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SALT DISSOLUTION IN THE SALADO FORMATION (UPPER PERMIAN) AND LAND SUBSIDENCE SOUTH OF IMPERIAL, PECOS COUNTY, WEST TEXAS

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Abstract—Natural dissolution of the Upper Permian Salado salt has occurred at many places in west Texas and southeast New Mexico. At three sites just southwest of Imperial, in west Texas, dissolution of Salado salt in old boreholes is causing the land surface to subside. At one site, subsidence resulted in concentric ground ruptures that extend at least 1000 ft (305 m) from the borehole. This subsidence has required regrading the adjacent highway twice, at a cost of more than $1 million, and now the highway will probably be relocated at a cost exceeding $10 million. At the second site, high-salinity brine is emitted from the borehole and is forming a 62-acre (25-hectare) lake in the shallow subsidence depression. More than 750 L of brine is coming to the surface every minute at this site, and the brine, with a salinity of about 100,000 parts per million (ppm), is also releasing potentially lethal amounts of hydrogen sulfide. Wells at these two sites were initially drilled for oil in the early 1950s, but they were repurposed as water wells when no oil was discovered. The third site, an area of about 100 by 200 ft (30 by 61 m), has subsided at a rate of about 4 in./yr (10 cm/yr). At all three sites, the shallowest significant Salado salt bed is probably about 20–40 ft (6–12 m) thick and at a depth of 850–1050 ft (259–320 m).

INTRODUCTION

A recent study by Kim and Lu (2018) described three sites (herein referred to as Sites A, B, and C) of land subsidence, ground fissures, and the appearance of a new lake that formed above, or adjacent to, abandoned boreholes in an area just southwest of the town of Imperial in Pecos County, Texas (Figs. 1, 2). At Sites A and C, InSAR data show that the ground surface subsided at a rate of about 4 in./yr (10 cm/yr), and at Site B a lake (Boehmer Lake) formed where artesian brine from a borehole is escaping into a large surface depression (Kim and Lu, 2018). The purpose of the current study, which covers about 20 mi^2 (83 km^2), is: (1) to describe the local subsurface geology, especially the thickness, depth, and structure of the Permian Salado Formation and the salt beds that are being dissolved beneath these subsidence features; and (2) to discuss further the land subsidence and problems at these three sites just southwest of Imperial.

Depths and thicknesses on geophysical logs used for this study were all originally recorded in feet; therefore, depths and all other numbers are given in English system (with metric system in parentheses) in this report.

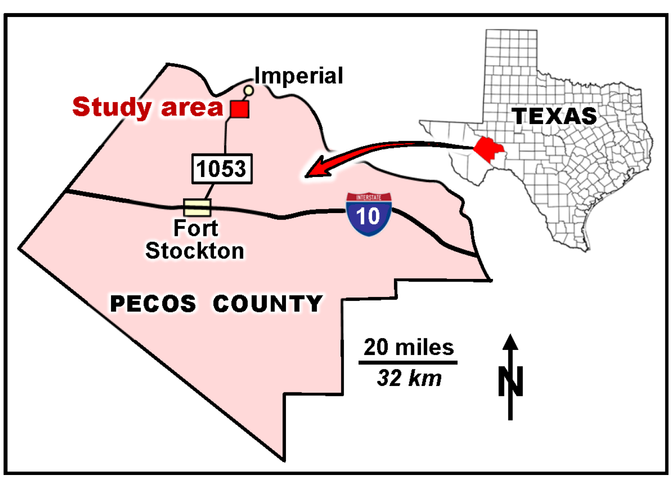

FIGURE 1. Map of Pecos County, west Texas, showing location of study area along Farm-to-Market Road 1053, just southwest of Imperial.

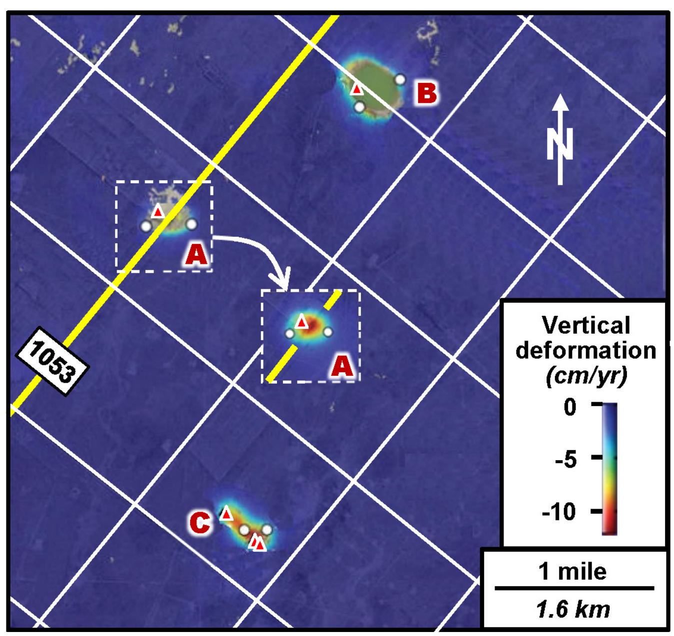

FIGURE 2. Cumulative ground subsidence at three sites (A, B, and C) at, or adjacent to, wells (shown by red triangles) just southwest of Imperial, Texas. Modified from Kim and Lu (2018). Small white dots are sites where deformation data were determined by Kim and Lu (2018). The offset map of Site A shows more clearly the vertical deformation beneath and adjacent to FM 1053. The InSAR acquisition period for the three sites was: Site A, multiple pairs of satellite data within 6 to 12 days; Site B, 2.5 yrs; and Site C, 2.5 yrs (Kim and Lu, 2018).

