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Abstract

In recent years the mechanism of pressure solution creep (PS) has been recognized as playing an important role in the cavern closure creep after cavern abandonment. PS is difficult to measure adequately both in the laboratory and in the field. In the laboratory, the duration of the experiment can be a problem, as the resulting strain rates may require long periods of highly stable conditions so that the creep signal exceeds the measurement uncertainties, and the measurement is significant. PS creep can be measured at elevated temperatures in combination with reduced grain size, but then relies on extrapolation down to field temperature. Field measurements are generally not possible as the stress state at the cavern wall is within the field where dislocation creep is dominant. Additionally, grain size can vary with depth along the cavern wall, making it difficult to robustly predict PS at the cavern scale. A field scale test would also circumvent any sampling bias that laboratory tests may have.

We have conducted a combination of a field test at elevated pressure and a numerical model that allows us to constrain a number of creep parameters including PS parameters. Our “reverse engineering” approach starts with a field test. A brine-filled cavern (at a depth larger than 1 km) is held at a maximum pressure (here set at 0.18 bar/m) for several weeks to transient effects to dissipate. The pressure is then gradually reduced. At each pressure change, the volume of flowing out is recorded so that the compressibility is known. Between steps, the pressure increase is allowed to occur naturally.

Using the numerical model the pressure rise is modelled using a 2D axisymmetric model. The parameters that determine the creep are systematically varied until the resulting digital twin pressure vs. time curve best matches the field measurements. The temperature state and any changes thereof within the cavern are calibrated by two temperature logs before and after the test. This allows the pressure increase due to brine thermal expansion to be precisely considered.

Our results show that we can successfully calibrate PS at the field scale. We can show that PS creep is slightly slower than if determined by laboratory tests alone.

Key words: Computer Modeling, Rock Mechanics