SAND2025-10580C

SOLUTION MINING RESEARCH INSTITUTE
679 Plank Road
Clifton Park, NY 12065, USA

Telephone: +1 518-579-6587
www.solutionmining.org

Technical Conference Paper

1965 – 2025

Well Collar Compression at the Bryan Mound SPR Site

Hannah Maurer, Albuquerque, NM

SMRI Fall 2025 Technical Conference
29-30 September 2025
Wichita, Kansas, United States

Solution Mining Research Institute Fall 2025 Technical Conference
Wichita, Kansas, United States 29-30 September 2025

Well Collar Compression at the Bryan Mound SPR Site

Hannah Maurer
Sandia National Laboratories, Albuquerque NM, USA

Abstract

The Strategic Petroleum Reserve (SPR) Bryan Mound site has a history of well deformation in the caprock, most notably around the 700 to 900 ft (213 to 274 m) depth range. This deformation appears to be caused by casing compression which is most commonly observed at casing collars. In a typical well collar joint, a small increase in inner diameter is observed at the threaded casing connection. Collar compression is characterized by a decrease in the well inner diameter resulting in a restriction at the collar. This is likely the result of one section of casing being pushed inside an adjacent casing section at the collar joint.

A review of Multi-Arm Caliper (MAC) logs for each well at the Bryan Mound site has been conducted, with a focus on identifying wells that experience collar restrictions and characterizing the resulting deformation. Collar restrictions have been identified in 24 of the 47 Bryan Mound wells. An analysis of additional relevant datasets follows the well-by-well MAC analysis. This includes a spatial analysis of the deformation locations, well temperature logging data, pulsed eddy current (PEC) logs, and proximity of SPR Bryan Mound wells to historic sulfur mining wells.

Wells at Bryan Mound experiencing collar restrictions have been identified, in addition to wells that have mid-casing concerns within the areas of interest. All collar restrictions that have been identified at the Bryan Mound site have been found within the caprock. There is a history of sulfur mining within the caprock, which has undoubtedly left lasting impacts on the geology of the Bryan Mound dome in the areas in which mining took place. Elevated temperatures in the caprock, resulting from sulfur mining, are still present today. At this time, it appears that differences in the presence of collar restrictions between wells are likely the result of individual well responses to localized variations in the Bryan Mound geology.

Key words: Caverns for Liquid Storage, Corrosion, U.S. Strategic Petroleum Reserve, Well Casing, Well Integrity, Well Logging

Introduction

This report summarizes a comprehensive analysis of the Bryan Mound Multi-Arm Caliper (MAC) data (Maurer, 2024) with a specific emphasis on identifying wells that have collar restrictions, which has been a noted phenomenon observed in wells across the site. The collar compression present across the site is likely related to the geologic impacts of sulfur mining that took place on the dome before it was converted to and SPR storage site. Several other relevant datasets related to Bryan Mound well integrity concerns have been explored including temperature logging data, pulsed eddy current logs, sulfur-mining well locations, and lost-circulation zones encountered during drilling. Collar compression has typically been identified within the caprock, making it the biggest area of concern for well deformation at the site.

General Site Background

Bryan Mound is one of four SPR sites situated along the Gulf Coast of the U.S. It is located in Brazoria County, Texas (Figure 1).

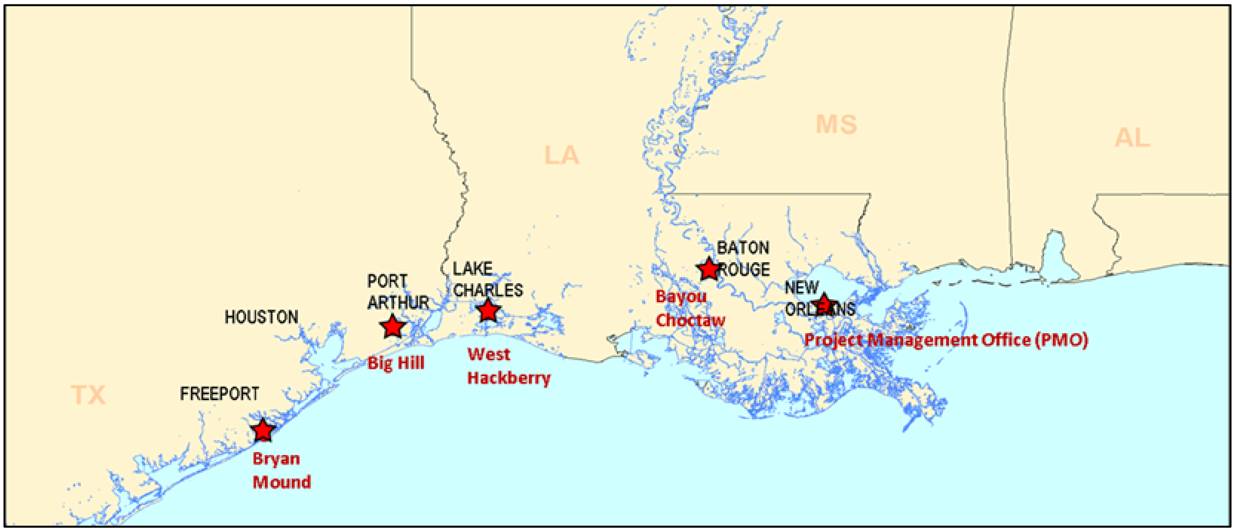

Figure 1. Locations of the four SPR sites on the Gulf Coast. The four sites are Bryan Mound, Big Hill, West Hackberry, and Bayou Choctaw

The Bryan Mound Site is composed of 20 active caverns, with 47 total wells. The site has a mixture of pre-existing caverns that were acquired by the SPR and caverns that were subsequently developed by the SPR specifically for petroleum storage. This has resulted in caverns having anywhere between 1-3 wells. The well configurations at Bryan Mound typically have a 16 in (41 cm) or 13 3/8 in (34 m) outer diameter for the innermost casing. Several of the wells at this site have been remediated with a liner, resulting in a reduced diameter for the innermost casing.

The Bryan Mound caprock is generally circular in map-view and the shallowest caprock elevation is documented at -682 ft (-208 m) and is located in the northwest region of the caprock (Lord, 2007). The caprock is known to have three main zones. The uppermost zone consists of limestone with water or sulfur filled pore space. The middle zone is a transition zone and consists of limestone, gypsum, sulfur and anhydrite. The lowermost zone consists mainly of anhydrite. The caprock is approximately 300 ft (91 m) in thickness. The Bryan Mound salt dome is generally cylindrical and flat across the top. The shallowest documented salt intercept is at an elevation of -1043 ft (-318 m) and is located in the center of the dome (Roberts B. L., 2015).

