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COPPER IN THE "RED BEDS" OF OKLAHOMA

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FOREWORD

The purpose of this report is to make available for distribution general information that is available in the offices of the Oklahoma Geological Survey regarding copper deposits of the Red Beds of Oklahoma. Most of the deposits discussed in this report were checked in the field by the author during the summer of 1940.

COPPER IN THE "RED BEDS" OF OKLAHOMA

Introduction

The first mention of copper in Oklahoma is found in the report of Captain Randolph B. Marcy, entitled, "Exploration of the Red River of Louisiana in the year 1852", published by U. S. Senate, 33d Congress, Ist. session. In traversing the divide between Red River and Cache Creek in the region now known as Jefferson County, Oklahoma, the Marcy party found numerous small, detached fragments of copper ore. Later, with the opening of Oklahoma to settlers, copper minerals were detected in various places in the "Red Beds" and a few unsuccessful attempts were made to mine these. This activity has occasioned considerable interest in these deposits, and as the literature on the subject is meager, it was felt that a detailed study of the occurrences should be made and the results made available to the public.

Copper deposits are widespread in the "Red Beds" of the world and are rather similar in their geological features. The Oklahoma occurrences in most respects, share these features; consequently a brief resume of the general characteristics of such deposits will be given.

In the United States, "Red Beds" copper ores have been described from Oklahoma, Texas, Colorado, New Mexico, Arizona, and Utah. They also are known in Nova Scotia, New Brunswick, Bolivia, England, Bohemia, Turkestan, and Central Asia (Kirghiz Steepes). Furthermore, the famous Mansfeld, Germany, copper deposit is closely related to this type, though some of its features are distinctly different. The "Red Beds" ores are found in Upper Carboniferous, Permian, Triassic, or Jurassic sediments. Copper occurrences of this type also have been reported by Butler (1)* in the Devonian rocks of

*See bibliography at the end of this report.

Pennsylvania and in the Silurian of New Jersey, but these latter must be considered as exceptional. The copper ores occur in sandstone or shalo,especially in the former. These rocks are red in color but near the deposits they often are white. This color change has been interpreted by some geologists as due to the loss of iron oxides by the leaching action of ground waters.

The ores, usually of low tenor, are disseminated in irregular masses. Numerous attempts have been made to mine them in the United States but with few exceptions these efforts have been unsuccessful. The outstanding exceptions are:

Nacimiento, New Mexico (1886-1905) 6,300,000 pounds of copper. (2)
Pastura, New Mexico (1925-1930) 5,000,000 pounds of copper. (3)
Scholle, New Mexico, 1,006,068 pounds of copper and 7,872 ounces of silver. (3)

The common minerals in the copper deposits are malachite, chalcocite, and chrysocolla; while small amounts of chalcopyrite, covellite, bornite, azurite, tenorite, cuprite, atacamite, and native copper often are present. Rarely are all these minerals found in the same deposit but four or five are common. The gangue minerals are barite, gypsum, calcite, dolomite, pyrite, or marcasite, and these usually are sparingly present. Small amounts of galena and sphalerite are sometimes found. Chalcocite is the chief primary copper mineral and occurs as replacements in the cement of sandstone, or as replacements of pyrite or marcasite nodules, or as replacements of fossil wood. The psuedomorphs after wood often show perfect preservation of the cell structures. The pyrite and marcasite occur as concretions in sandstone or as psuedomorphs after fossil wood. Usually these iron sulfides are partially or completely altered to chalcocite and other copper minerals. In the pyrite or marcasite nodules,chalcocite usually replaces the earlier mineral,which action starts from the center and proceeds outwards. Thus many nodules will show a core of chalcocite and an outside shell of unreplaced iron sulfide. Malachite, azurite, and chrysocolla are the common alteration products of chalcocite, but occasionally there are small amounts of tenorite, cuprite, native copper, or atacamite.

Rogers (4) made microscopic studies of specimens of "Red Beds" copper ores from various localities in the United States. He found the minerals and their paragenesis were quite similar for the different deposits,and he gives the following scheme of paragenesis;

1. hematite (oldest)
2. pyrite
3. bornite
4. chalcocite, covellite, and late chalcopyrite
5. melaconite (tenorite)
6. hematite of the second generation, limonite, and quartz
7. azurite and malachite.

The copper ores often contain traces of nickel, cobalt, chromium, molybdenum, or selenium; also small amounts of lead, silver, uranium, or vanadium may be present. Commercial deposits of lead, silver, uranium-vanadium are known in the"Red Beds" but rarely do these contain much copper, although exceptions such as the Scholle, New Mexico, deposit, are found.

