STATE OF ARKANSAS

Arkansas Geological Commission
Norman F. Williams, State Geologist

INFORMATION CIRCULAR 27

MANGANESE RESOURCES OF THE BATESVILLE DISTRICT, ARKANSAS

by

R. B. Stroud, H. D. Kline, W. F. Brown and J. P. Ryan
U. S. Bureau of Mines

Printed by permission of the U. S. Bureau of Mines
Little Rock, Arkansas
1981

Previously published as USBM Reports of Investigations 5206, 5411, and 6478.

STATE OF ARKANSAS

Arkansas Geological Commission
Norman F. Williams, State Geologist

INFORMATION CIRCULAR 27

MANGANESE RESOURCES OF THE BATESVILLE DISTRICT, ARKANSAS

by

R. B. Stroud, H. D. Kline, W. F. Brown and J. P. Ryan
U. S. Bureau of Mines

Printed by permission of the U. S. Bureau of Mines
Little Rock, Arkansas
1981

Previously published as USBM Reports of Investigations 5206, 5411, and 6478.

CONTENTS

United States Bureau of Mines

Report of Investigations 5206

by

H. D. Kline and J. P. Ryan

MANGANESE RESOURCES OF THE BATESVILLE DISTRICT, ARK.: INTERIM REPORT 1

by

H. D. Kline[1] and J. P. Ryan[2]

CONTENTS

TABLES

1/ Mining engineer, Bureau of Mines, Region IV, Batesville, Ark.
2/ Mining engineer, Bureau of Mines, Region IV, Rolla, Mo.

Report of Investigations 5206

ILLUSTRATIONS

INTRODUCTION AND SUMMARY

Manganese ores have been mined in the Batesville district since 1849. Although not continuous over the intervening years, production had totaled approximately 432,000 tons of manganese ore and ferruginous manganese ore to the end of 1953. The ores occur in deposits, essentially low in manganese content, distributed over an east-west belt 24 miles long and 4 to 8 miles wide, the core of which is about 6 miles north of Batesville, Independence County. Although the reserves of high-grade ores in the district are comparatively small, the large deposits of subgrade ores and low-grade manganiferous material comprise potential sources of supply of manganese that may have increasing future importance.

The manganese occurs as primary oxide and carbonate minerals in relatively flat-lying limestone and shale formations in which they were originally deposited and as oxides in residual clays resulting from decomposition of the shale and limestone. Most of the deposits underlie from a few to over a hundred feet of sedimentary chert, but many occur in the residual clays on exposed slopes of chert-covered hills.

Most of the ore production has been won by hand mining and hand sorting. Lean ores have been upgraded by using log washers and jigs to a limited extent.

In furthering its program of developing domestic sources of supply of critical and strategic minerals necessary for national defense, the Government, through various agencies, has conducted extensive investigations on manganese resources of the district. Explorations of manganese carbonate and wad deposits by the Bureau of Mines in 1940-42 and by American Zinc Co. of Arkansas, acting as agent for Metals Reserve Company, in 1942, are described in a Bureau of Mines report (6).3/ Results of phases of Bureau of Mines mineral-dressing research on processes for upgrading low-grade ores of various types are reported in Bureau of Mines reports (3, 4, 7, 8).

In 1949 the Bureau of Mines initiated a program of correlating available data on mine developments and ore production and conducting surveys and investigations to estimate reserves of various types of manganiferous material in the district. As part of the program, the Bureau in 1951 investigated manganiferous residual clays in selected sites adjacent to the Southern Hill mine in the western part of the district. The work included churn-drilling 18 holes aggregating 1,692 feet of bore and sinking 6 shafts, totaling 444 feet. To provide access to drill sites, 5,626 feet of road was made by a bulldozer. Thirteen of the drill holes cut low-grade manganese-bearing clay, and five showed only traces of manganese or were blank. From the 6 shafts, 11,710 pounds of samples of manganese-bearing clay was channel-cut and shipped to the Bureau of Mines station at Rolla, Mo., for subsequent mineral-dressing research.

3/ Underlined numbers in parentheses refer to citations in the bibliography at the end of this report.

During the latter half of 1951 the Westmoreland Manganese Corp., assisted by the Government through the Defense Minerals Administration and Defense Minerals Exploration Administration, extended the exploration of residual clays on its properties covering the Southern Hill, Page, Polk-Southard, and Turner mines. Under 2 separate contracts, the corporation churn-drilled 93 holes, aggregating 7,629 feet of bore. Residual clays containing manganese oxides were penetrated in 73 holes; 20 holes were blank. In the following year the corporation, under a contract with the Defense Materials Procurement Agency for exploiting the explored deposits, churn-drilled 103 additional holes aggregating 7,681 feet and core-drilled 12 holes aggregating 1,025 feet.

In 1953 and early 1954 the Bureau of Mines made a reconnaissance on 21 land sections in the eastern part of the district and cut 80 samples, aggregating 561 feet of vertical channel, on outcrops of manganiferous limestone. In addition, 91 samples aggregating 754 linear feet were cut from residual manganiferous deposits in the area.

The factual data obtained from explorations by the Bureau of Mines and Westmoreland Manganese Corp. and data on the reconnaissance of manganiferous areas in the eastern part of the district are presented in this report, which covers the period from June 1949 to July 1954. The results of subsequent investigations and reconnaissance of manganiferous areas will be reported at future intervals as the work progresses.

ACKNOWLEDGMENTS

The cooperation of the various property owners and lessees is gratefully acknowledged. Thanks are especially due to H. H. Holloway, William Stringham, and Fuller Highsmith, former executive officers of the Westmoreland Manganese Corp., for supplying information on exploration drilling by the corporation.

LOCATION AND PHYSICAL FEATURES

The Batesville manganese district, as usually defined, is an area 24 miles long from east to west and 4 to 8 miles wide from north to south, lying mainly in Independence County, with extensions west into Izard and Stone Counties and north into Sharp County. The more active part of the district is bounded on the east by the meridian of Pfeiffer post office and on the west by West Lafferty Creek. The most southerly mine, the Cason, is 2-1/2 miles north of Batesville, a city of about 6,500 population and the county seat of Independence County (fig. 1).

The district is a hilly area on the southern border of the Ozark Plateau. Drainage is southward into White River through Cave Creek, Sullivan Creek, Polk Bayou, East Lafferty Creek, West Lafferty Creek, Wilson Creek, and lesser tributaries. Altitudes range from about 300 feet in the hollows to about 800 feet on the highest hills.

Some of the region is under cultivation; but, on the whole, it is classed as lightly to well wooded grazing land. Oak, hickory, walnut, and ash are available and are conserved for mine timbering.

Spur lines of the Missouri Pacific Railroad and hard-surface roads run from Batesville to Pfeiffer on the east and to Cushman in the west central part of the district. Branching secondary roads feed the major sectors of the district; semi-improved roads and trails serve most of the mines.

