UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Mineral Resources of the Belle Starr Caves Wilderness Study Area, Sebastian and Scott Counties, Arkansas

By

Boyd R. Haley and Robert L. Earhart
U.S. Geological Survey
and
Raymond B. Stroud
U.S. Bureau of Mines

Open-File Report 80-356
1980

Contents

Illustrations

Tables

Summary

The results of mineral evaluation studies in the Belle Starr Caves Wilderness study area, which covers about 6,036 acres (2,444 ha) of the Ouachita National Forest in western Arkansas, indicate the area has a good potential for small amounts of natural gas. In addition, the area has a good potential for coal resources. The potential for deposits of metallic minerals is very low.

The Belle Starr Caves Wilderness study area is in the southern part of the Arkansas Valley section of the Ouachita Mountains province. The exposed rocks in the area consist of sandstone, siltstone, and shale of Pennsylvanian age. The rocks are gently folded and the easterly trending axis of the Poteau syncline is in the central part.

Rocks as old as Ordovician in age have been penetrated by wells drilled for natural gas near the area. Natural gas was discovered in 1902 about 3 mi (4.8 km) north of the area. The wells produce natural gas from reservoirs at depths to about 6,000 ft (1,830 m). The southern limit of the deposits has not been established. Gas has also been found about 7 mi (11.3 km) southeast of the study area. The rocks with natural gas occurrences are present at depth in the study area and it seems probable that at least small volumes of gas underlie the area.

The Hartshorne coal seam in the McAlester Formation, which is present at shallow depth in the Belle Starr Caves study area, has been mined in the outlying areas. Assuming a 50 percent recovery rate and an average thickness of 2 ft (0.6 m), the area may be underlain by 11.3 million short tons (10.3 million t) of minable coal. Other coal seams in the underlying rocks are thin and discontinuous and thus are of limited commercial interest.

Heavy metals detected from the analyses of rock samples are highest in the carbonaceous shale beds, but the values are too low to be of economic significance. None of the sandstone, siltstone, or stream sediment samples contained unusually high amounts of metals.

Introduction

The Belle Starr Caves Wilderness study area covers about 6,036 acres (2,444 ha) in Sebastian and Scott Counties, Arkansas. It spans lat 35°00′ N. and long 94°11′ W. (fig. 1). The area comprises the upper part of the drainage basin of Rock Creek in the Ouachita National Forest.

Elevation ranges from about 2,360 ft (719 m) above sea level to about 700 ft (213 m) above sea level. Access to the area is provided by a U.S. Forest Service road along its southern border and by a private road that is near its northeastern corner.

The area is covered by parts of the following 15-minute topographic maps: southeastern Greenwood, southwestern Barber, northwestern Waldron, and northeastern Bates. The base map for plate 1 consists of these parts that have been enlarged to a scale of 1:48,000.