Sulfur Mining at the Bryan Mound Site

In the early 1900's sulfur was discovered in the caprock of the Bryan Mound dome and was extensively mined from 1912 – 1935 by Freeport Sulphur Company. A 2015 Sandia report provides an in-depth review of the sulfur extraction process that took place at Bryan Mound (Kirby & Lord, 2015).

Sulfur was found at depths of 700 to 900 ft (213 to 274 m) in the Bryan Mound dome through a series of exploration wells and was subsequently mined using the Frasch process. Patented by Herman Frasch in 1891, the Frasch process involves injecting large amounts of hot water (around 330° F, 166° C) into the earth in order to liquify the sulfur which is then brought to the surface. One well was said to be able to remove sulfur from an area of about one-half acre (2023 m^2). Freeport Sulphur, reported that when drilling into the dome they found approximately 760 ft (232 m) of gravel and caprock, followed by about 150 ft (46 m) of sulfur bearing limestone, with the sulfur deposits ending from around 900 to 1100 ft (274 to 335 m).

Beds of pure sulfur ranging in thickness from a few inches to several feet were noted. It is reported that during the sulfur extraction process at Bryan Mound 1897 wells were drilled and a total of approximately 5,000,000 long tons (5080235 metric tons) of sulfur was produced. The effects of this extensive mining have likely led to increased temperatures and a more cavernous caprock in areas most affected by the sulfur production.

Bryan Mound Multi-Arm Caliper (MAC) Data

Multi-Arm Caliper (MAC) logs have historically been used to identify deformation in wells across the SPR. MAC logs taken at Bryan Mound are typically performed with a 56 or 60-arm radial tool, which is raised throughout the length of the casing. The data produced from a MAC logging event provides radial measurements for each arm with depth. Sandia has developed a systematic way to quantify and evaluate this data so that it can be compared across wells of different configuration. A Sandia report published in 2021 provides and in-depth explanation of the current Sandia MAC evaluation process (Roberts B. L., 2021). In order to evaluate well integrity at Bryan Mound, MAC logs have been analyzed for each well at the site. The following analysis of the Bryan Mound collar compression focuses mainly on minimum diameter measurements throughout the wellbore, which have been calculated from the radial arm MAC data. It should be noted that all minimum and average diameter values discussed in this report are inner diameter values. Additionally, the expected casing inner diameter for a given outer diameter may differ depending on the casing weight. Although these minimum diameter measurements are only a small portion of the entire MAC well evaluation process, they are the best way to identify the decrease in diameter which is typically observed at a casing collars and is the focus of the deformation analysis in this report.

Collar Compression Identification

The Bryan Mound site has a history of well deformation in the caprock, most notably around the 700 to 900 ft (213 to 274 m) range. This deformation appears to be caused by casing compression which is most commonly observed at casing collars. The unlined wells at the Bryan Mound site have short thread coupling (STC) joints. In a typical STC collar joint for a non-lined well, a small increase in diameter is observed at the threaded casing connection. Collar compression is characterized by a decrease in the well diameter at the collar, which is likely the result of one section of casing being pushed inside an adjacent casing section at the collar joint due to axial compression.

An example below shows data from well BM-5, where a casing compression has been identified around 797 ft (243 m). Figure 2 shows minimum diameter measurements for the entire 13 3/8 in (34 cm) casing. In the minimum diameter data, a clear decrease in the inner diameter of the well can be identified in the collar at approximately 797 ft (243 m). Although identifying a decrease in the minimum diameter curve is a good first check, it is not sufficient to conclusively say that there is a collar restriction at that depth. There are several cases where a decrease in the minimum diameter is caused by a single arm reading or debris in the well that is only present in a small number of radial arm measurements at a given depth. A suspected casing restriction should always be confirmed with a comprehensive review of radial arm data from the MAC log at the depth of concern. Even in cases where a decrease is seen in the maximum diameter curve as well, signaling that all diameter measurements at a given depths have been reduced, the radial arm data provides a better picture of what is going on and can help characterize the uniformity and severity of the collar restriction. Figure 3 shows radial arm data taken from the 2013 MAC log run on well BM-5, with cross sections taken both at and above the collar restriction. From this data, a clear and uniform decrease in the diameter can be observed at 797 ft (243 m).