GEOLOGICAL SETTING AND STRATIGRAPHY

Imperial and the current study area are located on the Central Basin Platform, which separates the Delaware Basin on the west from the Midland Basin on the east (Fig. 3): these major structural provinces are part of the Permian Basin of west Texas and southeast New Mexico. The Upper Permian (Ochoan) Salado Formation is one of eight evaporite units that are part of the Greater Permian Evaporite Basin that extends from west Texas to northern Kansas (Johnson, 2021). The subsurface boundary between the Central Basin Platform and the Delaware Basin is the Capitan Reef, a massive limestone and dolomite reef that fringed the Delaware Basin during Guadalupian (Late Permian) time.

The Salado Formation, the subject of this study, extends westward from the Central Basin Platform over the Capitan Reef and then across the Delaware Basin: the Capitan Reef is in the subsurface about 4 mi (6.4 km) west of the study area (Hiss, 1976). Along some of the eastern part of the Delaware Basin, the Salado directly overlies, or is nearly in contact with, the buried Capitan Reef aquifer, and unsaturated water from the Capitan has migrated upward and dissolved much, or locally all, of the salt in the Salado Formation: this has resulted in development of a large dissolution trough, filled with up to 1800 ft (549 m) of Cenozoic alluvial sediment northwest of the study area (Fig. 3). Whereas this dissolution trough resulted from an upwelling of unsaturated water from the underlying Capitan aquifer, the dissolution of Salado salt in the current study area, and the resultant local trough filled with more than 300 ft (91 m) of Cenozoic sediments, is due to downward migration of meteoric waters. Such downward migration of meteoric waters is also the explanation for the larger sediment-filled trough in the central part of the Delaware Basin (Maley and Huffington, 1953; Fig. 3).

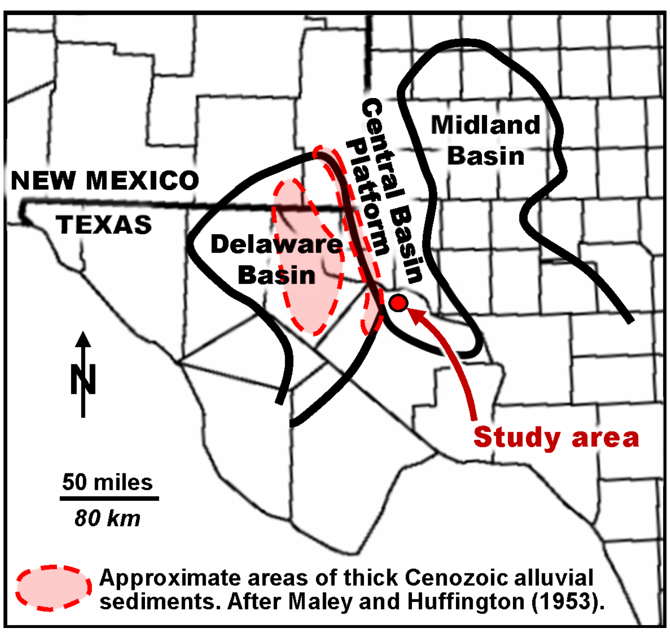

FIGURE 3. Location of study area on the Central Basin Platform in Pecos County, Texas. Map after Keller and others (1980).

Principal stratigraphic units in the study area are, in ascending order, the Upper Permian Tansill, Salado, and Rustler formations (Fig. 4). They are overlain successively by undifferentiated Permian and Triassic red beds and Cenozoic alluvium. On geophysical logs, the Rustler Formation and top of the Salado are readily identified, but the Salado–Tansill contact, and identification of salt units within the Salado, are difficult to identify, except on caliper, sonic, and/or density logs. A total of 26 geophysical logs were used in this study: more logs showing Salado strata are available within the study area, but they lack clear definition of the salt beds and were not used.

ERA	SYSTEM	SERIES	FORMATION
Cenozoic			Alluvium, 200-300 ft (61-91m)
Mesozoic	Triassic		Permian and Triassic red beds, 200-250 ft (61-76 m)
Paleozoic	Permian	Ochoan	Rustler, 150-190 ft (46-58 m)
			Salado, 425-810 ft (130-247 m)
		Guadalupian	Tansill, 150-200 ft (46-61 m)

FIGURE 4. Stratigraphy and thickness of subsurface sedimentary rocks in the study area. Based on data in the current report and in Armstrong and McMillion (1961).

NATURAL SALT DISSOLUTION

The formation of major interest is the Salado Formation, which consists of salt (NaCl, halite) interbedded with anhydrite (or gypsum) and lesser amounts of limestone and red beds (Fig. 5). Dissolution of Salado salt in the area has occurred naturally, probably since early in the Cenozoic Era. Natural dissolution by downward migration of meteoric water here is proven by removal of salt from the upper half of the Salado between wells 1 and 2 (Fig. 5) and even further dissolution of the middle salt beds between wells 2 and 3. The effect of this natural dissolution of Salado salts in a southeasterly direction can be seen clearly in a structural cross section (Fig. 6). The uppermost salt beds are removed first, then the middle salt beds are dissolved, and the lowest salt beds extend farthest to the southeast and underlie the entire study area. Natural dissolution is occurring downward from the top, and the accumulation of thick Cenozoic alluvium above this dissolution zone shows that it was probably going on since long before human settlement—possibly for millions of years.

Natural dissolution is further attested by high concentrations of dissolved solids in ground water in the unconsolidated gravel, sand, silt, clay, and caliche in the overlying Cenozoic alluvium in the study area. Chlorides in the alluvium here range from 1620–5010 ppm (parts per million), sulfates from 1540–3560 ppm, and total dissolved solids from 5020–13,300 ppm (Armstrong and McMillion, 1961): ionic concentrations in the study area are the highest for all ground water samples in the Cenozoic alluvium of Pecos County. In later work, Bumgarner et al. (2012) reported two analyses of water from the aquifer just east of Imperial: samples Q42 and Q43 had 3930 and 4770 ppm chlorides, and 2600 and 3020 ppm sulfates, respectively.

