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MINERAL RESOURCE SURVEY
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The information contained in this circular was gathered by units of the WPA Geological Investigation Project, sponsored by The University of Texas, Bureau of Economic Geology. The purpose of this survey is to assemble information concerning the mineral resources of Texas and make it available to the public. It is hoped that this information will be a contribution to the industrialization of the State. The following report is based in part on information obtained by Work Project Nos. 18197, 18512, 49036, and 49040.

STRONTIUM MINERALS IN TEXAS*

By Glen L. Evans

INTRODUCTION

Strontium occurs in nature in the form of the minerals celestite, strontianite, and brewsterite. Of these minerals, celestite, the strontium sulphate, is by far the most common and is for that reason the principal strontium ore. Strontianite, the strontium carbonate, is more valuable as an ore because of the case with which it can be converted into the various strontium compounds of industrial usage but is rarely found in quantities large enough to have commercial importance. Brewsterite, or strontium silicate, is comparatively rare and has no present economic importance.

Strontium metal has at present no economic application, but strontium compounds are employed in a variety of uses. Their most characteristic property is ability to impart a brilliant red color to flames. Because of this ability to produce a highly visible and distinctive flame, strontium salts are employed in the manufacture of fireworks, in fuses and signal flares for both civil and military uses, and in tracer bullets. In addition to the uses in pyrotechnics, strontium compounds are employed in gas refrigeration, in the process of refining caustic soda for the rayon industry, in the steel industry as a flux and scavenger agent in the manufacture of certain open-hearth steels, in paints as pigment, in rubber and plastics as a filler, and in chemicals and medicines. Recently some Texas celestite has been utilized as an admix in drilling muds where it serves principally as a weighting agent, to counteract high gas pressures. The specific gravity of celestite is 3.9.

The United States has not been a large consumer of strontium minerals and compounds except during the abnormal conditions brought about by war. Except for periods during the first World War and in the present war when domestic sources have supplied a part of the Nation's requirements for strontium minerals, virtually the entire consumption has been imported from Great Britain and Germany. The American markets are near the eastern seaboard, and the principal known deposits, at least until recently, are located in the western states, particularly California, Arizona, and Washington. Due largely to the relatively high cost of overland transportation between the deposits and markets, the domestic deposits have not been able to compete in normal conditions with the cheap and excellent imported ores. The profitable production of domestic ores for use in the manufacture of strontium salts has been possible only in war time when the minerals and salts command an abnormally high price. The considerable quantities of Texas celestite which have been recently produced have been shipped to intra-state markets for use in drilling muds which does not necessitate the conversion into other salts. The Texas celestite has not been influenced by imported minerals but does to some extent compete with domestic barytes.

The occurrence of celestite and minor amounts of strontianite in Texas has been known for many years, and reports of deposits in different localities have appeared at intervals since as early as 1889. The minerals were first reported in the Mt. Bonnell—Mt. Barker district of Travis County where celestite and some associated strontianite occur in the form of nodular masses and in geodes within certain beds of the Glen Rose formation of Lower Cretaceous age. At two different times unsuccessful attempts were made to develop commercially these Travis County deposits. In 1904 Mr. R. C. Walker of Austin produced at Mt. Bonnell 17 tons of celestite which was shipped to Germany for experimental purposes. The same deposit was again worked to a limited extent in 1917, and some small quantities of celestite were sold for domestic consumption.

Following the discovery of strontium minerals at Mt. Bonnell, many other similar deposits in the Glen Rose formation have been recognized in a number of Texas counties, ranging from at least as far south as Uvalde County to as far north as Somervell County. In fact, it is now apparent that celestite and its weathering derivative, strontianite, are rather persistent minor constituents of the Glen Rose, and they can usually be found in some quantity wherever this formation is extensively exposed within the State. Until a comparatively recent date celestite was not known to occur in other formations, and the only deposits recognized were the typical nodular occurrences wherein the celestite comprises from less than 1 per cent to a maximum of perhaps 10 per cent of the total deposit. The nodular deposits are not feasible mining propositions even in times when celestite commands an abnormally high price, because of the low ratio of celestite to the worthless rock which must be mined to recover the ore.

Within the past few years considerable interest has been exhibited in two new celestite districts centering respectively in Nolan and Brown Counties, Texas. Each of these districts contains a number of celestite deposits which are large enough to have definite possibilities of commercial development. Mining has been carried on intermittently at one locality in the Nolan County district since 1938 and at several localities in the Brown County district since 1940. The two districts have produced to date a total of approximately

*Assistance in the preparation of these materials was furnished by the personnel of Work Projects Administration Official Project Nos. 665-66-3-233, 165-1-66-695, and 265-1-66-214.

5000 tons of raw celestite. Practically all of the celestite was produced for use as a weighting agent in drilling muds, a use to which this mineral has apparently not previously been applied. The principal producers are Mudrite Chemicals, Incorporated, Houston, Texas; Bennett-Clark Company, Nacogdoches, Texas; and Milwhite Company, Inc., Houston, Texas; but some minor quantities of celestite were produced by individuals for experimental and trial order purposes.

The deposits in the Nolan and Brown County districts are noteworthy, particularly at this time, because they represent large reserves of strontium minerals and because war-time conditions can be expected to bring about increased demands for strontium compounds with consequent stimulation of interest in domestic sources. The deposits have not been described in published reports and so may not have come to the attention of some potential producers and consumers. Also the deposits have proven to be of commercial importance, at least in a measure, and no other deposits of comparable size are known in this general region of the United States.

A field unit of Work Projects Administration Project No. 165-1-66-695, sponsored by the Bureau of Economic Geology of The University of Texas, was set up in 1941 to investigate the celestite deposits of the Nolan County district, and a similar unit has been in operation in the Brown County district since the early part of 1942. The work of these units, under supervision of Mr. Richmond L. Bronaugh, has extended considerably the knowledge of both districts, and this report is based largely upon the results obtained by them. For convenience of reference, these two districts will be designated in this report at the Nolan district and the Brown district.

NOLAN DISTRICT

A number of deposits of strontium minerals occur in the Nolan district. Celestite is present in important quantities, but strontianite, although found in most or all of the deposits, is present in only very minor quantities. The known deposits lie within a relatively narrow belt extending over a distance of about 45 miles in a north-south direction. The principal deposits are within Nolan County, but the mineralized area extends southward into northern Coke County and northward as far as central Fisher County.

Geology and occurrence.—The celestite deposits of the Nolan district are found in the Double Mountain group of upper Permian age. In the northern part of the district, in Fisher County, the celestite is apparently restricted to the single horizon of the Claytonville dolomite near the top of the Peacock (Whitehorse-Cloud Chief) formation. In the central part of the district, near Sweetwater in Nolan County, the main deposits occur at several horizons within the group of strata from 30 to 110 feet below the Claytonville, but minor occurrences are found at several levels still lower in the section. The deposits of the Blackwell area in the southern end of the district also occur at several horizons and may correlate in part with the celestite-bearing beds of the central area, or they may be somewhat lower in the section. No definite horizon marker was noted in the immediate vicinity of the southernmost deposits.

The rock strata comprizing the celestite zone consist of soft sands and sandstone, shales, and thin beds of dolomite and dolomitic limestone. The dominant color of the sandstones and shales is red or reddish brown, but some of the sands have been leached to a light gray or white. The dolomites are gray, brown, and pinkish. The strata have a gentle regional dip to the west or northwest.

The exposures of the celestite zone are within the lowlands east of the main plains escarpment. However, in most of Coke County and in central Nolan County the zone is covered by the Cretaceous overlap, and in portions of Fisher County it is concealed beneath the Triassic. Also at numerous places along the strike, the zone is partially or completely masked by Quaternary stream deposits, sheet wash and creep from the adjacent highlands, and by wind-blown sands. Thus the celestite zone is exposed in a series of disconnected exposures which are sometimes difficult to locate. The Claytonville dolomite (formerly known as the Sweetwater dolomite) is the most persistent and easily recognized unit which can be utilized in locating the celestite horizons in the northern and central portions of the district. This dolomite is from 12 to 18 inches thick and characteristically forms low east-facing escarpment. The several dolomite and dolomitic limestone beds occurring beneath the Claytonville are discontinuous and for this reason are not useful as horizon markers except within localized areas.

The celestite occurs as partial and, more locally, as complete replacements in the dolomite and dolomitic limestone beds. It also occurs in thin seams and in nodule sequences along bedding planes and as well developed crystals lining calcareous geodes in the sandstone beds. Celestite or strontianite may occasionally form the cementing material in localized segments of the sandstones. It is only in the case of replacement in the dolomite beds that the celestite occurs in quantities of commercial importance.

The celestite appears most commonly in the form of white, somewhat massive, crystalline aggregates in which the individual units are closely packed and do not exhibit typical crystal faces. An appreciable percentage of the mineral is granular in form, occurring both as beds or seams consisting entirely of granulitic celestite and as individual grains disseminated in the carbonate rocks. Concretionary celestite is often seen along bedding planes in the Permian rocks but is not directly associated with the principal deposits. Occasionally excellent small tabular crystalls of transparent celestite are found within geodes and in solution cavities. Rarely a coarse fibrous variety of a pale greenish-blue color is found in cracks and joints in the celestite beds and in contiguous strata. This type of occurrence suggests that the fibrous variety is recrystallized from the original celestite.

Localities and description.—Although a large number of minor celestite deposits occur in widely scattered places in Coke, Nolan, and Fisher Counties, the best known deposits which may have commercial importance are confined within three relatively localized areas. These areas are definitely related geologically in that the celestite deposits of each have a similar mode of occurrence and all are within the upper Permian beds, but they are separated from each other geographically. For convenience, each area will be given the name of the town to which it is nearest, and the individual deposits or localities will be designated by the name of the owner or owners on whose land the deposits occur. The three areas are Sweetwater, Blackwell, and Roby. The Sweetwater area is separated from the Blackwell area to the south by a broad divide of overlying Cretaceous rocks and is separated from the Roby area to the north by a long belt of almost barren strata. A map of each area is included in this report to show the location and distribution of the main deposits.

SWEETWATER AREA

The central part of the Sweetwater celestite area is located in Nolan County near Shaufler Switch about 5 miles south and west of Sweetwater. The area extends from Lake Trammel dam northward about 3 miles along both sides of Sweetwater Creek valley and along tributary valleys entering Sweetwater Creek from the west. The celestite occurs as a replacement in several different dolomite

beds (see section I for stratigraphic relationship). In none of the beds is the degree of mineralization uniform over the entire area. Beds 2 and 4 of the section are by far the most extensively mineralized; both contain celestite in some quantity at almost every place where they are exposed in the area. Beds 6 and 8 contain relatively minor amounts of celestite and only in isolated localities on the west side of Sweetwater Creek.

The thickness of these strontium-bearing beds varies considerably, the beds being in general thickest where mineralization in them has been most complete, and thinnest where little or no replacement has taken place. Each of the dolomite beds exhibits to some degree thin bedding bands or laminations, along the planes of which solution cavities and passages are often developed. Replacement by celestite may have taken place concurrently with the solution and removal of the dolomite. The celestite has formed as crystal growths within these bedding plane openings, more or less filling them, as well as on the upper and lower surfaces of the beds. In some few places the beds have been expanded, apparently by the force of crystal growth, to as much as two or three times their apparent original thickness. More commonly the vertical expansion has been relatively slight, and the beds consist of roughly alternating bands of celestite and thin bands of pink or gray dolomite. The dolomite bands sometimes contain some percentage of fine granulitic celestite.

