STATE OF ARKANSAS

ARKANSAS GEOLOGICAL SURVEY

GEORGE C. BRANNER

STATE GEOLOGIST

INFORMATION CIRCULAR 2

CINNABAR IN SOUTHWESTERN ARKANSAS

BY

GEORGE C. BRANNER

LITTLE ROCK

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LETTER OF TRANSMITTAL

ARKANSAS GEOLOGICAL SURVEY

Little Rock, Arkansas

May 28, 1932

Hon. Harvey Parnell,
Governor, State of Arkansas,
Little Rock, Arkansas.

Sir:

I have the honor to submit herewith the report, "Cinnabar in Southwestern Arkansas," by George C. Branner.

The discovery of cinnabar in southwestern Arkansas has created interest throughout the United States and the present report has been prepared to provide information regarding the geology of the area and the character of the cinnabar deposits. Present indications are that the Arkansas field may prove to be one of the important quicksilver districts in this country.

The Arkansas deposits are of somewhat unusual interest in that they are the most eastern occurrences of cinnabar in quantity in the United States and that cinnabar has heretofore never been known to occur in any part of the Ouachita Province. In addition, the distribution of the mineral presents unique features.

Respectfully submitted,

George C. Branner

State Geologist.

CONTENTS

ILLUSTRATIONS

ABSTRACT

The Arkansas cinnabar area as it is now defined is limited principally to Pike County but also extends into Howard and Clark counties. The cinnabar occurs principally as fracture fillings in steeply-dipping Mississippian sandstones and is believed to be of hydrothermal origin. At least 34 separate occurrences have been discovered up to the present time. Most of these lie very nearly in a straight line about 20 miles in length which nearly coincides with a stratigraphically located anticlinal axis. Of the remaining deposits, all but two are apparently related to a fault crossing this axis. At present there are two areas in which there are important mining operations, one located approximately 7.5 miles north of Murfreesboro and the other located approximately 5 miles south of Amity, both in Pike County. Up to April 9, 1932, two companies had produced a total of 1,981 pounds of quicksilver. One company has been operating since April 21, 1932, on a 24-hour basis.

INTRODUCTION

The discovery of cinnabar in Arkansas has created much interest in this country and there has been a considerable demand for data concerning the geology and distribution of the deposits. In this report an attempt is made to set forth all important information concerning the occurrence of the cinnabar and the topography, geology, and mineralogy of the region. The report is necessarily a statement of progress. It supplies information additional to that contained in an article by the writer 1/ published August 30, 1931, and a later article by W. M. Weigel 2/ published December 14, 1931.

ACKNOWLEDGMENTS

Acknowledgments are made to the following individuals for valuable assistance: H. D. Miser, of the U. S. Geological Survey, for valuable comments on this report; Leo Yount, President of the Southwestern Quicksilver Company, for permission to visit the holdings of that company and for generous cooperation in the furnishing of information; N. H. Stearn, Vice President of the Southwestern Quicksilver Company, for assistance in connection with the accumulation of information and for valuable comments on this report; C. Hyde Lewis, of H. W. Gould and Company, for information supplied; J. M. Hansell, of the Arkansas Geological Survey, for valuable assistance in the field and for many helpful suggestions in the preparation of this report; Leland Palmer, of the Southwestern Quicksilver Company, for assistance in the field. W. N. Bemis, E. W. Cantley and Wes Russell, of the Arkansas Quicksilver Company, for information furnished and for valuable assistance in connection with field work; Bryan Parks for field work and the contribution of information concerning prospects and structure; Austin F. Rogers and R. L. Sohlberg, of Stanford University, for a contribution relative to the petrography of the Pike County cinnabar; Walter F. Hintze, of Murfreesboro, for assistance in the field, W. M. Weigel, of St. Louis, and Howard Millar, of Murfreesboro, for information supplied.

LOCATION AND ACCESS

The area in which the Arkansas cinnabar deposits occur is within the Athens Plateau division of the Ouachita Province and lies between the central portion of the Ouachita Mountains (the Novaculite Uplift) and the Gulf Coastal Plain. (See Pl. 1.) The cinnabar has been found principally in Pike County, but it also occurs in western Clark and eastern Howard counties, which are adjacent to Pike County on the east and west respectively.

State Highway 27, which connects with U. S. Highway 70 at Kirby, passes from north to south through the central part of the cinnabar area to Murfreesboro. The

1/ Branner, G. C., Cinnabar in Arkansas: Arkansas Gazette, August 30, 1931.
2/ Weigel, W. M., New quicksilver discoveries; Eng. and Min. Jour., vol. 132, pp. 495-497, 1931.

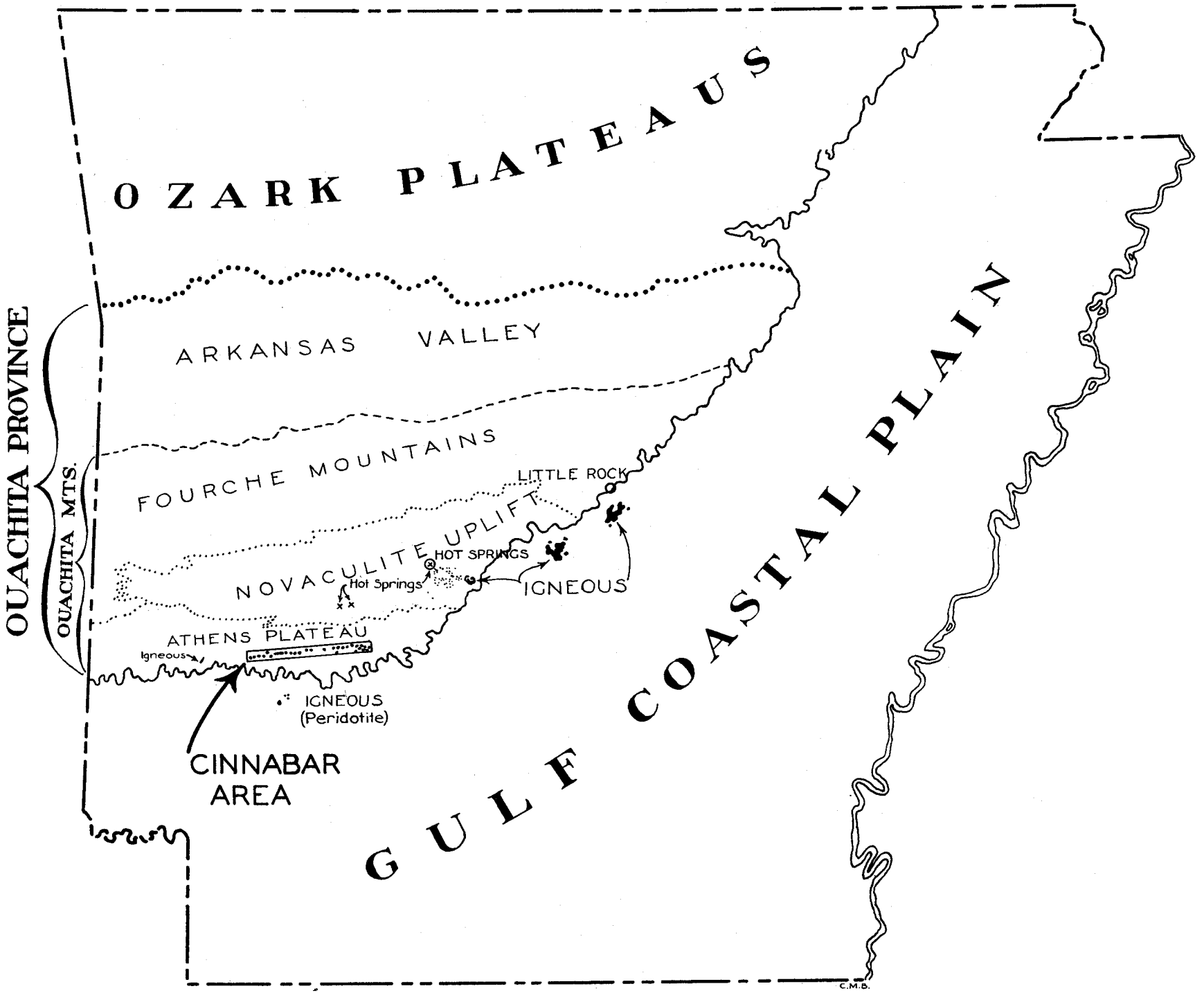


PLATE 1. MAP OF ARKANSAS SHOWING PHYSIOGRAPHIC PROVINCES AND CINNABAR AREA.

Little Missouri River area is reached from State Highway 27 by a country road which follows the Cowhide Creek valley for 5.7 miles. The area south of Amity is reached from either Glenwood or Kirby by State Highways 8 and 84, respectively, to Amity and from Amity south by country road for 5.4 miles to near Nutt's Crossing, on the Gurdon to Norman branch of the Missouri Pacific Railroad. This railroad follows Antoine Creek along the eastern edge of the Antoine Creek area. The Pike City branch of the Missouri Pacific Railroad reaches Pike City, in southeastern Pike County, and the Nashville, Graysonia and Ashdown Railroad connects Murfreesboro, in southern Pike County, with Ashdown, which is on the Kansas City Southern Railroad and the St. Louis and San Francisco Railroad. The location of the highways and railroads is shown in Plate 2.

TOPOGRAPHY AND DRAINAGE

Topography

The topography and drainage of the cinnabar region are shown in Plate 2. The surface of the portion of the Athens Plateau in which cinnabar has been found is composed of alternating ridges and valleys, which have a usual trend of N. 80° E. The usual relief of the ridges is from 100 to 350 feet. The crests are usually sharp and often are not more than 200 feet across. The width of the valleys is commonly from one-half to three-fourths of a mile, and the ridges have about the same width at their base. The maximum elevation above mean sea level found in the Athens Plateau is about 1,000 feet and the minimum about 350 feet.

Drainage

The portion of the Athens Plateau in which the cinnabar has been found is drained by a trellis system of relatively small streams. The two major south-flowing streams are the Little Missouri River and the Antoine Creek with tributary creeks flowing east and west, following the valleys. The Little Missouri River has a maximum, measured, daily discharge of 8,740 second feet and a minimum of 5 second feet. Antoine Creek is much smaller and in dry weather has no surface flow. Both of the two major streams referred to are superimposed and have cut down through the east-west sandstone ridges. The courses taken by these streams probably were determined, to some degree, by the faulting and distortion of these areas. These conditions probably permitted more rapid erosion of these areas and consequently faster reduction in relief, than of areas of regular folding. For this reason, a study of the drainage may assist in the location of irregular structural conditions within the Athens Plateau. This possibility is discussed further under "Suggestions for Prospecting and Development."

DISCOVERY OF CINNABAR

There is no certain proof available that cinnabar was found in Arkansas previous to 1930. On October 4, 1897, four mining claims on the "Quicksilver Lode" in sec. 25, T. 6 S., R. 27 W., Pike County, were filed at the Pike County Courthouse at Murfreesboro, Arkansas, by A. G. Jones, Mary Mitchell and A. G. Jones, F. W. Pavey, and B. Gross. The filing of these claims is very suggestive of the discovery of metallic quicksilver, or other quicksilver minerals, in the area on which the claims were filed, although subsequent prospecting in that locality has not disclosed their presence.

W. M. Weigel 3/ states, "The original discovery of cinnabar in Arkansas may antedate the present discovery by many years. I have had a report that the records at Mount Ida, the county seat of Montgomery County, lying just north of Pike County, contain the record of the filing on a cinnabar claim in southwestern Montgomery County about fifty years ago."

3/ Weigel, W. M., op. cit.

Arkansas cinnabar, so far as can be determined, was first identified on June 29, 1931, by W. M. Weigel, of St. Louis, Missouri. Specimens were sent to Mr. Weigel by Walter F. Hintze, of Murfreesboro, and were from sec. 1, T. 7 S., R. 26 W., near the Little Missouri River. Specimens from this area were received on July 16, 1931, by the Arkansas Geological Survey from Mr. Hintze, and were identified on that date.

Specimens from the Antoine Creek area, in sec. 28, T. 6 S., R. 23 W., were first identified on July 22, 1931, by Moritz Norden, of Hot Springs.

Cinnabar was first found, but not identified, in the Little Missouri River area, in sec. 1, T. 7 S., R. 26 W., in April, 1930, by Crown Cox, a farmer boy, and in the Antoine Creek area, in sec. 28, T. 6 S., R. 23 W., in May, 1930, by D. F. Short, of Amity.

DISTRIBUTION OF DEPOSITS

The distribution of the known occurrences of cinnabar in place is shown in Plates 2 and 3. The Little Missouri River deposits are shown in Plate 3 under reference numbers 27 to 31, both inclusive, while the Antoine Creek deposits are shown under reference numbers 1 to 14, both inclusive.

The occurrences shown in Plate 3 are listed herewith and are numbered in accordance with the numbers shown in that plate.

OCCURRENCES OF CINNABAR IN PLACE

(Located in Pike County unless otherwise specified)

No.	Location	Sec.	Twp.	Range	Fee Owner	Lessee
1.	NW NE	19	6 S	23 W	Warner Deering	The Exploration Company
	Clark County					
2.	SE SW	29	6 S	23 W	Ozan-Graysonia Lbr. Co.	
3.	SW SW	28	6 S	23 W	Ozan-Graysonia Lbr. Co.	Arkansas Quicksilver Company
4.	SW SW	28	6 S	23 W	Ozan-Graysonia Lbr. Co.	Arkansas Quicksilver Company
5.	SE SW	28	6 S	23 W	Ozan-Graysonia Lbr. Co.	Arkansas Quicksilver Company
6.	SE SW	28	6 S	23 W	Ozan-Graysonia Lbr. Co.	Arkansas Quicksilver Company
7.	NE NW	33	6 S	23 W	Ozan-Graysonia Lbr. Co.	Arkansas Quicksilver Company
8.	NE NW	33	6 S	23 W	Ozan-Graysonia Lbr. Co.	Arkansas Quicksilver Company
9.	NE NW	33	6 S	23 W	Ozan-Graysonia Lbr. Co.	Arkansas Quicksilver Company
10.	SE NW	33	6 S	23 W	Ozan-Graysonia Lbr. Co.	Arkansas Quicksilver Company
11.	SE NW	33	6 S	23 W	Ozan-Graysonia Lbr. Co.	Arkansas Quicksilver Company
12.	NE NE	34	6 S	23 W	Southern Kraft Corp.	
	Clark County					
13.	S½ SW	34	6 S	23 W	Southern Kraft Corp.	
	Clark County					
14.	NE NW	5	7 S	23 W	Ozan-Graysonia Lbr. Co.	
15.	NW SE	26	6 S	24 W	T. P. Palmer	
16.	NE SW	26	6 S	24 W	Southern Kraft Corp.	
17.	NW SW	26	6 S	24 W	Ozan-Graysonia Lbr. Co.	
18.	SW SE	27	6 S	24 W	Louis & Pasquale Marino	C. Mining Corporation
19.	SE NE	3	7 S	24 W	Ozan-Graysonia Lbr. Co.	
20.	NW	33	6 S	24 W	Southern Kraft Corp.	
21.	SE NW	32	6 S	24 W	C. Caponetto	C. Mining Corporation
22.	SW NW	32	6 S	24 W	Southern Kraft Corp.	
23.	NW NW	2	7 S	25 W	Joe Cox	Arkansas Cinnabar Mining Co.
24.	NW NW	3	7 S	25 W	J. H. Funderburk Estate	
25.	NW NW	4	7 S	25 W	Johnson Heirs	
26.	NW SW	5	7 S	25 W	Mrs. Lula Bell	

No.	Location	Sec.	Twp.	Range	Fee Owner	Lessee
27.	(SW SE (SE SW (SW SW	6 6 6	7 S 7 S 7 S	25 W 25 W 25 W	Johnson Heirs D. L. Parnell and R. B. Carroll	Southwestern Quicksilver Co.
28.	SW NE	12	7 S	26 W	Arkansas P. & L. Co.	George Bell
29.	SE SW	1	7 S	26 W	G. J. Parker	Southwestern Quicksilver Co.
30.	SW NE	11	7 S	26 W	G. J. Parker	Southwestern Quicksilver Co.
31.	SW NE	11	7 S	26 W	G. J. Parker	Southwestern Quicksilver Co.
32.	NE SE	9	7 S	26 W	Southern Kraft Corp.	
33.	(SE SE (NE NE (Howard County	12 13	7 S 7 S	27 W 27 W	William Pyle	Z. A. Copeland
34.	(Near south line (NE NW (Howard County	13	7 S	27 W	Z. A. Copeland	

For detailed descriptions of the above occurrences see section on "Descriptions of Occurrences of Cinnabar in Place," page 21.

