

U.S. GEOLOGICAL SURVEY CIRCULAR 1019



Review of the General Geology and Solid-Phase Geochemical Studies in the Vicinity of the Central Oklahoma Aquifer

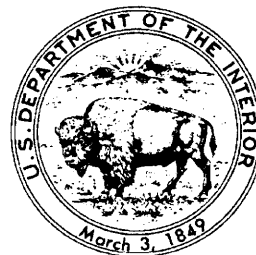
Review of the General Geology and Solid-Phase Geochemical Studies in the Vicinity of the Central Oklahoma Aquifer

By ELWIN L. MOSIER and JOHN H. BULLOCK, JR.

Review of the general geology and of previously reported geochemical studies that relate to the vicinity of the Central Oklahoma aquifer

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DEPARTMENT OF THE INTERIOR
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CONVERSION FACTORS

For readers who wish to convert measurements from the metric system of units to U.S. customary units, the conversion factors are listed below.

Metric unit	Multiply by	To obtain U.S. customary unit
meter (m)	3.281	foot
kilometer (km)	0.6214	mile

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Abstract

The Central Oklahoma aquifer is the principal source of ground water for municipal, industrial, and rural use in central Oklahoma. Ground water in the aquifer is contained in consolidated sedimentary rocks consisting of the Admire, Council Grove, and Chase Groups, Wellington Formation, and Garber Sandstone and in the unconsolidated Quaternary alluvium and terrace deposits that occur along the major stream systems in the study area. The Garber Sandstone and the Wellington Formation comprise the main flow system and, as such, the aquifer is often referred to as the "Garber-Wellington aquifer." The consolidated sedimentary rocks consist of interbedded lenticular sandstone, shale, and siltstone beds deposited in similar deltaic environments in early Permian time. Arsenic, chromium, and selenium are found in the ground water of the Central Oklahoma aquifer in concentrations that, in places, exceed the primary drinking-water standards of the Environmental Protection Agency. Gross-alpha concentrations also exceed the primary standards in some wells, and uranium concentrations are uncommonly high in places.

As a prerequisite to a surface and subsurface solid-phase geochemical study, this report summarizes the general geology of the Central Oklahoma study area. Summaries of results from certain previously reported solid-phase geochemical studies that relate to the vicinity of the Central Oklahoma aquifer are also given; including a summary of the analytical results and distribution plots for arsenic, selenium, chromium, thorium, uranium, copper, and barium from the U.S. Department of Energy's National Uranium Resource Evaluation (NURE) Program.

INTRODUCTION

Solid-phase geochemical studies of the Central Oklahoma aquifer are a result of the National Water Quality Assessment (NAWQA) Program of the U.S. Geological Survey. The Central Oklahoma aquifer,

which underlies about 8,000 km² occurs mostly within the Oklahoma City 1°x2° quadrangle (scale 1:250,000) and extends slightly south into the Ardmore 1°x2° quadrangle. The solid-phase geochemical study area is between lat 34°45' and 36°00' N. and long 96°45' and 97°45' W. and includes the following counties: all of Oklahoma, Cleveland, and McClain; most of Logan, Lincoln, and Pottawatomie; and parts of Kingfisher, Payne, Canadian, Grady, Seminole, Garvin, and Pontotoc (fig. 1).

At various localities in the aquifer, ground-water concentrations of toxic elements such as arsenic, selenium, and chromium approach or exceed the primary drinking-water standards of the Environmental Protection Agency (U.S. Environmental Protection Agency, 1975). Some wells also show evidence that radionuclides of uranium and thorium are entering the ground-water system. In the interest of further development of the aquifer, it is important to know the location of the natural contaminant problem and, moreover, to know the solid-phase sources and geochemical causes of the elevated trace-element concentrations. The objectives of the solid-phase geochemical investigation are (1) to determine the toxic-element concentration levels in various surface and subsurface solid-phase geologic materials, (2) to determine how easily toxic elements are extracted and mobilized from the geologic media by the ground-water system, and (3) to identify areas in the aquifer likely to have high concentrations of naturally occurring contaminants.

The principal sources of ground water in the Central Oklahoma aquifer used for municipal and industrial purposes are the Garber Sandstone and the Wellington Formation; hence, the aquifer has often been called the "Garber-Wellington aquifer." However, the water in the underlying Admire, Council Grove, and Chase Groups, and in the overlying alluvium and terrace deposits is part of the same flow system and, therefore, these units are considered as parts of the Central Okla-

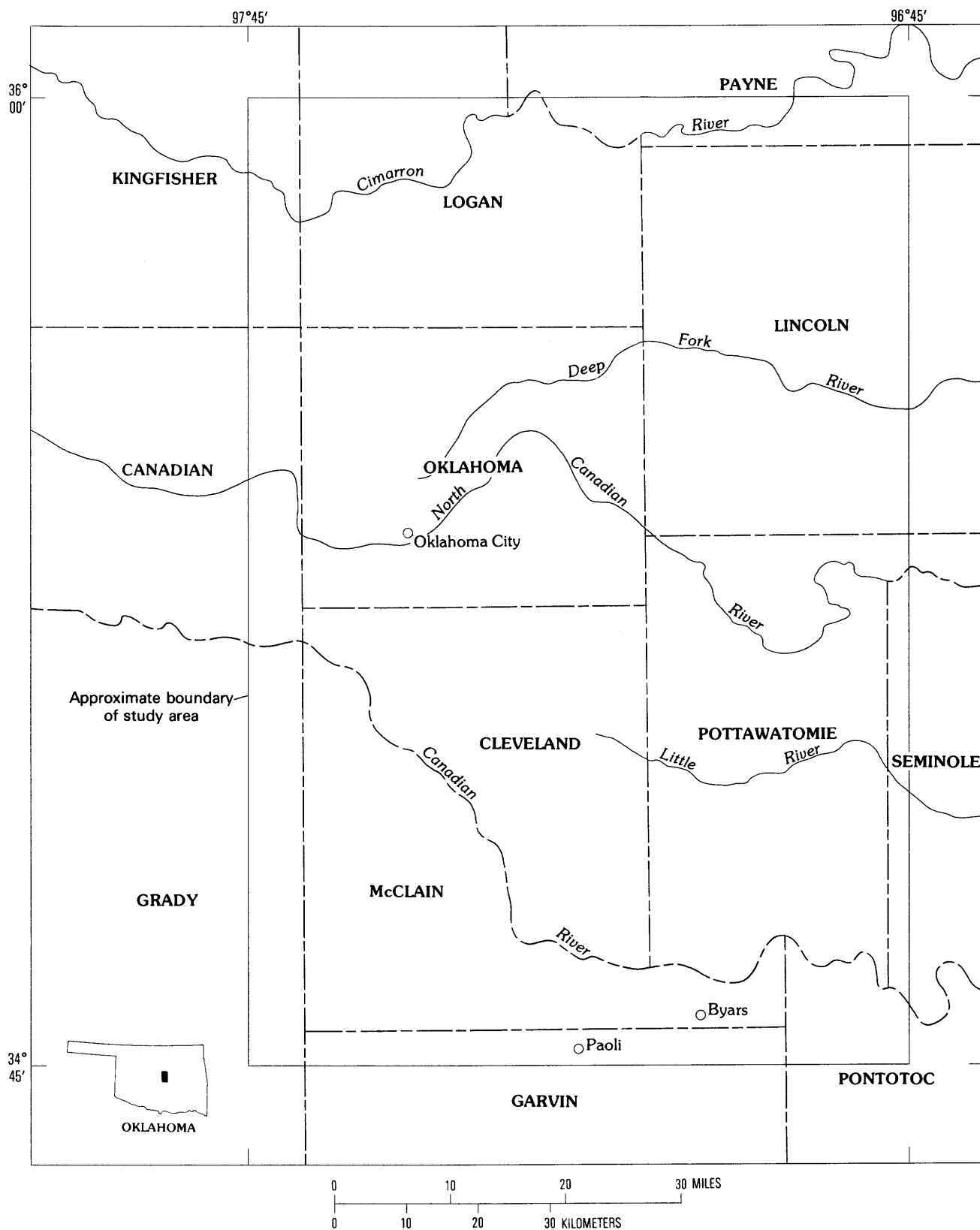


Figure 1. Index map of study area showing counties.

homa aquifer. The consolidated sedimentary rocks in the aquifer are lower Permian deltaic deposits that consist mainly of sandstone with interbedded shale, mudstone, and siltstone.

