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1993, pp. 211-218. https://doi.org/10.56577/FFC-44.211

in:

Carlsbad Region (New Mexico and West Texas), Love, D. W.; Hawley, J. W.; Kues, B. S.; Austin, G. S.; Lucas, S. G.; [eds.], New Mexico Geological Society 44th Annual Fall Field Conference Guidebook, 357 p. https://doi.org/10.56577/FFC-44

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DISSOLUTION OF PERMIAN SALADO SALT DURING SALADO TIME IN THE WINK AREA, WINKLER COUNTY, TEXAS

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Abstract—The Wink area, on the east edge of the Delaware Basin, was the site of dissolution of Permian Salado salts during Salado time. The Wink area is above the crest of the deeply buried Capitan Reef and is just 2 mi east of a major dissolution trough that contains anomalously thick Late Permian, Triassic and Cenozoic sediments. Salado-age dissolution had not been recognized previously because of the obvious dissolution, collapse and infilling of the nearby dissolution trough during post-Salado time. The Salado Formation is informally divided into eight units, based upon examination of geophysical logs of 47 wells drilled in the four-section study area in Winkler County, Texas. Anomalous local thinning of Salado salt units, accompanied by anomalous thickening of overlying Salado rock units at the same site, is the major evidence of this Salado-age dissolution; anomalously thick local accumulations result from sedimentary filling of depressions created by dissolution and subsidence of underlying salts. Each of the Salado units thins anomalously by 15-50 ft at one or several sites in the area, whereas five of the younger units thicken anomalously by 10-45 ft above the sites of thinning. These thickness anomalies typically occur within horizontal distances of 1000 ft or less.

INTRODUCTION AND GEOLOGIC SETTING

Winkler County and the Wink area are located astride the boundary between the Delaware Basin on the west and the Central Basin Platform on the east (Fig. 1). These major structural provinces are part of the greater Permian Basin of west Texas and southeast New Mexico and each is characterized by a different sequence of Permian strata (Fig. 2). The provinces are separated by the Capitan Reef, a massive limestone and dolomite reef that fringed the Delaware Basin during Guadalupian time. Permian strata younger than the Capitan are Ochoan in age and consist mainly of evaporites of the Castile, Salado and Rustler Formations, overlain by red-bed shales and siltstones of the Dewey Lake Formation. Above the Permian are the Late Triassic Tecovas and Santa Rosa Formations (Dockum Group), which in turn are overlain by Cenozoic alluvium deposited across a large area of the Delaware Basin and Central Basin Platform.

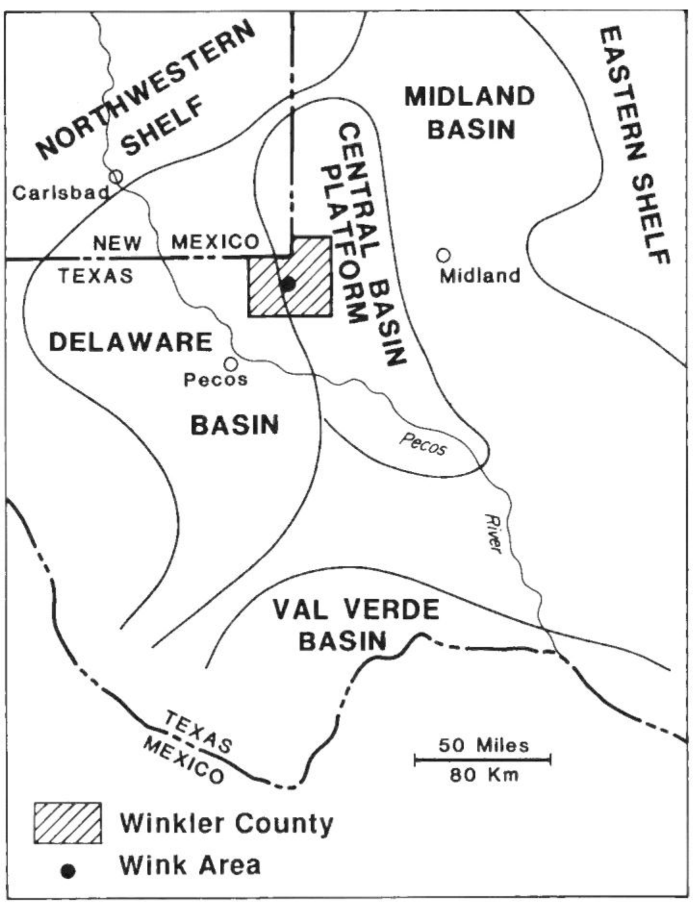


FIGURE 1. Map showing location of the Wink area, Winkler County, Texas.

Natural dissolution of salt beds of the Salado Formation in western Winkler County began during Late Permian time and still may be going on today (Baumgardner et al., 1982). Abnormal thinning and thickening of individual salt units in the Salado, as well as local thickening of each of the overlying formations of Permian, Triassic and Cenozoic age, indicate that this process of dissolution and subsidence has occurred intermittently in the Wink area and began even before the end of Salado deposition.

System	Series	Delaware Basin	Central Basin Platform	
Quaternary		Alluvium	Alluvium	
Triassic		Santa Rosa Tecovas	Santa Rosa Tecovas	
Permian	Ochoa	Dewey Lake Rustler Salado Castile	Dewey Lake Rustler Salado	
	Guadalupe	Delaware Mountain Group: Bell Canyon Cherry Canyon Brushy Canyon	Capitan Reef	Artesia Group: Tansill Yates Seven Rivers Queen Grayburg San Andres Glorieta

FIGURE 2. Stratigraphic section of Permian and younger strata in Winkler County (after Baumgardner et al., 1982).

This report focuses on subsurface evidence of natural dissolution of Salado salt units in the Wink area during Salado time. The study area comprises four sections (4 mi^2) of land about 2 mi north of the town of Wink (secs. 34, 35, 40 and 41 in Block B-5 of the Public School Land Survey). Within the study area, which is part of the Hendrick oil field, 227 petroleum tests and other boreholes have been drilled, mostly during the oil-boom years of 1926-1930. Oil production is mainly from the Yates Formation, with some from the overlying Tansill Formation. Geophysical logs suitable for correlation of units within the Salado are available for 47 of the 227 wells.