Natural dissolution of Salado salt beds results in significant decrease in thickness of the entire formation to the southeast. In the northwest part of the area, where salt is more fully developed (Fig. 5), the Salado is as much as 810 ft (247 m) thick (Fig. 7). With removal of some, or most, of the salt beds, thickness of the Salado is reduced sharply to the southeast where it is as little as 425 ft (130 m) thick, a decrease in thickness of 385 ft (117 m) within about 6 mi (9.6 km).

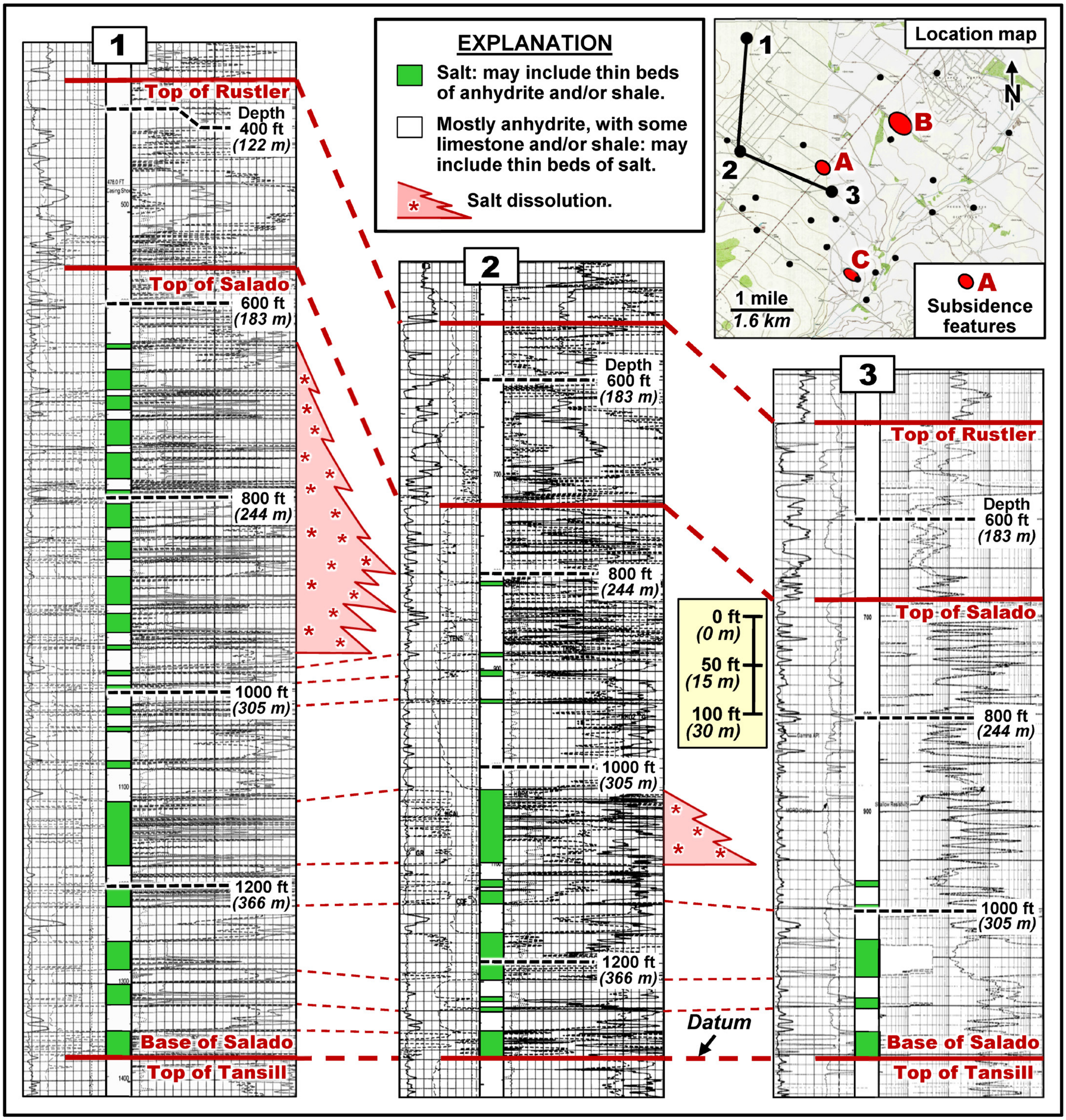

FIGURE 5. Stratigraphic cross section showing natural dissolution of Salado salt southwest of Imperial, Texas. Well 1: Gamma-Ray, Caliper, Neutron, Density log; RIM Operating, Inc., Dickinson, Edward, II-A-#10; sec., 29, Blk. 3, H&TC RR; elev. 2525 ft (743.3 m) (API #42-371-38787). Well 2: Gamma-Ray, Caliper, Neutron, Density log; Hunt Oil Co., Pecos Valley Unit 5-09H; sec. 28, Blk. 3, H&TC RR; elev. 2451 ft (747 m) (API #42-371-37042). Well 3: Gamma-Ray, Caliper, Dual Laterolog log; Browning Oil Co., Inc., Pecos Valley 34 No. 2; sec. 34, Blk. 10, H&GN RR; elev. 2456 ft (748.6 m) (API #42-371-37985).

The depth to anhydrite beds at the top of the Salado Formation ranges from 562–588 ft (171–179 m) in the north to 608–766 ft (185–233 m) in the south (Fig. 8). The highest significant salt beds in the Salado are about 100 ft (30 m) below the top of the formation in the northwest (Fig. 5, well 1), and about 350 ft (107 m) below the top farther south (Fig. 5, well 3). Therefore, in all parts of the area, except in the far northwest, the upper portion of the Salado is dominated by anhydrite (or perhaps by gypsum, if the anhydrite has been hydrated by salt-dissolving water).

