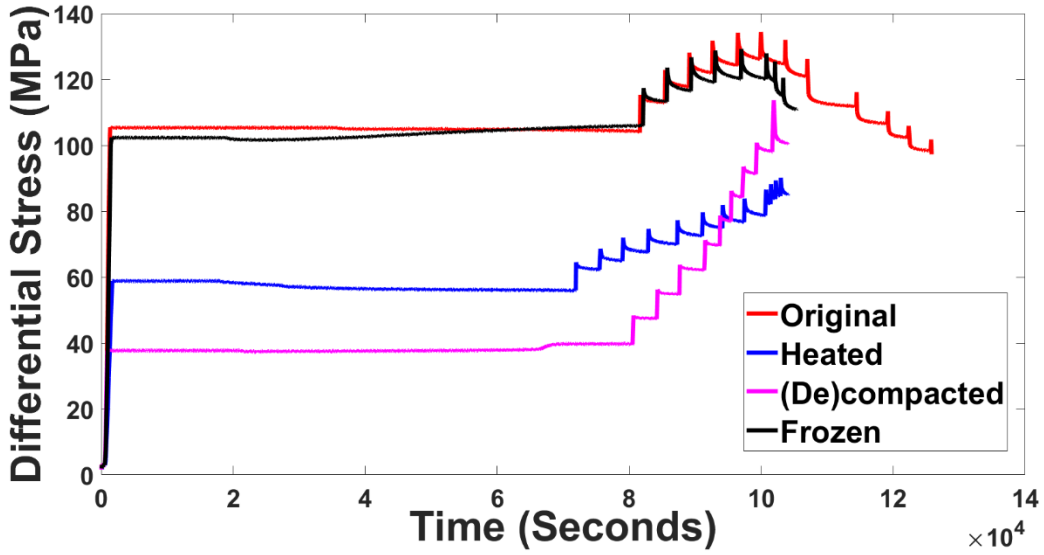
Limestone sample after experiment

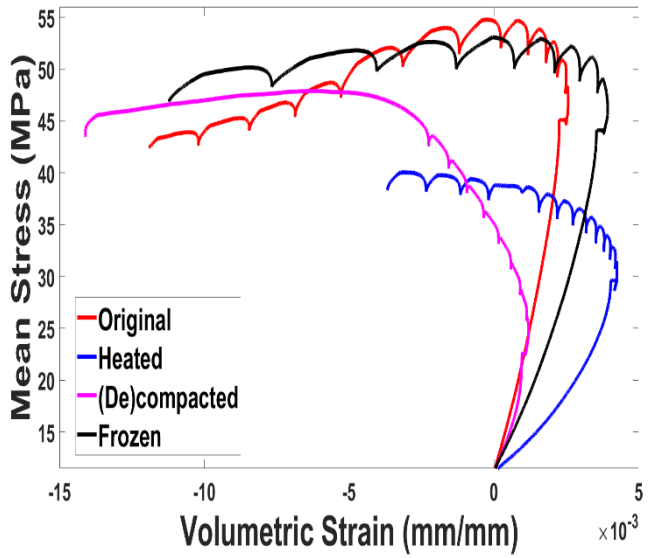


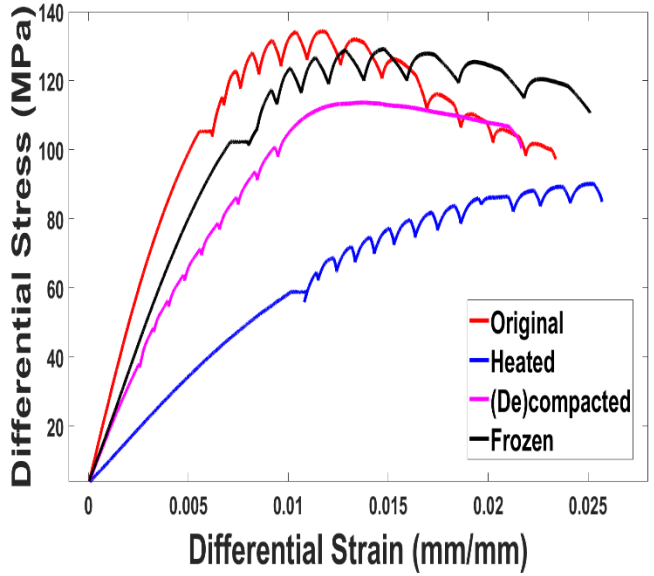
- New experimental procedure with 4 alternating stages of creep and stress relaxation is performed in laboratory triaxial experiments.
- Volumetric and shear response to triaxial loading was recorded.

