SAND2019-3739C

Assessing Cavern BC-20 Sidewall Integrity in Vicinity of Edge of Salt Dome at Bayou Choctaw SPR

SMRI Spring 2019 Technical Conference

New Orleans, Louisiana, USA

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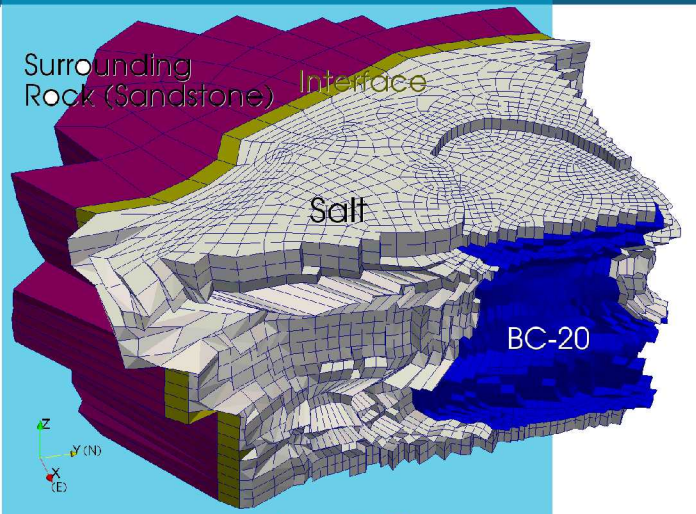

Edge Pillar

PRESENTED BY

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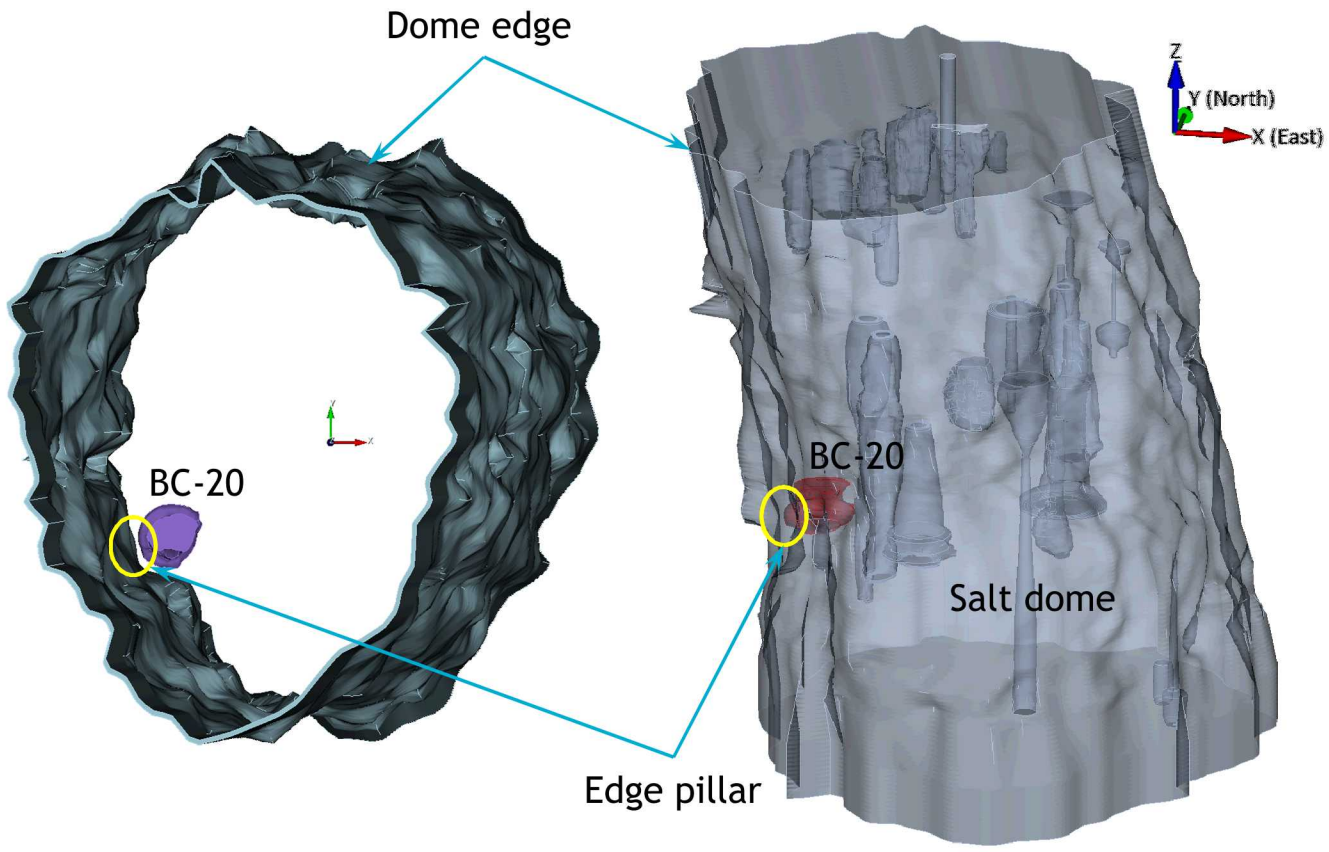
Storage Sites

