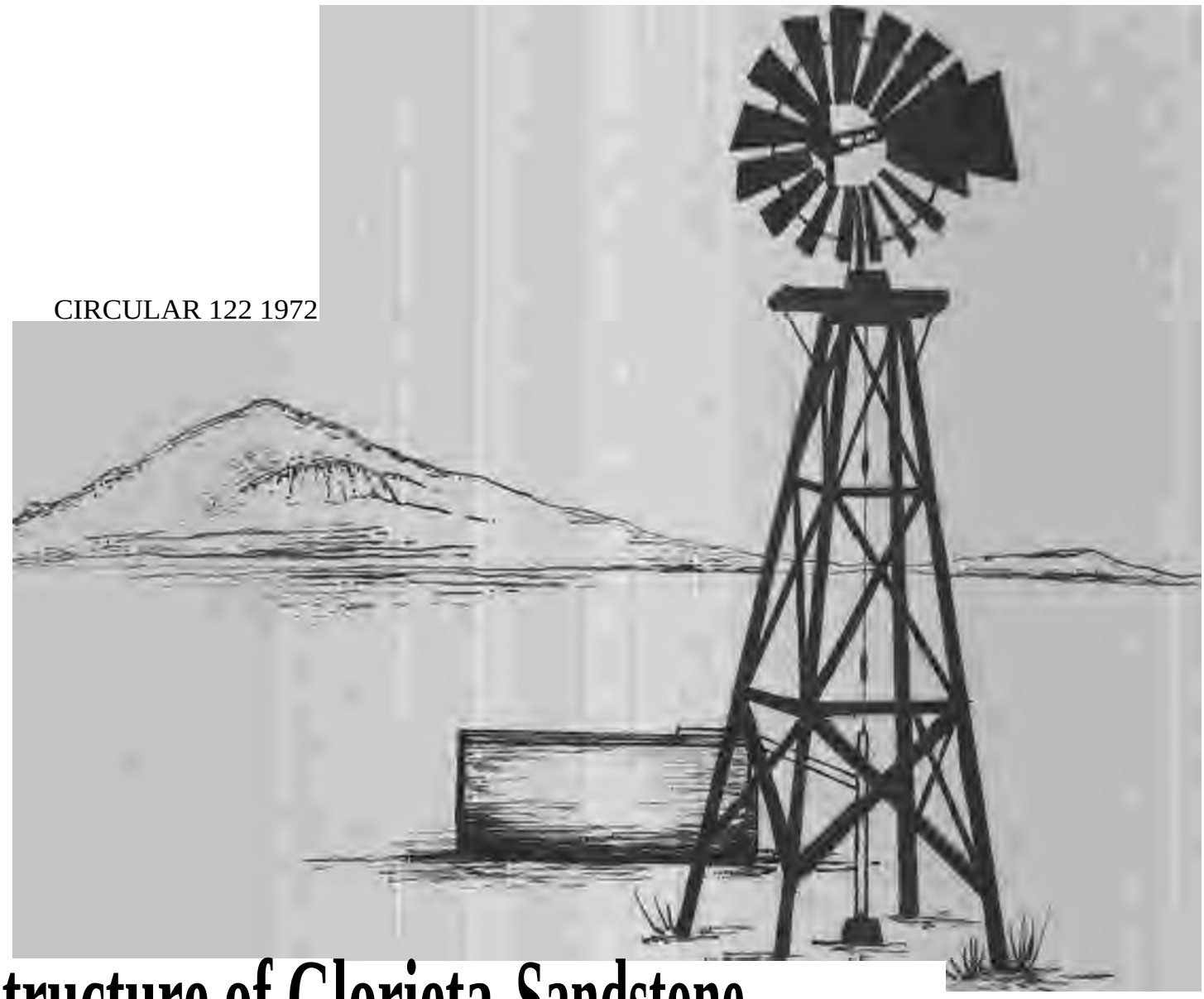
CIRCULAR 122 1972



Structure of Glorieta Sandstone in Northwest Chaves County New Mexico

NEW MEXICO STATE BUREAU OF MINES AND MINERAL RESOURCES

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STRUCTURE OF GLORIETA SANDSTONE IN NORTHWEST CHAVES COUNTY, NEW MEXICO

New Mexico State Bureau of Mines and Mineral Resources

Circular 122

STRUCTURE OF GLORIETA SANDSTONE IN NORTHWEST CHAVES COUNTY, NEW MEXICO

by
R. L. Borton

Socorro

1972

ABSTRACT

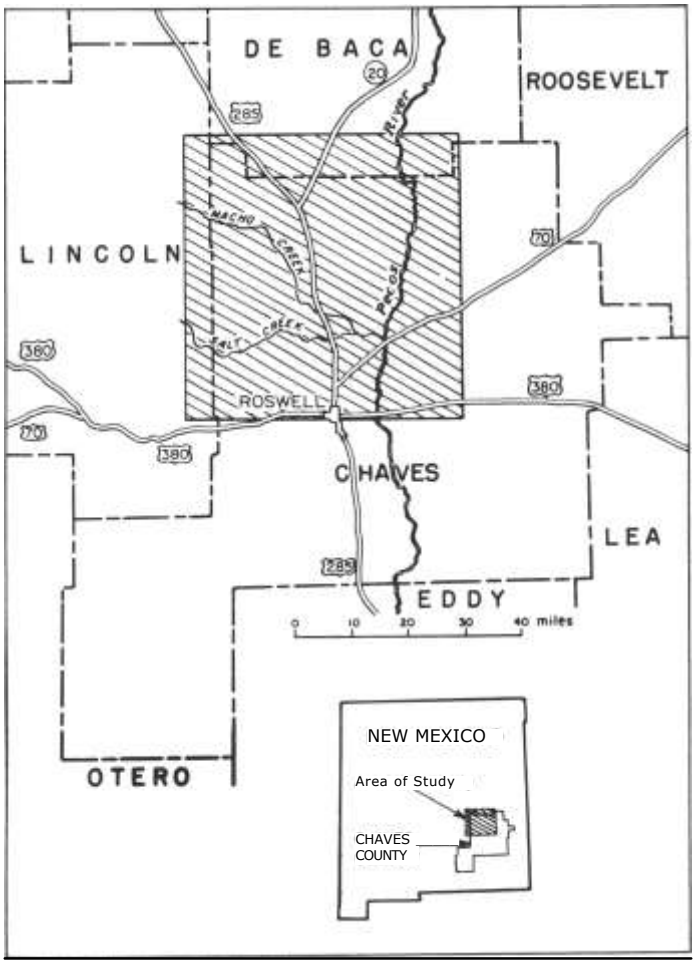
Construction of a structure map of the top of the Glorieta Sandstone of Lower Permian age shows the formation dipping generally east to southeast at about 70 feet per mile. The altitude of the top of the Glorieta declines from 4,400 feet in the west-central part of the area to 1,100 feet in the southeast corner where the Glorieta is overlain by about 2,700 feet of younger Permian and Triassic rocks. The eastern portion of the area is characterized by gentle undulations and minor changes in strike; a fault of small displacement parallels the northernmost of two east-west diabase dikes. The western part of the area is deformed by two northeast-trending faulted anticlines with apparent displacements of as much as 200 feet, and by two large collapse features coincident with major drainages.

