Experiences with blanket level measurement in solution mining caverns of Salinen Austria

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Abstract: Due to the high content of insolubles the height of Austrian borehole-caverns is normally in a range of only 5 - 20 m. Therefore the solution process precludes leaching in large vertical steps. Solution mining only works by leaching of thin slices day by day. That is why we need exact information about the level of the brine-blanket-interface, which has to advance maximally 2 cm per day upwards.

Before 1991 the position the brine-blanket-interface was estimated in a very inaccurate manner on basis of the blanket pressure data.

Salinen Austria started to install blanket level measuring tools in ist borehole wells in 1991.

Together with two producers we improved the systems and nowadays our tools give information about the exact position of blanket level.

Main advantages:

- exact control of the leaching process in the cavern
- efficient sump-leaching in the initial phase of cavern-operation
- efficient leaching of a dome in the final phase of cavern-operation

1. INTRODUCTION

Salinen Austria wins brine for salt production in underground mines and through surface borehole-wells. The primary working method is leaching in borehole wells. The most important limitation in this method is the proportion of insolubles present in the salt deposits which is normally in the range from 30 to 50 percent.

Winning from the surface works with 12 ¼ " well holes which are sunk down to a depth of up to 700 m to reach the salt deposits found

in a depth of 300 to 700 m. Production strings are used with a diameter of 3 ½ " and 7".

In underground mining, a number of horizontal drifts at different levels are driven through the overburden into the salt deposits. Well holes are drilled from a gallery within the salt deposit down to the next gallery level below or all the way down to the bottom of the deposit. Accordingly, the depths of these boreholes with a diameter of 240 to 300 mm cover a wide range from 50 m to 300 m. The production strings consist of an outer pipe with diameters from 4 " to 5 ½ " and an inner pipe with diameters from 2 " to 3 ½ ". Figure 1 below shows the well head of a modern well. As blanket medium, compressed air or oil is used.

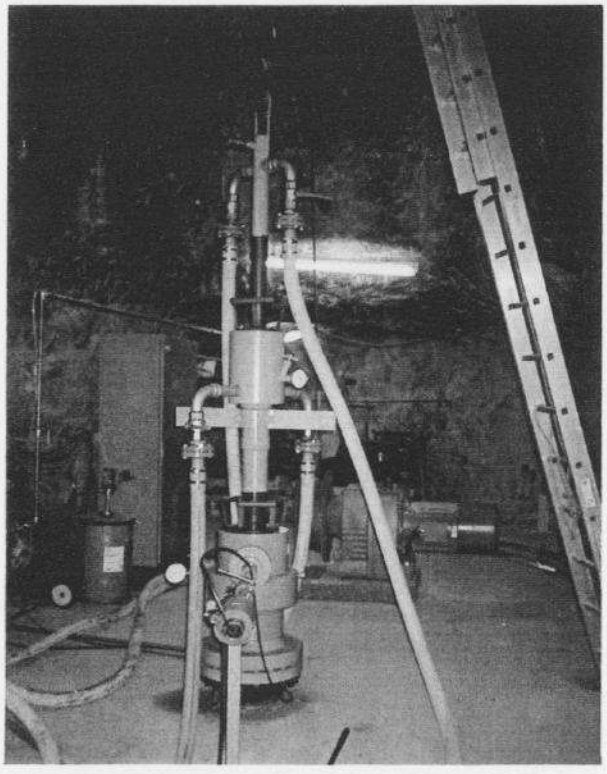

Figure 1. Well head of the latest generation

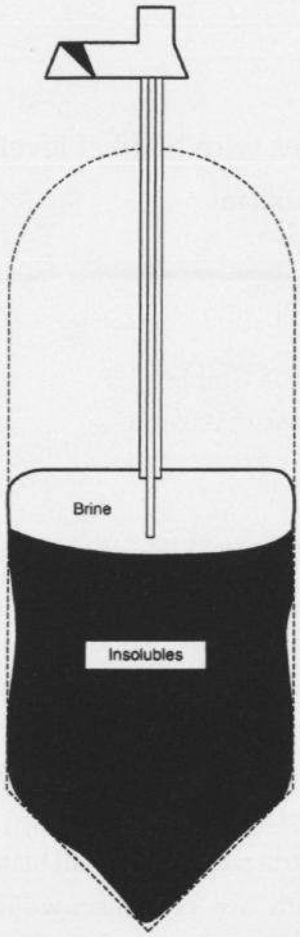

Figure 2. Diagrammatic proportions of open cavity and insoluble residues

The high proportion of insolubles in our salt deposits precludes leaching in large vertical steps since the insolubles remaining would backfill the cavern and eventually plug the borehole (see figure 2). A horizontal slicing system of leaching must therefore be employed. By this method, a succession of thin horizontal layers is leached away through raising of the blanket level in relatively short intervals of one

or several days. Low cavity temperatures of approximately 5 °C lead to very low leaching rates. In vertical direction, the advance of the leaching interface which can be achieved in a day is limited to maximally two centimeters.