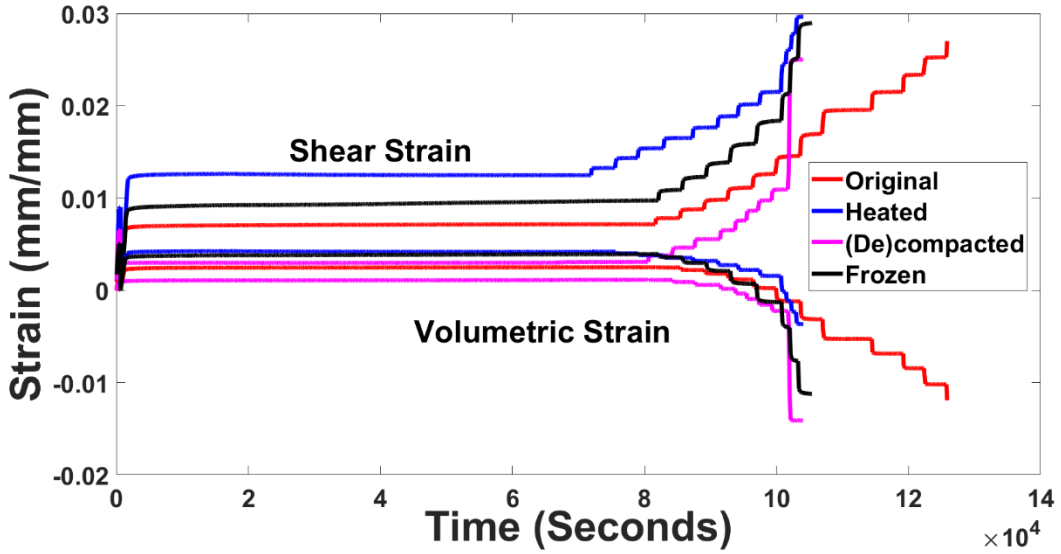
Sabitova et al., 2019, EAGE

Creep in Dry Artificial Samples



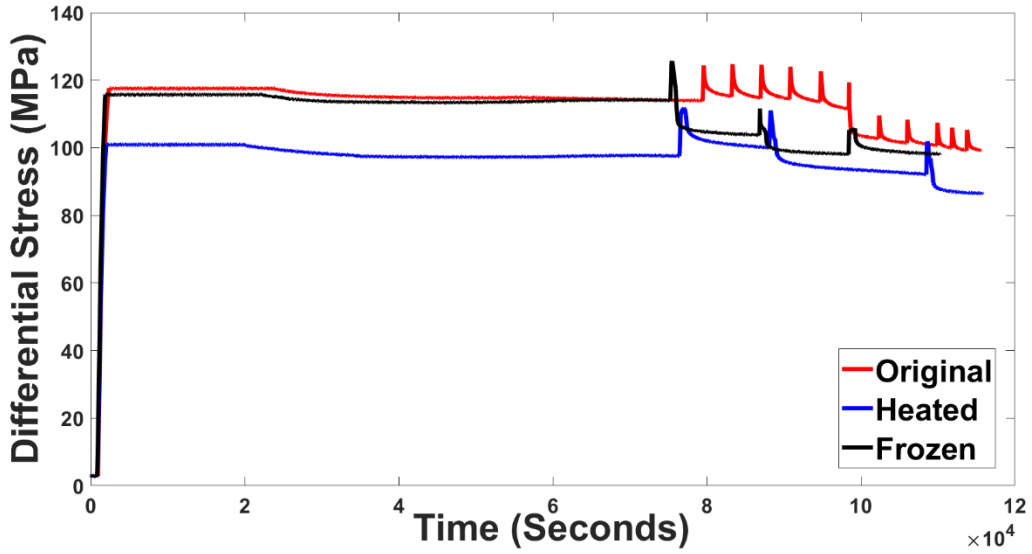


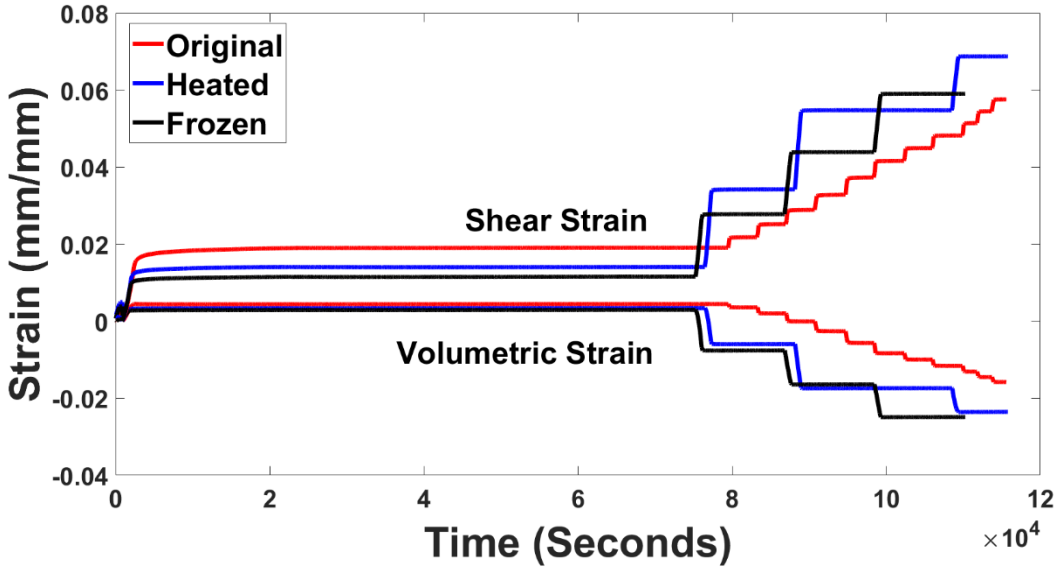


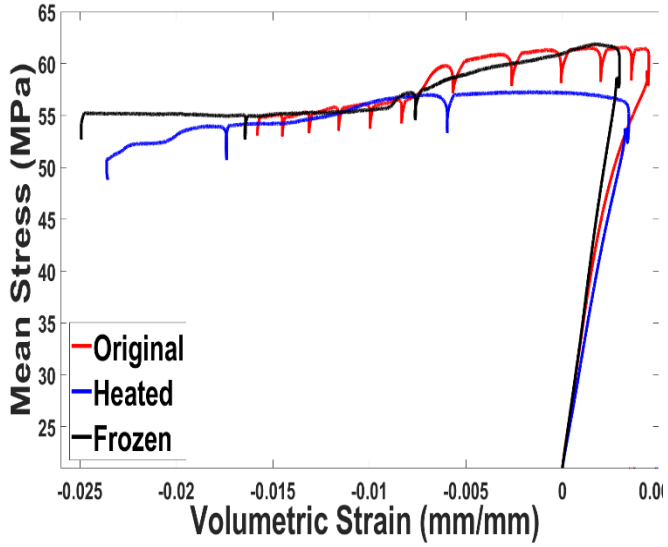


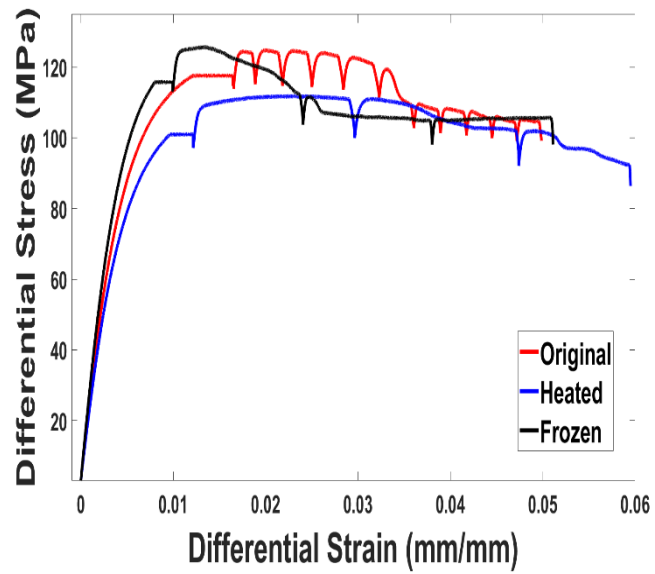
- All samples exhibit transition from compaction to dilatancy with increasing stress
- Prolonged decompaction stages were observed before development of macroscopic fracture
- Preliminary heating/cooling, freezing/melting and pre-loading affect mechanical strength and creep behavior of samples

