Abstract

Closure of a salt cavern depends on the salt properties, the cavern environment (depth, overburden, temperature, natural boundary conditions, etc.), cavern geometry, number of caverns in the cavern field, and the cavern's stress history (operating pressures). In this paper, we present a method to estimate "future" cavern closure rates especially of gas storage caverns based on a fundamental knowledge of these parameters. Using three dimensional finite element models, we have evaluated the closure versus time of a single cavern in a cavern field in which the other caverns in the field are "active" for a series of different internal pressure cycling scenarios. A polynomial curve can be fitted to each closure versus time analysis result (scenario). The derivative of that curve with respect to time gives an expression that permits calculation of the closure rate for a specified time.   We have developed these curves, fits and closure rates for a series of loading scenarios.

Each cavern's stress history cycle consisted of an internal pressure that was varied inside the cavern for specific time intervals. In our closure rate analysis, for simplicity we chose a readily available stress value representative of the lithostatic stress at the ¼ cavern height. From this stress value, we subtracted the internal pressure. This gives a readily available "differential" stress measure (σ_b) for a specified time interval. The differential stress measure (σ_b) raised to the power of "n" (σ_b^n) is calculated for each time interval. The σ_b^n values for each time interval are then summed and divided by the total time. This gives a time averaged σ_b^n.

We then plot cavern closure rate versus time averaged σ_b^n for a set of analyses. We are able to fit a single functional relationship through the data with reasonable success. This relationship can be used to calculate closure rate for the cavern for other loading conditions by simply calculating the time averaged σ_b^n, which can be done with a spreadsheet.