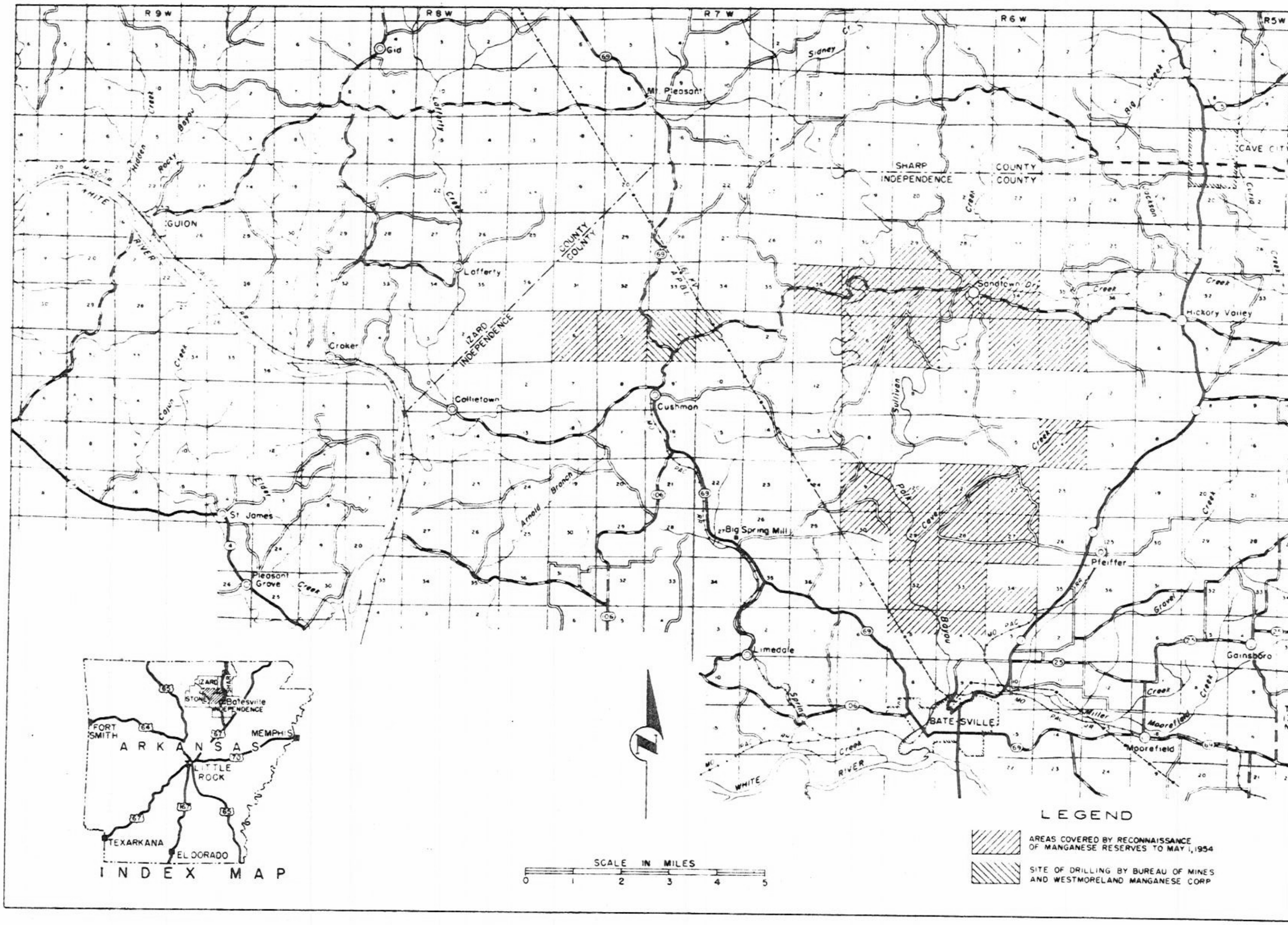


Figure 1. - Batesville manganese district, Ark.

PROPERTY OWNERSHIP

Ownership and description of the properties on which the Bureau of Mines conducted churn-drilling and shaft-sinking investigation in 1951 follow.

Land description (T. 14 N., R. 7 W.)	Acres	Owned or controlled by	Leased to
NW1/4SE1/4 sec. 4	40	Southern Mining & Manganese Co.	Westmoreland Manganese Corp.
SE1/4NE1/4 sec. 4	40	Westmoreland Manganese Corp.	-
Part of NE1/4SE1/4 sec. 4 lying north of WPA	2.05	Stella Henry	-
NE1/4SW1/4 sec. 4	40	Southern Mining & Manganese Co.	Westmoreland Manganese Corp.
Part of NE1/4SE1/4 sec. 4 lying south of WPA road	37.95	R. F. Wilson and R. M. Baxter	-

The tracts covered by the Bureau of Mines reconnaissance in 1953 and 1954 are owned or controlled by various persons not listed herein.

HISTORY AND PRODUCTION

Since 1849, when mining began, to the end of 1953 total production from the manganese deposits of the Batesville district was approximately 196,000 long tons of manganese ore (35 or more percent manganese) and 236,000 tons of ferruginous manganese (10 to 35 percent manganese). Most of the output was obtained during two periods of continued activity - from 1885 to 1898 and from 1915 to the present (1954). Peaks of production were reached during World Wars I and II, 1917-18 and 1944-45. Many early mine operations and the individuals and organizations connected with them are described by Miser (1).

GEOLOGY AND ORE DEPOSITS

The geology and manganese mineralization of the Batesville district are adequately described by Miser (1, 2). The rocks of the area are sedimentary and consist of sandstone, limestone, shale, and chert ranging in age from Ordovician to Carboniferous. A generalized section of the formations present is given in figure 2. Of these formations, Fernvale limestone and the Cason shale - host rocks of the primary manganese mineralization - are of maximum importance.

Structural deformation of the rocks is not pronounced. Only a few displacement faults are evident, and folding is limited to anticlines and synclines of local import. For the most part the formations occupy nearly horizontal positions, with a slight general dip southward.

The Boone chert overlies much of the district. Remnants of the lower part of the formation crown most of the hills in the manganiferous area, and chert boulders comprise much of the talus accumulations on the hillsides. In places the chert lies on Devonian or Silurian rocks - all lenticular formations of sporadic occurrence in the district - but for the most part it rests on Cason shale, on Fernvale limestone where the Cason is absent, or on residual clays resulting from weathering and decomposition of these formations.

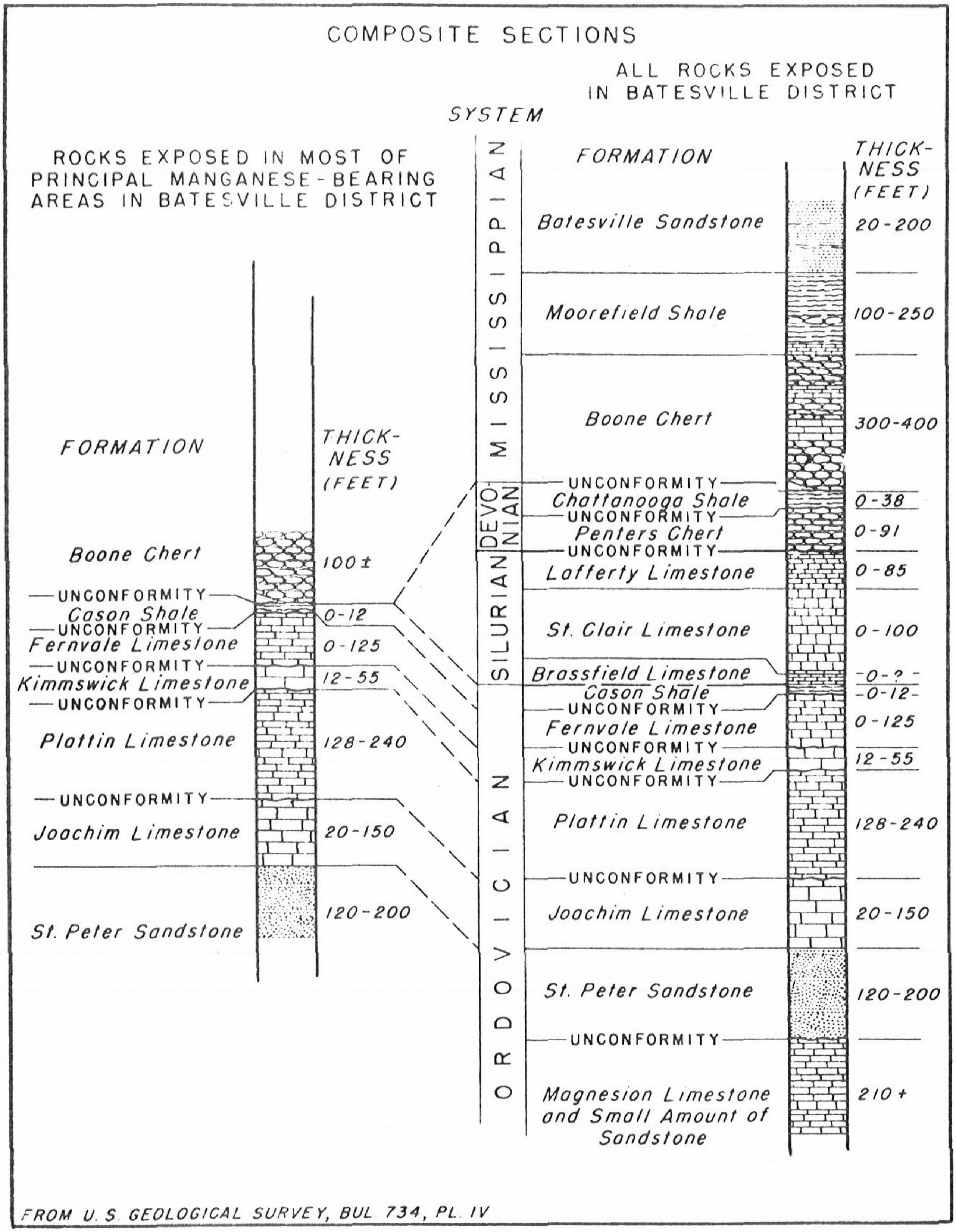


Figure 2. - Generalized sections of the Paleozoic rocks exposed in the Batesville district.

The Cason shale is a phosphatic, lenticular formation renging in thickness from a feather edge to 12-1/2 feet. It occurs mainly in the eastern and western parts of the district and is absent over much of the central part.

The Fernvale limestone, which has been eroded from much of the district and has a maximum thickness of about 125 feet where present, rests unconformably on the Kimmswick limestone. Weathering and solution of the formation have progressed downward irregularly - in some places slightly, in others it has completely altered the limestone to residual clays, which rest on deeply eroded and pitted limestone surfaces.

The manganese mineralization is ascribed to deposition of carbonated and oxides from circulating hypogene solutions in the top beds of the Fernvale limestone and in the Cason shale. Prevalent manganese minerals in the district, in order of abundance, are the oxides, carbonates, and silicates. The principal oxides are hausmannite, psilomelane, braunite, wad, manganite, and pyrolusite. Rhodochrosite and other carbonates are widely distributed. The silicates bementite and neotocite have been identified.

The principal types of manganese deposits are:

1. Unaltered or slightly altered deposits of the primary minerals, rhodochrosite, hausmannite, and braunite, in place in the Cason shale and upper 30 to 50 feet of the Fernvale limestone under protective covers of Boone chert or St. Clair limestone. The manganese content of these deposits seldom exceeds an average of 5 percent, but, in places, concentrations in the Cason shale and upper few feet of the Fernvale limestone contain enough manganese to have been mined and marketed as "carbonate ore" and "ledge ore" containing a maximum of 40 percent manganese.