Bed 4 is the horizon from which celestite is being mined on the Boothe Brothers ranch, one-half mile north of Ada School. This bed is normally more completely mineralized and is somewhat thicker than the other celestite-bearing beds. Also it is usually more accessible to open-pit mining because it typically forms the cap of low bluffs and is either exposed at the surface or covered by only a thin mantle of overburden for some distance back from the outcrop. Bed 2 does not usually form an independent bluff; its outcrop in the area is nearly everywhere almost directly beneath that of bed 4; consequently, it is covered by a minimum of 4½ to 6 feet of overburden.

Section I. Measured along slopes of Sweetwater Creek valley about 2 miles north of Lake Trammel, Nolan County, Texas. Asterisks indicate horizons containing celestite.

	Thickness Feet
Cretaceous, Basement sands.	
Unconformity.	
Permian, Peacock formation—	
12. Claytonville dolomite, hard, gray, laminated, often containing manganese dendrites along planes of laminae and frequently marked by small solution caverns. The Claytonville has been cut out locally in this area by the unconformity at the base of the Cretaceous	1.2
11. Red sandy shales	12.0
10. White, relatively hard sandstone	2.8
9. Red and gray sandstone with thin shales	16.0
* 8. Dolomite, brown to yellowish. This member forms a prominent ledge along the west slope of the valley west and northwest from Ada School	0.7
7. Red and gray poorly consolidated sands with some shales	48.0
* 6. Dolomite, grayish to snuff-brown, locally containing replacement of celestite, especially on the upper surface. This is the dolomite on which Ada School is built	0.8
5. Red sands and some shale containing a characteristic thin zone of lavender-colored flaky shale and very thin beds of white sands about 6 feet below the top of the bed	21.5
* 4. Dolomite and celestite; celestite mined on the Boothe ranch was from this horizon; thickness varies, about	1.2
3. Red sand, soft	4.5
* 2. Dolomite and celestite; thickness varies, about	0.8
1. Red sandstone and thin sandy shales	30.0
Total	139.5

Boothe locality (A)[1].—This locality is 0.5 mile north of Ada School on the top of a low bluff on the east side of Sweetwater Creek, at the site of an open-pit mine. This deposit is fairly typical of the occurrence of celestite in the Sweetwater area, and much of the following description will apply equally well to other deposits within the area. In the Boothe deposit the best celestite is found in bed 4 which at this locality is from 14 to 20 inches in thickness. Bed 2 which is from 8 inches to 1 foot thick is also present at the locality but is not being mined because it contains a somewhat lower portion of celestite and is covered by 4 to 5 feet of overburden.

The rock being mined consists of white crystalline celestite irregularly interbedded with thinner bands and lenses of pinkish and gray celestitic dolomite. The celestite occurs throughout the entire thickness of the bed but is more concentrated in the upper portion. The quality of the material is fairly uniform for a distance of about 600 feet along the outcrop, but the proportion of dolomite and other diluents in the bed increases in both directions along the outcrop away from the locality. The percentage of strontium sulphate in the rock mined probably will not exceed 70 to 80 per cent. No attempt has been made to concentrate the material except for casual hand sorting to remove the larger pieces of dolomite and the incrustation of secondary calcium carbonate which is often present on the lower surface of the bed. It is understood that before being used in drilling muds the rock is being ground and acid treated to remove most of the carbonates.

The mining in the Boothe deposit has been confined to date to a narrow strip along the outcrop, but test trenches and reentrant gullies indicate that the thickness and quality remain fairly uniform for at least several hundred feet in from the outcrop. An estimate of at least 40,000 tons of quality comparable to that which has been mined, covered by a maximum of 3 feet of overburden, seems to be conservative.

[1]On the several accompany maps pertaining to the Nolan district, the localities are designated to letter - (A), (B).

Ed Evans locality (B).—This locality extends southward along the rim of a low bluff starting from 0.1 mile southwest of Ada School and 1 mile south of Lake Trammel dam. The celestite-bearing horizons in this locality are in beds 2 and 4 and are a continuation of the celestite horizons of the Boothe deposit. Minor amounts of celestite occur in both beds at different places across this farm. The celestite is fine grained and is usually disseminated in the dolomite. In the exposed portion of the beds the ratio of celestite to dolomite seems to be everywhere quite low. A trial order shipment of the strontium rock was taken from this locality, but no mining has been carried on.

L. B. Scott and D. Roy locality (C).—The deposits at this locality are approximately 5.5 miles southwest of Sweetwater on the west side of the Panhandle & Santa Fe Railroad and a paralleling county road. The outcrops occur along the rim of some low east- and north-facing bluffs. At this locality celestite occurs in beds 2, 4, and 6. The mineralization in beds 2 and 4 is similar to that of the Boothe deposit, but the average thickness of the beds is not as great. Where present in bed 6, the celestite is usually confined to the upper part of the bed and is rarely more than 2 to 3 inches thick.

The portion of the locality most suitable for mining is on top of the low bluff formed by bed 4 at the places where this bluff most nearly approaches the railroad. Mining from a relatively narrow band paralleling the outcrop will yield large quantities of celestite.

The best concentration of celestite observed at any place in bed 2 is on the south bank of the tributary creek near the line between the Scott and Roy land, one-half mile west of the railroad. At this place the strontium rock locally attains a thickness as great as 18 to 20 inches, then thins abruptly to a layer only 1 to 1½ inches thick. The thicker portion of the deposit contains a relatively high proportion of celestite in crystal aggregates and is comparable in quality to the best material being mined on the Boothe property. The deposit, however, appears to be small, and unless it widens away from the outcrop only a limited tonnage could be recovered. The deposit underlies an area of several thousand square feet in which it is covered by overburden 5 to 10 feet thick, but the thickness and quality of the celestite in this covered area are not known except from the outcrop indications. Bed 4 is present at this locality and is 4 feet above bed 2, but, contrary to usual conditions, it contains a lower percentage of celestite than bed 2.

The celestite deposit in bed 6 occurs about 0.3 mile west of Shaufler Switch about 30 feet above and on the slope back of the first low bluff facing the railroad. The occurrence is similar to that described in the lower dolomite beds. The quantity of material is so small as to have little interest as a commercial possibility, but it suggests the likelihood of other, and perhaps larger, concentrations of this same horizon.

Somerville locality (D).—This locality is on the Sommerville farm about 5 miles southwest of Sweetwater and 0.5 mile northwest of Shaufler Switch on a low bluff along both sides of a small tributary creek. The celestite at this locality occurs in beds 2 and 4 and is similar to the deposits at the Boothe and Scott localities except that the celestite bands are thinner and the rock is more porous and friable. Earthy impurities have entered the small cavities within the outcropping portion of the beds. Very little difference is observed in degree of mineralization of the two beds; both contain appreciable percentages of celestite which is rather intimately interbedded with dolomite layers, and for this reason the mineral could not be concentrated by hand sorting. The beds have an average thickness of about 10 inches. A large quantity of the strontium rock is present at and near the surface.

E. W. W. Hopkins locality (E).—This locality is on the E. W. W. Hopkins farm, 1 mile west of Shaufler Switch, in a pasture about 400 feet south of the field fence and along the west slope of a ridge. The celestite at this locality occurs in or near the horizon of bed 8. Only one or two very small outcrops are visible, the remainder of the bed being covered by sheet wash and soil. Several test holes at this locality indicate that the deposit is quite variable in respect to both quality and quantity. The thickest observed portion of the bed was from 8 to 10 inches and contained an unusually high percentage of crystalline and granular celestite, while the thinner portions, which are only about 2 or 3 inches thick, consist of low grade material. This locality has possibilities of economic development provided reasonably large areas of the thicker and better portions of the bed can be located. A considerable amount of trenching would be necessary to test this possibility.

The localities and deposits listed above represent the best concentrations of celestite located in the Sweetwater area. Most of the deposits, specifically those occurring in beds 2 and 4, do not actually terminate within the described localities, since these two beds are continuous from one deposit to the other, as shown by the outcrop line on the map of the Sweetwater area. However, the strontium rock seen in the intervening spaces is either too low in quality or is in such small quantities as to have very little importance. The beds which contain celestite are covered in a number of places, particularly on the east side of the divide between Cottonwood Creek and Sweetwater Creek and along the west slope of Sweetwater Creek valley. In all probability other concentrations of celestite exist within these covered areas.

Quality and quantity.—No precise statement as to the quality of the strontium rock in the Sweetwater area can be made at this time because the percentage of strontium sulfate present is so variable from place to place that a very large number of carefully chosen samples would have to be analyzed before the average quality could be ascertained. Most of the material is low grade, probably only 40 to 60 per cent strontium sulfate, but in some of the deposits described above, material containing 80 to 90 per cent or more of strontium sulfate can be obtained. The tonnage of easily mined raw celestite of all grades in the combined localities described in the Sweetwater area is estimated at 200,000 tons.

Accessibility.—Practically all of the celestite in the Sweetwater area is easily accessible to good secondary roads, and railway facilities are especially fortunate. Shaufler Switch on the Panhandle & Santa Fe Railroad is located near the center of the area and is within not more than 2 or 3 miles of all the known deposits. Sweetwater, which is serviced by two railroads and good highways, is within 6 or 7 miles of the most distant deposit in the area.

BLACKWELL AREA

The Blackwell area of celestite deposits lies in the southern part of Nolan County and in the northern part of Coke County. The known deposits extend from the valley of Brushy Creek on the south to at least as far north as the Blackwell-Maryneal road. The central portion of the area lies near Antelope School, 4 miles west of Blackwell, and about 1.2 miles north of the Nolan-Coke County line. The celestite occurs in several separate deposits, the best and most extensive of which are within the southern one-half of the area. There is a good possibility that additional deposits occur in the unexplored territory along and to the south of the valley of Brushy Creek in Coke County.

The celestite deposits of the Blackwell area which have potential commercial importance occur in beds from 2 inches to more than 8 inches thick. Here, as in the Sweetwater area, the celestite appears to be a replacement in dolomite or dolomitic limestone. Unlike the occurrence in the Sweetwater area, however, the replacement within a given bed is more often nearly or quite complete. Where present in the deposit, the dolomite or limestone is usually in the lower part of the bed and is relatively easy to separate from the celestite.

The celestite occurs in both crystalline and granular form. It is usually white but not inferequently tinted pinkish, yellow, and dark gray by included impurities. Impurities in the beds include unreplaced portions of the original carbonate rocks and earthy materials which have entered the bed through cavities and joints, particularly near the outcrop where weathering has rendered the bed more porous.

In the Blackwell area the celestite deposits occur in several horizons. The beds containing the mineral do not appear to be continuous except over localized portions of the area. In the following section (section II), the stratigraphic relationship of several horizons can be seen.

Section II. In Double Mountain Permian in southern Nolan County, Texas

This section starts in a bluff of Antelope Creek, one-fourth mile west of Antelope School and adjacent to north side of county road on the Oden farm; all beds above bed 14 in the section are measured at successive upstream points from the above locality, while all beds below bed 10 in the section were measured at successive downstream points. Measurements were made with steel tape and hand level. Astrisks indicate horizons containing celestite.

