Viscoelasticity of Bentonite: Impact on radial flow through wellbore

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Problem

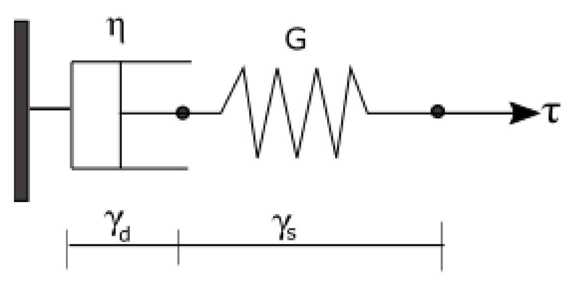
Fluid filled rocks are one of the most common features of earth systems notably, ground water and oil and gas reservoirs. Presence of fluids modify the mechanical behaviour of rocks and the current knowledge is limited to rock filled with Newtonian fluid (water). This project investigates the behaviour of rock filled with viscoelastic non-Newtonian fluids.

Basic Concepts

Deborah number

$$De = \frac{\lambda}{t_{exp}}$$

Maxwell model



$$\tau = \mu\dot{\gamma}_d = \frac{\mu}{\lambda}\gamma_d$$
$$\gamma = \gamma_d + \gamma_s$$
$$\dot{\gamma} = \frac{\tau}{\mu} + \frac{\dot{\tau}}{G}$$

In simplest 3D form:

$$\boldsymbol{\tau} + \lambda\dot{\boldsymbol{\tau}} = 2\mu\mathbf{D}$$

- $\dot{\tau}$ **is time derivative of stress tensor**
- **D is tensor for rate of strain defined as** $\mathbf{D} = \frac{1}{2}\left(\nabla\mathbf{v} + \nabla\mathbf{v}^T\right)$

Material and method

- Sodium bentonite powder mixed with deionized water to get 6.4 %wt and 7.5 % wt.
- Mixture cured for 16hrs under room temperature
- Experiments performed using Rotational DHRheometer(TA Instrument)
  - Steady shear test
  - Oscillatory test

References

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[2] Guillopé, C. and Saut, J-C, Existence results for the flow of viscoelastic fluids with a differential constitutive law, *Nonlinear Analysis, Theory, Methods and Applications*, 15 (1990), 849-869

[3] Barnes, HA, The yield stress- a review of $\pi\alpha\nu\tau\alpha$ $\rho\epsilon\iota$ - everything flows?, J. Non-Newtonian Fluid Mech., 81 (1999), pp. 133-178.

Acknowledgements

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Viscosity: Effect of applied shear stress and temperature

In steady shear experiment three phases observed: a Newtonian plateau, shear thinning and shear thickening.