Previous geologic descriptions and maps of all or parts of the study area have been made by Gould (1905), Aurin and others (1926), Patterson (1933), Miser (1954), Hart (1974), and Bingham and Moore (1975). Further summaries of the general geology and structure of the area are published by county by a number of authors in Oklahoma Geological Survey Bulletin 40 as part of the series "Oil and Gas in Oklahoma" (Gould, 1930).

This report summarizes the geology of the study area and some of the principal features of the solid-phase geochemical data that have been previously reported on the Central Oklahoma aquifer. The amount of geologic information available concerning water quality, outcropping strata, and oil and well-drilling data is imposing, but little surface and (or) subsurface geochemical information exists.

GEOLOGIC SETTING

The generalized geologic map (fig. 2) and the description of the geologic units that crop out in the study area are taken from Hart (1974) and Bingham and Moore (1975). Rocks that are exposed in the study area are Pennsylvanian and Permian consolidated sedimentary units that are known generally as the red beds and unconsolidated terrace deposits, alluvium, and sand dunes of Quaternary age. Structurally the surface formations generally dip gently to the west at about 10 m/km and strike slightly west of north. The formations are apparently conformable and become progressively younger to the west. Sediments that make up the Permian beds were deposited by a large fluvial system flowing from the east into a Permian basin that extended into western Oklahoma and Texas. Patterson (1933) placed the main part of the delta in approximately the area of central Oklahoma County.

Pennsylvanian Rocks

The oldest rocks exposed in the study area are red-brown to gray shale and red-orange-brown fine-grained sandstone of Late Pennsylvanian age that occupy the eastern one-eighth of the study area. These rocks make up the Vanoss Group and yield limited to moderate amounts of water of poor to fair quality. The ground water contains high concentrations of dissolved solids which may make the water unsuitable for some

purposes. Total thickness of the group ranges from 75 to 150 m and increases to the north.

Permian Rocks

Overlying the Pennsylvanian rocks are siltstones, sandstones, and shales of Permian age. It is the Permian rocks that are generally called the red beds; however, color change can not be used as a key for distinguishing the Pennsylvanian-Permian contact (Aurin and others, 1926; Anderson, 1941).

The Permian rocks exposed in the study area are, in ascending order, the Admire, Council Grove, and Chase Groups, Wellington Formation, Garber Sandstone, and the Hennessey and El Reno Groups. Hart (1974) and Bingham and Moore (1975) indicated that the El Reno Group, which crops out in the southwest corner of the study area, consists of the following six formations, in ascending order: Cedar Hills Sandstone, Duncan Sandstone, Chickasha Formation, Flowerpot Shale, Blaine Formation, and Dog Creek Shale. They also indicated that the Hennessey Group, which crops out in the northwest corner and to the east of the El Reno Group in the southwest corner of the study area, consists of the following four formations, in ascending order: Fairmont Shale, Kingman Sandstone, Salt Plains Formation, and Bison Formation. For this report, these two groups, the Hennessey and El Reno Groups, are shown as single units on the geologic map (fig. 2).

The strata referred to as the Admire, Council Grove, and Chase Groups overlie the Vanoss Group and crop out to the west of the Vanoss Group in the eastern portion of the study area. Rocks of the Admire, Council Grove, and Chase Groups are red-brown to gray shale and orange-brown fine-grained, crossbedded sandstone that grade into arkosic sandstone and conglomerate toward the south. The Admire, Council Grove, and Chase Groups contribute ground water to the Central Oklahoma aquifer and are collectively 90–180 m thick.

The Wellington Formation and the Garber Sandstone are the main water-bearing units of the Central Oklahoma aquifer and crop out across the middle portion of the study area. These two units are a single aquifer system because their lithologies and water-bearing characteristics are similar (Wood and Burton, 1968). The units are a complex of interfingering lenticular beds of sandstone, siltstone, and shale that can change in thickness over very short distances. In general, the sandstones are fine to very fine grained and friable. The most common matrix is a fine red mud. The sandstone beds vary in color from white to pink, orange, deep red, or purple and most beds show rather deep hematitic staining. The percentage of sandstone in the aquifer varies throughout the study area. Carr and Marcher

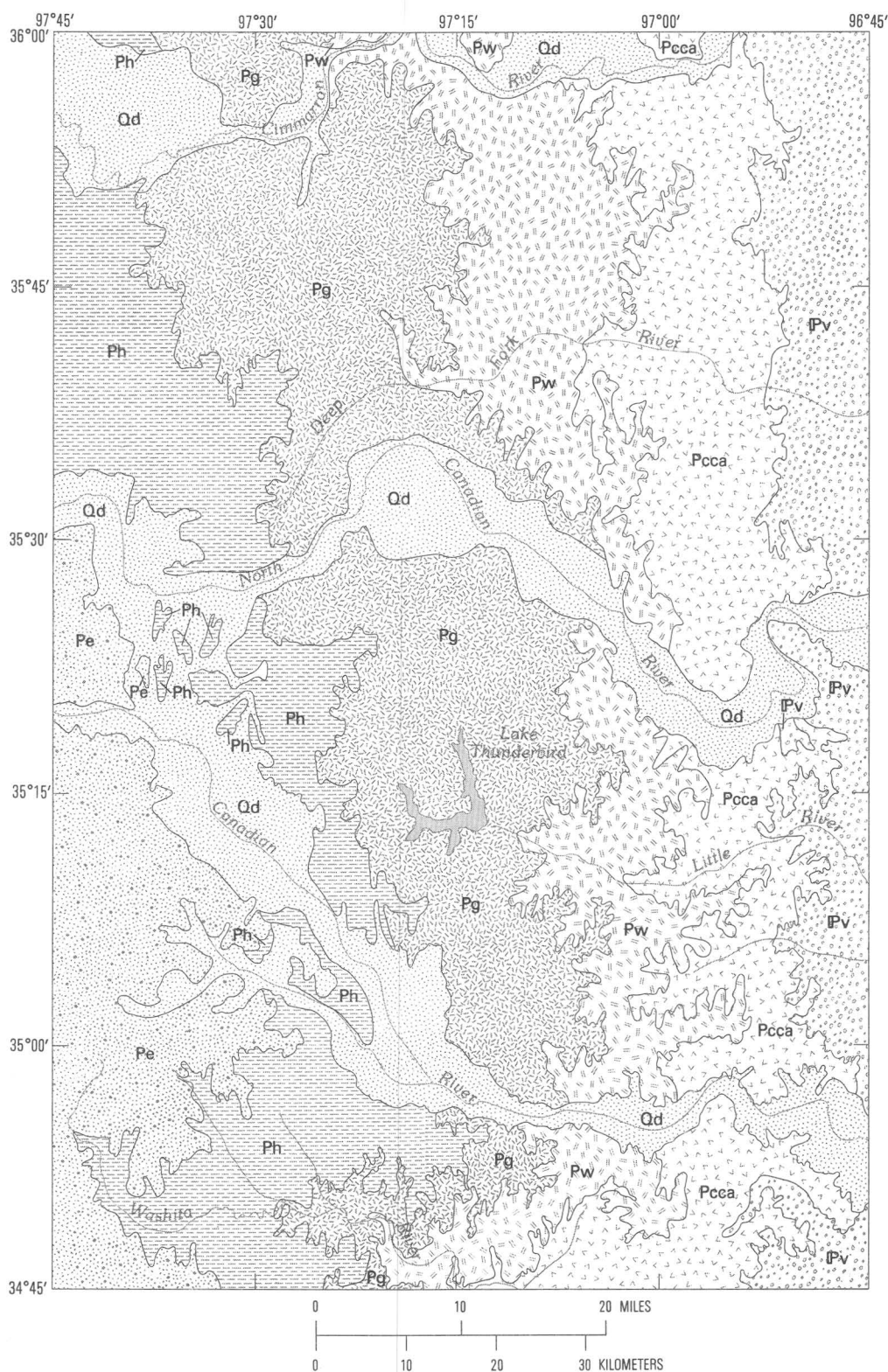


Figure 2 (above and facing page). Generalized geologic map, Central Oklahoma aquifer, Oklahoma. Data modified from Hart (1975) and Bingham and Moore (1975).