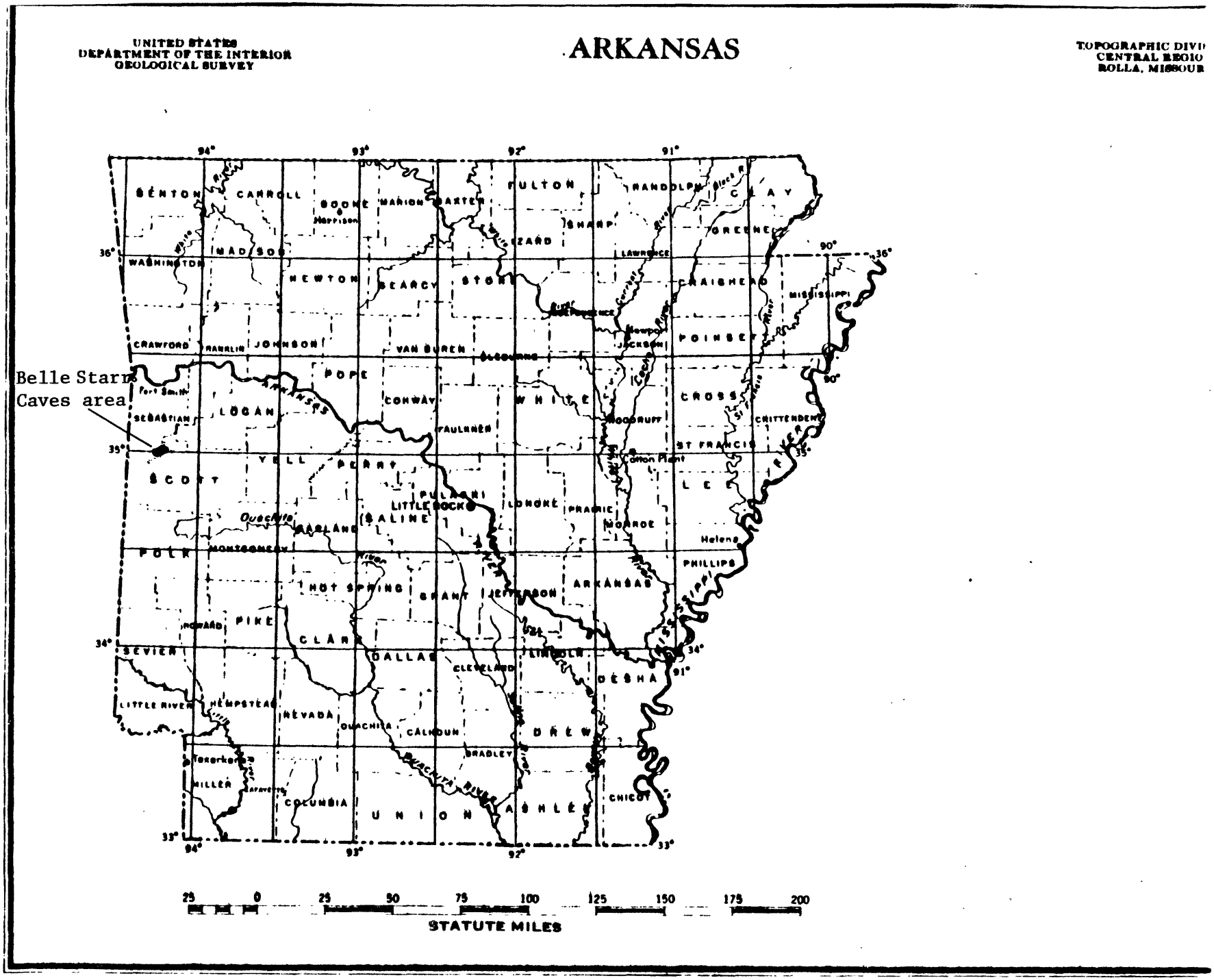

Figure 1.--Index map of Arkansas showing the location of the Belle Starr Caves Wilderness study area.

Previous geologic studies

Reinemund and Danilchick (1957) published a geologic report on the Barber quadrangle, and Haley and Hendricks (1968) published one of the Greenwood quadrangle. The geologic map (pl. 1) of this report is based on their reports plus information about the geology of the Bates quadrangle acquired by Haley in 1977.

Present investigations

The purpose of this report is to evaluate the mineral and fuel resources of the study area. The geology was compiled by Boyd R. Haley, U.S. Geological Survey, the mineral assessment was by Raymond B. Stroud, U.S. Bureau of Mines, and geochemical investigations were by Robert L. Earhart, U.S. Geological Survey.

Geology

Geologic setting

The Belle Starr Caves Wilderness study area is in the southern part of the Arkansas Valley section of the Ouachita Mountains province. The exposed rocks are all assigned to the Savanna Formation of Pennsylvanian age. Parts of the area contain alluvium and terrace deposits of Holocene and Pleistocene age. Older rocks are exposed north and south of the study area and have been penetrated by wells drilled for natural gas 3 mi (4.8 km) to the north (pl. 1).

