OKLAHOMA GEOLOGICAL SURVEY

Robert H. Dott, Director

Mineral Report No. 21

GROUND WATER IN THE CHEROKEE AREA, ALFALFA COUNTY, OKLAHOMA

by

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NORMAN

1950

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Prepared in cooperation between the U. S. Geological Survey and the Oklahoma Geological Survey

Introduction

This report summarizes information in the files of the State and Federal Geological Surveys at Norman, Oklahoma, on the ground-water resources in the vicinity of the city of Cherokee, Alfalfa County, Oklahoma, together with data furnished by City and County officials and the personal observations made by the writer on March 11 and 12, 1949. It was undertaken under the terms of a cooperative agreement between the two Surveys, by which the ground-water resources of Oklahoma are being studied and evaluated systematically. One phase of this program is to make accessible to public officials, where the public welfare may be served, the information that may be on hand. Cherokee is the principal user of ground water in Alfalfa County.

Geography

Cherokee is centrally located in, and is the county seat of, Alfalfa County, in northwestern Oklahoma. It is the supply center for an area of substantial farms. In 1940 it had a population of about 2,500, which subsequently has increased to an estimated 3,000 to 3,500. The surrounding area is a gently undulating plain that slopes northward or north-eastward toward the valley of Salt Fork and the Great Salt Plains. The latter is a shallow elliptical basin southeast of Cherokee, and is distinguished by a white incrustation of salt over much of its surface. North of Salt Fork the land rises somewhat more abruptly and is hilly.

/ District Geologist, Ground Water Branch, U. S. Geological Survey, Norman, Oklahoma.

Cherokee Municipal Water Supply

For many years the City of Cherokee has pumped its water from wells within the city limits. Because of a flat monthly water rate, water consumption is unusually high, at times reaching a peak of 2,500,000 gallons per day during summer.

In 1938 the city had five gravel-walled wells 12 to 24 inches in diameter and 35 to 49 feet in depth.1/ They were equipped with electrically driven centrifugal and turbine pumps capable of delivering 300 to 900 gallons of water per minute. Under normal operating conditions, yields of 300 to 350 gallons per minute were obtained from individual wells, although one of the wells was reported to have yielded 825 gallons per minute during its initial test. The water-bearing beds were described as sand and gravel and the static water levels in 1938 were said to be 15 to 20 feet below the surface. In addition to these wells, from which water was pumped directly into the distribution lines, the city had a 12-inch well 35 feet deep, without a gravel wall, in the park. This was used for filling a swimming pool.

In March 1949 the water-supply system was similar but not identical. New wells had been drilled to replace old ones that had failed. The total had become six, but the sixth well had not yet been put in service. The well in the park had not been connected to the mains and seemed to be on the point of failure, owing, possibly, to encrustation or corrosion of the screen. A well drilled in the southern part of the city during 1948 had proved a dry hole, although it encountered a favorable-looking bed of gravel. Static water levels were reported as 12 to 18 feet below the land surface.

1/ Reported by Water Superintendent E. E. Cramer to the writer in 1938.

Table 1
Cherokee city water wells, March 1949

Well No.	Location	Depth (feet)
1	Power plant, North part of town	38 ?
2	Washington and Fulton Streets	36.7
3	Franklin and Second Streets	35.7
4	Between Colorado and Massachusetts Streets on an alley off 7th Street	40
5	Between 5th and 6th, and Massachusetts and Pennsylvania	38.5
6	½ block East of intersection of Nebraska and Washington Streets (pump not yet installed)	38.0

Contamination of water supply. In tests made by a mobile laboratory of the Oklahoma State Department of Health, the water from all the municipal wells was found to be contaminated. To cope with the contamination, chlorination equipment was installed at well 5, and during the early months of 1949 all the municipal water supply was being taken from this well, which was reported to be furnishing 500 gallons per minute, 23 hours a day. It was evident that this well would not be able to meet the heavy demand for water during the summer.

The contamination was thought by the County Superintendent of Health and by the City Manager to come from the city sewers, which are not new and which, having been laid at a depth of 6 feet, are only about 6 feet above the water table in some parts of town. This explanation appears reasonable, and if correct it means that new wells drilled within the city limits are not likely to obtain uncontaminated water.

The problem, however, goes beyond contamination, for the hardness of the water is also a matter of concern. An analysis made in 1934 of water from the Cherokee public supply shows the total hardness as 516 parts per million (table 2). One user reports a cost of $6 to $7 per month for home water softening, not to mention the incidental costs arising from the rapid formation of scale in pipes, cooking utensils, and automobile radiators.