GEOLOGY AND MINERALOGY

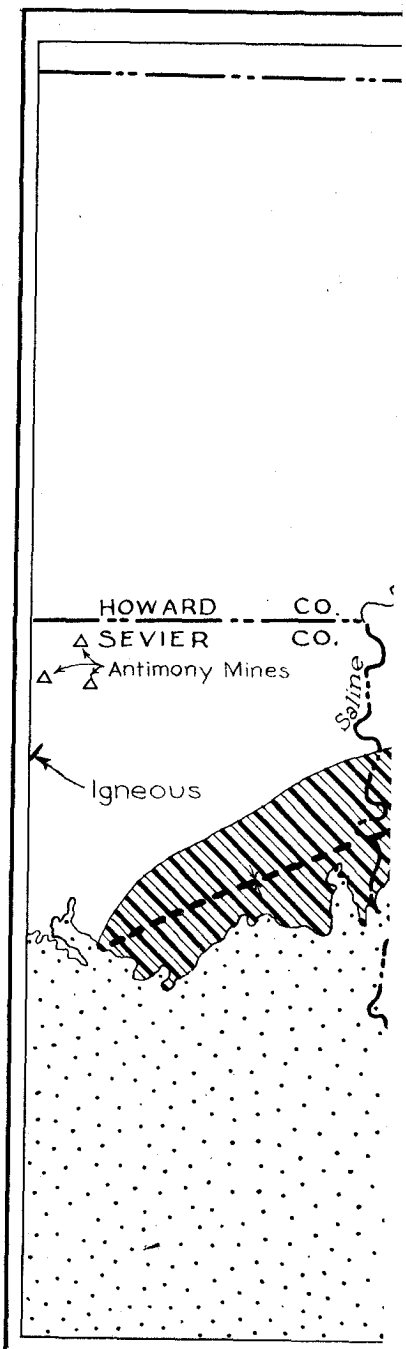
Regional Geology

The surface rocks of the Athens Plateau are Paleozoic (Carboniferous) shales and sandstones. The formations lie immediately south of the Novaculite Uplift and have been intensely folded by north and northwest acting forces which have caused the intense compression of the Athens Plateau and raised the central portion of the Ouachita Mountains (the Novaculite Uplift). The cinnabar area, lying in the southern part of the Athens Plateau, is, therefore, part of a broad belt of intensely folded shales and sandstones. These are overlapped by sediments of the Gulf Coastal Plain a few miles south of the cinnabar area. (See Pls. 3 and 4.)

Stratigraphy

The formations present in the central and western part of the cinnabar area have been mapped and described by Miser and Purdue 4/. The areal mapping of the portion of the area east of the Caddo Gap Quadrangle is shown on the Geologic Map of Arkansas 5/. The formations present are all of Carboniferous age. They consist of the Stanley shale and Jackfork sandstone formations of the Mississippian system, and the Atoka formation of the Pennsylvanian system. The following description of these formations, as they occur in the Caddo Gap and DeQueen Quadrangles, is compiled from Miser and Purdue 6/.

4/ Miser, H. D., and Purdue, A. H., Geology of the DeQueen and Caddo Gap quadrangles, Arkansas: U. S. Geol. Survey Bull. 808, p. 136, 1929.
5/ Geologic map of Arkansas, Arkansas Geol. Survey, 1929.
6/ Miser, H. D., and Purdue, A. H., idem.


HOWARD CO.
SEVIER CO.
Antimony Mines
Saline
Igneous

Geologic Formations Present in the Cinnabar Area

System	Series	Formation	Thickness in feet	Character of Rocks
CARBONIFEROUS	Pennsylvanian	Atoka	6000	Sandstone and shale in nearly equal amounts. Sandstone is hard, micaceous, ripple marked, and is usually brown but may be light to greenish gray, contains quartz grains of medium size, and occurs in beds from a few inches to twelve feet thick. In some parts, the formation is all sandstone through a thickness of 75 to 100 feet. Small quantities of asphalt are found here and there in the sandstone and fragments of plant and fossil wood are common. On the west bank of Antoine Creek, east of the Caddo Gap quadrangle, 20 feet of the formation bears thin beds of carbonaceous material resembling coal. Shale is sandy and micaceous and is dark to coal-black, but weathers to a rusty color. Turning darker, it finally becomes pea-green before changing to red plastic clay. It differs from the shale of the formations beneath in being exposed in fewer places, in having a more basic appearance, and in breaking down into small splinters and granular fragments instead of flakes. Black, compact chert, in a layer reaching a thickness of several inches, occurs at a few places.
	Mississippian	Jackfork sandstone	5000-6000	Chiefly sandstone but contains some shale and millstone grit. Sandstone is compact and ranges from fine to coarse-grained, the major portion being quartzitic. Sandstone occurs in beds, most of which are from 6 inches to 10 feet thick, but many are much thicker, the thickest bed observed measuring 84 feet. On talus slopes it occurs in hard, angular blocks, and when long exposed forms rounded gray boulders, some of which weather by exfoliation. The characteristic color of the unweathered sandstone is light-gray though some is bluish-gray, greenish-gray or even white, and the color of the weathered portions is light-gray, yellow, or brown, the gray color being the most common. Shale occurs as beds of green, finely fissile clay. The shale in the upper part aggregates possibly 400 feet on the Little Missouri River, and that in the lower part of the same locality comprises two or three beds from 6 to 10 feet thick, but it constitutes a larger portion of the formation in pro-

Geologic Formations Present in the Cinnabar Area (cont.)

System	Series	Formation	Thickness in feet	Character of Rocks
CARBONIFEROUS	Mississippian	Jackfork sandstone (cont.)	5000-6000	bably most other parts of the Caddo Gap and DeQueen quadrangles. Altered feldspar grains occur in much of the formation, and mica flakes are common, especially in the greenish beds. Other minerals which have been observed in thin sections are zircon, tourmaline, titanite, chlorite, pyrite, and magnetite.
		Stanley shale	6000	Mainly shale, about one-fourth sandstone and some tuff and conglomerate near base. More sandstone occurs in the lower and upper parts than in the middle. A bed of dense black chert 2 to 6 inches thick occurs in the formation probably near the middle. Shale fissile, bluish black and black in fresh exposures along streams, green, yellow, or brown in more weathered exposures along roads. Shale is argillaceous, though much is sandy; it breaks into thin, hard plates with smooth, glossy surfaces containing mica flakes. In places at base it is carbonaceous enough to blacken the fingers. Joints cut the shale and many of them are occupied by quartz veins from a fraction of an inch to one foot thick. Fresh sandstone is hard, tough, compact, quartzitic, rather fine-grained, and greenish or bluish-gray, and occurs in layers as much as 18 feet thick. The altered sandstone is soft, porous, more or less earthy, and green, yellow, or brown. Conglomerate near base is composed of novaculite pebbles in dense siliceous matrix.
		Hatton tuff lentil	0-90	Tough and compact, massive and homogeneous, and contains quartz veins.

Structure

The structure of the Caddo Gap and DeQueen Quadrangles has been described in detail by Miser and Purdue 7/. The Stanley shale, Jackfork sandstone, and Atoka formation are intensely folded throughout the entire area and lie in a consecutive series of anticlines and synclines. The folds, for the most part, have been respon-

7/ Miser, H. D., and Purdue, A. H., op. cit.

sible for the erosion of the area into sandstone ridges and shale valleys. The folding throughout the entire area is remarkable for its regularity, with the exception of local disturbances. While the surface dips in the cinnabar area usually vary between 60 and 90 degrees south, in a few places they are slightly overturned to the north. Slickensided rocks are very common and show striations at all angles, although the most usual direction is parallel to the direction of the dip. The location of the axes of the anticlines and synclines in the cinnabar area and vicinity is shown in Plates 3 and 4, and a north-south section of the Athens Plateau is shown in Plate 4.

It should be kept in mind that many of these axes, and in particular the axis of the Cowhide Creek anticline, are located almost entirely on the basis of stratigraphic information. For this reason, the degree of accuracy with which the axis of the Cowhide Creek anticline is located, as shown in Plates 3 and 4, is no greater than that of the mapping of the formations. As the mapping is of a reconnaissance type, detailed field work may disclose that the location of certain of the axes should be shifted. Stearn 8/ has raised a serious doubt as to the accuracy of the position of the axis of the Cowhide Creek anticline as mapped. Stratigraphic information now available leads to the conclusion that the axis of the Cowhide Creek anticline should be shifted northward an undetermined distance.

It is of much interest to observe the trends of the topographic axes of the main ridges in the Athens Plateau, as shown in Plate 5. For the most part, these represent the strike of the beds, although some exceptions to the general rule have been observed. It will be noted that several pronounced variations are present in the nearly east-west trend of these ridges in the Little Missouri River area and the Antoine Creek area, both of which are known to contain deformed areas several square miles in extent in which the strike of the beds changes abruptly.

There are two, and probably several, areas in which the folded rocks have been subjected to forces which have produced irregular and intense deformation in addition to the east-west folds. These two areas, which have previously been referred to, lie (1) north of Murfreesboro along the valley of the Little Missouri River, in secs. 6 and 7, T. 6 S., R. 25 W., and secs. 1 and 12, T. 7 S., R. 26 W., and (2) along the Antoine Creek, south of Amity, in secs. 28, 32, and 33, T. 6 S., R. 23 W.

The structure of the Little Missouri River area is shown in the areal structure maps and the vertical section. (See Pls. 3, 4, and 6.) In this area a movement -- apparently folding -- across the strike of the beds, whereby they diverge from their normal regional strike by a distance of probably between 3,000 and 4,000 feet, has taken place. It is uncertain whether this movement has been accompanied by major faulting.

The structure of the Antoine Creek area is indicated in the areal structure maps. (See Pls. 3, 4, and 7.) This area has been cross-faulted on the east by the Amity fault, which represents a tear movement having a vertical component in the order of several miles and a northwest-southeast movement of perhaps equal, or greater, magnitude. The magnitude and character of the movement have not been determined in detail.

On the ridges lying near Antoine Creek, in the SW.¼ of sec. 28, T. 6 S., R. 23 W., and the N.½ of sec. 33, T. 6 S., R. 23 W., apparently there has been an offset to the south of the N. 80° E. trending ridges on the order of from 1,300 to 2,000 feet. This appears to be a fold, as the strike of the beds changes from N. 80° E. on the west to N. 55° W., and then to N. 60° E. on the east. Just what relation this offset has to the Amity fault is not yet known.

8/ Stearn, N. H., Personal communication dated May 25, 1932.

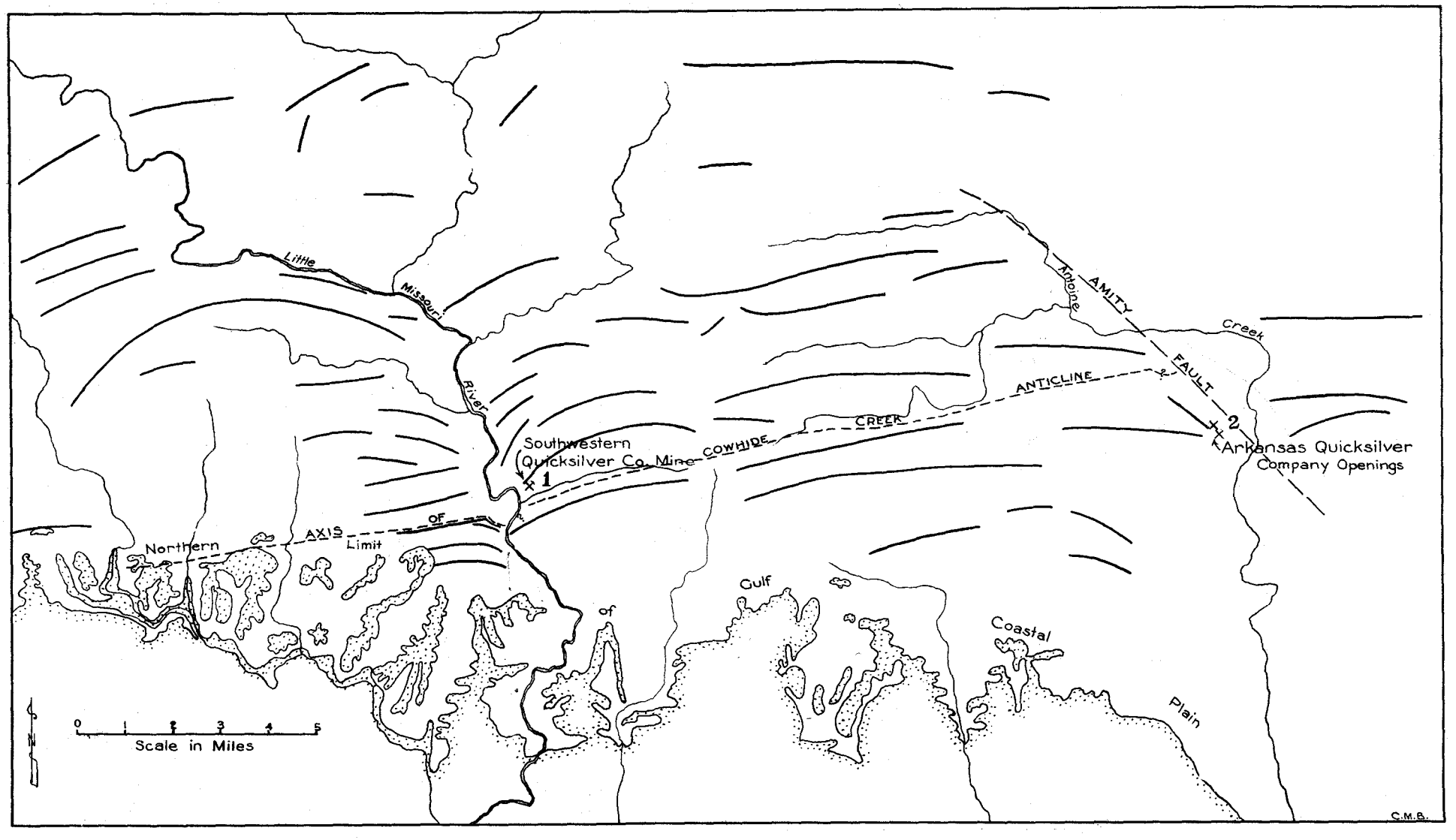


PLATE 5. MAP OF SOUTHERN PORTION OF THE ATHENS PLATEAU SHOWING AXES OF RIDGES.

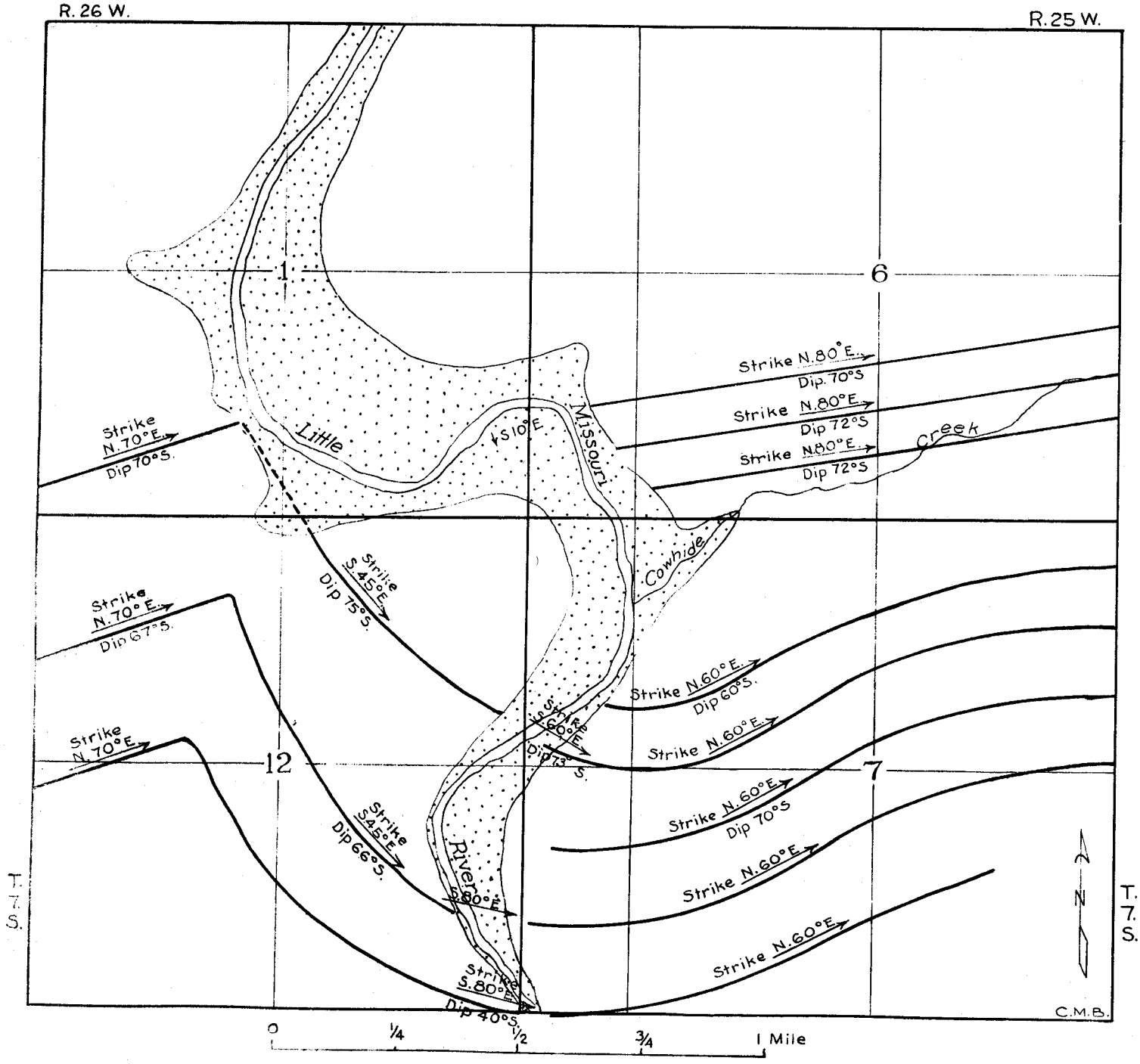


PLATE 6. SKETCH MAP OF STRUCTURE OF LITTLE MISSOURI RIVER AREA. THE STRUCTURE LINES SHOW THE STRIKE OF THE SANDSTONE BEDS.