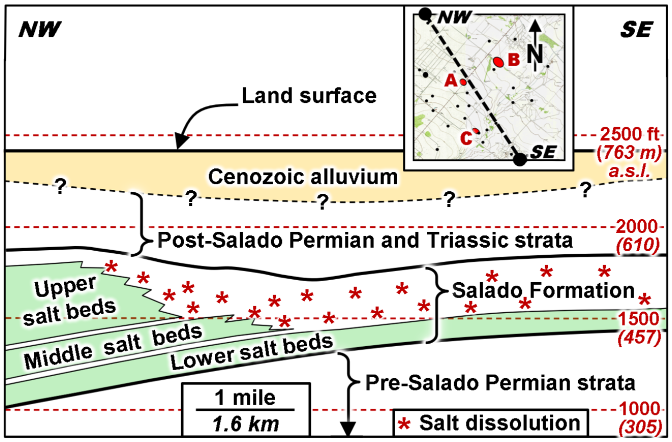

FIGURE 6. Schematic NW to SE structural cross section across study area showing dissolution of Salado salt beds and subsidence of overlying strata into dissolution trough. The upper and middle salt beds of Salado were dissolved from the central and southeast parts of the cross section. Cenozoic-alluvium data generalized from cross section A–A' in Armstrong and McMillion (1961). Interpretation of the Salado and other pre-Cenozoic strata is based on Figure 5 and maps presented in Figures 7–11. Elevations on cross section are in feet (*meters*) above sea level.

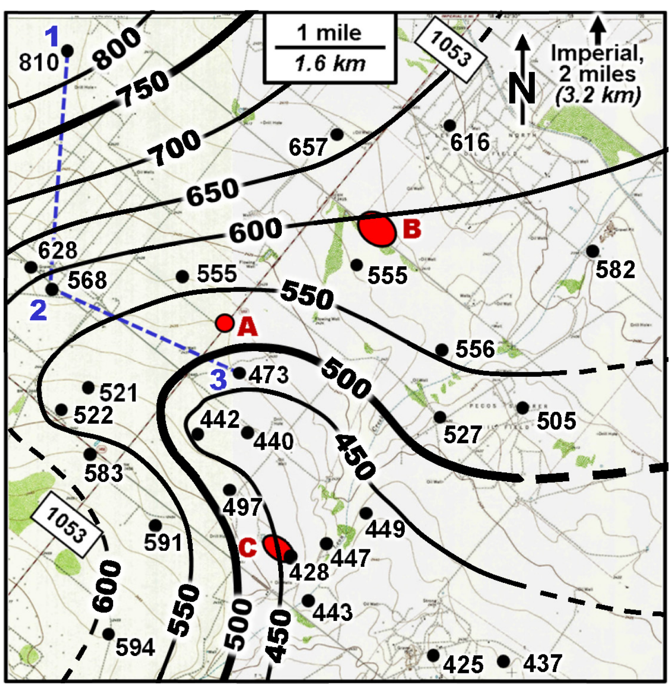

FIGURE 7. Thickness of the Salado Formation southwest of Imperial. Contour interval is 50 ft (15 m).

The depth to the shallowest significant salt bed in the Salado ranges from 668 ft (204 m) in the north to 1070 ft (326 m) in the southwest (Fig. 9): in this report, "significant salt bed" means a salt bed that is at least 10 ft (3 m) thick. As shown in Figure 5, there are, or can be, several beds or zones of salt thinner than 10 ft (3 m) in the upper and middle parts of the

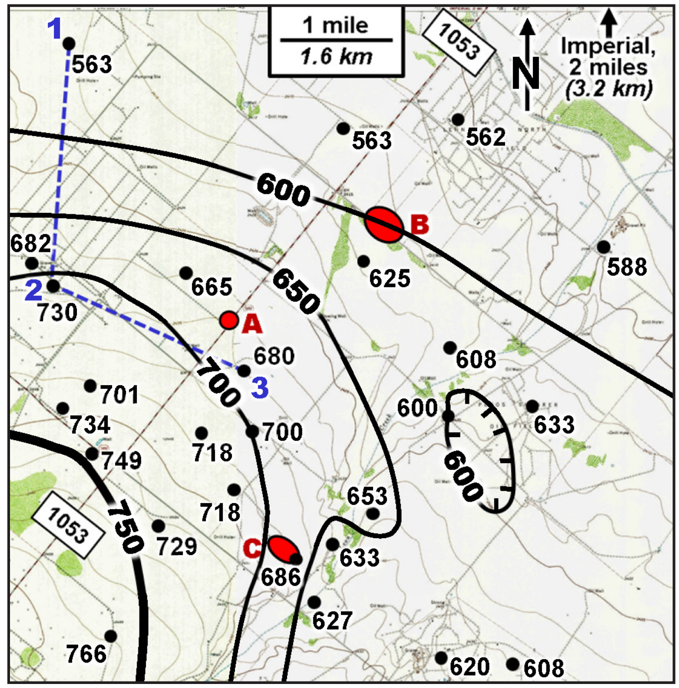

FIGURE 8. Depth to the top of the Salado Formation southwest of Imperial. Contour interval is 50 ft (15 m).