INTRODUCTION

This report, in preliminary form, was presented as a paper at the 23rd Annual Meeting of the New Mexico Geological Society in Santa Fe, April 25, 1969. The report is part of a study of the geology and ground-water resources of an area of approximately 2,300 square miles in northwest Chaves County, New Mexico. The investigation was sponsored by the New Mexico State Engineer Office and the U. S. Geological Survey.

Geologists accompanying early United States exploratory expeditions in the 1800's (Wislizenus with Col. Doniphan in 1846-1847, Marcou with Lt. Whipple in 1853-1854, and Blake, using Marcou's notes) mapped exposures of the Glorieta Sandstone along the Santa Fe Trail near Pecos, New Mexico. This sandstone was then believed to be of Cretaceous age. Newberry (with Ives in 1857-1858 and Macomb in 1859) described an exposure near Pecos as a massive, yellowish-white sandstone, 150 feet thick, without fossils, and of Cretaceous age. In 1869, Hayden (1869, p. 65; 1873, p. 165) described it as yellowish-gray sandstones of Jurassic age and was so quoted by Stevenson (1881, p. 34).

The Glorieta Sandstone was originally called the "Glorietta Sandstones" by C. R. Keyes (1915a, p. 257, 262; 1915b, p. 2, 7) who dated it as Cretaceous and defined it as the "main body of Dakota series around the south end of the Rocky Mountains." Keyes gave no type locality, but from the context of his publications it is presumed that the name was derived from Glorieta Mesa in Santa Fe and San Miguel Counties, New Mexico, or from the town of Glorieta near the north end of the mesa. In 1919, Hager and Robitaille considered the Glorieta Sandstone to be the upper member of the Yeso Formation of Permian age in eastern New Mexico, and in 1920, C. L. Baker assigned it to rocks of Upper Triassic age in east-central New Mexico. In 1921, J. L. Rich correctly stated its age and stratigraphic position by describing it as a 300- to 500-foot sandstone of Permian age underlain by the Yeso Formation and overlain by the San Andres Formation.



Location and extent of report area.

Needham and Bates, in 1943, considered the Glorieta as being of formation rank because of its wide distribution, lithologic persistence, bold topographic expression, and stratigraphic importance. In their type section, at Glorieta Mesa near the village of Rowe in San Miguel County, it is described as consisting of 116 feet of white to gray, medium to coarse-grained, quartzitic, cliff-forming sandstone in beds 2 to 6 feet thick which weathers pale yellow, and a basal 20 feet of poorly exposed buff to white, soft, thin-bedded sandstone. It was further described as being conformable with the underlying Yeso Formation and the overlying San Andres Limestone, having a thickness of 12 to 287 feet, and as being the stratigraphic equivalent of the Hondo Sandstone Member of the Chupadera Formation of Lang (1937).

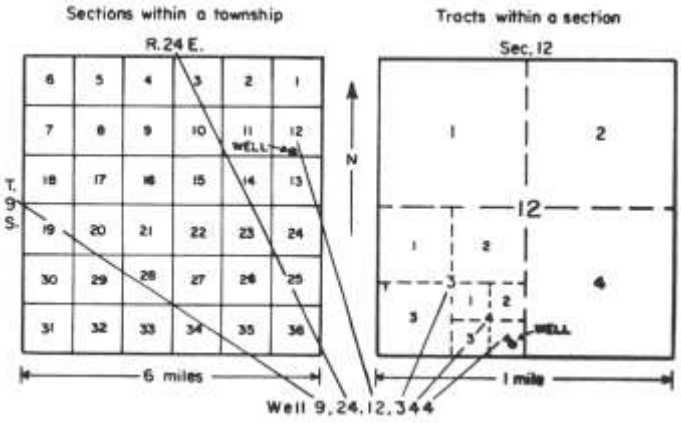
From 1944 to the late 1950's, the sandstone was considered to be the lower member of the San Andres Formation by the U. S. Geological Survey and was called the Glorieta Sandstone Member or the Hondo Sandstone Member (Harbour has recently demonstrated that the Glorieta and Hondo are distinct stratigraphic units west of this report area). However, during this period, geologists of the New Mexico State Bureau of Mines and Mineral Resources and many petroleum geologists treated it as a separate formation. The U. S. Geological Survey adopted it as a formation in 1957 as a result of work in the northwestern part of New Mexico by Dane and Bachman. Usage of Glorieta Sandstone as a formational name is now accepted.

The Glorieta Sandstone is present in nearly all parts of New Mexico and commonly is 100 to 200 feet thick. In the literature, it is reported to range in thickness from 10 to 12 feet in southern Eddy and Lea Counties to as much as 520 feet in northeastern Torrance County. Other significant thicknesses are 240 feet in northeastern Catron County, 300 feet in the Zuni Mountains, 200 to 250 feet in San Miguel County, 225 feet in northwestern Mora County, as much as 150 feet in the Sandia Mountains, and an average of 150 feet in the Raton Basin. The Glorieta extends into north and west Texas where it is called the San Angelo Sandstone; in south-central Colorado, it is called the Lyons Sandstone, and in east and northeastern Arizona, it has been given many names including Upper De Chelly Sandstone, Coconino Sandstone, and Black Creek Member of the De Chelly Sandstone. In southeast Arizona it may be the equivalent of the Sherrer Formation, and in southwest Kansas it is correlated with the Cedar Hills Sandstone. The Glorieta Sandstone is a producing formation in some oil fields of west Texas and southeast New Mexico, and in northeastern New Mexico shows of oil and carbon dioxide have been reported in oil tests. It serves as an aquifer in northwest Chaves County and in other parts of New Mexico, and in eastern Arizona. In northeastern New Mexico it is the host rock for ore deposits, and in north-central New Mexico it has been considered as a possible source of glass sand.