General Geology

The bedrock formations of Alfalfa County are mainly red shale and red fine-grained sandstone, of Permian age, underlain by Pennsylvanian and older Paleozoic rocks. These bedrocks underlie the entire county. They generally yield only meager supplies of ground water. Overlying them in parts of the county are unconsolidated stream-laid alluvium and terrace deposits, of Quaternary age, which generally yield water to wells rather freely.

Ground Water In Terrace Deposits

Terrace deposits consist of materials laid down by streams, which since the time of deposition have shifted their channels laterally and have cut them to lower levels. The terrace deposits, therefore, are adjacent to and topographically higher than the present streams. They consist of sand, gravel, and clay, and mixtures thereof, in irregular layers and in proportions that differ from place to place. In Oklahoma the coarser beds in the terrace deposits generally yield water to wells more freely than the bedrocks do, and on the whole the water is of better quality than that from the bedrocks. It also may be better than water from alluvium, but the quality is not uniform throughout the deposits. Replenishment of the ground water in the terrace deposits comes mainly from rain falling on their surfaces.

Terrace deposits in the vicinity of Cherokee. Although all geologic maps known to the writer show the city of Cherokee to be underlain directly by Permian red beds, it is evident that the surface rocks are terrace deposits. In the first place, the city water wells encountered gravel and sand foreign to the red bedrock formations of the region, and their relatively high and long-sustained yields greatly exceed the abilities of most wells in the bedrocks. In the second place, the light-brown sandy soils,

gently undulating topography and ill-defined drainage of the area around Cherokee are more typical of terrace deposits than of the bedrocks. The time available for field investigation did not permit mapping the outline of the terrace deposits on which Cherokee is located, but an automobile traverse across them was made as shown in figure 1. The thickness of the terrace deposits in the Cherokee area, as indicated by the public-supply wells, ranges from 35 to 49 feet, assuming that the wells all reach the bottom of the deposit but do not enter the underlying bedrocks. South and southwest of the city, farm wells reported to the State Mineral Survey2/ as tapping water in sand or gravel range in depth from 30 to 125 feet (fig. 1), but as records of the drilling are not available there is no assurance that the deeper ones do not penetrate the bedrocks beneath the terrace deposits.

The thickness of the deposits is likely to be far from uniform, because the surface on which they were laid doubtless was uneven and because the present land surface is uneven. In places the deposits may be too thin to contain water, as, for example, along the north line of sec. 30, T. 26 N., R. 11 W., where a few small red spots in the road indicate that the graders may have scraped up flakes of the red beds. Likewise, along the road near the NW cor. sec. 5, T. 25 N., R. 11 W., the bedrocks are exposed. Between these two localities and Cherokee, however, are several square miles where the terrace deposits may be thick enough to contain a great deal of ground water.

It is normal for terrace deposits to be highly irregular in lithology as well as in thickness. Beds of sand or gravel may grade into silt or clay within short distances. The coarser and cleaner gravels may be confined to winding buried channels whose location cannot be predicted from surface evidence. The many farm wells that apparently failed to find water-bearing sand or gravel west and southwest of Cherokee (fig. 1)

2/ A WPA project sponsored and directed by the Oklahoma Geological Survey; tables of well records in Survey files in Norman.