2. Irregularly distributed deposits of oxides and wad in residual clays lying on upper Ordovician limestones, principally the Fernvale limestone, under mantles of Boone chert. The clays have resulted from weathering and solution of Cason shale and Fernvale limestone, the disintegration of which caused slumping and shattering of the chert beds.

3. Deposits in residual clays and talus, usually representing both vertical slumpage and downslope creep of deposits of type 2 from which the Boone chert and other rock covering has been eroded. The absence of excessive overburden makes these hillside deposits available for comparatively low cost prospecting and mining - hence, they have accounted for a considerable part of the ore production of the district.

4. Placer deposits resulting from water transportation of type 3 deposits to other sites. The attendant washing has removed much of the clay and fine-size manganese minerals, leaving the coarser particles and lumps of oxides in a matrix of soil, gravel, and boulders.

The manganese deposits of the Southern Hill, Page, Polk-Southard, and Turner mines and vicinity correspond to type 2. The deposits occur in an irregular blanket of residual clay overlain by bedded Boone chert or fragmental Boone chert with clay filling and resting on Fernvale limestone or on Kimmswick or Plattin limestones where the Fernvale is completely disintegrated. The surface of the limestone is deeply serrated and presents a profile of alternating pits, into which the clay bed has subsided, and pinnacles of limestone, which extend into the clay; in places the chert has slumped below the tops of the pinnacles. The clay bed ranges in thickness from a few feet near the tops of the pinnacles to as much as 60 feet in the hollows in the limestone. The bed of residual clay persists over the area except where removed by erosion, but the manganese deposits in it are sporadic and of dissimilar mineral characteristics, although all the manganese minerals are oxides, principally a psilomelane-type oxide. Hausmannite, wad, and pyrolusite are present also. The iron content, in the form of oxides, exceeds that of total manganese.

Although the deposits of the Batesville district generally are composed of bodies of low-grade manganiferous material in which the manganese minerals are predominantly fine size, many contain hand-sortable chunks of high-grade oxides in sufficient quantity and grade to make selective mining by hand methods profitable. Attempts have been made to upgrade the lean oxide ores by using log washers and jigs, and several such plants were in operation in early 1954 (fig. 3). Because such methods do not recover fine-sized manganese minerals, their economical use is restricted to deposits that contain more than normal quantities of coarse, hard psilomelane and hausmannite.

DEVELOPMENT AND MINING

Both hand-mining methods, through shafts, tunnels, and small pits, and mechanized operations in large opencuts have been used in developing and recovering the ores in the Batesville district. Much of the manganese ore was produced by hand mining from many small underground mines (fig. 3). In recent years, bulldozers and power shovels have been used to a considerable extent in exploiting the manganese deposits, and most of the operators are currently using a combination of mechanical and hand-mining methods. In present practice the overburden is usually stripped from a manganese-bearing clay deposit with a bulldozer, and hand miners using picks and shovels and wheelbarrows dig and sort out the high-grade lump ore for direct shipment. The remaining manganiferous material containing the finer-size manganese minerals is stored separately and sent to a log washer or washer-jig-type mill if considered of suitable grade; otherwise, it is wasted. In some opencut mines, where conditions permit, the entire face of manganiferous clay is dug with a shovel or dragline, loaded in trucks, and hauled to a central washing plant for treatment to recover a manganese concentrate. Shaft mining, which produced a large part of the ore in past years, is still used in several places. The shafts, ranging in depth from 20 to 130 feet or more, are sunk vertically through chert and clay capping to the ore horizon with a pick and shovel. Cribbing split from oak logs is used to support the shaft walls. The waste rock and manganese-bearing material are loaded into small buckets and removed from the shaft by hand or power winches. Mechanical blowers generally are used to ventilate the deeper shafts, although kerosine burners, utilized extensively in the past to create an updraft and provide ventilation, are still used in a few shafts. Because of the irregular distribution of the ore bodies, their small size, and the unevenness of the underlying limestone surface, underground workings usually are not extended far from the shafts. It is considered generally more economical to sink new shafts in the search for ore than to extend the workings laterally any appreciable distance from the shaft. In areas where churn-drilling exploration disclosed ore, shafts were sunk over the drill holes; advantage was taken of the existing holes to facilitate development and mining of the indicated ore bodies.

Because of the wide variation in mineral characteristics and grade of most of the deposits mining was highly selective; and, as a result of fluctuating manganese prices, much of the manganiferous material that could be mined only during periods of high prices was wasted when prices were low.

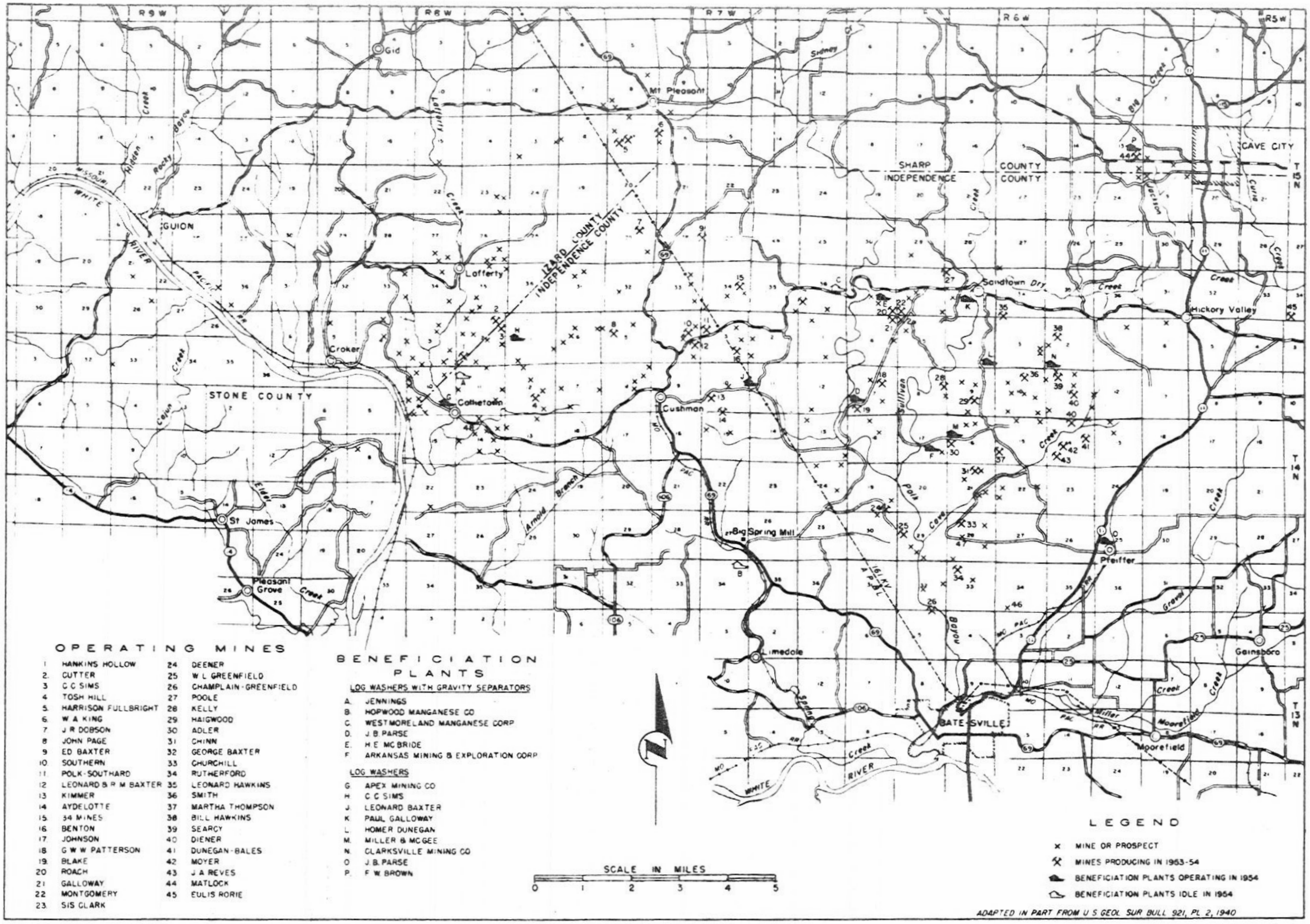


Figure 3. - Mines, prospects, and beneficiation plants, Batesville manganese district, Ark.

Much of the ore mined during the past 12 years was discovered and developed as a result of drilling and shaft sinking financed by Government agencies during World War II. Most of the shallow, higher grade deposits found in this work have been mined or are being exploited.

WORK BY BUREAU OF MINES

Exploration - Southern Hill and Vicinity

Churn Drilling

The churn-drill holes bored by the Bureau of Mines in the early part of 1951 were located generally east and west of the Southern Hill opencut mine, in areas where geological conditions favor extensions of known manganese-ore-bearing clays (fig. 4). Eighteen holes aggregating 1,697 feet of bore were drilled. Approximately 5,626 feet or road was made with a bulldozer to provide access to drill-hole sites. All holes were drilled with an 8-inch bit through overburden and chert to the horizon in the clay bed at which sampling was to begin. Then 6-1/4-inch casing was installed and drilling continued through the manganese-bearing zone with a 6-inch bit, the casing following closely - within a few inches of the bottom of the hole - to avoid contamination.