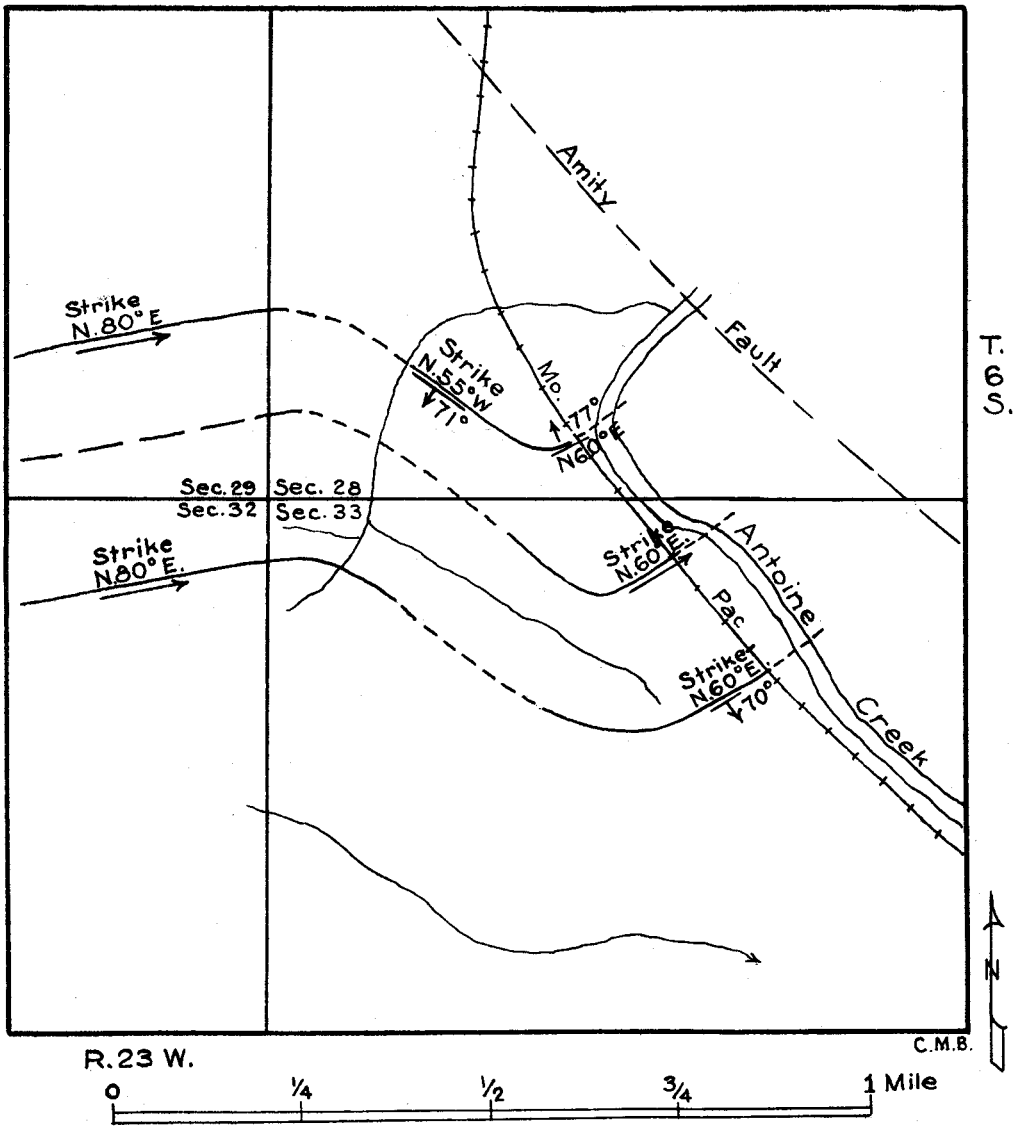


PLATE 7. SKETCH MAP OF STRUCTURE OF THE ANTOINE CREEK AREA. THE STRUCTURE LINES SHOW THE STRIKE OF THE SANDSTONE BEDS.

Methods of Occurrence

At present three types of cinnabar occurrences are known in the Athens Plateau. These are:

1. Fracture fillings. This includes joint and bedding plane occurrences.
2. Dissemination in sandstone. This, as yet, is comparatively rare.
3. Association with vein quartz. This is quite rare, being found at only one point.

Most of the cinnabar deposits found, up to the present time, occur in discontinuous and irregular areas of highly fractured sandstone. In addition, regular joint systems and bedding planes in sandstone and shale frequently carry films of cinnabar. In at least one point (NW.¼ of sec. 33, T. 6 S., R. 23 W.), the mineral occurs in the disseminated form, associated with minute veinlets spreading through sandstone. On the Parker property in sec. 11, T. 7 S., R. 26 W. (Gap Ridge), true breccia, the fragments of which measure about one and one-half inches in length, was found. (See Pl. 8.) On the Parker property in sec. 1, T. 7 S., R. 26 W., crystals of cinnabar were found in quartz veins which spread through both sandstone and shale. (See. Pl. 9.) Free quicksilver was also found at this point, and occurs as droplets in small, irregular cavities in sandstone, in quartz veins, and in sandstone fractures. Apparently, these were at one time filled with crystals of cinnabar which were oxidized and reduced.

A diagrammatic representation of the types of cinnabar mineralization which are found in the Little Missouri River area is shown in Plate 10.

Relation of Mineralization to Stratigraphy

Up to the present time, cinnabar has been found only in the Stanley shale and Jackfork sandstone. Assuming that the mapping as shown in Plates 3 and 4 is correct, twelve of the occurrences are in the Stanley shale and eighteen are in the Jackfork sandstone. These figures arbitrarily rate the occurrences in secs. 28 and 33, T. 6 S., R. 23 W., as five, and those in sec. 6, T. 7 S., R. 25 W., as one. In the writer's opinion, the fact of the association of cinnabar with either the Stanley shale or Jackfork sandstone is not necessarily significant. On account of the intense folding of the entire Athens Plateau, cinnabar may be expected to occur in any zones of fractured sandstone in the entire area, whether they be in the Stanley shale, the Jackfork sandstone, or the Atoka formation.

Relation of Mineralization to Structure

Most of the known cinnabar deposits seem to be consistently identified with the axis of the Cowhide Creek anticline. This anticline extends from Antoine Creek across the Little Missouri River into northeast Howard County, where it passes beneath the Gulf Coastal Plain. The length of the exposed axis is 24 miles. With two exceptions, the remainder of the deposits apparently are identified with the Amity fault or with subsidiary faults related to the Amity fault. (See Pl. 3.)

The two occurrences, in sec. 3, T. 7 S., R. 24 W., and sec. 5, T. 7 S., R. 23 W., respectively, may represent a second line or axis of mineralization, which apparently is not an anticlinal axis but lies between the axis of the Cowhide Creek anticline and the syncline to the south. The similarity and steepness of the folding over larger areas within the Athens Plateau leads to the belief that there may be several lines or axes of mineralization.

In addition to the occurrences of cinnabar which are directly related to fracturing, jointing, and bedding planes, there also appears to be a direct relationship between the mineralization and the association of the shales and sandstones, although this fact has not been verified in every case by any means. On the Parnell-Carroll

PLATE 8. Specimen of cinnabar and sandstone breccia. Darker material is cinnabar. From the Parker property, sec. 11, T. 7 S., R. 26 W.

PLATE 9. Specimen showing a quartz vein containing crystals of cinnabar. From the Parker property, sec. 1, T. 7 S., R. 26 W.

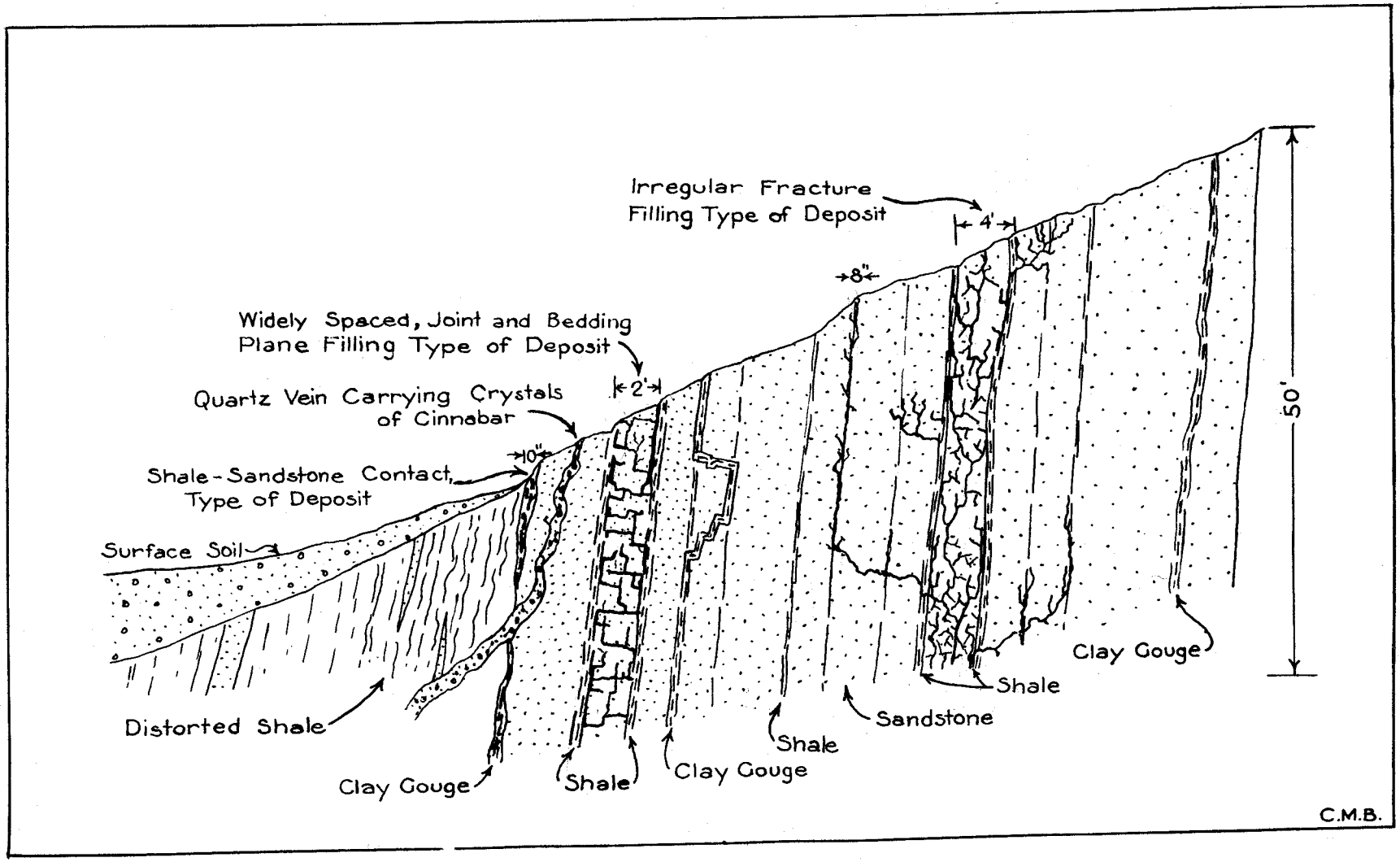


PLATE 10. DIAGRAM SHOWING DIFFERENT TYPES OF CINNABAR OCCURRENCES IN STEEPLY DIPPING SANDSTONE AND SHALE BEDS IN THE LITTLE MISSOURI RIVER AREA.

tract, in sec. 6, T. 7 S., R. 25 W., and the Parker tract, in sec. 11, T. 7 S., R. 26 W., the mineralization occurs in sandstone which is, on the lower portion of the ridges on the south, immediately in contact with relatively thick bodies of shale. Presumably these shale bodies, as compared with the sandstone, were relatively impervious to mineral-bearing solutions, and, for this reason, the shale-sandstone contact probably acted as a guide to these solutions. In this way a zone of richer mineralization probably was created along the mineralized contacts and in the fractured sandstones which lie near these contacts.

In summing up the available evidence concerning the relationship between geologic structure and the occurrence of the cinnabar, the following conclusions appear to be reasonable at the present time:

1. All of the deposits, except two, are on, or near, an anticlinal axis or a cross fault or "break" of this axis. The two exceptions noted (i.e., sec. 3, T. 7 S., R. 24 W., and sec. 5, T. 7 S., R. 23 W.) lie on the same ridge of steeply dipping and fractured Jackfork sandstone, and lie between the Cowhide Creek anticline and the synclinal axis to the south.

2. All of the deposits apparently are related to locally fractured or distorted zones, or to sandstone-shale contacts.

3. The richest mineralizations yet found occur in the following areas: (a) an area near the Little Missouri River along the Cowhide Creek anticline, which has been strongly disturbed by cross-faulting, folding, and the shifting of an area of considerable size, and (b) an area on the west side of the Amity fault where intense folding and faulting is present. In both of the above areas local rock movements have taken place after the major folding of the Athens Plateau.

All of the fractured and distorted sandstone on or near the Cowhide Creek anticline does not contain cinnabar by any means. The discovery of cinnabar in sec. 3, T. 7 S., R. 24 W., and sec. 5, T. 7 S., R. 23 W., is of basic importance in that it indicates the possibility of lines or axes of mineralization entirely separated from the Cowhide Creek anticline and the Amity fault. For this reason, it is believed that the entire area of folded Paleozoic rocks in the Athens Plateau, and especially that lying between the Cowhide Creek anticline and the Gulf Coastal Plain, may be locally mineralized. The fact that the occurrences, for the most part, lie along well defined lines, or axes, suggests that the intruded magma from which the cinnabar presumably is derived is buried beneath, or near, these lines or axes. This is discussed further under "Prospecting."

It should be further noted that it is obviously impossible to limit the area of possible mineralization by cinnabar strictly to the folded formations lying within the Athens Plateau. It may be that cinnabar will be found in the vicinity of buried intrusions through the entire Ouachita province. However, as the Athens Plateau probably was covered by beds of Cretaceous age at the time of the mineralization of the Paleozoic rocks there, that area doubtless has suffered less erosion since mineralization than other portions of the Ouachita province not so protected. This leads to the belief that cinnabar deposits, which may have existed in other portions of the Ouachita province and were not so protected, may have been removed by erosion.

Metallic Minerals Present in the Ouachita Mountains

The principal metallic minerals which have been found in the Ouachita Mountains are those of antimony, copper, iron, lead, manganese, and zinc. Lesser amounts and traces of the minerals of bismuth, gold, nickel, silver, and tin also occur. Comstock 9/ records the presence of the following metallic minerals in west central

9/ Comstock, T. B., A preliminary examination of the geology of western central Arkansas: Arkansas Geol. Survey Ann. Rept., vol. 1, 1888.

Arkansas:

Antimony

Stibnite (Sb_2S_3)
Stibiconite ($Sb_2O_4.H_2O$)
Cervantite (Sb_2O_4)

Bismuth

Bismuthinite (Bi_2S_3)

Copper

Native copper (Cu)
Chalcopyrite ($CuFeS_2$)
Azurite ($2CuCO_3.Cu(OH)_2$)
Freibergite ($4(Cu,Ag)_2S.Sb_2S_3$)
Chalcanthite ($CuSO_4$)
Tetrahedrite ($4Cu_2S.Sb_2S_3$)
Tennantite ($4Cu_2S.As_2S_3$)

Iron

Limonite ($2Fe_2O_3.3H_2O$)
Hematite (Fe_2O_3)
Magnetite (Fe_3O_4)
Pyrite (FeS_2)
Marcasite (FeS_2)
Pyrrhotite (FeS)
Chalcopyrite ($CuFeS_2$)
Siderite ($FeCO_3$)
Goethite ($Fe_2O_3.2H_2O$)
Turgite ($2Fe_2O_3.H_2O$)

Lead

Galena (PbS)
Cerussite ($PbCO_3$)
Anglesite ($PbSO_4$)

Manganese

Braunite ($MnMnO_3$)
Psilomelane (MnO_2MnO,H_2O)
Pyrolusite ($MnO_2.H_2O$)
Manganite ($Mn(OH_3).Mn_2O_3$)
Wad ($MnO_2.H_2O$ impure)
Asbolite (hyd. CO & Mn oxides)

Nickel

Millerite (NiS)

Silver

Argentiferous galena (PbAgS)
Freibergite ($4(Cu,Ag)_2S.Sb_2S_3$)
Tetrahedrite ($4Cu_2S.Sb_2S_3$)

Zinc

Sphalerite (ZnS)
Smithsonite ($ZnCO3$)
Calamine ($Zn.OH)_2SiO_3$)

Traces of cobalt, gold, and tin are also reported.

Hess [10] states that in the area in which antimony has been mined in northeast Sevier County, near Gillham, the original minerals in the veins contain:

Quartz (SiO_2)
Stibnite (Sb_2S_3)
Jamesonite ($2PbS.Sb_2S_3$)
Zinkenite ($PbS.Sb_2S_3$)
Galena (PbS)
Sphalerite (ZnS)
Pyrite (FeS_2)
Chalcopyrite ($CuFeS_2$).
Siderite ($FeCO_3$)
Calcite ($CaCO_3$)

Traces of arsenic, bismuth, cadmium, silver, and, minutely and rarely, gold are found. Cervantite (Sb_2O_4) and bindheimite ($Sb_2O_5.PbO.H_2O$) occur as oxidation products of stibnite (Sb_2S_3) and jamesonite ($2PbS.Sb_2S_3$) respectively.

