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Overview of salt caverns and solution mining

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Summary

The current global political landscape and the resulting energy security crisis for countries reliant on natural gas and crude oil imports have underscored the critical importance of storage capacity for strategic hydrocarbon resources. Among various storage solutions, underground storage in salt caverns plays a particularly vital role due to the scalability, cost-effectiveness, and safety of salt caverns. While previously a topic of interest primarily for specialists, the underground storage of hydrocarbons, as well as novel applications such as CAES and hydrogen storage, has now become widely recognized and frequently discussed in the media.

Originally, salt caverns were created as empty cavities left behind after solution-mining rock salt through boreholes. Today, brine is commonly a by-product of the salt leaching process, with the primary objective being the creation of salt caverns. These caverns are utilized for storing both liquid and gaseous hydrocarbons, as well as for industrial waste disposal, energy storage via compressed air, and carbon dioxide sequestration. Recently, global research efforts have intensified to explore the feasibility of hydrogen storage within these formations.

Salt caverns can be emplaced in tabular salt deposits, salt diapirs, or even thin salt beds (Figure 1) (BGS 2008), with their shape, size, and construction methods tailored to local geological conditions and investor requirements. The cavern construction process involves dissolving salt rock with leaching media such as freshwater, wastewater, brackish water, or seawater. Two hanging string columns are installed within the last cemented casing to facilitate the simultaneous injection of leaching media and extraction of brine (Warren 2016). The annular space between the casing and the outer string is used for injecting an insulating medium. The leaching process is meticulously controlled by adjusting the depth of the hanging string shoes, modifying brine circulation, and repositioning the cavern roof (Figure 2). The development of the cavern is monitored through calculations of extracted salt and periodic echometric measurements.

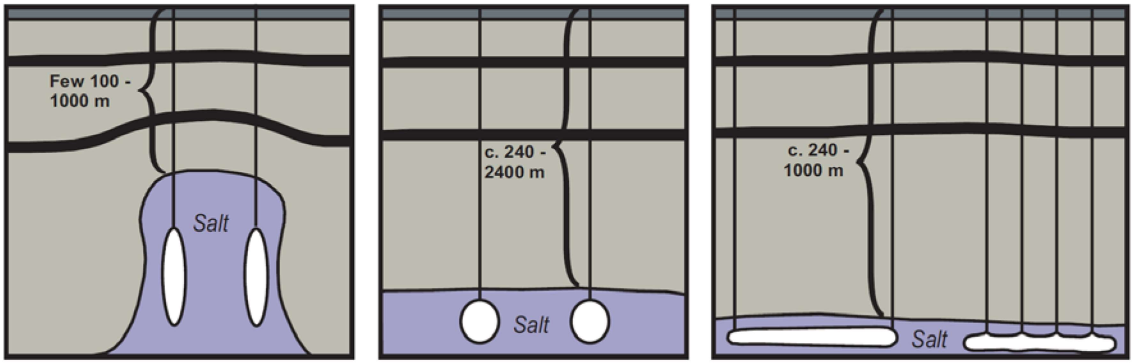

Figure 1. Salt caverns in different salt deposits (BGS, 2008)

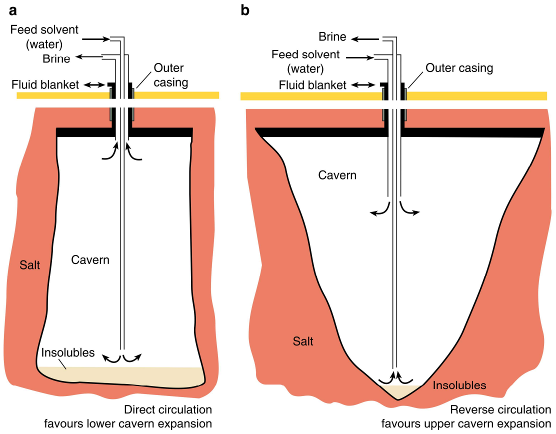

Figure 2. The solution mining process. a – direct brine circulation, b- reverse brine circulation (Warren 2016)

Most salt caverns feature a single access point. However, multi-entrance caverns with two or three access points are created. Additional wells can be either drilled before mining begins or by adding extra wells to existing caverns. Multi-entry caverns can be also created by merging single-entrance caverns. The operational approach for salt caverns varies depending on their intended use and operator requirements. Generally, gas storage caverns function based on gas compression, while liquid storage caverns utilize brine as a displacement medium.

With over 80 years of operational history, salt caverns have proven to be among the safest, most efficient, and economically viable methods for storing hydrocarbons and managing hazardous waste, reinforcing their significance in global energy security and environmental sustainability.

References

British Geological Survey (BGS) (2008): Underground storage. Mineral Planning Factsheet, 22 p.
Warren J. K., 2016. Evaporites A Geological Compendium, Second Edition, Springer, 1307 p.