OKLAHOMA GEOLOGICAL SURVEY
CARL C. BRANSON, DIRECTOR

Mineral Report 27

URANIUM IN OKLAHOMA, 1955

by

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NORMAN
1955

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FOREWORD

This report supercedes Mineral Report 26 and incorporates additional material accumulated since that report was written. Much remains to be learned of radioactive materials in Oklahoma; therefore this is an interim report designed to help citizens interested in exploration for uranium. A map to show areas of different rock types is included (see Figure 1).

INTRODUCTION

Uranium may well be the fuel of the future. Search for commercial deposits is enjoyable and may be profitable. If such search is conducted in Oklahoma with the proper attitude one can enjoy the outdoors, learn much of geology, and perhaps find a commercial deposit. As of this date no radioactive deposit of proven commercial value has been found in the state. Uranium occurs in rocks of all geologic ages and of all lithologic types. It is as truly a universal material as gold, pyrite, and quartz. Nearly all worth-while-while deposits have been found in areas of less than 20 inches of rainfall, but it is by no means proven that the ores are leached from all rocks in regions of greater rainfall.

Uranium (as well as germanium, gallium, etc.) is held by carbon as shown by the fact that most commercial deposits are in coal or carbonaceous rocks. The penetration is slight, and a thick bed of coal is less likely to be valuable for its uranium than is a thin bed. Uranium salts in solution occur in brines, none as yet shown to be profitable to process for extraction. If a method is found to concentrate uranium from brines, these occurrences may become important.

Other ores have been found in volcanic bodies and pegmatites. These are to be sought along faults, dikes, sills, and in rocks affected by volcanism.

Oklahomans who wish to prospect for uranium should obtain the excellent pamphlets "Prospecting for Uranium" prepared by the U. S. Atomic Energy Commission and the U. S. Geological Survey, and "Prospecting with a Counter" prepared by the U. S. Atomic Energy Commission. These pamphlets can be purchased for $0.45 and $0.30, respectively, from the Superintendent of Documents, Washington 25, D. C.

A prospector will need a good Geiger counter or a scintillator in order to detect radioactive material. He should remember that no instrument penetrates deeply, and that he will detect only such radioactive material as is at or within a few inches of the land surface.

Nearly all land in Oklahoma is privately owned or is in Indian lands. Permission of the owner should be obtained before prospecting. Mineral rights must be purchased from the owner, or, in the case of Indian lands, obtained by bid at public auction. Ore is purchased only by the U. S. Atomic Energy Commission or by licensed buyers. Ore must assay a minimum of

0.20 percent U_3O_8 to be salable. In order to determine value, a discoverer should submit at least a one pound sample truly representing deliverable quality of ore to U. S. Geological Survey, Geochemistry and Petrology Branch, Building 213, Naval Gun Factory, Washington 25, D. C.; Chief, Rolla Branch, Metallurgical Division, U. S. Bureau of Mines, Rolla, Missouri; or Chief, Salt Lake City Branch, Metallurgical Division, U. S. Bureau of Mines, Salt Lake City, Utah. If such ore proves commercial he should apply for a license. A price of $3.50 per pound is guaranteed until 1958 and a bonus is paid for new production. Another type of bonus of $10,000 is payable for discovery of a new deposit after 20 short tons of ore or concentrate assaying 20% or more U_3O_8 is produced.

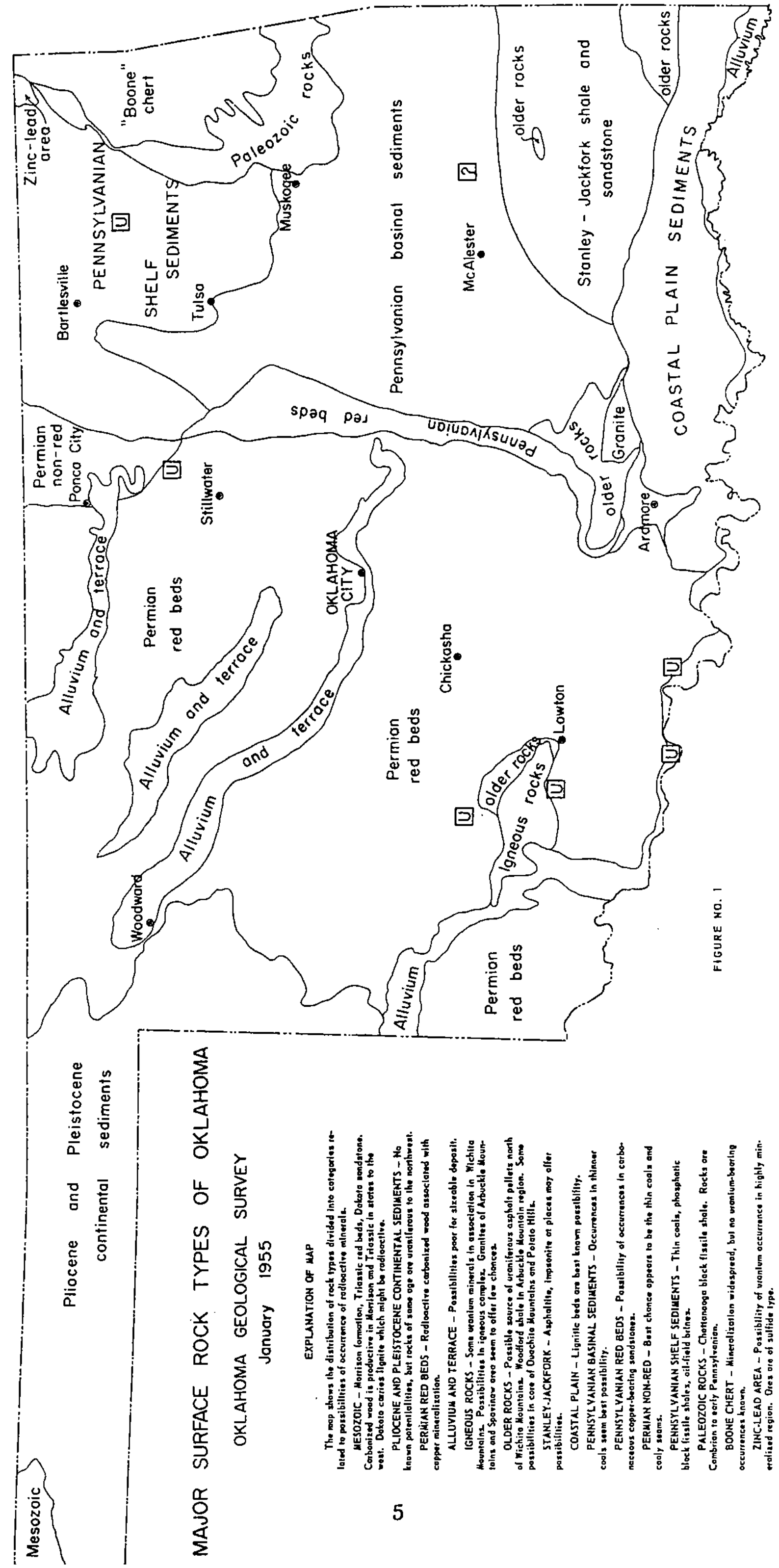
The Oklahoma Geological Survey will determine radioactivity by Geiger counter of samples submitted from deposits within the state provided that an accurate locality is given. The determination is made without charge and the location is held confidential.