In discussing the metallic minerals found in the Paleozoic portion of the Caddo Gap and DeQueen Quadrangles, Miser and Purdue [11] record the minerals noted by Hess [12] in the antimony district and refer also to the occurrence of the following minerals:

10/ Hess, F. L., The Arkansas antimony deposits: U. S. Geol. Survey Bull. 340, pt. 1, pp. 241-252, 1908.
11/ Miser, H. D., and Purdue, A. H., op. cit.
12/ Hess, F. L., idem.

Copper

Native copper (Cu)
Chalcopyrite ($CuFeS_2$)
Azurite ($2CuCO_3.Cu(CH)_2$)
Malachite ($CuCO_3.Cu(OH)_2$)

Iron

Limonite ($2Fe_2O_3.3H_2O$)
Magnetite (Fe_3O_4)
Pyrite (FeS_2)
Marcasite (FeS_2)
Chalcopyrite ($CuFeS_2$)

Lead

Galena (PbS)

Manganese

Psilomelane (MnO_2MnO,H_2O)
Pyrolusite ($MnO_2.H_2O$)
Manganite ($Mn(OH_3).Mn_2O_3$)

Silver

Argentiferous galena (PbAgS)

Zinc

Sphalerite (ZnS)

Honess [13] States that the following metallic minerals occur in the Ouachita Mountains of Oklahoma and Arkansas: sphalerite (ZnS), galena (PbS), pyrite (FeS_2), chalcopyrite ($CuFeS_2$), psilomelane (MnO_2MnO,H_2O), rhodocrosite ($MnCO_3$), and wad ($MnO_2.H_2O$ impure).

Of the metallic minerals listed above, manganese minerals are the only ones that occur within the Ouachita Mountains in any quantity, and are not found in the Athens Plateau. The manganese minerals are confined almost entirely to the Novaculite Uplift and occur in the Arkansas novaculite.

Mineralogy and Petrography of Ores

The mineralogy and petrography of the cinnabar has been studied by R. L. Sohlberg, under the direction of Dr. Austin F. Rogers, of Leland Stanford, Jr., University. The results of Mr. Sohlberg's study, dated April 1, 1932, are given herewith:

"A suite of some twenty specimens of cinnabar and associated minerals were examined both megascopically and microscopically. Of these, fourteen were from the Parker, Parnell, and Bell properties along the Little Missouri River, while the remaining six came from the Bemis property to the east.

"The country rock is a brown-gray sandstone which, on fracturing, presents a smooth, clean-cut surface indicating that it may be quartzitic. That this actually is the case is confirmed upon closer microscopical examination for the quartz grains frequently show enlargements of secondary quartz in optical continuity with the original grain. The sandstone has been extensively fractured and faulted. The fissures so formed have been filled with vein quartz, cinnabar and dickite, a kaolin mineral.

"Cinnabar, the chief ore mineral, occurs for the most part well crystallized along fractures and bedding planes of the sandstone. Most of the cinnabar is found in vein quartz although there are veinlets of this mineral in the country rock. The greater part of the cinnabar in the country rock consists of dissemination, however.

"Occurring sometimes as an interstitial filling, sometimes as a replacement of quartz is dickite, the kaolin mineral. It is found as pseudohexagonal crystals and aggregates and is identified by its optical properties. Its indices of refraction are: n_α=1.560, n_β=1.565, n_γ=1.567, the birefringence (n_γ-n_α) thus being .007. All

13/"Honess, C. W., Geology of the southern Ouachita Mountains of Oklahoma: Oklahoma Geol. Survey Bull. 32, pt. II, 1923.

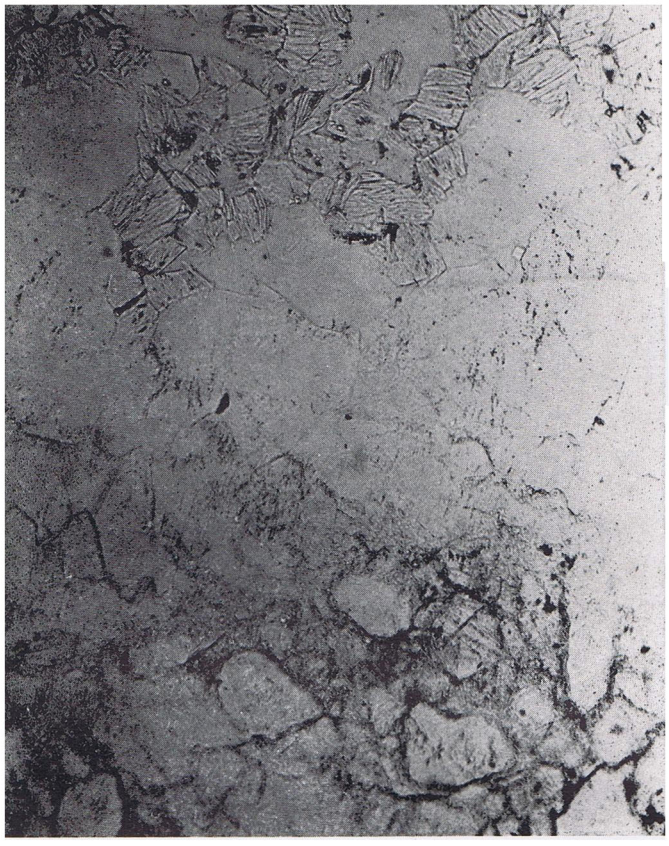


PLATE 11. Microphotograph. Magnif. ca. x 100. Vein quartz bordering on crushed zone of country rock. Aggregates of dickite with scattered cinnabar in upper field. The rounded character of the detrital quartz grains can be noticed in the lower part of the photograph.

PLATE 12. Microphotograph. Same as Plate 11 but with crossed nicols. The sharp boundary between the vein quartz and dickite gouge should be particularly noticed.

indices are ± .002. Optical character is biaxial positive and the maximum extinction angle observed is 15° 14/. Twin crystals seem to be fairly frequent. According to Ross and Kerr 15/, who have studied the kaolin group at length, each of the three kaolin minerals, kaolinite, dickite and nacrite show typical X-ray diffraction patterns and can best be distinguished by this means. The birefringence, determined by means of the Berek compensator, is .004. The discrepancy between this value and $(n_\gamma - n_\alpha)$, obtained through the use of index liquids, can only be satisfactorily explained by assuming that dickite, which is soft, has been gouged during the grinding of the section, rendering it thinner than the more resistant quartz which was used to determine the thickness of the section.

"A brownish-yellow variety of dickite also occurs which has a higher double refraction, probably due to iron in solid solution. Difficulties would be encountered in making a quantitative determination by chemical means as iron stain is also present. The indices of refraction of the brown variety of dickite are: n_α=1.560 and n_γ=1.572 .002, $(n_\gamma - n_\alpha)$ being .012. The birefringence as determined by means of the compensator is .006. The higher double refraction obtained by means of the compensator for the brownish dickite indicates that this variety of the mineral actually contains iron. All gradations from the colorless dickite to the brown variety has been noted. The iron has probably been introduced by means of circulating waters.

"The dickite everywhere replaces the quartz. As the dickite is generally regarded to be of hydrothermal origin, the intimate association of this mineral with the ores strongly suggests the same origin for the ores.

"The cavities of the near surface ores generally contain small crystals of cinnabar. These are penetration twins and are similar to those from Ouen-Shan-Tchiang, China, described by Termier 16/ and those from Nikitowka, Russia, by Tschermak 17/. The Arkansas crystals resemble the Chinese crystals more closely than they do the Russian.

"The forms present are the unit rhombohedron $\{10\bar{1}1\}$ modified by the trigonal trapezohedron $\{42\bar{6}3\}$. The rhombohedron dominates, the trapezohedral faces being present on only a few crystals and then imperfectly developed.

"Some of the cinnabar occurring near the surface is associated with calomel and free quicksilver. Usually such cinnabar has been coated very thinly with metacinnabar. This is regarded as secondary and probably due to contact of the cinnabar with descending dilute acid sulphate waters 18/. At first glance these crystals might be thought to consist wholly of metacinnabar, but a polished surface does not corroborate this and, inasmuch as the crushed material seems to consist only of cinnabar, it is concluded that the metacinnabar is present only as a thin coating.

"In one case stibnite was noted. Associated with this is stibiconite ($H_2Sb_2O_5$). The stibiconite is an alteration product of the stibnite and the striated or bladed appearance of the last named is preserved in the stibiconite. Intimately associated with the stibiconite is cinnabar as small particles. As all gradations between these

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14/"The mineral was at first thought to be nacrite, but, according to a written communication received by G. C. Branner, Clarence S. Ross, of the U. S. Geological Survey, who has examined material from this locality, is of the opinion that it is dickite having obtained extinction angles as high as 17°.

15/"Ross, C. S., and Kerr, P. F., The kaolin minerals: U. S. Geol. Survey Prof. Paper 165, 1930.

16/"Termier, M., Sur le cinabre et l'onofrite de Ouen-Shan-Tschiang: Bull. de la Soc. Fran. de Min., vol. 20, p. 204, 1886.

17/"Tschermak, G., Min.und Petr. Mitt., vol. 7, p. 361, 1886.

18/"Allen, E. T., Crenshaw, J. C., and Merwin, H. E., The sulphides of mercury; their crystalline forms and genetic conditions: Am. Jour. Sci., 4th ser., vol. 34, p. 341, 1912.

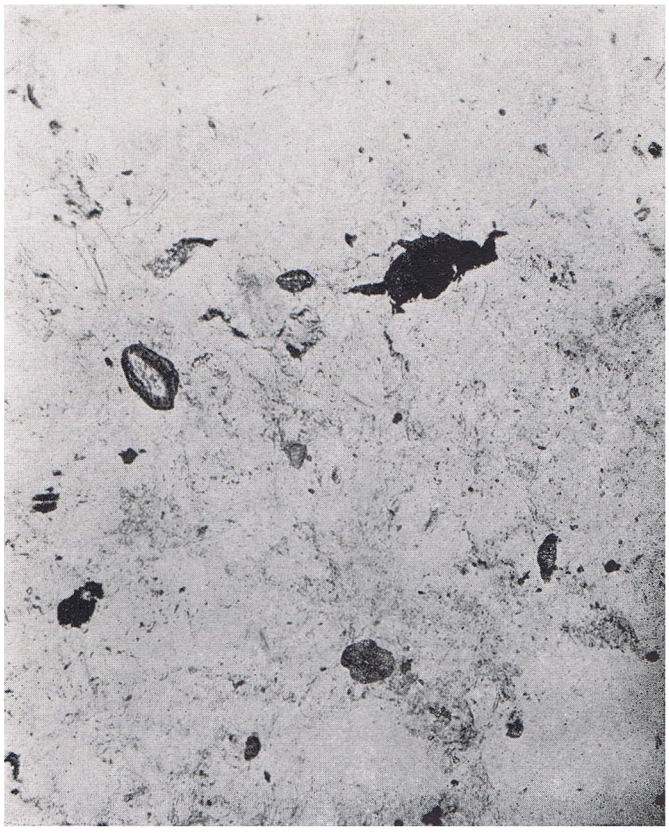

PLATE 13. Microphotograph. Magnif. ca. x 100. Detrital minerals in the country rock. Zircon and tourmaline grains are present with occasional laths of sericite. Twinned feldspar crystals are often observed.

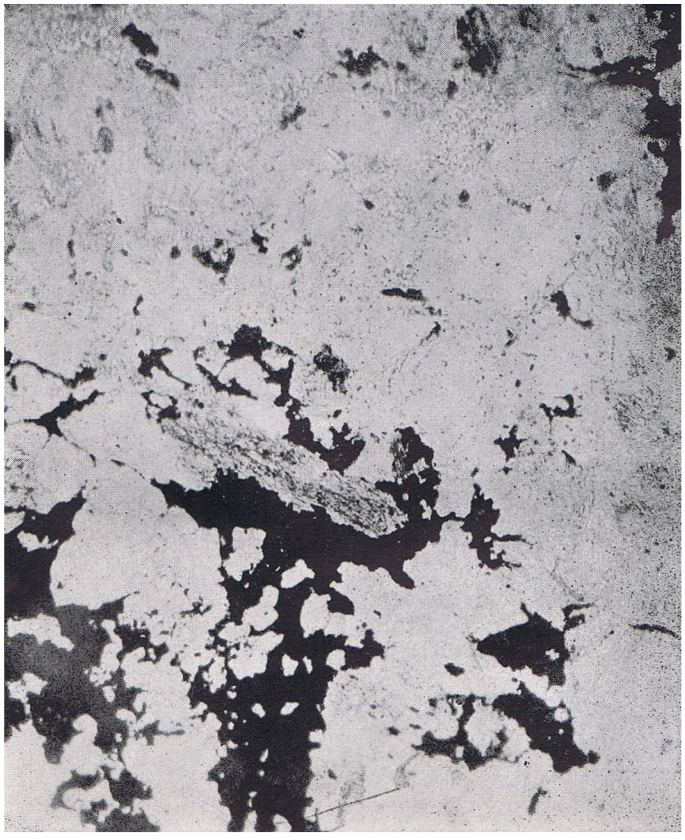

PLATE 14. Microphotograph. Magnif. ca. x 100. Cinnabar which has been deposited in the interstices of the quartz grains in the country rock. In the center of the photograph is an altered rock fragment.

small particles and the massive cinnabar have been observed, indications are that only one generation of cinnabar is present, this being later than the stibnite.

"Egelstonite in small amounts has been identified in a few cavities. The occurrence of this mineral is interesting because of its comparative rarity.

"Extensive fracturing and faulting of the sandstone has taken place, followed by the formation of vein quartz in the fractures. During the closing stages of the formation of the deposits hydrothermal solutions of great penetrating quality arose along the fractures and fissures depositing cinnabar and dickite simultaneously. That these were formed at the same time is evidenced by the intimate association observed between the two minerals. Small particles of cinnabar are often scattered throughout patches of the dickite, and borders of dickite surround larger masses of cinnabar. Some movement undoubtedly has taken place after the period of deposition of the ores because cinnabar cuts directly through quartz grains and narrow, crushed zones border the quartz veins.

"Summary

"1. All mineral relationships and associations point to a hydrothermal origin for the deposits.

"2. The cinnabar, vein quartz and dickite have been deposited at approximately the same time.

"3. The cinnabar is probably later than the stibnite because of its association with stibiconite, the alteration product of stibnite.

"4. A small amount of movement has taken place after, as well as before, the formation of the deposits.

"Brief Description of Sections

"Specimen No. 1 (See Pls. 11 and 12) from the Parker property has been taken at the edge of a vein so the thin section illustrates the relationship of the vein material to the country rock. As can be observed in the photomicrograph of No. 1, a narrow crushed zone borders the vein quartz and grades into the country rock. The contact with the vein material indicates that the movement along the fracture has dislodged grains of quartz from the original sandstone which have been recemented with crushed material.

"Specimen No. 3 (See Pl. 13) from the Parnell-Carroll property is country rock but shows in addition thicker zones of secondary quartz indicating closer proximity to a vein.

"Specimen No. 8 (See Pl. 14) from the Parnell-Carroll property is typical country rock. Cinnabar and dickite fill all available interstices between the grains of quartz. These grains, representative of the country rock at large, measure .12 mm. in diameter.

"Specimen No. 10 (See Pls. 15 and 16) from the Bell lease show small veinlets of cinnabar cutting the country rock. Secondary quartz is also prominent.

"Specimen No. 11 (See Pls. 17 and 18) from the Parker property is typical of the vein quartz. The grains have a decided anhedral outline. The average size of the grains in the veins is .2 mm. in diameter. Dickite occurs both scattered through the quartz grains themselves, replacing these, and in the small interstices between the grains. The brown variety of dickite is observed to grade imperceptibly into the colorless variety."

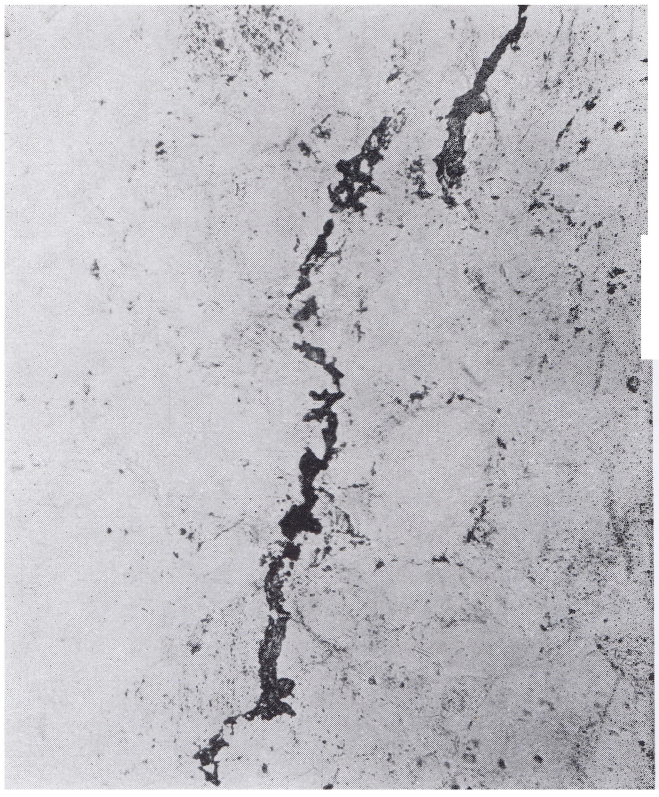

PLATE 15. Microphotograph. Magnif. ca. x 100. Cinnabar veinlet in the country rock (quartz sandstone). This is typical country rock.

