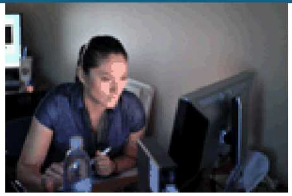
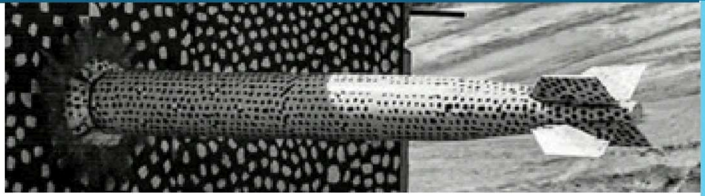
SAND2019-6974C

Geomechanical Evaluation of the Stability of the Caprock Roof and Salt Boundary of an Abandoned Cavern in Salt Dome





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PRESENTED BY

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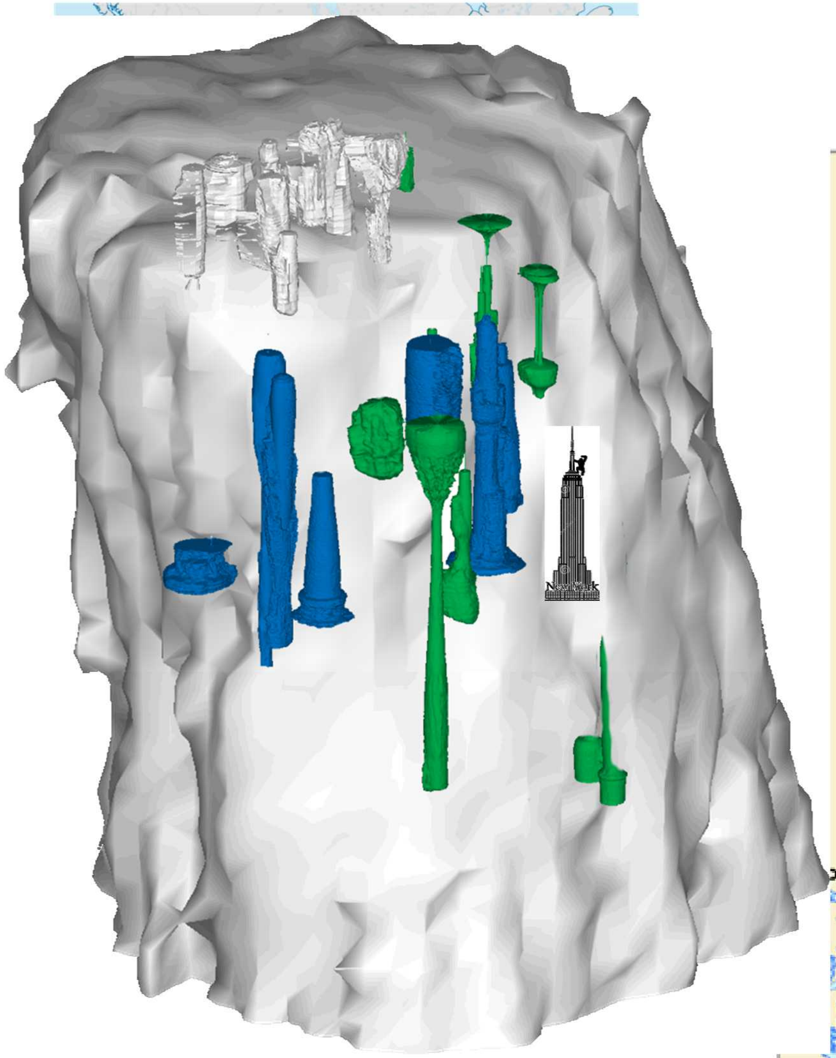
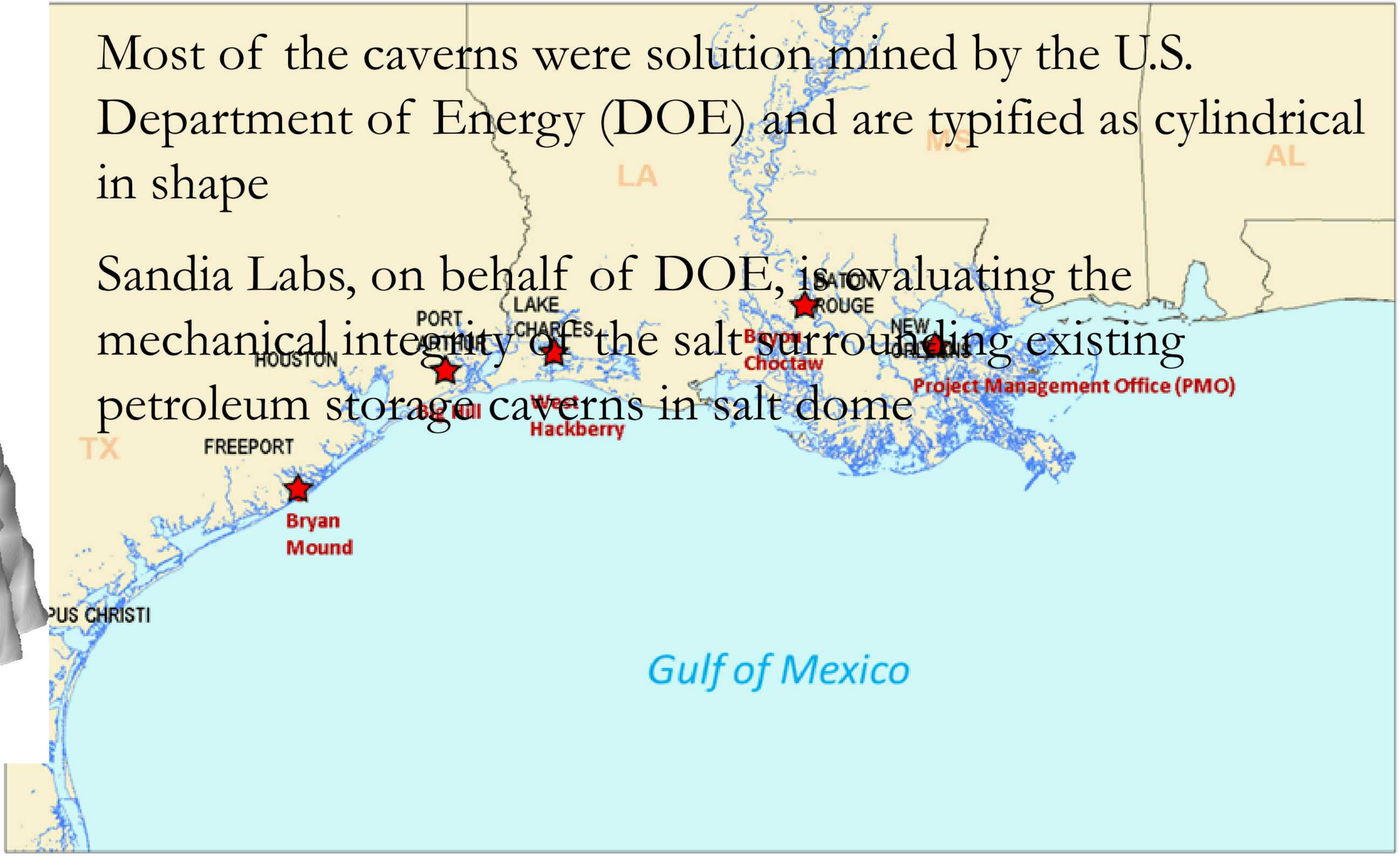
SPR