EXPLANATION



Alluvium, terrace deposits, and dune sand (Quaternary)—Sand, silt, clay, and gravel of fluvial and eolian origin. Thickness ranges from a few meters to about 30 m



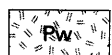
El Reno Group (Upper Permian)—Red-brown to orange-brown fine-grained sandstone, with some variegated conglomerate, shale, and siltstone. Thickness ranges from 60 m to about 225 m



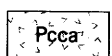
Hennessey Group (Lower Permian)—Reddish-brown blocky shale with some interbedded orange-brown to greenish-gray siltstone and reddish-brown fine-grained sandstone. Grades into Garber Sandstone. Thickness ranges from 40 m to nearly 200 m



Garber Sandstone (Lower Permian)—Mostly orange-brown to red-brown fine-grained sandstone, irregularly bedded with red-brown shale and mudstone conglomerate. Thickness ranges from 50 m to 120 m



Wellington Formation (Lower Permian)—Red-brown shale and orange-brown fine-grained sandstone, containing much maroon mudstone conglomerate to the south. Thickness ranges from about 50 m to 150 m



Chase, Council Grove, and Admire Groups (Lower Permian)—Red-brown to gray shale and orange-brown fine-grained, crossbedded sandstone; grades southward into arkosic sand and conglomerate. Thickness ranges from 90 m to 180 m



Vanoss Group (Pennsylvanian)—Red-brown to gray shale and orange-brown fine-grained, crossbedded sandstone; grades southward into arkosic sand. Total thickness ranges from 75 m to 150 m

(1977) reported that studies of geophysical logs in Logan and Oklahoma Counties show that the sandstone composes 35–75 percent of the aquifer and averages about 50 percent. Sandstone beds reach a maximum thickness of 12 m, but 1.5–3-m beds are most common. The combined thickness of the Wellington Formation and Garber Sandstone is 100–270 m.

In the approximate western one-fourth of the study area, the aquifer is confined by shales and siltstones of the Hennessey Group. The Hennessey Group ranges from 40 to 200 m thick and becomes thicker to the west and south. The Hennessey consists mainly of massive shale beds that range from a few centimeters to 3 m or more in thickness with less common layers of well-indurated siltstone and sandstone beds that similarly range from a few centimeters to about 3 m in thickness. Generally, the contact between the Garber Sandstone and the Hennessey Group can be readily detected because of changes in the geomorphology and vegetation. Areas underlain by sandstone are characterized by rolling steep-sided hills that are chiefly forested with scrub oak, whereas areas underlain by shale are typically rather flat, grass-covered prairies that are mostly devoid

of trees. Exceptions are areas where outcrops of well-indurated beds of Hennessey siltstone and sandstone have weathered to form low shelves or ledges or local areas where the contact appears to be gradational.

Rocks of the El Reno Group were the last Permian beds to be deposited in the study area. These rocks crop out in the western part and southwest corner of the study area and are mostly of the Duncan Sandstone with some Chickasha Formation. The Duncan Sandstone is mainly red-brown to orange-brown fine-grained sandstone, with some mudstone and shale. The Chickasha Formation is a variegated mudstone conglomerate and red-brown to orange-brown silty shale and siltstone, with minor amounts of orange-brown fine-grained sandstone. The Duncan Sandstone and Chickasha Formation are 30–50 m thick and form the hilly area that is located in the western part of McClain County and extends into Grady County to the west and Garvin County to the south.

In contrast to the rest of the study area, the strata south of the Canadian River, in the southwestern and southern portion of the study area, strikes southwest and dips northwest. North of the Canadian River, the older Pennsylvanian formations in Pottawatomie County strike east of north, whereas the strike of the top of the Permian Hennessey in Cleveland County is west of north. Thus, there is a hublike center in the approximate vicinity of the Canadian River in eastern McClain County from which the formations are spread apart (Anderson, 1927). The hublike center in eastern McClain County indicates the southeastern termination of the northwest-southeast synclinal axis of the Anadarko Basin, which is a geosyncline that dominates structural features in western Oklahoma.

Quaternary Deposits

The Quaternary deposits of the study area include terrace deposits of one or more levels adjacent to and associated with broad alluvium-filled stream and river valleys and dune sand. Terrace deposits are relics of old stream systems that have since cut valleys to lower levels. Wind-blown sand accumulates on the northern side of major rivers due to the prevailing south winds and forms in places rather large dunes that are 6–10 m thick. Three major rivers with wide alluvium-filled valleys cut across the area from west to east. These include the Cimarron River to the north, the North Canadian River in the central part of the study area, and the Canadian River to the south. The Deep Fork of the North Canadian River, between the North Canadian and Cimarron Rivers, and

the Little River, between the North Canadian and Canadian Rivers, also have significant alluvium-filled valleys but do not transect the total width of the study area.

SOLID-PHASE GEOCHEMICAL STUDIES

Reports on surface and (or) subsurface solid-phase geochemical studies in the vicinity of the Central Oklahoma aquifer are limited. However, there are numerous reports concerning copper-bearing formations in Permian red-bed strata in the region (Schmitz, 1896; Haworth and Bennet, 1901; Tarr, 1910; Richards, 1915; Fath, 1915; Rogers, 1916; Merritt, 1940; Ham and Johnson, 1964; Hill, 1967; Stroud and others, 1970; Smith, 1974; Fay, 1975; Hagni and Gann, 1976; Kidwell and Bower, 1976; Rose, 1976; Waugh and Brady, 1976; Cox, 1978; Lambert, 1979; Elrod, 1980; Ripley and others, 1980; Berendsen and Lambert, 1981). The red-bed copper deposits are found world-wide and generally occur in comparable geological environments of late Paleozoic and (or) early Mesozoic age. Mineralization usually occurs in gray to greenish argillaceous material enclosed by typical red oxidized sandstone and shales of the red-bed strata and is nearly always associated with carbonaceous matter, especially carbonized and fossilized wood, plant stems, and grasses. Chalcocite is the primary copper mineral and occurs as a replacement mineral in the cement of sandstone, in iron sulfide nodules, and in fossilized wood. Other copper minerals, some of which are alteration products of chalcocite, are also common. Pyrite and marcasite occurrences, either as concretions in sandstones or pseudomorphs after wood, generally are partially or completely replaced by chalcocite and other copper minerals. The mineralized zones, which are usually small, occur as lenses, pods, and layers in the enclosing sediments. Because these deposits, with few exceptions, are low in tonnage and grade, the primary interest to geologists has not been their economic importance but rather the unique circumstances connected with their origin.

The copper-bearing Permian red-bed strata of Oklahoma occur in a sinuous belt as wide as 300 km that extends from north-central Texas through Oklahoma to southeastern and south-central Kansas (Stroud and others, 1970). Specific to the Central Oklahoma aquifer study area, Merritt (1940) mentioned two areas of copper occurrences: one in the far south-central part of the study area near the town of Paoli in Garvin County and the other near Byars in McClain County, about 15 km to the northeast of the first occurrence. Both occurrences are typical, distinctly local red-bed deposits, and although they contributed a few tons of ore in the early part of the century, they have no commercial value today. Shockey and others (1974) described the Paoli

deposit as a copper-silver solution or roll-front similar, except for mineral content, to uranium roll-fronts found in Wyoming and New Mexico.

Extending through the entire north-south length of the Central Oklahoma aquifer study area and corresponding closely with the top of the Garber Sandstone is a zone of barite mineralization (Ham and Merritt, 1944). Near the southern boundary of the study area the top of the Garber Sandstone and the zone of barite mineralization make a large bend and continue on to southwestern Oklahoma and north-central Texas. The zone of barite mineralization roughly correlates with the copper belt, and in many of the references listed above, barite is mentioned as being associated with the red-bed copper ores. Barite occurs in the red beds in the form of concretions, veins, cement, and disseminated grains. Although the total volume is extensive, the barite does not occur at any one location in sufficient concentrations to be economically important. Of all the types of barite occurrences, the ones that have received the most attention are the sand-barite rosette concretions. These rose-shaped crystal aggregates of barite are especially abundant in central Oklahoma and locally are found weathering out of sandstone, particularly the Garber Sandstone, or in Quaternary gravels derived from the weathering of sandstone. Because of the roselike configuration, the sand-barite rosettes are of special interest to collectors and they have been selected as Oklahoma's official state rock. They occur in only a few places in the world, and as such there has been some scientific interest to explain their origin (Tarr, 1933; Ham and Merritt, 1944).