The sampling procedure follows: When the bailing sludge became dark, indicating that manganese-bearing clay had been penetrated, it was discharged into a trough connected to a Jones-riffle-type splitter; one half of the sludge was caught in tubs and the other half discharged as tailings. Part of the sludge retained in the tub was immediately panned; if appreciable manganese was present, casing was installed in the hole, the drill-run cut to 2-1/2 feet, and sampling continued. The sludge caught in the tub was sent to the drier in capped pails, where it was transferred into drying tubs. After the entire sample was dried, it was quartered with a Jones riffle-type splitter. One quarter was panned and redried for mineral observation; the second quarter was shipped for analyses; the third quarter was stored locally; and the fourth quarter was shipped to Rolla for storage. In all, 75 samples were analyzed by a commercial laboratory. Pertinent data on Bureau of Mines churn-drill holes are shown in table 1; the detailed logs of the holes are presented at the end of this report.

Shaft Sinking

To obtain large samples for mineral-dressing tests on the manganese-bearing clays penetrated in the drill holes in the Southern Hill area, 6 shafts aggregating 444 linear feet were sunk over churn-drill holes. Of this total, 299 feet was sunk over holes bored by the Bureau of Mines and 145 feet over holes bored by Westmoreland Manganese Corp. under DMEA contracts subsequent to Bureau drilling (fig. 4). Samples aggregating 11,710 pounds were taken from the shafts and shipped to the Bureau of Mines laboratories at Rolla, Mo.

The shafts were sunk, for the most part, with pick and shovel. The hard chert capping was loosened by setting off blasting charges, as required, in the drill hole. Cribbing was split from oak logs and installed to maintain a cross section 4 feet square. Power winches were generally used to remove the rock and clay loaded into small buckets.

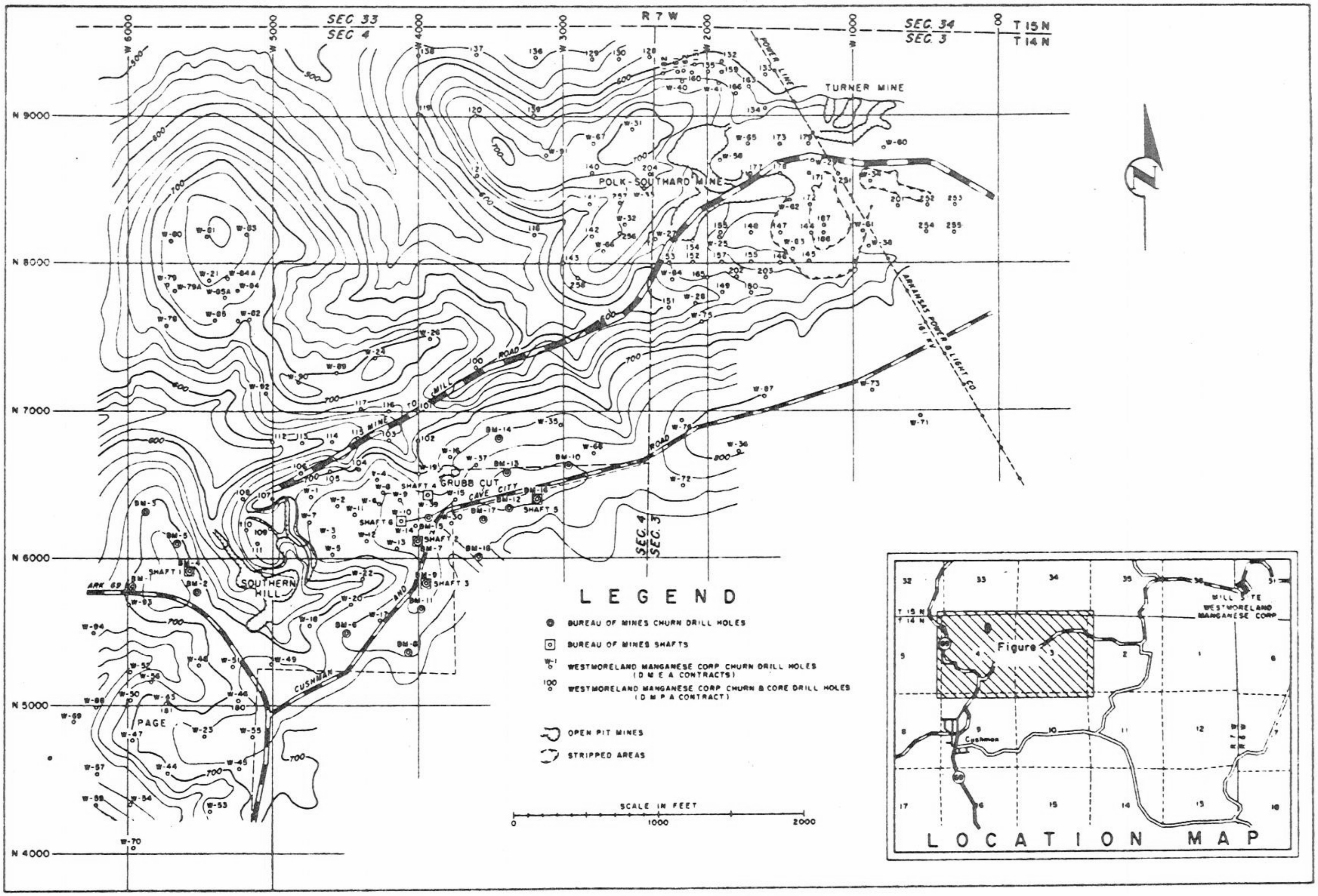


Figure 4. - Southern Hill, Page, Polk-Southard, and Turner sites.

TABLE 1. - Pertinent data on holes drilled by the Bureau of Mines

Hole No.	Coordinates, feet		Collar elevation, f.a.s.	Completed depth, feet	Soil, chert, clay		Manganiferous clay					
							Interval, feet		Thickness, feet	Analysis, percent		
	North	West			From-	To-	From-	To-		Mn	Fe	P
BM-1	5,807	5,971	717	85	0	45	45	75	30	Trace	-	-
BM-2	5,765	5,523	715	78-1/2	0	40	40 70	60 75	20 5	2.74 2.61	5.45) 8.50)	0.54
BM-3	6,313	5,879	702	85	0	45	45	55	10	Trace	-	-
BM-4	5,912	5,586	717	64	0	43-1/2	43-1/2	51	7-1/2	3.83	11.3	1.45
BM-5	6,100	5,664	712	65	0	35	35	45	10	1.80	10.4	.70
BM-6	5,488	4,474	744	123	0	90	90	115	25	2.06	5.86	.29
BM-7	6,117	3,985	765	108	0	70	70	85	15	6.82	12.63	.36
BM-8	5,353	4,045	744	123	0	105	105	110	5	Trace	-	-
BM-9	5,827	3,919	766	120	0	82-1/2	82-1/2	100	17-1/2	7.30	13.17	1.38
BM-10	6,627	2,936	788	99	0	90	90	92-1/2	2-1/2	3.67	9.10	1.85
BM-11	5,650	3,950	763	62	0	47-1/2	47-1/2	57-1/2	10	2.78	10.70	2.50
BM-12	6,335	3,353	783	150	0	108-1/2	108-1/2	145	36-1/2	4.51	8.40	1.40
BM-13	6,582	3,369	791	53	0	45	45	50	5	Trace	-	-
BM-14	6,815	3,412	759	32-1/2	0	22-1/2	22-1/2	27-1/2	5	1.66	8.00	1.11
BM-15	6,276	3,908	763	168	0	157-1/2	157-1/2	165	7-1/2	2.63	8.03	1.69
BM-16	6,399	3,151	781	56	0	42-1/2	42-1/2	52-1/2	10	4.58	12.30	.52
BM-17	6,261	3,529	778	105	0	80	80	100	20	3.66	10.15	.71
BM-18	6,012	3,549	760	115	0	115	-	-	-	-	-	-

The manganese-bearing clay samples were obtained by cutting a channel 12 inches wide and 4 inches deep in each of the 4 walls, giving, theoretically, 1-1/3 cubic feet of sample material in place for each 1-foot depth of shaft. All shaft samples were analyzed in the Bureau of Mines laboratory at Rolla, Mo.

Pertinent data on shafts sunk by the Bureau of Mines are shown in table 2.