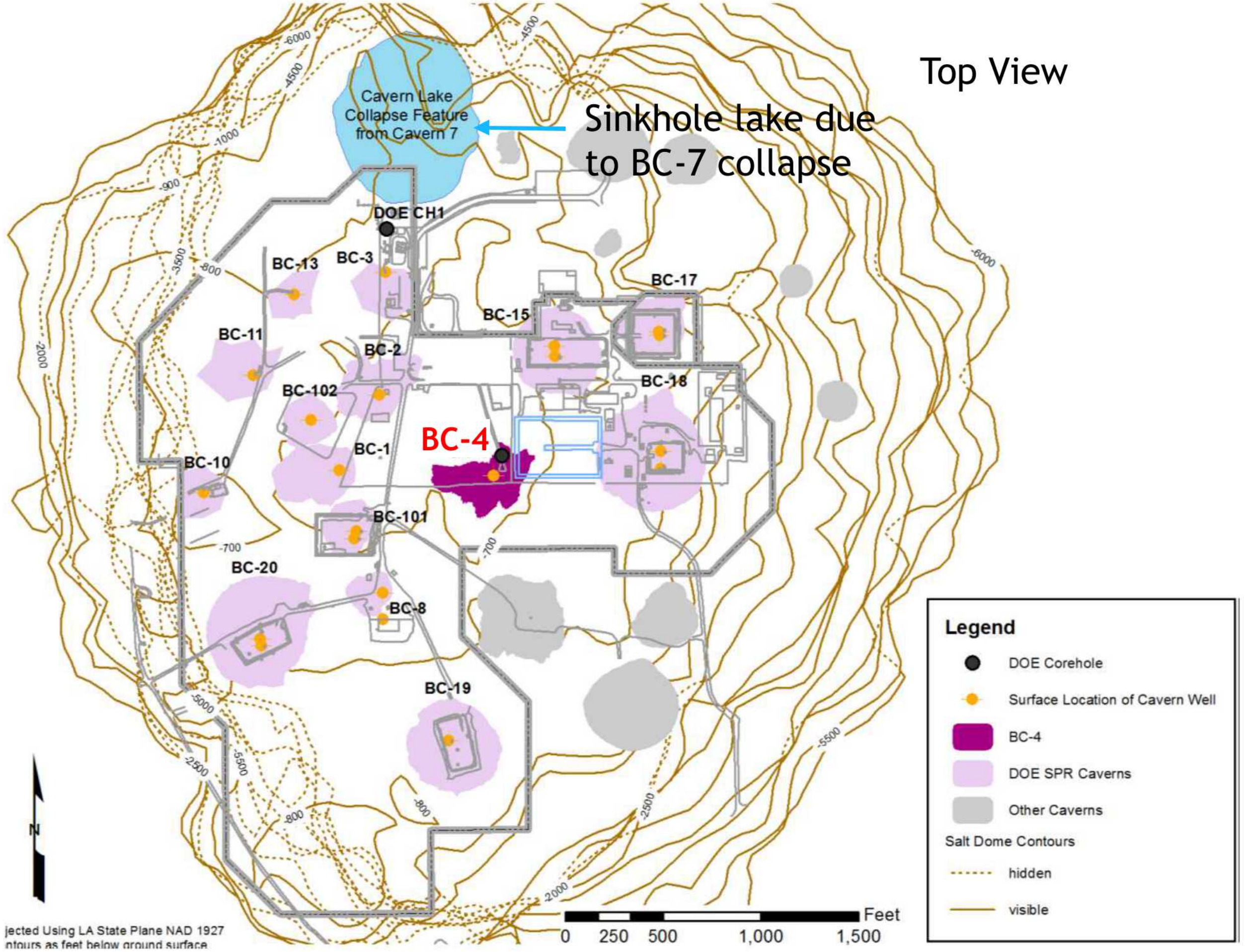
The U.S. Strategic Petroleum Reserve (SPR) stores crude oil in 60 caverns at four sites located along the Gulf Coast