WELL-NUMBERING SYSTEM

The system of numbering wells in this report, used generally by the Geological Survey and the New Mexico State Engineer throughout the State, is based on the common subdivision of public lands into sections. The number, in addition to designating the well, locates its position to the nearest 10-acre tract in the land network. The number is divided by periods into four segments. In this report, the first segment denotes the township south of the New Mexico base line, the second segment denotes the range east of the New Mexico principal meridian, and the third segment denotes the section; and the fourth segment, which consists of three digits, locates the well in a particular 10-acre tract. For this purpose, the section is divided into four quarters, numbered 1, 2, 3, and 4, in the normal reading order — the northwest, northeast, southwest, and southeast quarters, respectively. The first digit of the fourth segment indicates the quarter section, which usually is a tract of 160 acres. Similarly, the quarter section is divided into four 40-acre tracts numbered in the same manner, and the second digit denotes the 40-acre tract. Finally, the 40-acre tract is divided into four 10-acre tracts, and the third digit denotes the 10-acre tract. Thus, well 9.24.12344 is in the SE 1/4 SE 1/4 SW 1/4 sec. 12, T. 9 S., R. 24 E. If a well cannot be located accurately to a 10-acre tract, a zero is used as the third digit, and if it cannot be located accurately to a 40-acre tract, zeros are used for both the second and third digits. Letters a, b, c, etc., are added to the last segment to designate the second, third, fourth, and succeeding wells in the same 10-acre tract.

The system of numbering wells is illustrated below.



The well-numbering system in sections not one mile square is as follows: seven measurements of 1/8 mile each are made from the southeast corner of the section parallel to the south and east lines. The tracts are numbered in the same manner as those in the 1-mile-square sections, except that the location is scaled from the southeast corner.

text continued on page 8

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Well 4.21.33.111 (PVACD No. 9)		
San Andres Limestone		
Dolomite, dove-gray, finely crystalline, slightly silty.	10	530
Glorieta Sandstone		
Sandstone, white to light yellow-brown, quartzose, well sorted, fine grained, subangular, very calcareous; some dolomite, dove-gray, finely crystalline, arenaceous.	10	540
Sandstone, white to light yellow, quartzose, friable, well sorted, subangular, fine to medium grained, dolomitic, silty.	170	550
Yeso Formation		
Sandstone, as above; some siltstone, brown-red and gray; trace of gypsum, white.	40	720
Well 7.20.16.413 (PVACD No. 1)		
San Andres Limestone		
Limestone, dove-gray, very finely crystalline, some very silty; trace of quartz crystal fragments (much twinned) and dolomite, light blue-gray, semi-translucent.	8	382
Glorieta Sandstone		
Limestone, dove-gray, very finely crystalline, and limestone, light gray, silty, arenaceous, appearing like birdseye variety; abundant quartz sandstone, white, friable, fine to medium grained, slightly limy, well sorted, subrounded, clear to slightly milky.	5	390
Sandstone, as above	30	395
Sandstone, as above. Some dolomite, black very finely crystalline; trace of white, chalky gypsum.	10	425
No sample	5	435
Sandstone, as above. Much of it heavily iron-stained; some limestone, dark-gray, possibly represents thin-bedded limestone within the Glorieta Sandstone.	10	440
Sandstone, quartz 50 percent, light gray, fairly well-cemented with calcareous silt. Limestone, 50 percent medium gray-brown, medium crystalline, slightly porous; trace of mudstone, iron-stained and containing fragments of quartz and limestone.	5	450
Limestone, dirty gray, silty and slightly arenaceous; and sandstone, white to gray, limy, slightly silty, well sorted, subangular to subrounded; trace of light-gray chert, semi-translucent.	10	455
Sandstone, as above. Much of it stained yellow; trace of limestone, light-gray to cream, slightly arenaceous, microcrystalline, dull, some with manganese dendrites.	3	465
Sandstone, as above.	10	468
Sandstone, white, friable, fine to medium grained, subangular to subrounded, clear to slightly milky, calcareous.	8	478
No sample.	4	486
Sandstone, as above.	2	490

WELL LOGS (continued)

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
No sample.	3	492
Sandstone, as above, but becoming better cemented and carrying a heavy iron stain.	20	495
Yeso Formation		
No sample. Top of Yeso Formation according to driller's log.	15	515
Sandstone, as above, 50 percent. Limestone, 50 percent, light-gray, very argillaceous, soft, slightly micaceous; trace of gypsum, soft and chalky.	5	530
Siltstone, brick-red, mustard and gray, soft, calcareous. Contains thin stringers of limestone, light yellow-brown, medium crystalline.	15	535
Well 9.20.11.233 (Texam No. 1 Federal-Blount)		
San Andres Limestone		
Limestone, gray-brown; some vugs filled with calcite; trace of dark-brown, hard, highly ferruginous limestone from 474 to 479 feet.	16	463
Limestone, light gray; some pink, very fine grained limestone.	4	479
Glorieta Sandstone		
Limestone, 70 percent light-gray and some pink, very fine grained; 30 percent white, calcareous, medium grained, angular, well-sorted sandstone.	7	483
Sandstone, white calcareous, medium grained, angular, well sorted.	7	490
No sample.	7	497
Sandstone, white, calcareous, medium grained, angular, well sorted; stained yellow from 543 to 546 feet.	42	504
Sandstone, 70 percent calcareous, medium grained, angular, well sorted, stained yellow; 30 percent light-gray, very fine grained limestone, trace of mica.	5	546
Limestone, 80 percent gray and yellow with trace of chert; 20 percent calcareous, medium grained, angular, well sorted sandstone stained yellow; sandstone decreasing and some clear quartz fragments (2-4 mm) from 557 to 568 feet.	17	551
Limestone, 70 percent, gray-buff, very fine grained; 30 percent yellow-stained sandstone.	12	568
Sandstone, 95 percent white, fine grained, friable, well sorted, yellow-stained; 10 percent gray, very fine grained limestone.	9	580
Sandstone, 70 percent white, fine grained, friable, well sorted, yellow-stained; 10 percent gray, very fine grained limestone.	4	589
Sandstone, 95 percent white, fine grained, friable, well sorted, yellow-stained; 5 percent gray, very fine grained limestone.	7	593
Sandstone, 70 percent; 30 percent gray, very fine grained limestone.	5	600
Sandstone, 95 percent white, fine grained, friable, well sorted, yellow-stained.	13	605