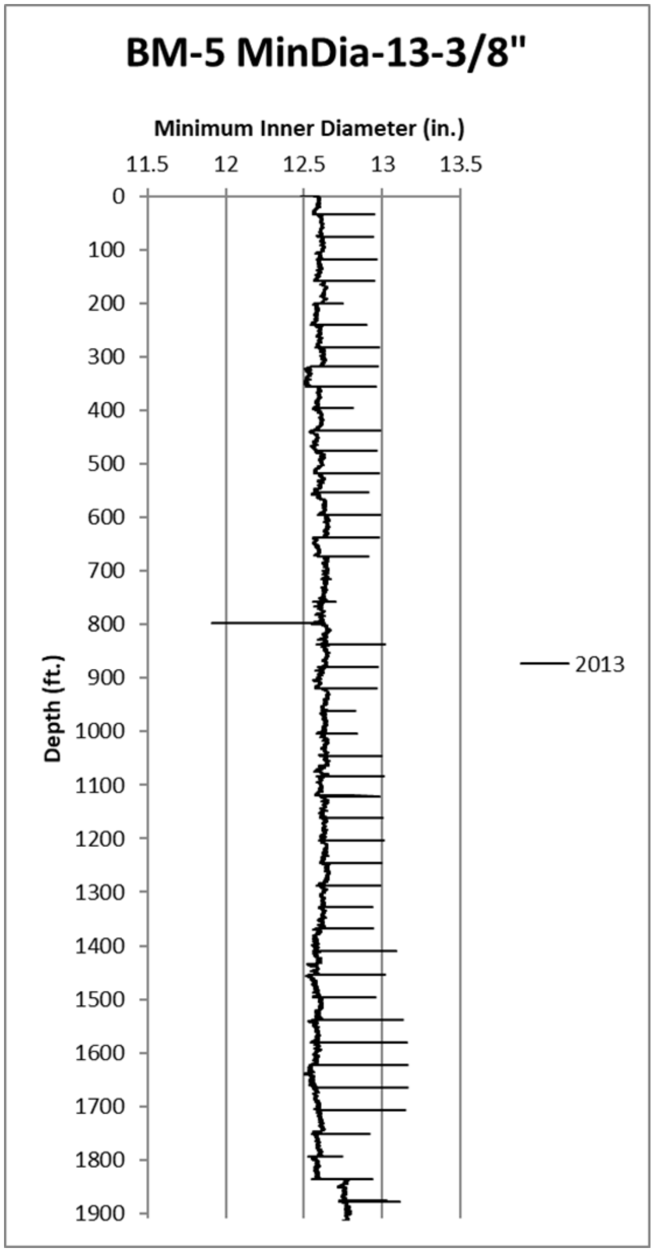

Figure 2. BM-5 minimum diameter curve from 2013 MAC data

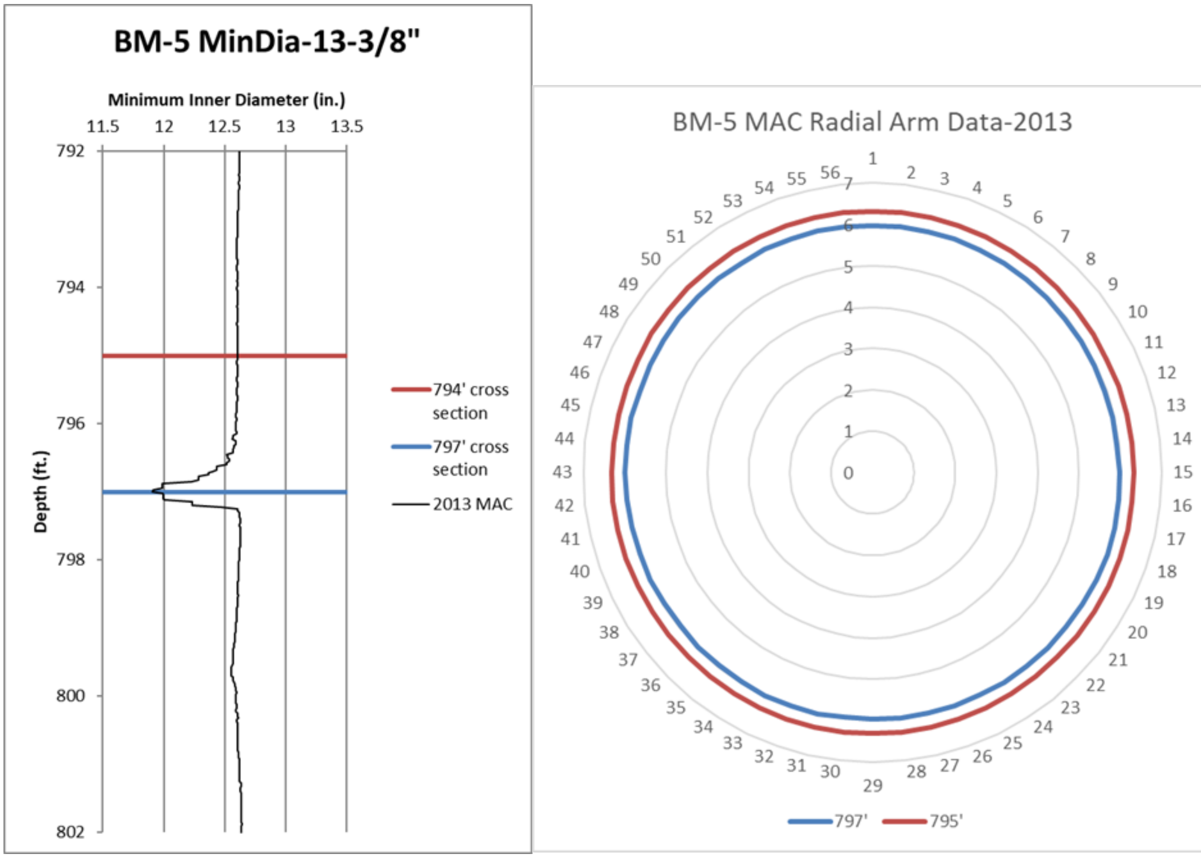

Figure 3. Cross sections of BM-5 2013 MAC data at the depth of casing restriction (blue) and above the restriction (red).

A 3D visual of the radial arm data near the casing collar restriction can be seen in Figure 4. As observed in the cross sections shown above, a clear restriction in the casing can be seen at 797 ft (243 m). Again, this is the opposite of what we would expect to see at a typical STC casing collar. Figure 5 provides an example of a normal casing collar in BM-5, with a small collar kick at the joint location as expected. There are several cases in this report where a radial restriction is present at a casing collar but appears minimal in the MAC data. It should be noted that even in cases where a collar restriction is present but not severe, the absence of a normal collar kick is likely indicative of a compression issue at the collar.