Most of the caverns were solution mined by the U.S. Department of Energy (DOE) and are typified as cylindrical in shape

Sandia Labs, on behalf of DOE, is evaluating the mechanical integrity of the salt surrounding existing petroleum storage caverns in salt dome



Location of BC-4



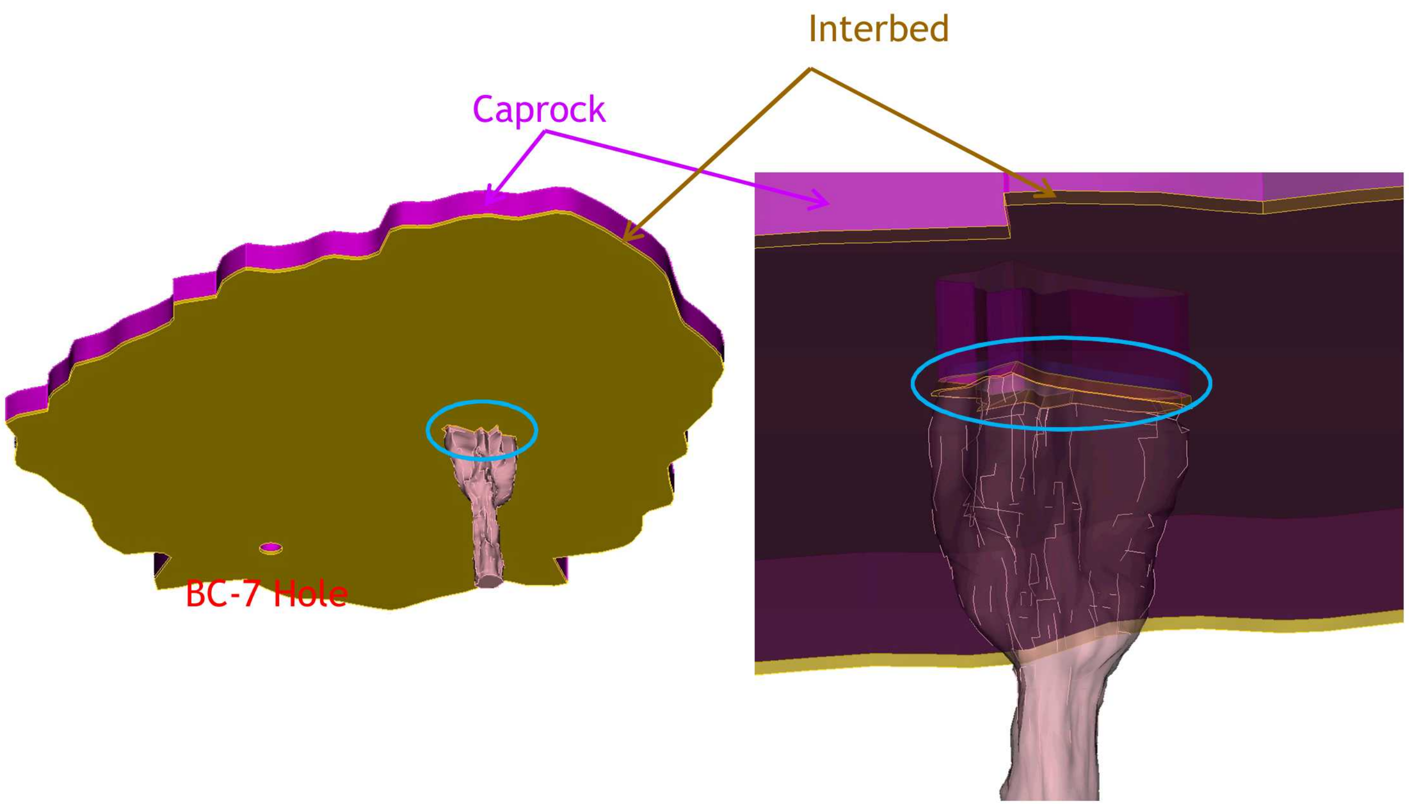
BC-4 is located at the center of the dome

The blue area indicates the sinkhole lake due to BC-7 collapse.

BC-4 was originally drilled for brine production in 1935 and was abandoned in 1954 following the collapse of the nearby Cavern 7

BC-7 was drilled for the brine production in 1942, but collapsed in 1954 because the cavern pressure was lost when the cavern roof was leached to the caprock bottom

BC-4 and Caprock Roof



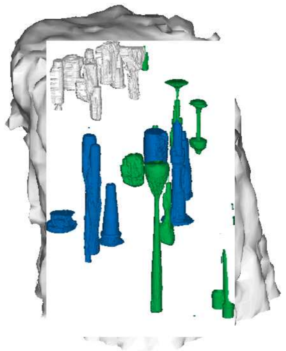
BC-4 is leached through three lithological layers, i.e. the caprock, interbed and salt layers