Color is not conclusive as to presence of uranium. Uranium minerals are black (pitchblende), yellow-orange (carnotite), green (copper-uranium minerals), or their color may be masked by that of the matrix or of associated minerals. There are dozens of known uranium minerals.

It appears advisable to issue a warning against placing too much credence on Geiger and scintillation counters in quantitative estimation of uranium in ores. First, topography may have a marked effect on measurements of radioactivity. It should be understood that the counter measures radioactivity rather than the amount of uranium, thorium, or other radioactive material. Second, the counter reading may be strongly influenced by the size of the sample. A strong reading may be obtained in the presence of a sizable deposit whereas a lump of the same material taken away from the ore body may show very little. This is known as mass effect. Third, a counter gives reliable measure of the uranium content only when the decay products of uranium are present in appropriate amounts; that is when the sample is in equilibrium. Pitchblende and carnotite ores produced in the United States have been shown to be in equilibrium. Secondary uranium minerals, weathered radioactive deposits, weathered fissure and vein ores of all types, and radioactive spring deposits usually are not in equilibrium and their radioactivity as measured by the counter is not a reliable quantitative test of the content. In these instances chemical analysis is the only safe procedure. To illustrate:

Lab. sample 10153. This is a representative sample of uranium-bearing sandstone from sec. 31, T. 5S., R. 12W. Cotton County.

		(Milliroentgen units per hour)
25 gms. wt. –	Geiger reading X10	0.052 MR/HR
	Background X10	0.005 MR/HR
	Corrected	0.047 MR/HR
	Therefore: X =	0.47 MR/HR
	Chemical analysis	0.043% U_3O_8



Lab. sample 10160. This is sandrock over which brine from a oil well had flowed for unknown time and in unknown quantity. The location was adjacent to a well producing from the Bartlesville sand in the Cushing area.

21 gms. wt. – Geiger reading	X10	0.115 MR/HR
Background	X10	0.005 MR/HR
Corrected		0.110 MR/HR

Therefore: X = 1.10 MR/HR

Chemical Analysis 0.021% U_3O_8

In the first instance, the Geiger gave a fair estimate of the uranium content. In the second instance, it did not. In explanation it is assumed that the brine contained radioactive material which deposited on and in the sandstone over which it flowed. However, it is a known fact that uranium is much more soluble than some of its decay products. Since the decay products exhibit radioactivity and uranium does not, it is reasonable to believe the uranium has been leached from the sandrock, leaving perhaps radium which is a decay product of uranium and which is radioactive. Of course, the radioactivity could also have been attributed to thorium-decay products. Under the conditions from which the samples were obtained it is thought that any appreciable amount of thorium is unlikely.

SANDSTONE LENSES OF SOUTHWESTERN OKLAHOMA

Modified from G. W. Chase, 1954

Sandstone lenses of Permian age containing radioactive bituminous material occur locally beneath a cross-bedded bituminous gray sandstone in the southern part of Jefferson and Cotton Counties, Oklahoma. The Honorable J. M. Bullard, member of the Oklahoma House of Representatives, called G. W. Chase's attention to the occurrences and spent a day in the field in order to show him the localities.

The first discovery of radioactive bituminous sandstone was made by Mr. Westbeard of Randlett, Oklahoma, on the Clinton Byars farm in Cotton County near the SW¼ of sec. 30, T. 5S., R. 12W. The sandstone lens crops out approximately 100 feet below the top of a bluff along the north side of Red River and lies beneath a cross-bedded bituminous gray sandstone. It has a maximum thickness of 15 feet near the center of the lens and is about 100 feet wide in the face of the bluff. The lens thins rapidly east and west into red Permian shales and appears to extend north and south. The sandstone ranges from light yellow through grayish-blue to pinkish red and shows well developed lamination due to thin layers of radioactive bituminous material and to a greenish mineral similar in appearance to malachite. The sandstone zone containing the greatest amount of radioactive bituminous material is approximately 14 inches thick and is grayish-blue. This lens is nearly 10 feet long, tapering at each end to a thin lens 0.5 inches thick and pinching out east and west in the sandstone. Scattered through the central

part of the sandstone lens and above and below the grayish-blue sandstone zone are numerous radioactive flat bodies of carbonized wood 0.5 inches thick cut by veinlets of a radioactive carbonate mineral and of a green copper mineral having a physical appearance similar to that of wavellite.

