IfG Institut für Gebirgsmechanik GmbH
Untersuchung - Prüfung - Beratung - Begutachtung

MEMORANDUM

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From: Armin Lindert, IfG

To: 5.1.2.e

Haaksbergen – update of cavern convergence prediction

For the mining application of the Haaksbergen brine production project AkzoNobel requested an update of the surface subsidence prediction based on the recent production plan which was newly developed by DEEP. in 2012.

Therefore, IfG Leipzig was requested to determine the convergence behavior of brine production caverns taking into consideration this new production plan (caverns with larger heights but smaller in diameter) and the results of the site-specific rock mechanical laboratory tests (IfG, 2012[1]). According to the new production plan a new generic cavern model was developed (Annex 1), which is now located about 100 m deeper than the preliminary model (IfG, 2010[2]) and represents one of the deepest caverns in this field.

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[1] IfG (2012): Rock-Mechanical Laboratory Investigations on Rock Salt from the AKZO Nobel well ISH-01, Institut für Gebirgsmechanik GmbH, Leipzig, 18/07/2012

[2] IfG (2010): Rock mechanical investigations and dimensioning for the new AkzoNobel NaCl-brine production field Haaksbergen, Institut für Gebirgsmechanik GmbH, Leipzig, June 30, 2010

On the basis of the method described in detail in the IfG report (2010[2]) IfG Leipzig has determined convergence rates for the following cases:
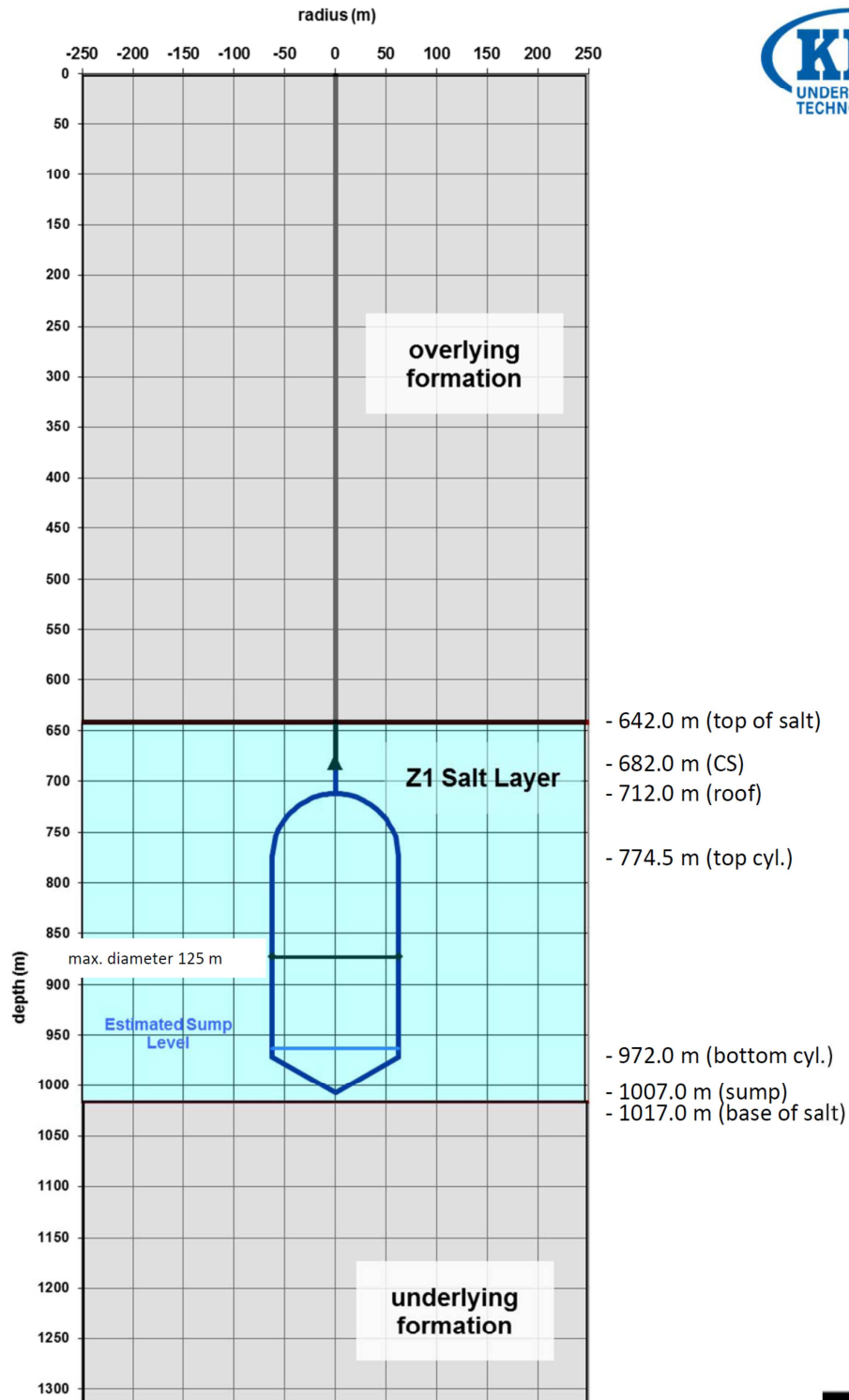
- new generic cavern model using the material reference parameters of Borth (GER),
- new generic cavern model using the material parameters of well ISH01,
- new generic cavern model with expanding the pillar (b_{pillar} = 175 m → 450 m)[3] and using the material parameters of well ISH01.

The results are summarized in the following table:

new generic cavern model with a pillar width of	reference parameters of Borth		material parameters of ISH01	
	wellhead pressure		wellhead pressure	
	0	5 MPa	0	5 MPa
	cavern convergence rate			
175 m	2.47 ‰/a	0.405 ‰/a	5.53 ‰/a	1.17 ‰/a
450 m	-	-	2.52 ‰/a	0.483 ‰/a

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[3] The expanded model with an outer radius of 450 m was studied, because due to the production planning of Haaksbergen the majority of the caverns will show in the final state only 4 neighbors instead of 6 in a perfect hexagonal field design. This will increase the minimum remaining salt pillar between caverns that can be considered for the load bearing system. While axi-symmetric models were used in the study, the effect of an increased salt pillar was taken into account by extending the outer boundary of the theoretical numerical model. For Haaksbergen field layout (cavern diameter 125 m, borehole spacing 300 m) the following notional salt pillar widths in dependence of the number of adjacent caverns can be estimated:

number of adjacent caverns	0 single cavern	1	2	3	4	5	6 field cavern
salt pillar width [m]	1000	862.5	725	587.5	450	312.5	175
ratio of salt pillar vs. max. cavern diameter	8	6.9	5.8	4.7	3.6	2.5	1.4

radius (m)

KBB UNDERGROUND TECHNOLOGIES

overlying formation

- 642.0 m (top of salt)

Z1 Salt Layer

- 682.0 m (CS)
- 712.0 m (roof)

- 774.5 m (top cyl.)

max. diameter 125 m

depth (m)

Estimated Sump Level

- 972.0 m (bottom cyl.)
- 1007.0 m (sump)
- 1017.0 m (base of salt)

underlying formation

Haaksbergen – Update of Generic Cavern Design (2012)
Maximum Diameter 125 m

DEEP.
Underground Engineering

Annex 1

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