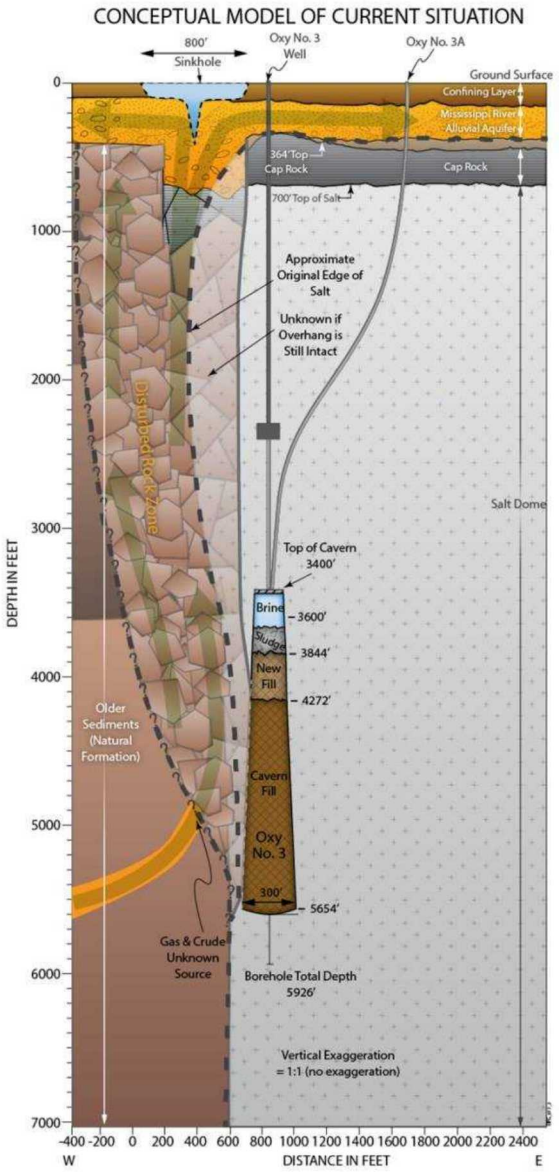
BC-20 and Dome Edge

BC-20 is very close to the dome edge.

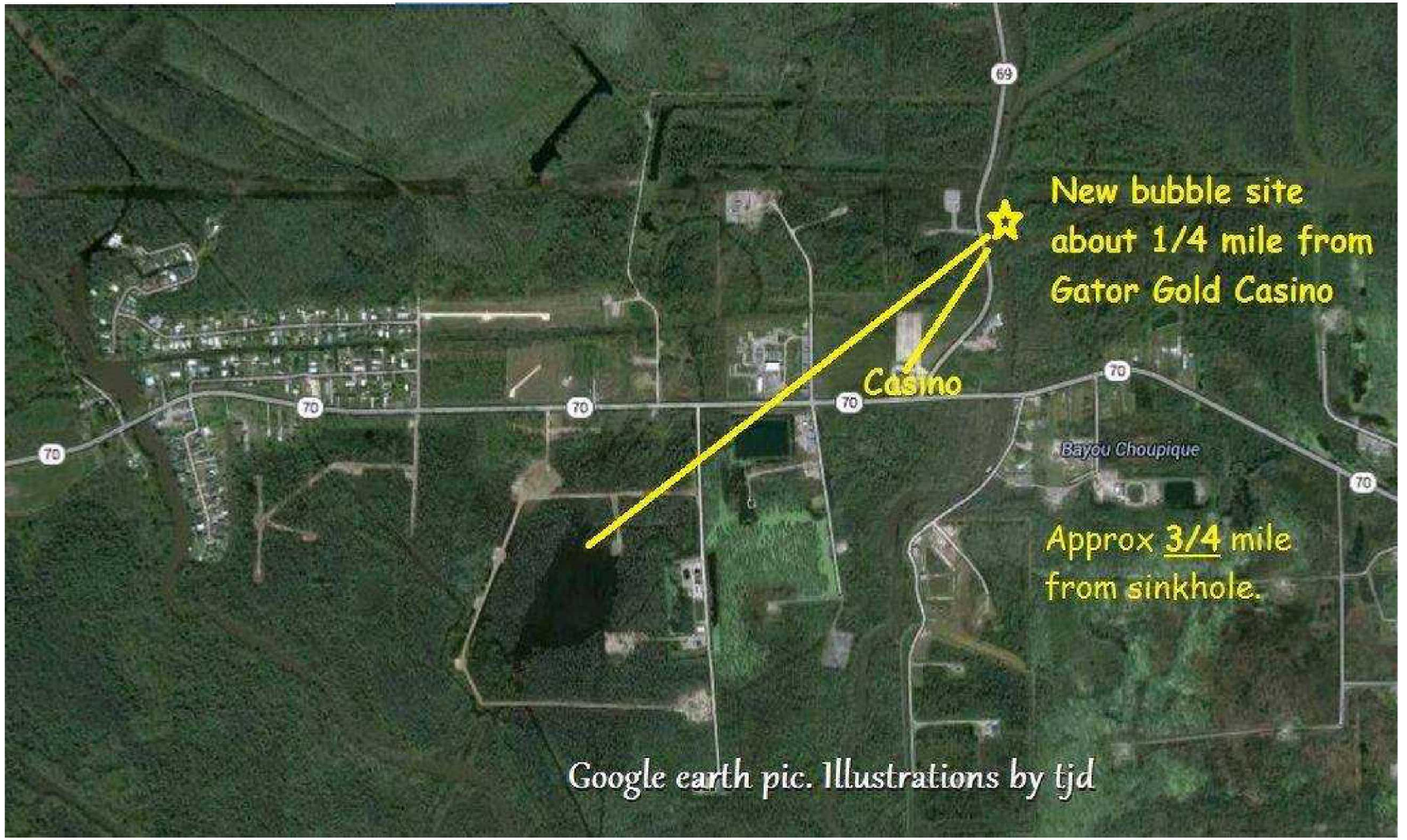
Need to check the structural integrity of the pillar between BC-20 and dome edge (called “edge pillar”)