Analysis of representative uranium-bearing sandstone from this locality showed 0.043 percent U_3O_8.

A second occurrence of sandstone containing radioactive minerals is on the farm of U. C. Miller in Jefferson County in the SW¼ of sec. 7, T. 5S., R. 8W. Here the sandstone occurs beneath a cross-bedded gray to black bituminous sandstone. The radioactive sandstone ranges from approximately 0.5 to 1.5 feet thick and is brownish-red on the weathered surface. In fresh exposures the rock is brownish-black to grayish-brown with a metallic appearance in localized spots within the rock. This sandstone occurs as a thin lens that can be traced from near U. S. Miller's south to the bluff overlooking Red River, but thins rapidly northward and grades into shale.

Fath described an occurrence of copper minerals with cupriferous fossil wood in red beds along the north bank of Red River in secs. 2 and 3, T. 5S., R. 11W. (Econ. Geology, vol. 10, pp. 140-150, 1915). Merritt has redescribed the occurrence (Okla. Geol. Survey, Min. Rept. 8). This deposit has not been tested for radioactivity. The copper occurs as chalcocite nodules replacing calcite cement in sandstone and replacing marcasite in shale. Malachite and azurite occur as secondary alterations.

These radioactive sandstone lenses and occurrences of copper minerals are associated with a cross-bedded bituminous gray sandstone shown on the new Geologic Map of Oklahoma (Miser, 1954). The sandstone is shown as being at the level of the base of the Garber sandstone of northern Oklahoma.

The bituminous sandstone crops out in southern and eastern Comanche County, dipping away from the south and east flanks of the Wichita Mountains (Fig. 2). On the south flank of the Wichita Mountains the sandstone has a south dip of approximately 100 feet per mile.

In structurally high areas in eastern Tillman County, southern Cotton County, southern Jefferson County, and east-central Carter County this cross-bedded bituminous sandstone is exposed on or around the topographic highs on the structures as a cap rock and at numerous places along drainage channels.

The cross-bedded bituminous sandstone associated with radioactive sandstone lenses was mapped in Cotton County and in parts of eastern Tillman County as the upper part of the Auger conglomerate in the upper part of the Wichita formation (M. J. Munn, 1914). This conglomerate grades from a conglomerate to a cross-bedded bituminous dark gray sandstone and was described by Munn as follows:

> No single exposure is typical of this conglomerate lentil, because each bed is variable from place to place. However, the lentil as a whole does not change so much from one outcrop to another that it may not be recognized wherever exposures are good. Toward the east, in Rs. 12 and 11, the clay-limestone conglomerate bed becomes more sandy and loses its characteristic lumpy conglomeratic appearance. If the writer's correlations are correct the conglomerate bed becomes darker and harder toward the east, and in many places has the smooth-grained appearance of a calcareous, somewhat

ferruginous sandstone and weathers out of the inclosed sandstone as irregular, slablike lenses or more or less round to flattish concretionary masses, some of which are several feet in length.

The measured section of the exposure in the bluff on the north side of Red River in sec. 30, T. 5S., R. 12W. (Munn, 1914, p. 19) is here simplified.

Beds exposed in "breaks" on north side of Red River in sec. 30, T. 5S., R. 12W.

		Feet
Quaternary:		
1.	Sand, loose brownish to reddish, coarse, massive; seems to be wind blown; capping bluff	15-30
Permian (Wichita formation):		
2.	Sandstone, reddish, thin bedded, ripple marked; poorly exposed under the loose sand	4
3.	Clay or shale, whitish, with some thin-bedded shaly sandstone	2
4.	Clay, red to grayish (mostly red), with some soft, reddish, thin, smooth, gray calcitic lime concretions	40
5.	Sandstone and clay. Sandstone reddish, blocky to platy, cross-bedded and very irregular bedded	15
6.	Clay and sandstone; deep-red clay, interbedded with and changing locally to reddish and grayish clayey sandstone. The clay in many places contains smooth roundish gray clay-limestone concretions	10
7.	Sandstone contains near middle large round to flattish black concretions single and twinned, some of which are more than a foot in diameter. These sandstones and concretions change horizontally into red clay and shale and are extremely variable in occurrence	11
8.	Sandstone, dark gray and yellowish at base with black specks; changing to dark and harder limy irregularly bedded sandstone in middle, which carries flattish irregularly bedded layers of a very hard, close-grained, reddish to dark rock	9
9.	Sandstone, grayish to light canary-yellow, rather massive	7
10.	Sandstone, massive, soft canary-yellow to dark leaden gray, containing remains of fossil plants and small amounts of copper ore in lower 5 feet (zone of radioactive material)	12

		Feet
Permian (Wichita formation) — continued.		
11.	Clay and shale, whitish to light gray, changing to deep purple blocky clay with lumps and streaks of copper ore and shale or clay pebbles	2
12.	Shale, clayey, red and gray to green	10
13.	Conglomerate, clay-limestone; soft, gray to reddish, contains in places fragments of bones	2
14.	Clay, deep red to purplish with one or more thin layers of soft impure whitish sandstone near base; clay contains in lower part considerable number of rather small gray, roundish calcitic clay-limestone concretions	8
15.	Sandstone, 2-foot layer at top of soft whitish to gray sandstone which is weathering forms cylindrical holes which appear to have been made by burrowing animals or worms in the ancient sand beach. Under this layer is a massive reddish irregular bedded impure sandstone having many thin dark streaks made up of small round black specks which are slightly more resistant to weathering and appear as ridges on face of cliff. Near base is a massive layer carrying many round black cannonball-like concretions, the largest a foot in diameter. Sandstone very irregular bedded with many cross-bedded zones and whitish layer at base	21
16.	Clay, deep red, with thin purplish and ashen-colored layers, a few very thin layers of soft gray sandstone, and a layer of clay pebbles in gray calcareous clay at the bottom	20
17.	Sandstone, reddish, at top, changing to grayish toward bottom, massive irregular bedded	10
18.	Clay, principally deep red, with thin layers of sandstone and sandy shale, beds very poorly exposed with about 10 feet of greenish clay or shale at river level; about	50
		233

The cross-bedded bituminous sandstone (Bed No. 8) in the above description occurs approximately 100 feet below the top of the bluff and rests directly on 19 feet of sandstone (Beds 9 and 10) of which the lower 12 feet contains radioactive minerals.

