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The effect of temperature on mechanical and hydraulic properties of Flechtinger sandstone

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This research addresses the temperature dependence of static and dynamic elastic moduli and transport properties of Flechtinger sandstone at drained conditions. Static moduli were determined by stress-strain curves in a conventional triaxial test. Dynamic elastic moduli were derived from acoustic wave velocities. Flechtinger is an outcropping equivalent of north German basin reservoir rock (Rotliegend sandstone). The pore pressure was maintained constant at 1 MPa, confining pressure was cycled between 2 to 55 MPa and temperature increased step wise. The permeability of the Flechtinger sandstone at different temperatures was determined while keeping the downstream at a constant pressure of 1 MPa an applying constant flow rate.

The hydraulic (porosity, permeability) and poroelastic properties (drained bulk modulus, storage coefficient) were derived by employing drained poroleasticity theory and Darcy's law. The stress strain curves showed nonlinear behavior. Two types of nonlinearity in mechanical behavior of granular rock were distinguished in this study, one due to Hertizan contacts and crack closure and the other due to the temperature and stress dependence of physical properties. The drained bulk modulus showed pressure and temperature dependence. Applying pressure always increased the drained bulk modulus of Flechtinger sandstone. In contrast, the effect of temperature was pressure dependent. Both compressional and shear wave velocity increased by increasing pressure and temperature. The compressional wave velocity was increasing 31% with increasing effective pressure from 1 to 54 MPa. Moreover, it was raised 3.5% with increasing temperature from 25˚C to 140˚C. The interrelation between thermal expansion coefficient and bulk modulus, and the path dependence of heat transfer processes govern the temperature effect on granular rock and changes in pore geometry.