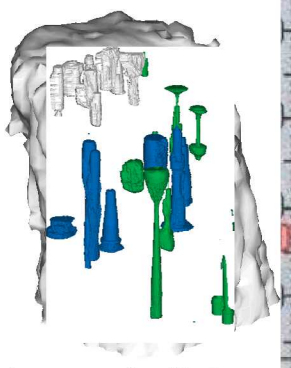
Bayou Corne Sinkhole (Reference Case)



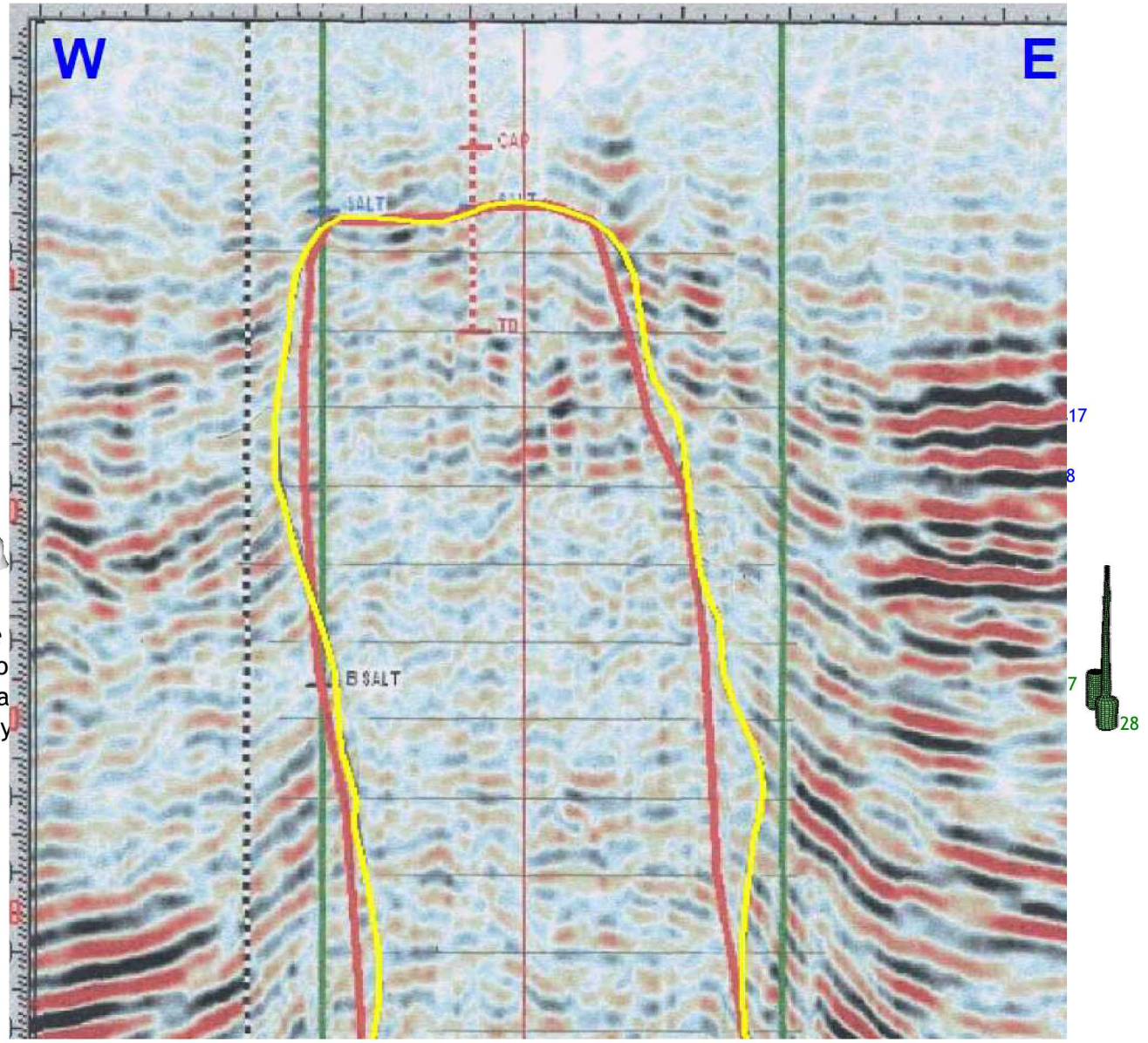
- The sinkhole was created due to cavern collapse (Oxy3) in Napoleonville salt dome in Louisiana



FE Model Capturing Realistic Geometries



Images of salt dome caverns obtained fro the seismic and sona surveys, respectively