BC-4 roof intrudes into the caprock

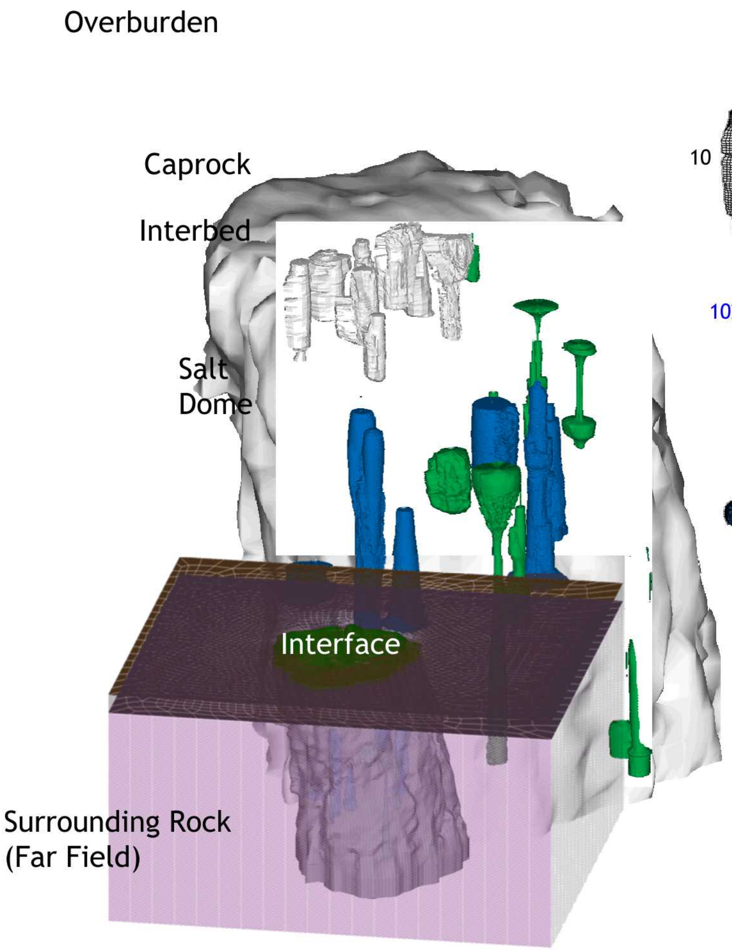
BC-4 is currently filled with brine and will not hold pressure at the wellhead

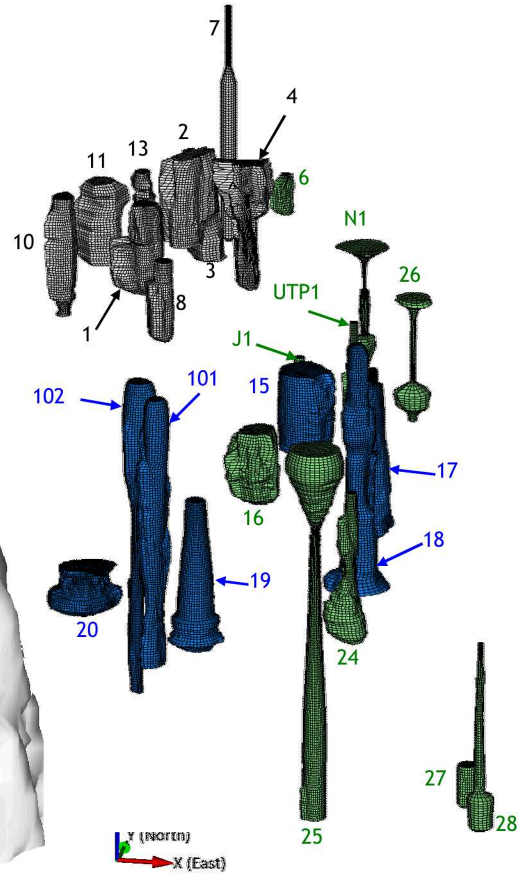
BC-4 stability has been the object of continuing concern because of its geologic similarity to collapsed BC-7

FE Model Capturing Realistic Geometries



Images of salt dome and caverns obtained from the seismic and sonar surveys, respectively



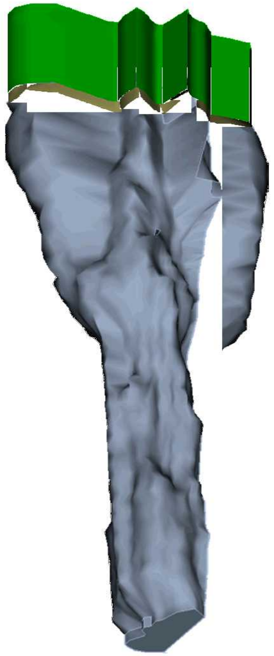


3D salt dome and caverns images based on the seismic and sonar survey data

U.S. Strategic Petroleum Reserve stores crude oil in the seven blue caverns

Green shows privately owned caverns, and grey depicts abandoned caverns

BC-4 with Extra Skin and Caprock Roof



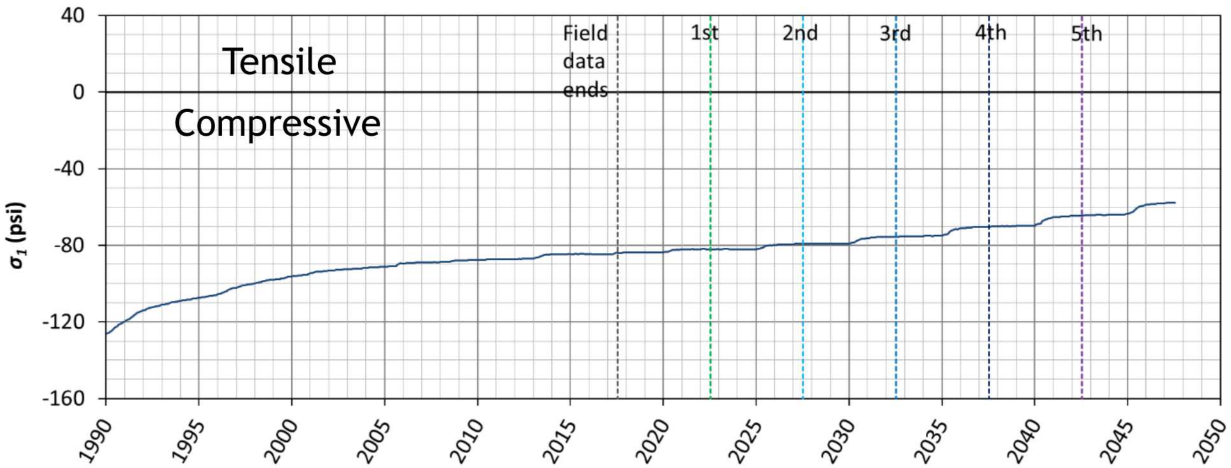
BC-4 cavern cavity with caprock roof along with a surrounding interbed skin and salt skin layer used in the geomechanical model