The Auger conglomerate extends eastward from Cotton County into Jefferson County where it was mapped by J. R. Bunn (1930) as the Ryan-Asphaltum sandstone. The cross-bedded bituminous gray sandstone occurs in the upper part of the Asphaltum sandstone and the Ryan sandstone is composed almost entirely of this cross-bedded dark gray sandstone. Bunn describes the Asphaltum sandstone and the Ryan sandstone in part as follows (1930, p. 10):

Asphaltum Sandstone

The most important sand horizon from the standpoint of areal mapping is the Asphaltum sand. This sand zone is exposed in the vicinity of the town of Asphaltum and occurs through parts of Tps. 3 and 4S., Rs. 4 and 5W. It marks the Healdton uplift and is exposed over or around the Loco pool, the Healdton pool, the Hewitt pool, the other undeveloped anticlinal features along the Healdton uplift.

The Asphaltum consists of a series of gray buff, yellow, calcareous sandstones, generally massive, friable, and medium-grained, but locally laminated and thin-bedded. The thickness of this sand ranges from 20 to over 50 feet and consists of one or more members, separated by intervening shale beds. A nodular limestone stringer from two inches to one foot in thickness occurs uniformly 12 to 18 feet above the top of the sand throughout parts of Tps. 3 and 4S., Rs. 4 and 5W. In parts of Tps. 3 and 4 S., Rs. 4 and 5 W., this sandstone is saturated with asphalt, and several seeps of gas and heavy oil occur.

Ryan Sandstone

A sandstone having the same general description and occurring in approximately the same stratigraphic position as the Asphaltum is typically exposed in the scarps immediately southeast and northwest of the town of Ryan. The sandstone here consists usually of one member, massive to thin-bedded, with a thickness of 17 to 28 feet.

The Ryan sandstone is exposed irregularly through parts of Tps. 6 and 7 S., R. 7 W. With very few gaps, it can be traced northwest through T. 5 S., R. 8 W., and parts of T. 4 S., Rs. 8 and 9 W. It appears to thicken in this direction, and in the bluffs bordering "Dead Man's Gulch" in T. 4 S., Rs. 8 and 9 W., at least three distinct members are present, forming a sand zone with a thickness in excess of 60 feet. The sandstone can be traced irregularly northeast from Ryan through parts of T. 5 S., Rs. 5, 6, and 7 W., the strike gradually swinging in a broad loop, circling the plunging northwest end of the Nocona structural uplift. The sand is poorly exposed through this area, but can be followed by the Cuesta-like topography, long dip slopes, sandstone float, and the sandy nature of the soil. It is characteristically exposed again through sec. 14, 15, 22, and 23, T. 6 S., R. 5 W., where the general normal northeast dip into the Ringling Basin can be clearly seen.

The cross-bedded bituminous sandstone in western Cotton and Comanche Counties and in eastern Tillman County becomes a thin conglomerate

bed. In eastern Cotton County and southwestern Jefferson County the sandstone is well developed cross-bedded fine-grained dark bituminous sandstone with a calcite cement. North and east of T. 5S., R. 9W. in Jefferson County, the sandstone loses much of its bituminous material and is at many places poorly cemented. The rock becomes a light gray to white iron-stained cross-bedded sandstone with only a trace of bituminous material.

The bituminous gray sandstone occurs at the base of a series of sedimentary beds of Garber age and marks the contact between the rocks of Garber and Wellington age (see geologic map, Figure 2). This contact as shown on the geologic map is somewhat generalized in a few areas, but for the most part it is accurate in areas where prospecting can best be done for other possible radioactive sandstone lenses. The beds extend south across Red River into Texas and should be examined there for possible occurrence of radioactive sandstone lenses.

The association of the radioactive material with a marker bed indicates the line of outcrop along which more lenses of rock bearing radioactive minerals might be found. It is possible that the radioactive minerals are concentrated at places along an unconformity between the rocks of Wellington age and those of Garber age. The residual material in the basal part of the Garber is the expected site of concentration.