WELL LOGS (continued)

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Sandstone, white, fine grained, friable, well sorted, yellow-stained; some gray siltstone.	6	618
Sandstone 50 percent, white, fine grained, friable, well sorted, yellow-stained; 50 percent gray and gray-brown limestone; trace of gray siltstone.	4	624
Limestone, 90 percent, dark-gray and buff, very fine grained; trace of white chert; some pink limestone intergrown with gray limestone from 631 to 635 feet.	7	628
Limestone, 50 percent, and 50 percent sandstone with trace of brown and gray, very calcareous siltstone.	5	635
Sandstone, 90 percent silty, very calcareous, fine grained, angular; 10 percent medium-gray, very fine grained limestone; trace of black chert.	5	640
Sandstone, 80 percent silty, very calcareous, fine grained, angular; 20 percent gray and yellow, calcareous, arenaceous siltstone.	4	645
No sample.	8	649
Yeso Formation		
Sandstone, 95 percent, yellow and white, calcareous; 5 percent red, calcareous siltstone; trace of limestone grains; some silty gray sandstone from 661 to 664 feet.	7	657
Sandstone, 60 percent yellow and white, calcareous; 40 percent red, very calcareous, arenaceous siltstone.	6	664
Sandstone, 50 percent yellow and white, calcareous; 50 percent red and mustard siltstone.	4	670
No sample.	3	674
Siltstone, white, gray, red and mustard, arenaceous and calcareous; trace of gray chert, and yellow siltstone with ironstone inclusions from 681 to 684 feet.	7	677

Well 10.20.16.44 (PVACD No. 2)

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
San Andres Limestone		
Limestone, light gray-brown, semi-translucent, finely to very finely crystalline, and dolomite, light-gray, very silty; trace of white chert.	15	310
Glorieta Sandstone		
Sandstone, gray-white, friable, quartzose, calcareous, well sorted, grains subangular to subrounded; zones within this interval are silty, highly iron-stained, or contain partings of yellow clay; occasional fragments of white gypsum.	53	325
Sandstone, as above, with abundant dolomite, light gray, silty, very finely crystalline; sandstone is well cemented with calcite.	12	378
Dolomite, dove-gray, very finely crystalline, slightly silty.	25	390
Dolomite, as above, with some white, friable sandstone as above, becoming iron-stained and well cemented at base of interval.	25	415
Yeso Formation		
Transition zone containing sandstone, yellow to brown, silty, fine grained, well cemented with calcite and iron; dolomite, dirty gray, very finely crystalline; siltstone, gray and	24	440

WELL LOGS (continued)

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
brownish-yellow, calcareous; scattered fragments of soft white gypsum; traces of pyrite in the gray siltstone.		
Well 10.21.16.222 (PVACD No. 3)		
San Andres Limestone		
Limestone, light-buff, soft to hard, finely crystalline, dolomitic; large number of loose, clear, calcite cleavage fragments. Driller logged cave at 494-500, lost all drilling water.	16	484
Glorieta Sandstone		
Sandstone, white, quartzose, fine grained, well sorted, poorly cemented with calcite, many grains well rounded and frosted.	42	500
Dolomite and limestone, light buff, very finely crystalline; abundant cleavage fragments of clear calcite.	13	542
Dolomite, light dove-gray, very finely crystalline.	16	555
Sandstone as from 500-542 with thin partings of dolomite, gray, very finely crystalline; sandstone becomes progressively siltier, better cemented, more poorly sorted, and mottled with yellow iron stain 600-625.	54	571
Dolomite, medium gray, very finely crystalline, silty; some sandstone, yellowish-gray, silty, calcareous, iron-stained.	5	625
Yeso Formation		
Dolomite, dark gray-brown, very finely crystalline.	20	630
Dolomite as above with abundant siltstone, brick-red, gray, black, slightly calcareous.	5	650
Well 10.24.34.443 (PVACD Strat. Test)		
San Andres Limestone		
Core No. 20, 979-1012 feet. Cut 33 feet and recovered 29.7 feet.		
Anhydrite, gray, finely to medium crystalline, some dark-brown, fractured, inclusions, tight.	2	979
Anhydrite, gray to dark-gray, finely to medium crystalline, some horizontal healed fractures; some inclusions of darker gray dense anhydrite in irregular shapes.	5.5	981
Glorieta Sandstone		
Sandstone, very fine grained, well cemented, anhydritic to very anhydritic; well rounded, well sorted, nonporous.	3.5	986.5
Sandstone, light-gray, very fine grained, friable, well sorted, well rounded, good porosity, sulphur staining throughout; this zone probably lost 3.5 feet of core.	2	990
Sandstone, very fine grained, light-gray, very anhydritic, thin wavy shale partings in minor amounts; very tight; places have greater percentage anhydrite than sand, but still basically sand.	15.3	992
Anhydrite, gray, very finely crystalline, tight.	1.4	1007.3
Core No. 21, 1012-1050 feet. Cut 38 feet and recovered 36 feet.		