	Thickness Feet
Trinity sandstone.	
Unconformity.	
Double Mountain Permian—	
41. Sandstone, soft brown, eroded at top	2.0
40. Shale, soft, brownish red	4.0
39. Sandstone, soft, light brown mixed with gray	3.2
38. Clay, brown, sandy	1.6
37. Sandstone, medium soft, brownish	2.2
36. Sandy shale, platy bedding, brown	1.6
35. Sandstone, soft, white, medium to coarse in grain size	2.6
34. Sandstone, massive, medium grained, light brown	4.0
33. Shale, reddish brown, sandy	0.7
32. Sandstone, massive, medium hard, medium grained, brown grading to gray and white in upper portion	6.1
31. Clay, cocoa-brown	1.0
30. Sandstone, medium grained, white	0.8
29. Siltstone, coarsely nodular, cocoa-brown	3.6
*28. Dolomite with varying amounts of celestite replacement; bed is wavy in attitude, irregular in thickness	0.8
27. Clay, cocoa-brown, containing some lighter colored streaks of fine-grained sand and silt	2.1
26. Sandstone, medium hard, saccharoidal texture, gray to white	1.1
25. Sandstone, micaceous, fine grained, light brown	3.2
24. Sandstone, medium hard, light reddish brown	7.5
23. Sandstone, very well stratified, light gray to white	4.9
22. Siltstone, coarsely nodular, cocoa color, jointed	4.0
*21. Clay, silty, brown, containing seams of celestite	0.8
20. Sandstone, fine grained, brown with gray flecks	2.8
19. Sandstone, medium soft, cocoa-brown	2.0
18. Siltstone, brownish, thin bedded and nodular	2.0
17. Sandstone, massive, brown, medium hard	8.7
16. Sandstone, hard, white with greenish tint	1.0
15. Siltstone, nodular, medium hard, cocoa-colored	4.2
14. Sandstone, buff-brown with gray at top and bottom of bed	2.7
*13. Sandy clay and clayey sand containing thin layers of celestite at and near base	4.2
12. Sandstone, semi-indurated, medium fine grained, white	4.8
11. Sandstone, containing abundant fine particles of muscovite, slightly indurated, reddish brown	6.4
10. Silty clay, sand-streaked, gray-flecked, reddish-brown bed, contorted from formation of secondary minerals	6.5
* 9. Dolomite or limy material largely replaced by celestite; bed or seam is buckled and jointed	0.5
* 8. Sandstone, massive bedded, micaceous, semi-indurated, very well stratified; contains joint seams and geode filling of celestite, reddish to yellowish brown	22.8
7. Siltstone, brownish, jointed	1.0
* 6. Celestite in thin layers and in concretion sequence	0.2
5. Sandstone, brownish, containing fine muscovite particles	2.4
4. Clay, silt streaked, reddish brown	1.2
3. Sand, fine, semi-consolidated, yellowish brown	3.0
2. Silty, clay, reddish brown, with gray streaks	2.0
1. Sandstone, medium grained, saccharoidal texture, light gray	1.7
Total section measured	138.9

The Permian strata within this area have a gentle dip to the west or northwest. Some abnormally steep dips were observed in a few places, apparently due to slumping and perhaps to local structural conditions. In such places dips from 2 to 4 degrees are not uncommon. At one place on Antelope Creek a series of small reverse faults were seen.

The celestite deposits in the Will Whitesides, Jr., the Rufe Whitesides, the McFarlane and Moore, and the Oden localities are at or near the horizon of bed 28 in the above section.

Will Whitesides, Sr., locality (A).—This deposit is in Coke County, 5.5 miles west of Blackwell on the county line road and 1 mile south of the Nolan-Coke County line, in the bed of Brushy Creek at the crossing of a ranch road. At this locality is an exposure of more than 1000 square feet of a celestite bed averaging 6 to 7 inches in thickness. The exposed portion extends downstream from the road crossing. At and for a short distance above the crossing in the stream bed, and along both sides of the channel, is an additional area of from 3000 to 4000 square feet in which the celestite is overlain by an alluvial covering from 6 inches to 4 feet thick. Samples collected from this deposit are good grade material, containing only a relatively small percentage of unreplaced dolomite and other impurities. The main body of the bed is crystalline and granular celestite in which cavities lined with excellent tabular crystals are not uncommon. Some masses up to 3 inches thick of coarse fibrous greenish-blue celestite are found on the upper surface and in joints within the bed.

The commercial possibilities of the deposit are limited in that mining operations would necessarily be confined to the relatively small area in which the bed is either exposed or covered by only thin overburden. Also, the position of the deposit in a stream bed would subject any workings to the danger of occasional flooding. The deposit is less accessible than most of the other deposits in the Blackwell area.

Rufe Whitesides locality (B).—This locality lies in Nolan and Coke Counties 5 miles west of Blackwell along the county line road and extending from this road southward for about 1200 feet around two low ridges projecting eastward into a cultivated field.

The bed in which the celestite occurs at this locality is from 3 to 7 inches thick. At most of the places where it was examined this bed was found to consist almost entirely of crystalline and granular celestite, although in some places from 1 to 4 inches to dolomite or limestone is present in the lower part. On the low ridge immediately adjacent to the south side of the county line road this bed is at or very near the surface, but on the second and somewhat higher ridge to the south it is overlain by 12 to 18 feet of sands except along the weathered slopes. The outcrop is everywhere inconspicuous and, particularly on the second ridge, is often completely concealed by sand creep.

A large quantity of raw celestite could be easily and cheaply recovered from this deposit provided work was confined to a belt following the outcrop and extending inward from it to the limit of shallow stripping. In an area of about 4000 square yards at this locality the celestite bed is overlain by only a thin overburden of soft sands, and it is probable that at greater depths the bed underlies a much larger area. The thickness and quality of the celestite could not be expected to be uniform over the entire workable portion of the locality, but from surface indications a large percentage of good quality material is present, and the occurrence is such that concentration by hand sorting methods would be practical.

Will Whitesides, Jr., locality (C).—This deposit is located 4.8 miles west of Blackwell on the county line road and 0.3 mile north of the road. It is on the southeast end of an uncultivated ridge extending into a cultivated field and extends both north and south from a farm house at the locality.

The type of occurrence of the celestite is altogether similar to that of the Rufe Whitesides locality described above, and both deposits probably belong to the same horizon. The bed averages 3 to 6 inches thick and consists of good quality celestite. The outcrop is inconspicuous at best, but it is usually marked by a relatively dense growth of vegetation, particularly by the small thorny shrub known as catclaw. At several places the slope of the ridge above the outcrop is very gentle, and consequently a considerable area of the bed is at a very shallow depth. The most practicable place seen for producing celestite from this deposit is on the flat surface on the southeast end of a low ridge about 700 feet south and west of the farm house. At this place the celestite bed underlies a thin mantle of soil and sand over an area of nearly 2000 square yards. The mineralized portion of the bed was not traced to its limits in either direction along the strike due to covering of the outcrop by sand creep from higher levels.

R. L. McFarlane and Moore locality (D).—This locality is 4.6 miles west and 1 mile north of Blackwell, about 0.4 mile southwest from Antelope School, and 400 feet south of an east-west county road, near the top of a low ridge.

Celestite occurs at two horizons at this locality. The lower horizon seems to be discontinuous and contains a poor grade of material in the places where it was examined. The upper bed may be coextensive with the deposits on the Will Whitesides, Jr., and the Rufe Whitesides localities, and possibly with the celestite bed of the J. A. Oden locality. This bed is from 3 inches to a maximum of 7 to 8 inches thick. Outcrops are very poor, but the horizon can be approximately located by its topographic expression: the slopes of the ridge are comparatively flat for a short distance above the celestite horizon and usually steepen perceptibly immediately below it. The soft sand and clay strata immediately above and below this horizon do not produce inequalities in the slope profile.

A number of test pits in the north side of a cultivated field and in the edge of the adjacent pasture on the McFarlane land revealed celestite of good quality. The bed is continuous eastward across the Moore farm but apparently decreases in quality in that direction. This deposit has potential commercial importance because the material is of good quality, and considerable quantities could be mined from very shallow depths. Also, the deposit is readily accessible to a good graded road.

J. A. Oden locality (E).—This locality is 4 miles west and 1.5 miles north of Blackwell and about 0.5 mile north of Antelope School near the top of a broad divide between prongs of Antelope Creek.

The Oden deposit is similar in occurrence and in quality to the deposits on the Whitesides and McFarlane land. The celestite occurs at different levels and may be in more than one bed. However, different horizons were not found in juxtaposition, and, since slumping is known to occur in the immediate vicinity, it is possible that a single bed appears at varying levels. No good outcrops are present in any part of the deposit due to the tendency of the soft overlying sand to mask the lower slopes. In places the position of the bed can be determined by pieces of celestite "float" on the slopes slightly below the level of the horizon. Often it is necessary to dig test trenches at the approximate horizon to find the celestite in place.

The celestite is good quality and averages 4 to 5 inches in thickness. Through the central portion of the divide the bed is from 12 to 16 feet beneath the surface, but on the east end of the divide and on the north and south slopes, areas of considerable size can be found in which the deposit is covered by less than 3 feet of soft overburden.

Joe Jordan locality (F).—This locality is 5 miles west and 3.2 miles north of Blackwell and extends for some distance along both sides of Eagle Creek. The best exposures are in some prominent bluffs on the west side of the creek, 0.2 mile west and north of the Jordan ranch house. At this locality celestite occurs in several horizons, as indicated in section III below, but in only two horizons, beds 10 and 18 of the section, is the mineral found in any appreciable quantities. From the above mentioned bluffs these two beds can be traced in successive outcrops for a distance of at least one-fourth mile in each direction along the west side of Eagle Creek valley. Opposite the prominent bluffs on the east side of the creek, bed 10 outcrops near the top of a lower bluff where it is overlain by several feet of terrace gravel; other good outcrops of the same bed appear on the east side of the creek about 1800 feet upstream from this point.

Both celestite-bearing beds are contorted and have a tendency to thicken and thin markedly in short regular intervals. The thickness will sometimes vary as much as 300 per cent within a few feet along the strike. The average thickness at the above locality is not more than 4 inches and may be somewhat less. The beds often consist of irregular wavy gray and reddish bands. The celestite present is mostly in granular form, but some small crystalline masses are also present. Both beds contain a high percentage of impurities, including limestone, calcite, sand, and iron oxide. Except for selected localities where some of the material may be pure enough for use in drilling muds or for other uses which do not require a high grade of celestite, this locality does not seem to have possibilities for commercial development.

Section III. In Double Mountain Permian, Nolan County, Texas.

This section was measured along a steep bluff on the west side of Eagle Creek on the Jordan farm, about one-fourth mile west-northwest of the farm house and 2½ miles north of section II. Asterisks indicate horizons containing celestite.

	Thickness Feet
Trinity sandstone.	
Unconformity.	
Double Mountain Permian—	
24. Sandstone, gray, medium fine grained	2.5
23. Shale, reddish brown	3.0
22. Sandstone, soft, brown, fine grained	3.0
21. Sandstone, medium soft, uniform gray	3.8
20. Sandstone, fine grained, micaceous, brown with gray splotches	5.8
19. Shale, silty, cocoa-brown	1.5
*18. Celestite bed, largely coarsely crystalline, irregular in thickness; bed is wavy or buckled	0.1 to 0.5
17. Sandstone, micaceous and silty, brown and gray	5.9
16. Shale, brown with bluish-gray tints	1.8
15. Sandstone, white, well bedded with harder layers at top	3.0
14. Shale, brown, soft	1.7
13. Sandstone, mostly massive but more thin bedded at top, lower portion brown but grading upward to gray	5.8
12. Sandstone, massive, cocoa-brown in the main but grading upward to gray; soft sands	7.7
11. Shale, soft, reddish brown with gray spots	4.9
*10. Celestite bed; bed consists of several indefinite layers; is contorted and wavy in section	0.3 to 0.8
* 9. Sandstone, thin bedded at top with thin seams of celestite along bedding planes, cocoa-brown	5.5
8. Sandstone, medium hard, well bedded, white	0.9
7. Sandstone, fine grained, cocoa-brown	3.0
6. Sandstone, well bedded, white	1.5
* 5. Sandstone, micaceous, containing numerous cracks and geodes filled with celestite, pinkish-tan color	4.5
4. Sandstone, micaceous, medium hard, massive bedded and brown in lower portion, gray and well stratified in upper portion; gray portion has "efflorescent" surface texture	6.4
3. Clay, reddish brown, grading upward to siltstone	2.3
2. Sandstone, fine grained, pinkish brown	2.2
1. Silty clay, red with bluish flecks	2.0
Stream bed.	
Total	79.1 to 80.4

Other deposits of similar material, probably an extension of beds 10 and 18, occur on prongs of Eagle Creek near the crossing of the Blackwell-Maryneal road. Also, one bed of similar appearance outcrops near Antelope School in Antelope Creek; this is bed 9 of section II.