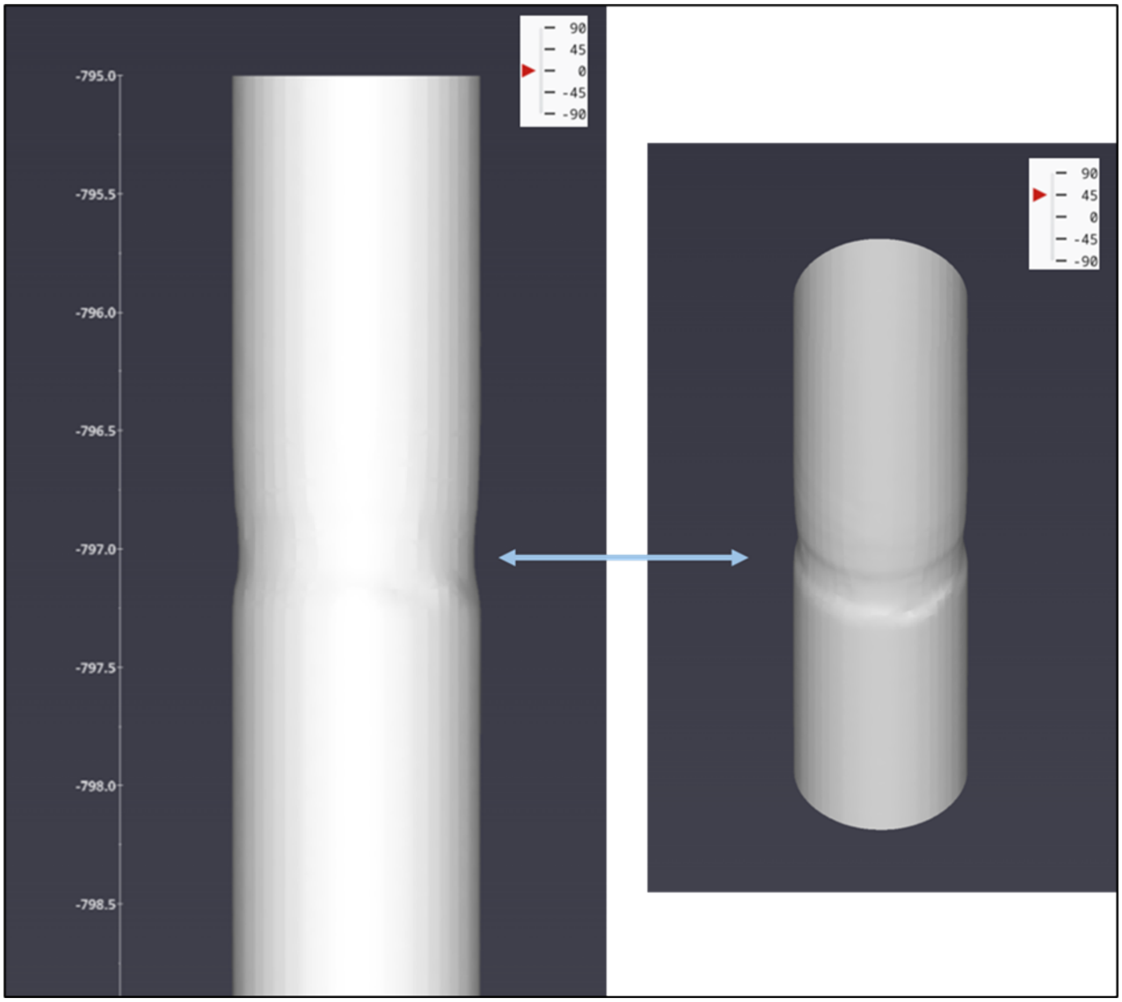

Figure 4. 3D visual of BM-5 2013 MAC radial arm data at the casing restriction

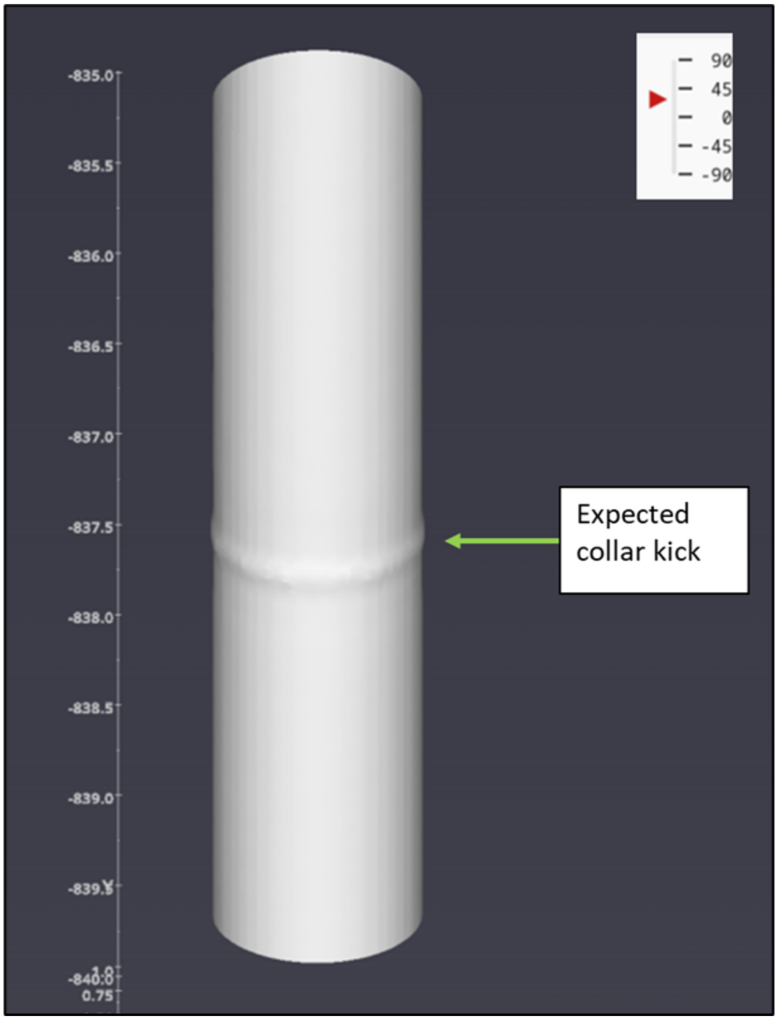

Figure 5. 3D visual of normal collar joint in BM-5

Well deformation as a result of casing compression has been observed in 24 of the 47 wells at the Bryan Mound site, with varying degrees of severity. The table below provides a summary of which wells have experienced this type of deformation and the depth at which it occurred. If the same casing restriction was observed in multiple MAC surveys for a given well, the exact depth of the restriction was recorded from the most recent survey that showed deformation.

Table 1. Summary of BM MAC collar compression analysis

Well	collar restriction depth (ft. rel. BHF)	collar restriction depth (ft. rel. MSL)	well lined since collar restriction last noted?	additional comments:
BM-001A	845.5	834.1	yes	none
BM-002				decrease in min diameter between collars around 784.85'
BM-002A				decrease in min diameter between collars around 851.8'
BM-004A				minimal deformation around SCRIF
BM-004B	878.1	864.3	yes	none
BM-004C				minimal deformation around 1100'-1200'
BM-005	797.0	789.8	no	none
BM-005A	750.1	742.9	no	minimal deformation around 1482'
BM-005C				none
BM-101A	898.7	892.4	yes	minimal deformation around 920'-930' and 1970'-1988'
BM-101C	902.6	896.3	yes	none
BM-102B	867.6	862.7	yes	none
BM-102C	907.4	901.5	yes	none
BM-103B	999.5	993.7	yes	minimal deformation around SCRIF and 1455'
BM-103C				none
BM-104A	905.9, 942.8	896.1, 933.0	no	moderate deformation from 1040'-1060'
BM-104B	881.6	871.9	no	moderate deformation at SCRIF
BM-104C	804.7, 885.3	795, 875.6	no	minimal deformation around SCRIF
BM-105B	810.8	797.7	no	moderate deformation around 1115'
BM-105C				possible debris, causing restriction around 207'
BM-106A	881.9	866.4	yes	none
BM-106B	834.2	818.5	yes	none
BM-106C	848.3	832.0	no	none
BM-107A				deformation around 1326'-1359'
BM-107B				Decrease in min diameter near collar around 810.2'. Deformation around 1950'-2008', possible cement
BM-107C	835.9	820.9	yes	none
BM-108A	865.3	849.3	no	moderate deformation around 1040'-1060'
BM-108B	873.9	858.6	no	none
BM-108C				none
BM-109A	828.9	812.9	no	minimal deformation around SCRIF
BM-109B	825.1	809.5	no	minimal deformation around 1215'
BM-109C				minimal deformation around SCRIF
BM-110A	844.7	829.2	no	decrease in min diameter between collars around 990'
BM-110B				none
BM-110C				none
BM-111A				isolated instances of min diameter decreases, results of 1-4 radial arm measurements
BM-111B				none
BM-112A	887.3	876.3	yes	none
BM-112C	873.6	862.6	yes	none
BM-113A				decrease in min diameter between collars around 882.4'
BM-113B				none
BM-114A				minimal deformation around SCRIF
BM-114B				minimal deformation around SCRIF
BM-115A				moderate deformation from 960'-1040'
BM-115B				minimal deformation around SCRIF
BM-116A				deformation at 983.3'
BM-116B				minimal deformation around SCRIF

Analysis of additional relevant datasets

After a comprehensive review of the Bryan Mound MAC data was completed, several additional datasets were explored to see if they offered any possible correlations or explanations for the well deformation observed at the Bryan Mound site. Temperature logging data, pulsed eddy current logs, sulfur mining well locations, and lost circulation zones during drilling were all identified as datasets worth looking into. A brief summary of the results for each analysis are provided below.