The advancing rate applied by small-increment raising of the blanket level is a crucial parameter for exact control of the leaching process. Within the frame of reference given by the local content of insolubles, the vertical advancing rate and the circulation rate are those process parameters which are used to control the leaching process in a way that the desired diameter of the cavity is obtained.

It follows from the above that exact logging of the blanket level with an accuracy of a few centimetres is essential to the optimization of this method of leaching.

2. DEVELOPMENT OF BOREHOLE WELL METHOD FROM 1958 - 1991

The first attempts to use borehole well methods under the difficult conditions of alpine salt mining date back to the year 1958. After years of development efforts, the technology was finally mature enough to be used on a large scale. The first borehole in a surface-brinefield went into operation in 1967, and in 1971, the technique was for the first time used in underground mining. Before 1991 the blanket position could only be estimated on the basis of the blanket pressure data. Since the frictional behaviour of the production pipe strings can vary markedly depending on gypseous deposits, blanket positions determined on the basis of pressure data can be erroneous by up to 10 metres.

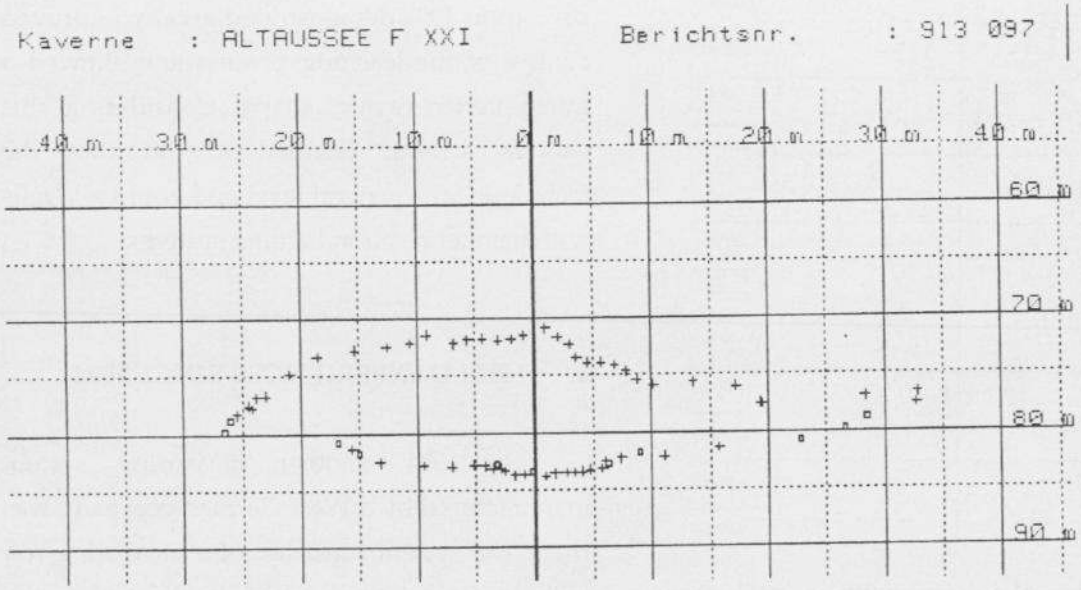

Figure 3. Irregular shape of a cavern in 1991

Frequently this led to an irregular cavern roof and to poor control of the cavity shape (see fig. 3). Too small a cavern diameter causes a loss of recoverable reserves, whereas too large a diameter weakens the pillars between the individual cavities.

Hardly ever was it possible at that time to achieve a satisfactory dome shape of the final cavern roof.

Finally the enlargement of a new cavern during the initial phase performed rather poor. The cavities widened at angles ranging from 40 to 60 degrees and even more (fig. 4).