WELL LOGS (concluded)

Stratigraphic unit and material	Thickness (feet)	Depth (feet)
Dolomite, dark-brown, dense to very finely crystalline, slightly fossiliferous, very sandy.	14	1012
Anhydrite, gray, very finely to finely crystalline, sandy.	3	1026
Sandstone, very light-gray, very anhydritic, very fine grained, isolated spots of bleeding sulphur water in middle 1029.	2	1029
Sandstone, as above, very slightly shaly, sulphur stain in some thin layers; tight.	2.5	1031
Sandstone, gray, anhydritic, slightly dolomitic, very fine grained, slightly friable, sulphur odor.	12	1033.5
Anhydrite, very sandy, sulphur odor on fresh break; very tight.	3.5	1045.5
Dolomite, dark-gray to brown, sandy, dense to very finely crystalline, trace shale, very tight.	1	1049
Core No. 22, 1050-1077 feet. Cut 27 feet and recovered 23.5 feet.		
Dolomite, dark-brown to gray, finely to medium crystalline, anhydritic, few hairline shale partings; trace stylolites; tight.	9.7	1050
Dolomite, dark-gray, dense to lithographic, tight.	0.4	1059.7
Anhydrite, gray to clear, densely to coarsely crystalline, much dense gray dolomite included.	4.3	1060.1
Dolomite, dark-gray, dense, some anhydrite filling vugs to 1 inch; minor fractures, tight; very scattered, thin horizons of porosity, probably not interconnected; dolomite slightly siliceous, lighter in color in basal part; thin sandy zone in middle 1072.	10.1	1064.4
Core No. 23, 1077-1081 feet. Cut 4 feet and recovered 4 feet.		
Dolomite, gray, dense, tight.	0.5	1077
Sandstone, gray, very fine grained, anhydritic, dolomitic.	3.5	1077.5
Core No. 24, 1096-1102 feet. Cut 6 feet and recovered 5 feet.		
Sandstone, gray, very fine grained, very slightly friable, anhydritic, dolomitic, speckled with sulphur stain.	6	1096

LITHOLOGY

Field descriptions of the Glorieta vary widely, but nearly all workers cite exposures as being light-buff or orange to yellowish-brown, composed of well-sorted, subangular to subrounded, fine to medium-grained quartz particles cemented in varying degrees by calcium carbonate, silica, or iron oxide. The upper part of the formation is commonly well-cemented and forms cliffs or ledges; the lower part is commonly soft and friable, and, in some areas, includes thin silt beds or carbonate intervals. The Glorieta is usually thin to medium-bedded with crossbedded units alternating with evenly bedded units; it is singularly unfossiliferous. Mineralogically, the Glorieta has been described as being 90 to 98 percent quartz, which is commonly limonite-stained and exhibits secondary enlargements; heavy minerals present in trace amounts include zircon, tourmaline, magnetite, leucoxene, and ilmenite.

The Glorieta Sandstone does not crop out in northwestern Chaves County. The nearest outcrops, in Lincoln County, are approximately 12 miles to the west and northwest where it is about 200 feet thick, and about 5 miles to the southwest where it is about 100 feet thick. Harbour (1970) has described two distinct Permian sandstone units in this area (eastern Lincoln County) and determined that the upper unit was the Hondo Sandstone of Lang (1937) and that the lower unit was the Glorieta Sandstone of the southern part of Chupadera Mesa as mapped and described in detail by Wilpolt and Wanek (1951). Study of well cuttings and logs of 25 wells that penetrated the sandstone section in the northwest Chaves County area revealed that only 3 wells (7.20.16.413, 9.20A1.233, and 10.21.16.222), located in the western part of the area, had definite upper and lower portions. The remaining wells had sandstone sections that were essentially solid (4.21.33.111) or consisted of interbedded sandstone and carbonate beds of variable thickness and number. More than half of the logs included limestone stringers in the bottom part of the unit and, in a number of instances, as much as 30 feet of limestone and dolomite was noted. The Hondo is a tongue of the Glorieta, according to Kelley (1971), and becomes an indistinguishable part of it when mapped regionally. In the subject area the Glorieta Sandstone has range in thickness from 180 feet in the northwest to 60 and 73 feet in the east and southwest, respectively. The average thickness in the 25 wells is 114 feet.

Lithologic descriptions of drill cuttings or cores of the Glorieta Sandstone interval of six wells follow. The 116 feet of Glorieta cored in well 10.24.34.443 (PVACD Strat. Test), has been described by Havenor (1968) and is used here with his permission; all other descriptions are by the author.

STRUCTURE

Of the more than 700 wells drilled in northwestern Chaves County area (including irrigation, stock, domestic, oil, recharge, observation, and stratigraphic), only 91 penetrated the top of the Glorieta Sandstone deep enough to contour the top of the sandstone (see well table following text). Glorieta tops, in most instances, were determined by examination of cuttings or cores, or were picked from driller's logs. In some instances, particularly in old oil tests for which logs could not be found, reported tops from State and Federal files were used. Altitudes and locations of all wells were determined from U. S. Geological Survey topographic maps.

The Glorieta, at its greatest depth in the area, is underlain by about 2,000 feet of Yeso Formation and is overlain by about 1,250 feet of the San Andres Limestone, more than 1,000 feet of the Artesia Formation, and 200-300 feet of the Dockum Group (Triassic); it lies from 325 feet below the land surface in the southwestern part of the area to 2,690 feet below the land surface in the extreme southeastern part, dipping generally east to east-southeast at about 70 feet per mile.

Stratigraphic Units

System	Series	Group or Formation
Triassic		Dockum Group
		Artesia Formation
	Upper	San Andres Limestone
Permian	———	
	Lower	Glorieta Sandstone
		Yeso Formation

The structure of the top of the Glorieta Sandstone in the eastern half of the mapped area (map at centerspread) is characterized by gentle undulations, minor changes in strike, and two east-west trending, diabase dikes (Railroad Mountain and El Camino del Diablo) of Tertiary(?) age in the southeastern part of the area. Existing data do not reflect any displacement along the dikes. On the basis of Glorieta tops picked in two pairs of closely spaced wells, however, a fault of small displacement has been located about two miles south of and nearly parallel to the northernmost of the two dikes. This fault, downthrown as much as 75 feet on the south and extending westward to about the center of T. 8 S., R. 26 E., probably is related to faulting noted in the Cato-San Andres oil field some 20 miles to the east (written communication, May 1969, B. F. Hoffacker, Jr., Grover and Hoffacker, Midland, Texas).

The structure of the western half of the area is considerably more complex, being complicated by Tertiary(?) faulting and folding and by post-Artesia solution. In the southwest and south-central part of the area two faulted anticlines trend generally northeastward. The westernmost of the two, the

Border Hills structure, extends about 6 miles into the mapped area as a rather narrow distinctive ridge with a topographic relief of about 200 feet near its junction with U. S. Highway 70-380. Although it appears from the air to be downthrown on the west, there is no reasonable way of contouring the top of the Glorieta without showing it as being downthrown on the east with a maximum displacement of about 150 feet diminishing northeastward and dying out in the vicinity of State Highway 48. Fracturing and other indications of movement in line with the structure have been observed approximately 4 miles beyond State Highway 48 in Rock Tank Draw (sec. 14, T. 8 S., R. 21 E.).