Temperature Logging Data

Bryan Mound temperature logging data has historically shown a unique temperature profile in comparison with the other three SPR sites. Temperature logs at Bryan Mound show a notable increase in temperature in the caprock often reaching maximum temperatures of 130 - 159° F (54 - 71° C), which cannot be explained by the normal geothermal gradient. The concentration of higher temperatures in the caprock is a result of the sulfur mining that took place at the BM dome. As discussed earlier, this sulfur mining process relied on injecting extremely hot water (around 330° F, 166° C) into the caprock to retrieve the sulfur, which affected the temperature profile in the mining region and as a result is still observed in recent temperature logs taken at the site (Kirby & Lord, 2015) (D'Appolonia, 1980). Figure 6 shows a visualization of the Bryan Mound well temperature data. The wells have been color coded to match the temperature measurements taken along each well, and a clear pattern of increased temperatures in the caprock can be observed.

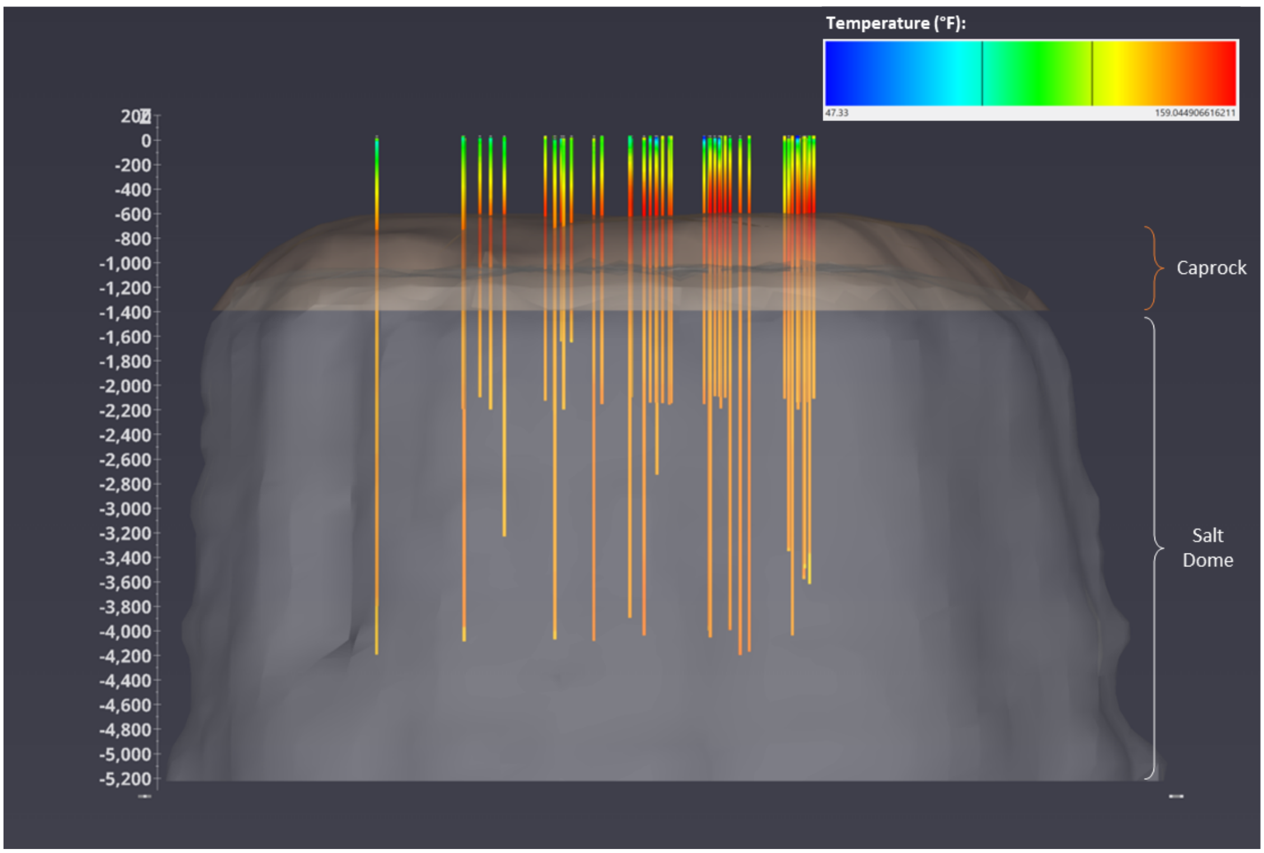

Figure 6. EVS visualization of BM well temperature data with caprock (orange) and salt dome (white) models included for reference

This temperature logging data was then used to create a 3D temperature gradient model. This model was created in Earth Volumetric Studio (EVS) using the Franke/Neilson inverse distance weighting formula. While there were some slightly lower temperatures on the northeast and southwest sides of the dome, the overall pattern of uncharacteristically high temperatures in the caprock is present across the entire dome, and there are no major indications at each depth to predict or explain why some wells are experiencing casing compression, while others do not.

At this time, we can say that the temperature data at the site shows a significant increase in temperatures near the caprock region most notably around 700 - 900 ft (213 - 274 m), which is also the same general depth region where sulfur mining took place. In terms of temperature variations between wells, there do not seem to be any trends strong enough to differentiate between the wells that experience collar compression and those that do not. Although the temperature data alone cannot be used to provide a well-specific explanation for the collar compression locations, it does further illustrate that the geologic effects of the sulfur mining are still very much present in the subsurface today as seen by the high temperatures observed in the caprock.

Pulsed Eddy Current Logs

Pulsed Eddy Current Logs are used to evaluate casing thickness and can be helpful in identifying wells with pipe thickness loss. At the time of this report there are a total of 19 wells at the Bryan Mound site that have PEC logs. It should be noted that several different vendors have been used to run these types of logs. While direct comparison between vendors is difficult due to differences in grading and interpretation techniques, any PEC logs with notable corrosion have been identified. Figure 7 and Figure 8 below were taken directly from the GOWell logging report for the PEC run on BM-116B (GOWell, 2020). These figures show the maximum pipe thickness loss per joint for the 20 in (51 cm) and 30 in (76 cm) casings, where a clear increase in pipe thickness loss around the sulfur mined zone can be observed, likely due in part to corrosion of the pipe. A similar pattern of pipe thickness loss in the sulfur mined zone has also been noted in the BM-115B and BM-116A PEC logs.