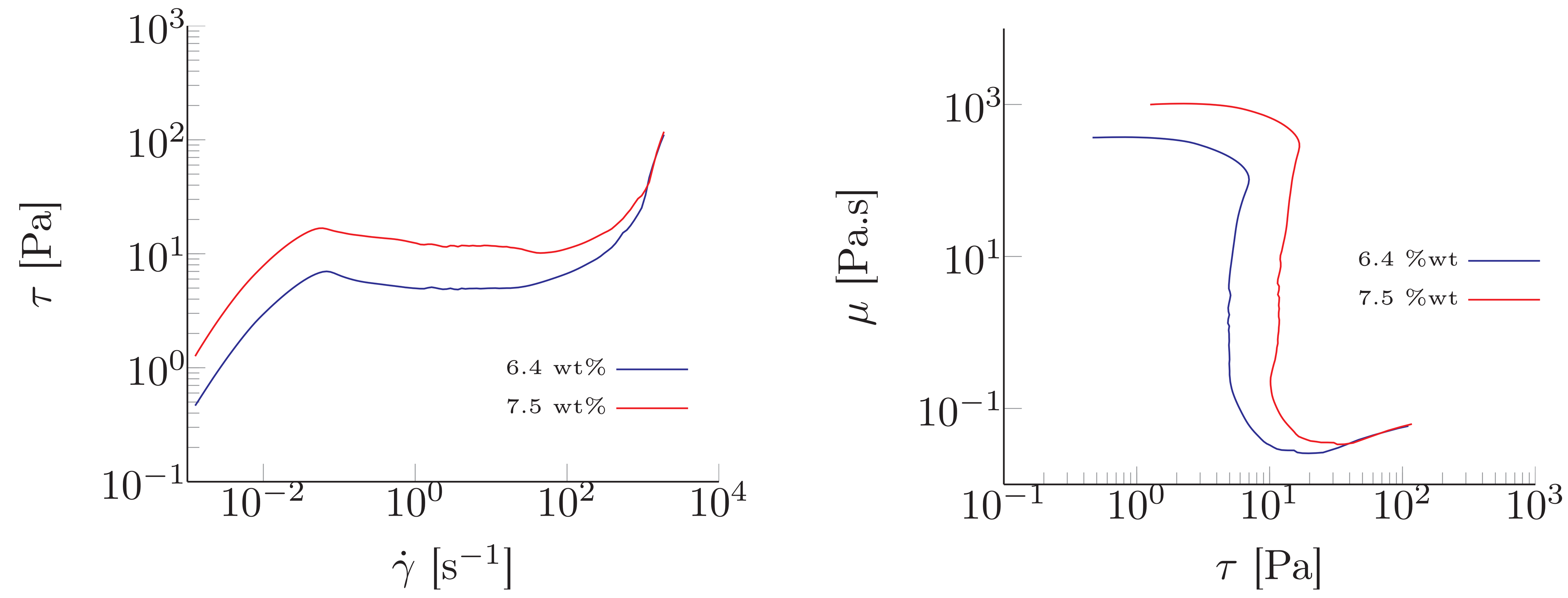

Figure 1: Effect of applied shear stress

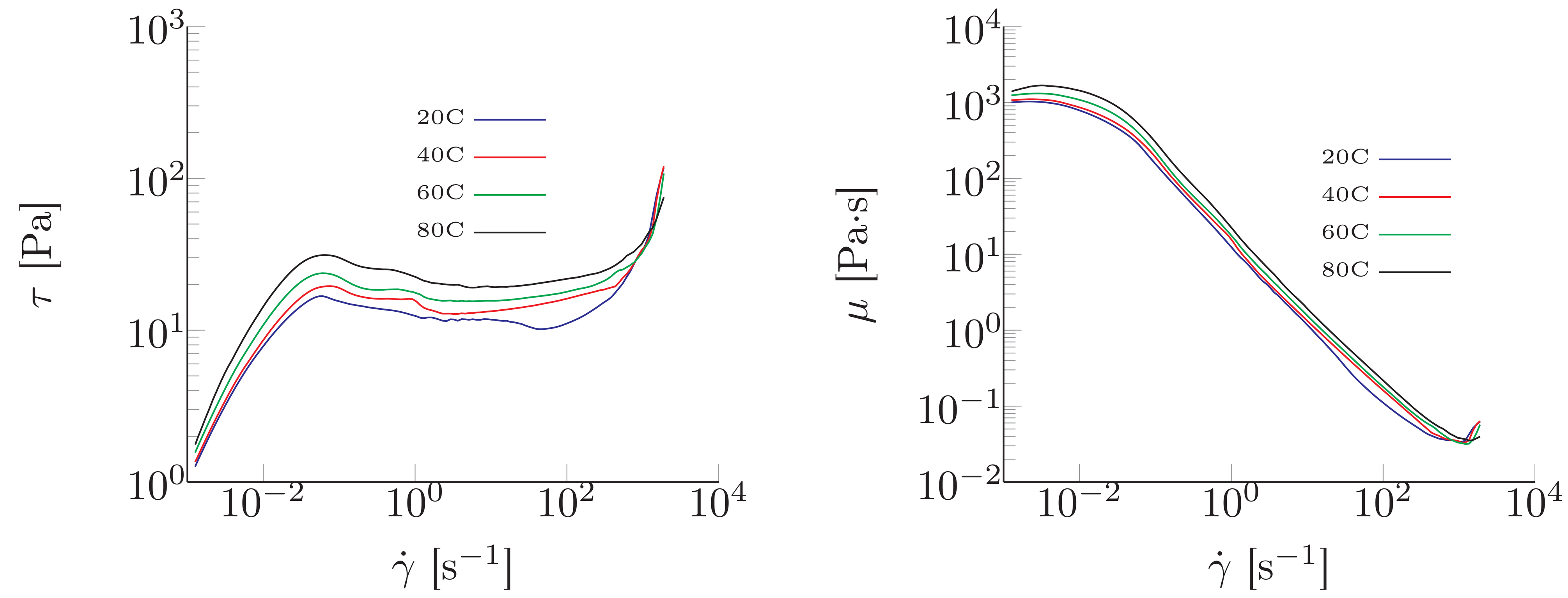

Figure 2: Effect of temperature

Viscoelasticity: Effect of temperature and frequency

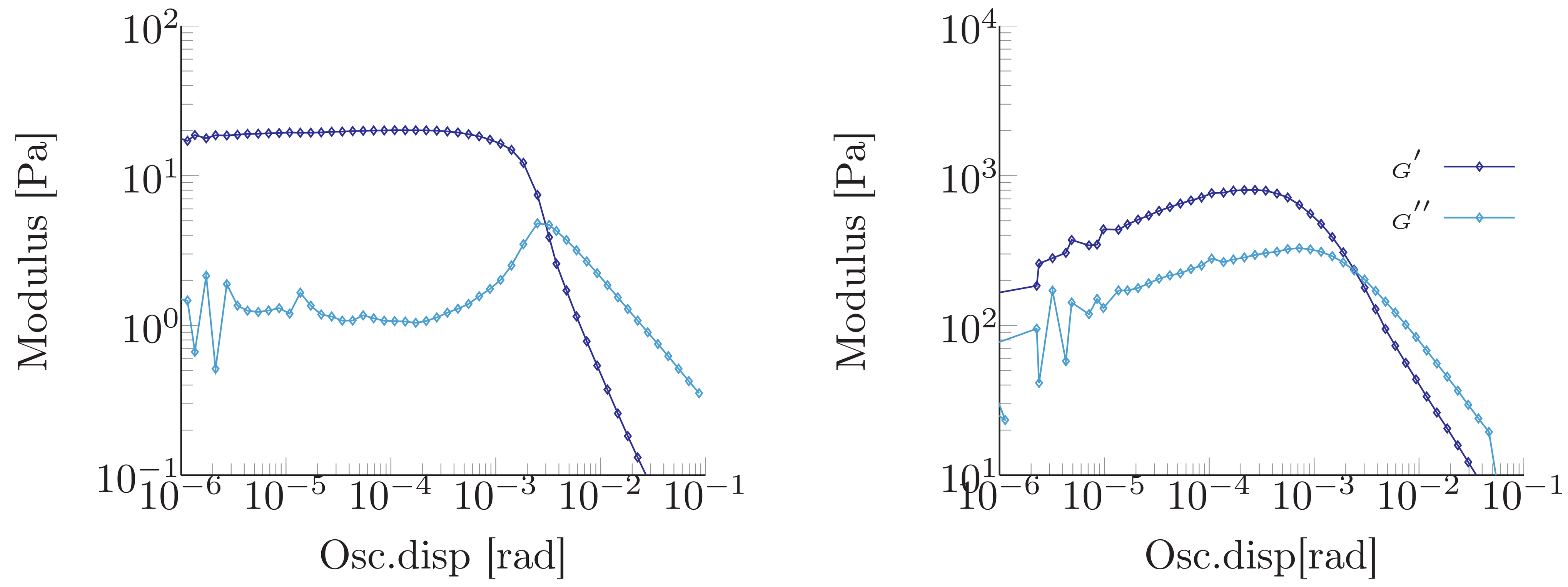