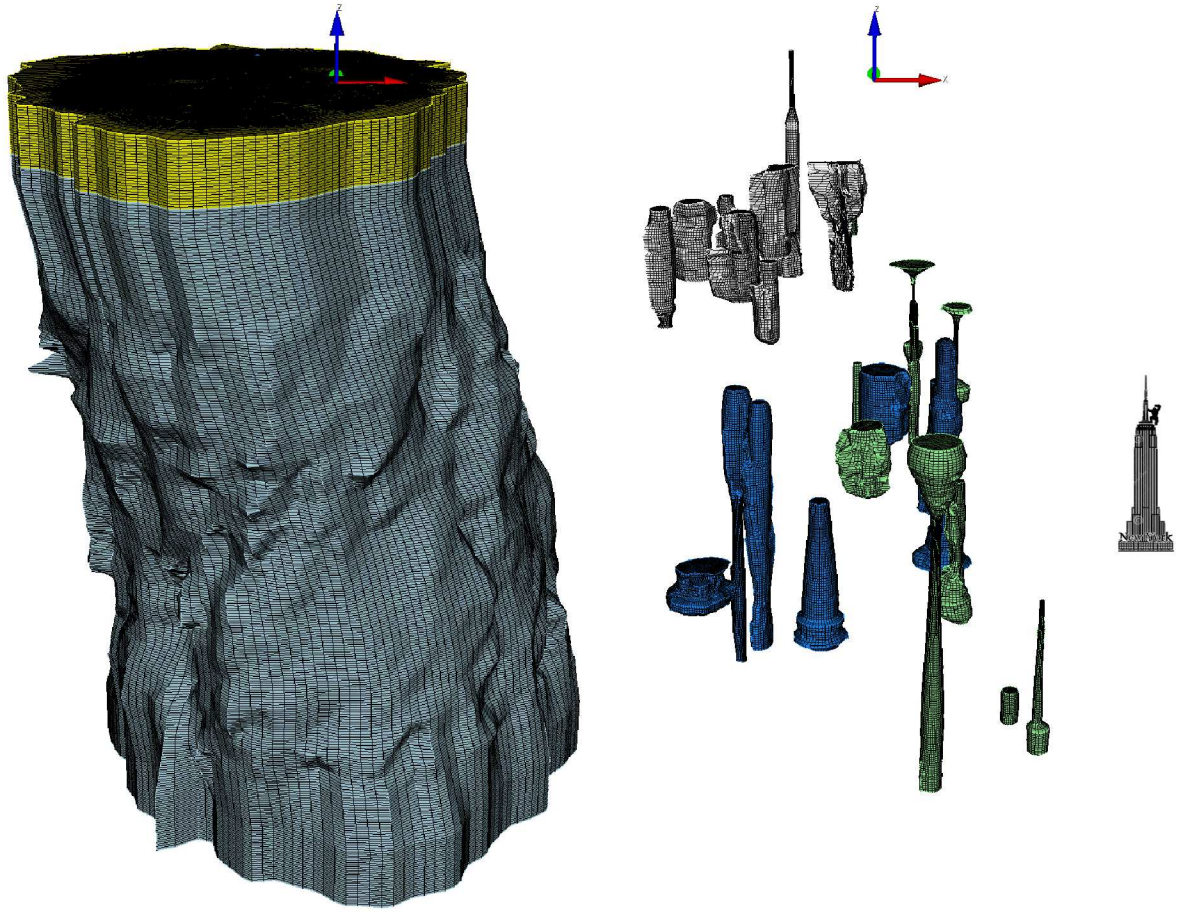
Seismic survey result in Bayou Choctaw - yellow curve indicates the dome boundary

3D salt dome and caverns images

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

Green shows privately owned caverns, and grey depicts abandoned caverns

Dome and Caverns



The salt dome is 1743 m high, while

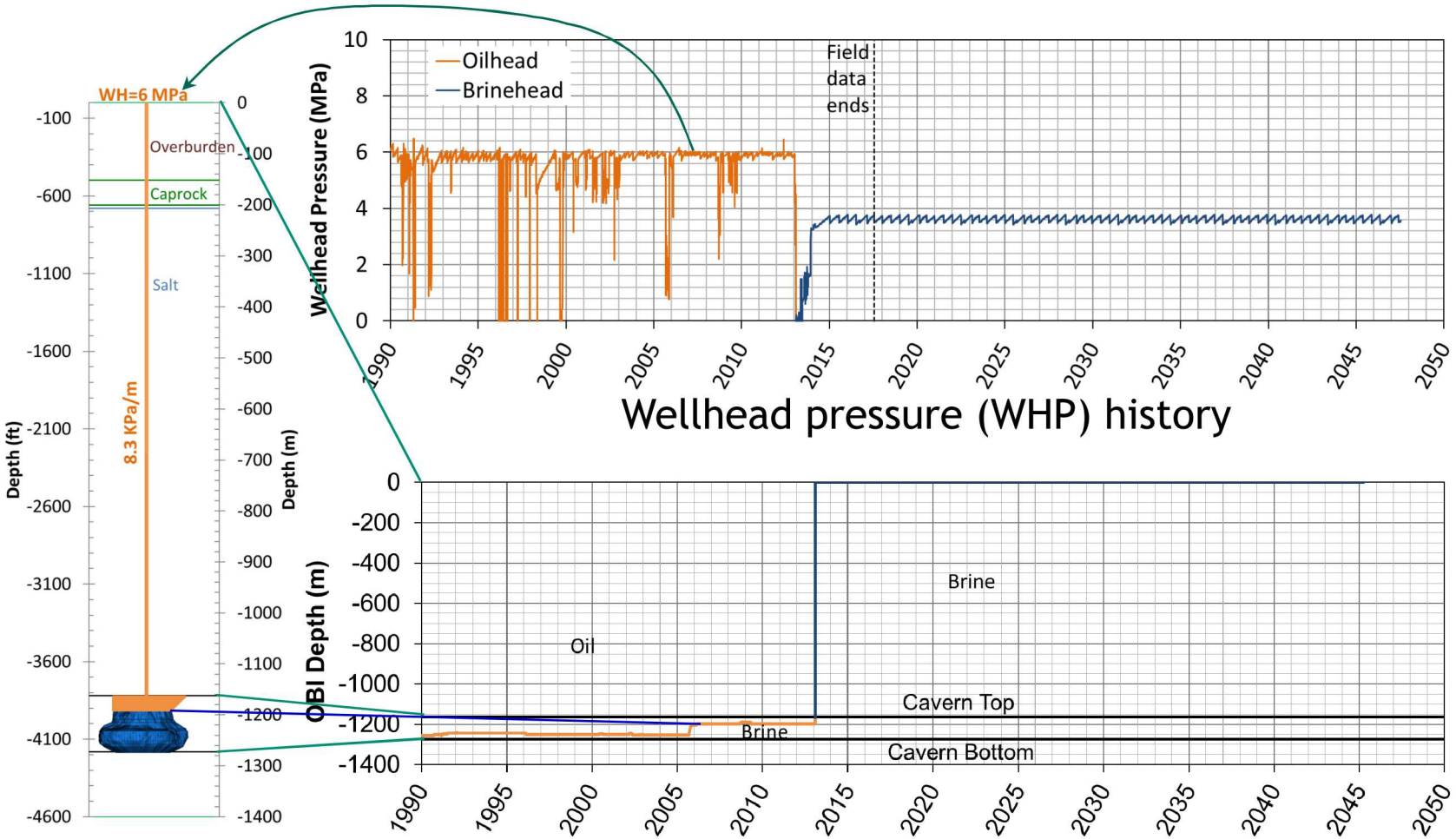
The largest cavern height is approximately 914 m.