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

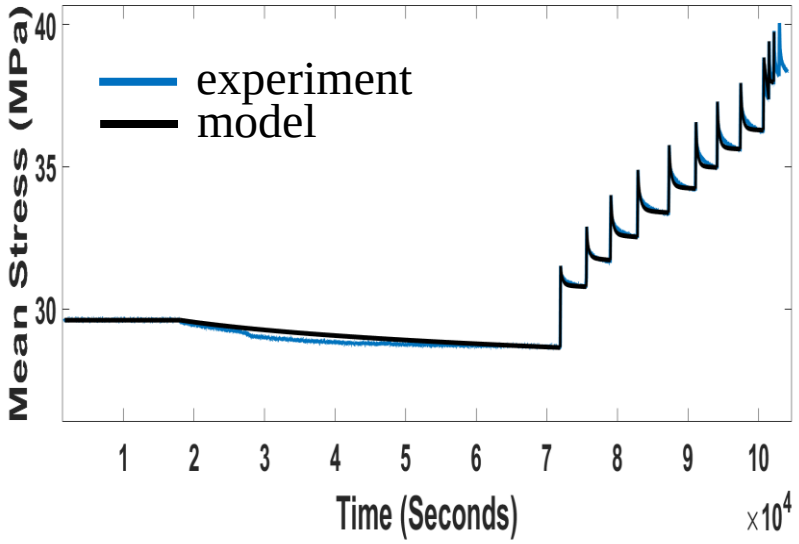
Effective mean stress

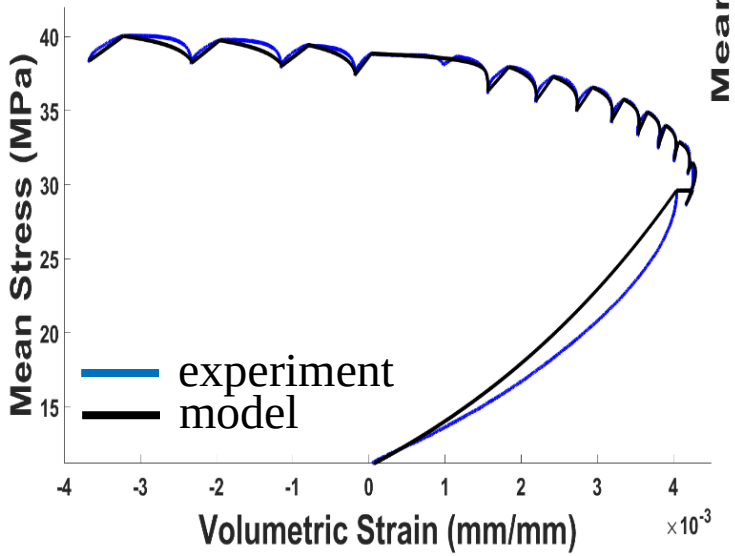
Compaction/dilation transition stress

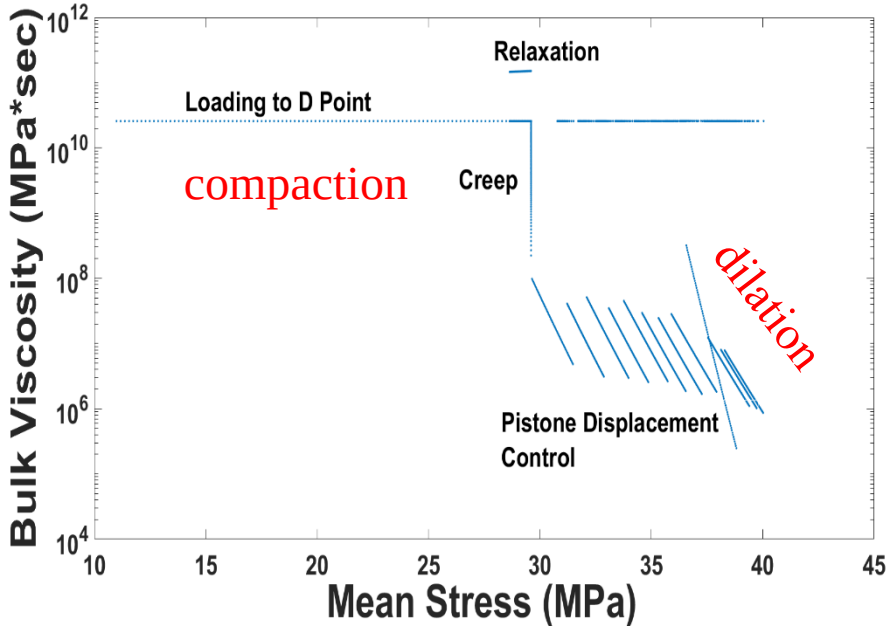
$$\dot{\varepsilon}^{v}_{kk} = \frac{\sigma_m - \sigma_0}{\eta}$$

Volumetric strain rate

Bulk viscosity, η , 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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