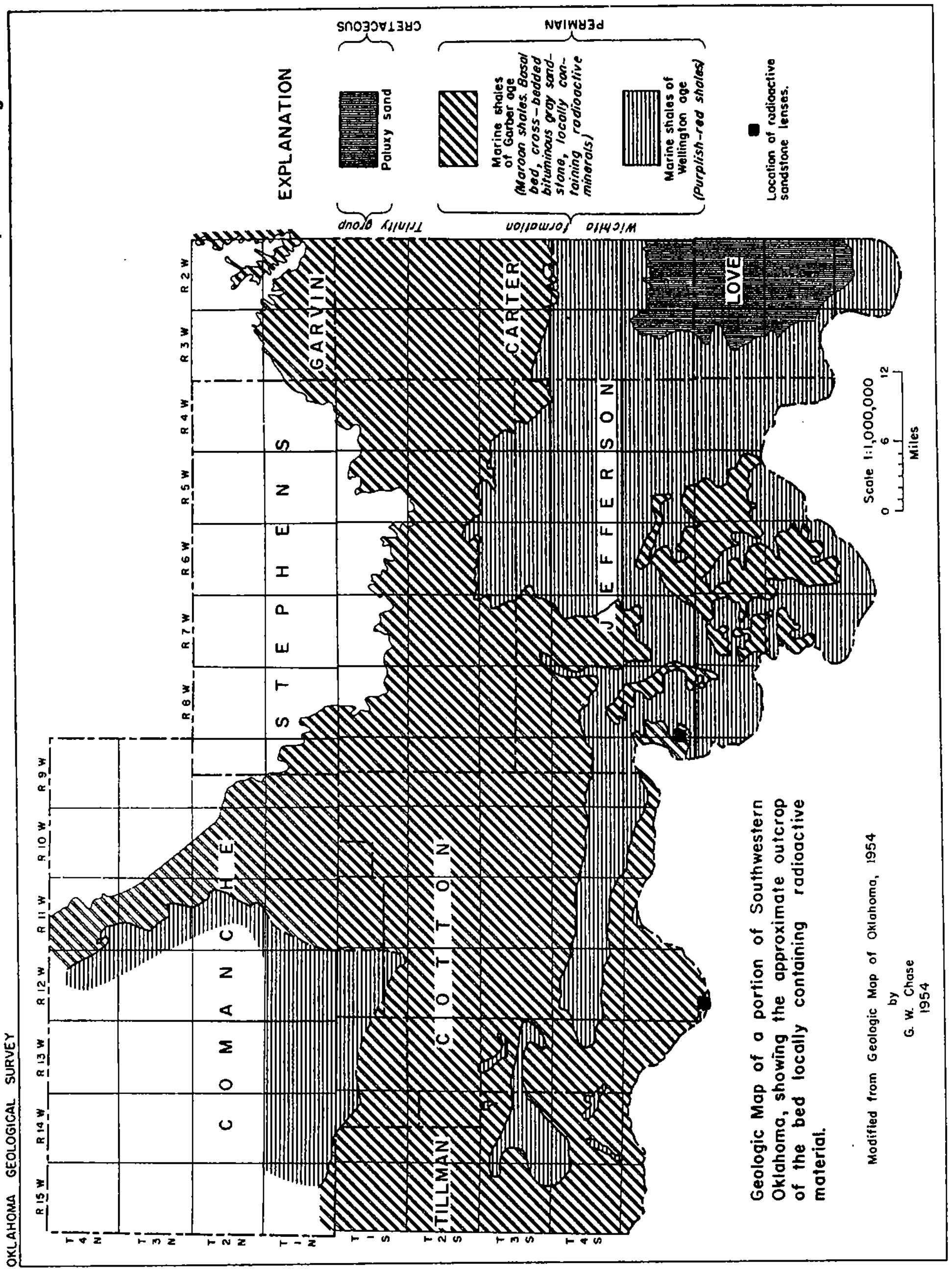
Asphaltic sandstone near Asphaltum in northern Jefferson County yields uranium (Hail, 1954, p. 143). Asphalt content 8.07%; Ash 0.97%; Uranium in ash 0.0125%.

The Wellington-Garber contact should be examined for radioactivity northward into Kansas. The contact is shown north from North Canadian River as Pg on Pwa on the Geologic Map of Oklahoma (Miser, 1954). The contact extends from north-central Okla homa County through Guthrie, west of Perry, Billings, and Tonkawa, and near the west line of Kay County. The contact may be more accurately mapped by geologists if a radioactivity detector be used.

PLANT REMAINS IN NORTH-CENTRAL OKLAHOMA

In Pawnee, Payne, Osage, and Noble Counties there are small areas of non-commercial copper deposits with associated radioactive carbonized wood. These deposits are at several levels in the red sandstones of Wolfcampian and Leonardian (Permian) age. The best known is the Lee Uto prospect in Pawnee County from which channel samples yield 0.002 to 0.068 percent uranium (Beroni, 1954, p. 170). Selected samples contain 16.3 percent uranium (Hill, 1953, p. 203). Similar deposits noted by the Oklahoma Geological Survey in earlier years, and not tested for radioactivity, are:

Center of NE¼ NW¼ sec. 35, T. 21N., R. 1W., Noble County. Old shaft to 40 feet dug for lead. Six inch seam of coal reported.



Geologic Map of a portion of Southwestern Oklahoma, showing the approximate outcrop of the bed locally containing radioactive material.

Modified from Geologic Map of Oklahoma, 1954 by G. W. Chase 1954

NW¼ NE¼ NW¼ sec. 19, T. 20N., R. 1E., Noble County. F. M. Elgin deepened dry well, found small amount of galena and black lignite. Material is at 32 feet.

	Feet
soil	22
Ss., buff	1.5
sh., red	8.5
Ss., buff	16.5
sh., blue	3.5
"mineral vein"	0.5
shale, blue	2.5

SW¼ SE¼ NE¼ sec. 24, T. 20N., R. 1W., Noble County. Adit to 75 feet into hillside. Streaks of black coaly material with chalcopyrite and stains of malachite and azurite.

NW corner NE¼ SW¼ NW¼ sec. 19, T. 22N., R. 4E., Pawnee County. Shaft to 8 feet, malachite and azurite stains in red sandstone.