The easternmost structure, Sixmile Hill, is not as apparent on the surface as is the Border Hill Structure. It is a broader linear feature, with about 100 feet of topographic relief, which can be traced about 10 miles northeastward from the south border of the mapped area to Toltec Hills in the west-central part of T. 9 S., R. 24 E., and (with some imagination) beyond, to the vicinity of Salt Creek where it crosses U. S. Highway 285. At this point it may curve gradually northward as suggested by anomalous drilling conditions in two deep wells located in T. 8 S., R. 24 E., and the presence of aligned sinkholes along its extension. There is also a strong possibility the structure splits in the vicinity of Toltec Hills, which are located in the western part of sections 17-20, T. 9 S., R. 24 E. The northeast branch may extend as far as the northeast part of T. 7 S., R. 25 E., as suggested by a series of prominent hills and aligned sinks. Sixmile Hill structure, in the vicinity of Roswell, has been downthrown about 100 to 200 feet on the west with displacement diminishing rather rapidly northeastward.

The two structures described above, and at least three others south of the mapped area, transect the Roswell basin. They have been described in some detail by Merritt, Bean, Nye, Renick, Maddox, Havenor (1968), Stipp, and in recent publication by members of the Roswell Geological Society (1968) as simple folds, as normal, high-angled, and thrust-faulted anticlines, and as exhibiting some or no horizontal displacement, with differing versions of the relative displacement, if any. Hypotheses concerning the origin of the structures are nearly as abundant and diverse as their description.

In addition to the features described above, the structure map of the Glorieta Sandstone shows the presence of two closed depressions in the west-central and northwest part of the area. Study of well logs, as related to the surface geology and drainage in the area, indicates the following: 1) the Glorieta in the northern and larger of the two depressions, herein named Yoder Sink, has been depressed about 350 feet, 2) the San Andres Limestone is abnormally thin along the east-west axis of the sink, having a thickness of 300-400 feet as compared to 500-600 feet in flanking wells, and 3) more than 400 feet of red and yellow clay and silt of Quaternary age and some limestone of the Artesia Formation overlie the San Andres Limestone in the sink area. The same general situation exists in the smaller depression to the south, herein named Ball Sink, where the Glorieta has been depressed about 150 feet. The San Andres in the sink is about 320 feet thick as compared to more than 500 feet in nearby wells, and the sink contains 195 feet of red and yellow clay of Quaternary age and some limestone of the Artesia Formation overlying the San Andres. Surface rocks surrounding both of the sinks are San Andres limestone (the contact of the San Andres with the overlying Artesia is located 6-12 miles eastward) and both sinks are coincident with major drainageways, the northernmost called Padilla Creek, the southernmost being an unnamed tributary of Salt Creek.

The three anomalies at Yoder and Ball Sinks (the depression of the Glorieta Sandstone, the presence of an abnormally thin section of San Andres Limestone, and the presence of the two surface depressions) can be explained by two hypotheses: 1) the Glorieta and the overlying formations were downwarped in post-Artesia time by solution and removal of evaporites from the underlying Yeso Formation and of gypsum and the more soluble carbonate beds of the San Andres and the overlying Artesia Formation by circulating ground water, and 2) the Glorieta was downwarped in pre-Artesia time, at least in part, by solution and removal of evaporites from the underlying Yeso Formation while the San Andres was being thinned locally by subaerial erosion, and the surface depressions were developed by solution and collapse in Cenozoic time. The second hypothesis is not supported by evidence of pre-Artesia solution in the area...all observed San Andres-Artesia contacts are conformable and no evidence is known for non-marine conditions in San Andres or Artesia time in or near this area.

During much of post-Artesia time this area was above sea level, and was receiving terrestrial sediments. Therefore, fresh ground water circulated down into Permian rocks and some solution took place during this time. The bulk of solution and deformation, however, probably took place during late Cenozoic time during the latter part of which Padilla Creek and the unnamed Salt Creek tributary were superimposed on the Permian terrane. The development of the surface drainage was accompanied by subsurface solution and removal of evaporites from the Yeso Formation, and of gypsum and the more soluble carbonates from the San Andres by circulating ground water. Deformation was most pronounced along the stream courses because of stream losses which localized and concentrated ground water solutional activities. This resulted in down-warping of the Glorieta Sandstone and overlying formations and thinning of the San Andres Limestone in the sink areas. Debris carried by surface waters filled the depressions as they subsided.

