Literature assessment

Salt caverns for gas storage / Numerical modelling

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1 Talk to Hassan Abadi (profile)

He mentioned a sponsor: RESPEC website

- Impact of the cycles in stability
- Low energy density of the caverns (H_2)
- MIT - Mechanical Integrity Test (using N_2)

2 [Goulart et al., 2020] Technology readiness assessment of ultra-deep salt caverns for carbon capture and storage in Brazil

Paper funded by FAPESP RCGI (Research center for gas innovation - link). Founder sponsors: Shell and Fapesp. One of the authors is Alvaro Maia, a ex-Senior Consultant in Petrobras (well drilling, geomechanics).

They study caverns of up to 150x450m, created by dissolution, with geomechanical simulations.

- Well is the critical element of an underground storage system, special attention to the cement.
- May store 4 billion Sm^3
- Used simulator COVES, developped by Alvaro Maia in the 1980s (See [Costa, 1984])

See also: [Abreu et al., 2023]

3 [Caglayan et al., 2020]Technical potential of salt caverns for hydrogen storage in Europe

4 [Li et al., 2021] Investigation of thermal-mechanical effects on salt cavern during cycling loading

Thermo-dependent salt creep. Thermo mechanical simulation. Pressure cycles, collapse and tensile fractures.

5 [Coarita-Tintaya et al., 2023] Hydromechanical modelling of salt caverns subjected to cyclic hydrogen injection and withdrawal

2D models, to consder cyclic loading, with fundamental creep and plasticity. Storage depths varying from 350 to 1350m. They claim the deeper is more mechanically unstable. They find the caverns are feasible.

Regarding formation of hydrogen plume (I could not completely understand the physics yet):

> In addition to the hydromechanical modelling, an analysis of the hydrogen extent within the rock mass is carried out. Since water and hydrogen are immiscible, we assume hereafter that the threshold capillary pressure of rock salt is much higher than hydrogen pressure within the cavern due to the nanometric size of pore throats and hence no free gas phase will be flowing. Assuming hydrogen is a non-reactive solute (no chemical reaction or sorption with salt), we use the following mass transport equation to delineate the extent and mass of dissolved hydrogen plume. Transport of dissolved H2 is only driven by advection (Darcy's law) and by diffusion, since mechanical dispersion is negligible due to the low permeability of the porous medium.

6 [Zhao et al., 2022] Feasibility analysis of salt cavern gas storage in extremely deep formation: A case study in China

7 Goals of the caverns

7.1 Energy storage

- Regulate variations between renewable energy production and peak power demands ([Coarita-Tintaya et al., 2023])

7.2 Disposal

8 The physics

I see huge concern with geomechanical behavior, targeted to creep, collapse and tensile fracturing. The cyclic behavior of the pressure is a significant difference compared to oil drainage and waterflooding.

- Geomechanics: creep, thermal, tensile fracture, shear fractures
- Chemical: dissolution
- Cyclic operations
- Temperature dependent creep
- Plume extension (H_2 dissolved in water)

References

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