Economic possibilities.—Even though the celestite deposits of the Blackwell area occur in rather thin beds, there are several advantageous features which might make economic production possible. In at least four of the localities large quantities of good quality celestite could be easily and cheaply obtained by simply stripping away the thin soft overburden. The nature of the occurrence of the mineral is such that concentration by hand sorting is feasible. All of the deposits can be reached by trucks and other equipment necessary to mining except in excessively rainy periods. None of the known deposits is more than 8.5 miles by road from Blackwell which is serviced by a railroad and a paved highway. The total cost of mining and transporting the raw celestite to Blackwell under present conditions should not exceed a maximum of $3.00 per ton.

ROBY AREA

Minor amounts of celestite occur at numerous places in the Claytonville dolomite in Fisher County, but the only known deposits of any importance are within the Roby area. This small area lies east of Buffalo Creek in the Hobbs community in the central part of the county and is crossed by State Highway No. 15 about 11.5 miles west of Roby.

The celestite in this area is confined to the single horizon of the Claytonville dolomite in which it occurs as a replacement mineral. Most of the mineral is in coarse white crystalline aggregates, but some smaller amounts of grenulitic celestite are also present. The dolomite stratum containing the celestite is continuous between the several deposits, the deposits being separated only by unmineralized portions of the bed.

Will Martin locality (A).—The deposit at this locality covers about 10 to 12 acres on the top of a narrow ridge in a pasture, one-fourth mile south of State Highway No. 15 and one-fourth mile west of a north-south county road. In some of this locality the celestite-bearing stratum has been affected by slumping sufficient to produce a relief of about 15 feet within short distances along the direction of the normal strike of the bed. The slumping is evidenced in localized depressions and also in an abnormally steep westward dip in the dolomite bed across the narrow ridge. The steep dip is not evident in other near-by exposures and so is probably the result of large scale subsidence in the area immediately west of the present ridge rather than to structural folding. Some of the best concentrations of celestite lie within the slump depressions, and there may be some relation between the deformation of the bed and the replacement by the celestite, although at other but smaller deposits within the area no evidence of slumping was observed.

In the Martin locality the celestite-bearing dolomite is everywhere either at the surface or covered by only a few inches of soil. The extent to which the celestite has replaced the dolomite varies widely from place to place within the deposit. In some restricted places practically the entire bed from 12 to 18 inches thick has been replaced, but in the greater part of the deposit celestite does not comprise more than 30 per cent of the total bed. The celestite is usually most concentrated in the upper one-half of the bed.

Other localities.—There are several small deposits of celestite on the north side of State Highway No. 15, as indicated on the accompanying map of the Roby area. Much of the celestite in these deposits appears to be high grade material, but it occurs in such small quantities as to make the deposits of very doubtful economic importance. The celestite is usually in sheets or layers of irregular thickness on the upper surface of the bed and to some extent interbanded with the dolomite. The celestite is not easily detached from the dolomite.

Any successful production of celestite in the Roby area would involve selection of the most completely mineralized portions of the deposits, particularly in the Will Martin locality. In these places are available many thousands of tons of celestite comparable in quality to that now being utilized in the drilling mud market. Some of the crystalline masses of celestite are comparatively pure, and it is possible that by careful hand sorting a considerable tonnage of high grade material could be obtained. This process, however, would probably involve the handling of from two to three tons of rock for each ton of high grade concentrate obtained and consequently may be practicable. A trial order of about 25 tons of the raw ore was recently shipped from the Martin locality to an eastern consumer.

BROWN DISTRICT

The Brown celestite district lies in eastern Brown County and extends into adjacent parts of both Comanche and Mills Counties. The best and most extensive deposits, and those with which this report is primarily concerned, lie within the area in eastern Brown County shown on the accompanying map. Other occurrences have been found south, east, and northeast of the mapped area, but so far as is known the material in these deposits is often quite impure and is present in only unimportant quantities. The deposits in the mapped area extend for about 9 miles in a general north-south alignment roughly corresponding to the strike of the strata in which the deposits occur.

Geology and occurrence.—The celestite of the Brown district occurs near the middle of a section of strata about 250 feet thick belonging to the Trinity group of Lower Cretaceous age. The lower and upper parts of this Trinity section consist primarily of soft sands and clays, but near the middle is a zone consisting of impure limestones, shales, and fine sands, which presumably represent a marginal facies of the Glen Rose formation. The celestite is associated with the impure limestones and shales of the middle zone. The middle zone is usually easy to locate, as the several relatively resistant members characteristically form low cuestas and flat-topped stream divides, whereas the lower and upper parts of the Trinity weather into gentle, sandy slopes. The following incomplete section is fairly typical of the middle zone within the extent of the mapped area.

Section IV. Measured on the west slope of a small valley along an east-west road separating lands owned by Pierce Burns and R. L. Miller; about 13 miles north-east of Brownwood, Brown County, Texas. Asterisks indicate horizons containing celestite.

	Thickness Feet
*11. Sandy shale, greenish gray, soft, contains stringers of fibrous celestite in lower portion	11.2
*10. Celestite bed, white to yellowish brown; bed contains shale parting near middle and is limy in upper part; both granular and aphanitic varieties of celestite are present	0.8
9. Shale, green, soft, and occasionally containing calcite nodules	0.9
8. Sandy limestone, yellowish gray, impure, nodular	1.3
7. Shale and sandy shale, greenish to tan	6.8
6. Limestone, bright yellow with black flecks, hard, massive	2.3
5. Sand, gray, soft	1.2
4. Sandy limestone, bright yellow with black flecks, medium soft	0.8
3. Sand and sandy clay, blue-gray and reddish, soft	9.5
2. Shale, blue, soft	0.3
1. Limestone, yellowish gray, nodular, fossiliferous	0.9
Total	35.8

This section cannot be matched bed for bed even in near-by exposures, since some of the members are subject to rapid change of facies. The general character of the section, however, remains fairly constant throughout the mapped area. The celestite bed, bed 6 of section IV, and the limestone bed, bed 10, are the most persistent recognizable members, and although they are absent from the section in some places, they can be found in most of the area where the middle zone is exposed. Also, the interval separating these members remains rather constant in thickness but changes in lithologic character from place to place. A stratum of green shale usually about 1 foot thick, but sometimes several times this thickness, always lies immediately above the celestite bed, but the underlying stratum may be either sandstone, limestone, or shale.

Celestite occurs in various horizons within the middle zone. The bedded or sheet deposits, which are by far the most extensive and are the only deposits which can be considered important from the standpoint of commercial development, remain at or near the horizon of bed 6 throughout the area; but celestite in veins or seams, in disconnected irregular masses, and in geodes and nodules appears locally at different levels above and below this bed.

Several varieties of celestite occur in the Brown district. Most of the bedded material is coarsely granular in texture, but considerable quantities of both fine-grained or aphanitic material and of crystalline aggregates also occur and are more or less intermixed with the granular material. Fibrous celestite consisting of exceedingly slender white to pale blue acicular crystals is quite commonly associated with the bedded deposits and is found in veins and joints in other horizons. Occasionally excellent tabular crystals are found in geodes and in cavities within the bedded deposits.

The bedded deposits of celestite vary in thickness from about 2 inches to a maximum of 12 to 14 inches, the average thickness being perhaps 4 or 5 inches. The deposits everywhere contain varying percentages of impurities, most common of which are impure limestone and shale, but minor amounts of barium sulphate, calcite, and iron oxide are also usually present. Neither the thickness nor the quality of the celestite remains constant except in relatively limited localities. Outcrops of the bed, particularly where it is composed primarily of granular material, are often deceptive. Weathering tends to cause the constituent granules to loosen and separate and thus expand the bed to greater than its original thickness. These abnormal thicknesses are frequently seen in the outcrop along relatively steep slopes, where weathering is fairly rapid, but do not occur on the slowly weathering gentle slopes where the friable character has permitted the bed to be reduced and the particles assimilated into the soil. The expanded portions are relatively free of the carbonate diluents, presumably because of leaching concurrent with the expanding process, since limestone in some quantity seems everywhere present in the unweathered parts of the deposit.

Exposures of the celestite bed are often found as a series of disconnected outcrops each of which projects outward beyond the general line of strike. This feature is explained in part by the fact that localized segments or areas of the bed are more concentrated and contain a larger percentage of aphanitic or crystalline celestite, which is more resistant to weathering, than intervening segments of softer or less concentrated material. Test trenching conducted by the investigating field unit has shown that the celestite bed often, but not always, diminishes in quality and in thickness inward from the outcrop. This also is explained by differential concentrations in the bed.

The most important occurrences of celestite are in those deposits where the bed is near the top of stream divides and low ridges. In a number of such places in the Brown district considerable quantities of ore can be found at very shallow depths, and the deposits contain a greater than average percentage of dense and crystalline celestite. While the granular variety of celestite is often comparable in purity with the other varieties, it is usually less adaptable to mining because its tendency to crumble causes difficulties and losses in handling.

Localities.—The following list includes the names of owners on whose lands celestite occurs in the mapped area of the Brown district. The numeral succeeding each name is the location symbol by which the deposits of each ownership can be approximately identified. References to localities in the following description will make use of these symbols; thus, "Locality 5" refers to the deposit or deposits on land owned by Walker Baker, and "Locality 5-A" denotes a second tract of land of the same owner. These localities are designated by the numerals on the accompanying map of the Brown district.

Walter Burns	(1)	E. M. Routh	(15)
B. F. Fairchild	(2)	Mrs. M. Rodgers	(16)
Pierce Burns	(3)	Davis Estate	(17)
R. L. Miller	(4)	R. A. Dunsworth	(18)
Walker Baker	(5; 5-A)	Dunn Estate	(19)
George Dikes	(6)	Mrs. Amanda Hughes	(20)
Mary Chambers	(7)	Frank Evans	(21)
Boyd property	(8)	Truman Reagan	(22)
G. C. Maner	(9)	Bird Estate	(23)
Alpha Baker	(10)	W. L. Thomas	(24)
J. A. Faulkner	(11)	Thomas J. Hughes	(25)
K. Routh	(12)	Duke Douglas	(26)
G. L. Stewart	(13)	Clair Bettis	(27)
L. H. Hightower	(14)	Roundtree land	(28)

When more than one locality is underlain by the same deposit, or when several very similar deposits occur on adjacent localities, the related localities will be discussed in a group. The word "locality" is here used in part synonymously with "ownership," but in a restricted sense to indicate only that part of a given tract in which celestite occurs. The word "deposits" is used most often to refer to concentrated segments or areas which are considered minable and which are separated from other concentrations by intervening segments or areas which do not appear to be minable; it does not imply that the different deposits were laid down at different times.

Localities 1 and 2.—The celestite at these localities occurs in a bed averaging 2 to 3 inches in thickness and in quality is below the average area. Some small tonnages of the material could be easily obtained on the small knoll extending south from the road, where the bed is covered by only a thin veneer of soil.

Locality 3.—This locality contains three separate deposits from each of which celestite could be economically recovered. In all of the deposits the celestite is from average to much better than average in quality, and the deposits range in thickness from 5 to 14 inches. The deposit located on the west side of a small south-flowing creek is covered in part by overburden too thick for practicable mining, but an estimated 350 tons of good material could be obtained from depths less than 3 feet. The two deposits located on the east side of the small creek underlie relatively large areas of shallow overburden. These latter deposits are estimated to contain upward of 2000 tons of easily recoverable ore. Some excellent hard crystalline celestite ranging from 10 to 14 inches thick was found in several test holes extending southwest from the surface tank or pond for more than 300 feet. This material underlies 20 inches of green shale and a thin layer of soil; it is not exposed in surface outcrops.

