WORLD SALT SYMPOSIUM
June 19-21, 2018 Park City UT, USA

MUTUAL BENEFITS OF COMBINING POTASH PRODUCTION AND ABANDONMENT OF UNDERGROUND STORAGE CAVERNS

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A COMPANY OF GEOSTOCK ENTREPOSE

Untergrundspeicher- und
Geotechnologie-Systeme GmbH

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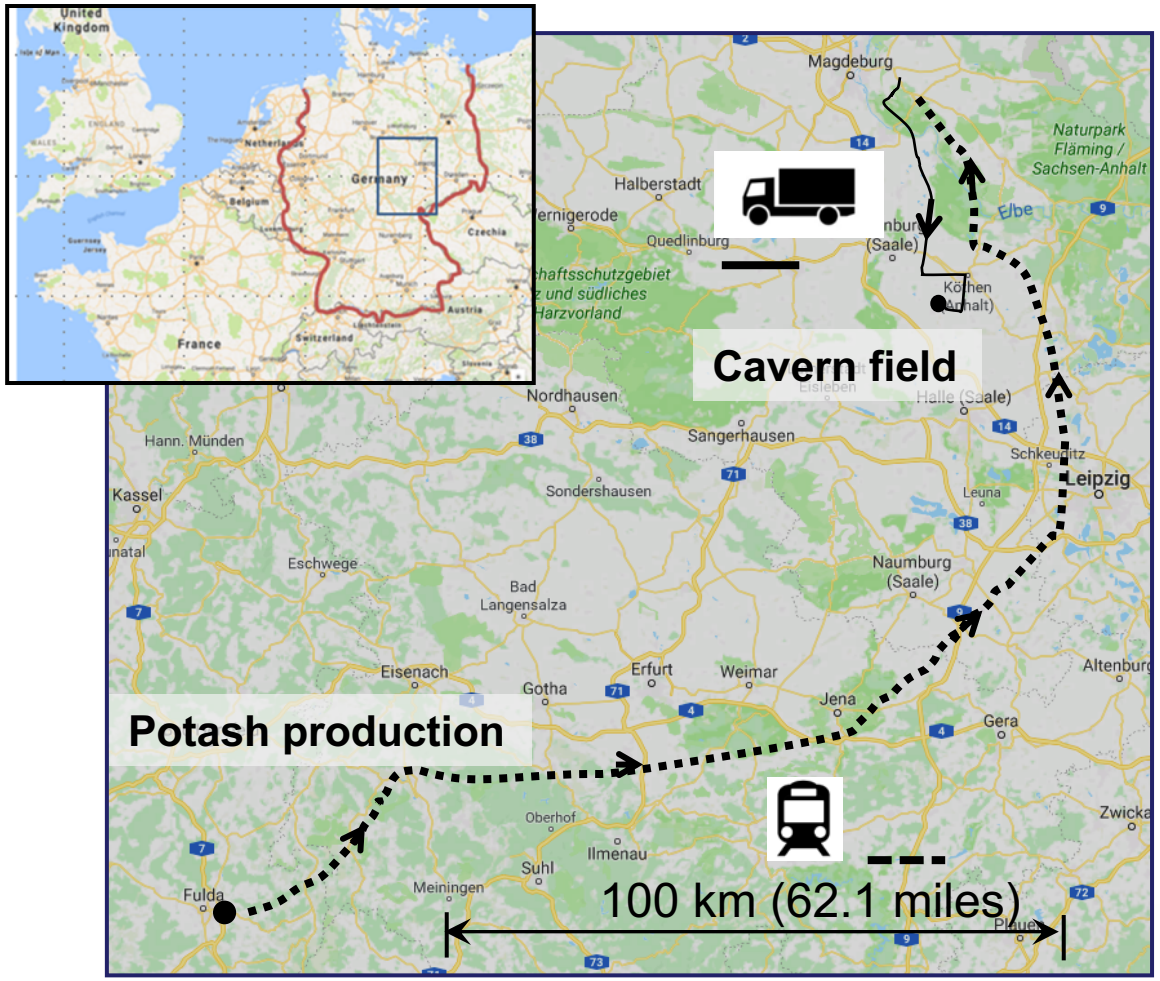
Project

- Potash production in Hessen
- Transport by train and trucks to Saxony-Anhalt
- Unload into brine production facility in Bernburg
- Flooding of salt cavern, formerly used as gas storage