SE¼ NE¼ NE¼ sec. 23 and S½ NW¼ NW¼ sec. 24, T. 22N., R. 3E., Pawnee County. Three shafts one to 40 feet. Copper carbonates, carbonized wood. Visited by Dott and Merritt, 7-18-40; see Fischer, Econ. Geology, vol. 32, p. 914, 1937. Merritt (1940) describes the occurrence as follows:

> **Pawnee County.** Copper minerals are found in a small area a few miles north of Lela. In sections 23 and 24, T. 22N., R. 3E., copper minerals occur in a conglomerate with limestone pebbles and a sand cement, of the Stillwater formation. This rock which is exposed in a small ravine is only a few feet thick and some sixty feet long. It lenses out and is surrounded by white, brown and red sandstones. Shallow trenches close to the conglomerate show copper minerals in the dumps, whereas dumps from three shafts 30 to 40 feet deep that have been sunk in the sandstone nearby show little or no copper. The copper minerals are chalcocite, malachite, and azurite. The chalcocite has replaced fossil wood and also occurs as small nodules.
>
> Copper also is reported in sec. 19, T. 22N., R. 3W. These deposits are too small to have any economic value.

SE¼ NW¼ NW¼ NW¼ sec. 28, T. 22N., R. 3E., Pawnee County. Copper carbonates in Permian red sandstones.

SE¼ SE¼ NW¼ sec. 24, T. 22N., R. 3E., Pawnee County. Mine and cores, copper minerals in sandstone and in fossil wood: Black streaks in cores.

Center north line SE¼ NW¼ and center of NE¼ SW¼ sec. 23, T. 20N., R. 3E., Payne County. On J. P. Hesser farm, 2 tunnels into sandstone. Seam containing malachite, chalcocite, and carbonized wood.

Center of SE¼ sec. 22, T. 20N., R. 3E., Payne County. Old shaft and tunnel on M. J. Burwell farm. Red sandstone with malachite, chalcocite, and cupriferous fossil wood. See Tarr, Econ. Geology, vol. 5, pp. 221-226, 1910, and Rogers, Econ. Geology, vol. 11, pp. 366-380, 1916. Merritt (1940) states:

Payne County. Copper minerals were discovered on the M. J. Burwell farm (SE¼ sec. 22, T. 20N., R. 3W.) in 1901. This deposit was described by Tarr in 1910 as having a 60-foot tunnel at the 25-foot level and also some crosscuts. He found chalcocite replacing fossil wood and sulfide nodules. Malachite, azurite, chalcanthite, and calcite also were present. Assays made at the University of Arizona showed 31.25 ounces of silver and 0.1 ounce of gold per ton, but the details of the sampling are not given. The fossil wood pieces were rudely parallel to one another and conformed with the dip of the rock, which is a clayey sandstone of the Stillwater formation (Lower Permian).

SW¼ sec. 23, T. 20N., R. 3E., Payne County. Tunnel to thin layer of chalcocite in fossil wood. Reported by Merritt (Okla. Geol. Survey, Min. Report 8 (1940) as follows:

> A half-mile east of this deposit in sec. 23, T. 20N., R. 3E., in another tunnel cuprified fossil wood is found in a bed a few inches thick. The tunnel extends 75 feet into the sandstone, from the side of a ravine, and exposes the thin lenticular copper bed for part of that distance. The layer is too small to have any economic significance. Chalcocite replaces fossil wood and part of the chalcocite has been altered to malachite.
>
> According to reports, copper minerals have been found in water wells in several farms of this district. Apparently there are several layers of cuprified wood, all thin and lenticular. The source of the copper probably was cupriferous sediments which formerly were exposed at higher levels to the east of this area.

"The common association of plant remains with the copper minerals is probably due to the precipitating action of organic matter on copper salts." (Merritt, Okla. Geol. Survey, Min. Report 8, 1940). Carbon acts in the same way as a precipitant of uranium, thorium, gallium, germanium, and vanadium salts.

COPPER DEPOSITS NOT ASSOCIATED WITH PLANT REMAINS

NE¼ sec. 35, T. 25N., R. 3W., Grant County. Copper occurs as malachite nodules in a thin blue shale in the Garber formation. Reported by Merrit (Okla. Geol. Survey, Min. Report 8, 1940) as follows:

> **Grant County.** A small cupriferous outcrop is found in NE¼ sec. 35, T. 25N., R. 3W. Malachite nodules are present in a thin blue shale belonging to the Garber formation, and also as loose fragments on the side of the hill. The total quantity of copper would only be a few pounds.

> **Cotton County.** O. F. Evans reported on two copper workings on the Matthews farm 3 miles east and 6 miles east, respectively, of Randlett, Cotton County. He states that malachite occurs in small fissures in red shale.

NE¼ SE¼ sec. 24, T. 24N., R. 8W., Garfield County. Native copper in this clay at 32 feet. Reported by Haworth and Bennett (1901, pp. 2-3), Reiter (1920, p. ʳ7), Merritt (1940). Merritt describes the deposit as follows:

> **Garfield County.** Native copper has been found in the vicinity of Hillsdale. Haworth and Bennett in 1901, described the occurrence of this mineral on the O. P. Barnes farm. The native copper was found at the bottom of a shaft 32 feet deep, in a six-inch seam of clay. The copper was present as thin plates, similar to tin foil, and from ½ inch to 2 inches wide. No other copper minerals were present. Reiter in 1920, reported that the shaft had been deepened and more native copper was encountered in a thin layer at 70 feet. Rocks exposed in this area belong to the Hennessey formation.
>
> The writer visited the deposit in July 1940. The old shaft was half filled with water and could not be inspected. The dump showed red shale but no copper fragments were visible; the latter probably had been picked up. The present owner of the farm, Mr. W. W. Thomas, had sunk a shaft 28 feet deep, a few hundred feet from the old workings. He found thin plates of native copper in a shale layer, 8 inches thick, at the bottom of the hole. Native copper also is reported from wells on a few other farms in the vicinity of Hillsdale, but in no case has any appreciable quantity been discovered.
>
> The origin of the native copper is obscure. Haworth and Bennett considered it to have been formed by the reducing action of ferrous sulfate on copper salts, but no evidence was advanced to support this theory.