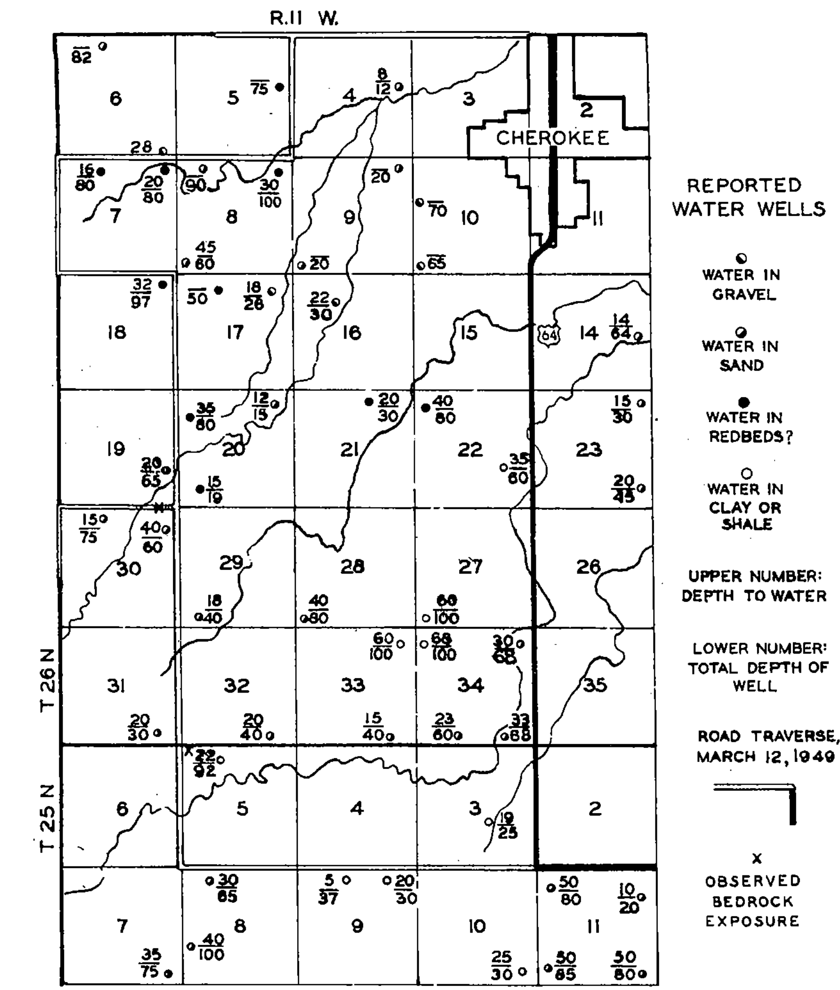
suggest that locally the terrace deposits consist almost entirely of fine silt or clay. It is evident, therefore, that test drilling affords the surest way of finding the thickest, cleanest, and most permeable water-bearing beds.

The slope of the water table and the consequent direction of movement of the ground water in the terrace deposits have not been determined, but probably the slope is northeastward, conforming approximately to the slope of the land surface. From this probability it follows that the contamination problem may be solved by developing a water supply outside the city limits and up the slope of the water table--that is, to the southwest. In this way, ground water would be intercepted as it moves toward the city and before it could become contaminated from the sewers.

As the terrace materials southwest of Cherokee are continuous with those surrounding the present municipal wells and therefore are part of the same underground reservoir, it is probable that the mineral content of the water is about the same as in the present city water supply, and that no marked difference in the hardness of the water can be expected (table 2).

Terrace deposits north of Salt Fork. A narrow strip designated on the geologic map of Oklahoma[3] as "terrace deposits and dune sand" parallels the north side of Salt Fork from the western boundary of the county eastward beyond Driftwood, and there spreads out over half a dozen townships extending nearly to Wakita in Grant County. How much of this area is underlain by terrace deposits, how much by dune sand, and how much by both, is not known. Dune sand is wind-blown sand drifted in hummocks. Although generally too thin to afford much reservoir capacity and in most localities entirely above the water table, dune sand has an important bearing on ground-water resources because it soaks up a relatively large fraction of the rain that falls on it. As the terrace deposits may also by sandy, the

3/ Miser, H. D., "Geologic map of Oklahoma"; U. S. Geol. Survey, 1926.



FARM WATER WELLS SOUTHWEST OF CHEROKEE, ALFALFA COUNTY, OKLAHOMA, AS REPORTED TO THE STATE MINERAL SURVEY.

annual replenishment of ground water in this area may be a fairly large part of the annual precipitation, which averages 25.41 inches at Cherokee.4/ As the rate of replenishment of the terrace deposits at Cherokee seems to have been adequate to meet the pumping load in the present city wells, it is probable that the replenishment of the terrace deposits north of Salt Fork is also adequate.

Locally, the geologic and topographic conditions are such that wells will overflow at the surface, as at the Oklahoma State Fish Hatchery in the NW¼ sec. 9, T. 27 N., R. 9 W., and at the Guffy place about 0.5 mile to the north near the W¼ cor. sec. 4. According to Superintendent Clyde Burelson,5/ a 4-inch pump installed in an 8-inch well at the hatchery yielded 750 gallons per minute, but the test was of short duration because the water level promptly was drawn down to the bottom of the suction pipe, which was 20 feet below the surface, and pumping was stopped. The sustained yield, therefore, was not actually determined. Mr. Burelson further stated that the average depth of wells in the immediate vicinity of the hatchery is about 30 feet, and that pumping in the well cut off the flow of other wells on the grounds. This is the normal and unavoidable effect of pumping. The 8-inch well currently furnishes by natural flow a substantial volume of water to maintain fish ponds.