Locality 4.—This locality includes one of the largest workable deposits of celestite in the Brown district. The thickness of the bed averages about 8 inches, and a large proportion of the celestite is aphanitic and crystalline varieties. The bed is locally separated by shale partings and contains small amounts of unreplaced limestone. Some open-pit mining has been carried on in this deposit by the Milwhite Company, Inc., at intervals during the past two years. The remaining easily recoverable ore is estimated at between 7000 and 8000 tons, and considerably larger quantities are available at depths up to 8 feet.

Localities 5 and 6.—These localities contain two deposits separated by a small tributary creek. The celestite bed in these deposits varies considerably in respect to both quality and thickness. Most of the celestite is granular in form and will usually crumble when being broken from the bed. Earthy impurities have been introduced into the badly weathered portions of the granular material. In both deposits are small areas of the bed in which much of the celestite is either fine grained or crystalline. At such places, one of the best of which is about 300 feet west of the farm house on Walker Baker's "west place," the celestite can be worked with only small losses due to crumbing. The quantity of workable celestite in Locality 5 is estimated at 650 tons. Locality 6 includes only the south tip of the east deposits and contains only a small tonnage of material. A small amount of celestite has been mined at Locality 5.

Localities 7, 8, 9, and 5-A.—Three separate workable deposits occur at these localities. The celestite varies from 2.5 to 10 inches in thickness, and much of it is better than average in quality. The westernmost deposit of these localities is the largest; it is estimated to contain more than 3000 tons of celestite at depths of less than 3 feet. A part of the celestite is hard fine-grained material which breaks from the bed in platy slabs and consequently would be very easy to handle. The celestite is unusually thick at several places at these localities, but a considerable thickness of overburden covers most of the thicker material. Several hundred tons of raw celestite were mined in the small central deposit (Localities 7 and 8) in 1941.

Localities 10 and 11.—At these localities large quantities of celestite are present, and most of it is easily accessible to open-pit mining. The principal deposit is continuous, or nearly so, over both localities. It ranges in thickness from 4 to 10 inches, and the quality is more than usually uniform. Most of the celestite is granular in form but is intermixed with dense and crystalline material and does not ordinarily crumble excessively in handling. A considerable tonnage of celestite has been mined from these localities during the past two years. A much larger quantity, conservatively estimated at 7000 tons, is still available.

On the south side of Teague Hollow, a small west-flowing creek to the south of the main deposit, are a series of small isolated deposits, each of which is estimated to contain from 150 to 400 tons of celestite within practicable mining depths.

Locality 12.—The celestite seen at this locality is largely crystalline and fibrous material. The quantity is apparently too small to be of importance, but such material as is present is of excellent quality. Test holes have shown that the bed is frequently absent from its horizon inward from the outcrop. The relatively large amount of fibrous celestite which presumably has been recrystallized from the original deposit suggests that solutions may have removed parts of this deposit.

Locality 13.—At this locality much of the celestite is on the surface, and the remainder is covered by a very thin overburden. Most of the material showing in the outcrop is massive, crystalline aggregates and in a stratum 6 to 8 inches in thickness. The quality is apparently higher than the average for the area. The amount of easily obtained celestite at this locality is estimated at 450 tons.

Localities 14, 15, and 16.—Most of the celestite at these localities which can be considered minable occur in rather narrow strips along the line of outcrop. The occurrence along the south side of a west-flowing creek, which passes through these localities, includes unusually thick deposits of crystalline and granular material. The average thickness through the localities, however, is no more than about 4 inches. Enough celestite to justify mining operation is visible in the surface exposures, but no estimates can be made of the total recoverable quantity because of the lack of sufficient subsurface information and because of the known discontinuous character of the bed.

At a point where a tributary creek forks into three smaller branches at Locality 14 is an interesting occurrence of disconnected, irregular masses of celestite which lie within or near the horizon of the bedded material. Some of these masses attain a thickness of nearly 2 feet and may weigh as much as a ton. The lower surface of the masses is flattened along an underlying hard limestone, from which it extends upward irregularly into a green, sticky shale. The laminae of the shale are contorted and clearly show the evidence of pressure or squeezing on both sides of the upward projection of the masses. The celestite within these masses is chiefly in a granular form but is in part crystalline, and some fibrous layers of fine acicular crystals occur along the margins of the mass and extend outward into the shale.

Locality 17.—The celestite bed at this locality outcrops almost continuously around a ridge projecting about one-half mile north from an east-west road which crosses the eastern margin of the locality. Outcrop thicknesses vary from around 2 inches to as much as 14 inches. The thicker portions are found on the east and northeast sides of the ridge and are limited in extent. At a point on the east side of the ridge, where the outcrop swings westward into the northeast corner of a field, the bed consists mainly of compact crystalline material of 10 or 11 inches in thickness. Test trenches show that this thickness is maintained for a short distance back from the outcrop, beyond which the deposit decreases rapidly in both quality and thickness. However, a considerable tonnage of good quality celestite could be obtained at this site by confining operations to a narrow belt near the outcrop. At the northeastern extremity of the outcrop is another thick segment of the exposed bed. At this place, however, the material is extremely crumbly and thins quite rapidly immediately inward from the outcrop.

Mining could be carried on within a strip 30 to 50 feet wide paralleling the outcrop around most of the remainder of the ridge. Beyond this narrow strip the thickness of overburden gradually increases and would ordinarily be too great for practicable mining. It is to be expected at this locality, as at other localities within the Brown district, that localized concentrations would be found within the bed during the process of extensive mining, and at such places the deposit could profitably be worked at a greater depth than would

ordinarily be possible. Estimates, based upon outcrop indications and data obtained from test trenches, indicate that approximately 3500 tons of raw celestite could be profitably recovered from Locality 17.

Localities 18, 19, and 20.—The celestite horizon passes into the north side of Locality 18 and probably also crosses beneath the southwest corner of this locality. So far as is known, the material is everywhere quite thin and is usually of inferior quality. It is doubtful whether any of the celestite at Locality 18 has commercial importance. At Localities 19 and 20 the celestite is similar to that of the Davis Estate (17) but is less extensive. An estimated 1000 to 1200 tons of raw celestite could be cheaply mined along a narrow strip inward from the outcrop and in a small area on the crest of a low ridge adjacent to the east side of the road east of Amanda Hughes' farm house. The material at these localities is comparable in quality to the average for the area.

Locality 21.—The workable celestite occurring at this locality is found near the top of several westward and southwestward projecting ridges. In each of these separate deposits the bed has an average thickness of only about 3½ inches but has the advantages of being very near and at the surface and largely good quality material. Measurements necessary for tonnage estimates were not made in all of these deposits, but it is probable that more than 1000 tons of material could be cheaply mined from the locality.

Locality 22.—The outcrop of the celestite bed at this locality extends from U. S. Highway No. 283 northward for a distance of approximately one-half mile. Over a part of this distance the bed is poorly exposed and in places can be followed only by surface float of material weathered from the bed. A high percentage of the material is fine grained and quite hard. The bed is from 3 to 4 inches thick in all of the places where it was examined. The most practicable places to work this deposit are in a small field east and south of the Reagan farm house and a short distance west from Steppes Creek, and within some uncultivated land along the upper edge of a flat eroded area, a short distance south of the field. In addition to these two places, some material could be obtained along the line of outcrop across the entire locality. South of the highway the bed is largely concealed beneath soil creep but where exposed appears similar to that north of the highway.

Locality 23.—Celestite occurs in two workable deposits at this locality. The first deposit is located approximately one-half mile north of the Mercer Gap road, starting at an abandoned farm house on the point of the southward projecting ridge and extending for some distance back along both sides and beneath the surface of the ridge. The bed is only 2½ to 3 inches in thickness, but the quality of the material is good, and a considerable area is overlain by only a thin, soft covering. Some of the celestite is granular in texture, but the bed, in the main, is sufficiently competent to be worked into blocks or slabs without undue crumbling and losses. A second deposit is east of Steppes Creek on the southwest point of a ridge in a cultivated field. This occurrence is similar to the other deposit at Locality 23 but probably contains a smaller quantity of workable material.

Locality 24.—The deposits at this locality cover a large area, much of which is on or near the crests of low ridges and stream divides and is covered by light overburden. The material is mostly crystalline and granular, but unusually large quantities of fibrous celestite are also present in the horizon. The thickness varies locally but will probably average from 3 to 4 inches. The tonnage of material which could profitably be mined at this locality is estimated at 2500 tons. There is a possiblity that concentrated and thicker parts of the bed could be found in test trenching, in which case much larger quantities might be profitably worked.

The principal impurity in this celestite is limestone included within the bed and locally comprising as much as 40 per cent of the total deposit. In most of the outcrops, however, only very small quantities of limestone could be recognized in the material.

Localities 25 and 26.—The celestite at these two localities does not appear to be in commercial quantities at any place. The type of occurrence, however, is interesting, and the deposits serve to indicate the possibilities of other more concentrated occurrences in this part of the area. At Locality 25 the celestite is in the form of a thin sheet, quite persistent throughout the exposed area but usually not more than 1 inch in thickness. The material consists of pink to reddish granular celestite and some small crystalls. The sheet or bed frequently expands into somewhat bulbous masses, inside of which are cavities containing beautiful and delicate tabular crystals. The occurrence at Locality 26 may be near this same horizon, but the section in which it occurs is somewhat different. At the latter locality the exposure is in a high bluff on the east side of Blanket Creek. The bed consists of crystalline and granular material and varies between 1 and 6 inches in thickness, the thicker portions being extremely localized.

Localities 27 and 28.—At Locality 27 celestite is found in two horizons in a steep bluff on the east side of Blanket Creek. The celestite in the upper horizon occurs as nodules and geodes immediately above and below the contact between a fine, grayish-yellow sand with an overlying bed of blue sand. The walls of the geodes found in the sand stratum consist of red and white celestite in closely packed massive crystals, from which almost perfect transparent tabular crystals extend inward and partially fill the central cavity. The geodes and nodules found in the overlying blue shale are similar to those in the sand but do not contain red celestite. Not infrequently the nodules contain adsorbed pieces of the rock stratum in which they occur. The bedding planes have been bent noticeably both upward and downward from the larger nodules and geodes. Thin stringers of fibrous and crystalline celestite radiate outward from the nodules and sometimes extend for a considerable distance along the bedding planes. Locality 28 is similar in occurrence except that in the lower horizon the geodes or bulbous masses are frequently connected by a thin layer of crystalline celestite.

Other localities in the Brown district.—Celestite has been recognized at several places outside of the mapped area in the Brown district, but the known occurrences do not have commercial importance. These localities, however, serve to indicate areas where further investigations might disclose larger or better deposits.

At a locality in Comanche County, 6.5 miles north of Blanket on the Caffey and Jim Lacey farms, some celestite occurs associated with much larger quantities of calcite. These minerals occur as replacements in a honeycombed, impure limestone stratum. Large masses of crystalline calcite occur in clay beds both above and below this horizon.

At a locality one-half mile south of Bethel Church on the Charles Bynum land in eastern Brown County a celestite bed outcrops intermittently around a small hill. This material consists of crystalline, granular, and fibrous varieties. The bed appears to average only about 2 inches in thickness but in very localized spots is as much as 1 foot thick.

Celestite is said to occur in a thin impure bed at a locality 4 miles east of Zephyr and north of the old highway in western Mills County. The strata in this area, however, are poorly exposed, and it would be difficult to tract the bed for more than a short distance; consequently the chances of finding concentrated areas do not seem good.