Figure 7. BM-116B pipe thickness loss for the 20” casing

Figure 8. BM-116B pipe thickness loss for the 20" casing

Figure 9 below shows a map of the wells at the Bryan Mound site, which have been color coded according to the results of the PEC log for that given well. Wells with notable pipe thickness loss in the sulfur mined zone have been marked in red, while wells without notable pipe thickness loss are shown in green. Any wells without a PEC log are shown in grey. Although there are a significant number of wells at the site without PEC logs, the three wells with notable corrosion (BM-115B, BM-116A and BM-116B) are all located on the southwest side of the Bryan Mound dome and are within relative proximity to each other. It should also be noted that while none of these three wells are experiencing collar compression, BM-116A does have mid-casing deformation present within the zone of corrosion identified in the PEC log. While there is not a direct link between collar compression and wells with corrosion noted in the PEC logs, they are likely both linked to the sulfur mining that took place at the site. The PEC logs provide additional insight into what is going on in that specific region and are able to capture data about the pipe thickness that we would not be able to get from a normal MAC run.

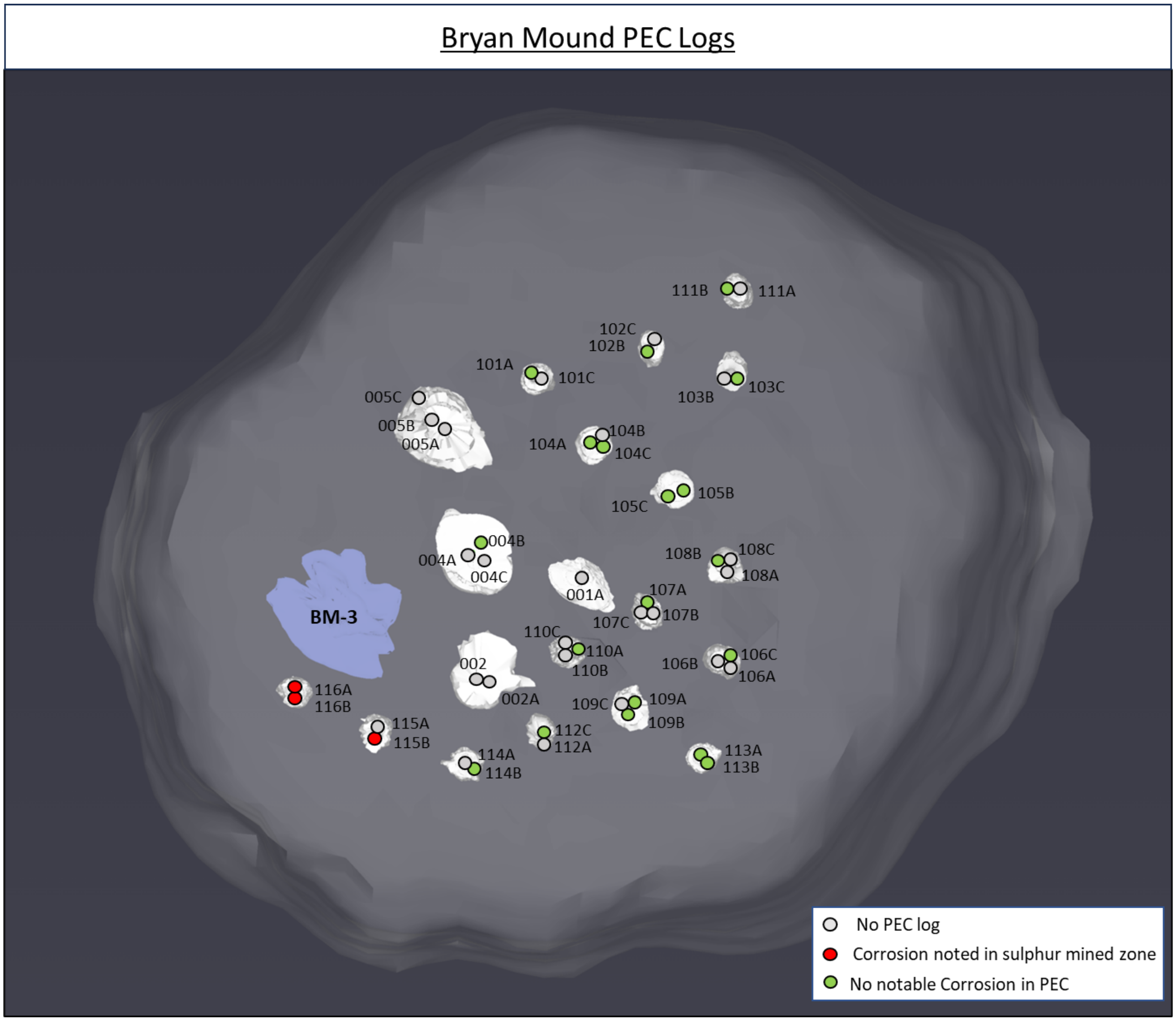

Figure 9. Bryan Mound wells with Corrosion noted in PEC logs

Sulfur Mining Well Locations

As mentioned earlier in the report, prior to being an SPR storage site, the Bryan Mound salt dome was used for sulfur mining operations. Due to the temporal and geologic effects of this type of mining, it is helpful to understand where the sulfur mining took place. Sandia has location data for a total of 436 known sulfur wells drilled at the Bryan Mound site. It has also been estimated that over 2000 sulfur wells were drilled at Bryan Mound, so the available dataset is not a complete record of all sulfur wells drilled at the site. Figure 10 shows the locations of BM Sulfur wells in relation to current SPR wells. SPR wells that exhibit a collar restriction are shown in orange, and SPR wells without a collar restriction are shown in grey. As seen in the figures below, all SPR wells are within relative proximity to sulfur mining wells. For all wells, a 2D distance between the x,y coordinates for each SPR well and the closest sulfur well were computed. For the wells experiencing collar restrictions, a 3D distance was calculated from the restriction depth to the closest sulfur well TD coordinate. When comparing the 2D distance between BM wells and the closest sulfur well, the average distance was approximately 25 ft (8 m) closer for wells with collar constrictions. However, there was a wide range of proximity distances observed in both wells with and without constrictions; therefore, a significant amount of variation is present in each data set. Because the wells that are not experiencing casing compression have no downhole depth to use for a 3D distance calculation, there is no way to compare these 3D calculations between the two groups.