The most extensive geochemical reconnaissance investigation in the study area has been conducted by the U.S. Department of Energy's Hydrogeochemical and Stream Sediment Reconnaissance Survey as part of the NURE Program. Geochemical data for stream-sediment samples that are within the boundaries of the Central Oklahoma aquifer area were obtained from reports provided by Union Carbide Corporation, Nuclear Division (1978a, b). These data are summarized in the geochemical distribution maps of figures 3–10.

A total of 1,629 stream-sediment samples were collected within the boundaries of the two quadrangles by personnel from the Bendix Field Engineering Corporation, Austin, Tex., under the auspices of the NURE staff. All samples were returned to the NURE project laboratory in Oak Ridge, Tenn., for preparation and analysis. From the data set, 522 samples fall within the boundaries of the Central Oklahoma aquifer study area. The <150- μ m fraction of the stream-sediment samples was analyzed. The elements that were determined, the analytical techniques that were used, and the detection limits are given in table 2.

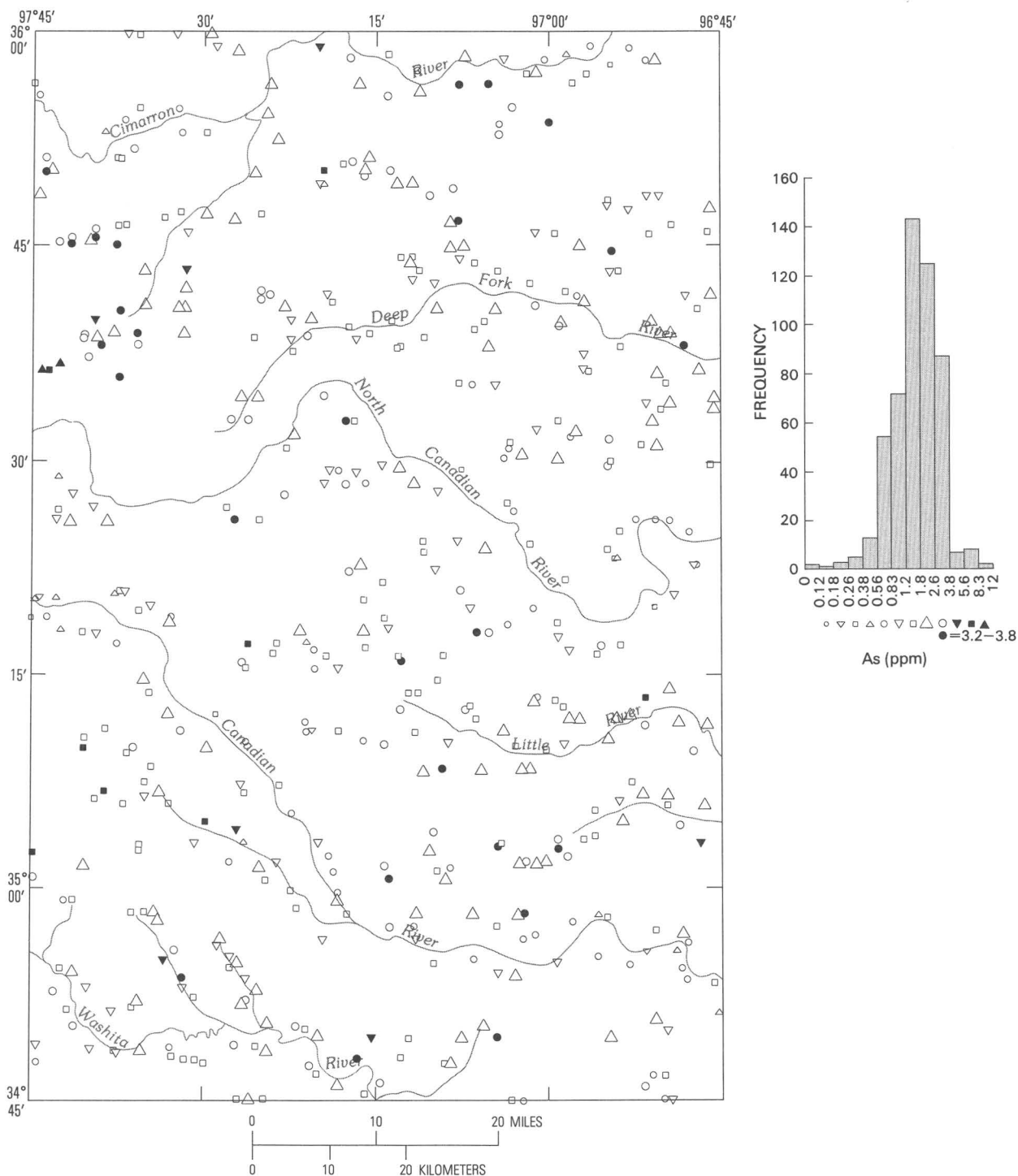


Figure 3. Geochemical distribution of arsenic (ppm) in stream sediments of the Central Oklahoma aquifer; 521 samples plotted.

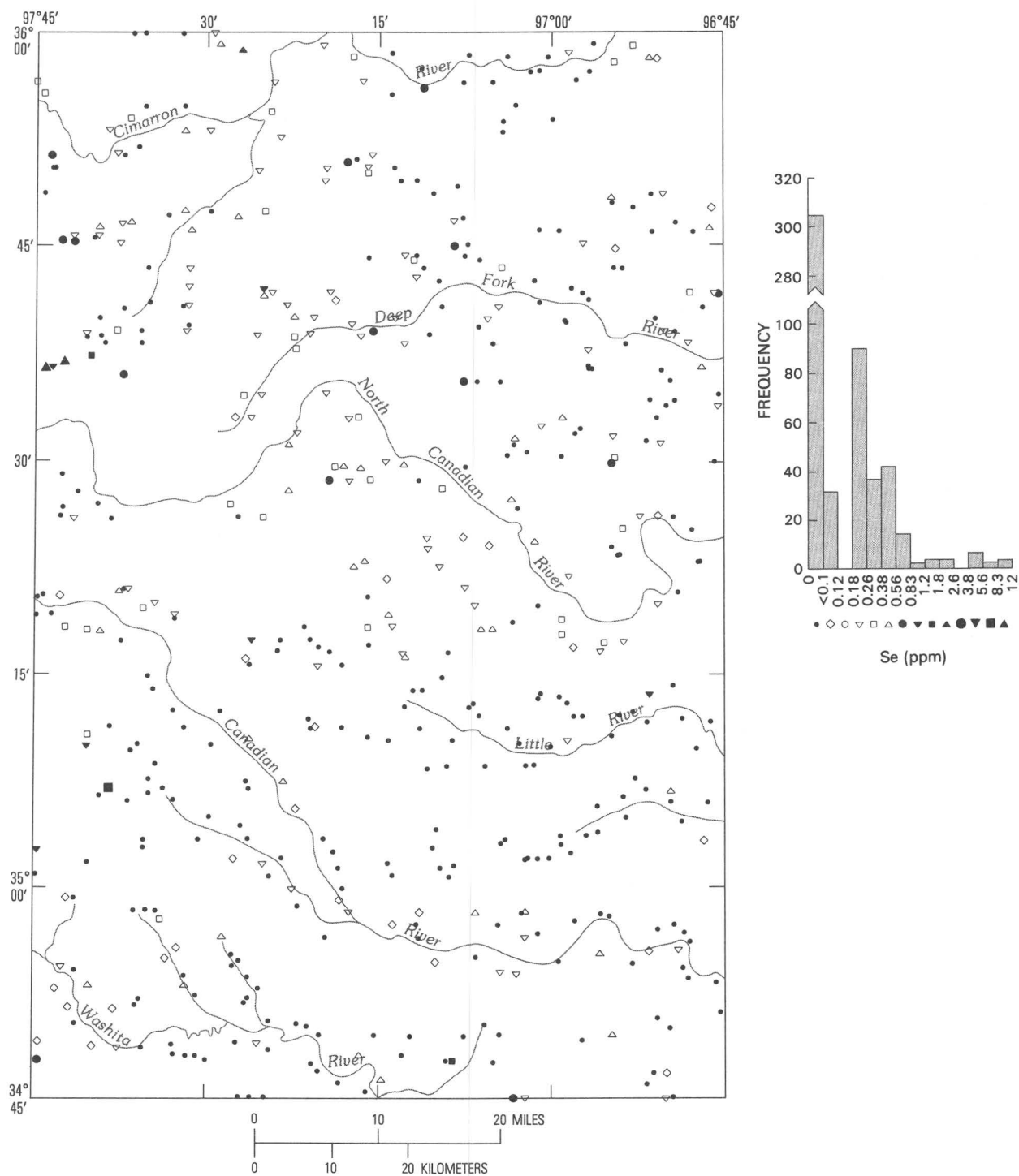


Figure 4. Geochemical distribution of selenium (ppm) in stream sediments of the Central Oklahoma aquifer; 522 samples plotted.