Quality.—The greater part of the celestite found in the Brown district is low grade material, averaging between 60 and 90 per cent strontium sulphate, but some relatively small quantities of high grade celestite of 90 per cent or more strontium sulphate are present, particularly in the deposits in the northern part of the mapped area. The high grade material is everywhere intermixed to some extent

with inferior grade materials. Most of the material in the deposits described above is comparable in quality to that now being utilized as a drilling mud admix but does not, in the raw state, meet the standards of commercial ores used for conversion into strontium salts. The production of such high grade ores from the Brown district would require careful selection of deposits and close sorting to remove inferior grade materials, or, if large quantities are to be obtained, some satisfactory method of mechanical or chemical concentration might be successfully employed.

OTHER LOCALITIES

Celestite deposits other than those of the Nolan and Brown districts are known in a number of localities within the State. The occurrence of massive crystalline celestite in nodules within the Glen Rose formation, as indicated in the introductory statements of this report, is widespread. Good examples of this type of occurrence can be seen at Mt. Bonnell in Travis County; near the heads of Lynch and Little Lucy Creeks and on Donaldson Creek east of Nix in Lampasas County; at several localities along Paluxy River in Somervell County; and at many other places within the outcrop belt of the Glen Rose formation. While the ratio of celestite to the rock of the enclosing bed is too low for profitable mining in all of the known localities of this type, it is possible that in areas of favorable weathering conditions commercially workable deposits may exist as residual concentrations. The most probable place to expect such concentrations would be on relatively gentle slopes where colluvial deposits may have accumulated shortly below the bed containing the celestite. Most of the nodules have a tendency to break down with sustained weathering and will not ordinarily withstand the effects of transport for more than a short distance from their source.

Taylor County.—An interesting deposit of celestite occurs 7.5 miles south of Merkel in western Taylor County; it is well exposed on the John D. Jones land in gullies and bad lands around the base of Castle Peak, 0.5 mile east of the Jones farm house.

This celestite occurs in the Chosa formation of the Clear Fork Permian from 50 to 80 feet below the unconformity at the base of the Cretaceous. Most of the celestite is in symmetrical biscuit-shaped nodules or concretions occurring within and along the planes of bedding between red sandy shales. The nodules are apparently not confined to a definite horizon but are most abundant in a thin zone between 15 and 20 feet below a flaggy, track-bearing, siltstone member, which is well exposed around the base of Castle Peak and which is an easily recognized local marker.

The nodules are commonly rather small, from 1½ to 5 pounds in weight, but occasionally larger specimens of 30 or more pounds are found. Some small transparent tabular crystals of celestite occur in cavities in a thin, bluish calcareous lentil on the south side of Castle Peak, and other minor quantities of the mineral occur in thin sheets or layers in joints and along bedding planes. At one place on the west slope of Castle Peak celestite forms the cement or filler in a conglomerate lens.

The nodular celestite is crystalline, pale blue in color, and of excellent quality. Some of the enclosing shale usually adheres to the outer surface of the nodules, but it can be easily removed by washing. The proportion of celestite is too low for practical mining of the shales, but a small tonnage of the nodular celestite has accumulated as residual deposits at the base of weathered slopes and in gullies and could be easily obtained. The amount of celesite in the surface residual deposits around Castle Peak probably will not exceed 30 tons.

MINING METHODS

Mining of celestite in the deposits of both Nolan and Brown counties has been an extremely simple procedure. All of the material has been produced from open pits at places where the celestite occurs at very shallow depths. During one period of about three days, a steam shovel was used for stripping the ore in the Miller locality (4) in Brown County, and at several times tractors have been employed in drawing plows to expose and break the material from the beds. Other than this, all of the Brown County material has been broken from the beds by means of horse-drawn plows. The use of plows in mining the celestite has proven fairly satisfactory and economical, except that in some places considerable losses are sustained from shattering the celestite into pieces too small for handling. In Nolan County the celestite is simply pried out of exposed ledges with hand tools. In all of the deposits the material is roughly sorted and loaded by hand.

FUTURE DEVELOPMENT

In event the production of celestite should expand to a large scale basis, and particularly when mining from beneath several feet of stratified rock or other hard overburden, mechanical methods such as tractor-bulldozers or steam shovels might prove to be more satisfactory than the methods now employed. However, the actual handling and loading of the ore, on whatever scale of production, can probably be best done by hand labor because inferior material can be eliminated in the process.

Except for small trial order shipments, the celestite produced in both the Nolan and Brown districts has been marketed for use in drilling muds, and presumably these markets can be expected to continue and possibly expand. As a drilling mud admix, celestite will have to compete in a measure with other minerals, particularly with barite, which are being used for the same purpose. In this market the celestite can be expected to command a price proportional to the degree of satisfaction with which it fills the requirements. The Texas celestite has several advantages over competing minerals. It occurs in very large quantities, can be mined easily and cheaply, and is relatively close to a large part of the high gas pressure areas of the Gulf Coast and Mid-Continent fields.

Only relatively small amounts of the known Texas celestite are sufficiently high grade to meet the standard of ores used in the manufacture of strontium compoounds. There is a possibility that the Texas ores could compete on the eastern markets, providing they can be satisfactorily concentrated by either mechanical or chemical methods. There would seem to be little doubt that the ore, at least in the better deposits in both the Nolan and the Brown districts, can be cheaply concentrated to a grade material of more than 90 per cent strontium sulphate. The cost of concentration, however, will depend in a large measure on the size of installation, and American markets may not be large enough to absorb such quantities as would make large installation practicable.

Factors which might influence the further commercial development of the Texas deposits are the loss, reduction, or increasing price of foreign shipments; increasing demands in the established uses, resulting from abnormal conditions; the development of new uses for the minerals or compounds; and the establishment of markets sufficiently close so that the Texas deposits can compete on a favorable basis with celestite or substitute minerals from other sources.

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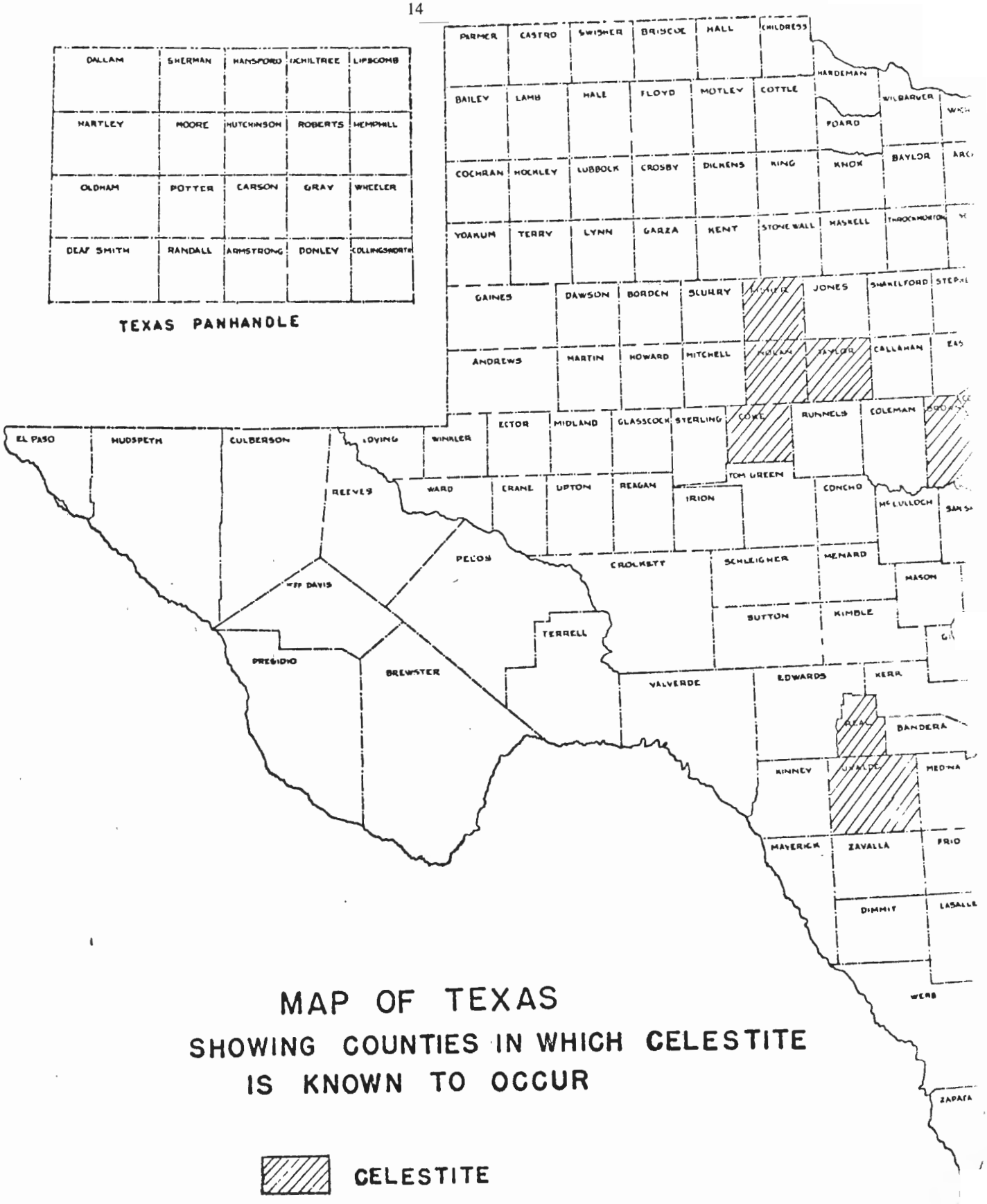
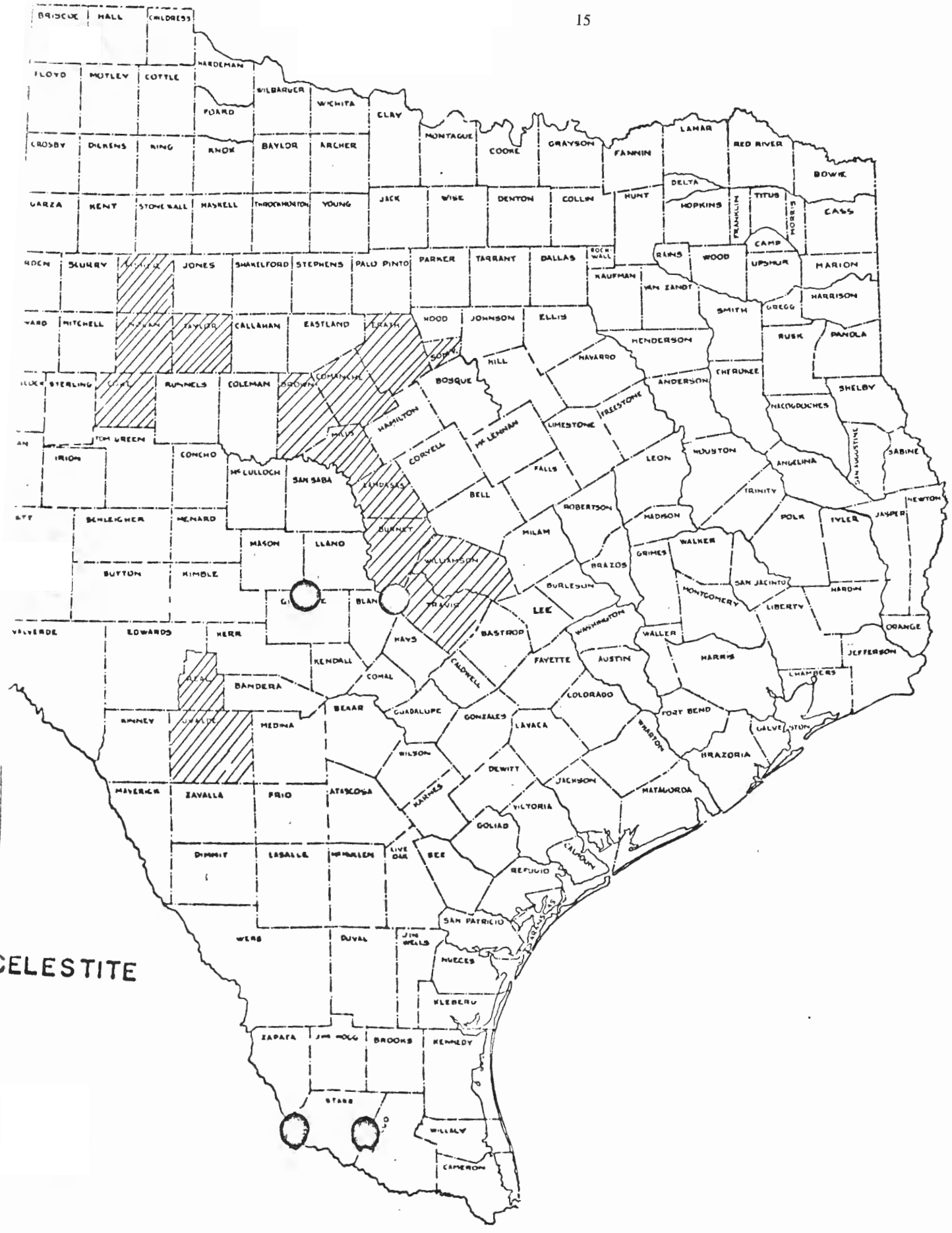