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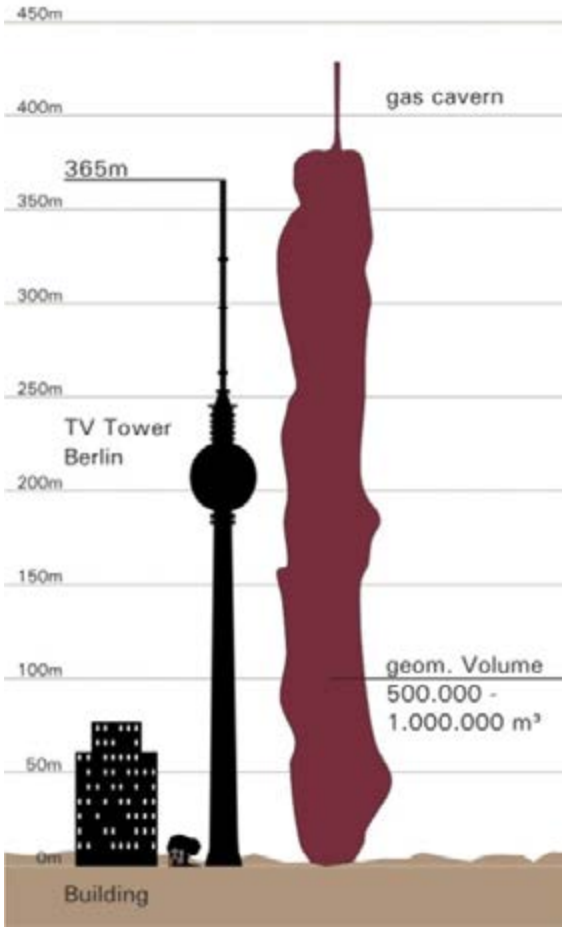
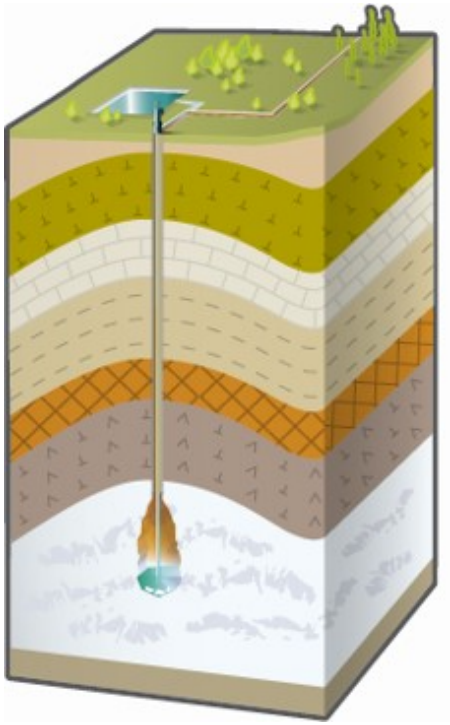
Cavern

- Caverns are artificially leached underground structures, tight and provide safe containment

- Rock salt formation

- facts:
  - Solution Mining: 1960
  - Gas (LPG) Caverns: 1969
  - 244 caverns in Germany, Storage of more than half of yearly consumption of gas of Germany





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Cavern Data (Project)

- Casing shoe: 520 m (1706 ft.) depth
- Cavern pressure: up to 100 bar (1.450 psi)
- Volume: 250.000 m³ (1.57 Mio bbl.)

Salt production: 0.5 Mio t = 2 Mio m³ brine

Gas storage: 22 Mio m³ of working gas

Contour of typical project cavern

Partners and Aims

Partner		Aims
• Potash producer	K+S	• Source of $MgCl_2$, Reducing of discharge
• Cavern construction and brine production (Solution Mining in Bernburg)	esco european salt company	• Operation of truck unloading and transport of brine to cavern
• Cavern use for natural gas storage (Gas Storage Operator in Bernburg)	VNG Gasspeicher	• Use of cavern discontinued due to geomechanical wear, Operation of flooding

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Lifetime of a Cavern

1. Solution Mining

Brine

Project Idea: volume for storage of not useable brine instead of weak brine/water