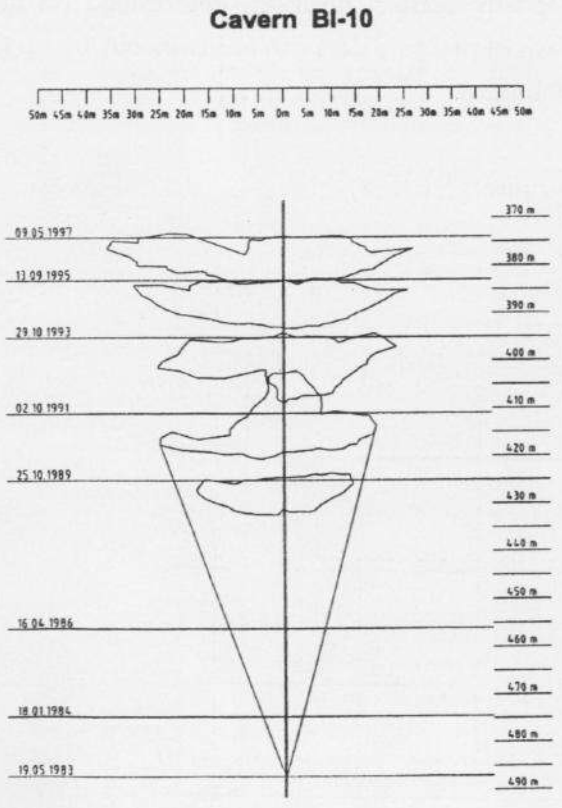

Figure 4. History of a cavern with an ineffective sump leaching phase before 1991

3. INTRODUCTION OF BLANKET LEVEL MEASUREMENT TECHNIQUES IN 1991

In June 1991, blanket position measuring tools were for the first time used on the author's initiative. The devices were installed in three existing caverns and used the electric conductivity measured by two annular electrodes attached to the outer production pipe. The system was purchased from a Thüringen-based German company with relations to the potash mining industry in the region. The measuring signal is transmitted to the well head by means of a cable running in the outer annulus of the production pipe string. A drawback of this simple and robust type of device with two electrodes was the necessity to raise the pipe string in relatively short intervals to follow the rise of the blanket/brine interface.

However, the results obtained made up for this inconvenience. Echolog surveying of the caverns in 1993 demonstrated greatly improved control of the leaching process and showed a much better cavern shape. Considering this success, it was decided to introduce the technique on a general level and equip all wells with blanket position logging systems.

4. FIELD EXPERIENCES SINCE 1994

In 1994, another measuring system manufactured by a West German company was tried. The system consisted of a measuring rod with 16 contact rings which is attached to the outer production string (fig. 7). The practical

experiences with this alternative design were also quite positive so that both types have been used from 1994 on.

Accurate measurement of the blanket level proved to be very useful in the sump leaching phase of new caverns. Exact logging of the blanket level to the centimetre and exact computational modelling of the leaching process made it now possible to achieve angles of around 20 degrees in cavity enlargement (see fig. 5). By consequence, the recovery factor could be increased substantially.

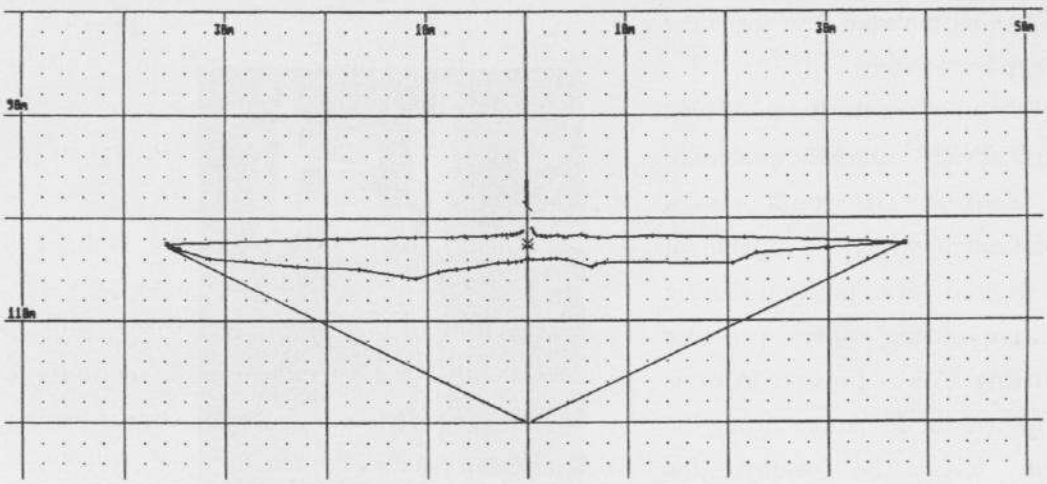

Figure 5. Excellent cavern enlargement in a low-quality-deposit (1996 -98)