MAP OF TEXAS

SHOWING COUNTIES IN WHICH CELESTITE IS KNOWN TO OCCUR

CELESTITE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COTTLE
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WILBARGER
WICHITA
CLAY
MONTAGUE
COOKE
GRAYSON
FANNIN
LAMAR
RED RIVER
BOWIE
CROSBY
DICKENS
KING
KNOX
BAYLOR
ARCHER
DELTA
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SCURRY
JONES
SHACKELFORD
STEPHENS
PALO PINTO
PARKER
TARRANT
DALLAS
ROCKWALL
KAUFMAN
VAN ZANDT
SMITH
GREGG
RUSK
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CHEROKEE
SHELBY
NACOGDOCHES
TOM GREEN
CONCHO
IRION
HAMILTON
MILLS
CORYELL
MC LENNAN
LIMESTONE
FREESTONE
LEON
HOUSTON
ANGELINA
SABINE
SAN AUGUSTINE
MC CULLOCH
SAN SABA
LAMPASAS
BELL
FALLS
ROBERTSON
TRINITY
NEWTON
TYLER
JASPER
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WALKER
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WALLER
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AUSTIN
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JEFFERSON
KENDALL
COMAL
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CHAMBERS
BANDERA
BEXAR
GUADALUPE
GONZALES
LAVACA
COLORADO
FORT BEND
GALVESTON
MEDINA
WILSON
WHARTON
BRAZORIA
DEWITT
JACKSON
MATAGORDA
MAVERICK
ZAVALLA
FRIO
ATASCOSA
MARTIN
VICTORIA
GOLIAD
DIMMIT
LASALLE
MCMULLEN
LIVE OAK
BEE
CALHOUN
REFUGIO
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WEBB
DUVAL
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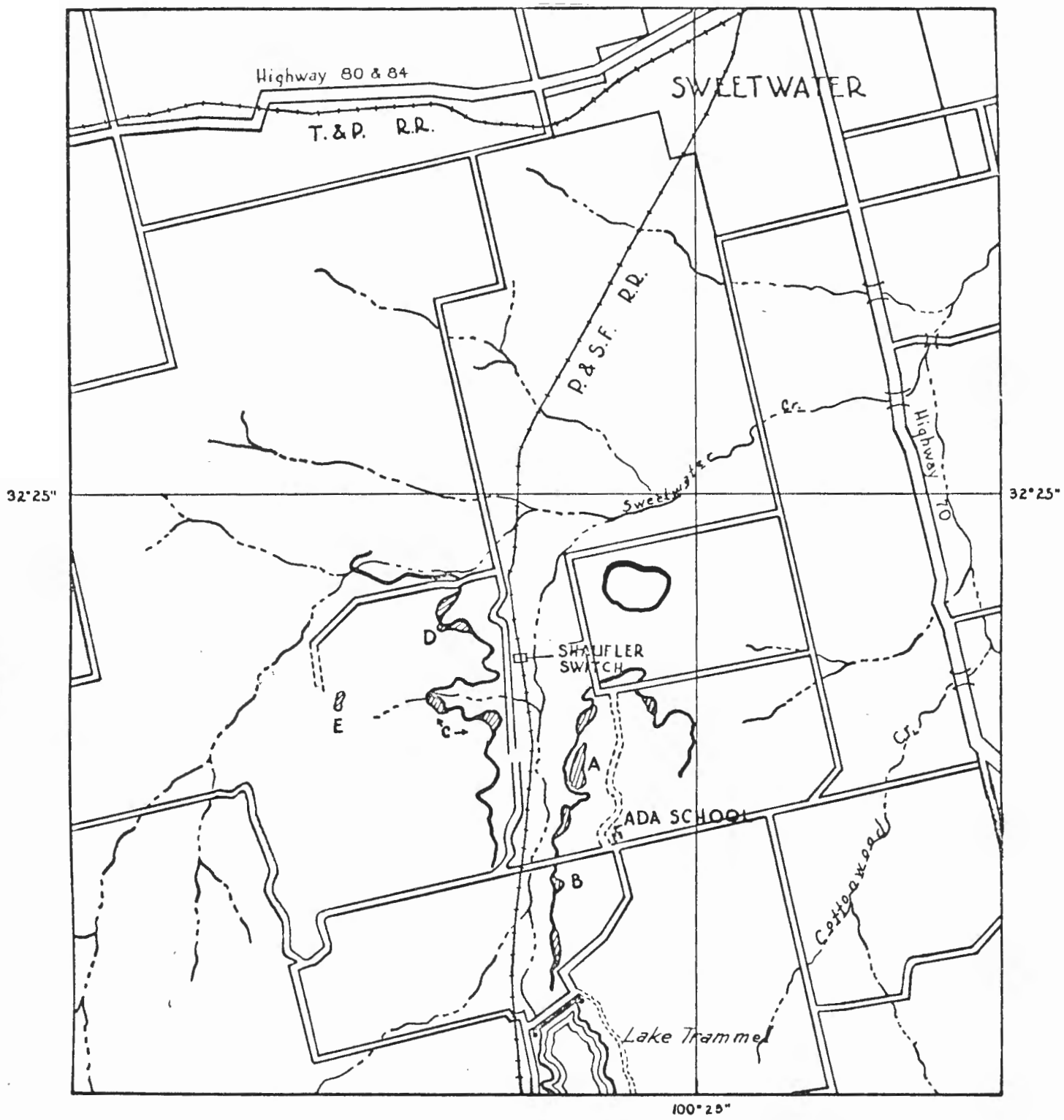
WILLACY
CAMERON

CELESTITE



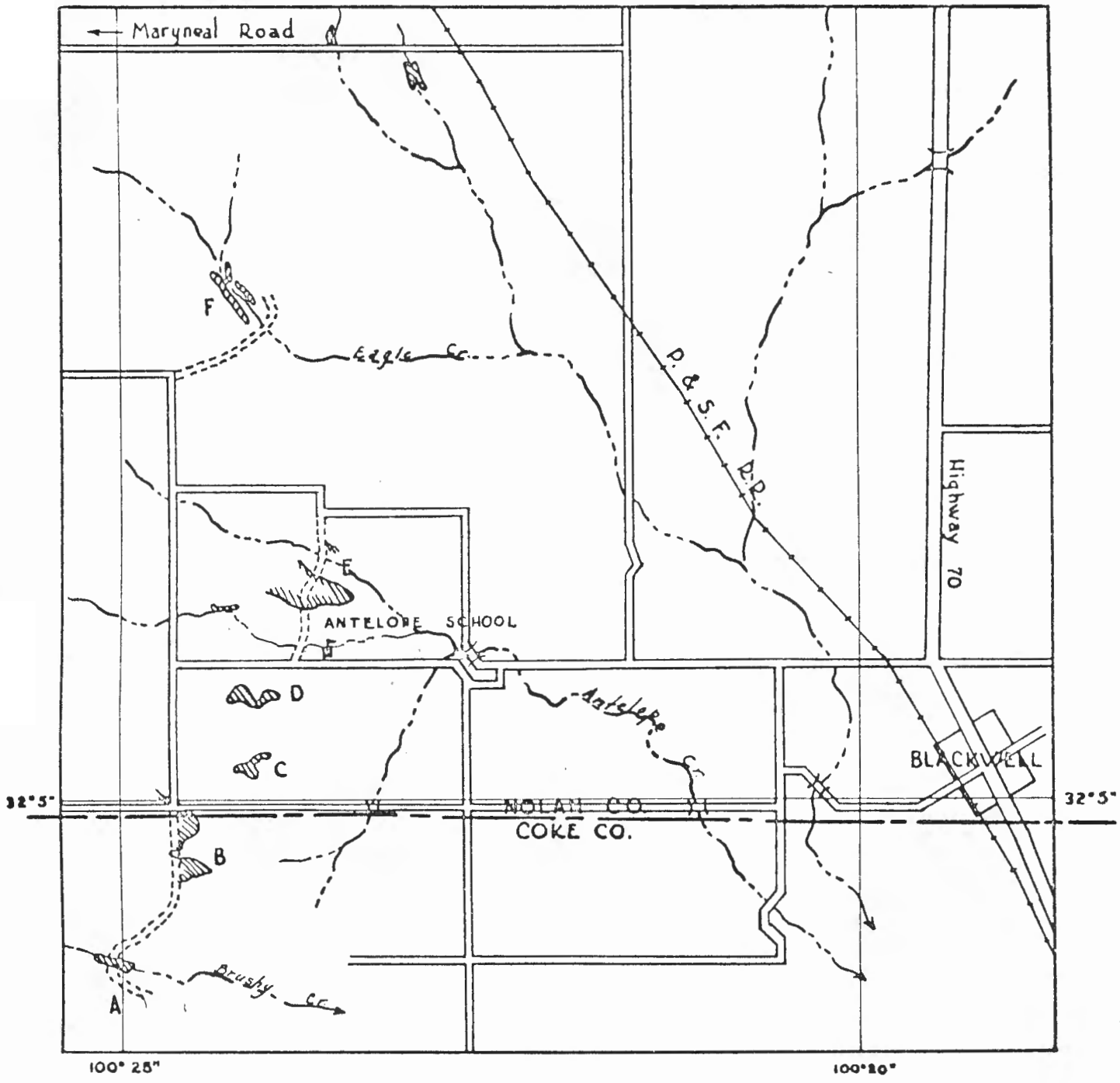
MAP OF SWEETWATER AREA, NOLAN COUNTY

SCALE : 1 inch = 1 mile

LEGEND:

Outcrop of celestite beds (No's 2 and 4)