Natural gas

Drilling

2. Gas Storage

Flooding of Cavern

Long-term safe abandonment

Water

Natural gas

3. Brine not useable

5 years

up to 40 years

1 year

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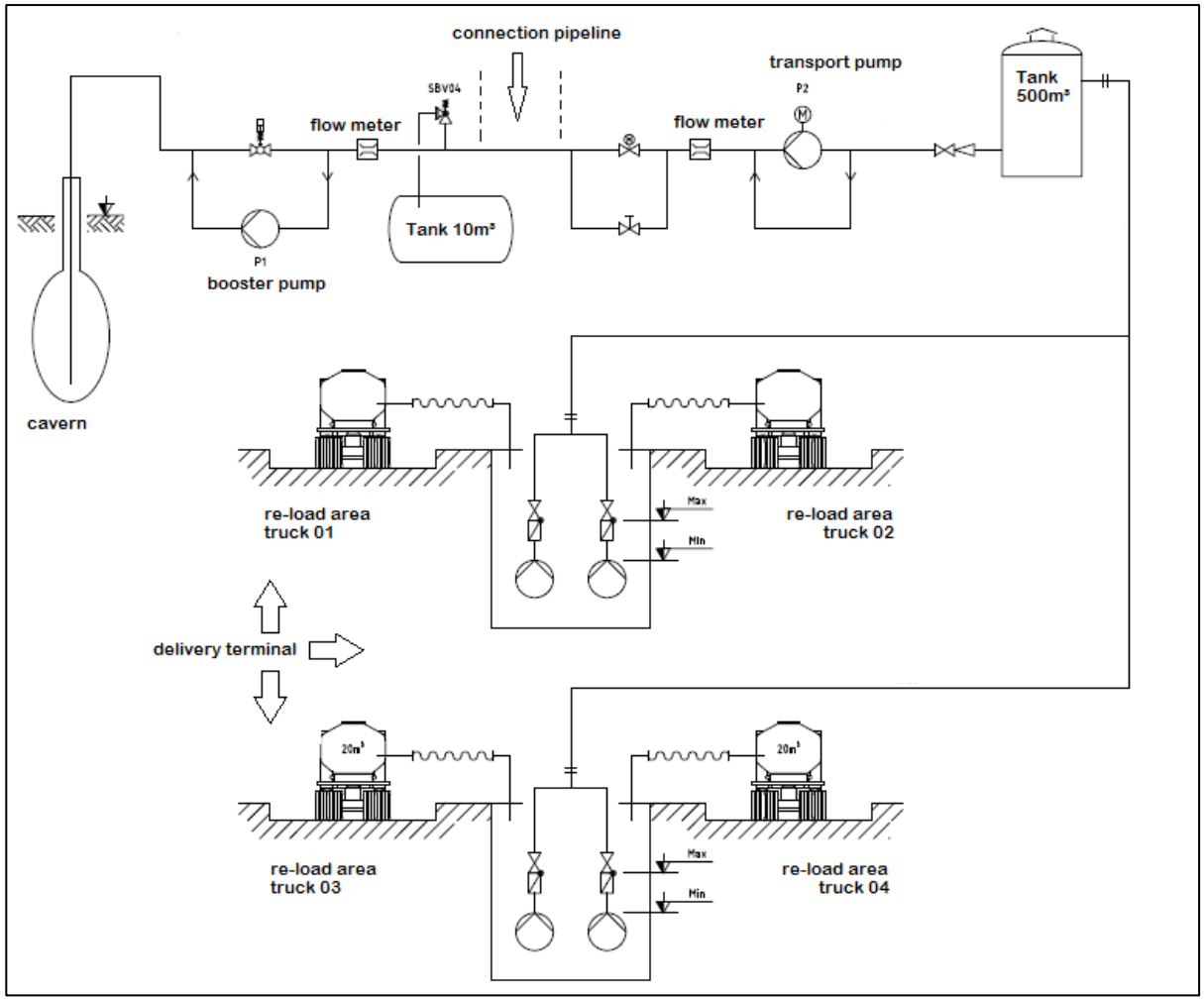
Surface Installation