The largest cavern volume holds approximately 19 million barrels (3 million m^3).

This new mesh is expected to provide more accurate solutions of the geotechnical concerns

This work is being filed as a non-provisional U.S. patent by Sandia/DOE (US Appl. No.: 15/435,904) on February 17, 2017

Cavern Internal Pressure



BC-20 is no longer used for SPR cavern since February 2013.

At present, BC-20 including wellbores is filled fully with brine rather than oil.

Cavern internal pressure at depth d:

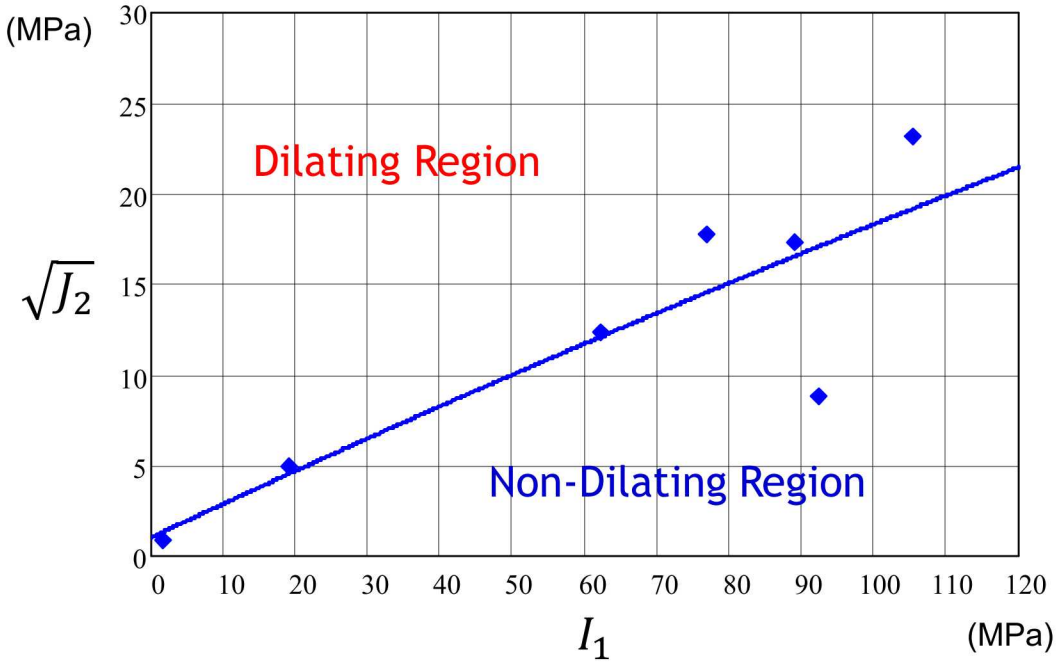
$$P = \rho g d + WHP$$

- ρ = fluid density
- g = gravity
- d = depth
- WHP = wellhead pressure

Salt Damage Criteria

Potential damage to/around the SPR caverns was evaluated based on two failure criteria: dilatant damage and tensile failure

The potential for tensile failure exists if the maximum principal stress (σ_1) is numerically zero or positive value



I_1 = First invariant of Cauchy stress tensor

J_2 = Second invariant of deviatoric stress tensor

Dilatant damage factor (*DF*):

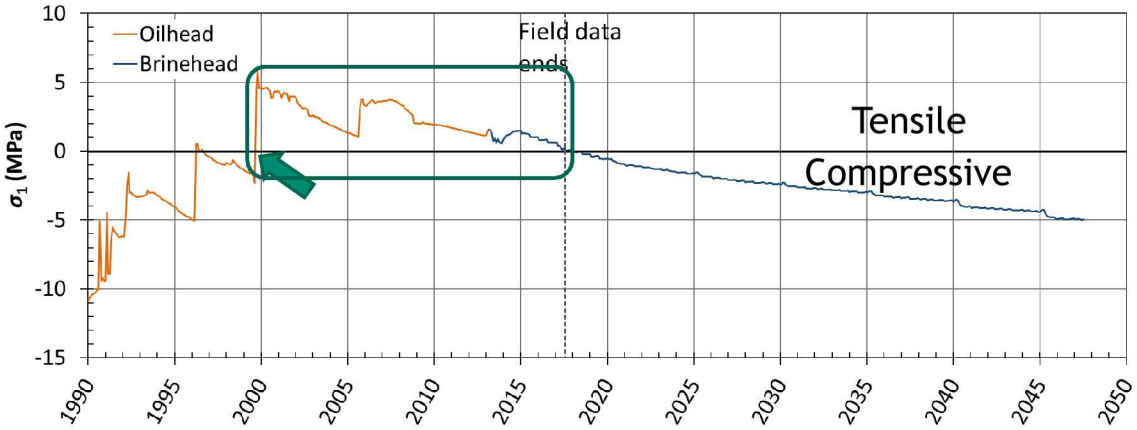
$$DF = \frac{a \cdot e^{n \cdot I_1} + c}{\sqrt{J_2}}$$