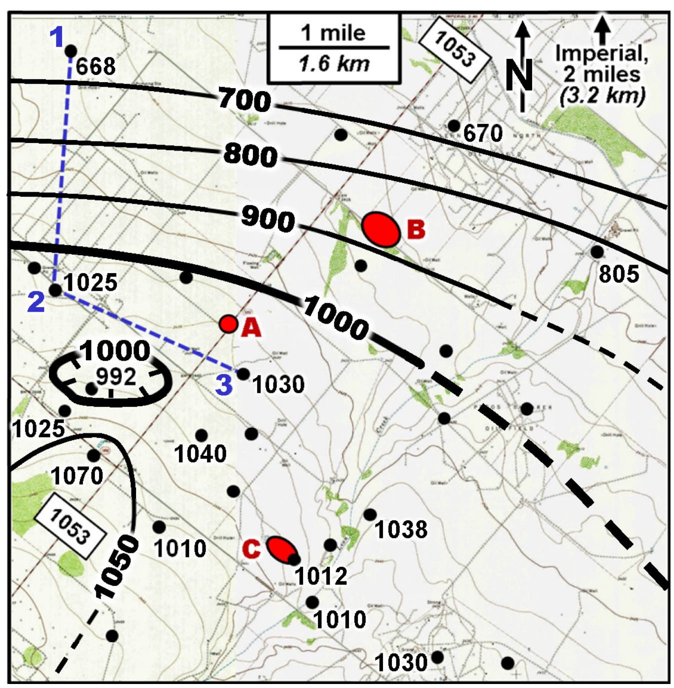

FIGURE 9. Depth to shallowest Salado salt that is at least 10 ft (3 m) thick southwest of Imperial. Contour intervals are 50 and 100 ft (15 and 30 m). Only wells with caliper, sonic, and/or density logs can assure identification of salt beds, so only wells with those logs show depth data on this map.

Salado: dissolution in these thin zones has not removed all the salt—yet. Although there are good data on the depth to the shallowest salt in the vicinity of Site C (Fig. 9), the depth to the shallowest salt beneath Sites A and B is less certain—but it is probably in the range of about 850–1050 ft (259–320 m).

STRUCTURE

Structure maps are presented for the base and the top of the Salado Formation (Figs. 10, 11). Significant differences in the structure at these two horizons are due to natural dissolution of Salado salt and the resulting decrease in thickness of the Salado Formation from 810 ft (247 m) in the northwest to as little as 425 ft (130 m) in the southeast (Fig. 7). There are no highly soluble salts beneath the Salado Formation at this location, so the contour map on the base of the Salado (Fig. 10) should be similar to the structural attitude of underlying strata for at least the next hundred meters or so. It should also be similar to the original structural attitude on top of the Salado before the salt was removed.

Structure on the base of the Salado is a broad, northwest-plunging anticline in the south and central parts of the area (Fig. 10), with the base of the Salado dipping at rates of about 50–150 ft/mi (9.5–28.4 m/km) away from the anticline axis. Overall, the Salado base dips toward the northwest: the elevation of the base drops from 1407 ft (429 m) in the southeast to a low of 1066 ft (325 m) in the northwest.

Structure mapping on top of the Salado Formation shows a much different configuration (Fig. 11). The overall pattern shows that the top dips toward the southwest, with elevations decreasing from 1851–1876 ft (564–572 m) in the north to a low of 1709 ft (521 m) in the southwest. This reversal in overall direction of dip of top-Salado structure, compared to base-Salado structure, results entirely from the thickness variation of the Salado Formation. The thickness variation results entirely from natural dissolution of salt in the Salado.

LAND SUBSIDENCE AT SITES A, B, AND C

Unsuccessful petroleum test wells drilled decades ago in the Imperial area were occasionally abandoned, without being properly plugged, or were repurposed as water wells. Some dry holes drilled into the brackish-water-bearing San Andres Formation, about 1000 ft (305 m) below the Salado Formation, south of Imperial, were left open and repurposed as water wells. Although this water has salinities of about 7000 ppm (total dissolved solids—mostly calcium and sulfate), it could be used to irrigate salt-tolerant crops: normal seawater has a salinity of about 35,000 ppm (mostly sodium and chloride). Some of these repurposed water wells flowed from the San Andres to the surface as artesian wells. Although these wells were originally drilled for oil, when they were repurposed for water production and reclassified as water wells, the Texas Railroad Commission, the state agency that regulates oil and gas activities in Texas, considers that the agency no longer has jurisdiction or authority over the well: hence, no agency assumes the authority or responsibility for plugging these wells at this time.

If a repurposed water well in the area is not maintained, or if an abandoned well is improperly plugged and sealed, then metal casing and pipe in the ground can corrode, and brackish artesian water can come in contact with, and dissolve, some of the Salado salt—thus forming brine and a dissolution cavity. This could lead to subsidence of the land surface above the dissolution cavity and could also cause some of the resulting

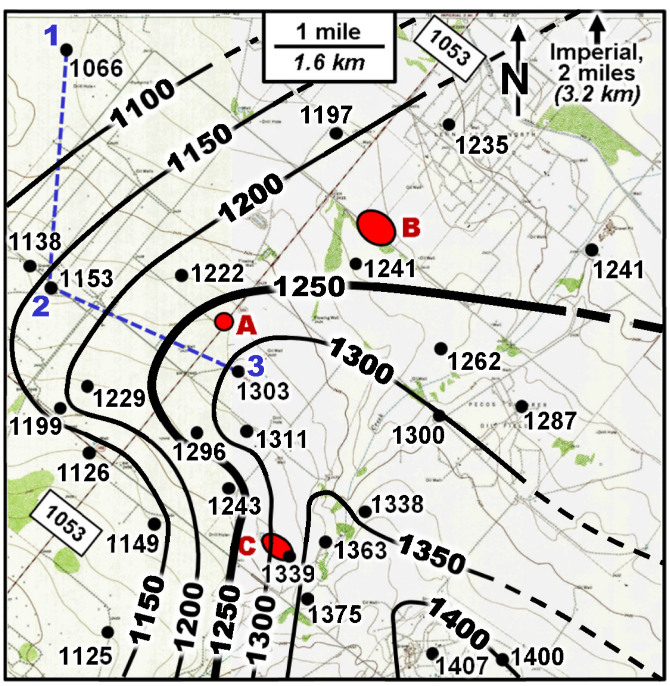

FIGURE 10. Structure-contour map showing elevation of the base of the Salado Formation southwest of Imperial. Contour interval is 50 ft (15 m).

