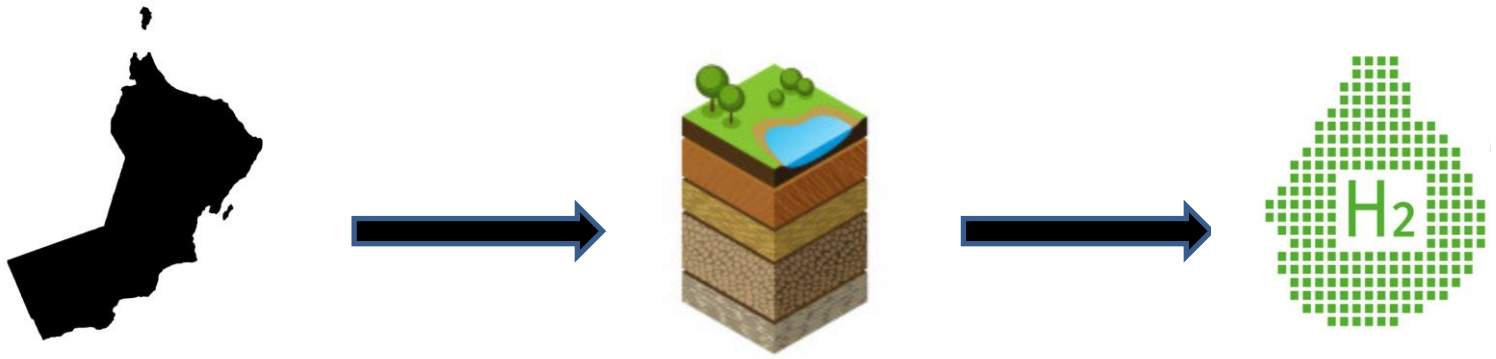
Comprehensive Assessment for Underground Hydrogen Storage in Oman



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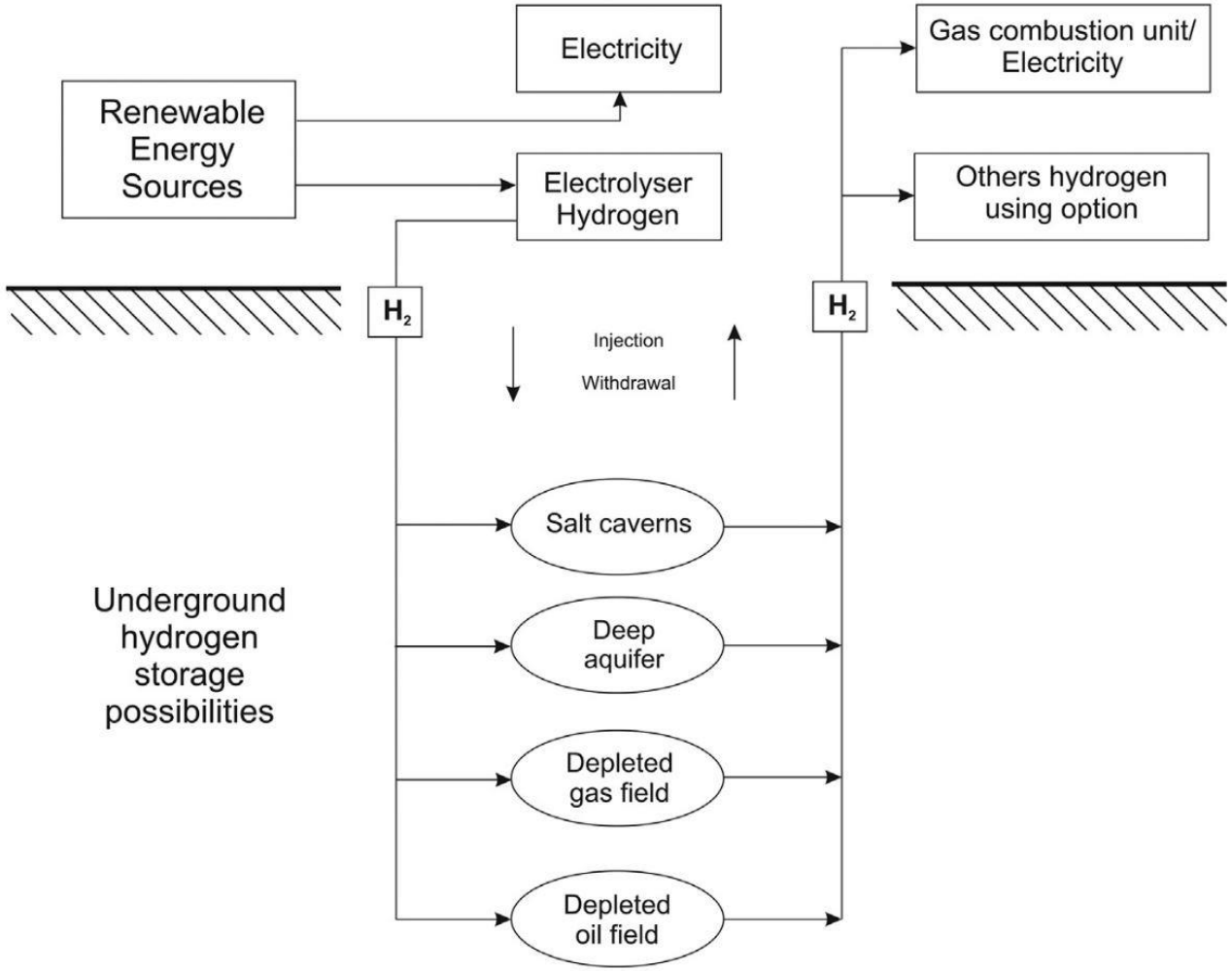
Outline