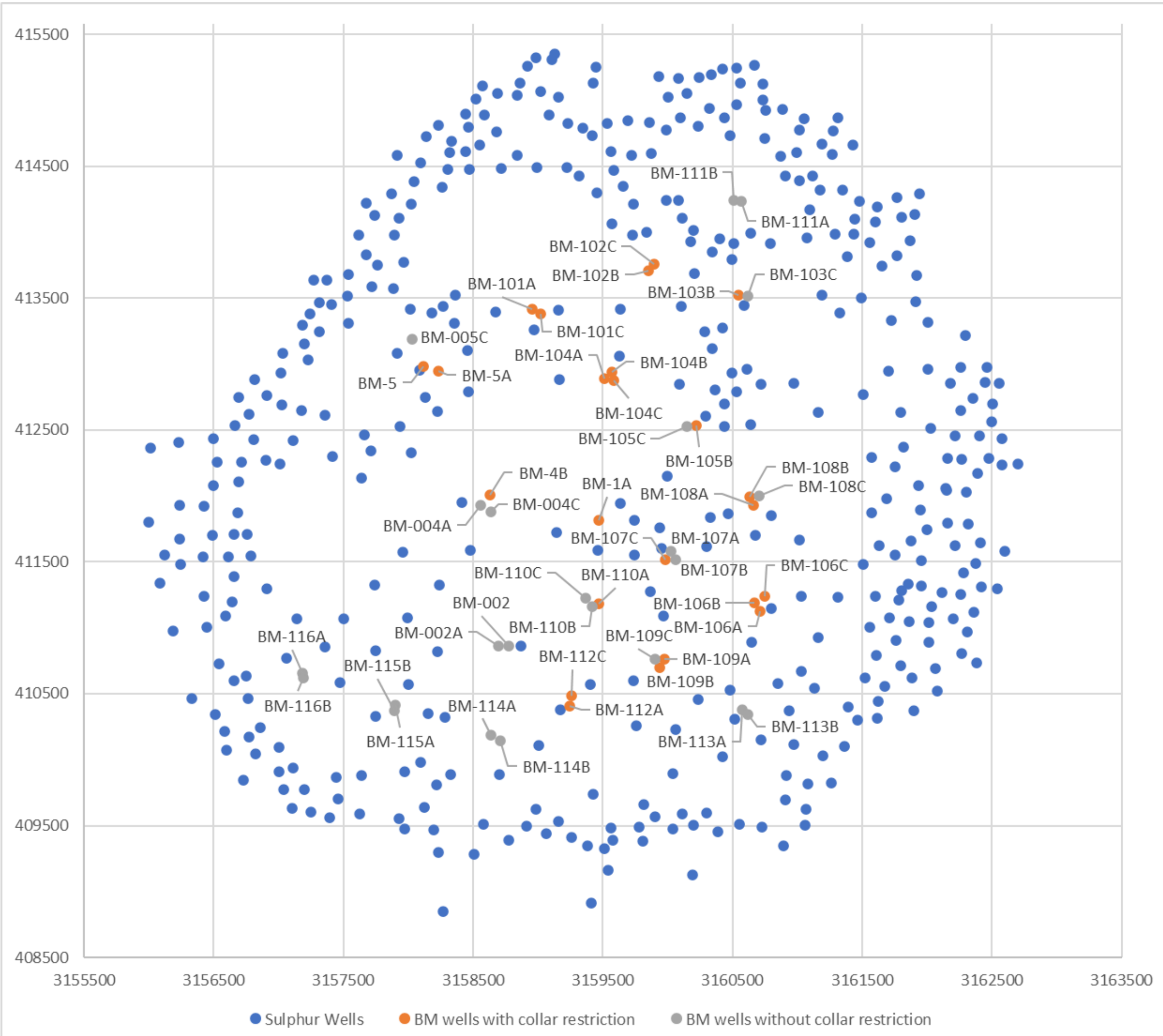

Figure 10. Bryan Mound labeled SPR and sulfur well locations

Although the sulfur mining has almost certainly had a significant impact on the Bryan Mound dome geology within the caprock, the available location data for BM sulfur wells does not provide any strong correlations between their proximity to individual SPR wells, and the likelihood of a well experiencing collar compression. Furthermore, the sulfur well data available at this time does not include well-specific production totals and is also only a subset of the total number of sulfur wells drilled at the dome. As we collect new well specific and sitewide data at the Bryan Mound site, this subset of sulfur well data is available to continue to examine possible correlations.

Lost Circulation Zones During Drilling

Many of the wells across the Bryan Mound site encountered lost circulation zones during drilling. While the presence of lost circulation zones during drilling operations is not unique to the Bryan Mound site, we do know that the Bryan Mound Caprock has additional void spaces due to the sulfur mining that took place at the site. Wells with significant lost circulation issues during drilling could be an indication that the well is in a region that was impacted by the sulfur mining. Drilling records for each log with available data were reviewed and a dataset of lost circulation zones was compiled.

It should be noted that just because circulation was lost at a specific depth does not mean that the void space responsible for the lost circulation is also at that depth. For example, there are several cases where circulation was lost in the salt, and it is assumed that the true void responsible for this loss was likely located at or above the salt-caprock interface (D'Appolonia, 1980). Some reports explicitly list depths associated with a void zone, and others just list the depths where circulation was lost during drilling. Additionally, some reports have very specific depths or small intervals of void space or lost circulation, while others provide a general lost circulation zone which is much larger. It is important to understand that the depths provided below are by no means an absolute measure of where void spaces in the geology occur. They are our best estimates based on the information available. If there is a large interval of lost circulation, it is unlikely that the entire interval is void space, and we can safely assume that the actual void is much smaller, if it exists. Not only is there variance in the depths due to the logging tools, but also due to differences in drillers and how detailed the reporting was for a given well. It is also possible that lost circulation issues did occur but were not explicitly reported in the drilling record.

Figure 11 below shows a summary of the lost circulation data at taken from the Bryan Mound well drilling reports. Wells with missing data or no comments about lost circulation were omitted from this figure. Although BM-102A has been plugged and abandoned and is not actively in use, it was still included in the figure below. Lost circulation depths are marked in red. Continuous lost circulation zones have been marked with a line between points (depths above the salt-caprock interface are marked in a darker red than those below the interface). The top of salt (grey) and top of caprock (yellow) have also been marked for each well. For the wells with both collar compression and lost circulation reported, the collar compression depths are shown in black. A total of 20 out of the 47 Bryan Mound wells (not including BM-102A) have identified lost circulation zones. As seen in Figure 11, the majority of the collar compression depths actually occur above the lost circulation zones.

Lost circulation zones have been recorded all across the dome and do not appear to be limited to a specific area. Additionally, there does not appear to be a significant correlation between wells with collar compression and those with lost circulation zones. Of the 47 Bryan Mound wells with available MAC data, 42 had available drilling records. Half of those drilling records belong to wells with collar compression and half belong to wells without collar compression. The wells without collar compression actually had a slightly higher rate of reported lost circulation zones with 12 out of 21 wells noting issues with lost circulation, in comparison with a slightly lower rate of 8 out of 21 wells with lost circulation zones for the wells with collar compression. With the data available at the moment there is no evidence to suggest that wells with reported lost circulation zones have a higher likelihood of collar compression. Again, it is likely that the occurrence of collar compression within wells is likely a result of localized variations in the geology that have been impacted by the sulfur mining operations, in combination with each well's unique response to those geologic forces.