This report therefore is based upon an abundance of data points in a relatively small area. It summarizes data presented by Johnson (1986) in a study of a collapse feature, the Wink Sink, which formed in 1980 as a result of dissolution of Salado salt (Baumgardner et al., 1982; Johnson, 1987).

LOCAL STRATIGRAPHY AND STRUCTURE

The stratigraphy and structure within the four-section study area are important in documenting local dissolution in the Salado Formation. The Salado is a thick sequence of interbedded salt (halite) and anhydrite. The formation ranges from about 1315 ft thick in the northeast to about 575 ft thick in the northwest (Fig. 3). Individual anhydrites typically are 10-50 ft thick, whereas the intervening salts commonly are 10-100 ft thick. Variations in thickness of the Salado Formation and of individual salt units are largely due to dissolution of one or more of the salt units during Salado and post-Salado times. The depth to the top of the Salado in the Wink area ranges from about 900 ft in the east to about 1600 ft in the west. For this study, the Salado Formation was informally subdivided into eight units (Fig. 4). This subdivision utilized the same anhydrite marker beds as shown in the cross sections of Baumgardner et al. (1982).

Structure-contour maps below and above the Salado Formation help to show that the causes and effects of some thickness anomalies in Salado units are restricted within the Salado Formation. The first map (Fig. 5A), contoured on the base of the Tansill Formation, shows structures beneath the Salado salts. A structural high over the Capitan Reef separates an eastward dip of 25 ft/mi from a westward dip of about 500 ft/mi. The steeper westward dip reflects the steeply sloping face of the reef (Fig. 6) and is not related to salt dissolution.

The second structure map (Fig. 5B), contoured on top of the Rustler Formation, represents structures above the Salado salts. The Rustler dips westward across the Wink area, 200-300 ft/mi east of the reef crest, and 400-500 ft/mi west of the reef. Locally, in the north, the Rustler dips about 1500 ft/mi. The steeper Rustler dips west of the reef mainly resulted from dissolution of the underlying Salado salts (Garza and Wesselman, 1959; Hiss, 1976; Baumgardner et al., 1982); as salt was dissolved during Late Permian and post-Permian times, the overlying Rustler subsided or collapsed to fill available space. This general westward dip extends another 2 mi west of the study area, to the axis of a major "dissolution trough" (Fig. 6).

DISSOLUTION OF SALADO SALTS

There is overwhelming evidence that Salado salts have been partly dissolved by natural processes in and near the Wink area and the principal conclusion of the current study is that at least some of the dissolution took place during Salado time. Abnormal and abrupt thinning of salt units, with concurrent thickening of overlying rock units above the same site, is the major proof for this natural dissolution. The dissolution has been episodic in various parts of the Wink area; it began as early as Salado time and then recurred during later Permian, Triassic and Cenozoic times. Some natural dissolution of Salado salts still may be occurring, but there is no evidence to confirm or refute this.

The Salado Formation consists chiefly of salt, with lesser amounts of anhydrite and minor amounts of dolomite and shale. Where salt

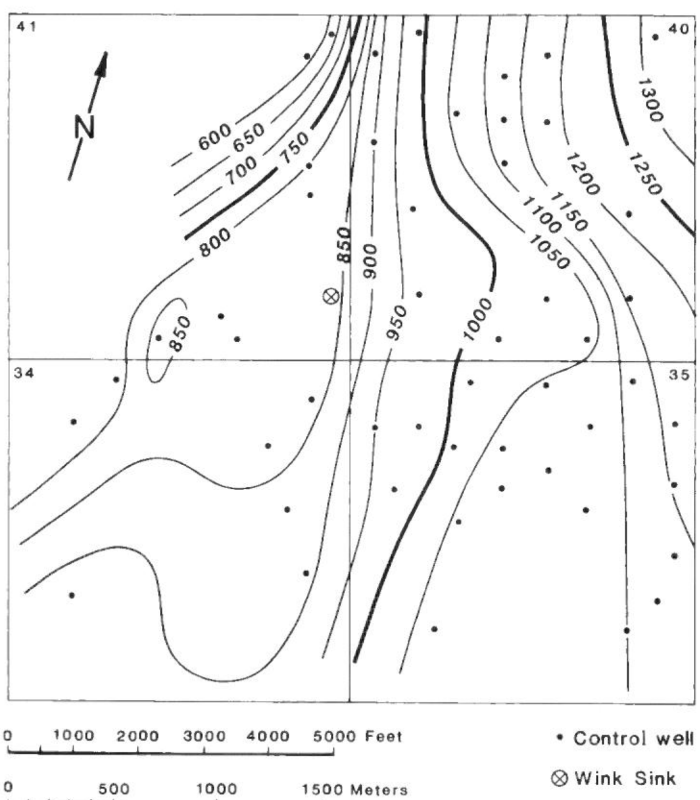


FIGURE 3. Thickness of Salado Formation in the Wink area; contour interval is 50 ft (15 m).

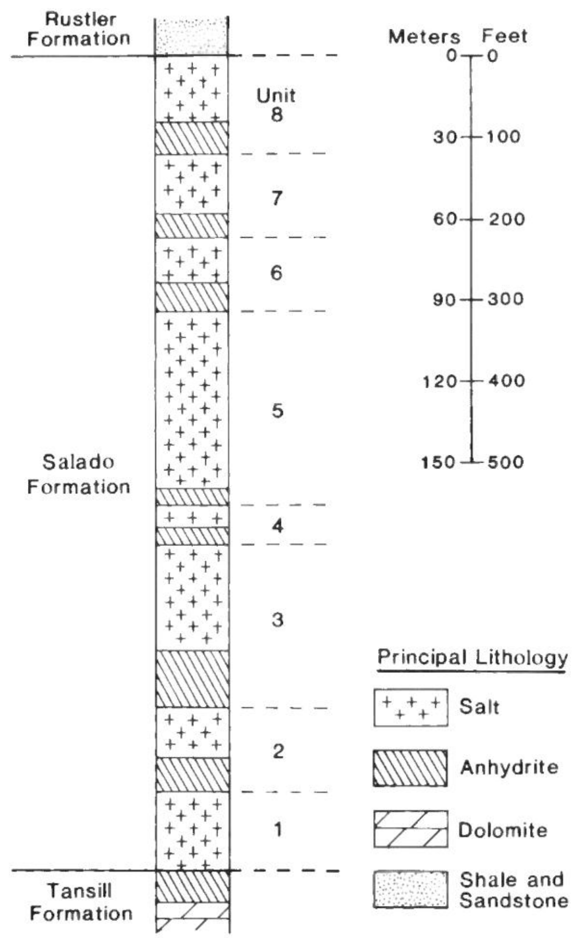


FIGURE 4. Generalized columnar section of Salado Formation in the Wink area; Salado is informally subdivided into 8 units.