- Research Objective
- Technical background on underground hydrogen storage (UHS)
- Methodology
- Discussion
- Result
- References

Research Objective

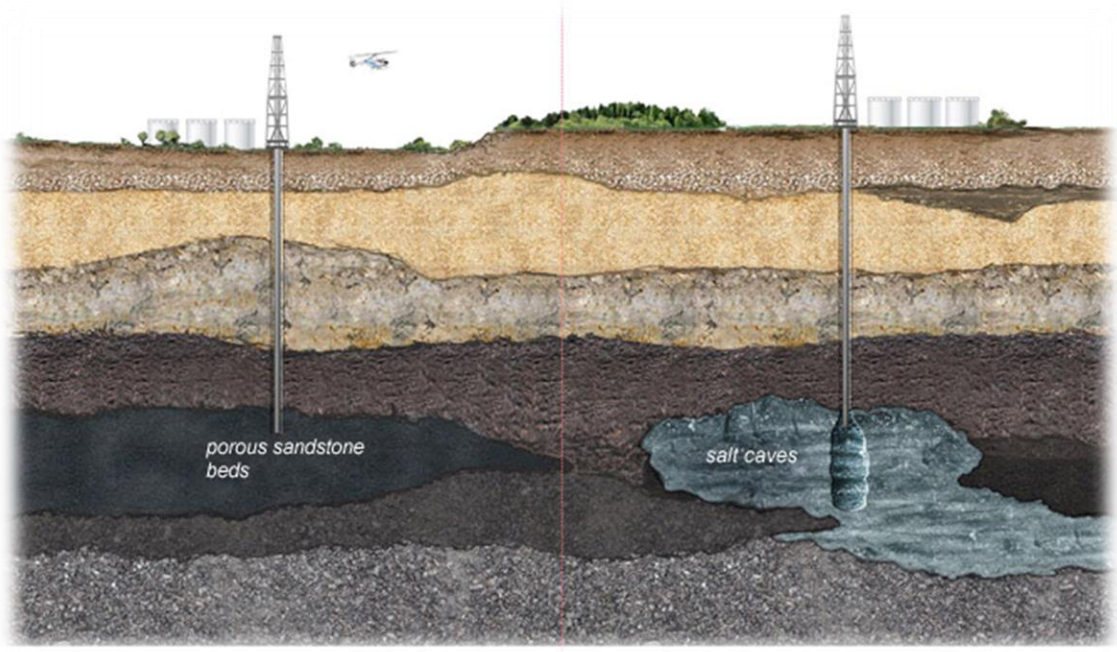
- Identify geological deposit in Oman that can be used for hydrogen storage
- Analyze and screening salt deposits for hydrogen storage suitability
- Propose salt cavern design for salt leaching