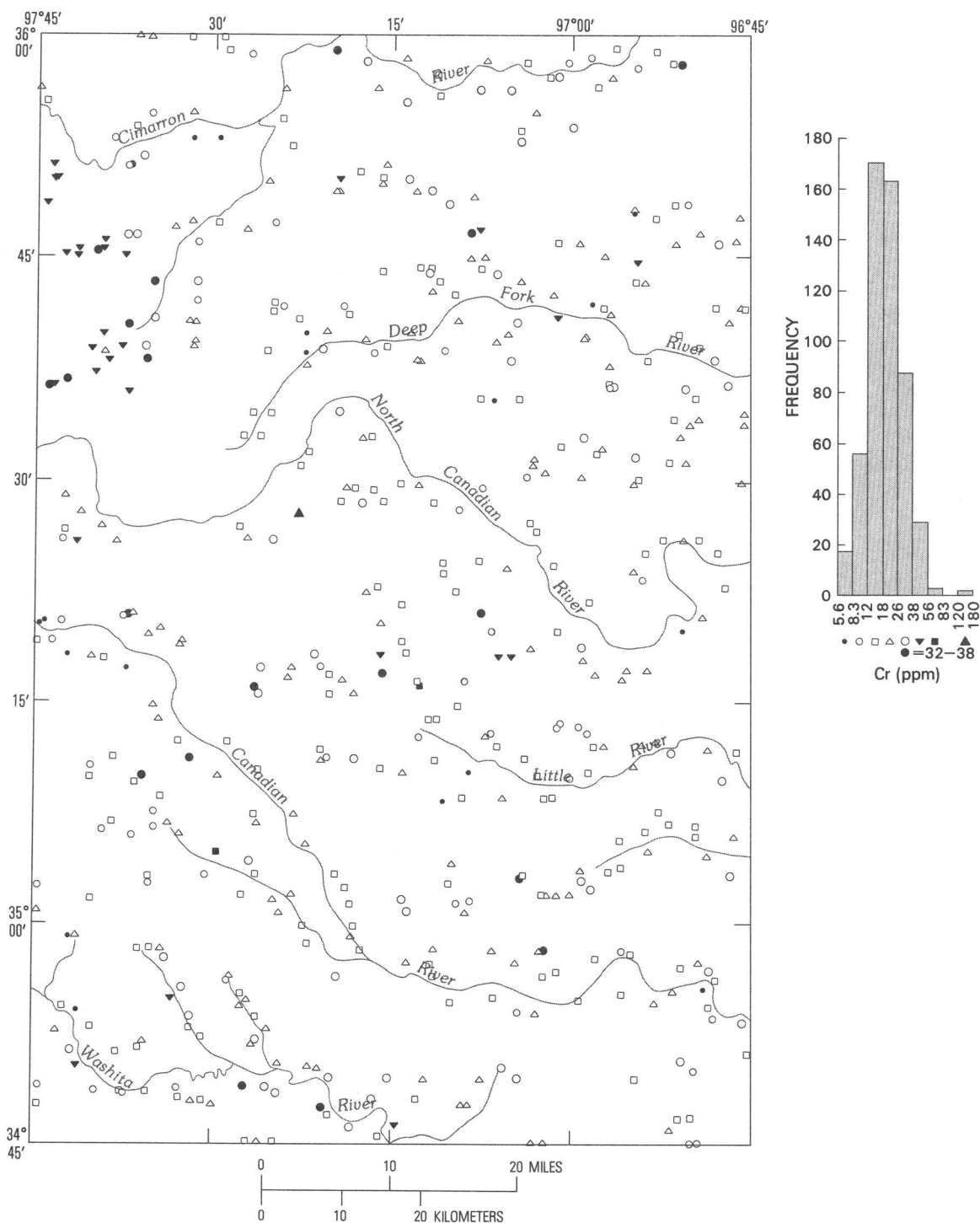


Figure 5. Geochemical distribution of chromium (ppm) in stream sediments of the Central Oklahoma aquifer; 522 samples plotted.

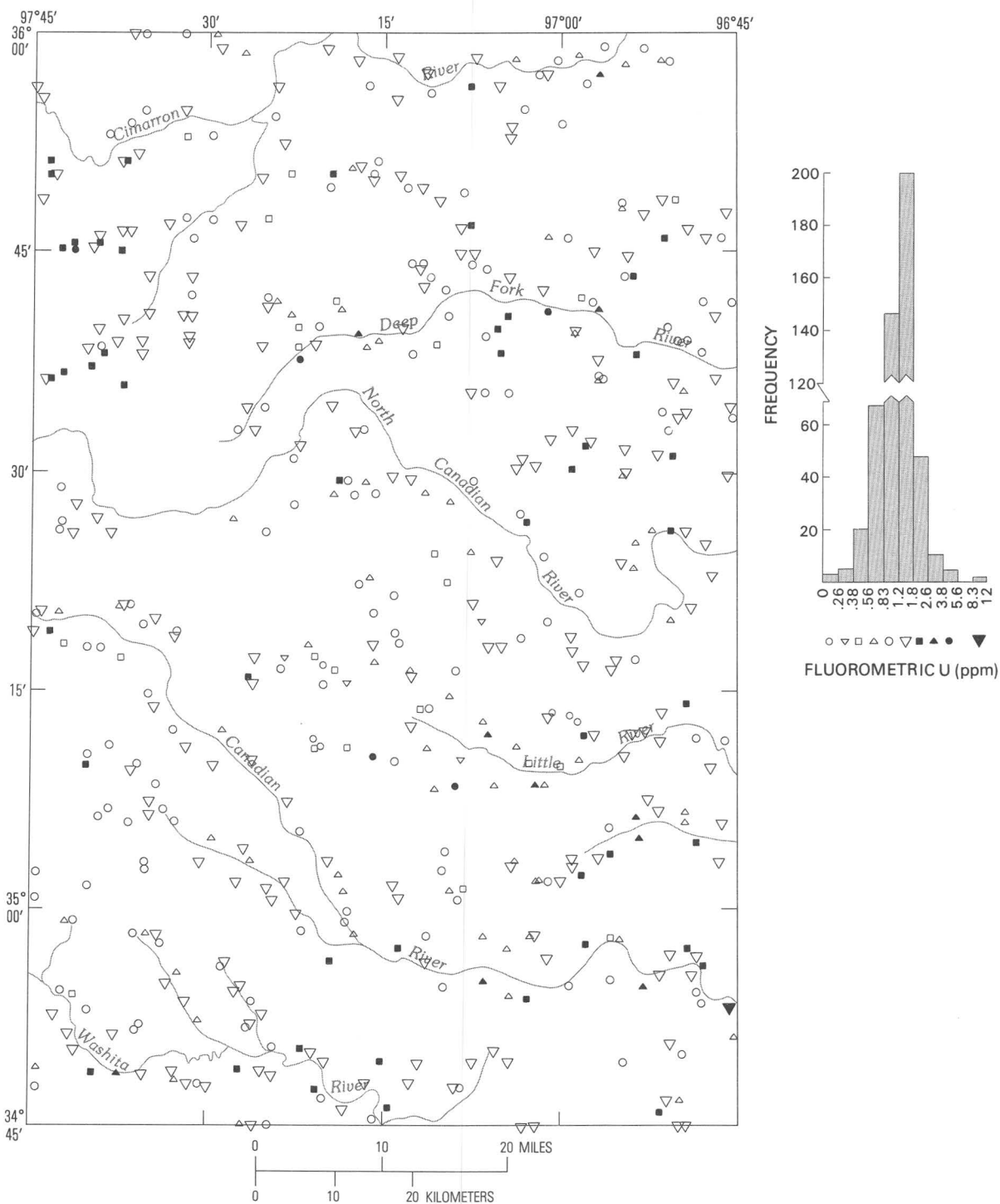


Figure 6. Geochemical distribution of fluorometric uranium (ppm) in stream sediments of the Central Oklahoma aquifer; 516 samples plotted.