Stratigraphy

Rocks older than the upper one-third of the Atoka Formation have been penetrated by the Wilson Production Co., E. J. Harp No. 1 well located 2,047 ft (630 m) from the south line and 1,397 ft (426 m) from the east line of sec. 32, T. 5 N., R. 30 W. The lithologic descriptions of these rocks in the text and the thicknesses given in table 1 are from Haley's examination of the cuttings from this well.

Table 1.--Stratigraphic nomenclature of the rocks in or near the Belle Starr Caves area, Arkansas

	Unit	Thickness
Pennsylvanian	Savanna Formation	660 ft (201 m)+
	McAlester Formation	1,300 ft (396 m)
	Lower Hartshorne Coal Bed	
	Hartshorne Sandstone	4 to 80 ft (1,224 m)
	Atoka Formation	17,000 ft (5,182 m)+
	Morrowan Rocks	1,015 ft (309 m)
	Conformable contact	
Mississippian	Pitkin Limestone	110 ft (34 m)
	Fayetteville Shale	110 ft (34 m)
	Moorefield Formation	333 ft (100 m)
	Boone Formation	10 ft (3 m)
	Conformable contact	
Devonian	Chattanooga Shale	110 ft (34 m)
	Penters Chert	30 ft (9 m)
	Conformable contact	
Silurian	St. Clair Limestone	220 ft (67 m)
	Conformable contact	
Ordovician	Cason Shale	20 ft (6 m)
	Fernvale Limestone and	40 ft (12 m)
	Kimmswick Limestone	
	Plattin Limestone	100 ft (30 m)
	Joachim Dolomite, St. Peter	932 ft (284 m)+
	Sandstone, and Everton Formation,	
	undivided	

Ordovician

Rocks belonging to the Everton Formation, St. Peter Sandstone, and Joachim Dolomite consist principally of finely to coarsely crystalline dolomite and fine- to medium-grained sandstone. These rocks have not produced oil or gas in Arkansas; however, Haley (1971, p. 28) reported dead oil in cuttings from wells drilled about 15 mi (24 km) to the north. Oil-soaked erratic boulders of these rocks are present in the Johns Valley Shale of Morrowan age where it crops out about 14 mi (22 km) to the south.

The Plattin Limestone is a dense to granular limestone. The Kimmswick and Fernvale Limestones are finely to coarsely crystalline limestone. The Cason Shale is a light-greenish-gray pyritic shale.

Silurian

The St. Clair Limestone consists predominantly of granular limestone with some thin beds of granular dolomite. Natural gas is produced from the St. Clair in the Bonanza Gas Field about 12 mi (19 km) north of the study area, but none was reported from the St. Clair in the Harp Well.

Devonian

The Penters Chert is a medium- to dark-gray dense chert.

Devonian-Mississippian

The Chattanooga Shale is a grayish-black shale, some of which is pyritic, and in the upper part some of the shale is siliceous.

Mississippian

The Boone Formation is grayish-black pyritic dense chert. The Moorefield Formation is comprised of silty shale, siltstone, limy siltstone, and silty limestone. The Fayetteville Shale is predominantly dark gray shale with a few thin beds of dense limestone in the upper part. The Pitkin Limestone is a fine to medium crystalline limestone, much of which contains fine to coarse oolites.

Pennsylvanian

The Morrowan rocks of this report cannot be divided with certainty into the Hale Formation and the Bloyd Shale as they can elsewhere in Arkansas. The rocks penetrated by the Harp well consist of shale, limestone, and sandstone with some siltstone. Natural gas was not reported from these rocks in the well, but the Morrowan rocks provide large amounts of natural gas in the area to the north.

The Hartshorne Sandstone is mostly sandstone with minor amounts of shale. A thin coal bed of local extent is present in the Hartshorne about 4 mi (6.4 km) east of the study area.