dissolution has occurred, the stratigraphic section equivalent to the original salt-bearing strata is thinner by an amount essentially equal to the thickness of salt layers that have been removed. Salado strata originally were deposited uniformly over great distances and abrupt thinning of the salt units in most salt areas (including western Winkler County) clearly results from dissolution of the salt, either syndepositionally or sometime after its deposition (Adams, 1944; Maley and Huffington, 1953; Bachman, 1976; Kirkland and Evans, 1976; Anderson et al., 1978; Mercer and Hiss, 1978; Powers et al., 1978, 1990; Anderson and Kirkland, 1980; Johnson, 1981, 1987; Baumgardner et al., 1982; Lambert, 1983; Holt and Powers, 1990; Hovorka, 1990). In other geologic settings, such abrupt thinning might result from rapid facies changes along a basin margin, or from creep or flowage of salt due to subsequent loading or tectonic movements. None of these explanations has been suggested for the Wink area by earlier workers, nor are they supported by evidence from this study. Castile Formation salts in nearby parts of the Delaware Basin have depositional pinchouts and locally are thin and thick as a possible result of tectonics, slumping and gravity foundering (Hovorka, 1990; Powers et al., 1990). The Castile, however, has bed thicknesses, loading history and facies relationships that are markedly different from those of the Salado.

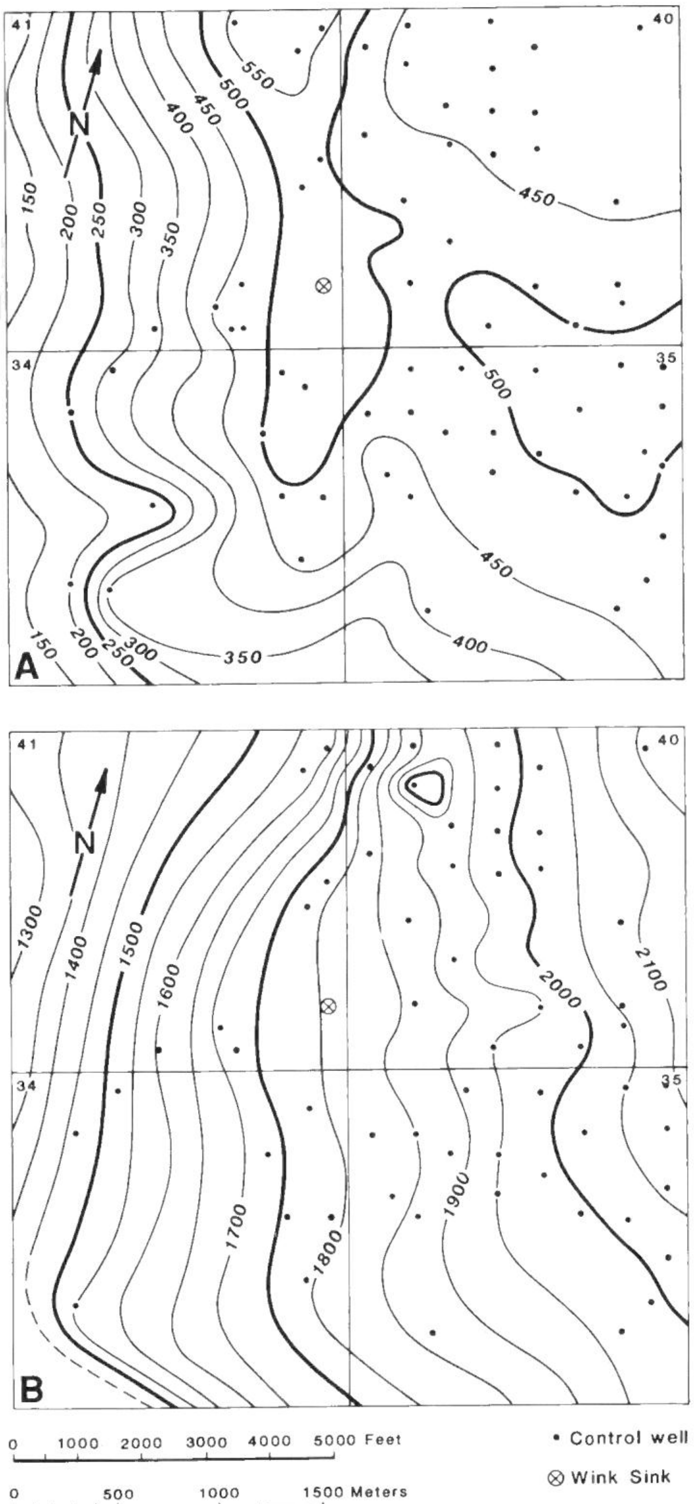


FIGURE 5. Structure-contour maps on base of Tansill Formation (A) and top of Rustler Formation (B) in the Wink area (modified from Baumgardner et al., 1982). Contour interval is 50 ft (15 m); datum is sea level.

Salado salt units, as herein defined (Fig. 4), consist of salt zones that each have a persistent basal anhydrite zone. The lowest unit, however, consists only of a salt zone, because the underlying anhydrite is considered part of the Tansill Formation. The base of each unit can be recognized readily on most geophysical logs and can be correlated from well to well within the study area (Fig. 7). Although the precise lithology and thickness of individual beds within each unit are not easily determined in most of the well logs, they can be fairly well determined in seven key wells within the four-section study area (Table 1). For these seven key wells, sonic logs (for six wells) and neutron-porosity logs (for one well) are available. These logs are significantly more reliable for distinguishing between salt, anhydrite and shale than are the gamma ray/neutron logs available for the remaining wells in the area. Because precise lithologic data were available for only 7 of the 47 wells, it was necessary to map only the gross thickness of each unit (Fig. 8).