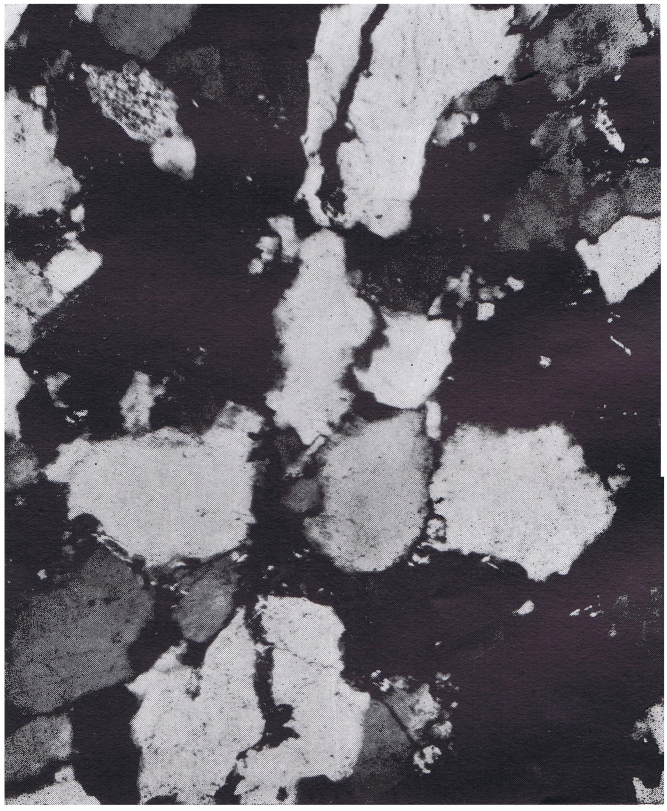

PLATE 16. Microphotograph. Same as Plate 15 but with crossed nicols. Attention is called to the upper and lower part of the photograph, where the cinnabar is seen to cut directly through the quartz grains. Secondary enlargement of quartz grains in left center field is not very prominent.

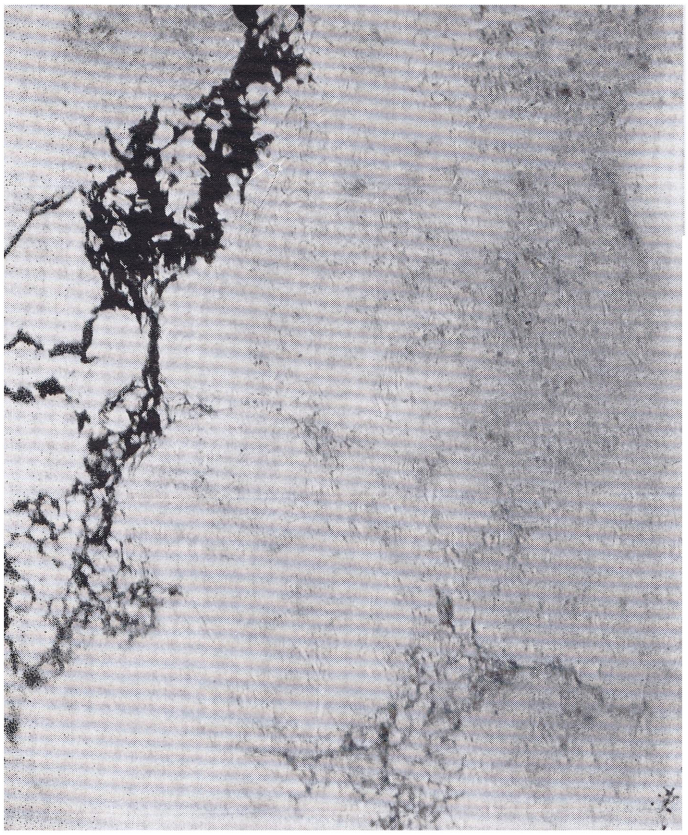

PLATE 17. Microphotograph. Magnif. ca. x 100. Cinnabar veinlet in vein quartz. Crystals of dickite are replacing quartz. In the lower right hand corner the brown dickite is seen to grade into the colorless variety.

PLATE 18. Microphotograph. Same as Plate 17 but with crossed nicols. Shows quartz anhedra with smaller quartz crystals. Attention is called to the very irregular outline of the grains. All quartz is of the same generation.

Origin of Deposits

From evidence available it is assumed that the commonly accepted explanation of the origin of cinnabar deposits (that is, deposition by hot waters ascending from a magma) applies to the Arkansas cinnabar. Its association with stibnite, quartz and dickite, which latter mineral is according to Ross 19/ always of hydrothermal origin, tends to verify this belief, as does the presence of two warm springs near Caddo Gap in sec. 23, T. 6 S., R. 25 W., and sec. 19, T. 4 S., R. 24 W., 14 and 14½ miles respectively north of the axis of the Cowhide Creek anticline, and the presence of igneous (peridotite) intrusions near Murfreesboro, in secs. 14, 21, 23, and 28, T. 8 S., R. 25 W., 8¼ to 9½ miles respectively south of the axis of the Cowhide Creek anticline. Also, a five-foot dike of ouachitite, a basic, igneous rock within the Athens Plateau, is located about 7 miles east of Gillham, in Sevier County, in the SE.¼ of sec. 9, T. 7 S., R. 30 W. 20/. This dike is about 21 miles west of the most western occurrence of cinnabar (NE.¼ NW.¼ of sec. 13, T. 7 S., R. 27 W.) now known.

The above explanation of the origin of cinnabar requires a magmatic source of heat and a supply of quicksilver in some combination to the solutions which transported it to the areas where it was deposited as cinnabar.

Although igneous rocks which fulfill these requirements are not exposed in the district, it is possible that the intrusions near Murfreesboro and Gillham may represent, respectively, volcanic necks and a dike from a parent magma, a portion of which may underlie the cinnabar area.

Other hot springs and exposed igneous rocks in central and southwestern Arkansas are shown on the physiographic map of Arkansas. (See Pl. 1.) These consist of the hot springs at Hot Springs, Garland County, located approximately 32 miles northeast of the east end of the cinnabar area, the Potash Sulphur Springs igneous area in southeast Garland County, the Magnet Cove area in northern Hot Spring County, numerous dikes and sills in southeast Garland and northwest Hot Spring counties, and the igneous areas near Bauxite, Saline County, and immediately south of Little Rock, Pulaski County. These areas have been described by several writers, the most detailed description being given by Williams 21/.

There are three outstanding facts in regard to the relation between the time of the folding and erosion of the Athens Plateau and the time of the cinnabar deposition.

1. The mineralization followed the major folding. This is indicated by the fact that the mineralization is confined to fracture and fault zones which were formed after the major folding.

2. Some movement, probably minor, has taken place since mineralization. This is indicated by the presence of some slickensides on mineralized faces.

3. Erosion has followed deposition. This is indicated by the fact that mineralization extends to the crests of the ridges and also by the presence of quantities of sandstone float which contain cinnabar.

We may assume from the above and from the commonly accepted explanation of the origin of cinnabar deposits that the mineralization occurred after a period of igneous activity at some time following the time of major folding. The age of such

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19/ Ross, C. S., Discussion of informal communication, Washington Acad. Sci. Jour., vol. 22, pp. 290, 1932.

20/ Mitchell, G. J., Antimony in southwest Arkansas: Eng. and Min. Jour., vol. 114, pp. 450-455, 1922.

21/ Williams, J. F., The igneous rocks of Arkansas: Arkansas Geol. Survey Ann. Rept., 1890, vol. 2, 1891.

mineralization is discussed below.

Concerning the process of mineralization, it is probable that the intrusions took place along lines of structural weakness, which are represented in two instances by the axis of the Cowhide Creek anticline and the Amity fault. These intrusions probably approached the surface and mineralizing solutions then ascended, principally through fractures in sandstone.

Age of Mineralization

If we assume that the mineralization took place following a period of igneous activity, then the logical time for the intrusions and consequent mineralization to have taken place appears to be the Upper Cretaceous period. This assumption is made in view of the fact that the peridotite necks near Murfreesboro are known to be of Upper Cretaceous age 22/ and that the Upper Cretaceous period is known to have been one of wide-spread igneous activity in southwestern Arkansas, southeastern Oklahoma, and northeastern Texas 23/. The assumption is further supported by the fact that no igneous rocks of earlier age are definitely known to exist in Arkansas. Mineralizing solutions rising through the folded and fractured sandstones and shales during early Upper Cretaceous time presumably reached the overlapped surface of the Ouachita peneplain and came in contact with the base of the Lower Cretaceous beds. These subsequently were removed by the erosion which followed and which created the Hot Springs peneplain.

Honess 24/ has stated, in connection with the occurrence of lead, zinc, copper, and other minerals in the Ouachita Mountains of Oklahoma:

"It is my opinion that the date of folding of the Ouachita Mountains of Oklahoma and Arkansas is middle-Pennsylvanian..... I am of the opinion, further, that as the folding of the mountains progressed, intrusions occurred. Among the deposits introduced at this time (middle-Pennsylvanian) in Oklahoma are: (1) lead, zinc, and copper sulphides in a quartz-carbonate gangue; (2) large quartz veins and quartz-orthoclase pegmatities; (3) carbonate, chiefly siderite, replacements, and (4) large asphalt dikes....."

It does not seem highly probable, however, as Miser 25/ has pointed out, that the Arkansas cinnabar mineralization took place during mid-Pennsylvanian time, since the folded rocks, which are now exposed on the surface of the Athens Plateau, were buried at great depth in mid-Pennsylvanian time. Cinnabar, however, almost always occurs as a near surface deposit.

DEVELOPMENTS

The following companies and individuals have undertaken the development of cinnabar in Arkansas, to May 28, 1932:

ARKANSAS CINNABAR MINING COMPANY

Office address: Owens Building, Murfreesboro, Arkansas.
Incorporated: May 12, 1932, State of Arkansas.
Capitalization: $3,500, 70 shares at $50 per share, all outstanding.
Officers: E. H. DeVore, Conway Hotel, Murfreesboro, Arkansas, Resident Agent.

22/ Miser, H. D., and Ross, C. S., Diamond-bearing peridotite in Pike County, Arkansas: U. S. Geol. Survey Bull. 735-I, pp. 279-322, 1922.
23/ Ross, C. S., Miser, H. D., and Stephenson, L. W., Waterlaid volcanic rocks of early Upper Cretaceous age in southwestern Arkansas, southeastern Oklahoma and northeastern Texas: U. S. Geol. Survey Prof. Paper 154, pp. 175-202, 1928.
24/ Honess, C. W., Communication of May 15, 1932.
25/ Miser, H. D., Communication of May 19, 1932.

Fourteen openings have been made by this company on its property in the NW.¼ NW.¼ of sec. 2, T. 7 S., R. 25 W., Pike County. For description of prospect, see Occurrence 23. See also Plate 19.

ARKANSAS QUICKSILVER COMPANY

Office address: McRae Building, Prescott, Arkansas.
Incorporated: November 12, 1931, State of Arkansas.
Capitalization: Common stock, 1,000 shares, no par value, all outstanding.
Officers: W. N. Bemis, President, D. K. Bemis, Agent.
Location of holdings: Secs. 28, 29, 32, and 33, T. 6 S., R. 23 W., Pike County. For description of prospects see Occurrences 3 to 11, both inclusive.

In November, 1931, this company installed a two-tube, type "D" Gould retort at Graysonia, Arkansas, and between the latter part of November, 1931, and January 15, 1932, retorted approximately 65,000 pounds of rock, recovering 1,293 pounds of quicksilver, which is an average recovery of 1.99 per cent. The retort was shut down between January 15 and April 9, 1932. At the present date (May 28, 1932) about 3,000 pounds of ore are being retorted daily, with recoveries of from 40 to 60 pounds of quicksilver every 24 hours. Twenty-five flasks of quicksilver were shipped on April 26, 1932. This was the first shipment of Arkansas quicksilver in bulk.

Over one hundred separate occurrences of cinnabar have been exposed by openings in secs. 28 and 33. (See Pls. 20, 21, 22, 23, 24, 25, 26, and 27.)

The following is an analysis of quicksilver retorted by the Arkansas Quicksilver Company, made by Ledoux & Company, New York City, on February 3, 1932:

Mercury	99.99+ per cent
Iron	Trace, not over 0.001 per cent
Heavy metals including:	
tin)	
antimony)	
arsenic)	
lead)	
bismuth)	Aggregate not over 0.001 per cent
copper)	
zinc)	
silver)	
gold)	

Analysis note: This sample is pure mercury with the exception of minute traces of iron and possibly a very small proportion of oxygen. We do not detect weighable proportions of any impurities.

GEORGE BELL

Office address: Nashville, Arkansas.
Location of holdings: Part of sec. 12, T. 7 S., R. 26 W., Pike County. For description of opening see Occurrence 28.

C. MINING CORPORATION

Office address: Murfreesboro, Arkansas.
Incorporated: December 9, 1931, State of Arkansas.
Capitalization: $25,000, common stock 1,000 shares at $25 per share, 560 shares outstanding. On April 30, 1932, the capital stock was increased to $45,000.
Officers: C. Caponetto, President; James K. Catalina, Vice President and Manager; Sarah Caponetto, Secretary; Pasquale Marino, Kirby, Arkansas, Superintendent.

PLATE 19. Opening in sandstone on Arkansas Cinnabar Mining Company property in sec. 2, T. 7 S., R. 25 W.

PLATE 20. View of hill in the Antoine Creek area, on which are located most of the Arkansas Quicksilver Company openings. In secs. 28 and 33, T. 6 S., R. 23 W.

PLATE 21. Tunnel 2 on Arkansas Quicksilver Company property in sec. 33, T. 6 S., R. 23 W. Note vertical sandstone beds.

PLATE 22

PLATE 23

PLATE 24

PLATE 22. Opening on top of hill shown in Plate 20 on Arkansas Quicksilver Company property in sec. 33, T. 6 S., R. 23 W.

PLATE 23. View of cut on Arkansas Quicksilver Company property in sec. 33, T. 6 S., R. 23 W.

PLATE 24. Small opening in hillside on Arkansas Quicksilver Company property in sec. 33, T. 6 S., R. 23 W.

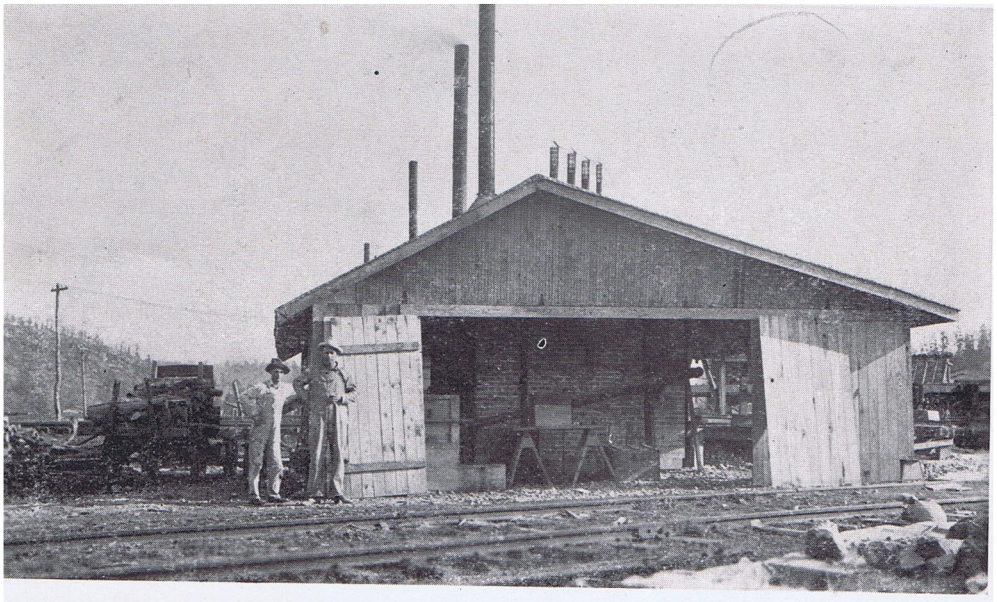

PLATE 25. Two-tube retort of Arkansas Quicksilver Company, Graysonia, Arkansas.

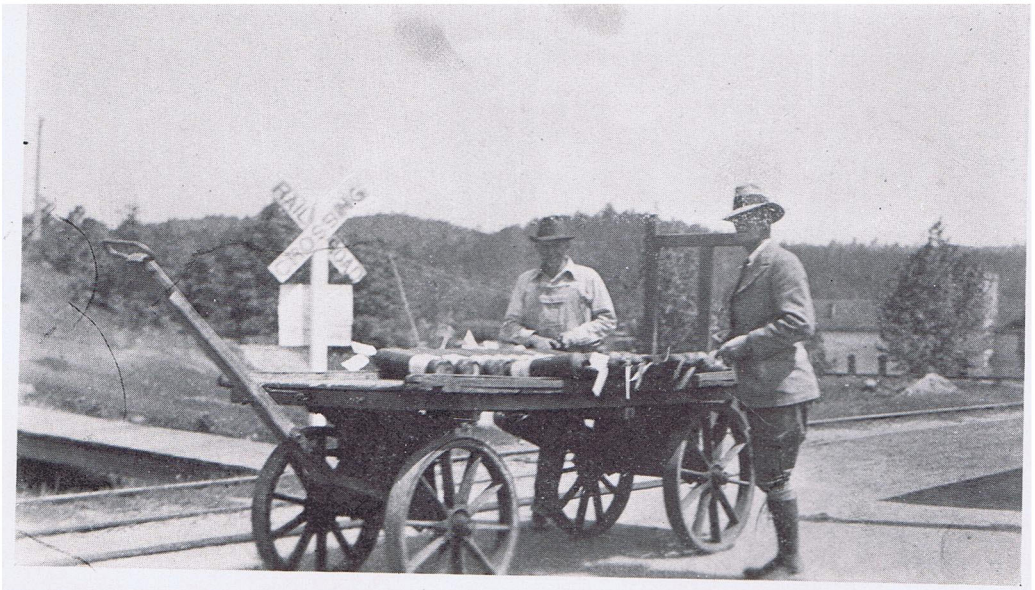

PLATE 26. First shipment of metallic quicksilver from Arkansas. Shipped by Arkansas Quicksilver Company, April 26, 1932.