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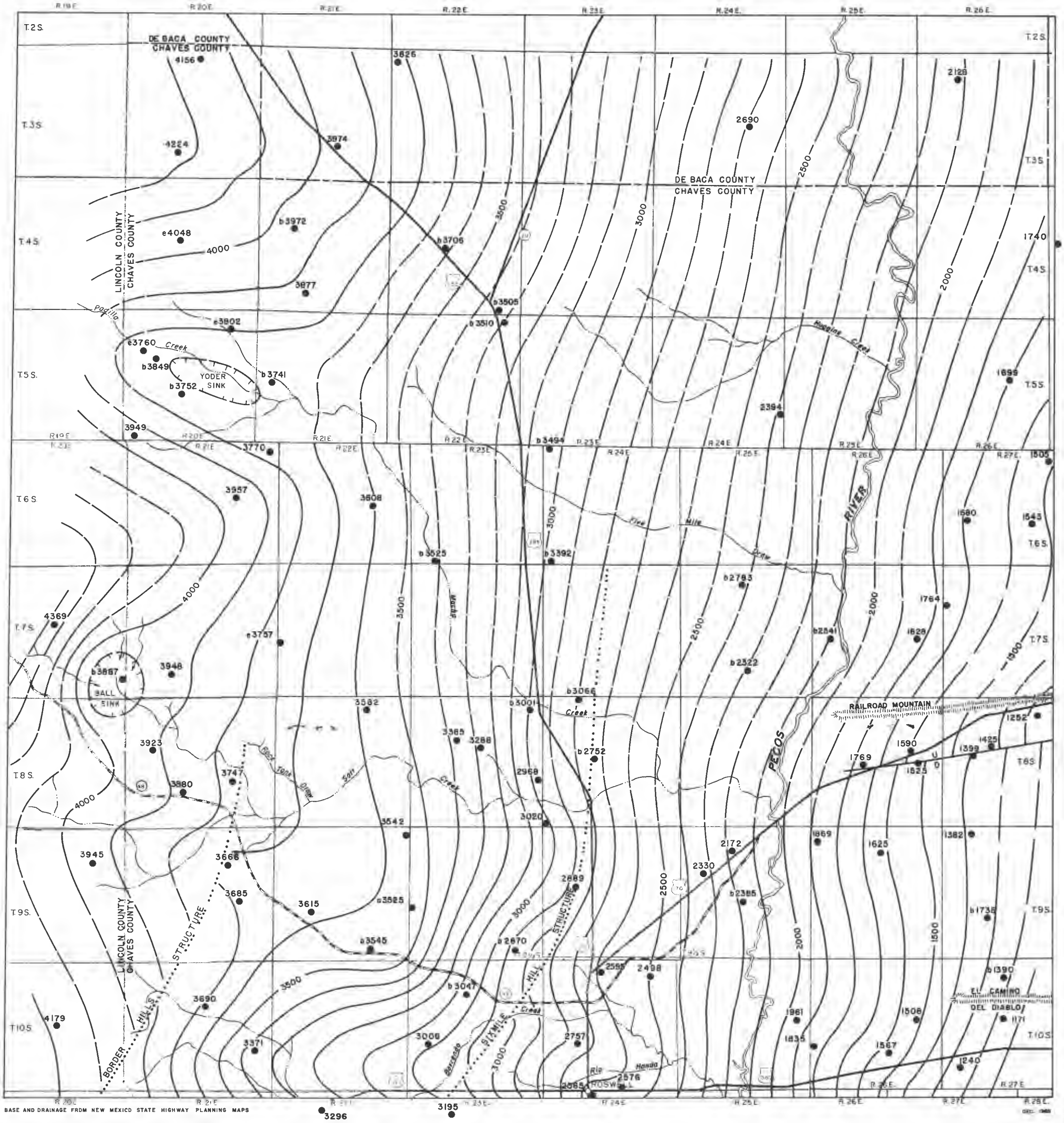

BASE AND DRAINAGE FROM NEW MEXICO STATE HIGHWAY PLANNING MAPS

STRUCTURE OF THE GLORIETA SANDSTONE

NORTHWEST CHAVES COUNTY NEW MEXICO

by

R. L. BORTON

NEW MEXICO STATE ENGINEER OFFICE

1969

SCALE IN MILES

—3500—, contours drawn on altitude of top of Glorieta Sandstone (dashed where approximately located); contour interval 100 feet; datum, mean sea level; ●3545, well location with altitude of Glorieta top (a, Glorieta top above this altitude; b, Glorieta top below this altitude; e, altitude of Glorieta top estimated); U/D, fault (U, upthrown side; D, downthrown side); ••••, structural zone (dashed where approximately located).

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Appendix follows

APPENDIX

Wells Used in Compiling Structure Map

Explanation

Location: See explanation of well-numbering system in text. All wells in Chaves County unless noted otherwise.

Name or owner: Name or owner at time of scheduling; PVACD, Pecos Valley Artesian Conservancy District; USGS, U. S. Geological Survey.

Altitude: Altitude, in feet, of land surface at well determined from U. S. Geological Survey topographic maps.

Depth to top of Glorieta Sandstone: Depth, in feet, of the top of the Glorieta Sandstone below land surface; a, Glorieta occurs above this depth; b, Glorieta occurs below this depth; e, Glorieta top estimated.

Altitude of top of Glorieta Sandstone: Altitude, in feet, of the top of the Glorieta Sandstone; a, Glorieta occurs above this altitude; b, Glorieta occurs below this altitude; e, Glorieta altitude estimated.

Remarks: L, well log available; S, well samples examined; T, geologic tops available.

Location	Name or owner	Altitude	Depth of well	Depth to top of Glorieta Sandstone	Altitude of top of Glorieta Sandstone	Remarks
3.20. 3.11a	Armstrong	4,706	700	550	4,156	L
28.332a	Dunlap Cattle Co.	4,624	595	400	4,224	L
3.21.27.144	Parsons	4,659	815	685	3,974	L, De Baca County
3.22. 6.134	Transcontinental No. 1 McWhorter	4,431	4,776	605	3,826	L, De Baca County
3.24.23.120	Nearburg and Ingram No. 1 Murray	4,054	5,372	1,364	2,690	L T, De Baca County
3.26. 8.222	Engle 1-X State	3,944	1,831	1,817	2,128	L T, De Baca County
4.20.16.343	Corn	4,623	605	e575	e4,048	Driller reports 30 feet of sand at bottom
4.21.17.210	Lewis	4,580	608	b608	b3,972	L
33.111	PVACD No. 9	4,417	760	540	3,877	L S
4.22.21.122	NM Highway Dept.	4,468	762	b762	b3,706	L S
35.444	Martin	4,345	840	b840	b3,505	L
4.27.18.320	Olson No. 1 Noble Trust	3,865	8,030	2,125	1,740	L T
5.20. 2.443	Roswell	4,372	600	e570	e3,802	Driller reports 30 feet of sand at bottom
7.443	Chav-Linc No. 1 Letitia-Emma	4,430	590	e670	e3,760	Glorieta top interpreted from drilling report
17.124	Yoder	4,408	590	b590	b3,849	L
21.433	McDaniels	4,542	790	b790	b3,752	L
31.341	Johnson	4,449	650	500	3,949	L
5.21.19.214	Boswell	4,356	615	b615	b3,741	L
5.22. 1.100	Martin	4,350	840	b840	b3,510	S
5.24.25.240	Sanders No. 1 Sanders	3,864	5,355	1,470	2,394	T
5.26.14.332	McBee No. 1 Federal-	3,936	6,606	2,237	1,699	T
6.21. 1.433	McKnight	4,375	622	605	3,770	L
6.21.14.333	McKnight	4,402	639	445	3,957	L
6.22.23.132	do.	4,223	640	615	3,608	L
6.23.32.333	El Paso Nat. Gas Co.	3,938	413	b413	b3,525	L
6.24. 6.314	McDaniels-Corn	3,994	500	b500	b3,494	L
31.334a	El Paso Nat. Gas Co.	4,057	665	b665	b3,392	L
6.27.11.220	Samedan No. 1 Chatten Ranch	4,041	6,923	2,536	1,505	T
20.333	Forest Oil No. 1 Federal Haystack	3,906	6,315	2,226	1,680	L T
6.27.26.111	Samedan No. 1 Smith Ranch	4,105	6,732	2,562	1,543	L T
7.20.16.413	PVACD No. 1	4,759	750	390	4,369	L S, Lincoln County
36.222	Ball	4,354	467	b467	b3,887	L, Lincoln County
7.21.29.334	do.	4,473	755	525	3,948	L
7.22.19.311	Corn	4,437	700	e680	e3,757	Driller reports well bottomed in sand
7.25. 4.444	Ward No.1 Balin-Federal	3,833	1,050	b1,050	b2,783	L S
27.330	Cities Service No. 1 Federal	3,602	1,280	b1,280	b2,322	L S
7.26.19.242	Frady No. 1 Everett	3,576	2,035	b1,035	b2,541	L S
23.242	Fisher No. 1 Etz	3,818	2,005	1,990	1,828	T
7.27. 7.330	O'Neill No. A-1 Lodewick-Federal	3,842	2,180	2,078	1,764	L T