Technical background on underground hydrogen storage



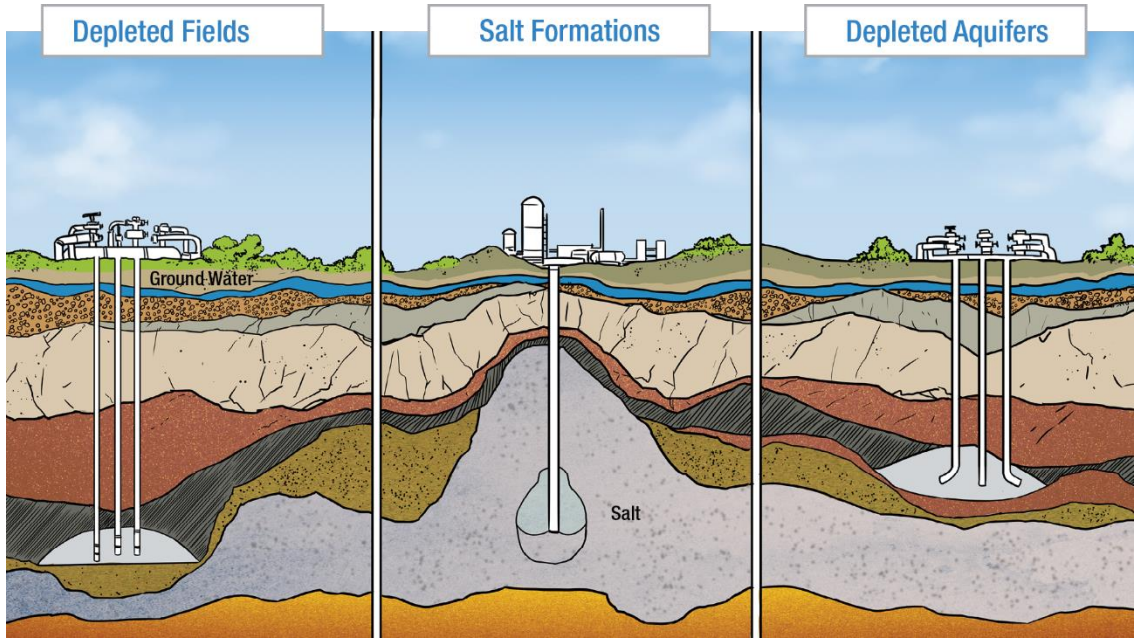
Depleted Oil /Gas Reservoir

- Geological conditions are well known
- Surface facility and subsurface data are available
- More technical development for hydrogen adaptability
- No prior experience for hydrogen storage