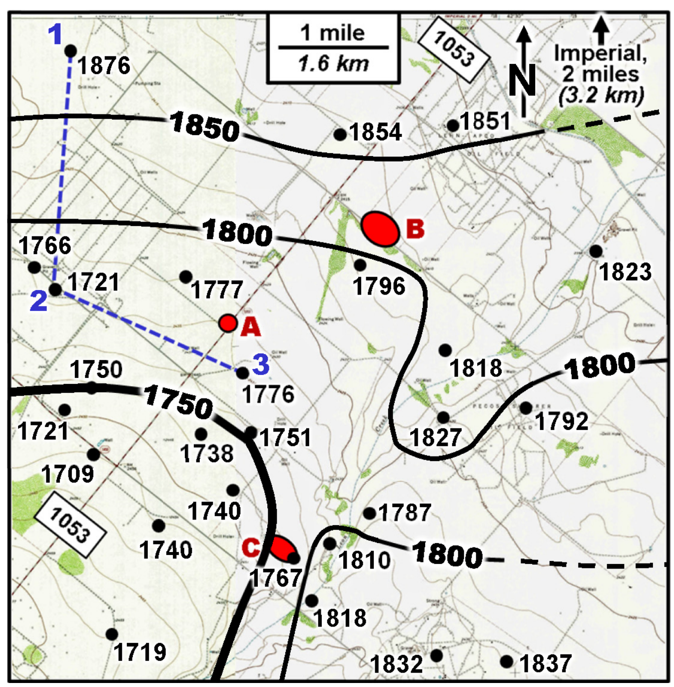

FIGURE 11. Structure-contour map showing elevation of the top of the Salado Formation southwest of Imperial. Contour interval is 50 ft (15 m).

salt-enriched artesian brine to rise through the borehole and reach the land surface. Extreme consequences might include development of sinkholes, where the land surface collapses into salt-dissolution cavities formed at depth, such as the Wink Sinks in nearby Winkler County, Texas (Baumgardner et al., 1982; Johnson, 1989; Johnson et al., 2003; Paine et al., 2021; Kim and Lu, 2021; Trentham and Henderson, 2021), and, in southeast New Mexico, the Jal Sink (Powers, 2003) and the JWS Sink (Land, 2013).

Subsidence at Site A

Site A is located adjacent to Farm-to-Market Road (FM) 1053, and subsidence here has had an adverse impact on the road itself (Figs. 2, 12). The shallowest significant Salado salt here is probably 20–40 ft (6–12 m) thick and at a depth of about 1000–1050 ft (305–320 m; Fig. 9). Kim and Lu (2018) used InSAR data to determine the amount of subsidence at the site. They measured a subsidence rate of about 4 in./yr (10 cm/yr) along the road and found that the area impacted by settling was round-shaped and measured about 1640 ft (500 m) in diameter. This large area of subsidence is attested by concentric ground fractures that extend about 1000 ft (305 m) from the well and pond located in the center of the depression (Fig. 12).

The following history of the abandoned well drilled at the center of Site A, and the subsidence that has occurred here since 2004, is based largely on reports by Malewitz (2017) and Mace (2021). Records are not available, but in 1950 or 1951 a well was drilled on the site to a depth of about 2800 ft (853 m) in search of oil; it has been referred to as the "Holladay well," named for the man who last owned the well. It was a dry hole, but it was kept open for a while as an artesian water well, producing brackish water from the San Andres Formation. Ultimately the well was abandoned and left unplugged.

In about 2004, the land around the well started sinking, and soon it impacted the adjacent FM 1053 by causing the highway

FIGURE 12. Concentric ground fractures extend at least 1000 ft (305 m) out from Site A subsidence feature adjacent to Farm-to-Market Road 1053. Pond at center of depression is about 180 ft (55 m) in diameter and covers about 0.5 acre (0.2 hectare). Location of repurposed Holladay well is shown by red triangle. Photo from Google Earth dated December 2019.

to sink to a dangerous level. In 2008, the Texas Department of Transportation (TxDOT) had the well plugged: the cost was $315,000 (Malewitz, 2017), and a part of the cost was borne by a local water district and development council. The well was plugged only in the upper part of the hole, and San Andres artesian water was still able to rise in the borehole and continue dissolving the Salado salts. Therefore, subsidence around the Holladay well has continued at a rate now estimated at 0.7 in./month (1.9 cm/month). According to aerial photos on Google Earth, artesian water from the Holladay well started forming a pond in the depression between April 2013 and August 2015, and by December 2019 the size of the pond had reached about 0.5 acre (0.2 hectare; Fig. 12).

Because subsidence of the highway made it difficult for drivers to see other vehicles on the road that were in the depression, thus limiting the driver's line of sight, TxDOT has twice raised the subsiding FM 1053 at a cost of about $500,000, and then spent another $500,000 to fix about 1 mi (1.6 km) of the road near the well (Malewitz, 2017). At present, TxDOT is considering rerouting the road to completely bypass Site A. The rerouted FM road would be along Buena Vista Road, about 5 mi (8 km) to the southeast and could cost between $10 million and $15 million (Malewitz, 2017).

Subsidence at Site B

Site B, about 1.5 mi (2.4 km) northeast of Site A, is the location of an abandoned well that has gushed salty water to the land surface and created a new lake, Lake Boehmer, that fills a salt-dissolution depression (Figs. 2, 13, 14). The shallowest Salado salt here is about 20–40 ft (6–12 m) thick and about 850–900 ft (259–274 m) deep (Fig. 9). InSAR data used by Kim and Lu (2018) show that two points on the shore of Lake Boehmer were experiencing subsidence at rates of 0.5 and 0.8 in./yr (1.27 and 2.03 cm/yr), but clearly the central part of the lake must be sinking at a faster rate.