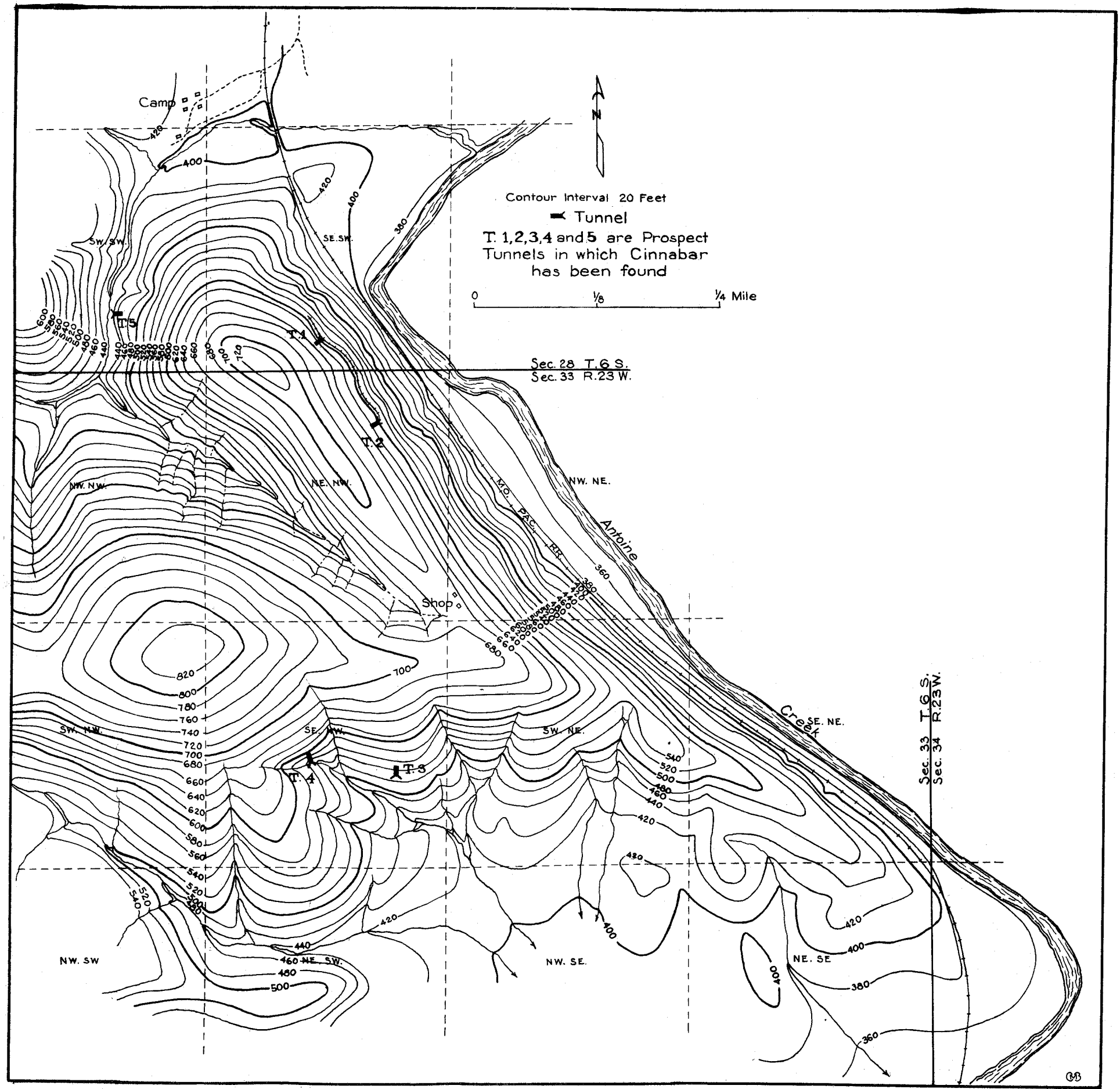

PLATE 27. TOPOGRAPHY AND LOCATION OF PROSPECT TUNNELS ON ARKANSAS QUICKSILVER COMPANY PROPERTY IN THE ANTOINE CREEK AREA. (BY COURTESY OF ARKANSAS QUICKSILVER CO.)

Location of holdings: In secs. 27 and 32, T. 6 S., R. 24 W., Pike County.
For description of prospects see Occurrences 18 and 21.

This company erected a crusher and a retort, with a rated capacity of 10 tons, and a condenser. The plant is located on State Highway 27, 1.2 miles south of Kirby, Arkansas. Operations were begun on March 9, 1932. According to Mr. C. Caponetto, it was the original intention of the company to establish a custom mill for the retorting of ore brought in by small producers. The plant was operated for a few days and then shut down. After replacing the condenser, the company, on or about April 4, 1932, resumed operations and, it is reported, continued for two weeks. A recovery of 12.5 pounds of quicksilver from 25 tons of rock was reported. (See Pl. 28.)

THE EXPLORATION COMPANY

Office address: Dugan-Stuart Building, Hot Springs, Arkansas.
Officers: R. B. Martin, Agent.
Location of holdings: Part of sec. 19, T. 6 S., R. 23 W., Clark County.
For description of prospect see Occurrence 1.

SOUTHWESTERN QUICKSILVER COMPANY

Office address: Kingsway Hotel, Hot Springs, Arkansas.
Incorporated: February 19, 1932, under the laws of the State of Delaware.
Capitalization: common stock, 100 shares, no par value, all outstanding; preferred stock, 1,350 shares at $100 per share, 840 shares issued and outstanding.
Officers: Leo Yount, President; N. H. Stearn, Vice President; (Miss) L. M. Vaughan, Secretary.
Location of holdings: Part of holdings are in secs. 1 and 11, T. 7 S., R. 26 W., and sec. 6, T. 7 S., R. 25 W., Pike County. For description of openings see Occurrences 27, 28, 29 and 30.

In October and November, 1931, an experimental three-tube, type "D" retort was erected on sec. 1, T. 7 S., R. 26 W., and 39,820 pounds of rock were retorted between November 8 and 20, 1931. Six hundred eighty-eight pounds of mercury, which is an average of 1.73 per cent, were recovered. The detailed report of 25 runs follows:

Date	Time Started Furnace	Hours Run	Ore Pounds	Hg Pounds	Hg Per Cent	Remarks
(Oct. 30 (to (Nov. 8			20,000	400	2.00	Result 7-day run, no detailed record
Nov. 13	1 a.m.	12	810	7	0.86	a/ West Gap Ridge ore (rather lean)
Nov. 13	1 p.m.	12	810	11	1.38	West Gap Ridge ore
Nov. 14	1 a.m.	12	800	9	1.13	West Gap Ridge ore
Nov. 14	1 p.m.	12	800	14½	1.81	b/ Top Mine Mtn. & c/ Gap Ridge ore
Nov. 15	6 a.m.	12	800	11½	1.44	Mine Mtn. ore (top)
Nov. 16	2 a.m.	8	800	8	1.00	Mine Mtn. ore
Nov. 16	2 p.m.	12	800	11	1.38	Mine Mtn. ore
Nov. 16	9 p.m.	7	800	8	1.00	Mine Mtn. ore
Nov. 17	7 a.m.	6	800	11	1.38	Mine Mtn. ore
Nov. 17	3 p.m.	7	800	9½	1.19	Mine Mtn. ore
Nov. 18	1 a.m.	8	800	11	1.38	Mine Mtn. ore (lean ore pile)
Nov. 18	7 a.m.	6	800	7	0.88	Mine Mtn. ore (lean ore pile)

a/ Refers to most western opening on Parker tract in sec. 11, T. 7 S., R. 26 W.
b/ Refers to Parker tract in sec. 1, T. 7 S., R. 26 W.
c/ Refers to either, or both, east or west openings on Parker tract in sec. 11, T. 7 S., R. 26 W.

PLATE 28. View of C. Mining Corporation plant, one mile south of Kirby, Pike County, Arkansas.

PLATE 29. View of Southwestern Quicksilver Company openings and plant in sec. 6, T. 7 S., R. 25 W., looking north.

PLATE 30. View of Southwestern Quicksilver Company openings and plant. Cut 12 is immediately in the rear of the plant.

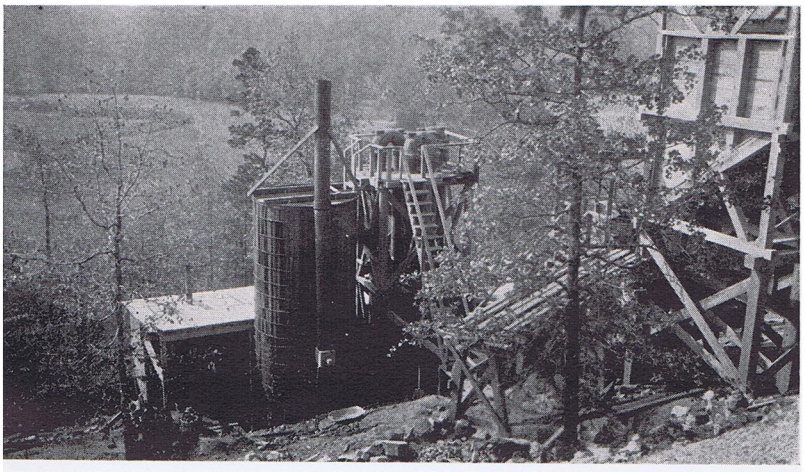

PLATE 31. View of Southwestern Quicksilver Company plant. Condenser and dust chamber.

PLATE 32. View of Cut 1 on Southwestern Quicksilver Company property in sec. 6, T. 7 S., R. 25 W., showing 90 degree bend of sandstone beds.

PLATE 33. View of Cut 12 on Southwestern Quicksilver Company property in sec. 6, T. 7 S., R. 25 W. Note sandstone bedding planes.

PLATE 34. View of small opening near Cut 12 on Southwestern Quicksilver Company property in sec. 6, T. 7 S., R. 25 W., showing hand sorting in cut and resorting at mouth of cut.

PLATE 35. View of Cut 15 on Southwestern Quicksilver Company property in sec. 6, T. 7 S., R. 25 W. Note sandstone bedding planes.

PLATE 36. View of cut across strike of sandstone and shale beds on Southwestern Quicksilver Company property in sec. 1, T. 7 S., R. 26 W. Cinnabar occurs as crystals in quartz veins. Free quicksilver also occurs here.

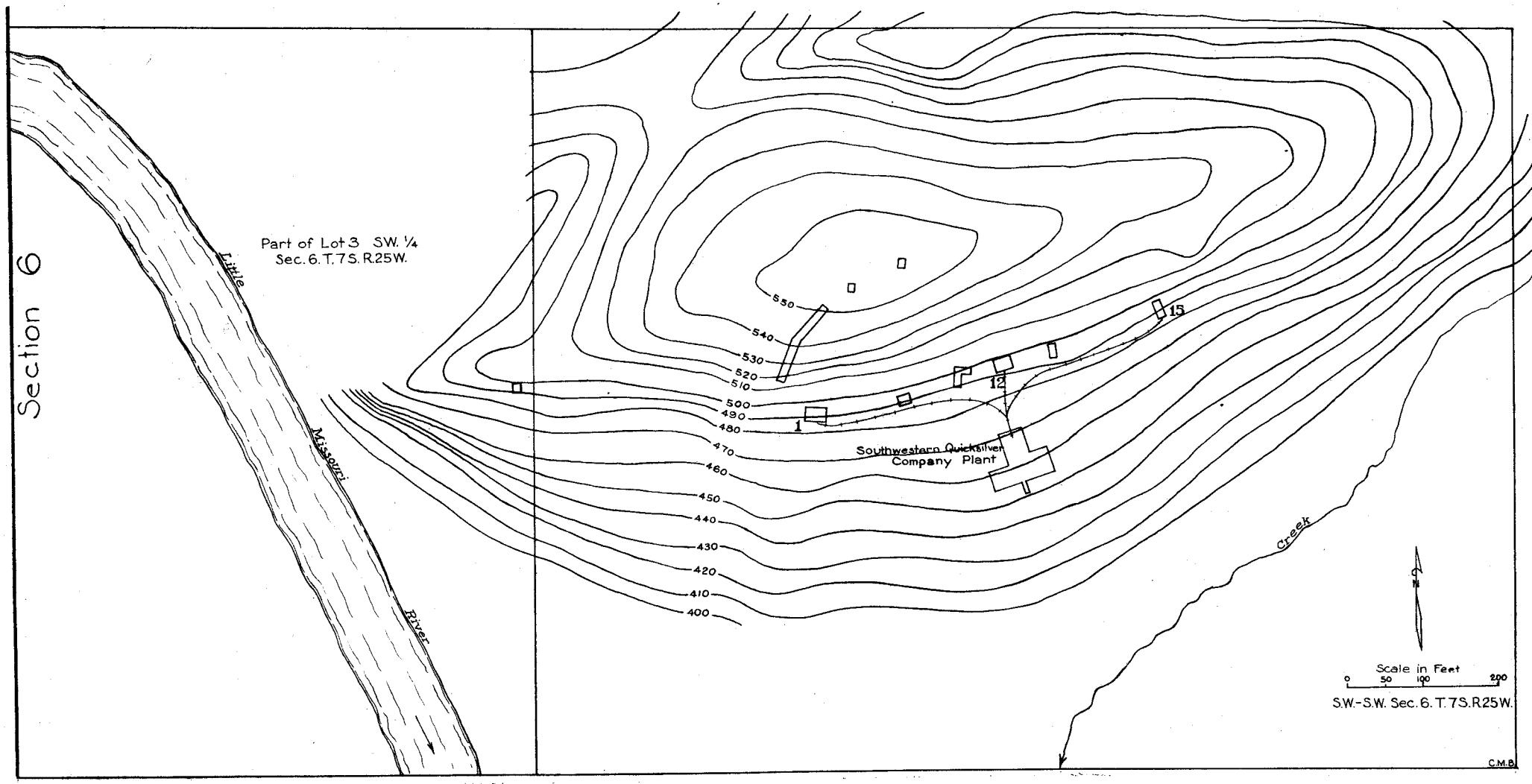

PLATE 37. TOPOGRAPHY AND MINE LAYOUT ON SOUTHWESTERN QUICKSILVER COMPANY PROPERTY IN THE LITTLE MISSOURI RIVER AREA. (BY COURTESY OF SOUTHWESTERN QUICKSILVER CO.)

Date	Time Started Furnace	Hours Run	Ore Pounds	Hg Pounds	Hg Per Cent	Remarks
Nov. 18	4 p.m.	7	600	5½	0.92	Mine Mtn. ore (lean ore pile)
Nov. 19	1 a.m.	7	800	15	1.88	Mine Mtn. ore (float)
Nov. 19	9 a.m.	7	800	19	2.38	Mine Mtn. ore (low grade pile)
Nov. 19	7 p.m.	8	800	12	1.50	Mine Mtn. ore (low grade pile)
Nov. 20	6 a.m.	9	800	12	1.50	Mine Mtn. ore (low grade pile)
Nov. 20	5 p.m.	10	800	7½	0.94	Mine Mtn. ore (low grade pile)
Nov. 21	1 a.m.	6	800	2	0.25	Mine Mtn. ore (low grade pile)
Nov. 22	1 a.m.	7	800	17¾	2.22	West Gap Ridge ore
Nov. 22	11 a.m.	8	800	8¼	1.03	Mine Mtn. & Gap Ridge ore (low grade pile)
Nov. 22	7:30 p.m.	8	800	22¾	2.84	Gap Ridge ore
Nov. 28	9 a.m.	8	800	20	2.50	Gap Ridge ore
Nov. 29	10:30 a.m.	7½	800	15½	1.94	Gap Ridge ore
Nov. 29	10:30 p.m.	8	800	12	1.50	Gap Ridge ore
Totals.....			39,820	688	1.73	(Average)

A crusher, with a capacity of from 8 to 10 tons per hour, a rotary, oil-burning Gould kiln, having a capacity of from 15 to 20 tons per day, an 8-tube condenser, and a dust separator have been installed on the Parnell-Carroll tract in the SW.¼ SW.¼ of sec. 6, T. 7 S., R. 25 W. The plant began operations on April 21, 1932, and has run continuously to the present (May 28, 1932). No figures concerning recoveries are available. (See Pls. 29, 30, 31, 32, 33, 34, 35, 36, and 37.)

The areal and structural geology of approximately 21 square miles has been mapped, under the direction of Dr. N. H. Stearn, by Dr. J. M. Hansell and Leland Palmer, and a quantity of valuable detailed geological data has been accumulated. The mapping is being continued under the direction of Dr. Stearn, who plans to continue his survey over the entire axis of the Cowhide Creek anticline and the trace of the Amity fault.