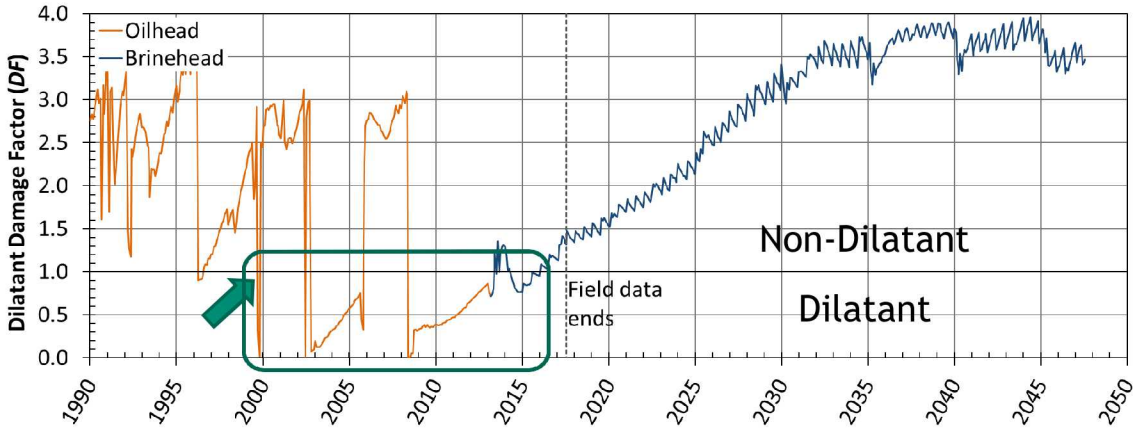
a = -118.8 MPa

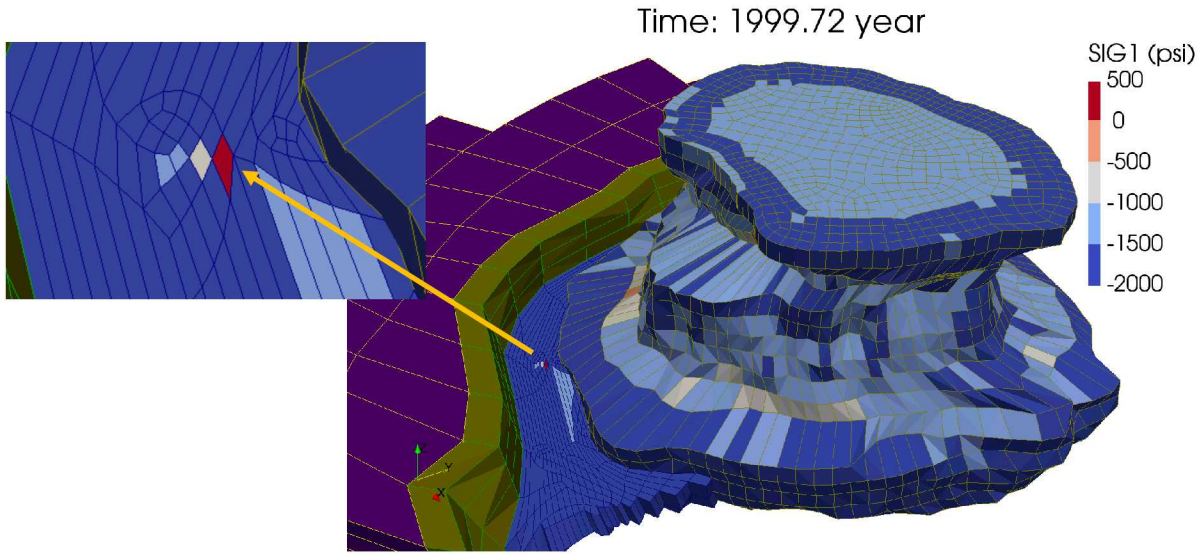
n = -1.574 x 10^{-3} (1/MPa)