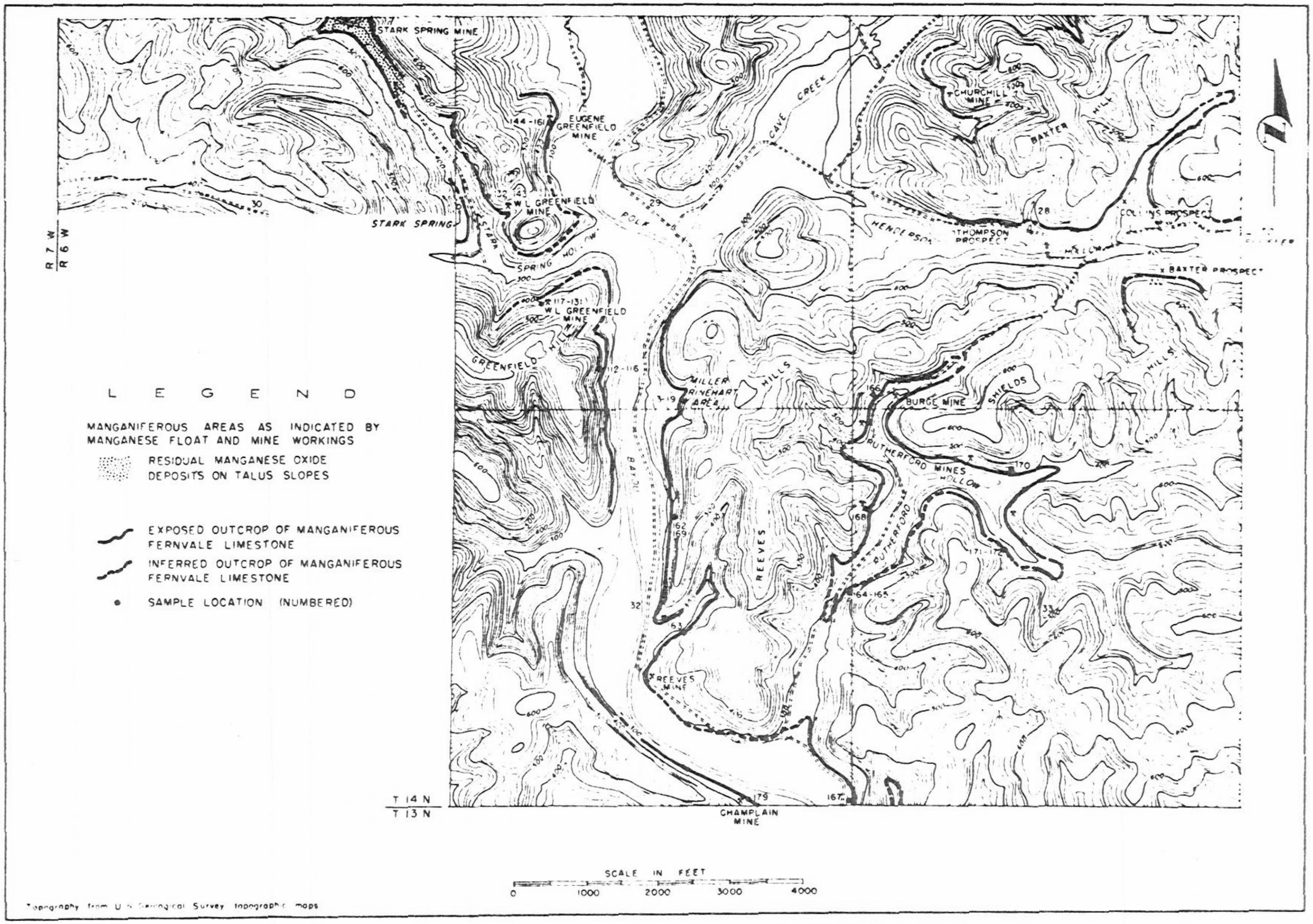
TABLE 2. - Pertinent data on shafts sunk by the Bureau of Mines

			Manganiferous clay						
	Over drill	Completed depth,	Interval, feet		Thickness,	Analysis, percent			Sample weight,
Shaft	hole-	feet	From-	To-	feet	Mn	Fe	P	pounds
1	BM-4	52	40-1/2	51-1/2	11	3.3	11.5	1.35	1,705
2	BM-7	85	71	84	13	11.7	19.5	.65	2,090
3	BM-9	110	83	100	17	9.7	13.3	1.50)	
								)	4,535
			100	110	10	2.8	7.6	2.42)	
4	W-39	76	59	76-1/2	17-1/2	9.8	12.1	1.02	2,140
5	BM-16	52	42	52	10	4.5	9.0	1.22)	
								)	1,240
6[1]	W-10	69	60	65	5	-	-	-)	

1/ Shaft not completed.

Reconnaissance of Manganiferous Areas

Early in 1953 the Bureau of Mines began reconnaissance of manganiferous areas to provide basic data for estimating reserves and evaluating the manganese potential of the Batesville district. To date, manganiferous areas in 21 land sections in the eastern part of the district have been surveyed, sampled, and mapped, and reserves have been estimated (fig. 1). Types of deposits, sample sites, and other data on the manganiferous areas are shown in figures 5 through 10. In sampling areas containing manganiferous clays, trenches and pits were dug to expose as much as practicable of the thickness of the residual clay, and 2- by 5-inch vertical channels were cut from the face of the trench or side of the pit. Outcrops of manganiferous limestone on hillsides were sampled by cutting vertical channels across the beds. Eighty-one trenches and pits aggregating 916 linear feet were excavated in the clay, and 754 linear feet was sampled. In the limestone an aggregate of 561 linear feet of 2- by 5-inch channel sample was cut. In all, 171 samples were taken from 101 separate sites; of these, 91 were manganiferous clay, and 80 were manganiferous limestone. To date, approximately 25 percent of the district has been covered by the survey. Pertinent data on samples of manganiferous clays and limestones are shown in tables 3 and 4.



Topography from U.S. Geological Survey topographic maps

Figure 5. - Manganiferous areas, sections 28, 29, 32, and part of 30, T. 14 N., R. 6 W., Independence County, Ark.

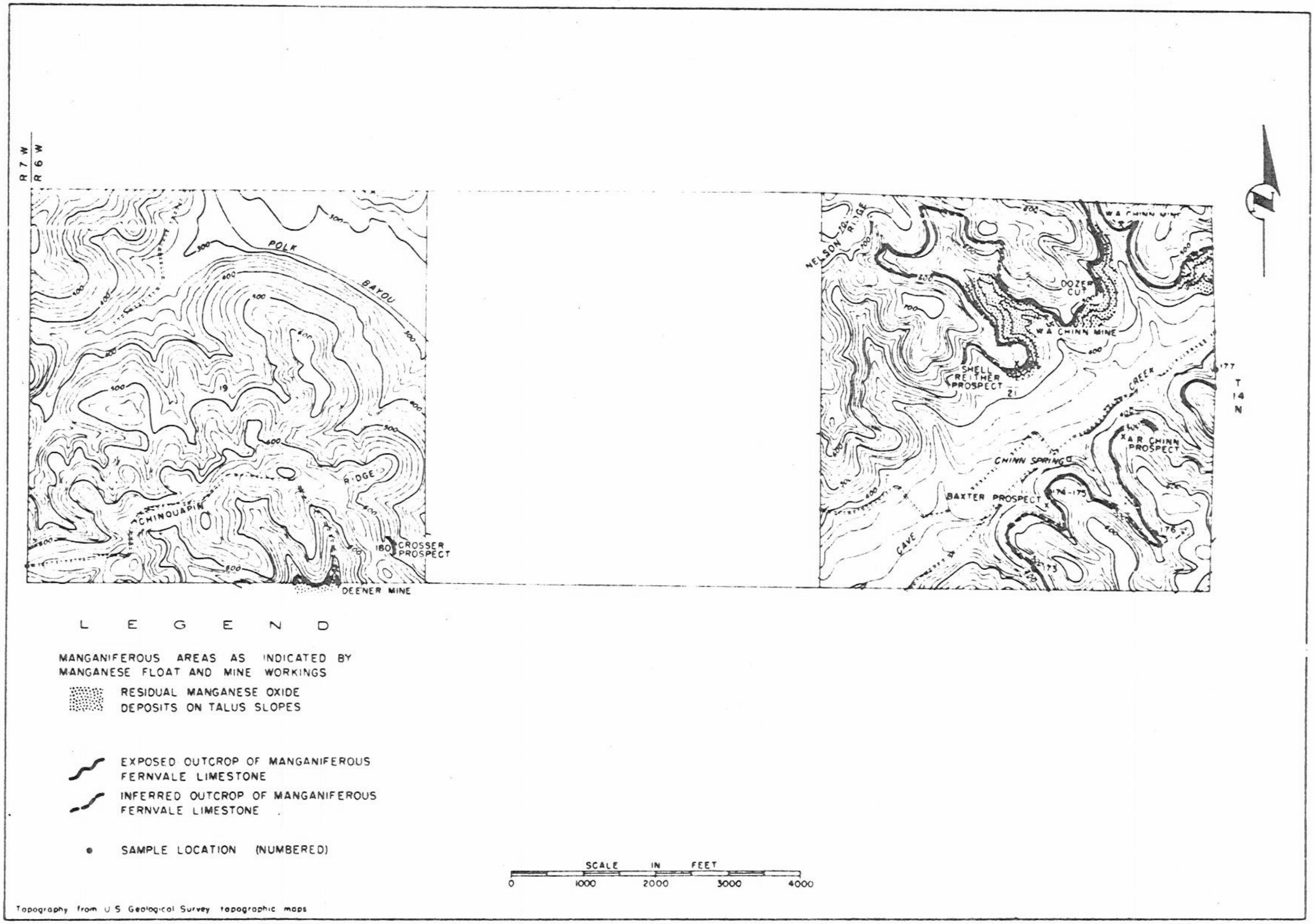


Figure 6. - Manganiferous areas, sections 19 and 21, T. 14 N., R. 6 W., Independence County, Ark.