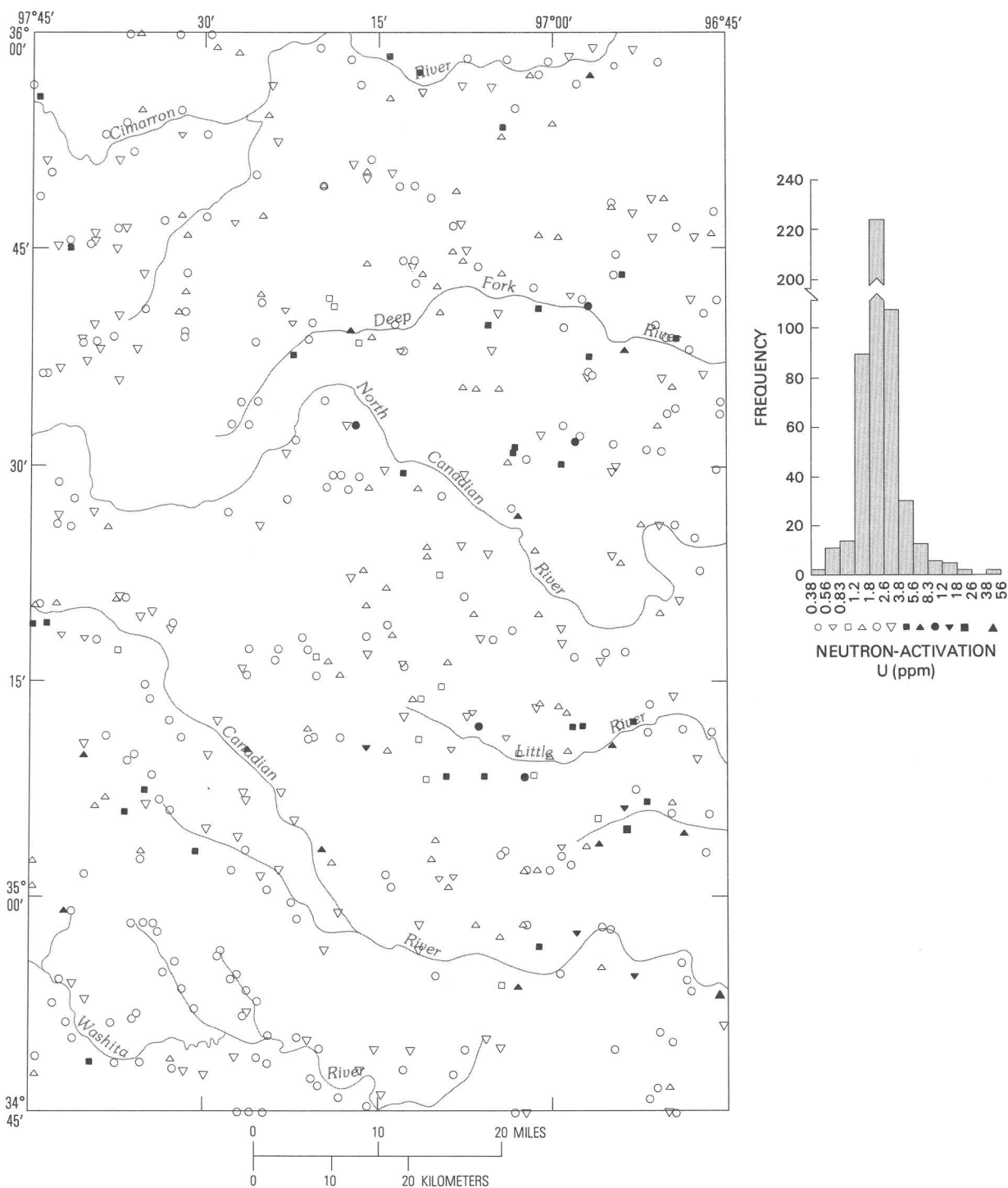


Figure 7. Geochemical distribution of neutron-activation uranium (ppm) in stream sediments of the Central Oklahoma aquifer; 495 samples plotted.

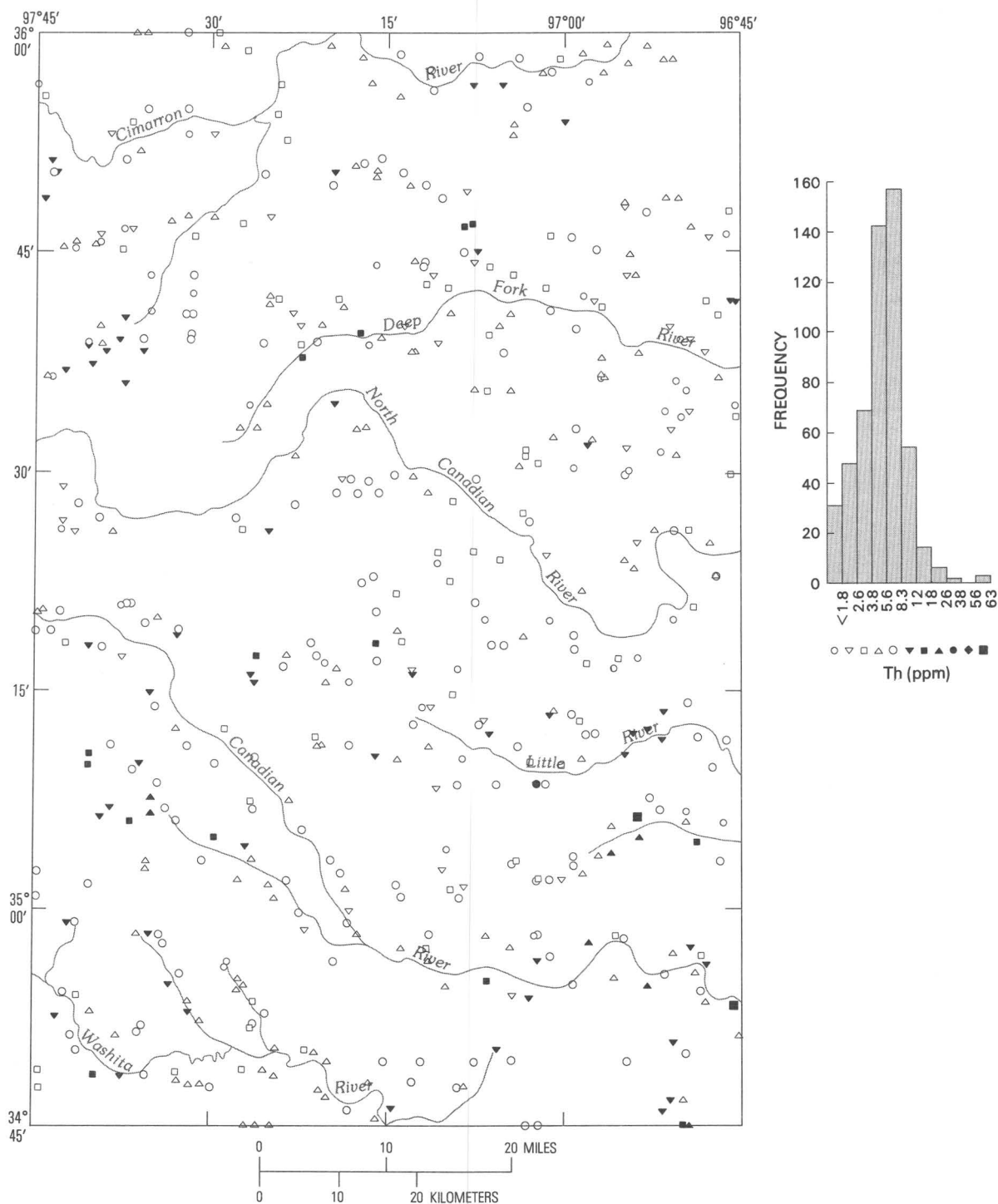


Figure 8. Geochemical distribution of thorium (ppm) in stream sediments of the Central Oklahoma aquifer; 522 samples plotted.