The McAlester Formation is predominantly shale with some siltstone and sandstone and one known coal bed near the base of the formation. This coal bed, the Lower Hartshorne Coal Bed, does not crop out but it does extend under all the study area and probably has an average thickness of 2 ft (0.6 m).

The Savanna Formation consists of shale with subordinate amounts of siltstone and sandstone. Coal beds are known to be present in the Savanna elsewhere in Arkansas, but none are exposed in the study area.

Pleistocene

Alluvial deposits in one or more terrace levels along Rock Creek consist of boulders, cobbles, pebbles, sand, silt, and clay, all of local origin.

Holocene

Alluvial deposits along Rock Creek consist of sediments of local origin. Colluvial deposits consisting mostly of sandstone fragments are on some of the steeper hillsides.

Structure

The report area spans the axis of the Poteau syncline. The rocks are folded but all dip less than 20^{o}. Faults are not known to be present, but Reinemund (1957) did map a down-to-the-south normal fault less than 0.5 mi (0.8 km) south of the study area.

Assessment of mineral resources

Surface rocks in the Belle Starr Caves study area are of Pennsylvanian age and consist mainly of alternating beds of sandstones, siltstones, and shales. The strata include the Atoka Formation, Hartshorne Sandstone, and the McAlester and Savanna Formations. Several of the sandstone beds in these formations would be sources of building stone and aggregate, but the prolific occurrence of aggregate materials outside the study area that are nearer potential markets would preclude the need to open quarries in the proposed wilderness.

The Poteau syncline, extending east and west, passes through the central portion of the study area. Anticlinal structures bound the Poteau syncline on the north and south, but only the rocks in the Hartford anticline on the north have been gas productive. No natural gas or crude oil has been found within or in the immediate vicinity of the Belle Starr Caves study area. However, natural gas was discovered in 1902 in the Mansfield gas field about 3.0 mi (4.8 km) from the study area in a well drilled on the Hartford anticline (pl. 1). Commercial quantities of natural gas have been produced from 13 of the 16 wells drilled since 1965. The nearest gas producing wells north of the study area are about 2.0 mi (3.2 km) in secs. 4 and 6, T. 4 N., R. 30 W., and in sec. 2, T. 4 N., R. 31 W. These wells produce natural gas at depths up to about 6,000 ft (1,830 m). Formations in the areas with gas production have been tested to depths of about 12,000 ft (3,660 m), but the southern limit of commercial deposits of natural gas has not been established.

About 7 mi (11.3 km) southeast of the study area, natural gas has been found in the Waldron syncline in the west-central part of T. 3 N., R. 29 W. W. L. Caplan (oral commun., 1977) of the Arkansas Geological Commission, Reinemund and Danilchick (1957), and Haley (1966) believed that there is

potential for at least relatively small volumes of natural gas in the study area. The U.S. Bureau of Land Management has issued oil and gas leases for all of the Belle Starr Caves study area except for about 1,400 acres (567 ha).

Coal seams of commercial significance occur in the McAlester Formation. These coal seams crop out outside the study area and probably underlie the area at depth. Other coal seams are known in the Atoka Formation, Hartshorne Sandstone, and Savanna Formation outside the study area, but these are of limited commercial interest because of their thinness and discontinuous distribution. They have not been noted in the Belle Starr Caves study area. As of June 1977, no Federal coal leases covered the study area. Private lands immediately north of the study area are leased for coal, and during 1977 an underground coal mine was active about 2 mi (3.2 km) northwest of the area.

