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Winsford mine: UK's largest salt mine - Fifty five years of rock mechanics investigations that are also used in the design of gas storage caverns

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Abstract

Cheshire in the UK has been a source of salt for hundreds of years, and the industry is mentioned in the Domesday Book. The first known salt mine started in 1682 and salt was mined at Winsford from 1844 until 1892, when the mine closed because the limited demand for salt could be supplied more easily from the Northwich mines - also in Cheshire.
Winsford mine reopened in 1928 after the premature closure of Adelaide salt mine, the last of the Northwich mines, because of flooding. Since then, several millions tonnes of salt were produced, primarily for road de-icing. Winsford mine is the UK's largest salt mine with more than eighty years of uninterrupted salt production and more than fifty five years of rock mechanics investigations whose results are also used in the design of gas storage caverns.
Systematic rock mechanics investigations in the mine began in the early 60's and continued uninterrupted to the present day. The linking, developing and extending of these investigations provided the opportunity for a detailed understanding of the geomechanical characteristics of the Cheshire salt formations. This has contributed not only to the design and development of the room and pillar mine workings, but also produced an in-depth understanding of the strength and creep characteristics of the Cheshire Triassic salt deposits where a large number of gas storage caverns exist.
Techniques for monitoring and recording the deformations of salt pillars, roof-floor roadway convergence and *in situ* stresses were introduced and an extensive instrumentation programme was implemented.
The underground data from the instrumentation programmes has shown that the convergence rates in the mine's panels were decelerating and the results provided a better understanding of the long term stability of the mine workings and defined the most significant parameters that affect the creep response of rock salt.
Moreover, to investigate the mechanical response of Cheshire Halite, under conditions similar to those predicted around gas storage caverns, a series of *in situ* tests were carried out in an instrumented cavern that was constructed in the mine and was subjected to cyclic pressure and temperature changes.
Analysis of the experimental results indicated that the *in situ* shear modulus of rock salt was significantly higher than the value derived from laboratory tests, while the corresponding Poisson's ratio was less than the respective value resulting from laboratory tests.
The underground data from the instrumentation programme confirmed that the Cheshire Triassic salt can be modelled as a WIPP (Waste Isolation Pilot Plant) creep visco-plastic material (also known as RE/SPEC model) whose plastic constitutive response conforms to the Drucker-Prager elasto-plastic model. Using the results of the *in situ* convergence data, a series of analyses were carried out employing a back-analysis approach and allowed the verification and the fine-tuning of the laboratory determined creep parameters.

Key words: Bedded Salt Deposits, Cavern Design**,** Caverns for Gas Storage, Geology, History, Instrumentation and Monitoring, Rock Mechanics, Underground mine/mining, United Kingdom.