SE¼ SW¼ sec. 31, T. 12N., R. 7E., Okfuskee County. Mines in zone along fault, veinlets of malachite and other copper minerals. The deposit is described by Merritt (1940) as follows:

> **Southwest Okfuskee County.** An unusual "Red Bed" copper deposit is found in SE¼ SW¼ sec. 31, T. 12N., R. 7E., on the farm of Mr. L. Jeffers. The copper minerals have been deposited in a normal fault in the Vanoss formation of upper Pennsylvanian age. The fault is one of the so-called en echelon faults which are common in this region; and probably is a fault zone, since two distinct faults with different angles of dip can be seen in one of the shafts. The rocks exposed at the surface are red to light colored sandstones, which are underlain by a red shale at a depth of 36 ft. according to the records of a drill hole. The sandstone at the surface contains disseminated copper minerals in an irregular outcrop, approximately an acre in area. The ore in the fault was in a vein 2 feet wide.

According to Mr. Jeffers, two attempts have been made to mine this ore. The first was in 1920, when 25 tons were obtained; and the second during the years 1931-1934, when 30 tons of ore were mined. Both lots were shipped to El Paso, Texas, but these ventures were not profitable. The workings in this deposit include a few shallow trenches, three shafts, 26, 30, and 60 feet deep respectively, and some 60 feet of underground workings at the 30-foot level. Unfortunately only the upper 10 feet of one shaft is open to inspection at the present time, due to the shafts being slumped, boarded up, or partly filled with water. Mr. Jeffers states that the ore was obtained from a vein, 2 feet wide, in one of the shafts and in the 30-foot level extending from this shaft. The other shafts were unmineralized.

The structure of this deposit is complex. Two faults with strike N 20° W and dips 45° and 61°, N 70° E respectively, were noticed; and fragments of black hematite on the dump show many slickensides. The faulting thus must have occurred at different times and some of it is later than the mineralization. The information available to the writer at this time is inadequate to define the structure and consequently no prediction can be made as to the extent of mineralization of the faults.

The chief ore mineral is malachite, which occurs in cryptocrystalline masses and also in aggregates of radiating and divergent needles. Small veinlets of malachite may be seen traversing the sandstone. Small amounts of azurite, chrysocolla, chalcocite, tenorite, and native copper were detected. Other minerals present are hematite, limonite, calcite, dolomite, and pyrite, the latter partly coated with melanterite. It is reported that a thin dolomite bed was encountered in a drill hole at a depth of 50 feet and that this rock showed galena, pyrite, and sphalerite.

Analyses of material from this deposit gave the following results (Shead, Okla. Geol. Survey Bull. 14, 1929):

	No. 1	No. 2
SiO_2	65.90	87.87
Al_2O_3	2.20	1.57
Fe_2O_3	8.91	7.75
CO_2	4.26	0.48
CuO	15.41	1.28
H_2O	0.36	0.43
H_2O	2.76	0.82
MnO	....	0.08
Total	99.80	99.88
Cu	12.31	1.02

No. 1 From vein material representing about 100 cubic feet of shipping ore.

No. 2 Sandstone containing the ore.

The writer believes this deposit was formed by precipitation of copper minerals from meteoric waters circulating through a fault zone. Apparently some of the faults are mineralized and others are not; this may be due to some of the faults being later in age than the mineralization. The slickensides on hematite give some weight to this interpretation. The meteoric waters also penetrated into the surrounding sandstone and precipitated disseminated copper minerals, as shown by the 1.02% copper content in the country rock. The ultimate source of the copper must have been the sedimentary rocks which previously were present in this area at higher elevations and since have been eroded. The cupriferous sediments may have been restricted to a local area which happened to overlie an en echelon fault. This accidental relationship would account for the absence of mineralization in most of the en echelon faults which are common in this region.

The extent of mineralization in this deposit can only be determined by core drilling, trenches, etc.

Sec. 18, T. 4N., R 1E., Garvin County. Malachite in red sandstone. Described by Merritt (1940). Copper also occurs in sec. 19 and sec. 20 near Paoli.

SW¼ sec. 33, T. 5N, R. 2E., McClain County. Malachite in Permian sandstone. Discussed by Merritt (1940) as follows:

> **Byars Deposit, McClain County.** The Byars deposit is located in the SW¼ sec. 33, T. 5N., R. 2E., about four miles southwest of Byars. According to Mr. Charles Baird now of Kansas City, Missouri, this deposit was worked in 1897 and 1898, and a little ore was hauled to the South Canadian River, where it was washed and the concentrates shipped to a smelter at Argentine, Kansas. The operations, however, were not profitable. Many test holes were made around the deposit at that time but these records are not available now.
>
> Redfield in 1927 comments on this deposit as follows: "In August 1913, 29 tons of ore were shipped from a surface working 5 miles west of Byars in McClain County. The smelter returns show that 1,300 ounces of silver were received, having a value of $785. The material is silver chloride in a soft, reddish sandstone. Several samples were collected from this locality by a representative of the Survey and were assayed, but did not show much of value."
>
> The writer visited this locality in June, 1940, and was unable to find any of the old workings, though small fragments of malachite were found scattered over the floor of the gully. Gullying has been extensive and the old holes and trenches may have been removed by erosion. The rocks are red sandstones and shale, locally leached white. Barite concretions with a radiating needle structure are common; and a few thin veinlets of barite with parallel needle crystals were seen traversing the shale. Dott (1932) classified

the rocks in this locality as belonging to the Stillwater formation.

ASPHALTIC DEPOSITS

The affinity of uranium for carbon is well known. Occurrence in coal and in carbonized wood indicates that hydrocarbons might carry uranium. The uraniferous asphalt near Asphaltum is mentioned above. Tar in the seeps from the Pennsylvanian shales into zinc mines near Picher contains 0.04 U in ash (0.073%) from the tar (Hill, 1953, p. 201).