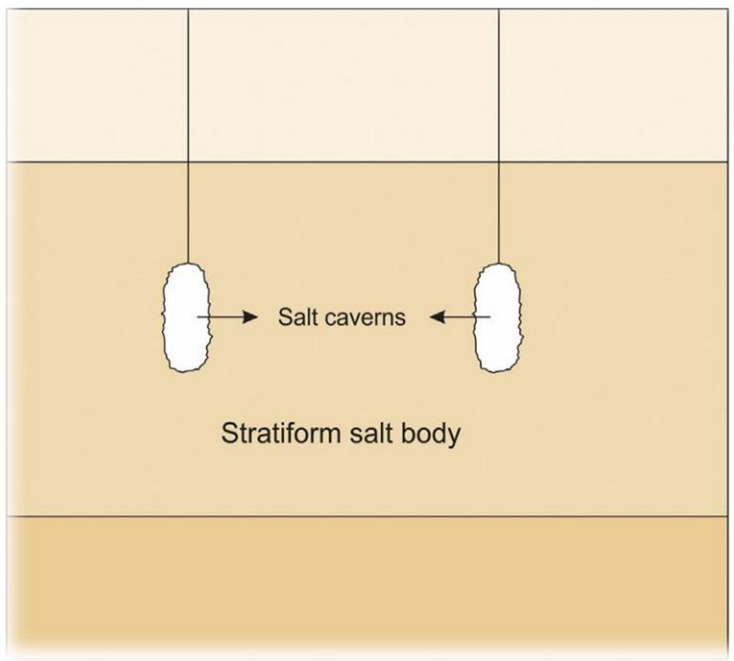


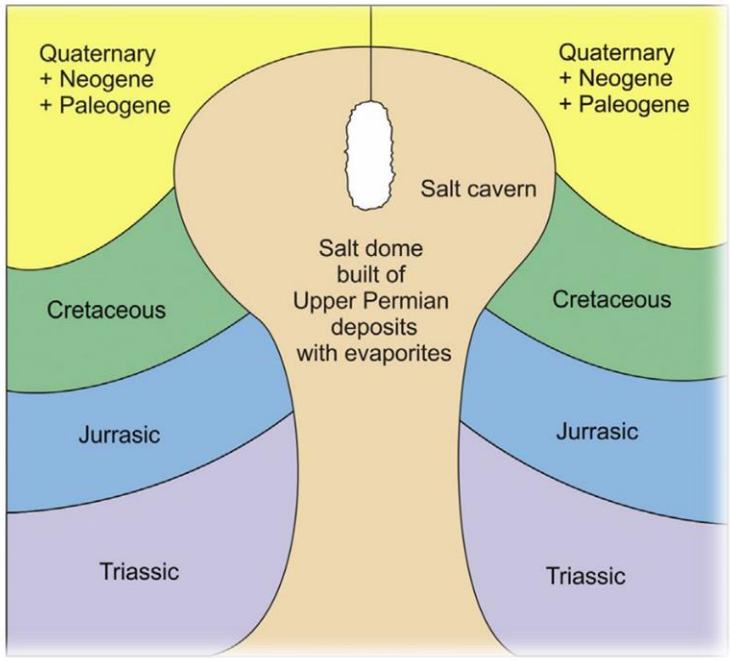
Deep Aquifer

- Optimal depth at ~ 2000m
- Characterized with high porosity and permeability
- Main two parameters : Good sealing and good reservoir conditions
- No prior experience for hydrogen storage



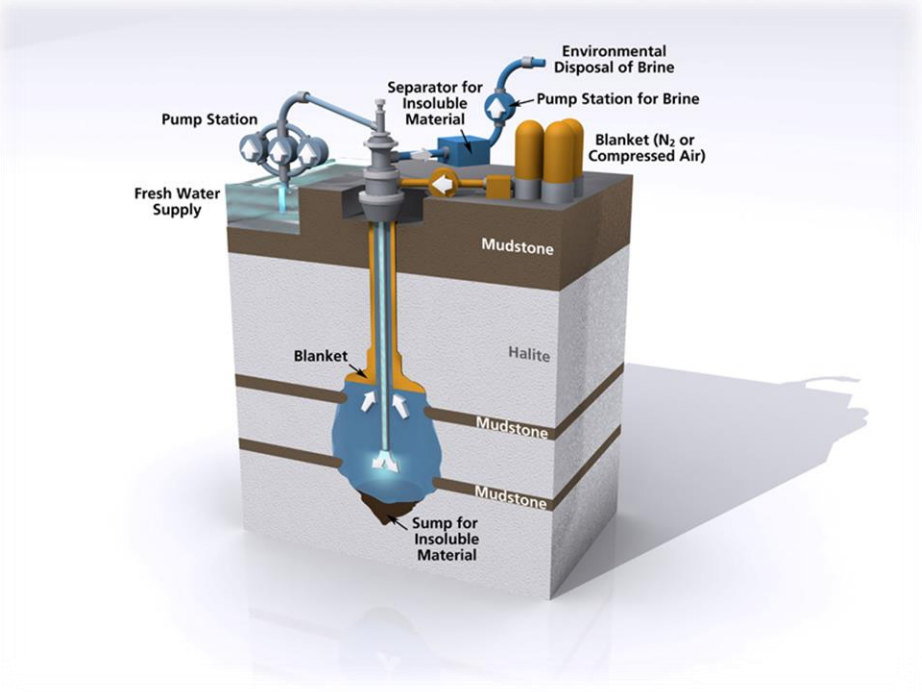
Salt deposits





Salt Cavern

- An artificial chamber created for storing purpose
- Salt low permeability, self-healing properties and resistivity for chemical reactions with the stored gas
- This type of storage has been done before in UK and USA for hydrogen storage



Existing hydrogen storage cavern

	Clemens (USA)	Moss Bluff (USA)	Teesside (UK)
Geology	Domal salt	Domal salt	Bedded salt
Operator	Conoco Phillips	Praxair	Sabic Petroleum
Stored fluid	Hydrogen	Hydrogen	Hydrogen
Commissioned [year]	1983	2007	~1972
Volume [m^3]	580,000	566,000	$3 \times 70{,}000$
Reference depth [m]	930	> 822	350
Pressure range [bar]	70–135	55–152	~45
Possible working gas capacity H_2 Mio [kg]	2,56	3,72	0,83