The two wells owned by Sheriff Ted Guffy are about 2 inches in diameter and are reported to be about 14 feet deep, having penetrated about 6 inches into the underlying red beds. They have flowed without significant diminution for the past 35 years. An analysis made in a commercial laboratory in 1927 indicated that the dissolved solids content of the water is only 86 parts per million and that the water is quite soft (table 3). Periodic tests by the Oklahoma State Department of Health have demonstrated that the water is "safe" from a bacterial standpoint, and it is being

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4/ U. S. Dept. Commerce, Weather Bur., "Climatological data, Oklahoma section, 1946."

5/ Oral communication

bottled for sale in the city.6/

A spring estimated to flow about 100 gallons per minute issues from the terrace deposits about 1 mile east of the State Fish Hatchery, and has been improved for domestic supply of a farm. Other springs are reported, and their total discharge doubtless is a significant amount.

During World War II the O. T. Medium Bombardment Station, north of Jet, Oklahoma, and 7 or 8 miles east of Cherokee, had two wells drilled in the SE$\frac{1}{4}$ sec. 35, T. 27 N., R. 9 W. The wells are on the north side of Salt Fork, and according to Police Chief Goss7/ are above the level of the flood plain, and hence must be in the area of terrace deposits. These wells were drilled 36 inches in diameter to depths of 43.5 and 44.5 feet, and were cased to a depth of 15 feet with 36-inch surface casing. Blank 8-inch casing was run in them to depths of 31 and 32 feet, with 14-inch slotted concrete screen extending to the bottom, and both wells were gravel-packed. In well 1 the static water level on completion was 12 feet below the surface, and in well 2, which is 1,000 feet farther from Salt Fork, it was 19 feet. Well 1 yielded on test 160 gallons per minute with a drawdown of 6 feet, or 10 gallons per minute per foot of drawdown. Well 2 yielded 75 gallons per minute with a drawdown of 10 feet, or 7.5 gallons per minute per foot of drawdown. An analysis of the water from one of these wells shows very low concentrations of the mineral constituents that were tested, and the water is only moderately hard (table 4).

The available information about the ground-water possibilities of the terrace deposits north of Salt Fork is sketchy, but it suggests that the ground water is probably of good quality and that fairly large yields may be obtained in favorable places. As in the terrace deposits surrounding the city of Cherokee, test drilling affords the best means of locating the thickest and most productive water-bearing sands and gravels.

6/ Guffy, Ted, oral communication.
7/ Oral communication

Terrace deposits near Aline. Terrace deposits and dune sand occur also in a strip about 15 miles long and ranging up to 5 miles wide in the southern part of Alfalfa County near Aline. This is part of a large area of such materials extending along the northeast side of the Cimarron River from near Waynoka in Woods County to the vicinity of Guthrie in Logan County. It has been tapped for municipal water supply by Alva, and extensive exploration for ground water has been conducted in it by the city of Enid, but no investigation of it in Alfalfa County has been made.

Ground Water In Alluvium

Alluvium is the material deposited by a stream. It may consist of gravel, sand, and clay in any proportion, and it underlies the flood plain or "bottom." It is generally thickest near the middle of a valley and thinnest where the flood plain adjoins the bluffs. It may be more than 100 feet thick along major rivers, but only a few feet along small creeks. In many places the alluvium is an excellent aquifer, both because the coarser beds in it will transmit water freely and because replenishment of the ground-water supply is likely to be greater in valleys than in adjacent areas.

The largest body of alluvium in the vicinity of Cherokee is along Salt Fork, and it doubtless is partly saturated, but the water in it may not be of very good quality. It is said that the ground water in the alluvium along Salt Fork is highly mineralized, but this report cannot be verified readily, as the Survey files contain no analyses representing this water from the vicinity of Cherokee. Smith8/ reports 10 analyses representing the public water supply of Alva, which were made between 1927 and 1937 when that city had five wells considered to be drawing water from the alluvium of Salt Fork. The dissolved solids reported in nine of these analyses was less than 800 parts per million and would

8/ Smith, O. M., "The chemical analyses of the waters of Oklahoma:" Oklahoma Agr. and Mech. College, Engineering Exp. St., Pub. 52, p. 394, 1942.

be acceptable for most domestic uses. The chlorides, which are indicative of the amount of common salt ($NaCl$) in the water, ranged from 10 to 209 parts per million. It has been reported that the water from the alluvium along Salt Fork is salty. The available analyses do not bear this out, but it should be kept in mind that they may not be representative of the water in the alluvium all along Salt Fork.