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Main Data

Transport

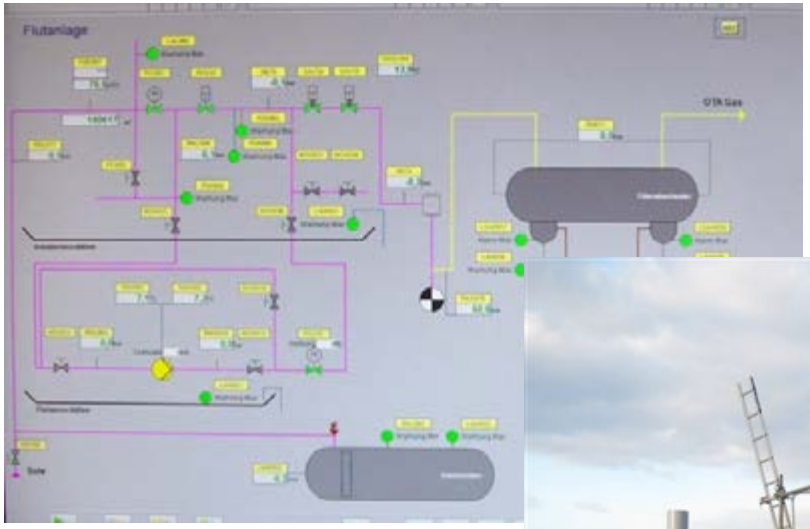
- One train per day = 64 containers

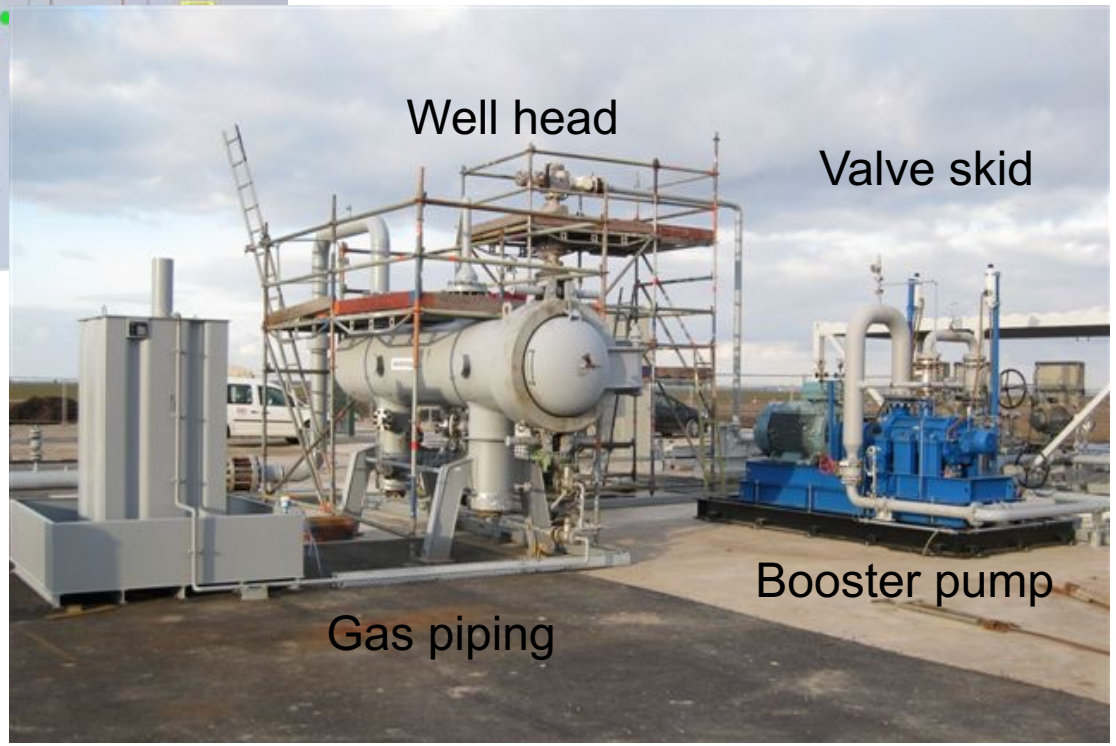
- 30-85 trucks are off-loaded per day container 24 m³ (6340 gal)

Flooding

- Flooding rate: 0 - 100 m³/h
- Average rate: incl. interruptions 43 m³/h (11359 gal/h)
- Time of Flooding: 7 - 8 months