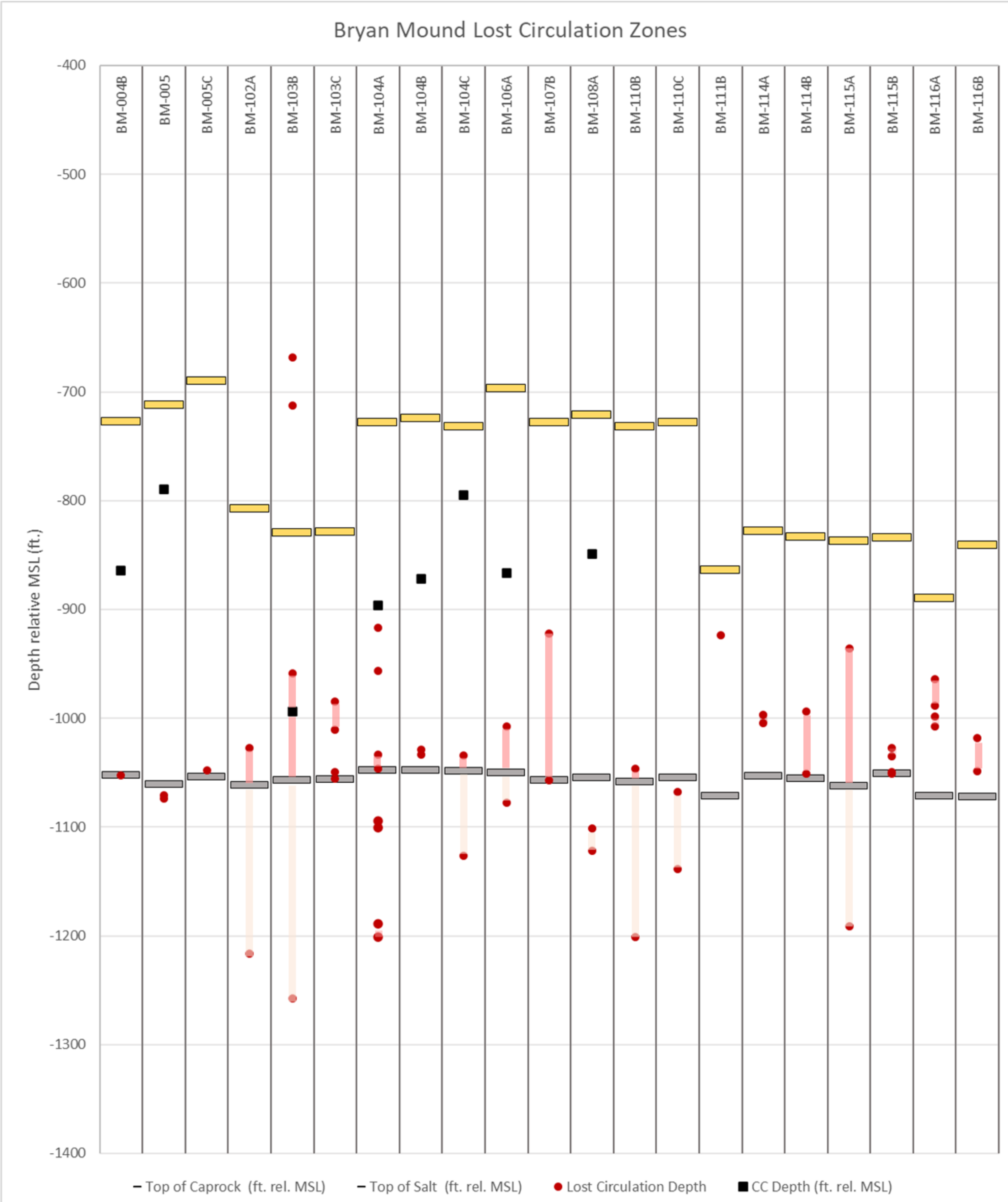

Figure 11. Bryan Mound Lost Circulation Zones. Lost circulation depths are marked in red. Continuous lost circulation zones have been marked with a line between points (depths above the salt-caprock interface are marked in a darker red than those below the interface). The top of salt (grey) and top of caprock (yellow) have also been marked for each well.

Conclusion

Collar restrictions as a result of casing compression have been observed at 24 of the 47 Bryan Mound wells analyzed in this report. While several of these wells have since been lined, the restrictions are still present and deformation is likely ongoing even if they can no longer be seen in recent MAC data because of the liners. The casing compression observed in the Bryan Mound wells is likely linked to the previous sulfur mining that took place in the caprock; however, there are no obvious indications at this time as to why certain wells are experiencing these collar restrictions while others do not. It is likely a result of localized variations in the geology that have been impacted by the sulfur mining operations, in combination with each well's unique response to those geologic forces.

Acknowledgements

The author would like to thank Anna Lord and David Hart for their technical reviews and valuable comments. This work was funded by the U.S. Department of Energy, Office of Cyber Security, Energy Security and Emergency Response (CESER), Office of Petroleum Reserves (PR), Strategic Petroleum Reserve (SPR) project.

References

D'Appolonia. (1980). *Geological site characterization, Bryan Mound Salt Dome,* in R. G. Hogan, *Strategic Petroluem Reserve (SPR) Geological Site Characterization Report: Bryan Mound Salt Dome*, Section II, SAND80711*.*

GOWell. (2020). *BM-116B Enhanced Pipe Detection Tool (ePDT) Well Integrity Log Interpretation.*

Kirby, C. L., & Lord, A. S. (2015). *Sulphur Extraction at Bryan Mound.* Sandia National Laboratories, Albuquerque, NM.

Lord, A. S. (2007). *An Updated Three-Dimensional Site Characterization Model of the Bryan Mound Strategic Petroleum Reserve Site, Texas.* Sandia National Laboratories, Albuquerque, NM.

Maurer, H. (2024). *Bryan Mound Collar Compression Study.* Albuquerque, NM: Sandia National Laboratories.

Roberts, B. L. (2015). *2014 Strategic Petroleum Reserve Bryan Mound Well Integrity Grading Report.* Sandia National Laboratories, Albuquerque, NM

.

Roberts, B. L. (2021). *Revisions to the Strategic Petroleum Reserve Well Grading System.* Sandia National Laboratories, Albuquerque, NM.

Roberts, B. L. (2024). *2024 Update of Comprehensive Review of Multi-arm Caliper Data for the Big Hill SPR Site.* Albuquerque, NM: Sandia National Laboratories.