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VERIFICATION OF THE SALT CREEP PARAMETERS USING DATA FROM THE ECHOMETRIC SURVEYS OF ALDBROUGH GAS STORAGE CAVERNS IN THE UK

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Abstract

The economics of gas storage in salt caverns are largely dependent on maximizing the ratio between the working gas and the cushion gas volumes. This ratio depends directly on the relative values of the maximum and minimum gas pressures permitted in the storage cavern. The maximum storage pressure is limited to a fraction of the vertical lithostatic stress, which corresponds to the weight of the overburden, in order to prevent fracturing and loss of containment. The minimum pressure required to ensure the geomechanical stability of the cavern is much more difficult to determine, and numerical simulations of cavern response during typical gas service cycles and conservative design criteria are used to evaluate the cavern stability at the minimum gas pressure. To carry out this required numerical geomechanical investigations it is necessary to use reliable creep constants preferably derived from *in situ* measurements (i.e. echometric surveys).

In the long term, salt behaves as a viscous fluid forcing caverns to gradually shrink and deep caverns, such as the Aldbrough caverns which are operated by SSE and lie at a depth of 1.8 km, experience notable creep closure rates as proved by direct measurement of the caverns' shape evolution through echometric surveys.

In this paper we present the results of the back-analysis employed to evaluate the creep parameters of the visco-plastic constitutive model used to model a number of Aldbrough caverns which have been developed in the Permian Zechstein II Fordon Evaporites. This investigation of the actual creep closure of Aldbrough caverns, has contributed in a comprehensive understanding of the *in situ* constitutive response of the salt mass that surrounds the caverns in the Aldbrough gas storage site. The paper describes how the creep closure history of Aldbrough caverns was back-analysed using the numerical finite difference method.

The salt was modelled as a WIPP creep visco-plastic material whose plastic constitutive response conformed to the Drucker-Prager elasto-plastic model. Of the available plasticity models the Drucker-Prager model was chosen being the most compatible with the WIPP reference creep law, since both models are formulated in terms of the second invariant of the deviatoric stress tensor. A series of finite difference numerical analyses were carried out employing a *trial-and-improvement* back-analysis approach by using the results of *in situ* convergence data derived from the echometric surveys of a number of Aldbrough caverns to verify the laboratory determined WIPP creep parameters. The investigations enabled us to better understand the long term volumetric closure of the caverns in the Aldbrough gas storage site and to define the parameters affecting the creep response of Fordon Halite.

Key words: Bedded Salt Deposits, Cavern Design, Caverns for Gas Storage, Computer Modelling, Geology, Rock Mechanics, Salt Properties, United Kingdom.