The Hartshorne coal seam of the McAlester Formation crops out and has been mined both at the surface and underground immediately north of the Belle Starr Caves study area. The same seam has been mined in an area 1 to 1.5 mi (1.6 to 2.4 km) south of the study area. The coal is near the base of the formation and the thickness at the outcrop ranges from about 15 in (38.1 cm) to as much as 47 in (119.4 cm) in the vicinity of the study area. During the present investigation, a channel sample was taken of a 24-in (61-cm) coal seam about 1.0 mi (1.61 km) north of the study in the SW1/4 sec. 8, T. 4 N., R. 30 W. The coal analysis of the sample was as follows:

(As-received basis)

Proximate analysis	pct.
Moisture	1.13
Volatile matter	19.77
Fixed carbon	75.45
Ash	3.64

Ultimate analysis	pct.
Hydrogen	4.76
Total carbon	85.83
Nitrogen	1.68
Sulfur	0.63
Oxygen	3.45
Btu value 15,230 (calculated)	

Based on the analysis, the coal would be ranked as low-volatile bituminous. The analysis is similar to those of coal from the Hartshorne seam given in the annual reports of the Arkansas State Mine Inspector of Coal Mines.

At the sampling site in section 8, two thinner seams of coal 8 in (20.3 cm) and 13 in (33 cm) thick overlie the thicker seam and are separated by 12 in (30.5 cm) to 24 in (61 cm) of shaly partings. To the west along the Hartshorne coal seam and approximately 2 mi (3.2 km) northwest of the study area, the coal is as much as 4 ft (1.2 m) thick and the various thinner seams appear to coalesce, thereby increasing the total coal thickness. For purposes of evaluation, an average thickness of 24 in (61 cm) was assumed for the coal seam underlying the study area. Assuming 1,850 short tons (1,678.3 t) of coal per acre (0.4 ha) per foot (0.3 m) of coal thickness and one-half recovery rate by underground mining methods, the study area may be underlain by 11.3 million short tons (10.3 million t) of recoverable coal. Should in-situ technology become feasible to exploit this type of coal deposit, then conceivably the total recovery would be greater. A hindrance to underground mining is the relatively steep dip of the coal seam at the outcrop. Measured dips range from 15^{o} to as much as 26^{o} to the south on the north limb of the syncline. On the south limb, the coal seam dips as much as 30^{o} to 35^{o} to the north. The beds tend to flatten rapidly toward the center of the Poteau syncline and the depth of burial of the coal seam could approach several hundred feet.

Geochemical investigations

Introduction

The geochemical evaluation of the mineral resources in the Belle Starr Caves Wilderness study area covers metallic mineral deposits. The estimate of the potential for metallic mineral deposits is based on the analytical results of 14 rock and 16 stream sediment samples. Rocks randomly sampled throughout the area are representative of the various rock types that crop out. In the course of sampling, outcrops were examined for visible indications of mineralization; none were found. Stream sediments from Rock Creek and its tributaries were collected from the finest grained material available in active parts of the stream. The sediments were sieved in the laboratory and the minus 80 mesh fraction was analyzed. All samples were analyzed for 30 elements by a semiquantitative spectrographic technique and for zinc by an atomic absorption method. The sample localities are shown on plate 1, and analytical results are given in table 2. Anomalous values of metallic elements were estimated by doubling the median value of the element in each sample type, rocks, and stream sediments. The results show that none of the samples contain economically significant amounts of metallic elements.

Table 2.--Analytical results of stream sediments and rocks from the Belle Starr Caves area

[All values are in parts per million except Fe, Mg, Ca, and Ti, which are given in percent. Zinc analyses are by an atomic absorption method. All other analyses are by a semiquantitative emission spectrographic method. Spectrographic analyses are by M. Erickson, and atomic absorption by B. Plasse. Lower limit of detection shown above elements. N, not detected; L, detected below measurable limit; G, greater than. Elements analyzed for but not shown in the table include Ag, As, Au, Be, Bi, Cd, Mo, Nb, Sb, Sn, and W. All samples contained undetected (N) amounts of As (200 ppm), Au (10 ppm), Bi (10 ppm), Cd (10 ppm), Mo (5 ppm), and W (50 ppm). All samples contained undetected (N) amounts of Ag except B-105--0.5 ppm and B-105--L (0.5). All samples contained 3 ppm or less Be, all samples contained undetected (N) amounts of Nb except B-105--20 ppm. All samples contained undetected (N) amounts of Sb except B-6--L (100 ppm), and all contained undetected (N) amounts of Sn except B-101 and B-105, which contained L (10 ppm)]