Gross-thickness data for Units 1-8 (Fig. 8) indicate the areas and ages in which salt dissolution probably occurred, because it is the salt layers (not the anhydrite or shale layers) within each unit that are markedly variable in thickness. Abrupt local thickening of one of the younger salt units probably represents a thick accumulation of sediment in a depression created by dissolution and subsidence of an underlying (older) salt unit in Salado time, just prior to, or during, deposition of the younger unit (Fig. 7). On the other hand, if one or more lower salt units are markedly thin locally, due to dissolution, and none of the overlying Salado units is thicker above the dissolution site, then it indicates that dissolution at that site did not occur during Salado time but at some post-Salado time.

Hovorka (1990) and Powers et al. (1990) showed that the Salado was deposited as extensive shallow-water evaporites and mudstones that were exposed intermittently. The shallow-water evaporites accumulated up to sea level and thus a thicker evaporite section was built up in depressions formed by dissolution and collapse. Intermittent exposure of the evaporite flats caused synsedimentary dissolution of some of the salt and it also provided a source of undersaturated water that could circulate down to underlying salts and cause dissolution.

Unit 1

Unit 1, at the base of the Salado Formation, consists mainly of salt. The unit lacks a basal anhydrite, but it contains several anhydrite beds that range in thickness from 2-10 ft and in aggregate are 20-30 ft thick in the key wells. The main anhydrite is about 20 ft above the base of the unit (Fig. 7). The principal thickness trends in Unit I are the marked thinning westward across the study area and several thick and thin local anomalies scattered throughout the area (Fig. 8A).

TABLE 1. List of seven key wells in study area for which sonic logs and neutron-porosity logs are available.

Operator	Lease and Well No.	Location
Worth Exploration Co.	Hendrick 1-A	NW¼ NE¼ NW¼ sec. 34
Worth Exploration Co.	Hendrick 2-A	SE¼ NE¼ NW¼ sec. 34
Pan American Petroleum Corp.	Hendrick-Weeks 3	SE¼ SW¼ NE¼ sec. 35
Pan American Petroleum Corp.	Hendrick T-89-C 6	NW¼ SE¼ SE¼ sec. 35
Westbrook Oil Corp.	T. G. Hendrick 1-A	C W½ NW¼ NE¼ sec. 40
Pan American Petroleum Corp.	Hendrick T-89-E 5	NW¼ NE¼ NE¼ sec. 40
Monsanto Co.	T. G. Hendrick 9	SE¼ SW¼ SE¼ sec. 41

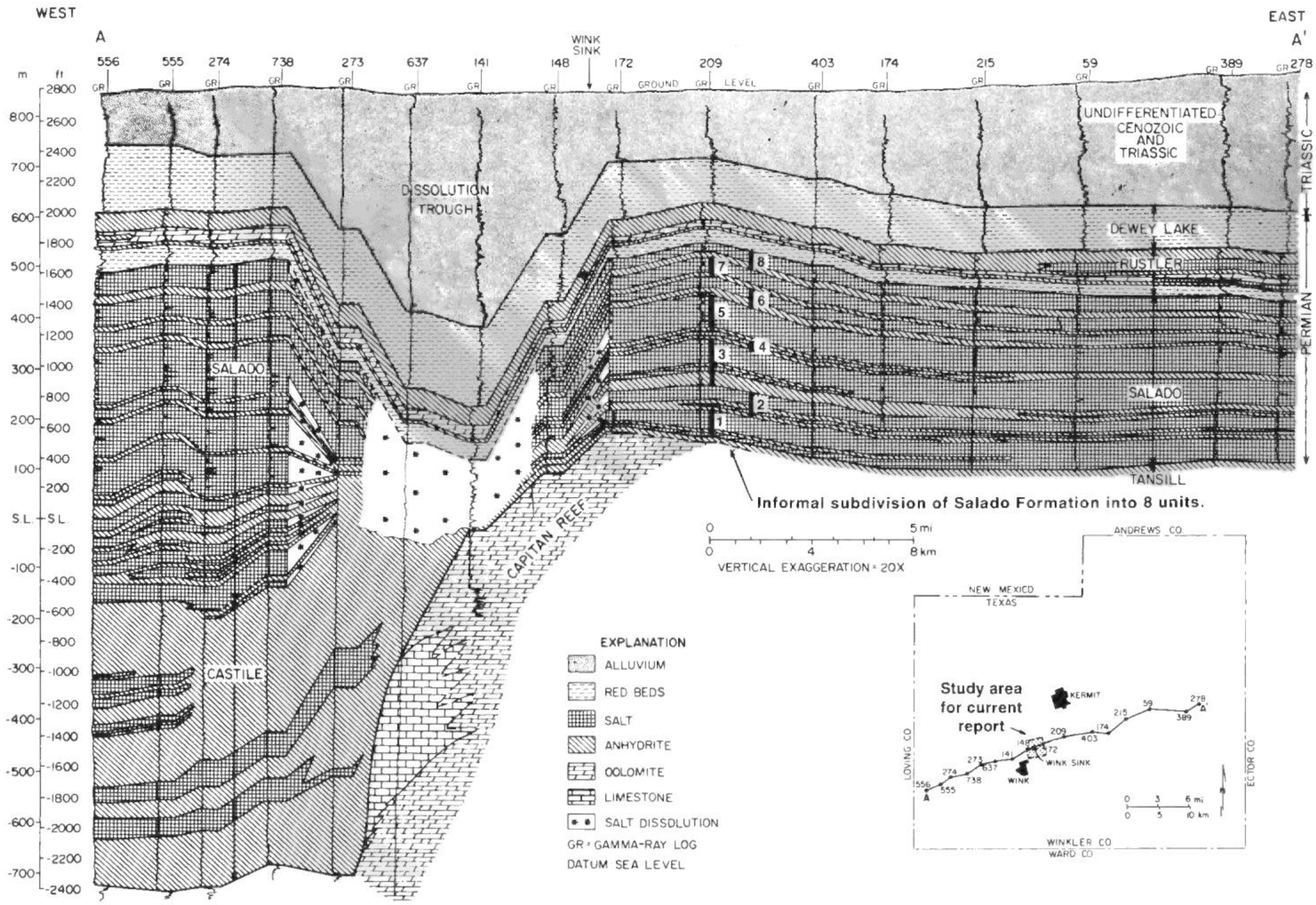


FIGURE 6. Regional east-west cross section A–A′ through the Wink area (modified from Baumgardner et al., 1982). Capitan Reef separates Delaware Basin (on left) from Central Basin Platform (on right); dissolution trough resulted from Late Permian through Cenozoic dissolution of Salado salts.