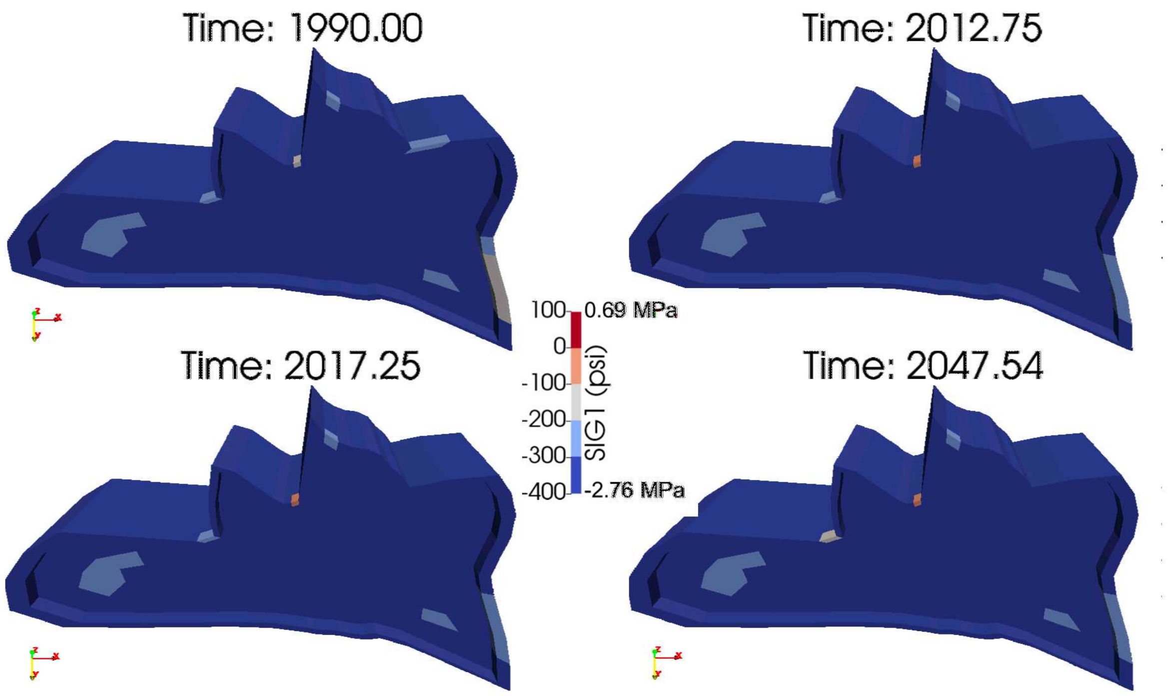
Based on the sonar data surveyed in 2003

The cavern height and volume are approximately 317 m and 994,442 m^3, respectively