Sample No.	(.05) Fe	(.02) Mg	(.05) Ca	(.002) Ti	(10) Mn	(10) B	(20) Ba	(5) Co	(10) Cr	(5) Cu	(20) La	(5) Ni	(10) Pb	(5) Sc	(100) Sr	(10) V	(10) Y	(1) Zn	(10) Zr
								Stream sediments											
B-1	2	0.5	0.1	0.5	1,000	30	300	15	100	30	50	50	20	10	L	70	50	62	500
B-2	1.5	.3	.05	.5	500	20	300	30	50	20	70	50	15	7	100	50	50	37	700
B-3	3	.7	.1	.7	300	20	700	30	100	30	70	50	15	7	100	50	50	64	200
B-4	5	.7	.15	1	1,000	30	1,000	30	100	50	70	70	20	15	100	150	50	74	300
B-5	5	.7	.1	1	500	30	700	30	100	50	70	70	20	15	L	200	50	90	200
B-6	5	.7	.1	1	500	30	700	30	100	30	70	50	20	15	L	200	50	83	200
B-7	2	.2	.07	.5	1,000	20	300	30	70	20	50	70	10	7	L	50	50	41	500
B-8	3	.7	.15	.7	1,000	30	500	20	150	20	50	70	20	10	100	150	30	74	300
B-9	3	.5	.1	.5	300	20	500	30	150	30	50	70	30	15	L	50	30	72	500
B-10	2	.5	.1	.5	1,000	30	500	30	150	50	50	70	30	10	L	70	50	66	300
B-11	2	.5	.07	.5	700	50	500	30	100	30	50	70	20	10	L	70	30	75	150
B-12	2	.5	.1	.5	500	50	500	30	150	30	50	70	20	10	L	70	50	61	500
B-13	2	.5	.1	.3	500	50	500	30	150	30	50	70	20	10	L	100	50	71	200
B-14	2	.5	.1	.5	300	50	300	30	70	20	50	50	20	10	L	70	50	68	300
B-15	2	.5	.07	.5	500	50	300	30	100	20	50	50	30	7	L	70	50	47	300
B-16	2	.3	.07	.3	300	30	300	30	70	30	30	50	30	7	L	70	30	53	300

Table 2.--Analytical results of stream sediments and rocks from the Belle Starr Caves area--Continued

Sample No.	(.05) Fe	(.02) Mg	(.05) Ca	(.002) Ti	(10) Mn	(10) B	(20) Ba	(5) Co	(10) Cr	(5) Cu	(20) La	(5) Ni	(10) Pb	(5) Sc	(100) Sr	(10) V	(10) Y	(1) Zn	(10) Zr
									Rocks										
B-100	5	.1	.3	.7	200	20	500	5	100	7	30	50	20	7	L	70	30	49	500
B-101	5	.1	.3	1	150	50	700	30	200	30	70	50	50	20	150	300	50	99	200
B-102	5	1.5	.15	.3	150	30	150	5	20	L	20	L	10	L	N	20	15	19	500
B-103	.5	1	.15	.2	200	10	1,000	20	20	5	20	20	15	L	N	20	20	38	70
B-104	3	1	.5	.3	200	L	100	5	70	5	20	L	N	L	L	15	15	15	200
B-105	2	2	.15	1	200	50	1,000	30	150	30	70	50	50	20	150	150	70	89	200
B-106	3	2	.07	.5	70	30	200	20	50	10	50	30	15	7	N	70	30	34	1,000
B-107	2	2	.2	.2	1,000	10	200	5	30	5	20	5	L	L	N	50	15	8	200
B-108	1.5	1.5	.2	.7	500	10	100	7	200	7	20	20	15	10	N	50	30	14	G(1,000)
B-109	1.5	1	.1	.5	1,500	10	500	5	200	7	L	L	L	5	N	30	15	21	150
B-110	.5	.15	.1	.2	300	N	100	5	50	10	N	5	10	L	N	20	15	9	150
B-111	.5	.2	.1	.3	300	L	100	5	20	10	L	5	N	5	N	20	15	7	150
B-112	.5	.2	.15	.07	200	N	70	5	30	10	L	200	N	L	N	15	20	15	150
B-113	1	.2	.1	.1	1,000	L	150	20	30	5	L	N	15	L	N	20	20	1	200