Progressive westward thinning of Unit 1 in the Wink area is most likely due to partial dissolution of salt beds approaching the main dissolution trough just to the west (Fig. 6). Support for this conclusion is the rather uniform thickness (150-200 ft) of Unit I in the nondissolution region that extends at least 15 mi east of the Wink area (Fig. 6). Local thickness anomalies within the study area probably resulted mainly from local variations in the rate or extent of salt dissolution. Inasmuch as Units 3, 4, 6, 7 and 8 are locally thicker above a large dissolution trough in the northeast part of sec. 34 and adjacent sections, or above a similar dissolution zone in the north-central part of sec. 35, it is likely that some of the dissolution of Unit 1 occurred in Permian (Salado) time just prior to, or during, deposition of Units 3, 4, 6, 7 and/or 8.

Unit 2

Unit 2 consists of a lower anhydrite zone and an upper zone that typically is interbedded salt and anhydrite. The lower anhydrite commonly is 35-50 ft thick in the key wells, whereas the upper salt zone typically is 40-100 ft thick. The upper zone generally is about half salt and half anhydrite in the eastern half of the area, but is almost entirely salt in the west. Unit 2 is 40-160 ft thick in the Wink area (Fig. 8B) and is uniformly 140-160 ft thick for about 15 mi farther east (Fig. 6).

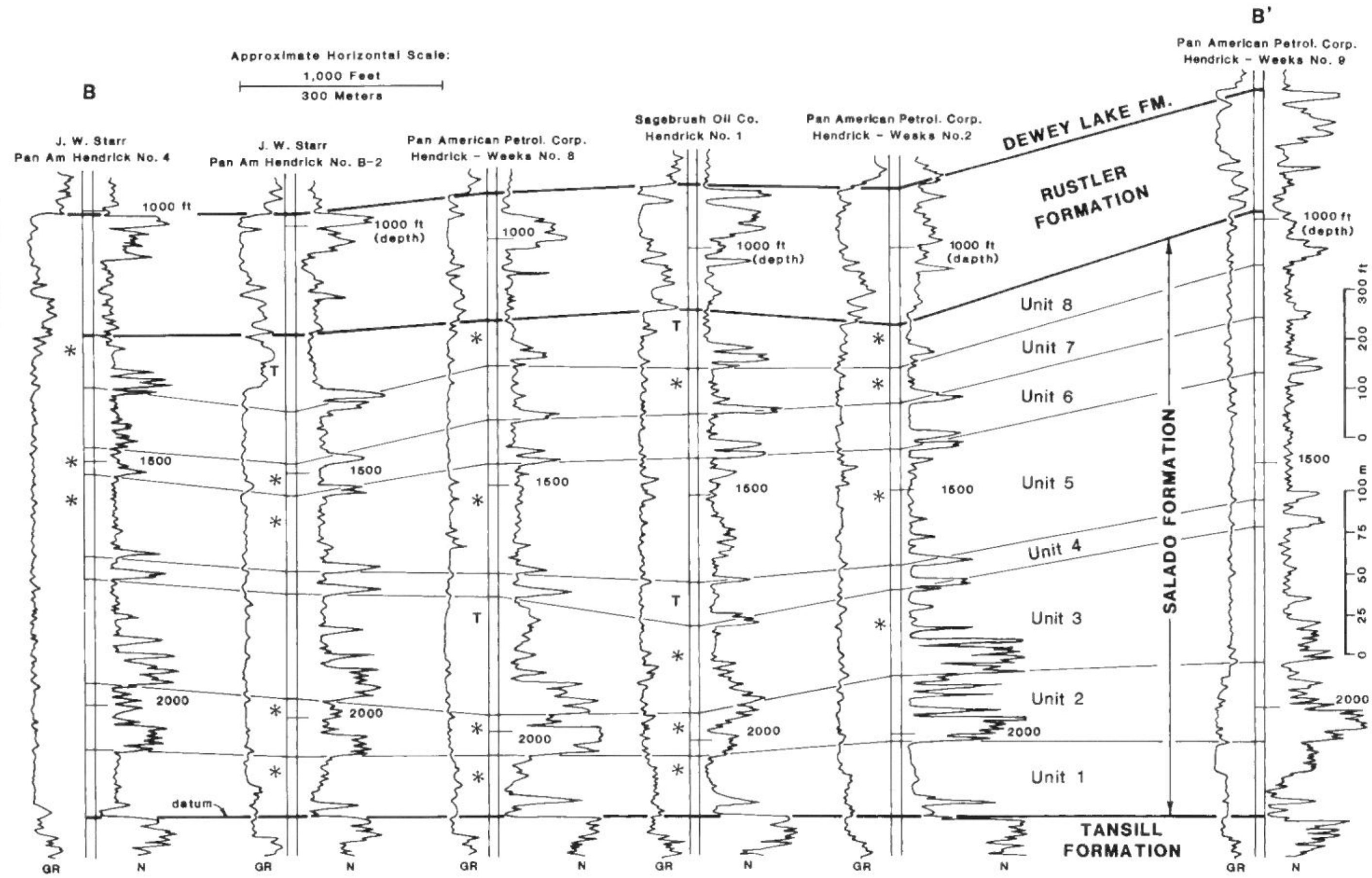
Extensive dissolution of salts in Unit 2 has occurred in several locations. One is along the western margin of secs. 41 and 34, reflecting proximity to the main dissolution trough just to the west, insofar as salt makes up only a small part of Unit 2 in the northeast part of sec. 41 and is totally absent from Unit 2 in the northwest part of sec. 34. A second is along the section line between secs. 35 and 40, where Unit 2 lacks salt and is 40-50 ft thinner in this elongate, trough-like area, than just to the north or south where Unit 2 contains about 30-50 ft of salt. In the central part of sec. 40 and the east-central part of sec. 35 Unit 2 is about 15-20 ft thinner and contains less salt than in nearby wells.

At least some of the Unit 2 salt dissolution apparently occurred during Salado time. Units 3, 4, 6 and 8 are each abnormally thick at one or more locations above the dissolution trough between secs. 35 and 40, and Unit 3 also is somewhat thicker above the sites where Unit 2 is abnormally thin in the center of sec. 40 and east-central sec. 35. This suggests that several episodes of Unit 2 dissolution occurred in the area before, or during, deposition of Units 3, 4, 6 and/or 8.

