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Geomechanical Stability of Solution Mined Caverns Near Salt Dome Edges, Including Influence of External Reservoir Depletion

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Abstract

Due to uncertainty in the precise location and character of salt dome lateral edges, solution mining operations occasionally create caverns closer to the edge of salt than anticipated. The risk for instability of such caverns can become significant when the salt wall thickness (distance between outer cavern diameter and outer edge of salt dome) becomes less than the average cavern radius. That is because vertical stresses in the thin salt wall increase while horizontal stresses decrease, leading to potential shear damage. A complicating factor may be introduced if there are soft and high permeability sands immediately outside the salt dome, and particularly if such sands experience pressure depletion through oil or gas production.

These issues may be investigated and described through analytical and 3D geomechanical simulations. In this paper we first describe the theoretical background and geomechanical processes involved, with illustrative elastic and creep model simulations. We present sample 3D geomechanical simulations for a range of scenarios in which cavern size and proximity to salt edge are varied. In general cavern stability risks increase with decreasing salt wall thickness, with increasing cavern size, and with increasing cavern depth.

We also present simulation scenarios in which external pressure depletion may be present, for a range of reservoir thicknesses and locations relative to the cavern level. In general, the influence of such depletion increases with reservoir thickness and with proximity to salt dome edge. Reservoir depletion stress effects decrease rapidly with lateral and vertical distance from the reservoir edge, and decrease within the salt wall over time due to creep deformation. The influence becomes insignificant if the pressure depletion zone is relatively thin or not located immediately adjacent to the thinnest and most critically stressed sections of the salt wall.

Key words: cavern stability, salt domes, salt caverns, reservoir depletion, numerical modeling.