Evaluation of metallic mineral resources

The outcropping rocks in the study area are sandstone, siltstone, and shale of Pennsylvanian age, and there are no known metallic mineral occurrences in these rocks within the area or in the surrounding region. A few of the samples from the Belle Starr Caves area contain weakly anomalous amounts of zinc and lead. The average value of zinc in stream sediments is 61 ppm, and in rocks 30 ppm. None of the stream sediments were anomalous and only 2 rocks, B-101 with 99 ppm zinc, and B-105 with 89 ppm, were weakly anomalous. B-101 is a dark-gray, sandy shale, and B-105 is a dark-greenish-gray shale; both are from the Savanna Formation. Although the zinc in these samples is anomalous relative to that in the other rock samples from the area, the zinc content is probably less than the average for shales collected elsewhere in west-central Arkansas, and it is considerably less than the average zinc content of 330 ppm in shales of Pennsylvanian age from southeastern Kansas (Vine and Tourtelot, 1969). Therefore, the zinc in the shales that crop out in the study area has no economic significance.

The lead content of stream sediments from the study area ranges from 10 to 30 ppm (table 1); none are anomalous. Lead in rock samples ranges from less than the lower limit of detection (10 ppm) to 50 ppm. The two shale samples (B-101 and B-105) that have the highest zinc content also have the highest lead content (50 ppm). The amount of lead in these samples is about 4 times greater than the average from 32 shale samples collected elsewhere in west-central Arkansas by Vine and Tourtelot (1969), but this difference has no economic significance.

In addition to lead and zinc, one shale sample (B-105) contained 0.7 ppm silver. All other samples have undetectable amounts, except B-107, a light-tan sandstone, which has less than 0.5 ppm. With the exception of lead,

the content of the various metals in shales of the study area is not significantly different from the averages in shales from other localities in west-central Arkansas. None of the siltstone and sandstone samples contained unusual amounts of metallic elements.

In conclusion, the Belle Starr Caves area appears to have a very low potential for metallic resources.

References

Haley, B. R., 1966, Geology of the Barber quadrangle, Sebastian County and vicinity, Arkansas: Arkansas Geological Commission Information Circular 20-C, 76 p.

Haley, B. R., and Hendricks, T. A., 1968, Geology of the Greenwood quadrangle, Arkansas-Oklahoma: U.S. Geological Survey Professional Paper 536-A, 15 p.; also published as Arkansas Geological Commission Information Circular 20-F, 15 p.

_____1971, Geology of the Van Buren and Lavaca quadrangles, Arkansas and Oklahoma: U.S. Geological Survey Professional Paper 657-A, 41 p.; also published as Arkansas Geological Commission Information Circular 20-1, 41 p.

Reinemund, J. A., and Danilchick, Walter, 1957, Preliminary geologic map of the Waldron quadrangle and adjacent areas, Scott County, Arkansas: U.S. Geological Survey Oil and Gas Investigations Map OM-192.

Vine, J. D., and Tourtelot, E. B., 1969, Geochemical investigations of some black shales and associated rocks: U.S. Geological Survey Bulletin 1314-A, 43 p.