Surface Installation – Cavern Site





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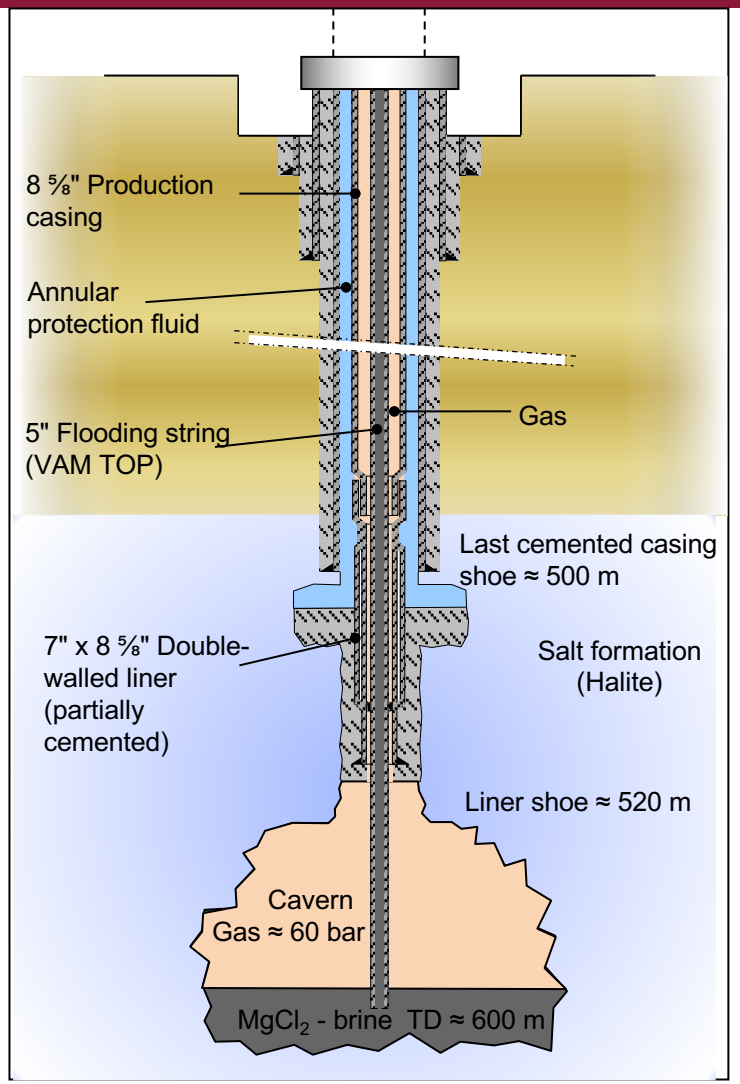
Subsurface Installation

- 5“-flooding-string reaches down to the sump
- higher corrosion rate of $MgCl_2$-brine compared to that of NaCl-brine
- Connectors are welded and gastight (two barriers)



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Brine

- Interaction between several types of brine
- Crystallization in surface equipment and subsurface
- Brine delivered: 10-30 °C (50-86 F)
  Undisturbed rock temperature:
  23 °C (73.4 F)
- Higher density of $MgCl_2$ was investigated by geomechanical study, density of NaCl ≈1.2 t/m³ (10.01 lb/gal)

Delivered brine	Typical load high $MgCl_2$ g/l
KCl	60
$MgCl_2$	270
$MgSO_4$	50
NaCl	40
Density	≈1.3 t/m³ (10.85 lb/gal)

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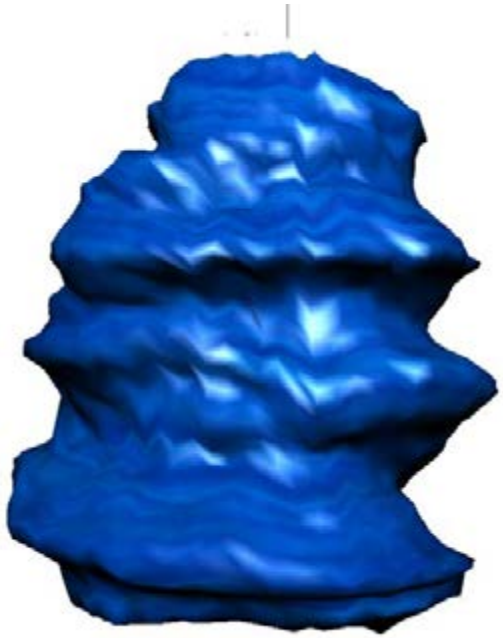
Subsurface Aspects

- After-effects due to crystallization and contour changes due to solution processes
  ⇒ on a negligible level