Gold (2021) and Mace (2021) recently discussed the history of subsidence and formation of Boehmer Lake, as well as the history of the well at Site B: the following is based in part on their reports. The well at Site B (the George T. Abell, Sloan Blair No. 1) was drilled for oil to a depth of 2727 ft (831 m) in 1951: it did not produce oil but was repurposed as an artesian water well that yielded brackish water from the San Andres Formation for irrigation. When irrigation at the site ceased, the well was abandoned, but not plugged. About 20 years ago, a significant amount of well water started flowing to the surface, and now the well is emitting more than 750 L of water per minute. But instead of being brackish, the water has a salinity of about 100,000 ppm. Clearly, brackish artesian water from the San Andres is ascending through salt beds of the Salado Formation, is dissolving some of the Salado salt, and is flowing to the land surface as a high-salinity brine.

Casing and/or other metal pipe left in the hole is probably somewhat corroded and is not preventing unsaturated San Andres water from invading the Salado salt beds. Mace (2021) notes that two other wells, about 3500 ft (1067 m) to the north and 5000 ft (1524 m) to the north-northeast of Site B, are also

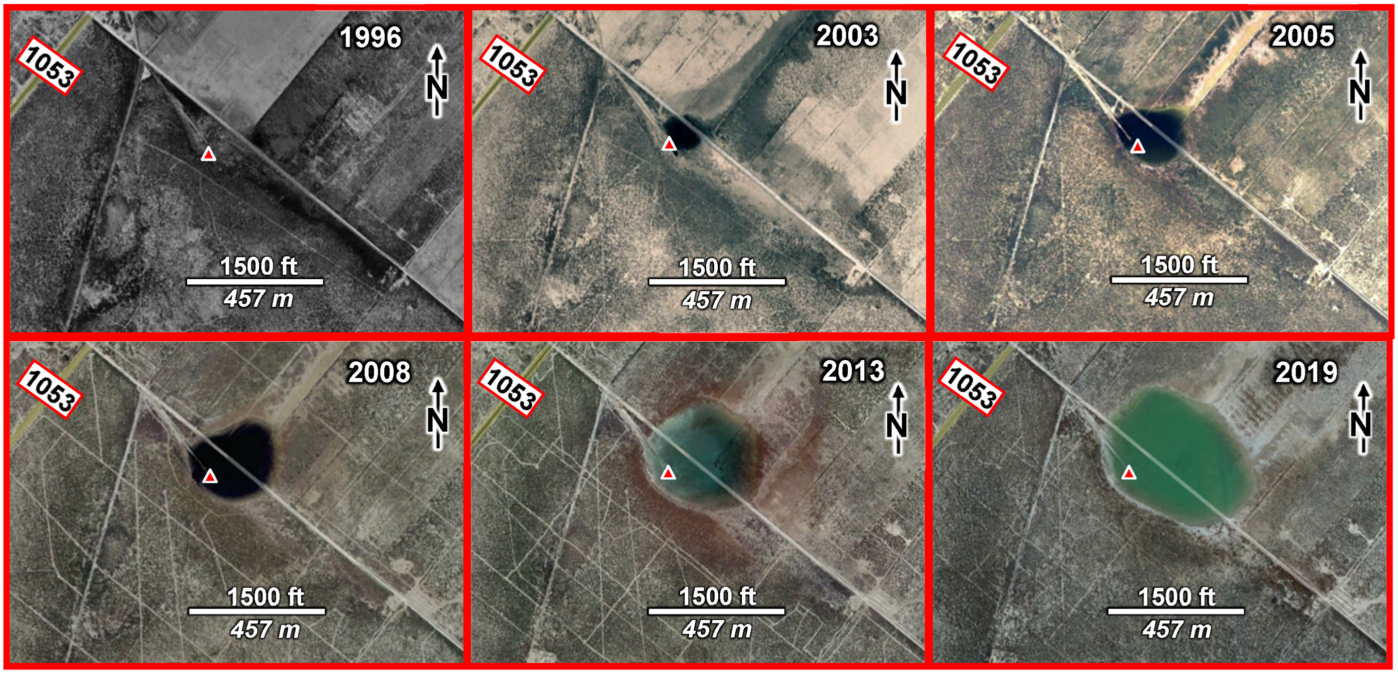

FIGURE 13. History of Lake Boehmer (Site B), which started to form by February 2003 when brine rose to the surface from an abandoned, repurposed water well (shown by red triangle). Water is filling a surface depression that results from dissolution of Salado salt at a depth of about 850–900 ft (259–274 m). Photos from Google Earth.

emitting artesian water at the surface. The water from both wells, with salinities of about 7000 ppm, is most likely coming from the San Andres Formation, and apparently it is not dissolving the Salado salt. There may be other wells in the area that are also emitting brackish artesian water from the San Andres Formation.

Dissolution of Salado salt has led to subsidence of the land surface around the Sloan Blair well at Site B, and, by February 2003, water from the well started forming a small pond at the surface (Fig. 13). After 2003, the land continued to subside, and the pond grew into Lake Boehmer—by December 2019 the lake was 2150 ft (655 m) long by 1575 ft (480 m) wide and covered about 62 acres (25 hectares; Fig. 14). Mace (2021) noted that in 2015 the U.S. Geological Survey found the lake water had a salinity of 94,700 ppm and a chloride content of 53,600 ppm. The high chloride content shows clearly that salt beds are being actively dissolved. A later electrical-conductivity test indicated a brine salinity approaching 125,000 ppm.