Unit 3

Unit 3 consists of a lower zone of anhydrite and an upper zone that is mainly salt. In the key wells, the lower anhydrite is 70-100 ft thick in the east and 20-50 ft thick in the west. The upper zone generally is 100-175 ft thick in the east and 30-80 ft thick in the west; it consists mainly of salt, but also contains several anhydrite and shale interbeds 5-10 ft thick. Unit 3 thins westward from 330 ft to 110 ft (Fig. 8C) and remains 250-300 ft thick for another 15 mi farther east (Fig. 6).

Major evidence of salt dissolution is the marked thinning to the west toward the dissolution trough. Superimposed on this trend is an east-west elongated area, in the southern part of secs. 40 and 41, where the salt thickness and total thickness are 30-75 ft less than at nearby lo-



∗= Anomalously thin unit: most likely due to dissoution of salt within unit.

T= Anomalously thick unit: most likely due to thicker accumulation of sediment in a dissolution depression formed just prior to or during depostion of thicker unit.

FIGURE 7. North-south stratigraphic cross section B–B′ showing correlation of Salado salt units in the Wink area; location of cross section is shown in Fig. 8.

calities. Because overlying Units 4, 7 and 8 are abnormally thick locally above this elongate dissolution area, it is possible that at least some of the Unit 3 dissolution occurred before, or during, deposition of Units 4, 7 and/or 8.

At several locations, Unit 3 is anomalously thick where the underlying Units **I** and 2 have been partly dissolved (Fig. 7). This apparently resulted from partial dissolution of Units 1 and/or 2 salt prior to, or during, Unit 3 deposition, thereby allowing for greater accumulation of Unit 3 sediments in the depressed areas where salt was removed. This occurs in the north-central part of sec. 35, where Unit 3 is 1040 ft thicker than in nearby wells and also in the center of sec. 40 (the thickness line is deflected to the west) and east-central sec. 35, where Unit 3 is about 10 ft thicker than in nearby wells.

Unit 4

Unit 4 consists of a basal anhydrite, 15-25 ft thick and an upper salt zone that is 20-30 ft thick in the key wells. At the top of the salt zone is a persistent shale bed 5-10 ft thick. Unit 4 is remarkably uniform in thickness; it is 30-55 ft thick in most of the Wink area (Fig. 8D) and is 40-50 ft thick for another 10 mi farther east (Fig. 6).

Unit 4 has not been dissolved to any significant degree at any place in the study area. Salt is present in all the wells and the rate of change of salt thickness between wells is gradual at almost all locations. The minimum thickness of Unit 4 is in the northeast part of sec. 41, probably due to partial dissolution of salt near the main dissolution trough farther west.

The only anomalous thickness is in the south-central part of sec. 40, where Unit 4 is 90 ft thick and consists of 25 ft of basal anhydrite, overlain successively by 60 ft of salt and 5 ft of shale. This thick deposit of Unit 4 overlies dissolution troughs in Units 2 and 3 (Fig. 7) and it is likely that some of the dissolution in Units 2 and/or 3 occurred just prior to, or during, deposition of Unit 4. Slight thickening (by about 10 ft) of Unit 4 in three wells on the east side of secs. 34 and 41 also may have resulted from minor dissolution of salt in Units **I,** 2 and/or 3 just prior to, or during, Unit 4 deposition.

Unit 5

Unit 5 is the thickest salt zone of the Salado Formation in the Wink area. The unit consists of a basal anhydrite, 15-20 ft thick and an upper salt zone 100-250 ft thick throughout the area. The zone is mainly salt, but it contains several shale and anhydrite beds 5-10 ft thick. Unit 5 is 120-280 ft thick in the Wink area (Fig. 8E) and is about 200 ft thick for 15 mi to the east (Fig. 6).

Evidence of salt dissolution in Unit 5 consists mainly of abrupt thinning along the west side of sec. 40 and in the northwest part of sec. 35; this most likely is related to the main dissolution trough farther to the west. Also, Unit 5 is about 30 ft thinner in the south-central part of sec. 40 than in nearby wells.

The anomalous thickening of Unit 5 in south-central sec. 41 is difficult to explain. Logs of Unit 5 in the three wells where the unit is thicker are difficult to interpret and there is no control to the west and northwest that could aid in the interpretation. This area may contain a thick remnant of salt, only slightly affected by dissolution, or perhaps the complexity results from proximity to the main dissolution trough, 1 or 2 mi farther west. This may also be a location where Unit 5 is thick due to partial dissolution of Units 1, 2 and/or 3 just prior to, or during, deposition of Unit 5; however, this is not the preferred interpretation.