These geometries are used to create the finite element mesh for the calculations

Caprock Roof of BC-4





Predicted maximum σ_1 over time

Contour plots on specific dates in the caprock roof of BC-4

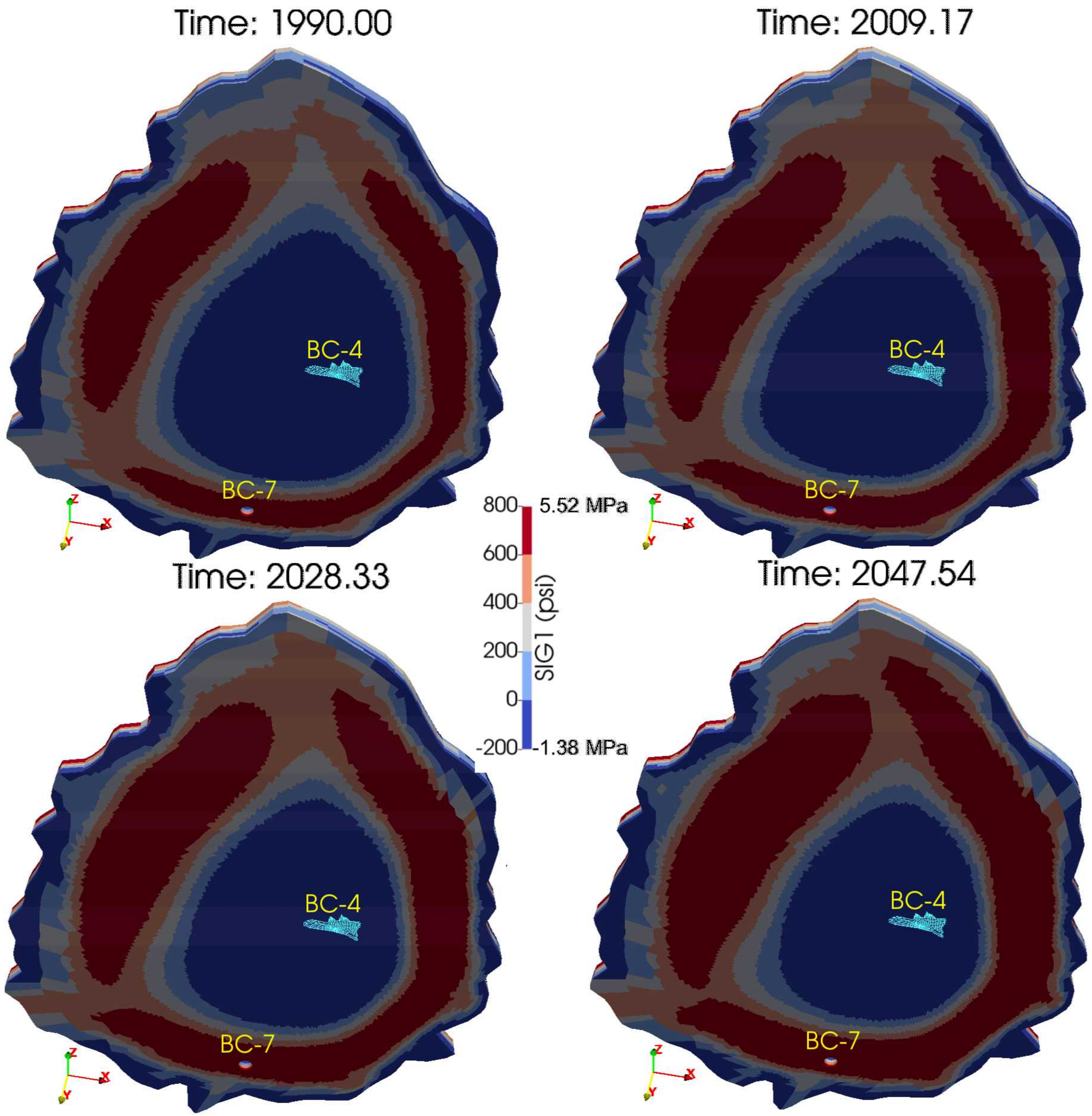
The caprock roof is predicted to be in compression states ($\sigma_1 < 0$) until the simulation ends (7/17/2047)

However, the σ_1 tends to increase toward zero

Potential for tensile failure may not exist until 2047 in the roof, but could be structurally unstable long time after

The structurally weakest area is located at the middle of the M shape of the south side of the roof

Comparison of BC-4 with BC-7



Contour plots of σ_1 on the base of the caprock predicted for 1990, 2009, 2028, and 2047

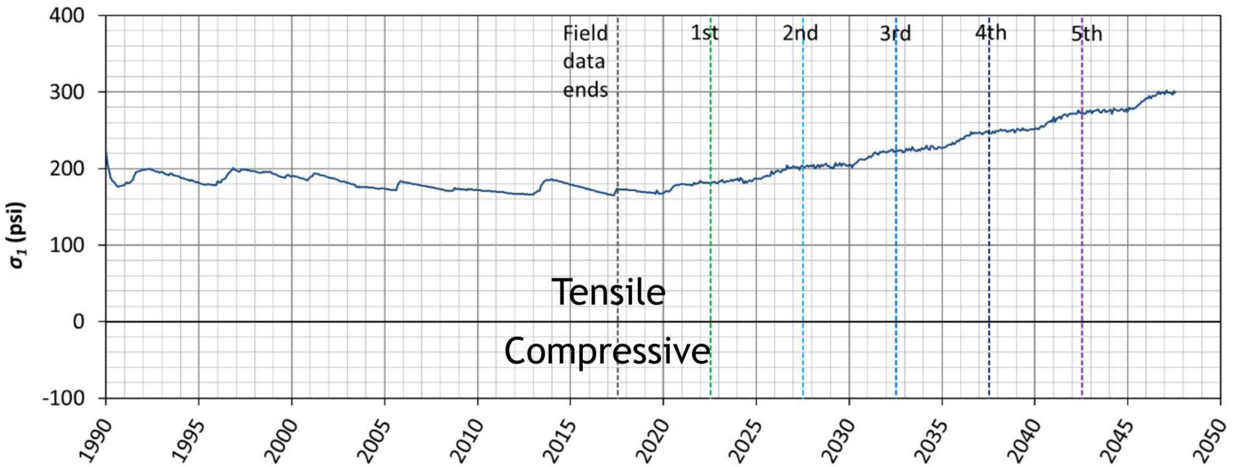
Caprock overlying BC-4 is predicted to be in compressive stress state ($\sigma_1 < 0$) until the simulation ends (2047), while the caprock surrounding BC-7 is predicted to be in tensile stress state ($\sigma_1 > 0$) from the simulation starts (1990)