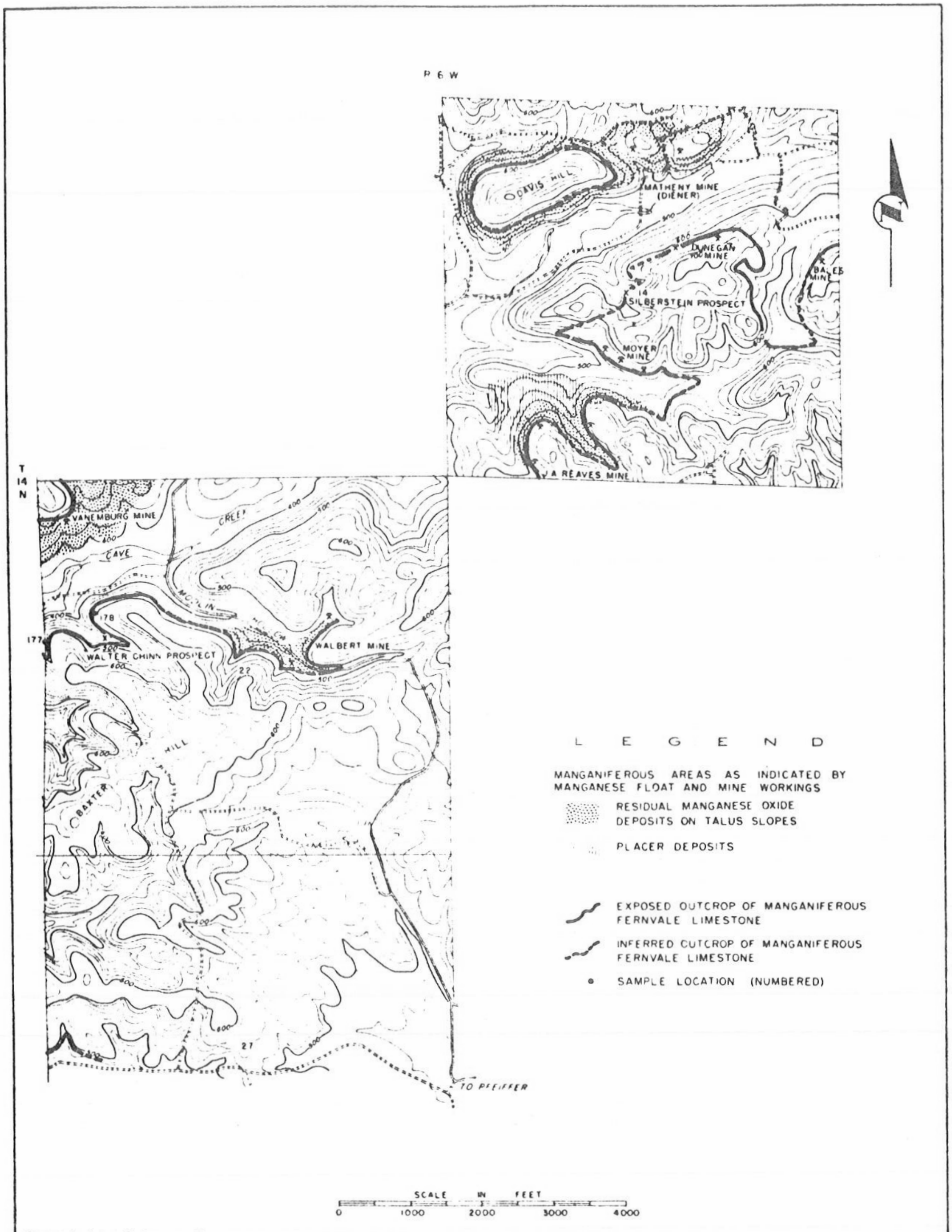


Figure 7. - Manganiferous areas, sections 14, 22, and part of 27, T. 14 N., R. 6 W., Independence County, Ark.

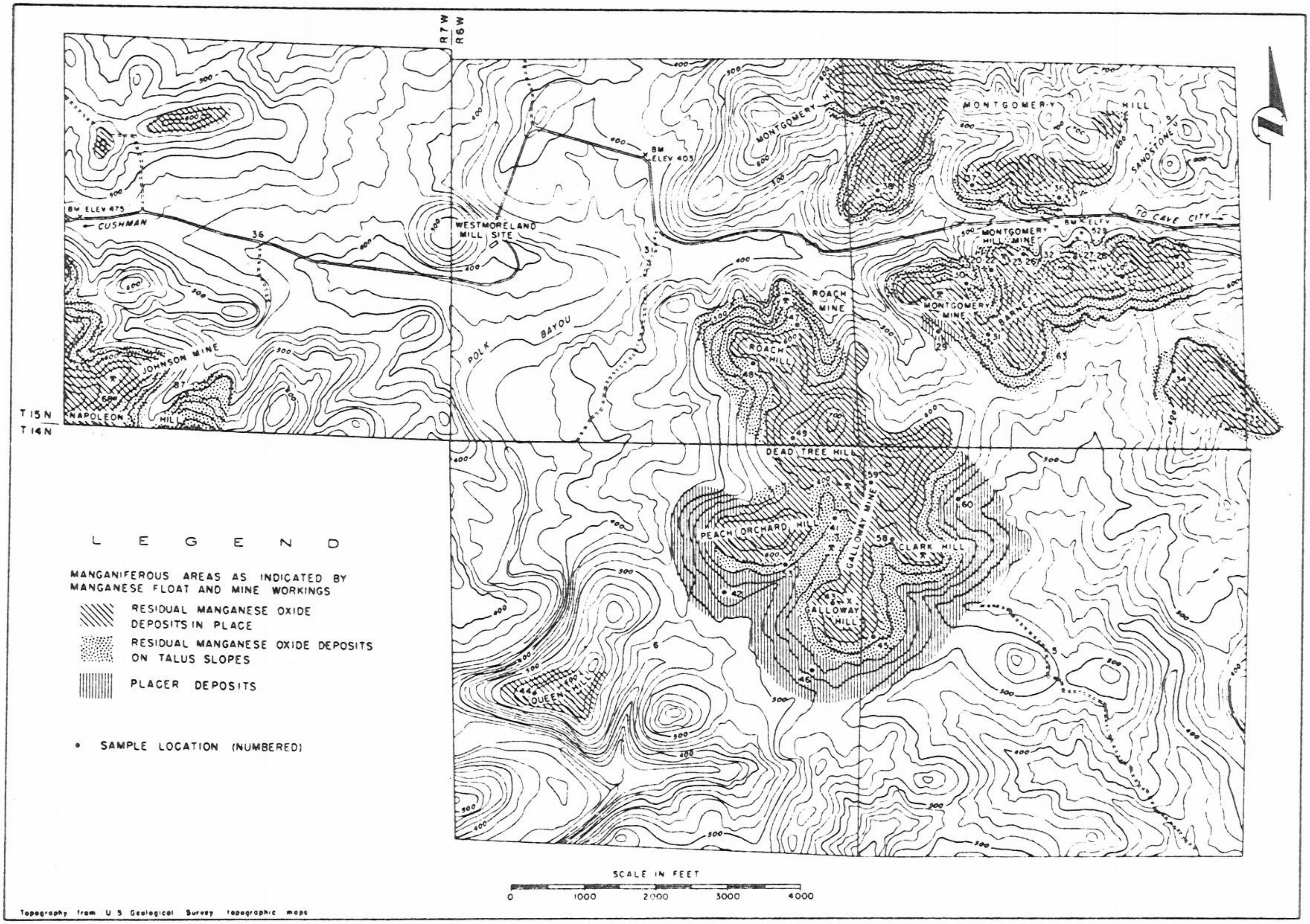


Figure 8. - Manganiferous areas, sections 5 and 6, T. 14 N., R. 6 W.; sections 31 and 32, T. 15 N., R. 6 W.; section 36, T. 15 N., R. 7 W., Independence County, Ark.