Figure 3: Effect of temparature at T=20 and T=80C

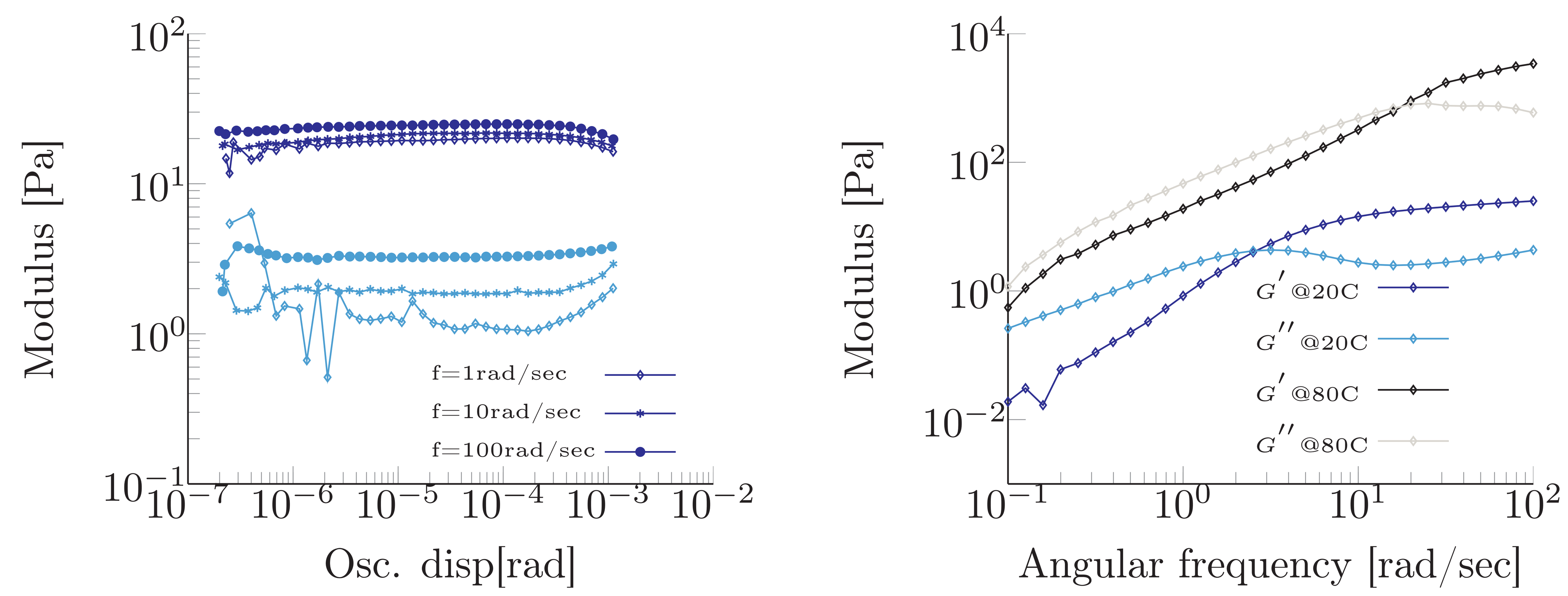

Figure 4: Effect of frequency

Conclusion

The viscosity of the tested drilling fluid is a temperature dependent with an increase of apparent viscosity as temperature increase for both concentrations. In the LVR ($\leqslant 0.001$ rad at T= 20^oC) sample show solid-like response. Higher temperatures gives nonlinear viscoelastic effect. $G^{'}$ show less dependent on frequency while $G^{''}$ shows highly dependent on frequency.