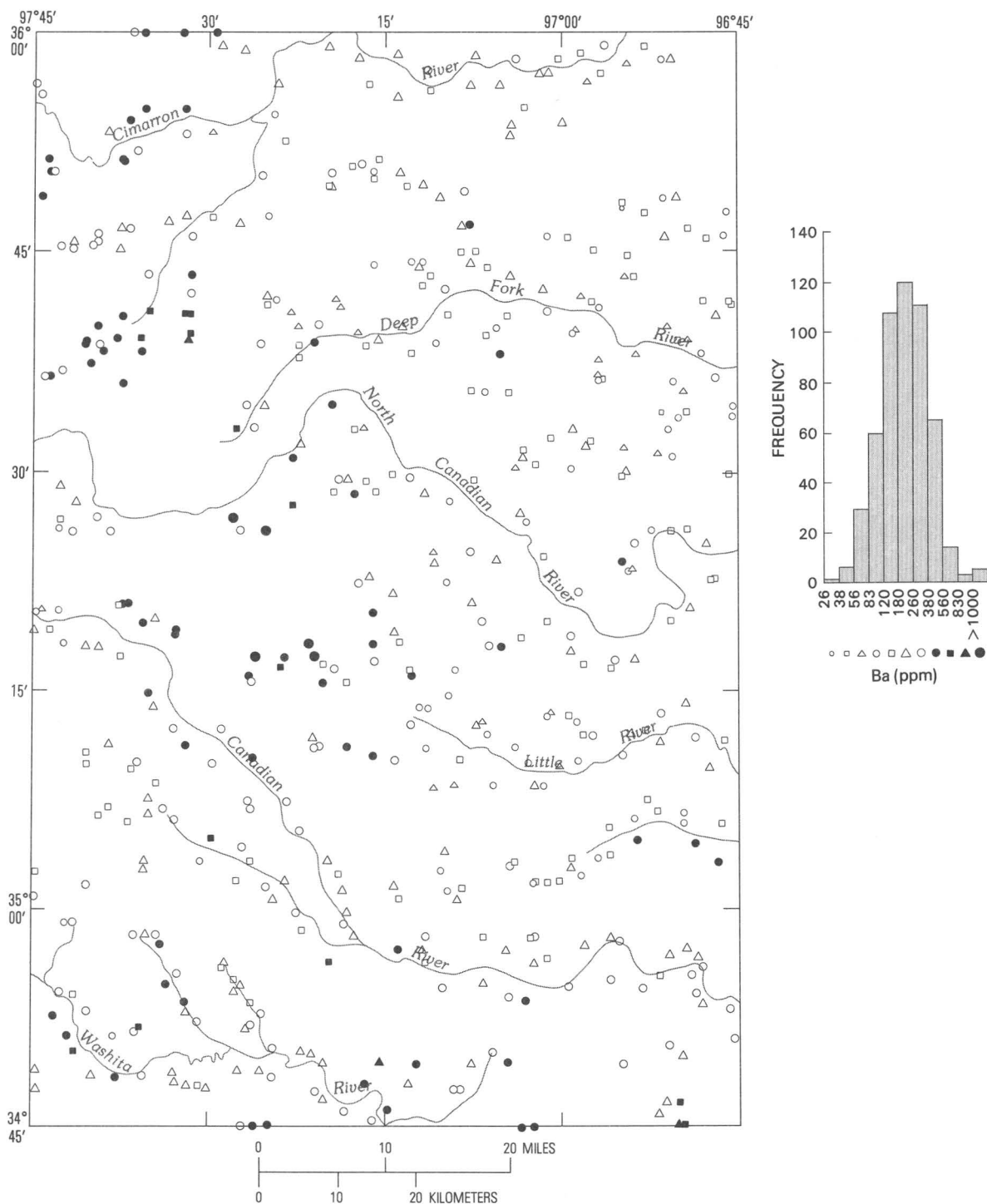


Figure 9. Geochemical distribution of barium (ppm) in stream sediments of the Central Oklahoma aquifer; 522 samples plotted.

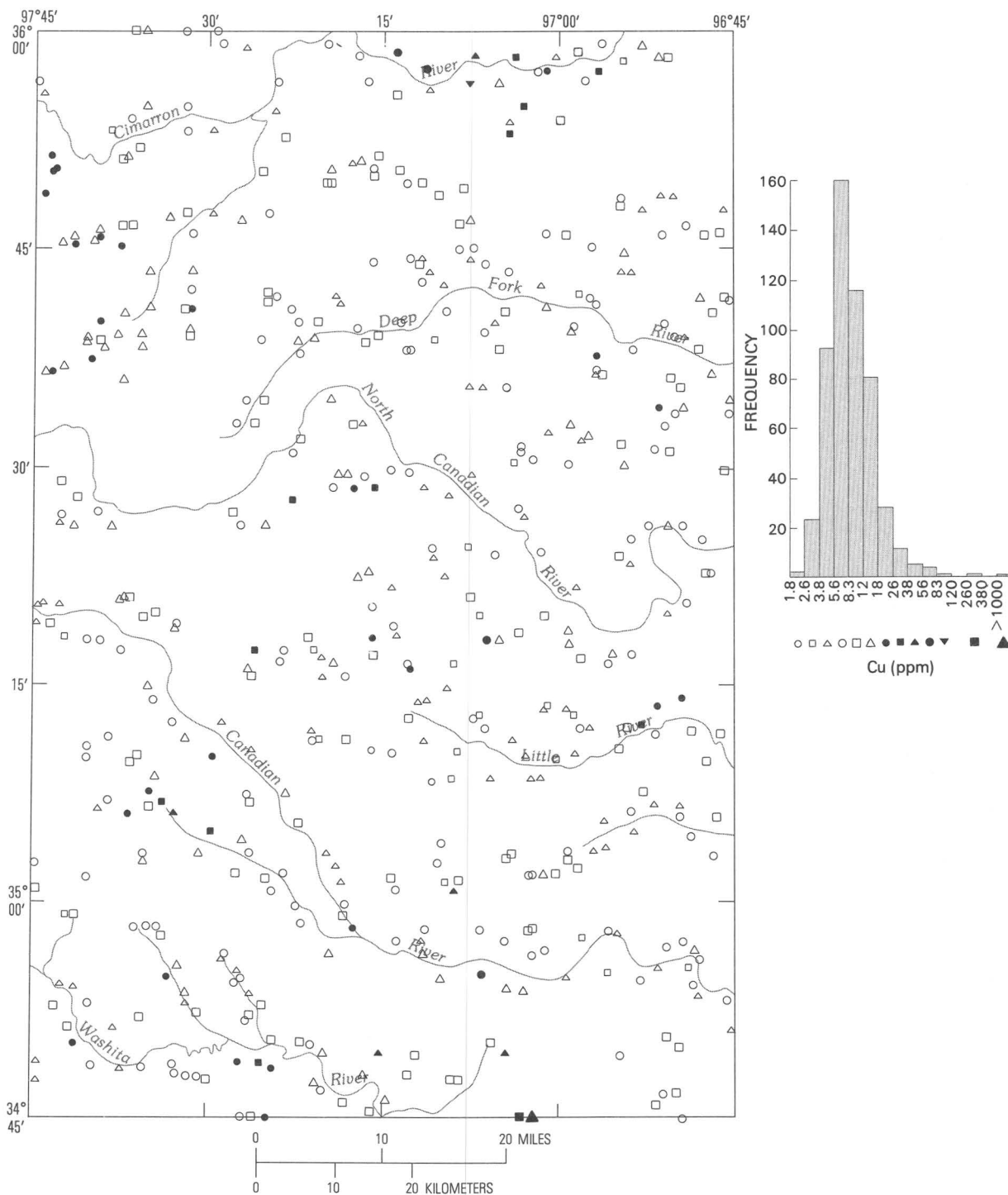


Figure 10. Geochemical distribution of copper (ppm) in stream sediments of the Central Oklahoma aquifer; 522 samples plotted.