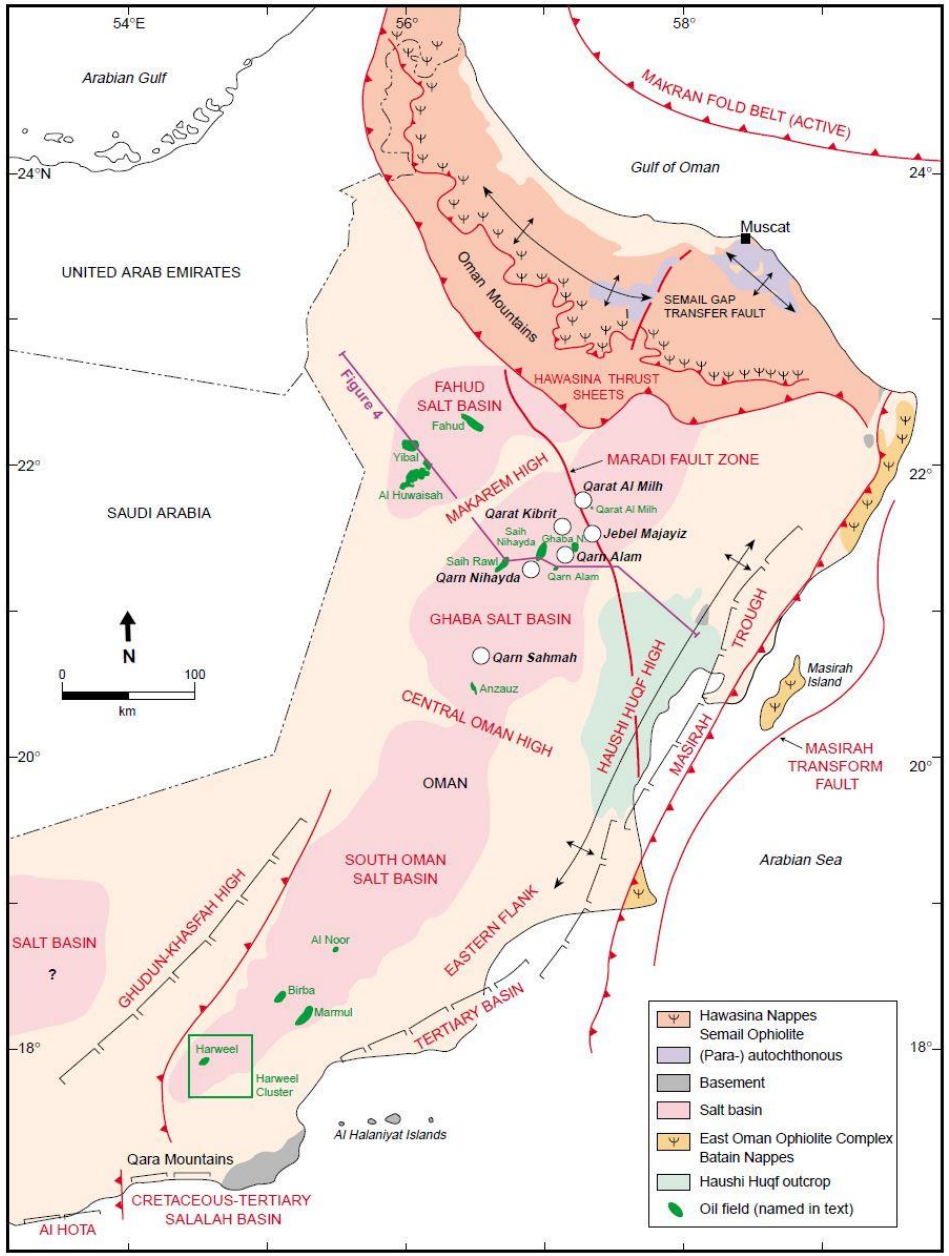
Summary

Technical specification	Deep aquifers	Depleted Oil/Gas	Salt caverns
Abundance	Appears mostly in sedimentary basins	Hydrocarbon accumulations zones	Salt basins in Oman
Estimated capacity	Very high	Very high to high	High. It can increase if more than one cavern were built
Experience	No prior experience	No prior experience	Good experience in USA and UK
Injection and production intervals	One, maximum two cycle per year	One, maximum two cycle per year	Up to 10 cycles per year
Bore holes per cavern	Few boreholes	Few boreholes	One bore hole
Storage use	Seasonal storage	Seasonal storage	Possible use for more than seasonal
Research fields	Leakage, reacting with the surrounding environment,	Reservoir pressure, biological and chemical reactions	Cavern convergence, periodic monitoring for salt shaping