Many investigators consider the "Red Beds" copper ores to have been formed by precipitation from meteoric waters,which obtained their copper content by the leaching of copper minerals disseminated in the sediments of the immediate region. Other geologists emphasize the stratigraphic confinement of the ores and believe that the copper was brought into the sea as detrital fragments or in solution, along with the sediments in which it is now found. Later some secondary enrichment by ground waters has taken place. The common association of plant remains with the copper minerals is probably due to the precipitating action of organic matter on copper salts. The function of organisms in the formation of copper deposits of this type must also be considered.

Twenhofel (5) writes, "The circulation fluids of many invertebrates contain copper in the form of a copper protein known as hemocyanin. As most organisms are eaten after death, most of this copper remains in organic circulation; but if dead organic matter is buried, copper is introduced into the sediments in this way."

"Red Beds" Copper Deposits of Oklahoma

The copper deposits of the "Red Beds" of Oklahoma are found in only a small part of the total "Red Beds" area, in fact, the distribution of the copper is distinctly local. With the exception of one occurrence in upper Pennsylvanian rocks, the copper is found in the lower Permian. For descriptive purposes the copper ores are classified and described in the following order.

1. Garvin-McClain Counties.
2. North-Central Oklahoma. This region is rather broad and includes local areas in Payne, Pawnee, Grant, and Garfield Counties.
3. Comanche, Cotton, and Jefferson Counties. This region includes many local outcrops containing small amounts of copper minerals.
4. Southwest Okfuskee County.
5. Other areas.

GARVIN-McCLAIN COUNTIES

(a) Garvin County. Copper minerals are found as nodules, disseminated in sandstone or weathered free on the surface, in an area of a few square miles just east of Paoli. The greatest concentration of malachite is in sec. 18, T. 4 N., R. 1 E., and a few tons of ore have been shipped from the lease of the Tecpee Queen Copper Co. Copper minerals also are found in the surrounding sections.

The rocks in the region are red sandstones and shales with local dolomite or barite cement and some manganese oxide staining. They have been classified by Dott (6) in unit 3 and probably correspond to the Garber formation in age. The rocks are cross-bedded, lenticular, and cannot be traced with certainty for any considerable distance at the surface. For this reason it is impossible to determine whether local structural conditions

have played any role in the concentration of the copper minerals. The rocks as commonly interpreted, were formed under sub-aerial conditions, probably as deltaic deposits formed by streams flowing from the east. This sedimentary history may account for the concentration of copper in this local region and its absence in the surrounding areas. The copper could have been brought in by a single stream and thus confined to the sediments of one delta. The small stringers of malachite in sandstone testify that at least part of the copper has been reworked by ground waters and somewhat concentrated. Also, gullying has removed local sandstone masses and left the malachite as residual fragments on the gully floor. The few tons of ore shipped from this region were obtained from this type of residual ore. The copper content of the sandstones is so low that even this enrichment produced only a few tons of ore, and the deposits now known in this region have no commercial value.

The chief copper mineral is malachite, often exhibiting needle-like crystals, and occurring as small fragments rarely more than an inch long. The fragments always contain considerable sand and two analysis by Shead (8) showed 12.93 and 23.0 percent copper respectively. The malachite also occurs as thin stringers traversing the sandstone and as thin films in the center of pyrite-sand nodules. Some of the malachite fragments show a little chalcocite in the interior and one fragment also contained a small piece of native copper. The malachite was formed by the alteration of the chalcocite. In some outcrops, many nodules, one-half inch in diameter or less, are present. These are mixtures of sand and pyrite with the latter partly altered to hematite. Small fragments of black, dense hematite containing some sand are often abundant in some of the outcrops.

An interesting feature of the area is the variety of barite types which occur. Barite is found in the sand as rosettes, as thin-bladed crystal aggregates, as dense, finely crystalline, gray cement. It also occurs in the center of calcite-clay concretions as coarsely crystalline, glassy masses.

(b) Byars Deposit, McClain County. The Byars deposit is located in the SW¼ sec. 33, T. 5 N., R. 2 E., 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 (9) 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 (7) classified the rocks in this locality as belonging to the Stillwater formation.

NORTH CENTRAL OKLAHOMA

This region is rather large and includes local cupriferous areas in Payne, Pawnee, Grant, and Garfield Counties. These counties will be discussed in turn.

(a) Payne County. Copper minerals were discovered on the M. J. Burwell farm (SE¼ sec. 22, T. 20 N., R. 3 W.) in 1901. This deposit was described by Tarr (10) in

*Letter to Robert H. Dott, dated April 4, 1929.

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).