Uranium in stream-sediment samples was analyzed by two techniques: a hot-acid-soluble uranium concentration (U-FL) and a total uranium concentration obtained by delayed neutron activation (U-NT). Arsenic and selenium were determined by hydride formation atomic absorption (AA), and the remainder of the elements were determined by plasma source emission spectroscopy (PS). A more detailed description of NURE procedures dealing with sample collection, preparation, analysis, and quality control and assurance can be obtained from Union Carbide Corporation, Nuclear Division (1979a, b). Statistical summaries for the measurable values of the elements are given in table 3.

Areal distribution plots and histograms are given for arsenic, selenium, chromium, fluorometric uranium, neutron-activation uranium, and thorium (figs. 3-8) because of their importance to this study and also for barium and copper (figs. 9, 10) because of their characteristic nature in red-bed formations. To present the analytical results in log increments, the boundaries for the concentration ranges in the histograms were chosen as the multiples of every second product of the reciprocal of the 12th root of ten ($(^{12}\sqrt{10})^{-1} = 0.825$) rounded to two figures (0.83, 0.56, 0.38, 0.26, 0.18, 0.12, and so forth). The areal distribution plots are helpful in identifying areas where the elements of interest show anomalous concentrations in the drainages and, therefore, may reveal areas of higher concentration levels in the bedrock from which the sediments were derived.

The density of the stream-sediment sampling from the NURE program gives reasonable coverage of the study area. The average and range of values for the NURE stream sediment samples and the average abundance in common crustal rocks, as given by Rose and others (1979), for arsenic, selenium, chromium, fluorometric uranium, neutron-activation uranium, thorium, barium, and copper are presented graphically in figure 11. The ranges of values are significantly large as compared to the average values which suggest "hot spots" in the study area. The areal distribution plots show a significant clustering of samples in the west-northwest corner of the study area that are anomalous in arsenic, chromium, fluorometric uranium, thorium, barium, copper, and to a lesser extent, selenium. The samples are from north-flowing tributaries of the Cimarron River that have been developed in the Hennessey Group. With the exception of the area described above, anomalous uranium values appear to be concentrated in streams in the eastern portion of the study area that have been developed in the Vanoss Group and the Admire, Council Grove, and Chase Groups. For the most part, the anomalous barium values delineate the barite belt.

Table 1. Detection limits of variables determined in stream-sediment samples

[Method: AA, atomic absorption; FL, fluorometry; NT, neutron activation-delayed neutron count; PS, plasma source emission spectroscopy. All values are in parts per million except values for Al, Ca, Fe, Mg, Na, and Ti, which are in percent. Detection limits for K and Sr were not given in Union Carbide Corporation, Nuclear Division (1979a, b)]

Variable ¹ limit	Method	Detection
Ag	PS	2
Al	PS	0.05
As	AA	0.1
B	PS	10
Ba	PS	2
Be	PS	1
Ca	PS	0.05
Co	PS	4
Cr	PS	1
Cu	PS	2
Fe	PS	0.05
Li	PS	1
Mg	PS	0.05
Mn	PS	4
Mo	PS	4
Na	PS	0.05
Nb	PS	4
Ni	PS	2
P	PS	5
Sc	PS	1
Se	AA	0.1
Th	PS	0.01
Ti	PS	0.001
U-NT	NT	0.02
U-FL	FL	0.25
V	PS	2
Y	PS	1
Zn	PS	2
Zr	PS	2

Anomalous copper values may suggest additional localities of stratbaound red-bed copper deposits, particularly the area along the Cimarron river in the northeast corner of the study area.

Table 2. Statistical summary for stream sediments of the Central Oklahoma aquifer

[522 samples. All values are in parts per million except values for Al, Ca, Fe, K, Na, and Ti, which are in percent. Statistics are computed on measured values only. FL, fluorometry; NT, neutron activation-delayed neutron count method]

Element	Measurable values	Minimum value	Maximum value	Mean	Standard deviation	Relative standard deviation (percent)
Ag	43	2.0	6.0	2.35	0.81	34.5
Al	521	0.26	9.2	1.98	1.40	70.7
As	520	0.20	11.6	1.82	1.19	65.4
B	365	10.0	125.0	21.2	13.5	63.8
Ba	522	32.0	2221.0	255.5	195.0	76.3
Be	383	1.0	7.0	1.13	0.44	38.9
Ca	514	0.05	5.2	0.53	0.60	113.2
Co	416	4.0	24.0	7.82	3.41	43.6
Cr	522	6.0	124.0	20.4	10.2	50.0
Cu	522	2.0	1369.0	13.6	61.9	455.2
Fe	522	0.27	4.42	0.98	0.51	52.0
K	522	0.079	2.43	0.69	0.42	60.9
Li	522	4.0	69.0	15.4	9.52	61.8
Mg	506	0.05	2.47	0.35	0.33	94.3
Mn	522	53.0	3258.0	338.2	273.3	80.8
Mo	16	4.0	8.0	4.63	1.02	22.0
Na	500	0.05	1.31	0.36	0.25	69.4
Nb	431	4.0	75.0	6.99	5.09	72.8
Ni	516	2.0	90.0	9.47	6.68	70.5
P	522	26.0	1568.0	174.1	130.5	75.0
Sc	521	1.0	13.0	2.95	2.05	69.5
Se	219	0.10	11.1	0.53	1.29	243.4
Sr	522	9.0	2300.0	65.6	112.8	172.0
Th	490	2.0	66.0	6.12	5.10	83.3
Ti	522	0.04	2.44	0.16	0.14	87.5
U-NT	495	0.55	46.0	2.68	2.65	99.1
U-FL	513	0.33	9.1	1.28	0.68	53.1
V	522	8.0	112.0	29.1	13.6	46.7
Y	522	1.0	70.0	8.62	5.66	65.7
Zn	522	4.0	69.0	21.2	11.8	55.7
Zr	522	25.0	880.0	97.5	77.6	79.6

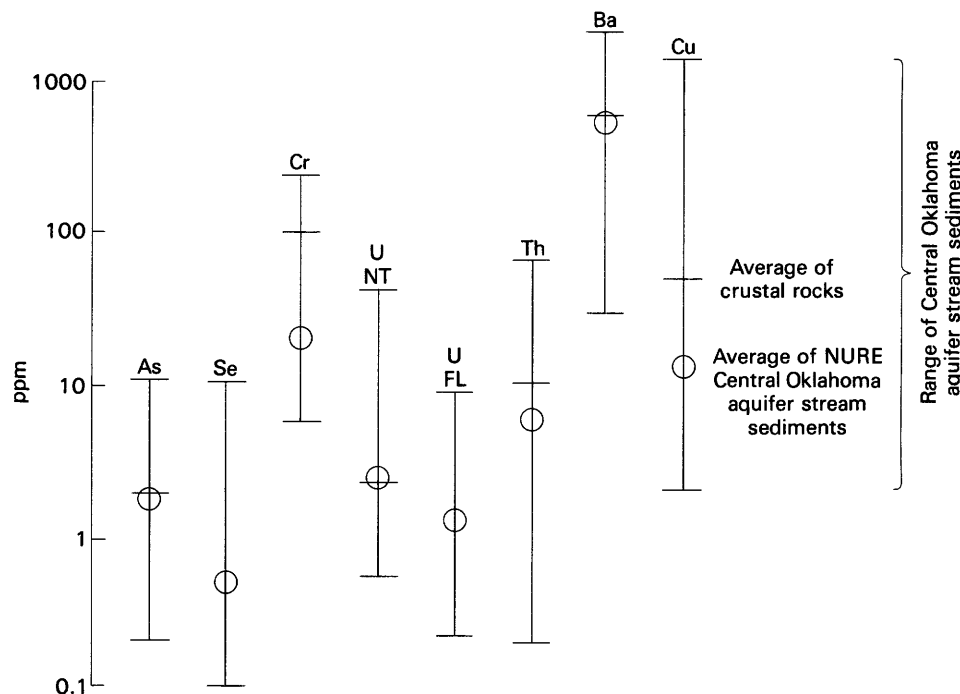


Figure 11. Average and range of values for NURE stream-sediment samples in the Central Oklahoma aquifer study area and average of crustal rocks for As, Se, Cr, U-NT, U-FL, Th, Ba, and Cu.

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