Methodology

- Salt dome depth needs to be more than 1 km (for Safety purpose and proper designing)
- Surface piercing salt dome are the best since they are easier to site
- Larger size/area of salt dome helps to build more than one cavern

Oman's Geology



Discussion

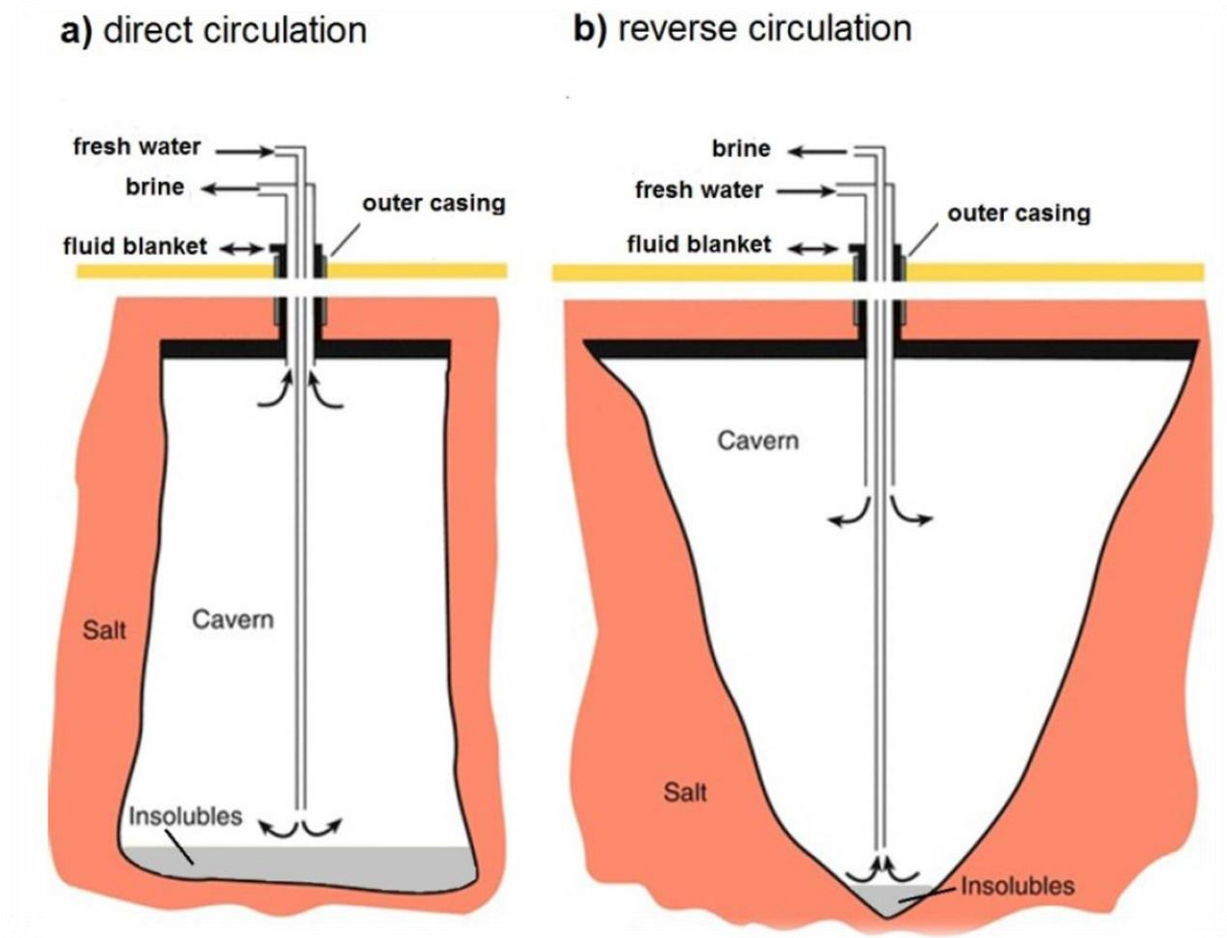
- Two salt domes shows good potential for underground storage
- Qarn Alam and Qarn Shamah
- The size of the other domes is relatively small