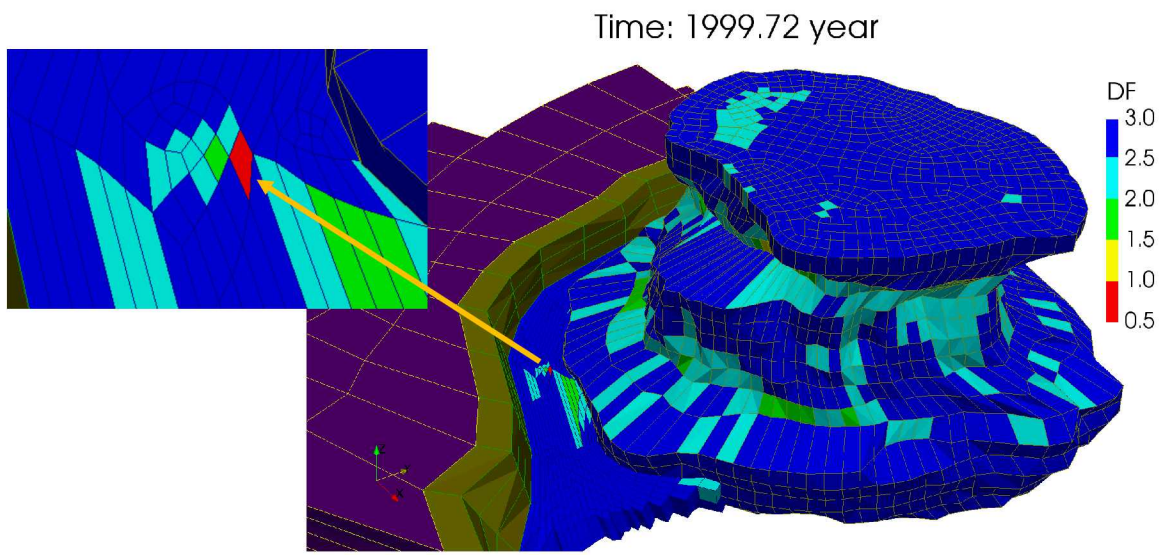
c = 119.8 MPa

σ_1 and *DF* in Edge Pillar



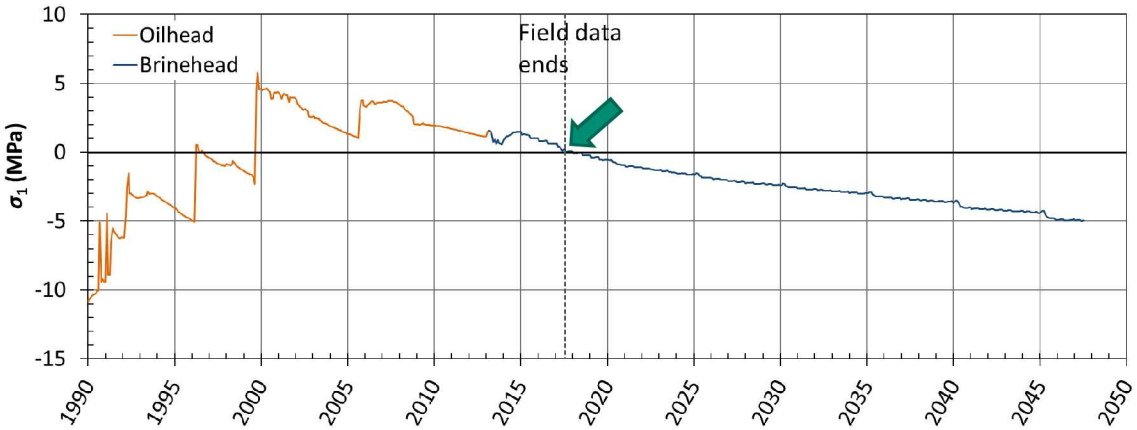




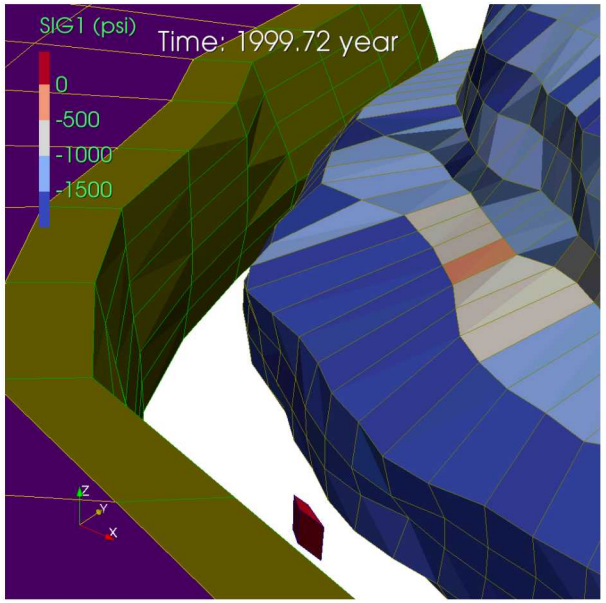


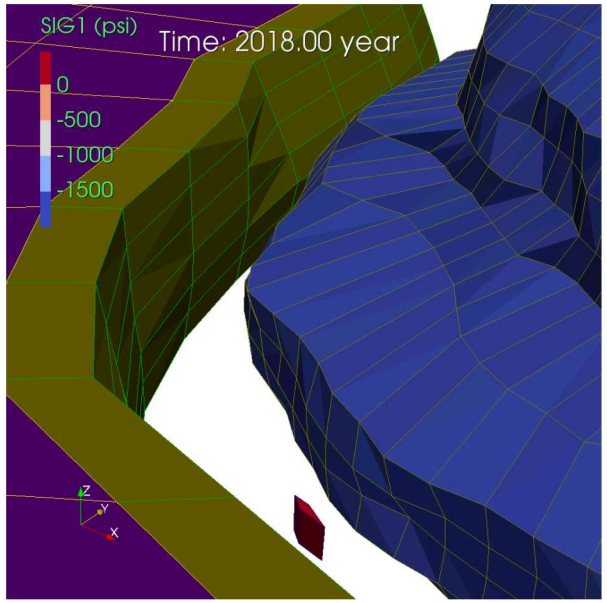
The critical element, which is in both a tensile and dilatant damage stress condition, is predicted to locate in the salt between dome edge and BC-20 at -1244 m depth

