Simulation of Horizontal Solution Mining Processes

P. Grönefeld and T. Pape

Kavernen Bau- und Betriebs-GmbH (KBB), Karl-Wiechert-Allee 4, 30625 Hannover, Germany

1. INTRODUCTION

The continuous rise in demand for technologies to solution mine thin salt deposits to produce brine has led to the development of new technical concepts incorporating state-of-the-art horizontal drilling techniques.

The most up-to-date approach is to combine a vertical production well with a horizontal injection well to solution mine thin potash beds.

In addition, the spatial and volume development of horizontal tunnel caverns for potash production, as well as the distribution of concentrations for two salts (KCl, NaCl) can also be computer simulated.

However, the cylinder models previously used for simulation are not adequate to analyse the situation involving horizontal tunnel caverns. A computer code was therefore developed to enable the use of a Cartesian coordinate system for the solution mining process.

1.1. Solution mining via horizontal wells with successive injection points.

The solution mining process depicted in figures 1 and 2 involves the initial conventional solution mining of a "start cavern" via a vertical well (A). Directional drilling is then used to drill towards this cavern horizontally from location B.

Because the solution mining process that then takes place in the brine-filled cavity does not develop rotation-symmetrically around the borehole, it only makes sense to simulate this process on the basis of models incorporating Cartesian coordinates.

This solution mining process involves running a leaching string into the horizontal well (B) which is then used to inject solvent into the salt deposit. The injection point is systematically shifted by stepwise withdrawal of the leaching string, which means that this solution mining process and/or the cavern, is developed in the direction of the horizontal drilling axis as a tunnel cavern. Blanket is used analogously to other methods to vertically limit upward leaching.

The different solubility of the calculated salts (KCl, NaCl) is clearly reflected in the preferential cavity formation shown in the vertical sections in figures 1a and 2a. A small sump cavern in the underlying NaCl bed is used to create dissolution surfaces and to accommodate the insoluble residues from the KCl bed.

In figures 1b and 2b, the injection string (B) has already been pulled back to interval 40-50 m. This reveals the distribution of concentration in the solution mined tunnel sections.

2. THE COMPUTER MODEL

A model based on Cartesian coordinates is divided up into block elements in the same way as polar coordinate models. This allows fine discretisation of the geological section which is being solution mined. Each separate block element can be assigned the following input parameters for two different salts (NaCl and KCl) based on the geological findings:

- Dissolution velocity
- Insoluble content.

This allows block elements or zones of insoluble to very highly soluble constituents to be defined. Naturally, the input of time-variable solution mining parameters is possible in addition to these quasi fixed-time data.

Changing the above mentioned leaching parameters at relevant time intervals makes is possible to simulate real horizontal solution mining processes.

The calculation results, such as cavern shape, concentration of produced brine, volume growth, total brine-filled volume, and salt extraction mass, enable history matching to be carried out with the actual measured values.

3. CALCULATION EXAMPLES

The calculation examples show that this programme produces plausible results. The diagram showing the distribution of concentration within the cavern also confirms the "realistic engineering" approach to calculate the concentration profile and thus produce realistic results.

The next steps in elaborating/checking the program involves carrying out further matches with real horizontal solution mining processes. The GALSIM3D programme presented here makes this possible.

Figure 1 a

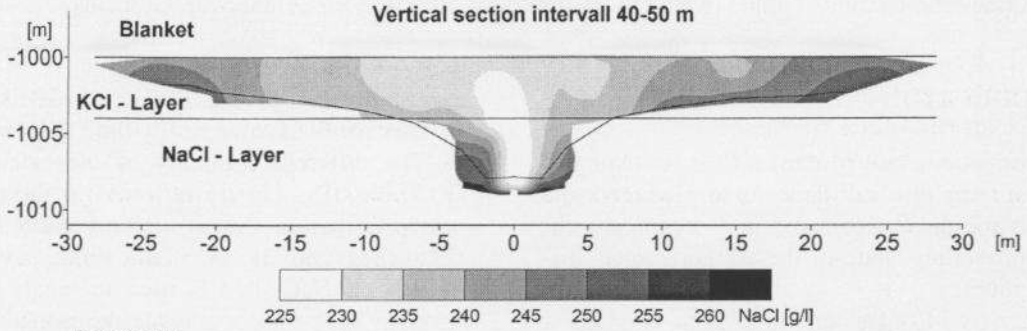
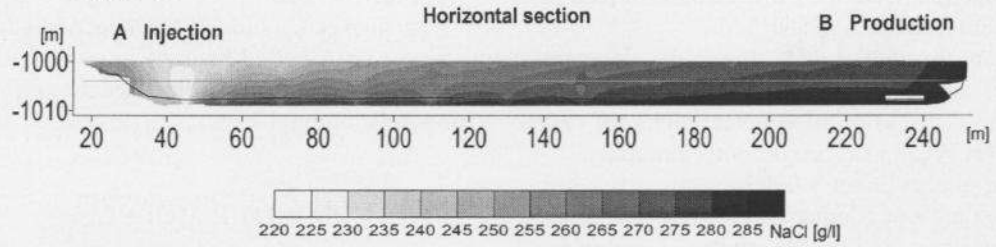


Figure 1 b



Horizontal leaching process, 300 days of operation
NaCl - concentration

Figure 2 a

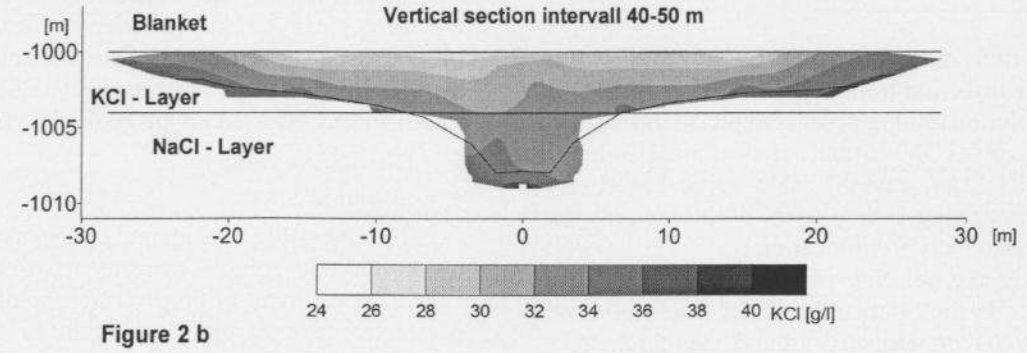
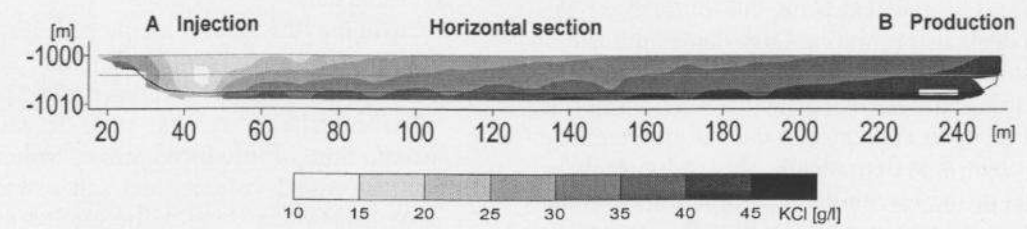


Figure 2 b



Horizontal leaching process, 300 days of operation
KCl - concentration