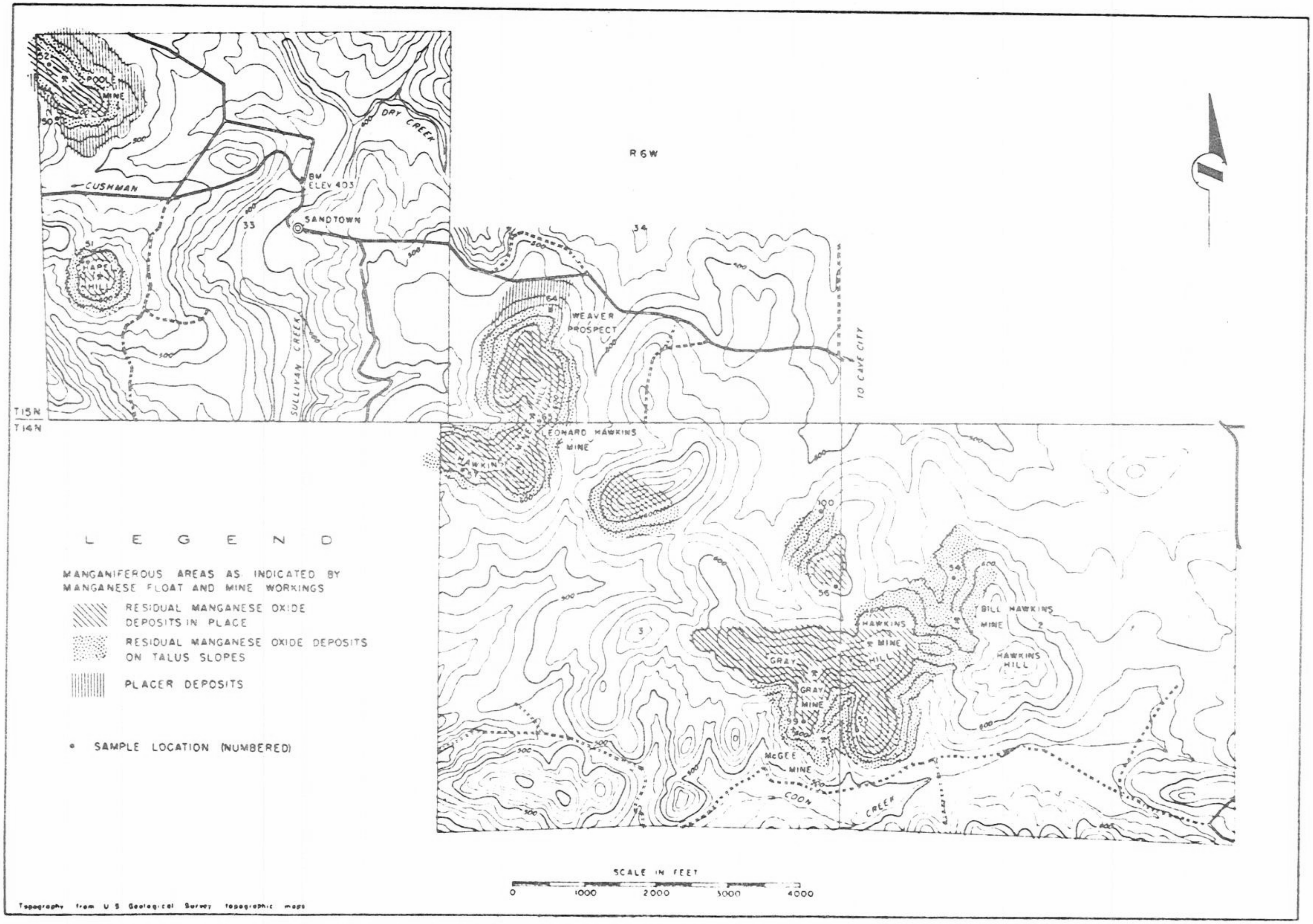


Figure 9. - Manganiferous areas, sections 2 and 3, T. 14 N., R. 6 W.; sections 33 and part of 34, T. 15 N., R. 6 W., Independence County, Ark.

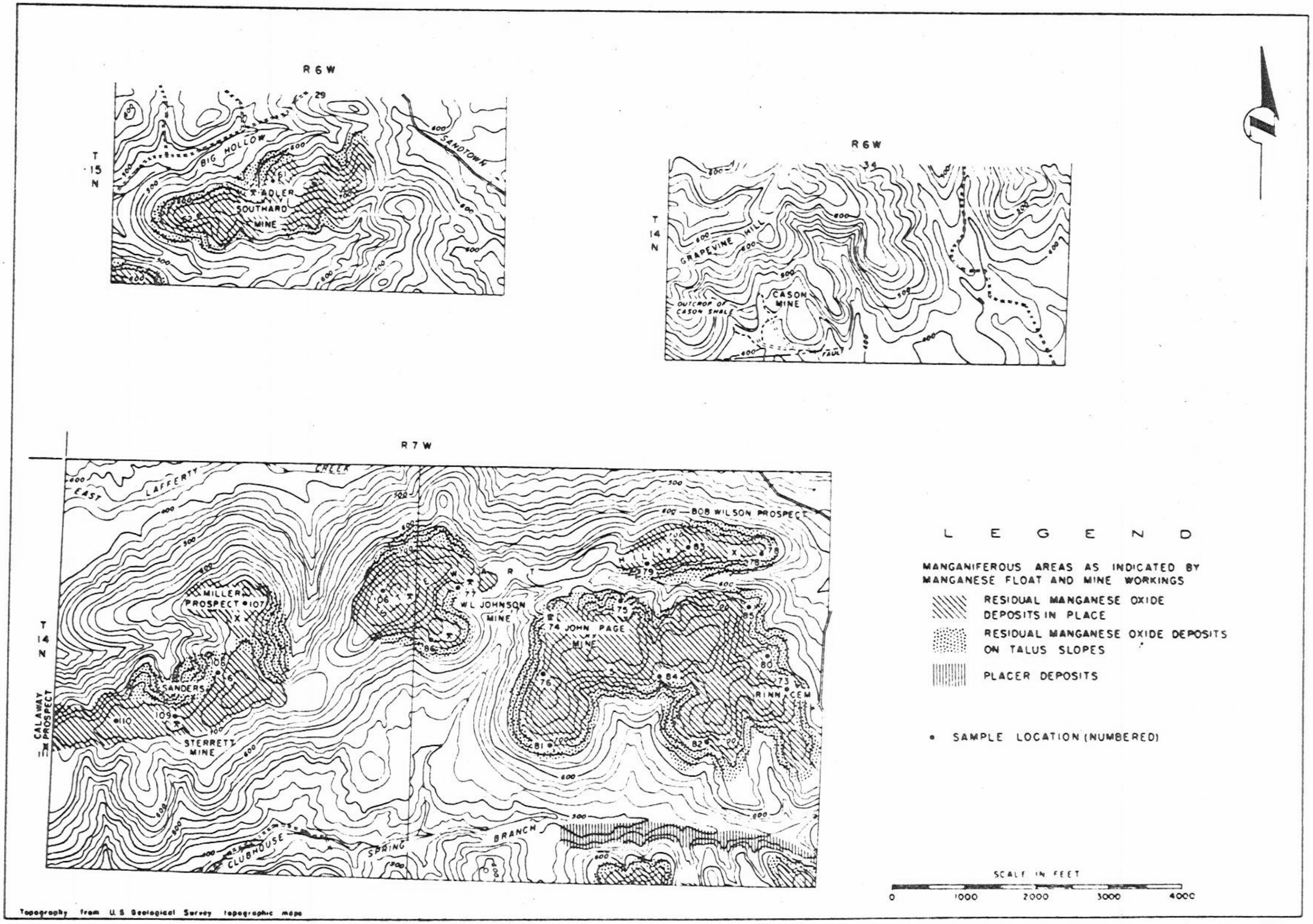


Figure 10. - Manganiferous areas, section 34, T. 14 N., R. 6 W.; sections 5 and 6, T. 14 N., R. 7 W.; section 29, T. 15 N., R. 6 W.; Independence County, Ark.

TABLE 3. - Pertinent data on samples of manganiferous clays

Sample No.	Location: Feet from southwest corner: North	East	Sec.	T.(N)	R.(W)	Thickness sampled, feet	Analysis, percent: Mn	Fe	P	Insol.
15 - 19	130	3,170	29	14	6	25	8.01	13.68	1.52	29.60
20 - 22	2,442	1,980	32	15	6	13-1/2	5.88	10.37	.47	-
23 - 26	2,640	2,376	32	15	6	17-1/2	11.63	11.43	.47	-
27 - 28	2,580	3,102	32	15	6	9	4.33	7.18	.47	-
29	1,584	1,122	32	15	6	5	3.54	6.80	.31	-
30	2,244	1,452	32	15	6	11	11.22	13.00	.31	-
31	1,518	1,716	32	15	6	10	1.69	5.00	.31	-
32	2,310	3,630	32	15	6	14	5.61	12.00	.31	-
33	2,640	4,356	32	15	6	18	5.23	6.10	.31	-
34	1,056	4,290	32	15	6	12	11.53	9.50	.33	-
35	528	40	33	15	6	22	10.61	11.61	.33	-
36	3,432	2,770	32	15	6	14	14.38	11.10	.37	-
37	3,564	1,584	32	15	6	12	4.54	7.00	.37	-
38	3,430	330	32	15	6	16	10.15	9.60	.37	-
39	4,686	390	32	15	6	9	15.38	10.38	.37	-
41	4,620	5,220	6	14	6	10	21.37	12.45	.30	-
42	3,630	3,640	6	14	6	4	6.80	5.90	.30	-
43	3,234	5,150	6	14	6	10	9.42	10.95	.30	-
44	1,980	1,056	6	14	6	4	12.07	11.95	.29	38.18
45	3,828	210	5	14	6	4	3.08	28.35	.30	37.17
46	2,574	4,884	6	14	6	5	3.87	5.15	.30	-
47	1,650	4,752	31	15	6	23	12.30	17.95	.30	-
48	1,122	4,092	31	15	6	5	13.07	10.00	.30	-
49	50	2,752	31	15	6	6	17.60	13.95	.30	-
50	4,092	110	33	15	6	5	2.46	4.85	.26	-
51	2,170	495	33	15	6	13	8.07	11.80	.46	48.45
52	4,818	-	33	15	6	6	18.11	6.25	.42	30.23
53	3,960	4,488	6	14	6	17	22.29	16.10	.30	-
54	3,432	1,584	2	14	6	9	7.69	15.15	.35	-
55	1,386	200	2	14	6	9	4.46	12.70	.35	-
56	3,300	5,478	3	14	6	4	9.38	13.85	.42	-
57	4,950	220	3	14	6	4	18.60	17.45	.42	-
58	4,356	400	5	14	6	12	13.84	12.85	.30	-
59	5,148	140	5	14	6	8	10.76	9.80	.79	-
60	4,884	1,386	5	14	6	10	5.38	9.55	.30	-
61	1,452	2,178	29	15	6	11	14.61	21.15	.79	-
62	930	1,188	29	15	6	4	12.30	24.30	.26	-
63	1,325	2,508	32	15	6	7	6.84	9.45	.31	-
64	1,518	1,400	34	15	6	7	9.53	9.90	.42	-
65	20	1,254	34	15	6	4	19.99	13.00	.42	-
68	390	700	36	15	7	16	10.92	9.70	.28	-
73	2,574	5,148	5	14	7	8	4.46)			-
74	3,498	1,848	5	14	7	9	6.38)			-
75	3,762	2,838	5	14	7	5	5.54)			-
76	2,772	1,782	5	14	7	13	3.54)			-
77	3,960	530	5	14	7	7	12.92)			-
78	4,488	4,752	5	14	7	5	14.92)			-
79	4,290	3,168	5	14	7	6	7.87)	9.80	.44	-
80	2,970	4,884	5	14	7	7	15.53)			-
81	1,790	1,914	5	14	7	6	3.23)			-

TABLE 3. - Pertinent data on samples of manganiferous clays (Con.)