COMMERCIAL POSSIBILITIES

With the knowledge available at this time, it is impossible to form any clear idea of the commercial values to be expected in the cinnabar area as it is now defined. On the Parnell-Carroll tract in the Little Missouri River area erratically mineralized zones, having an areal extent of 250 by 50 feet and a known depth of possibly 20 feet, exist, and cinnabar has been found on that tract through a maximum vertical range of 120 feet. In the Antoine Creek area, mineralized zones, having an areal extent of about 15 feet along the strike and about 8 feet across the strike, have been found. One of these mineralized zones has a known vertical range of about 90 feet, and cinnabar has been found through a maximum vertical range of 275 feet. Shale and sandstone contact deposits are also present in both of the above areas but little is known of their extent, either horizontally or vertically.

Concerning the depth to which the deposition may be expected to continue, no dependable estimate can be made. Many of the deposits in western United States become impoverished at a depth of a few hundred feet. On the other hand, the workings in the New Almaden Mine in California have been carried to a depth of 1,600 feet, in the New Idria Mine in California 1,060 feet, and in the Almaden mines in Spain 1,300 feet.

In this connection, it may be significant to consider the erosion which has taken place in the area since the deposition of the cinnabar. If we assume that the deposits are of Upper Cretaceous age, they probably at one time reached the surface of the Ouachita peneplain. It is estimated that the erosion of the Ouachita pene-

plain, which has taken place above the topographically low cinnabar deposits in the western part of the cinnabar area, has been on the order of 175 feet, and in the eastern part of the area 525 feet. (See Pl. 38.) It, therefore, may be assumed that the cinnabar deposits which occur at the topographically low points in the western and eastern areas lie approximately 175 and 525 feet, respectively, below the surface to which the mineralization originally extended.

At the present time it may be said that the situation appears to be distinctly encouraging for careful and systematic prospecting. The number of mineralized areas along the Cowhide Creek anticline and the Amity fault tend to bear out the belief that at least a few deposits, in the order of a few acres in extent each, will be found which will prove to be of sufficient size and richness to justify long term operation. Judging wholly from information now available, the indications are that the metallic content of the ore within the mineable areas will approximate that within the majority of the mineable areas of western United States, although there apparently are no facts to demonstrate that areas of exceptional richness and size may not be discovered.

Generally speaking, the presumption is that cinnabar mining in southwestern Arkansas will have to be conducted on much the same basis as it is in western United States: that is, low grade ore bodies will have to be located and their average quicksilver content estimated, followed by such exploitation as is justified by the price of quicksilver. Quicksilver at $100 or more per flask (76-pounds) will permit the opening up of deposits of relatively low grade, probably those with a content of something like one-half per cent quicksilver, or an even lower percentage, whereas quicksilver at $50 per flask will require a much higher grade to permit profitable operation.

Table 1 shows the average annual price per flask of quicksilver in the United States, together with the domestic production and value, for the period 1907-1930. The figures were taken from the records of the U. S. Bureau of Mines.

TABLE 1. - Average Annual Price, Production and Value of Quicksilver in the United States
U. S. Bureau of Mines Figures.
1907-1930 Inclusive.

Year	Average Price (New York) Per flask	U. S. Production Flasks	Value
1907	$ 41.50*	21,554*	$ 853,538
1908	44.84*	19,752*	872,446
1909	46.30*	21,072*	957,859
1910	47.06*	20,601*	958,153
1911	46.54*	21,256*	977,989
1912	42.46*	25,064*	1,053,941
1913	40.23*	20,213*	813,171
1914	49.15*	16,548*	811,680
1915	87.01*	21,033*	1,826,912
1916	125.49*	29,932*	3,768,139
1917	106.30*	35,159*	3,808,266
1918	123.47*	32,883*	3,863,752
1919	92.15*	21,415*	1,933,560
1920	81.12*	13,392*	1,066,807
1921	45.46*	6,256**	300,595
1922	58.95*	6,291**	368,348
1923	66.50*	7,833**	521,302

* 75-pound flasks (avdp.)
** 76-pound flasks "

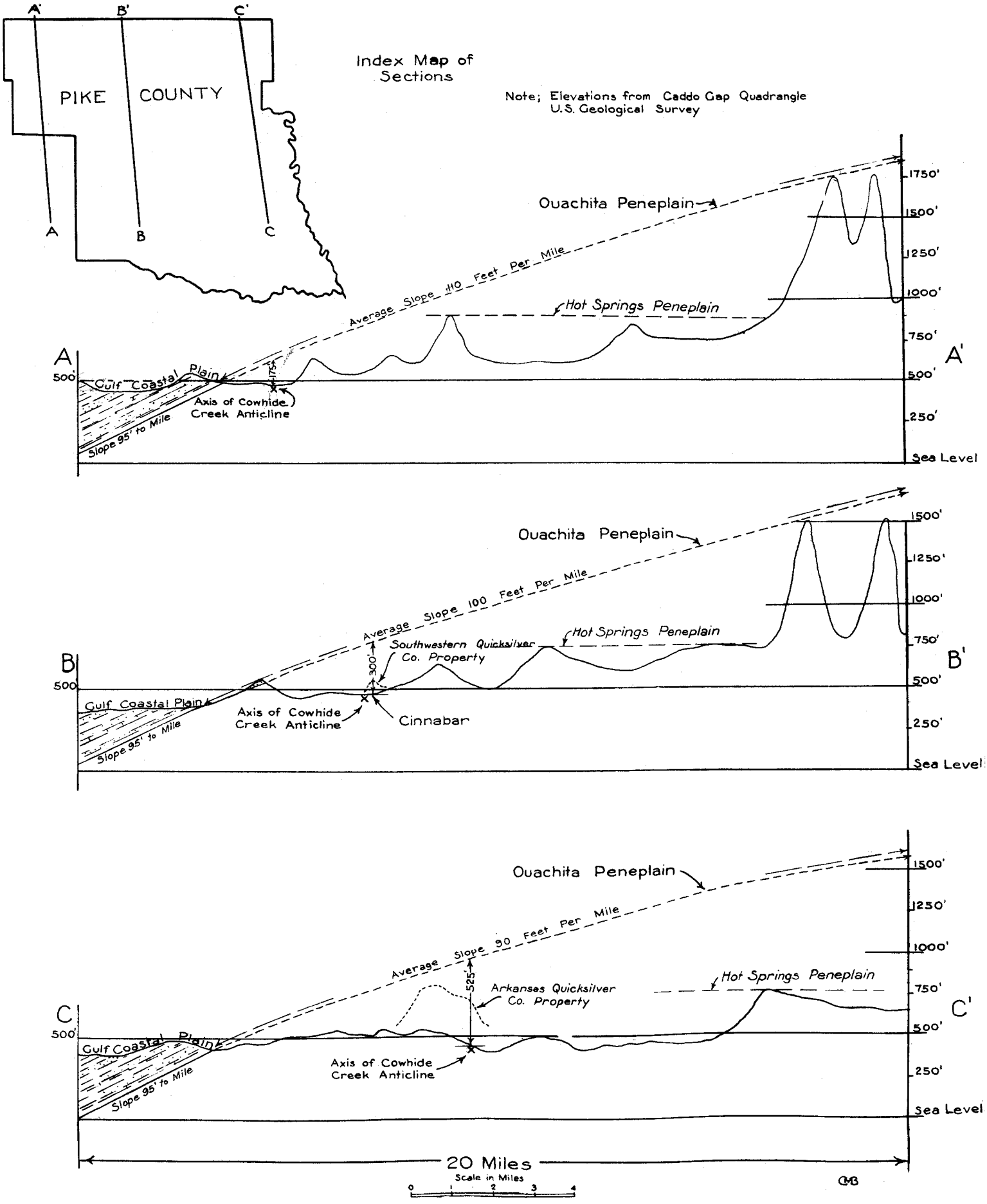

PLATE 38. SECTION SHOWING THEORETICAL EROSION OF THE ATHENS PLATEAU BELOW THE OUACHITA PENEPLAIN.

Year	Average Price (New York) Per flask	U. S. Production Flasks	Value
1924	69.76*	9,952**	$ 692,739
1925	83.13*	9,053**	762,616
1926	91.90*	7,541**	702,323
1927	118.16**	11,128**	1,314,782
1928	123.50**	17,870**	2,207,003
1929	122.15**	23,682**	2,892,638
1930	115.01**	21,553**	2,478,879

SUGGESTIONS FOR PROSPECTING AND DEVELOPMENT

Prospecting

In prospecting for cinnabar it is suggested:

1. That a thorough search be made for cinnabar-bearing rocks within the Athens Plateau, with especial attention being given to the Cowhide Creek anticline and the Amity fault zone, and that portion of the Plateau lying south of the Cowhide Creek anticline. Close examination should be made of rock in place and also the many fragments of loose sandstone which cover the crests and slopes of the ridges. The finding of cinnabar in this "float" has usually led to the discovery of the parent rock. The necessary requisites for this type of prospecting are the ability to identify cinnabar and a heavy hammer with which to break the rock in order that fresh surfaces may be examined. Fresh exposures of rock are necessary since the cinnabar, after exposure to the weather, turns black. This causes it to be easily overlooked and difficult to recognize.

The panning of soils for cinnabar and native quicksilver, especially on the slopes of the ridges, should be undertaken as ridge soils in the Little Missouri River area have been found to carry a high percentage of cinnabar crystals in several instances. The occurrence of cinnabar and native quicksilver in the soils furnishes a valuable clue to the location of the parent rock.

It should be remembered that, so far as is now known, cinnabar is confined to fractured and broken zones. This fracturing and breaking has created the necessary porous condition for the deposition of the cinnabar. Consequently, prospectors should search for zones of this character, which may be identified either from the sandstone in place or by the irregular weathering of fractured sandstone float.

The richest occurrences probably will be found along the sandstone-shale contacts, or in the relatively thin-bedded, highly fractured sandstone lying between shale beds.

2. That, in addition to prospecting the Paleozoic sandstones and shales, the base of the Lower Cretaceous sands and gravels, which bound the Athens Plateau on the south, and the base of the gravel outliers on the Athens Plateau be prospected for cinnabar. If it is assumed, as outlined under "Age of Mineralization," that the mineralizing solutions reached the surface of the Ouachita peneplain at a time when it was covered with Lower Cretaceous deposits, then it follows that porous beds, such as sands and gravels which occur in the base of the Lower Cretaceous, should be prospected.

3. That the area prospected be mapped in detail as to drainage, topography, rock structure, and stratigraphy over a sufficient linear and lateral extent to disclose the true relation of the local geology to that of the region as a whole.

4. That a magnetic survey be conducted to determine the magnetic variations

within the area being prospected as well as a sufficiently larger including area to determine the relation between the magnetic variations in the local area and the regional magnetic variations. Such a survey would disclose whether or not areas of relatively high magnetic intensity exist within the cinnabar area. The existence of such areas may indicate the presence of buried intrusive rocks that may have provided a source of the original mineralizing solutions. If such areas are found, a careful search may lead to the discovery of new mineralized areas. Magnetic surveys have been of much value in locating buried igneous masses in Gulf Coastal Arkansas [26].

Development

In the development of a mineralized area it is suggested:

1. That the mineralized area be exposed at intervals along the strike of the beds by trenches or test pits, in order to determine the lateral and linear extent of the mineralization and to gain a preliminary idea of the enrichment. If the exposures show a sufficiently rich deposit, further exploration is recommended by deep trenching, test-pitting, the sinking of shafts, drifting, or possibly by core or churn drilling, depending on the method most suited to the deposit. In making tonnage estimates great care should be exercised in order to be reasonably certain that the estimates are based on the proved presence of mineable ore as the known deposits are erratic and discontinuous.

2. That, in case it has not already been done, the physiography and geology of the area be studied in accordance with the third suggestion under "Prospecting."

3. That the relation between mineralization and structure, such as faults, folds, and fractures, and the relation of mineralization to sandstone and shale contacts and to individual stratigraphic units be studied in detail. Information of this character will be valuable in directing further exploration.

Generally speaking, profitable cinnabar mining in the United States necessitates the strictest economy as to the selection of the area to be mined, the process of mining, and plant operation. Because profit or loss usually depends upon the recognition of these facts, it is essential that the advice of experienced and competent men be followed in every branch of operation undertaken. Unless this procedure is followed within reasonable limits, a great deal of money may be expended by investors with slight prospect of return. Close attention to these facts, however, may result in the establishment of profitable operations.

DESCRIPTION OF OCCURRENCES OF CINNABAR IN PLACE

Occurrence 1 (Prospect)

Location: NW NE sec. 19, T. 6 S., R. 23 W., Clark County.
Fee Owner: Warner Deering.
Lessee: The Exploration Company.
Formation: Quartzitic sandstone.
Structure: Strike S. 43° E., dip 80° W.
Prospect: Trench 30 feet long, 12 feet wide, and 3 feet deep along the strike. Soft, somewhat weathered, dark gray sandstone beds are exposed.
Cinnabar: Occurs in a zone about 10 feet wide across the strike of the beds. It is distributed in thin layers along fracture planes which are mainly at right angles to the bedding planes. Free mercury is reported as occurring here.

26/ Stearn, N. H., A geomagnetic survey of the bauxite region in central Arkansas: Arkansas Geol. Survey Bull. 5, pp. 16, 1930.

Occurrence 2

Location: SE SW sec. 29, T. 6 S., R. 23 W., Pike County.
Fee Owner: Ozan-Graysonia Lumber Company.
Formation: Highly fractured, quartzitic sandstone.
Structure: Strike N. 50°-68° E. on nose of small fold. Dip not apparent in highly fractured rock.
Cinnabar: Occurs as fracture fillings associated with dickite.

Occurrence 3 (Prospect)

Location: SW SW sec. 28, T. 6 S., R. 23 W., Pike County.
Fee Owner: Ozan-Graysonia Lumber Company.
Lessee: Arkansas Quicksilver Company.
Formation: Quartzitic sandstone.
Structure: Strike S. 55° E., dip 71° S.
Prospect: Tunnel 30 feet long, 4 feet wide, and 6 feet high driven into end of the ridge nearly parallel to the strike of the beds, through quartzitic sandstone and into black shale. The opening is about 15 feet above the level of a small creek. This prospect is known as the Black Tunnel.
Cinnabar: Occurs as fracture and joint fillings in the quartzitic sandstone.

Occurrence 4 (Prospect)

Location: SW SW sec. 28, T. 6 S., R. 23 W., Pike County.
Fee Owner: Ozan-Graysonia Lumber Company.
Lessee: Arkansas Quicksilver Company.
Formation: Quartzitic sandstone, highly fractured.
Structure: Strike N. 70° E., dip 70° N.
Prospect: Pit about 6 feet in diameter and 4 feet deep, dug at the northwest end of the ridge about 80 feet above Occurrence 3. This prospect is known as the Russel Hole.
Cinnabar: Occurs as a small pocket deposit. Rich showing.

Occurrence 5 (Prospect)

Location: SE SW sec. 28, T. 6 S., R. 23 W., Pike County.
Fee Owner: Ozan-Graysonia Lumber Company.
Lessee: Arkansas Quicksilver Company.
Formation: Massive sandstone, highly fractured.
Structure: Strike S. 70° E., dip 70° N.
Prospect: Trench 20 feet long, 4 feet wide and 7 feet deep at the northeast end and near the crest of a ridge, and approximately at right angles to the strike of the beds. Slickensided sandstone shows striations at all angles.
Cinnabar: Occurs as fracture fillings in 2 feet of massive sandstone adjacent to a shale contact. The sandstone beds show evidence of slight faulting.

Occurrence 6 (Prospect)

Location: SE SW sec. 28, T. 6 S., R. 23 W., Pike County.
Fee Owner: Ozan-Graysonia Lumber Company.
Lessee: Arkansas Quicksilver Company.
Formation: Quartzitic sandstone and thin seams of shale.
Structure: Strike N. 38° E., dip 77° W.
Prospect: Tunnel 67 feet long, 4 feet wide, and 7 feet high driven at an angle of S. 59° W. through thickly bedded, hard gray sandstone into 2 feet of dark gray shale. This prospect is known as No. 1 Tunnel.

Cinnabar: Occurs as fracture and joint crack fillings at mouth of tunnel in sandstone.

Occurrence 7 (Prospect)

Location: NE NW sec. 33, T. 6 S., R. 23 W., Pike County.
Fee Owner: Ozan-Graysonia Lumber Company.
Lessee: Arkansas Quicksilver Company.
Formation: Quartzitic sandstone.
Structure: Strike S. 50° E., dip 53° N.
Prospect: Pit about 12 feet in diameter and 10 feet deep in sandstone and shale. The shale is much folded and slickensided. Pit is about 25 feet above Occurrence 4.
Cinnabar: Occurs as fracture fillings.

Occurrence 8 (Prospect)

Location: NE NW sec. 33, T. 6 S., R. 23 W., Pike County.
Fee Owner: Ozan-Graysonia Lumber Company.
Lessee: Arkansas Quicksilver Company.
Formation: Massive, fractured, quartzitic sandstone.
Structure: Strike S. 50° E., dip 63° S.
Prospect: Trench 26 feet long, 5 feet wide, and from 2 to 6 feet deep, about 15 feet below the crest of the ridge.
Cinnabar: Occurs as fracture fillings in the sandstone adjacent to the shale.

Occurrence 9 (Prospect)

Location: NE NW sec. 33, T. 6 S., R. 23 W., Pike County.
Fee Owner: Ozan-Graysonia Lumber Company.
Lessee: Arkansas Quicksilver Company.
Formation: Massive, fractured, dark-gray sandstone and interbedded shale.
Structure: Strike S. 85° E., dip 60° S.
Prospect: Trench 40 feet long, 5 feet wide, and from 3 to 16 feet deep.
Cinnabar: Occurs as fracture fillings.