Rogers (4) made microscopic studies of specimens from this deposit and found the concretions to be composed largely of chalcocite, pyrite, and sand, with a little covellite. On the exterior, pyrite predominated and in the center chalcocite. The latter replaced the pyrite and also to some extent, the sand. In the wood replacements the principal mineral was chalcocite with gray, metallic melaconite (tenorite) on the exterior of the cells. Covellite also was present in occasional patches.

The writer visited this deposit in July 1940, but the underground workings were filled with water and no inspection of them could be made. The dump showed a few fragments of cuprified wood. Apparently the ore was restricted to a thin bed and was too low in value to have commercial possibilities.

A half-mile east of this deposit in sec. 23, T. 20 N., R. 3 E., 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.

(b) Pawnee County. Copper minerals are found in a small area a few miles north of Lela. In sections 23 and 24, T. 22 N., R. 3 E., 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 or 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. 22 N., R. 3 W. These deposits are too small to have any economic value.

(c) Grant County. A small cupriferous outcrop is found in NE$\frac{1}{4}$ sec. 35, T. 25 N., R. 3 W. 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.

(d) Garfield County. Native copper has been found in the vicinity of Hillsdale. Haworth and Bennett (11) in 1901, described the occurrence of this mineral on the O. P. Barnes farm (NE$\frac{1}{4}$ SE$\frac{1}{4}$ T. 24 N., R. 8 W.). 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 $\frac{1}{2}$ inch to 2 inches wide. No other copper minerals were present. Reiter (12) 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. (11)

COMANCHE, COTTON, AND JEFFERSON COUNTIES

There have been several reports of copper minerals in these counties and many shallow trenches and holes have been dug. The writer visited a dozen of these localities in the vicinity of Waurika, Temple, Randlett, Lawton, and Cache. In most of the locations only a few fragments of malachite were detected and none of the deposits had any commercial possibilities.

The copper minerals occur as nodules in sandstone, shale, or calcareous conglomerate, or as fine disseminations and surface stains on sandstone. Also small pieces of fossil wood have been replaced by copper minerals. Fath (13) studied the occurrence of copper minerals in "Red Beds" of the Wichita group, exposed along the north bank of Red River in sections 2 and 3, T. 5 S., R. 11 W. He found the nodules in sandstone were due to chalcocite replacing the calcite cement of the sandstone; and that the nodules in shale, all of which are smaller than a hickory nut, were originally marcasite, and this sulfide has been partially replaced by chalcocite. Many of the nodules now show a chalcocite interior and an unreplaced outside shell of marcasite, indicating that the replacement started from the center of the nodule and progressed outwards. Fossil wood, likewise, has been partially replaced by chalcocite. Later surface agencies have altered the chalcocite to malachite and azurite.

The mineral atacamite was found by the Marcy party in its travels through this region in 1852. A new mineral named Marcylite also was reported but has been proved to be an impure atacamite. (14)

Deposits similar to those of this region are known south of Red River in Texas. In Archer and Wichita Counties, the copper ore is widespread in marls and clays, as pseudomorphs after wood, as nodules, and in the cement of the marls. A little silver is present in the ore and numerous attempts have been made to mine these deposits, but without success. (15,16)

The source of the copper in this area was probably chalcopyrite from the Pre-Cambrian rocks and veins of the Wichita Mountains. Erosion of these rocks has produced the arkoses of the Clear Fork-Wichita Group and undoubtedly these sediments contained small quantities of detrital chalcopyrite and also some copper minerals brought in by solutions. The chalcopyrite later has altered to chalcocite or malachite. The copper in the sediments which are some distance from the Wichita Mountains, such as those along Red River, may have derived their copper from the erosion of the cupriferous arkoses closer to the Wichitas.

SOUTHWEST OKFUSKEE COUNTY

An unusual "Red Bed" copper deposit is found in SE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 31, T. 12 N., R. 7 E., 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 foot 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 (8):

	#1	#2
SiO_2	65.90	87.87
Al_2O_3	2.20	1.57
Fe_2O_3	8.91	7.75

	#1	#2
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

#1. From vein material representing about 100 cubic feet of shipping ore.
#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.

OTHER AREAS

In addition to the areas discussed, copper has been reported from Pottawatomie, Pontotoc, Seminole, Lincoln, Logan, Noble, Major, Woods, Kingfisher, Blaine, Caddo, Washita, and Greer Counties. The locations of the occur-

rences are so vague that the writer has not attempted to find them. They are described by Gould (17) as follows: "In most cases nothing has been found but the greenish stain, but in a number of instances, for instance near Perry, in Noble County and Winnview, in Blaine County, small nuggets of native copper the size of a hazelnut occur, in some localities, scattered through the reddish clay-shale. In several instances tunnels have been driven into the red clay banks for as much as fifty feet and several gallons of these copper nuggets have been secured. In no case, however, has the amount of copper obtained justified the expenditure."

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