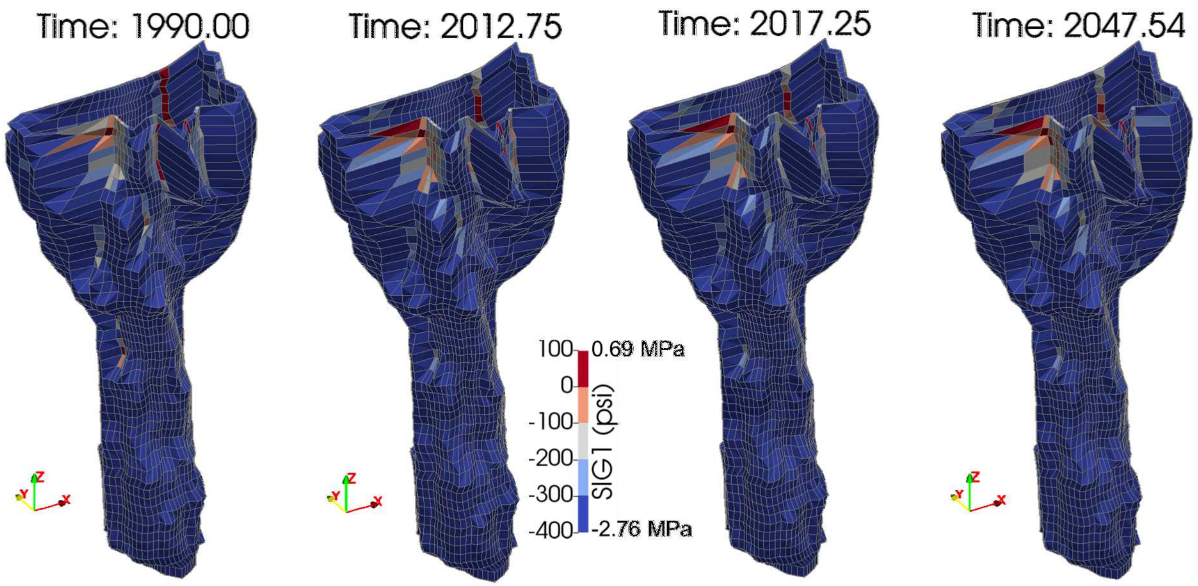
Large tensile stresses (>600 psi) distribute around the perimeter of BC-7that may be caused the cavern collapse in 1954

Compressive stressed area ($\sigma_1 < 0$) surrounding BC-4 in dark blue gradually decreases with time.

Therefore, even as the model provides justifiable reason to believe that a roof failure of BC-4 is not imminent, we need to continue monitoring the cavern roof integrity.

Salt Body of BC-4





Predicted maximum σ_1 over time

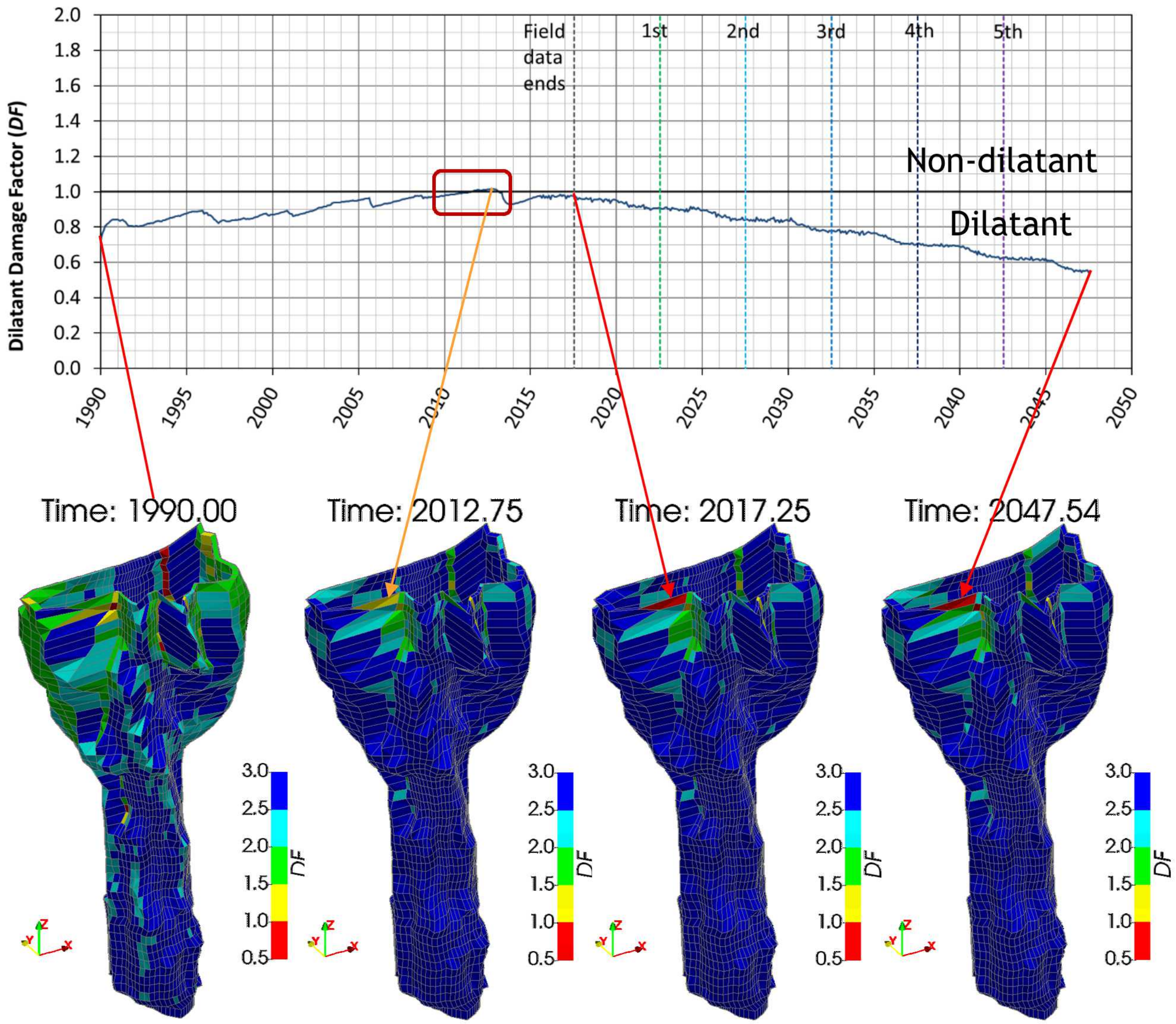
Contour plots on specific dates in the salt skin layers