APPENDIX (continued)

Location	Name or owner	Altitude	Depth of well	Depth to top of Glorieta Sandstone	Altitude of top of Glorieta Sandstone	Remarks
8.21.18.142	Jones	4,305	470	382	3,923	L
23.333	Childress	4,197	610	450	3,747	L
39.234	do.	4,230	565	350	3,880	L
8.22. 2.313	Corn	4,127	580	545	3,582	L
8.23. 1.322	Corn	3,701	700	b700	b3,001	L
15.132	Stevenson-White No. 1 Keyes	3,950	3,300	662	3,288	L S
16.111	Elliot No. 1 State	4,050	784	665	3,385	L
24.444b	Lewis No. 1 Ballard	3,682	2,888	714	2,968	L T
8.24. 5.112	Corn	3,644	578	b578	b3,066	L
16.333	PVACD No. 10	3,632	880	b880	b2,752	L S
31.333	Toltec No. 1 State	3,730	3,120	710	3,020	L
8.26.14.430	Dekalb No. 1 Duke	3,900	6,458	2,310	1,590	T
21.120	Antweil No. 1 Dekalb	3,800	6,463	2,031	1,769	T
23.222	Cities Service No. 1 Federal	3,920	2,954	2,395	1,525	T
8.27. 2.340	Sinclair No. 1 State-Chaves (129)	3,924	6,880	2,682	1,252	T
8.27.16.100	Colorado Gas and Fuel No. 1 Campbell-Hill	3,950	5,040	2,525	1,425	L T
17.320	Sinclair No. 1 State-Chaves (119)	3,974	7,022	2,575	1,399	T
9.20.11.233	Texam No. 1 Federal-Blount	4,428	3,562	483	3,945	L S, Lincoln County
9.21.10.422	Draper	4,273	755	607	3,666	L
23.123	Freitag	4,285	750	600	3,685	L S
9.22. 1.244	Marley	4,047	700	505	3,542	L
20.432	Corn	4,260	729	645	3,615	L
35.323	Cole Bros.	4,095	575	550	3,545	L
9.23.19.313	Marley	4,075	580	a550	a3,525	Logged only 550-580 feet all in Glorieta
35.424	Sons	3,695	825	b825	b2,870	L
9.24.17.314a	Toltec Oil No. 2	3,692	2,675	803	2,889	L T
9.25. 9.122	Neal No. 2 Harbert	3,590	1,427	1,418	2,172	L
17.111	Bent No. 1	3,670	1,403	1,340	2,330	L
21.244a	Reynolds No. 2 Federal	3,520	1,135	b1,135	b2,385	L
9.26. 6.320	Union Oil No. 1 Kitchens	3,706	5,755	1,837	1,869	L T
10.110	Honolulu Oil No. 1 McConkey	3,835	6,371	2,210	1,625	L T
9.27. 5.142	Shell Oil No. 1 State "CB"	3,920	2,650	2,538	1,382	L T
28.110	Whatley No. 1 Intex-State	3,820	2,095	b2,095	b1,735	L T
10.20.16.444	PVACD No. 2	4,504	503	325	4,179	L S Lincoln County
10.21.16.222	PVACD No. 3	4,190	672	500	3,690	L S
25.110	City of Roswell Test No 1	4,092	800	721	3,371	L T
10.23. 9.411	Cooper-McKnight	3,780	733	b733	b3,047	L
19.444	City of Roswell Test No. 4	3,828	822	822	3,006	L T
10.24. 2.440	Tannehill No. 1	3,548	2,086	1,050	2,498	L T
4.411	USGS Strat. Test	3,600	1,357	1,005	2,595	L T, No returns below 982 feet
10.24.20.433	Compton No. 1 Emerson	3,614	2,250	857	2,757	L
34.443	PVACD Strat. Test	3,560	1,155	984	2,576	L T S
10.25.13.340	Dekalb No. 1 Lewis	3,711	5,650	1,750	1,961	L T
10.26.14.444	Cactus Oil No. 2 State	3,750	2,273	2,242	1,508	L T
27.230	New State Pet. No. 1 Federal	3,695	2,242	2,128	1,567	L T
30.112	Shaffer Oil No. 1 Wilson	3,830	2,325	1,995	1,835	L T
10.27. 4.444	Smith No. 1 Humble-State	3,881	2,500	b2,491	b1,390	L
16.440	Honolulu Oil No. 1 Levick	3,850	7,215	2,679	1,171	L T
31.222	Sinclair No. 1 State-Chaves (180)	3,725	6,930	2,485	1,240	L T
11.22. 4.333	City of Roswell Test No. 2	3,930	797	634	3,296	L T
11.23. 8.222	Forsythe No. 2 Gibson	3,840	657	645	3,195	L
11.24. 4.114d	City of Roswell	3,570	1,471	1,005	2,565	L T