An additional problem at Lake Boehmer arose when the Middle Pecos Groundwater Conservation District (MPGCD) sampled air at the Sloan Blair well in February and March 2022 and found that it contained a high level of hydrogen sulfide (H_2S, a hazardous/lethal gas). Because of this potentially hazardous situation, MPGCD installed a gate to prevent public access to the lake. In May of 2022 the Texas Railroad Commission had the water and air at the Sloan Blair well sampled and tested for H_2S. It was determined that air samples contained as much as 110 ppm H_2S and a water sample as much as 57.5 ppm H_2S. For reference, the Occupational Safety and Health Administration (OSHA) of the U.S. Department of Labor recommends that a concentration of 100 ppm is immediately

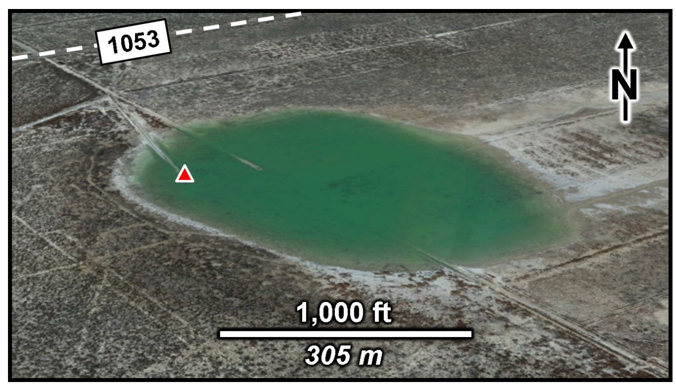

FIGURE 14. By 2019, Lake Boehmer (Site B) was 2150 ft (655 m) long, 1575 ft (480 m) wide, and covered about 62 acres (25 hectares) with high-salinity brine that rose to the subsiding land surface from an abandoned, repurposed water well (shown by red triangle). Oblique photo from Google Earth, dated December 2019.

dangerous to life and health and has the following symptoms/effects: "Coughing, eye irritation, loss of smell after 2-15 minutes (olfactory fatigue). Altered breathing, drowsiness after 15-30 minutes. Throat irritation after 1 hour. Gradual increase in severity of symptoms over several hours. Death may occur after 48 hours" (OSHA, n.d.). Clearly, H_2S adds to the hazardous situation at Site B, and the site should not be visited without appropriate protective gear.

Subsidence at Site C

Site C is another area of subsidence that is located about 1.9 mi (3.1 km) south of Site A (Fig. 2). Kim and Lu (2018), using InSAR data, showed that the land here had subsided at a rate of about 4 in./yr (10 cm/yr) over a period of 2.5 years. The area of subsidence is elongated in a NW–SE direction and measures about 100 by 200 ft (30 by 61 m), with three wells located near the ends of the depression.

Three wells have been drilled within, or adjacent to, Site C. Two wells at the southeast end of Site C were drilled about 50 ft (15 m) apart in 1948 (the Reischman RJ, JPK Campbell No. 3) and in 2003 (the Permian Resources Inc., Campbell B No. 19), and the well at the northwest end (the Aero Gas & Rfg. Co., JKP Campbell No. 2) was drilled in 1938: all three wells were drilled to depths of 1835 ft (559 m), or deeper.

Based on Figure 9, the depth to the shallowest significant salt in the Salado in all three wells is probably 1000–1050 ft (305–320 m) deep, and that salt unit is probably 20–40 ft (6–12 m) thick. It is not clear which of the wells, if any, is related to the subsidence at Site C. It appears that the ground around the Campbell No. 2 well (the northwest well) has had some water on the land surface off-and-on since January 1996 (Google Earth imagery dated January 8, 1996), and this was before one of the southeast wells was drilled. It is possible that the Campbell No. 2 well may have been emitting some artesian water to the land surface from the San Andres Formation since at least 1996, but this has not been field checked.

SUMMARY

Natural dissolution of the Late Permian Salado salt has occurred in the area southwest of Imperial, in Pecos County, west Texas, and the thickness of the Salado has been reduced by about 385 ft (117 m) due to dissolution. This has resulted in accumulation of more than 300 ft (91 m) of Cenozoic alluvium in the overlying dissolution trough, which is similar to the larger dissolution troughs to the northwest in the Delaware Basin, and it shows that natural salt dissolution has gone on for a long time in the area.

Major modern salt-dissolution and land-subsidence problems in the area result from two petroleum tests drilled in the early 1950s (Sites A and B) that did not find oil or gas and were repurposed as water wells that yielded brackish water with salinities of about 7000 ppm. The boreholes were not plugged, and brackish artesian water from the San Andres Formation has now risen to the overlying Salado salt beds: this water has dissolved some of the salt, and the resultant high-salinity brine now emerges from those two boreholes to the land surface.

Salt dissolution has resulted in subsidence of the land around the boreholes, and this has impacted the land surface for up to 1000 ft (305 m) from the Holladay well at Site A. As a result, about $1 million has been spent to repair the adjacent highway, FM 1053, and the cost of rerouting the highway would exceed $10 million. Salt dissolution and subsidence at Site B has resulted in high-salinity brine emerging from the borehole and creating the 62-acre (25-hectare) Lake Boehmer in the depression: the lake has a salinity of 100,000–125,000 ppm. In addition, the well at Site B is emitting H_2S gas to the surface in potentially lethal concentrations of as much as 110 ppm. Three wells were drilled within or adjacent to the subsidence at Site C between 1938 and 2003. There do not appear to be any serious effects of the salt dissolution and subsidence at Site C yet, although artesian water may have come to the surface as early as 1996. It is possible that other unplugged boreholes in the area may allow artesian water from the San Andres to ascend into the Salado salt and create similar salt-dissolution and land-subsidence problems.

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JWS sinkhole, formed by collapse of a brine well operation, northern Eddy Co., NM.