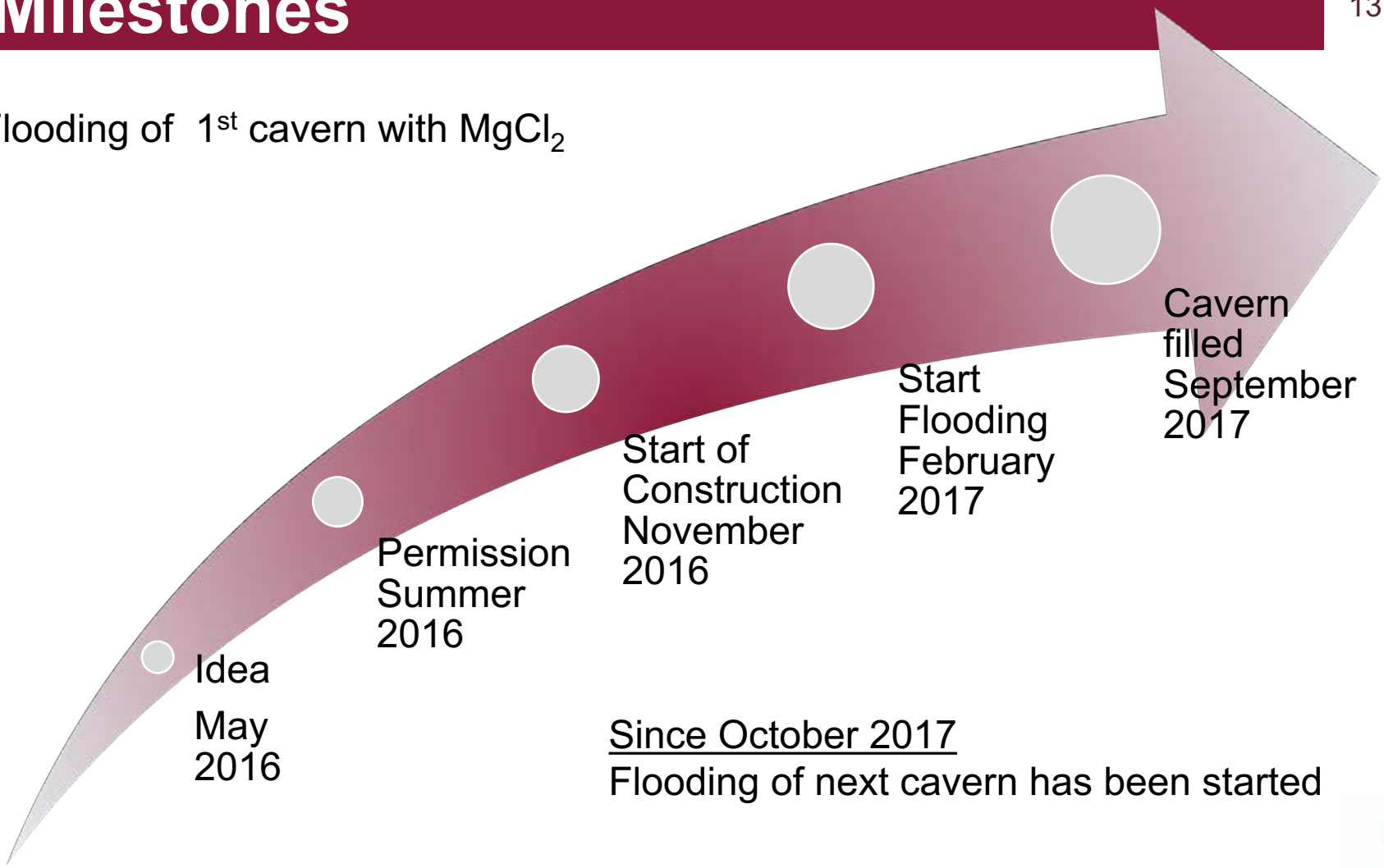
- Higher density of the $MgCl_2$-brine results in a higher internal pressure
  ⇒ counteracts the cavern convergence in the long term

- Warmer brine from potash production
  ⇒ time until temperature equalization in the cavern shorter



Milestones

Flooding of 1st cavern with $MgCl_2$



Since October 2017
Flooding of next cavern has been started

Summary

- Environmentally friendly technical solution
- Win-win-project for all partners
- Pull together:
  Example for cooperation of salt and potash producers and gas storage company

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Thanks

To Project partners:

Thanks to:

WORLD SALT SYMPOSIUM

Thank you for your attention!

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