ABSTRACT

A prediction model has been designed in the period 1994-1999 to model the NEDMAG surface subsidence field, resulting from solution mining and cavern convergence. The model matches the data from levelling exercises well and is believed to be a good tool to model the further development of the subsidence bowl. Levelling exercises act to validate the theoretical model and to fine tune on parameters. A major advantage of the model is also its simplicity allowing for rapid updates.

Input of the model is the cavern convergence (in cubic metres) of the individual caverns. This convergence needs to be estimated from experience and/or simple models, describing convergence as function of cavern size and cavern pressure.

There seems to be a direct relation between the convergence of a single cavern and the resulting subsidence effects. A Gaussian type of description can fit the cross section of the subsidence bowl of a single cavern well with three fitting parameters. Two parameters determine the shape of the bowl, (i.e. the distance to for instance 80, 50, 10 % of maximum subsidence) and another parameter links the maximum subsidence to the cavern convergence volume.

The total subsidence bowl from multiple caverns in a field is a simple superposition of each of the cavern-specific subsidence bowls.

Once the shape of the subsidence bowl is determined by levelling, subsidence can be predicted with the measured convergence volume per cavern. The convergence volume can be determined (i) by a volume and/or mass balance of injection and production or (ii) by comparing production results (theoretical cavern size at no convergence) and sonar-readings (actual cavern size). To predict future subsidence bowls, the convergence volume must be predicted by simple theoretical models, which calculate the convergence as a function of cavern pressure and cavern volume.

With these tools predictions of long-term subsidence have been made, up to a 50 year period. The convergence values have been derived from the production plan, assuming a balance between cavern growth by dissolution and cavern convergence. These forecasts allow local water-boards and municipalities to take subsidence into account when designing sewer systems, drainage systems and waterways. These civil works usually have a lifespan of 20-70 years. In the Nedmag Mining Area, the (relative) water table needs to be maintained within a small range (5-10 cm deviation to original values), by which predictive tools are a must.

The method may be applicable for other salt mining companies, where subsidence is an important issue.

Introduction

Salt mining in deep cavern systems is usually accompanied by surface subsidence, which is the result of salt creep and the consequential cavern convergence. For solution mining and for storage caverns, the (average) cavern pressure is far lower than the lithostatic (overburden gradient) pressure. The weight of the overburden, supported by the salt around the caverns, initiates a salt creep flow towards the cavern(s). The overburden reacts normally in an elastic