Salt skins is predicted to have experienced tensile ($\sigma_1 > 0$) since the simulation starts

Predicted tensile stressed areas in red were created at the upper cavern in 1990

Potential of tensile failure exists in the areas, i.e. the salt fall may occur at the areas

Salt Body of BC-4



Predicted minimum *DF* over time

Contour plots on specific dates in the salt skin layers

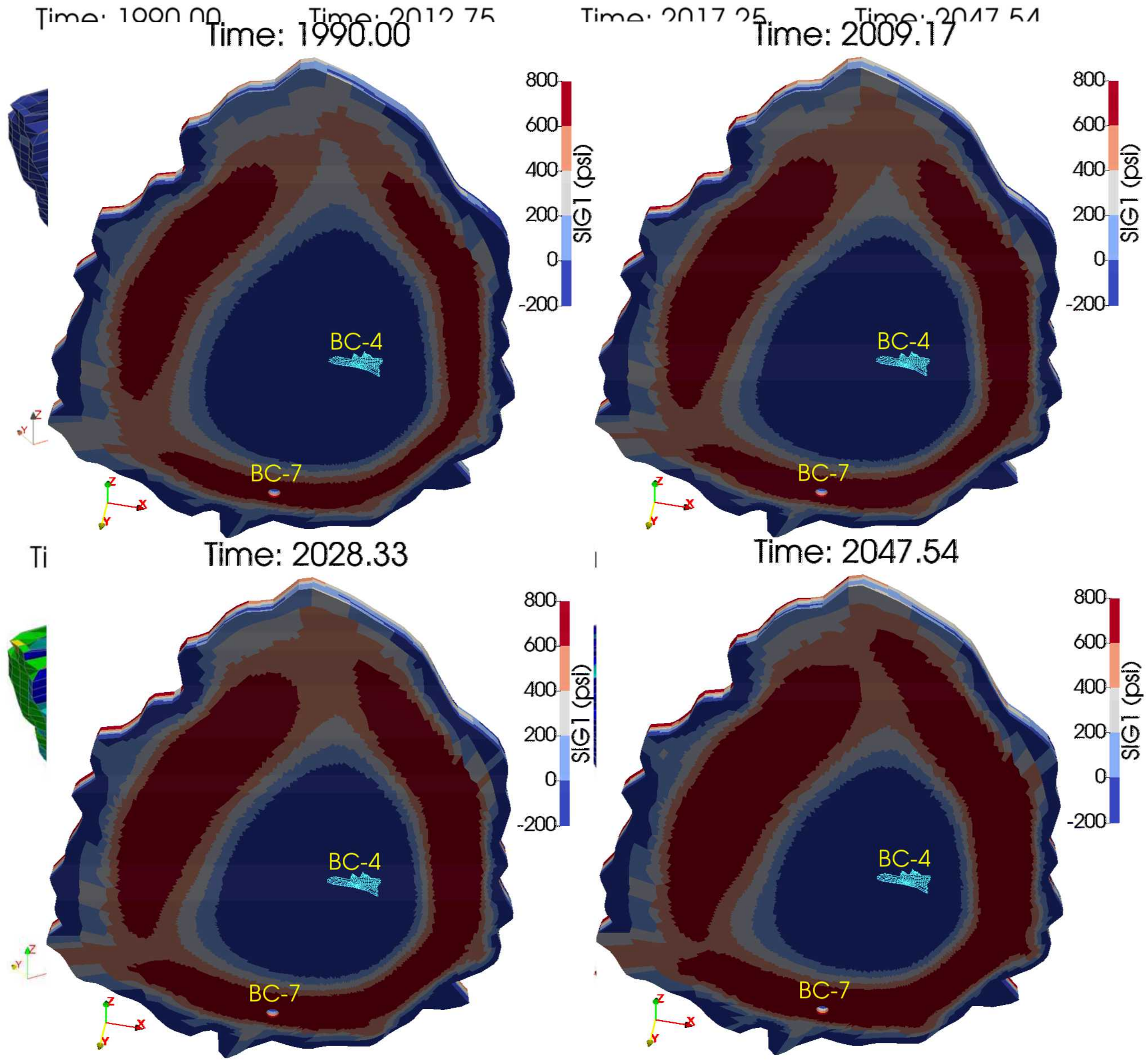
Salt skin layers are predicted to have experienced dilatant damage (*DF*<1) during the entire simulation period except 9/1/2011–6/4/2013

Predicted dilatant damaged areas in red were created in the upper cavern in 1990 and disappears in 2012 and appears again in 2017

Areas overlapped with the tensile stressed areas and the dilatant damaged areas are under the condition of both tensile failure and micro-cracking

Possibility of a salt fall is highly predicted there

Summary and Conclusions



Cavern roof in the caprock layer has no predicted risk of structural stability in the form of tensile failure for up to 30 years

Possibility of a salt fall is highly predicted in the upper cavern

The potential for salt falls is important for the overall integrity of the cavern, because these salt falls will likely occur from the near-roof portions of the cavern, they may over time degrade the roof and accelerate the transition from compressive to tensile stresses in the caprock roof

Model indicates that any sort of **roof failure is not imminent**; however, the **uncertainty due to salt falls** illustrates the importance of **continued monitoring such as subsidence and tilt** which may indicate a change in the cavern's integrity status