Salt Dome	Size (Surface Area)	Depth (Centroid)
Qarn Alam	1 x 6 km	10 km
Qarat Al Milh	0.5 X0.4 km	2.5 km
Qarn Shamah	2.8 X 2.5 km	3 km
Qarat Al Kibrit	0.7 X 0.5 km	15 km
Qarn Majayiz	3 X 1.4 km	Unknown
Qarn Nihidya	2.8 X 1.6 km	3 km

Salt Cavern Shaping

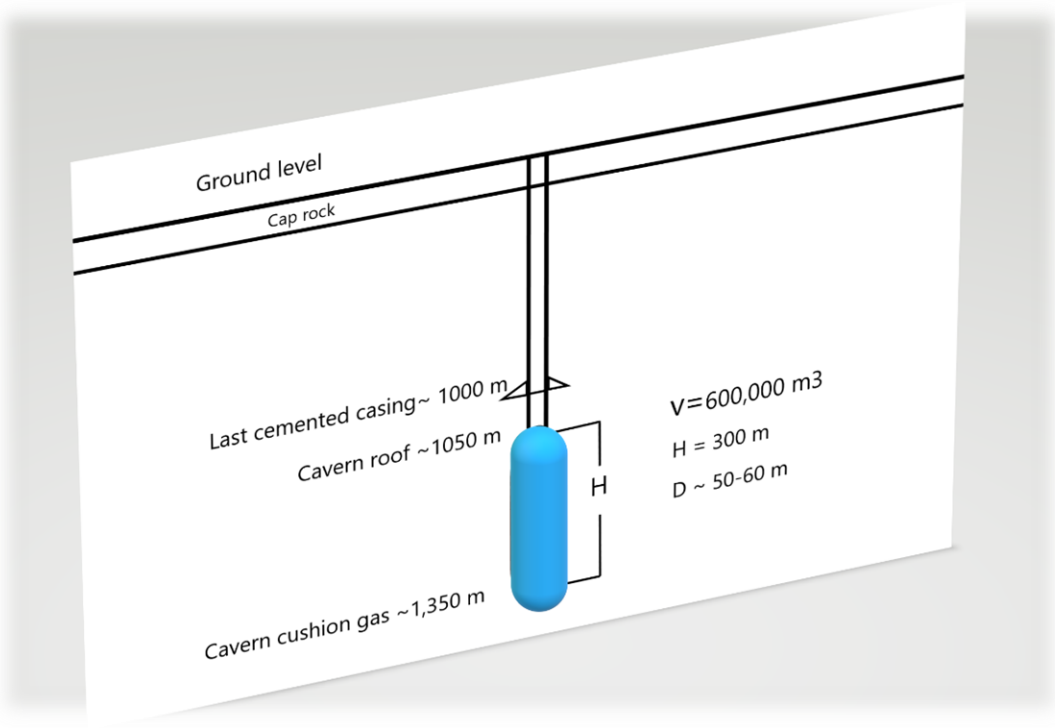
- Salt caverns are created in five phases

1. Initial phase
2. Leaching phase
3. Debrining phase
4. First filling phase
5. Cyclic loading phase



Results

- Single salt cavern can store up to 0.1 TWh of energy
- Estimated working gas of 40.8× 10^6 Kg of hydrogen
- Many factors are controlling the shape and dimensions of the cavern



* Proposed cavern design for Qarn Alam

Future work

- Hydrogen stored quantity will depend to large extent on the project aims on which energy system it will be used for .i.e. consumption, conversion, export.
- Detailed risk assessment and economic analysis for underground hydrogen storage.
- More advanced geotechnical study by modelling thermodynamic and mechanical properties of the salt dome.

References

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Potential of Underground Hydrogen Storage in Oman

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Multi-Criteria Evaluation of Large-Scale Hydrogen Storage Technologies in Oman using the Analytic Hierarchy Process

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