Even if the ground water in the Salt Fork alluvium at Cherokee were as low in mineral content as at Alva, it probably would be harder than is generally desirable for a public supply. The hardness at Alva ranged from 247 to 605 parts per million and that city abandoned the wells mentioned above. In 1941 a new well field was developed in the sand hills about 21 miles to the south. Representative analyses of the older Alva water supply and of the Cherokee water supply are given in table 2, at the end of this paper.

Ground Water in deposits of the Salt Plains

Unconsolidated sand, gravel, silt, and clay overlie the Permian bedrocks in the Great Salt Plains basin between Cherokee and Jet. These materials are considered by Theis9/ to have been deposited by Salt Fork while meandering south of its present course. He states that the gravel is mostly near the base, and the upper 2 or 3 feet of the deposits consists of interlaminated sand and silt. He suggests that the deposits may range from 20 to 25 feet in thickness. Their relation to the unmapped terrace deposits of the Cherokee area, adjacent on the west, is not known.

Although the deposits in the Salt Plains basin contain ground water, the salt crust on their surface indicates that the quality of the water is poor.

9/ Theis, C. V., "Preliminary geological report on the Salt Plains reservoir site, Oklahoma:" typewritten report, 1934, in files of U. S. Geological Survey, Norman, Oklahoma, and Washington, D.C.

Gould, Hutchison, and Nelson10/ in 1908 attributed the salt crust to the evaporation at the surface of salty water from "small springs which issue from the redbeds beneath the plain," and this explanation has been followed by later writers.11/ Gould12/ wrote that "on digging a hole a few feet deep in any part of the plains ....salt water begins to run in and in 10 minutes the hole will fill....to within 6 inches of the top," and Snider13/ reported an analysis by Buttram of ground water from the salt plain showing 152,100 parts per million of chlorine (Cl), 150,013 parts of soda (Na_2O), and relatively high concentrations of lime (CaO), magnesia (MgO) and sodium bicarbonate ($NaHCO_3$).

Ground water in bedrocks

The bedrock formations of the Cherokee area are red beds of Permian age which Clifton14/ described as "red shale and sandstone, with some interbedded ledges of lighter colored shales and sandstones." Locally, lenses of gypsum (hydrous calcium sulfate) are interbedded in the red shales.

Shales generally transmit water very slowly through joints and cracks, and a well in shale is not likely to yield more than enough water for domestic or stock use on a farm. The fine-grained sandstones in the Permian formations may not yield water much more freely. The

10/ Gould, C. N., Hutchison, L. L., and Nelson, Gaylord, "Preliminary report on the mineral resources of Oklahoma:" Oklahoma Geol. Survey Bull. 1, p. 36, 1908.

11/ Snider, L. C., "The gypsum and salt of Oklahoma:" Oklahoma Geol. Survey Bull. 11, p. 204, 1913. Theis, C. V., op. cit.

12/ Gould, C. N., "Salt" in "Brief chapters on Oklahoma's mineral resources:" Oklahoma Geol. Survey Bull. 6, p. 69, 1910.

13/ Snider, L. C., op. cit., p. 203.

14/ Clifton, R. L., "Oil and gas in Oklahoma: Woods, Alfalfa, Harper, Woodward, and Ellis Counties:" Oklahoma Geol. Survey Bull. 40, vol. II, p. 9, 1930; also, Bull. 40-A, p. 13, 1926.

gypsum interbedded in these rocks is soluble in water and when present in the water in considerable concentration results in the taste popularly described as "gyppy."

Locally, at least, the ground water in the bedrocks is salty at moderate depths. The Lane Oil and Producing Company's oil test drilled in 1919 in the NW$\frac{1}{4}$ NW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 1, T. 26 N., R. 9 W., (Vanosdol 1) encountered salt water at 200 feet or less beneath the surface, and salt interbedded with lime and shale was encountered between 1,207 and 1,211 feet beneath the surface. Water also was found between depths of 54 and 60 feet, but its quality was not recorded. The Ward and McInnis oil-test well in the SE$\frac{1}{4}$ sec. 21, T. 27 N., R. 10 W., (Watts 1) encountered water-bearing sand from 520 to 540 feet below the surface, but the quality of the water was not recorded. In the same well, salt was reported from 1,285 to 1,515 feet below the surface.15/