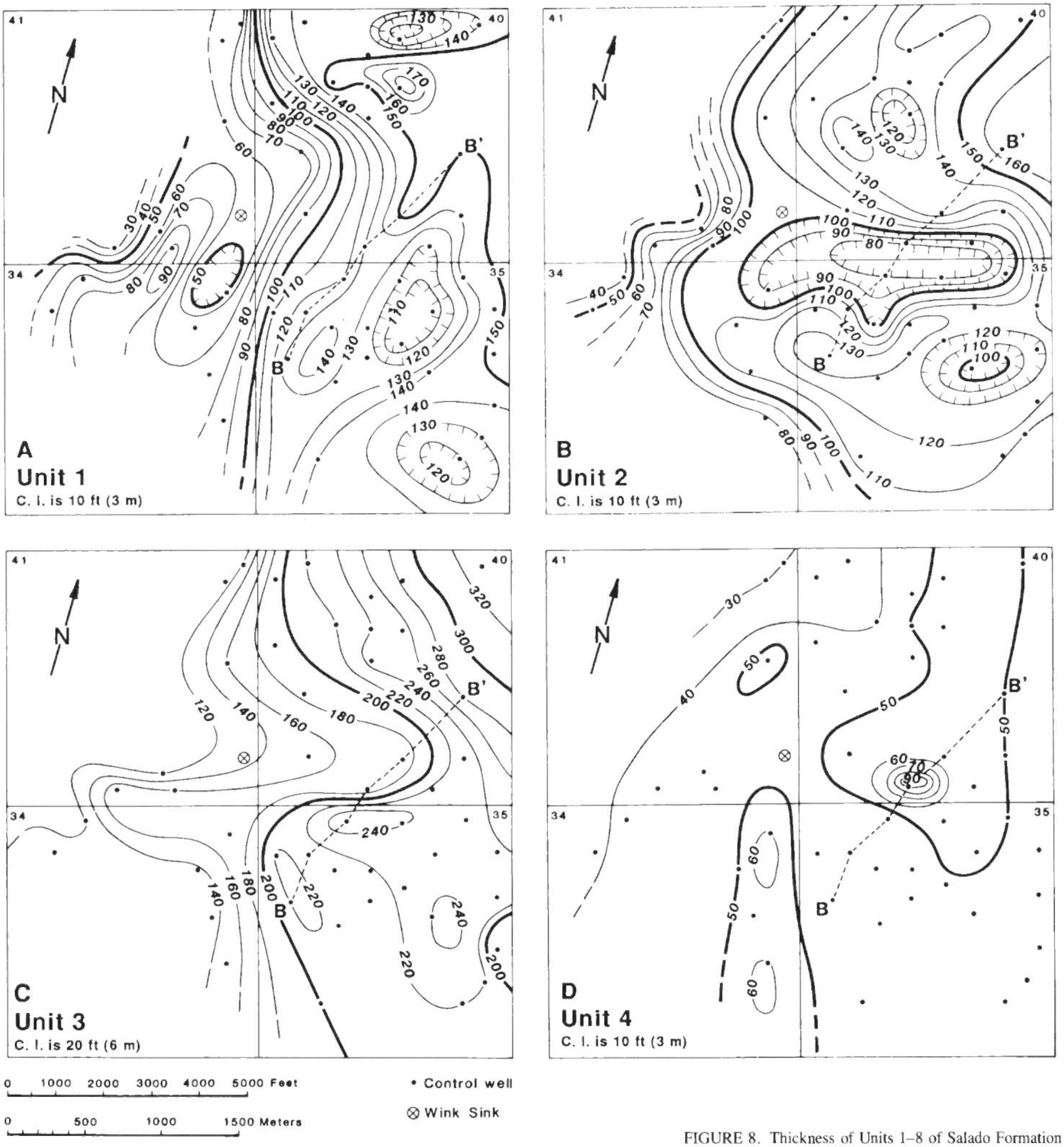


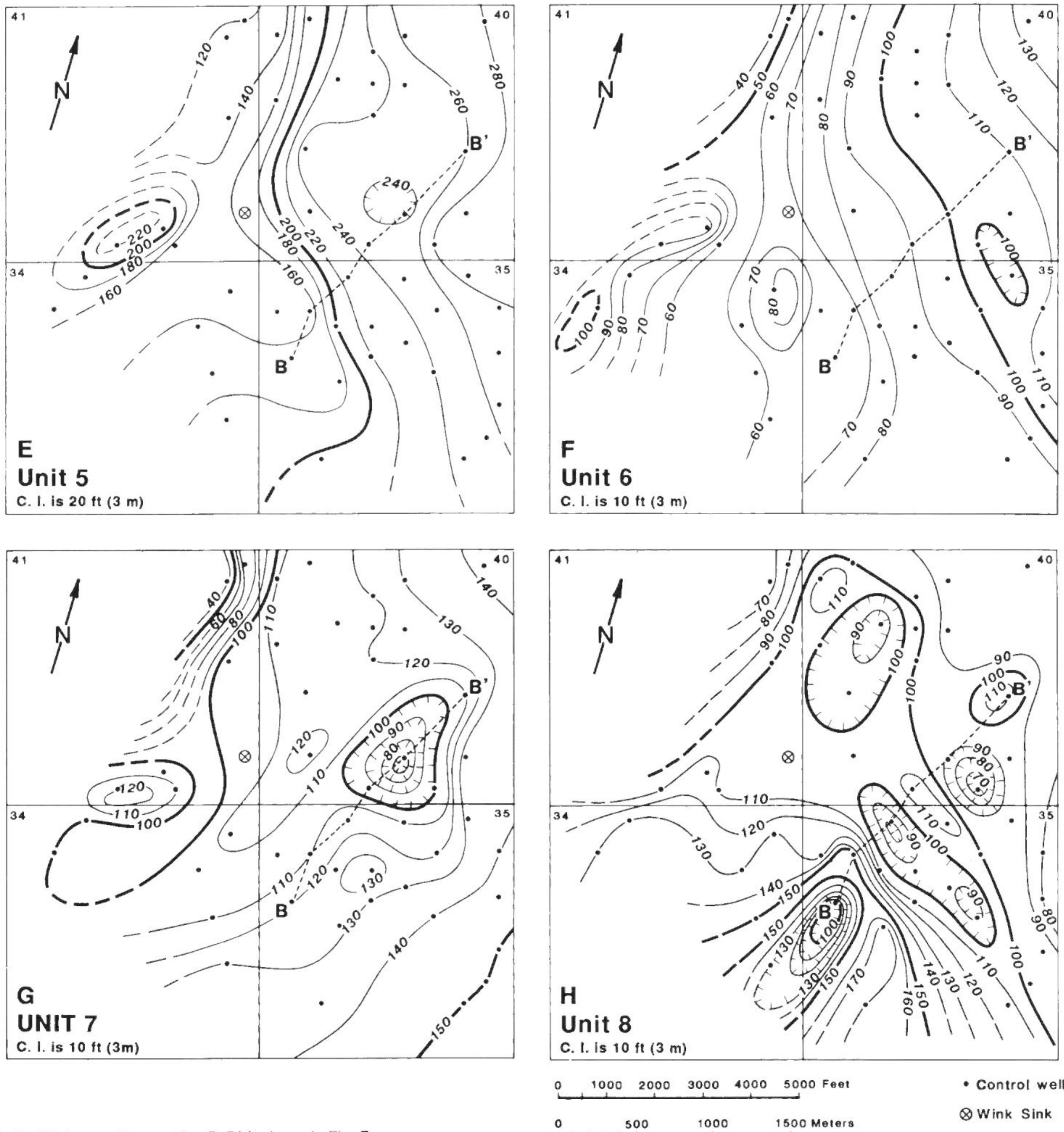
FIGURE 8. Thickness of Units 1–8 of Salado Formation

Unit 6

Unit 6 consists of a lower anhydrite zone and an upper salt zone throughout the area. In the key wells, the lower anhydrite is 30-40 ft thick in the east and 20-30 ft thick in the west; the salt zone typically is 50-70 ft thick in the east and 30-70 ft thick in the west. The salt zone contains several shale beds 5-10 ft thick. Unit 6 ranges from 40-130 ft thick in the Wink area (Fig. 8F) and is 80-120 ft thick for 15 mi farther east (Fig. 6).