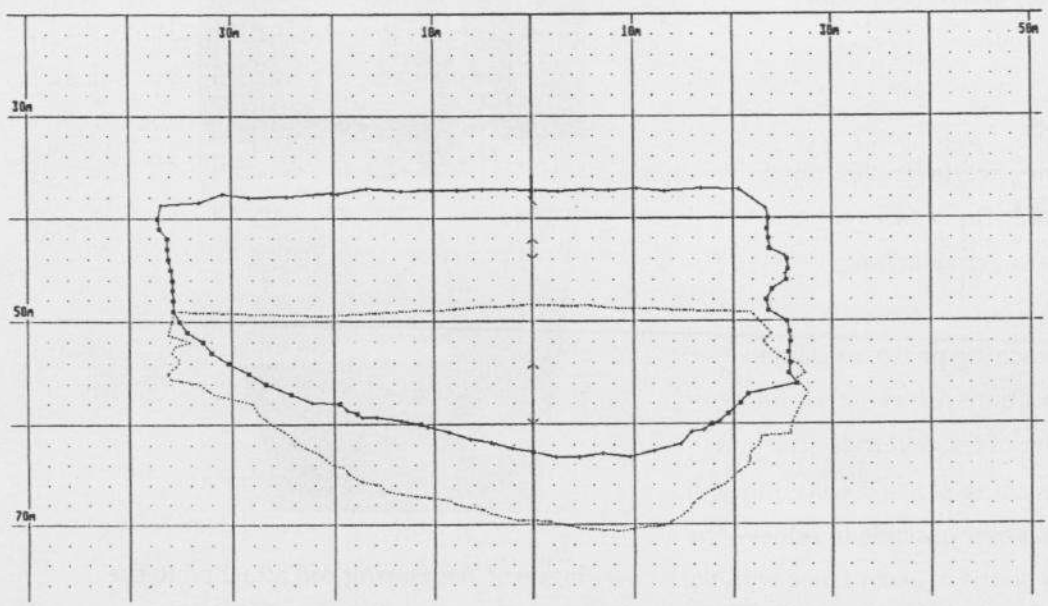

Figure 6. Good control of cavern-shape during the main leaching phase with vertical walls and a flat roof (1995 - 97)

Short-term pressure fluctuations in the cavern are frequent during the initial phase. With a compressible gaseous blanket medium, such pressure fluctuations result in pronounced ups and downs of the blanket level. It can even happen that the air-blanket blows out into the outer production pipe allowing the medium to escape at the well head. Uncontrollable operating conditions of this kind - much feared in the past - can be avoided by the new techniques to a very large extent.

Further development of the borehole well technologies aimed at fully automatic control of compressed air blankets. The result was a feedback control system which is capable of maintaining the desired level position during leaching irrespective of the cavern pressure fluctuations occurring. Air is pressed in or is blown off in response to deviations from the desired blanket level. So today the compressibility of air blanket is no longer a disadvantage in the winning of brine.

5. SUMMARY

Today, the method described is an indispensable tool for exact control of the various phases of cavern leaching:

- In the sump leaching phase, unstable operating conditions are avoided and a rapid widening of the cavern is achieved.
- In the main leaching phase, exact control of the process makes it possible to achieve the desired cavity shape in accordance with the mining plan (fig. 6).
- In the final phase, formation of a dome-shaped cavern can be ensured which has optimal long-term stability.

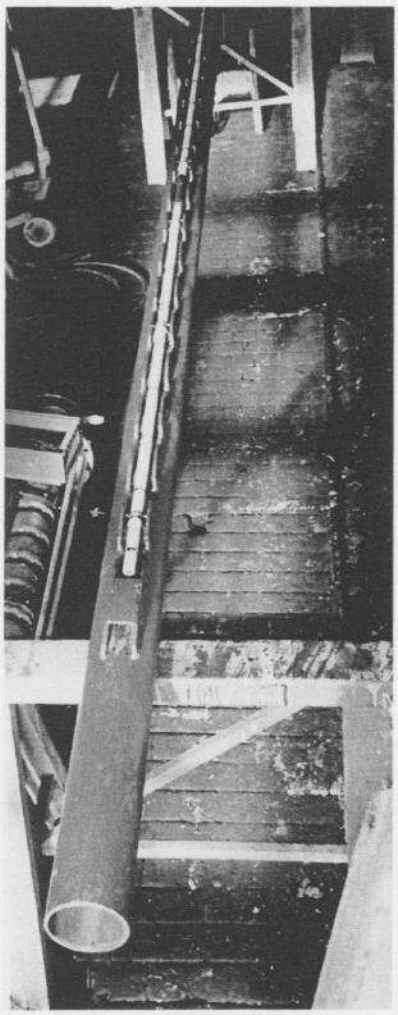

Figure 7. Measuring rod attached to the production string