Celestite deposit

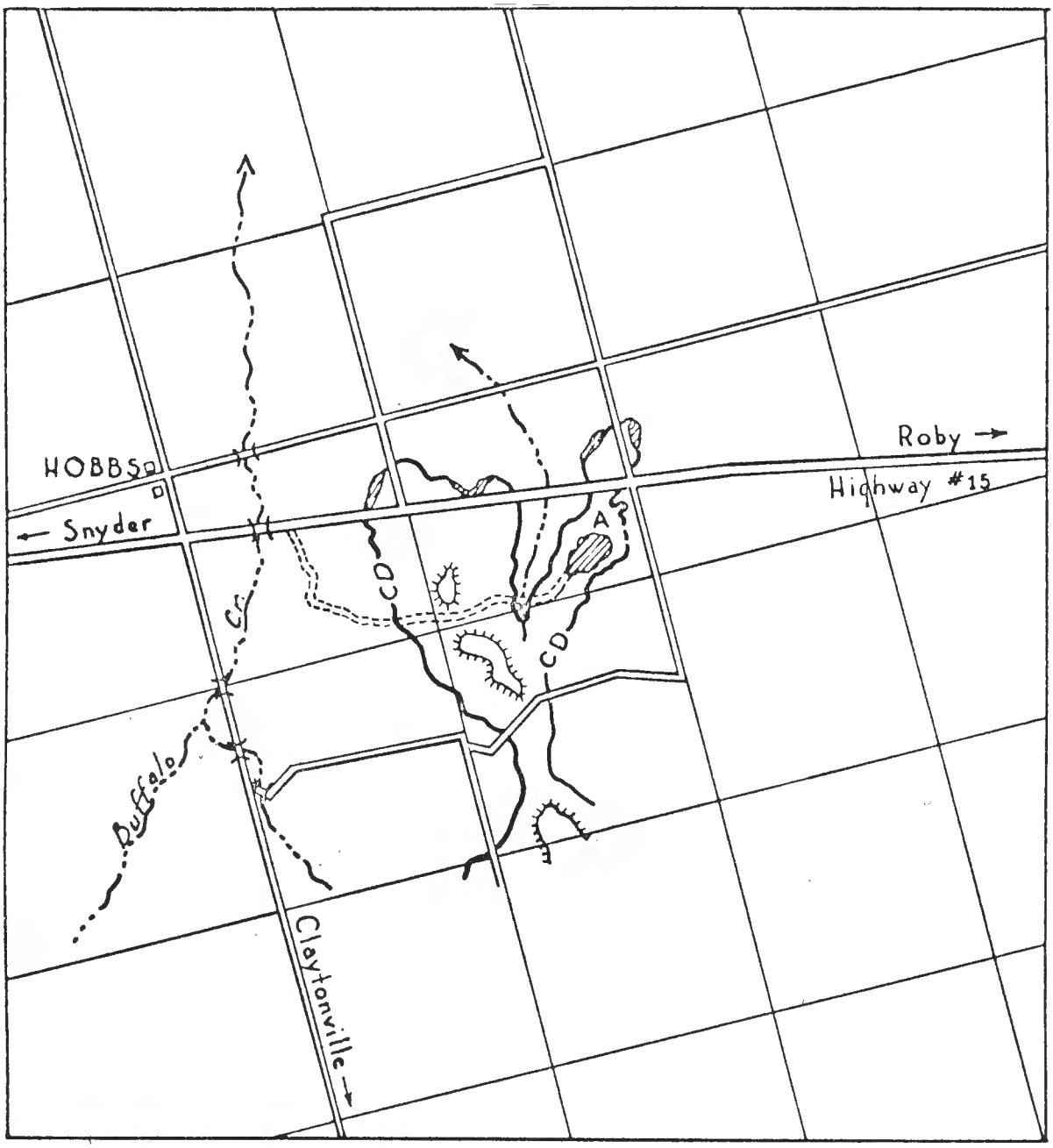


MAP OF BLACKWELL AREA, NOLAN & COKE COUNTIES

SCALE: 1 inch = 1 mile

LEGEND:

Celestite deposit

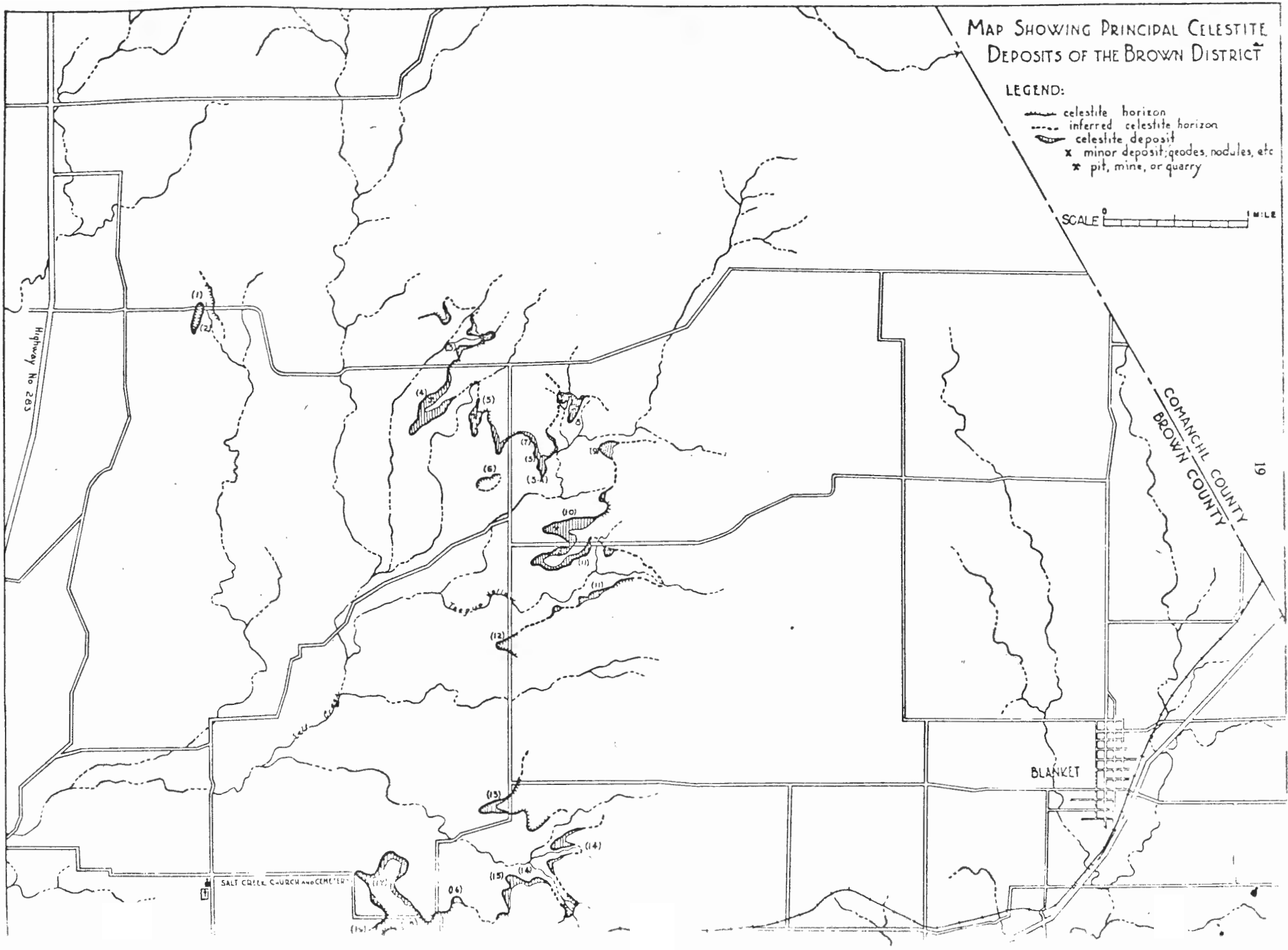


MAP OF ROBY AREA, FISHER COUNTY

SCALE: 1 mile

LEGEND:

CD — Claytonville dolonite
Celestite deposit
Triassic outlier


MAP SHOWING PRINCIPAL CELESTITE DEPOSITS OF THE BROWN DISTRICT
LEGEND:
celestite horizon
inferred celestite horizon
celestite deposit
x minor deposit; geodes, nodules, etc
* pit, mine, or quarry
SCALE 0 1 MILE
Highway No 283
COMANCHE COUNTY
BROWN COUNTY
BLANKET
SALT CREEK CHURCH and CEMETERY
(1)
(2)
(3)
(4)
(5)
(6)
(7)
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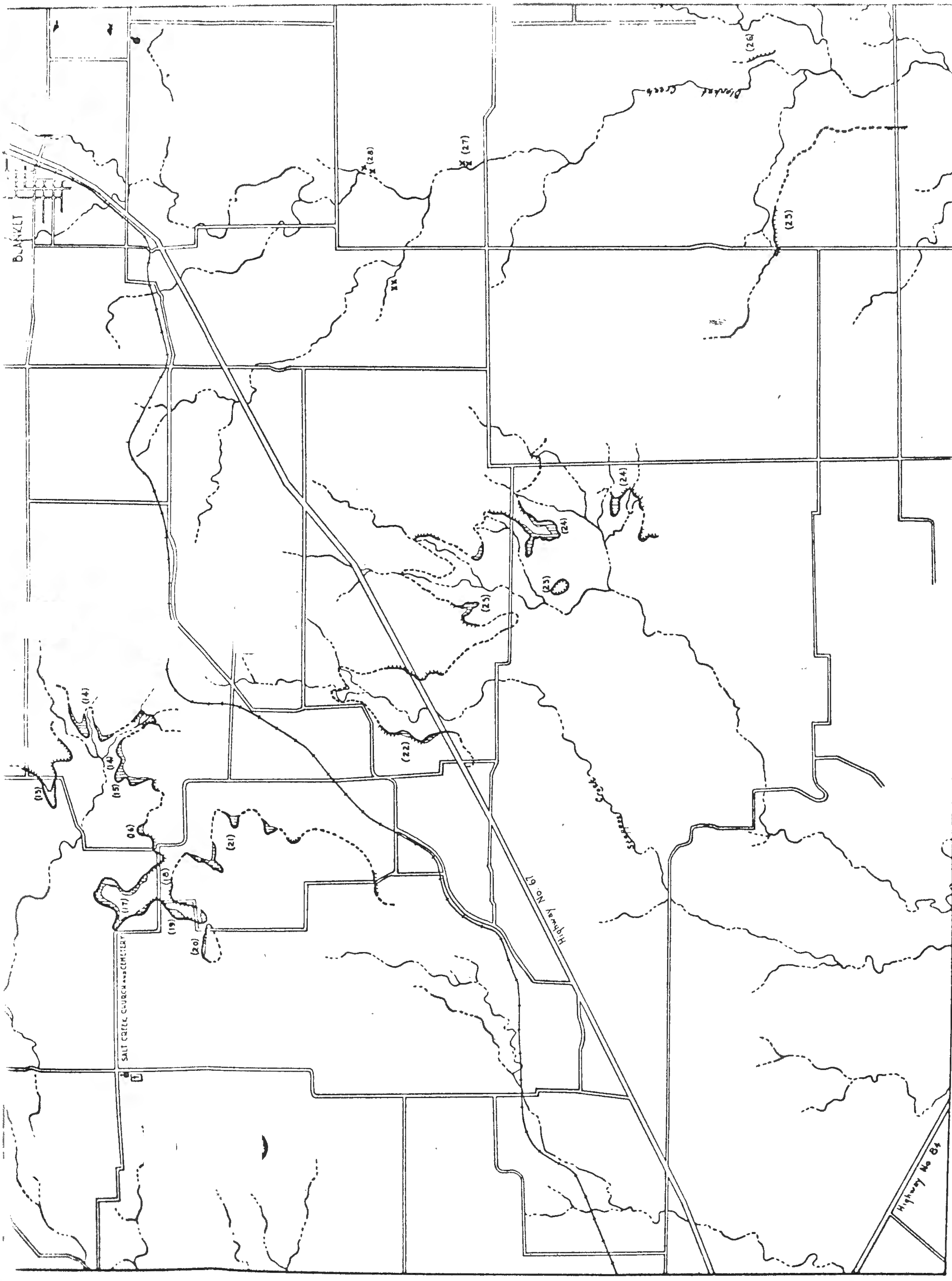
BLANKET
Blanket Creek
Highway No. 67
Highway No 84
SALT CREEK CHURCH and CEMETERY
(13)
(14)
(15)
(16)
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(18)
(19)
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