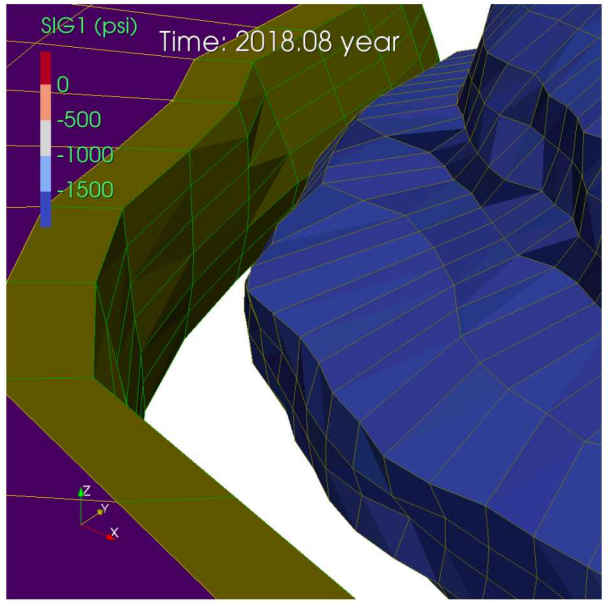
Contour Plots of σ_1



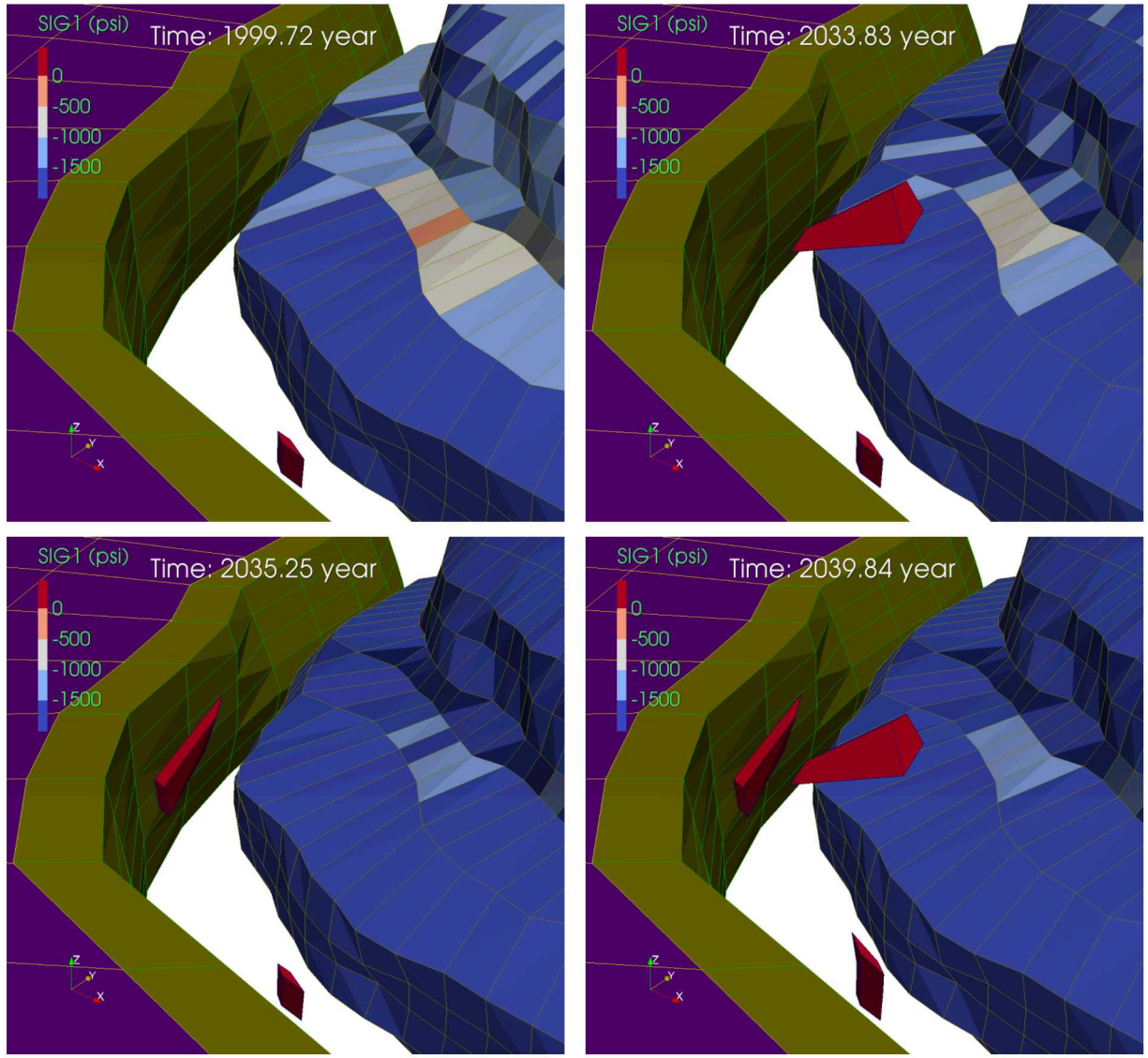
The tensile stressed area is predicted to be created in beginning and then disappear in 2018 because we filled fully the cavern and wellbores with brine since 2013







Before BC-20 was Decommissioned



Before BC-20 was decommissioned and filled with brine, a higher risk of structural failure existed

Predicted contour plots of σ_1 in 1999, 2033, 2035, and 2039 to show the area in tension (red) in the edge pillar

Tensile stressed areas have continued to develop and grow since the beginning

High possibility of salt fracture and crack propagation

Once a crack is created, the crack will continue to propagate with time because it is in tensile state.

Summary and Conclusions

The possibility of a loss in integrity of BC-20 is examined in the salt between the dome edge and the cavern.

The edge pillar is predicted to have experienced tensile but the tensile stressed area disappears in 2018, because BC-20 has been emptied of oil and filled fully with brine since February 2013.

Before BC-20 was decommissioned and filled with brine, a higher risk of structural failure existed.

The decision to convert BC-20 to a pressurized brine cavern proved effective and necessary.