Analyses are not available to show the chemical character of the ground water from the Permian bedrocks at Cherokee, but analyses of water from the bedrocks at Augusta, Carmen, and Helena, which are 21 to 25 miles south and southwest of Cherokee and on the outcrop of the Permian formations, indicate water of fairly good quality, with the dissolved solids ranging from 433 to 596, the total hardness from 104 to 469, and the chloride from 33 to 189 parts per million (table 5).16/

Conclusions

Ground water probably free of contamination but of about the same mineral character as the present water supply of Cherokee may be obtained from wells in terrace deposits southwest of the city. Test drilling would be necessary to find the most favorable locations for wells. Bacterial and chemical analyses of water from test holes would be desirable to determine whether

15/ Oil-well data from well logs filed with Oklahoma Corporation Commission

16/ Smith, O. M., op. cit., pp. 101-102, 247-248.

the water is bacteriologically safe and whether it is chemically suitable.

Ground water probably free of contamination and apparently of excellent chemical character is available in considerable volume from the terrace deposit north of Salt Fork. Test drilling of the water-bearing formation and bacterial and chemical analysis of the water would be desirable.

Ground water in the alluvium along Salt Fork may be adequate in quantity and relatively high yields may be expected from individual wells, but the water is likely to be high in mineral content and very hard.

Ground water in the bedrock formations is likely to be limited in quantity, generally less than 10 gallons per minute per well. Although some of it is of good quality, it may be too highly mineralized where the rocks include soluble minerals such as gypsum and salt.

Table 2.
Analyses of city water at Alva and Cherokee[17]
(Parts per million)

	Alva[18] 10-19-37	Cherokee[19] 11-29-34
Silica (SiO_2)	20	2
Iron (Fe)	0.1	0.1
Calcium (Ca)	145	97
Magnesium (Mg)	43	68
Sodium and potassium (Na+K)	39	60
Bicarbonate (HCO_2)	274	394
Sulfate (SO_4)	313	240
Chloride (Cl)	52	36
Fluoride (F)	...	...
Nitrate (NO_3)	...	32
Dissolved solids	792	776
Total hardness (as $CaCO_3$)	540	516
pH	7.1	7.3

17/ Smith, O. M., op. cit., pp. 247, 394.
18/ Aquifer interpreted as alluvium of Salt Fork.
19/ Aquifer interpreted as terrace deposit.

Table 3.
Analysis of water from Guffy well[20]
(Parts per million)

Free ammonia	0.02
Albuminoid ammonia	0.08
Total ammonia	0.10
Nitrate (NO_3)	0
Nitrite (NO_2)	0
Chloride (Cl)	12
Alkalinity	50
Sulfate (SO_4)	0
Calcium oxide (CaO)	20
Magnesium oxide (MgO)	10
Dissolved solids	86

20/ By C. E. Clifford, chemist, Medical Arts Laboratory, Oklahoma City, March 29, 1927.

Table 4.
Analysis of water from well at
O. T. Medium Bombardment Station21/
(Parts per million)

Aluminum (as Al_2O_3)	2
Iron (Fe)	0
Silica (SiO_2)	9
Calcium (Ca)	30
Magnesium (Mg)	4
Sodium and potassium (Na+K)	5
Carbonate (CO_3)	43
Bicarbonate (HCO_3)	2
Sulfate (SO_4)	13
Chloride (Cl)	10
Nitrate (NO_3)	2.5
Hydroxide (OH)	0
Free carbon dioxide (CO_2)	0
pH	7.8

21/ By Sidny Born, Consulting chemist, Tulsa, Oklahoma, February 2, 1943.

Table 5.
Analyses of ground water from Permian bedrocks,
Alfalfa County, Oklahoma22/
(Parts per million)

	Augusta	Carmen		Helena		
Date	1926	1934	1932	1936	1934	1932
Silica (SiO_2)	....	15	18	16	5	....
Calcium (Ca)	90	83	96	82	18	25
Magnesium (Mg)	33	23	56	15	20	10
Sodium and Potassium (Na+K)	26	86	14	124	162	212
Bicarbonate (HCO_3)	374	388	382	439	270	354
Sulfate (SO_4)	61	91	100	47	12	....
Chloride (Cl)	33	61	60	83	189	180
Fluoride (F)	....	0	0.6	....	0.5	1.2
Nitrate (NO_3)	....	0	....	12	8	....
Dissolved solids	433	550	576	596	572	....
Total hardness ($CaCO_3$)	310	300	469	267	125	104
pH	....	7.6	7.2	....	7.7	7.8

22/ Smith, O. M., op. cit., pp. 101-102, 247-248.