There are many occurrences of asphaltic sandstone, asphaltite, grahamite, and impsonite. Any of these might prove uraniferous. For localities see Oklahoma Geological Survey, Bulletin 2, Preliminary report on the rock asphalt, asphaltite, petroleum and natural gas in Oklahoma, by L. L. Hutchison, 1911. This bulletin is out of print and should be consulted in libraries.

ASPHALTIC PELLETS

Pellets of asphaltic material occur near to and north of the Wichita Mountains in southwestern Oklahoma. The pellets yield up to 9.2% ash, which contains as much as 9.30% U (Hill, 1953, p. 201). The occurrences are described by Hill (1954, p. 1377) as follows:

> The most uraniferous materials were small, black asphaltic pellets, which occur in bentonitic and arkosic red shale and sandstone of early Permian age. The relatively flat-lying Permian sedimentary rocks overlie steeply dipping petroliferous Ordovician limestone and dolomite and rounded ridges of Precambrian rhyolite porphyry on the north flank of the Wichita Mountains.
>
> The asphaltic pellets are insoluble in organic reagents, are botryoidal in shape, and range in diameter from 1 mm. or less to 5 cm. Many of these pellets contain smaltite and uraninite and an unidentified uranium mineral. The uranium and total radioactivity are evenly distributed within a pellet.
>
> The asphaltic pellets are largest and most numerous in permeable zones and along fracture openings and are associated with ground-water deposits. They are surrounded by bleached haloes in the enclosing rock and appear to be epigenetic. The internal structure of some pellets is similar to that of marcasite concretions. Their proximity to asphalt seeps suggests that the pellets may have been derived from that source. The presence of uraninite in the pellets, concentrations of rare earths in near-by asphalt, and similar concentrations in near-by hydrothermally altered granite suggest that some of the trace metals were derived indirectly from igneous sources.

BLEACHED AREAS IN RED ROCKS

In western United States uranium emanations have reduced the iron oxides in red beds and have thus become marked by gray or green areas in normal red rocks. Such areas in Oklahoma should be tested. The rocks over the Cement oil pool are bleached and altered, but have not been tested for radioactivity.

PHOSPHATIC BLACK SHALES

Black shales having fissile bedding and with considerable phosphate content occur at several levels in the rock column. These shales are notably radioactive in well surveys, and analyses have proven significant, but noncommercial, uranium content. In Oklahoma the principal phosphatic black shales are:

Woodford shale – Black shale grading to bedded chert. Occurs mainly in and near Arbuckle Mountains. Area of exposure in Black Knob Ridge near Atoka should be tested. Age is Upper Devonian or Lower Mississippian.

Chattanooga shale – Black fissile phosphatic shale exposed in Cherokee, Adair, Mayes, and Sequoyah Counties.

Senora formation – Black fissile shale with phosphatic concretions occurs beneath the Tiawah limestone, beneath the Verdigris limestone, and beneath the Blackjack Creek limestone (Excello shale), all lower middle Pennsylvanian in age. These shales occur in Wagoner, Rogers, Nowata, and Craig Counties.

Marmaton group – Phosphatic black shale is common below the Higginsville limestone, below the Pawnee limestone (Anna shale), and in the Bandera shale. Exposures are in Tulsa, Rogers, Nowata, and Craig Counties.

Missouri series – Fissile black shale with phosphatic concretions occurs above the Checkerboard limestone in Tulsa, Rogers, and Nowata Counties. The Muncie Creek shale and Heebner shale are notably phosphatic, but are not widely developed in Oklahoma.

BRINES

Salt water in wells and springs is known to be radioactive at places. Little definite information is available. Oil field brine in southeastern Nowata County is reported to yield uranium when filtered through activated charcoal. The process has not been proven to be commercial. The brine is in the Bartlesville and Burgess sands.

Brine springs in Salt Hollow, near Nicut, Sequoyah County, are reportedly radioactive. The hydrogen sulfide waters of Claremore springs and wells have been stated to contain "radium".

MISCELLANEOUS OCCURRENCES

A paper by W. T. Huang will soon report occurrences of radioactive minerals on the south flank of the Wichita Mountains.

Uranium rights to most of sec. 36, T. 6S., R. 2E., Love County, were recently up for auction by the Choctaw authorities. No information on the deposit is known to the Survey.

A newspaper report of uranium in coal near Red Oak appears authentic. No definite information is available. Thin coals and coaly beds in general should be tested. Such coals are at places known to contain germanium and gallium. Uranium seems to occur in much the same type of deposit.

In Cimarron County the Morrison formation lies upon Triassic red beds. These formations yield rich carnotite ores in New Mexico, Colorado, and Utah. No radioactivity has been reported in the Oklahoma exposures.

Bell, Goodman, and Whitehead (1940, Amer. Assoc. Petroleum Geologists, Bull., vol. 24, pp. 1529-1547) reported a number of occurrences of radioactive rocks and petroleums in Oklahoma.

Bartlesville sandstone – core at 494, 505, 512 feet in unnamed well in Nowata County.

Viola, McLish, and unidentified limestone in core of Moore 1A Harper in Fitts pool, Pontotoc Co.

Cromwell, Viola, McLish, and unidentified dolomite in Moore No. 7 Schauers of the Fitts pool.

Crude oil from these formations also proved radioactive.

W. H. Bradley (Occurrence of uranium deposits, Bulletin of the Atomic Scientists, vol. 4, 1950, pp. 149-152) has noted radioactivity in the Woodford cherts. McKelvey and Nelson (1950, Econ. Geology, vol. 45, pp. 35-53) have reported radioactivity in the Woodford and in other black shales.

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