The principal evidence of dissolution in Unit 6 is the general thinning of the unit westward toward the main dissolution trough. Moderate local dissolution may have occurred in the northeast part of sec. 35 and southeast part of sec. 40, where Unit 6 is 5-15 ft thinner here than in nearby wells.

Unit 6 is about 15 ft thicker in the northeast part of sec. 34; this may have resulted from partial dissolution of Units 1,2 and/or 5 just before, or during, deposition of Unit 6. It also may be a thick remnant of Unit 6 where the salt has been dissolved less than in the surrounding wells. The anomalous thickening of Unit 6 in the south part of sec. 41 and the northwest part of sec. 34 is not readily explained, but the causes may be similar to those presented previously for Unit 5 in the same location.



in the Wink area. Cross section B–B′ is shown in Fig. 7.

Unit 7

Unit 7 consists of a basal anhydrite, 25-30 ft thick, overlain by a salt zone that generally is 70-120 ft thick. The salt zone contains several shale beds 5-10 ft thick and several anhydrite beds up to 5 ft thick. Unit 7 is 40-150 ft thick throughout the area (Fig. 8G) and is uniformly 100-120 ft thick for 15 mi farther east (Fig. 6).

Pronounced dissolution in Unit 7 is seen in comparing two wells in the northeast corner of sec. 41 with the nearest well in sec. 40 (Fig. 8G); the total thickness of Unit 7 decreases westward here from 110 ft to 40 ft and the amount of salt decreases westward from 70 ft to 0 ft (this abrupt thinning of salt occurs in a horizontal distance of about 1000 ft). Pronounced dissolution also occurred in the south-central part of sec. 40, where the salt zone is 30-50 ft thinner than in nearby wells (Fig. 7). In addition, there is regional westward thinning of Unit 7 across the Wink area toward the main dissolution trough (Fig. 6).

Unit 7 is slightly thicker at two locations where the underlying salts are anomalously thin: in the southwest part of sec. 40, where Units 2 and 3 are anomalously thin; and in the northeast corner of sec. 34, where Units I, 2 and 5 are anomalously thin. The slight thickening at these two locations may have resulted from partial dissolution of one or more of the underlying salts just prior to, or during, deposition of

Unit 7, or from less dissolution of Unit 7 salts than in surrounding wells.

Unit 8

Unit 8, at the top of the Salado Formation, consists of a basal anhydrite, 35-40 ft thick and an upper salt zone 40-90 ft thick in the key wells. The upper salt zone contains several shale interbeds 5-10 ft thick. The top of the unit is not the same in all wells of the area, probably because of complex facies changes near the end of Salado time and because this uppermost salt was the first to be partly dissolved by descending, undersaturated waters. Thus, the thickness variation of Unit 8, from 65-170 ft, is more erratic than that of any other unit in the Salado Formation (Fig. 8H). The thickness of Unit 8 is more uniform, however, away from the Capitan Reef and the Wink area; Unit 8 is 120-140 ft thick for a distance of 15 mi to the east (Fig. 6).

Principal areas where Unit 8 salt dissolution may have occurred are in the northeast and south-central parts of sec. 41, in the northwest and southeast parts of sec. 40, and in the north-central and west-central parts of sec. 35. In all these areas, Unit 8 is 20-50 ft thinner than in nearby wells.

Unit 8 is anomalously thick at several locations in the study area, but only two of these locations are above a principal dissolution zone in the underlying salts. Along the boundary between secs. 35 and 40, Unit 8 is slightly thicker in two wells where Units 1, 2, 3 and 7 are abnormally thin; and in various places near the northern boundary between secs. 34 and 35, Unit 8 is moderately thicker in wells where Units 1, 2 and 5 are abnormally thin. It is possible that some of the dissolution of these lower salts may have occurred just prior to, or during, deposition of Unit 8.

CONCLUSIONS

In summary, all eight units in the Salado Formation appear to have been partly dissolved in various portions of the four-section study area. The only consistent pattern of dissolution is the progressive thinning of each unit westward across the study area toward the main dissolution trough. There is no pattern of salt dissolution that begins either in the deepest or the shallowest of the salt units and then works progressively up or down in any given locality. Instead, the principal zone or zones of dissolution at any locality may be in the lower, middle or upper part of the Salado and the remaining salt units may be affected or unaffected by this dissolution.

The time of dissolution of some of the Salado salts is inferred from the thickening of younger units above areas where some of the older salt has been removed. As a result, it appears that some of the dissolution occurred during Salado time just prior to, or during, deposition of Units 3, 4, 6, 7 and 8. In many areas, however, salt dissolution in the Salado is not accompanied by anomalous thickening of any of the younger Salado units and it appears that this dissolution occurred after Salado time, during later Permian, Triassic and/or Cenozoic time. Some natural dissolution of these salts may even be occurring at present, but there are no data currently available to prove this.

The mechanism of Salado-age dissolution in the Wink area is uncertain. Syndepositional salt dissolution is well documented in the Salado elsewhere (Hovorka, 1990; Powers et al., 1990), but in the Wink area the dissolution also occurred in Salado salt units that may have been buried tens to hundreds of feet below the surface. It is likely that Salado-age dissolution here resulted in part from proximity to the underlying Capitan Reef. The permeable Capitan may have been an outlet whereby brine (formed by salt dissolution) could escape and be replaced by unsaturated water. The pathways for downward movement of unsaturated water and resultant brine may have been fractures or karstic features that crossed the salt layers. Unfortunately, there is no proof that such pathways existed during Salado time, but such pathways must have existed later to allow dissolution and collapse in the nearby dissolution trough during Late Permian, Triassic and Cenozoic times.

ACKNOWLEDGMENTS

Publication of this report is approved by the Director, Oklahoma Geological Survey and appreciation is also expressed to Susan D. Hovorka and Dennis W. Powers for their review.

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