Occurrence 10 (Prospect)

Location: SE NW sec. 33, T. 6 S., R. 23 W., Pike County.
Fee Owner: Ozan-Graysonia Lumber Company.
Lessee: Arkansas Quicksilver Company.
Formation: Massive, fractured, quartzitic sandstone.
Structure: Strike N. 75° E., dip 70° S.
Prospect: Pit 5 feet in diameter and 8 feet deep, dug on the south side of a sandstone ridge which has a strike of N. 80° E. This ridge connects with a second ridge along which Occurrences 3 to 7 inclusive are located, and which has a strike of S. 50° E. This second ridge is roughly parallel to the Amity fault.
Cinnabar: Occurs as fracture fillings associated with dickite in a zone about 3 feet wide.

Occurrence 11 (Prospect)

Location: SE NW sec. 33, T. 6 S., R. 23 W., Pike County.
Fee Owner: Ozan-Graysonia Lumber Company.
Lessee: Arkansas Quicksilver Company.
Formation: Massive, fractured, and jointed quartzitic sandstone.
Structure: Strike N. 80° E., dip 69° S.
Prospect: Trench 10 feet long, 3 feet wide, and 11 feet deep.
Cinnabar: Occurs as fracture fillings associated with dickite in a zone about

3 feet wide through the entire length of the trench.

Occurrence 12

Location: NE NE sec. 34, T. 6 S., R. 23 W., Clark County.
Fee Owner: Southern Kraft Corporation.
Formation: Gray, quartzitic sandstone, cut by numerous fractures.
Structure: Strike N. 70°-80° E., dip 70°-90° S.
Cinnabar: Occurs as fracture fillings in sandstone.

Occurrence 13

Location: S½ SW sec. 34, T. 6 S., R. 23 W., Clark County.
Fee Owner: Southern Kraft Corporation.
Formation: Highly fractured, gray, quartzitic sandstone.
Structure: Strike N. 68° W. Dip not determinable but nearly vertical.
Cinnabar: Occurs as fracture fillings associated with dickite, and also appears to be disseminated.

Occurrence 14

Location: NE NW sec. 5, T. 7 S., R. 23 W., Pike County.
Fee Owner: Ozan-Graysonia Lumber Company.
Formation: Hard, gray, fractured, conglomerate sandstone.
Structure: Strike N. 80° E., dip 80° S.
Cinnabar: Occurs in fractures associated with dickite, and also appears to be slightly disseminated in conglomerate.

Occurrence 15

Location: NW SE sec. 26, T. 6 S., R. 24 W., Pike County.
Fee Owner: T. P. Palmer.
Formation: Fractured, gray sandstone.
Structure: Average strike N. 85° E., dip 70°-80° S.
Cinnabar: Occurs as fracture fillings associated with dickite.

Occurrence 16

Location: NE SW sec. 26, T. 6 S., R. 24 W., Pike County.
Fee Owner: Southern Kraft Corporation.
Formation: Fractured, hard, gray sandstone.
Structure: General strike N. 85° E., dip 80° S.
Cinnabar: Occurs as fracture fillings in sandstone associated with dickite.

Occurrence 17

Location: NW SW sec. 26, T. 6 S., R. 24 W., Pike County.
Fee Owner: Ozan-Graysonia Lumber Company.
Formation: Gray, quartzitic sandstone.
Structure: Strike N. 80° E., dip 80° S.
Cinnabar: Occurs as fracture fillings associated with dickite.

Occurrence 18 (Prospect)

Location: SW SE sec. 27, T. 6 S., R. 24 W., Pike County.
Fee Owner: Louis and Pasquale Marino.
Lessee: C. Mining Corporation.
Formation: Gray, quartzitic sandstone.
Structure: Strike N. 75° E., dip 71° S.
Prospect: Two trenches, each about 20 feet long and 4 to 6 feet deep. The

easternmost of these trenches was dug near the creek level on the end of a ridge parallel to the strike of the beds. Twelve feet of sandstone are exposed in the trench. Cinnabar could not be found in place here but reports from two reliable sources are that it is definitely present. The second trench is on the crest of the ridge and has been dug across the strike of the sandstone. Much dickite is present in the fractured sandstone but no cinnabar in place was noted.

Cinnabar: Occurs in joint cracks associated with quartz and dickite.

Occurrence 19

Location: SE NE sec. 3, T. 7 S., R. 24 W., Pike County.
Fee Owner: Ozan-Graysonia Lumber Company.
Formation: Fractured, gray sandstone breccia. Angular fragments in breccia cemented by lighter colored sandstone.
Structure: Strike N. 78° E., dip 70°-90° S.
Cinnabar: Occurs as fracture fillings associated with dickite and disseminated in sandstone along these fractures.

Occurrence 20

Location: NW sec. 33, T. 6 S., R. 24 W., Pike County.
Fee Owner: Southern Kraft Corporation.
Formation: Hard, gray, fractured sandstone.
Structure: Strike N. 70°-80° E., dip 80° S.
Cinnabar: Occurs as fracture fillings in sandstone.

Occurrence 21 (Prospect)

Location: SE NW sec. 32, T. 6 S., R. 24 W., Pike County.
Fee Owner: C. Caponetto.
Lessee: C. Mining Corporation.
Formation: Gray, quartzitic sandstone.
Structure: Strike N. 75° E., dip 70° S.
Prospect: Trench 20 feet long, 15 feet wide, and 4 feet deep, at the west end of a ridge and parallel to the strike of the beds.
Cinnabar: Occurs in joint cracks associated with dickite.

Occurrence 22

Location: SW NW sec. 32, T. 6 S., R. 24 W., Pike County.
Fee Owner: Southern Kraft Corporation.
Formation: Highly fractured, gray sandstone.
Structure: Strike N. 85° E., dip 72° S.
Cinnabar: Occurs as fracture fillings in sandstone.

Occurrence 23 (Prospect)

Location: NW NW sec. 2, T. 7 S., R. 25 W., Pike County.
Fee Owner: Joe Cox.
Lessee: Arkansas Cinnabar Mining Company.
Formation: Hard, fractured, gray sandstone interbedded with shale. The rock is broken along the joint planes, and has a pitted appearance and is called "honeycomb rock."
Structure: Strike S. 80° E., dip 70° S.
Prospect: Several shallow trenches and one test pit at intervals along the strike of the beds.
Cinnabar: Occurs as fracture fillings in sandstone. Small amounts of cinnabar in pits in the rock and along fractures. Native mercury is reported here.

NOTE: Several openings have been made immediately adjacent to Occurrence 23 on the west, but are not shown in Plate 3 as no cinnabar was actually found in place. A description of the openings follows:

Location: NE NE sec. 3, T. 7 S., R. 25 W., Pike County.
Fee Owners: D. O. Roller, C. H. Lumin and I. J. Brooks.
Formation: Highly fractured, interbedded sandstone and shale.
Structure: Strike S. 80° E., dip 80° S.
Prospect: Three main openings (2 shafts 25 to 30 feet deep, and one main trench 20 feet long and 3 feet wide) at east end of property, and two or three small trenches.
Cinnabar: No cinnabar could be found in place at any of the workings. Much dickite in the fractures. A one-tube retort is operated here at intervals.

Occurrence 24

Location: NW NW sec. 3, T. 7 S., R. 25 W., Pike County.
Fee Owner: J. H. Funderburk Estate.
Formation: Hard, fractured, gray sandstone. The sandstone outcrops along the crest of a low ridge.
Structure: Strike N. 80° E., dip 72° S.
Cinnabar: Two small pits, dug about 50 feet apart, show cinnabar occurring as fracture fillings in sandstone.

Occurrence 25 (Prospect)

Location: NW NW sec. 4, T. 7 S., R. 25 W., Pike County.
Fee Owner: Johnson Heirs.
Formation: Fractured sandstone. The sandstone outcrops along the crest of a low ridge.
Structure: Strike N. 80° E., dip 73° S.
Prospect: Pit 3 feet in diameter and 3 feet deep.
Cinnabar: Occurs as fracture fillings in joint cracks in fractures in sandstone.

Occurrence 26

Location: NW SW sec. 5, T. 7 S., R. 25 W., Pike County.
Fee Owner: Mrs. Lula Bell.
Formation: Fractured sandstone. The sandstone outcrops along the crest of a low ridge.
Structure: Average strike N. 80° E., dip 80° S.
Cinnabar: Occurs as fracture fillings in sandstone.

Occurrence 27 (Prospect)

Location: SW SE, SE SW, and SW SW sec. 6, T. 7 S., R. 25 W., Pike County.
Fee Owner: SW SE and SE SW Johnson Heirs; SW SW D. L. Parnell and R. B. Carroll.
Lessee: Southwestern Quicksilver Company.
Formation: Quartzitic sandstone and shale.
Structure: Strike usually N. 75°-80° E., dip 70°-80° S.
Prospect: The Parnell-Carroll tract is considered as one prospect. The hill on this tract lies immediately north of the extreme western end of the Cowhide Creek valley near a point where Cowhide Creek empties into the Little Missouri River. The hill is oval in shape, with an east-west axis of about 1,700 feet, and a north-south axis of about 750 feet. The maximum local relief is about 220 feet. Three major cuts (Nos. 1, 12, and 15) have been made. These are shown in the mine layout (Pl. 37) and are shown separately in Plates 32, 33, and 35.

Cut No. 1: This cut, which is about 10 feet wide, is driven through the shale which flanks the southern limit of the sandstone for about 40 feet, and exposes a bed of sandstone with a dip of about 75° S. The sandstone at the exposure has been bent to an angle of from 90° to 100°, the strike changing from N. 75°-80°E. in the eastern side of the cut, to N. 15°-20° W. in the western side, through a distance of about 7 feet. This bend extends up the slope of the hill for about 75 feet and then swings back N. 80°-85° E. Immediately above this cut the rock has been stripped for about 30 feet along the strike of the beds for about 8 feet directly across the dip.

Cinnabar: Occurs as fracture and joint crack fillings. It is estimated that from the top of the hill to the bottom of this cut, the mineralization has a vertical interval of about 42 feet. Probably the mineralization is more or less continuous at this point diagonally across the hill for about 460 feet. The width of this zone is estimated to be 30 feet.

Cut No. 12: This cut, which is about 12 feet wide, is driven through the shale which flanks the southern limit of the sandstone for about 60 feet, and exposes a bed of sandstone which has a strike of about N. 75° E. and a dip of about 73° S. Mineralization may extend along the strike for 75 feet each way in three beds of sandstone, each about 8 feet thick.

Cinnabar: Occurs as fracture and joint crack fillings and along bedding planes. Some stibnite was found in this cut.

Cut No. 15: This cut, which is about 10 feet wide, is driven through the shale which flanks the southern limit of the sandstone for about 35 feet, and exposes a bed of sandstone which has a strike of N. 80° E., and a dip of 74° S.

Cinnabar: Occurs as fracture and joint crack fillings and along bedding planes.

The greatest relief through which cinnabar has been found in the Little Missouri River area is on the Parnell-Carroll tract between the crest of the hill above Cut 1 and the creek bed at the extreme east end of the hill. The difference in elevation between these two points is approximately 120 feet.

Occurrence 28 (Prospect)

Location: SW NE sec. 12, T. 7 S., R. 26 W., Pike County.
Fee Owner: Arkansas Power and Light Company.
Lessee: George Bell.
Formation: Hard, quartzitic sandstone.
Structure: Strike S. 35° E., dip 73° W.
Prospect: Trench 40 feet long, 7 feet wide, and from 10 to 25 feet deep. Trench has a strike of S. 45° E. along the northwestern end of the sandstone ridge and gradually swings more to the east near the river. A second east-west trench, 25 feet long, 7 feet wide, and from 10 to 25 feet deep, connecting with and approximately at right angles to the first trench, and intersecting it at the southeast end, has been cut following the strike of the beds. Sandstone is much fractured and jointed.

A columnar section of the different beds exposed in the trench, cut at right angles to the strike of the beds, measured from east to west

is as follows:

7 ft. Hard, gray sandstone, prominently stained red with iron oxide along joint and fracture planes.
7 " Dark gray clay shale.
3 " Thin-bedded, hard, gray sandstone.
8 " Thick and thin-bedded, hard, gray sandstone.
4 " Dark gray clay shale containing plant remains.
10 " Massive, gray, quartzitic sandstone, fractured and jointed. The fracture and joint planes are often heavily stained with red iron oxide. This bed also carries cinnabar.

Cinnabar: Occurs as fracture and joint crack fillings in 10-foot sandstone beds.

Occurrence 29 (Prospect)

Location: SE SW sec. 1, T. 7 S., R. 26 W., Pike County.
Fee Owner: G. J. Parker.
Lessee: Southwestern Quicksilver Company.
Formation: Quartzitic sandstone and shale.
Structure: Strike and dip vary but, in general, strike is N. 55° E., dip 80° S.
Prospect: Cuts have been made along the southern flank of a small, nearly oval, hill. The long axis is about 450 feet and the short axis is about 400 feet. Local relief of the hill is about 90 feet, the main opening is near the west end of the hill and is shown in Plate 36. The rocks, which have been exposed along the south flank of the hill, are quartzitic sandstone and shale, and have a strike of N. 55°-85° E., and gradually swing around to the west end of the hill to S. 65° E., a change of about 60°. The crest on the west of the hill is at right angles to the strike and shows interbedded sandstone and shale which have been much distorted.
Cinnabar: Found as fracture and joint crack fillings in quartz veins and in crystal form. Some free mercury filling small cavities in the sandstone.

Occurrence 30 (Prospect)

Location: SW NE sec. 11, T. 7 S., R. 26 W., Pike County.
Fee Owner: G. J. Parker.
Lessee: Southwestern Quicksilver Company.
Formation: Quartzitic sandstone.
Structure: Strike N. 80° E., dip 90° S.
Prospect: Approximately 30 tons of rock have been removed from a cut about 15 by 20 feet in size, and with a maximum depth of 15 feet.
Cinnabar: Occurs as cementing material in cinnabar and sandstone breccia and in joint cracks and bedding planes. Some rich ore was found at this prospect. The cinnabar is erratically distributed through the beds. Seventy-five feet across the crest of this ridge a small opening has exposed cinnabar-bearing sandstone.

Occurrence 31 (Prospect)

Location: SW NE sec. 11, T. 7 S., R. 26 W., Pike County (300 yards west of Occurrence 30.)
Fee Owner: G. J. Parker.
Lessee: Southwestern Quicksilver Company.
Formation: Quartzitic sandstone.
Structure: Strike N. 80° E., dip 90° S.
Prospect: Approximately 20 to 25 tons of rock have been removed from a cut about 15 by 20 feet in size, with a maximum depth of 15 feet.
Cinnabar: Occurs as cementing material in cinnabar and sandstone breccia and in

Production of Quicksilver in Arkansas

Flasks of 76-lbs.

Year	Southwestern Quicksilver Co.	Arkansas Quicksilver Co.	Rock Fence	Russell tract (Hudgins)	Parker lease (Otto Bros)	Givens lease (Bell Mng Co)	Johnson Heirs (Yenglin)	Lulu Bell lease (Isbell)	C Mining Corp and others	Total
1931	10.0 a/	12.2 b/								22.2
1932	271.0 a/	4.8 b/ 35.3 c/ 40.1							3 e/	314.1
1933	281.0 a/	58.9 d/				1 f/				340.9
1934	391.0 a/	88.8 d/	14 e/	4 f/	1 e/	1 f/	6 e/	9 e/		514.8
Total	953.0	200.0	14	4	1	2	6	9	3	1,192.0
1935	16.0 a/ 969.0									16.0 1,208.0

a/ According to letter dated 10-23-35 from N. H. Stearn, Vice President of Southwestern Quicksilver Co.
b/ According to Information Circular 2, 'Cinnabar in Southwestern Arkansas, page 29. Prorated for November and December, 1931, and January, 1932.
c/ According to letter dated July 12, 1932, from George M. Schneider, Secretary of Arkansas Quicksilver Co.
d/ According to W. N. Bemis, President of Arkansas Quicksilver Co., August, 1934.
e/ According to letter dated February 15, 1935, from Howard A. Millar, Murfreesboro, Ark.
f/ According to letter dated March 25, 1935, from Howard A. Millar, Murfreesboro, Ark.

joint cracks and bedding planes. Some rich ore was found in this prospect. The cinnabar is erratically distributed through the beds.

Occurrence 32

Location: NE SE sec. 9, T. 7 S., R. 26 W., Pike County.
Fee Owner: Southern Kraft Corporation.
Formation: Gray, hard, fractured sandstone.
Structure: Strike N. 80° E., dip 90° S.
Cinnabar: Occurs as fracture fillings associated with dickite.

Occurrence 33

Location: SE SE sec. 12, T. 7 S., R. 27 W.)
NE NE sec. 13, T. 7 S., R. 27 W.) Howard County.
Fee Owner: William Pyle.
Lessee: Z. A. Copeland.
Formation: Gray, fractured, quartzitic sandstone.
Structure: Strike N. 80° E., dip 85° S.
Prospect: Trench 5 feet long, 1 foot wide, and 1 foot deep.
Cinnabar: Occurs as fracture fillings associated with dickite.

Occurrence 34

Location: Near south line NE NW sec. 13, T. 7 S., R. 27 W., Howard County.
Fee Owner: Z. A. Copeland.
Formation: Quartzitic sandstone.
Structure: Strike N. 80° E., dip 85° S.
Cinnabar: Occurs as fracture fillings in sandstone.