Sample No.	Location: Feet from southwest corner North	East	Sec.	T.(N)	R.(W)	Thickness sampled, feet	Analysis, percent Mn	Fe	P	Insol.
82	1,848	4,092	5	14	7	7	12.46)			-
83	4,438	3,828	5	14	7	6	12.00)			-
84	2,710	3,432	5	14	7	5	8.37)			-
85	3,675	4,620	5	14	7	9	9.54)			-
86	3,234	228	5	14	7	7	14.61)			-
87	495	1,720	36	15	7	9	10.92	13.00	0.36	-
99	1,452	5,082	3	14	6	14	14.30	16.00	1.15	-
100	4,356	5,200	3	14	6	6	10.30	12.50	.27	-
106	3,696	4,356	6	14	7	7-1/2	15.38)			-
107	3,564	2,640	6	14	7	12	11.53)			-
108	2,772	2,310	6	14	7	12	3.84)	3.60	.34	-
109	2,064	1,640	6	14	7	10-1/2	1.85)			-
110	1,985	915	6	14	7	13-1/2	8.61)			-
111	1,650	5,250	1	14	8	13-1/2	7.53)			-

TABLE 4. - Pertinent data on samples of manganiferous Fernvale limestone

Sample No.	Location: Feet from southwest corner North	East	Sec.	T.(N)	R.(W)	Thickness sampled, feet	Analysis, percent Mn	Fe	P	Insol.
3 - 14	130	3,170	29	14	6	30	5.36	2.48	0.34	1.88
112 - 116	560	2,046	29	14	6	12-1/2	8.60	1.80	.30	.31
117	1,452	1,188	29	14	6	2-1/2	1.46	9.30	.33	2.13
118 - 129	1,452	1,188	29	14	6	30	4.04	9.30	.33	2.13
130	1,452	1,188	29	14	6	2-1/2	2.15	9.30	.33	2.13
131	1,452	1,188	29	14	6	2-1/2	.92	9.30	.17	2.13
132 - 143	2,902	429	29	14	6	30	3.41	1.80	.31	1.72
144 - 161	3,894	1,320	29	14	6	44	5.72	3.00	.20	1.38
162	3,960	3,102	32	14	6	40	3.69	2.70	.33	2.54
163	2,508	2,970	32	14	6	22-1/2	4.31	3.10	.33	2.30
164	2,970	5,478	32	14	6	7-1/2	4.00	1.70	.17	.70
165	2,970	5,478	32	14	6	27-1/2	5.38	2.50	.33	1.80
166	140	325	28	14	6	30	5.38	3.00	.40	3.12
167	75	-	33	14	6	30	4.31	2.25	.26	2.50
168	4,092	175	33	14	6	20	4.00	2.75	.29	1.84
169	3,960	3,102	32	14	6	27-1/2	6.61	2.35	.27	2.22
170	4,620	2,178	33	14	6	30	4.46	2.25	.25	2.23
171	3,498	2,112	33	14	6	10	3.23	2.25	.30	2.59
172	3,498	2,112	33	14	6	15	5.23	2.50	.32	2.43

EXPLORATION BY WESTMORELAND MANGANESE CORP.

In 1951, the Westmoreland Manganese Corp., under 2 exploration contracts with the Government through Defense Minerals Exploration Administration, churn-drilled 93 holes aggregating 7,629 feet of bore on mine tracts extending east and west from the Southern Hill area (fig. 4). The drilling exploration disclosed substantial reserves of low-grade, manganese-bearing clay. In 1952 and 1953, under a contract with Defense Materials Procurement Agency for exploitation of the deposits discovered by the exploratory drilling, the corporation churn-drilled an additional 103 holes aggregating 7,681 feet and core-drilled 12 holes aggregating 1,025 feet of bore. Most of the holes drilled under DMPA contracts were in areas stripped of overburden. Pertinent data on the holes drilled by Westmoreland Manganese Corp., which penetrated clay containing 3 percent or more manganese over a minimum thickness of 6 feet, are given in table 5. Most of the analyses shown are the weighted averages of the analyses of several samples.

RESERVES OF MANGANIFEROUS MATERIALS

Estimated reserves of manganiferous residual clays or deposits derived from them, with estimated reserves of manganiferous Fernvale limestone, are summarized in table 6. The quantity and grade of the manganese-bearing materials are based on the results of churn-drilling exploration by the Bureau of Mines and Westmoreland Manganese Corp. in the western part of the district and on the results of reconnaissance to date by the Bureau in the eastern part of the district. Reserves of wad manganese disclosed by drilling explorations conducted by the Bureau of Mines and the American Zinc Co. of Arkansas during the period 1940-42 (6) are not included in table 6; these deposits, only a small part of which have been exploited, are estimated to contain at least 1,200,000 long dry tons averaging 23 percent manganese.

Owing to the irregular distribution and erratic content of the manganiferous clays and the general scarcity of exploratory openings in the areas covered by reconnaissance an estimate of their quantity and grade is only an approximation, unless exploration and sampling are more detailed. In areas inferred to contain manganiferous clays, 30 percent of the area was assumed to be ore bearing, and of the areas covered by manganese-bearing talus deposits, 10 percent was inferred to contain residual ore. A factor of 25 cubic feet per long dry ton of material in place was used in calculating tonnage. The extent and grade of the deposits of manganiferous limestone are more uniform than the clay deposits; hence in estimating reserves of manganiferous limestone, 40 percent of the area in which outcrops were sampled was considered to be underlain by mineralized beds averaging at least 28 feet in thickness. A factor of 14 cubic feet per long dry ton in place was used in calculating tonnage.

Inasmuch as only 25 percent of the area comprising the Batesville manganese district has been covered by the drilling explorations and reconnaissance described above, the total ore reserves shown in table 6 will be substantially augmented when surveys of manganiferous areas in the remainder of the district are completed.

TABLE 5. - Pertinent data on holes drilled by Westmoreland Manganese Corp.

Hole No.	Coordinates, feet		Collar elevation, f.a.s.	Completed depth, feet	Soil, chert, clay		Manganiferous clay					
							Interval, feet		Thickness, feet	Analysis, percent		
	North	West			From-	To-	From-	To-		Mn	Fe	P
W-2	6,353	4,551	751	62-1/2	0	48	48	62-1/2	14-1/2	16.97	8.25	0.32
W-3	6,147	4,571	764	64	0	46	46	54	8	3.11	14.33	.62
							54	64	10	2.15	13.07	.62
W-4	6,538	4,281	751	95	0	60	60	82-1/2	22-1/2	3.74	11.43	1.15
W-5	6,021	4,586	747	94	0	52-1/2	52-1/2	77-1/2	25	3.09	7.70	1.26
W-7	6,214	4,740	732	37-1/2	0	10	10	25	15	5.56	10.57	.41
							25	35	10	1.74	6.05	.41
W-9	6,399	4,126	757	101	0	67-1/2	67-1/2	100	32-1/2	3.24	11.95	1.14
W-10	6,251	4,118	761	112-1/2	0	62-1/2	62-1/2	112-1/2	50	12.55	8.53	.68
W-11	6,299	4,431	755	59	0	27-1/2	27-1/2	42-1/2	15	7.06	9.03	.31
W-12	6,116	4,351	759	102-1/2	0	62-1/2	62-1/2	100	37-1/2	8.16	8.76	.86
W-14	6,220	4,018	768	122-1/2	0	90	90	107-1/2	17-1/2	10.64	12.30	1.67
W-16	6,690	3,774	744	91	0	75	75	90	15	9.44	10.27	.82
W-17	5,576	4,260	751	92-1/2	0	67-1/2	67-1/2	90	22-1/2	11.62	15.89	2.53
W-19	6,574	3,997	716	59	0	37-1/2	37-1/2	57-1/2	20	5.01	11.35	1.24
W-20	5,687	4,458	715	81	0	60	60	80	20	4.78	8.93	.38
W-21	7,884	5,437	750	140	0	92-1/2	92-1/2	135	42-1/2	4.06	9.45	.64
W-23	4,788	5,466	725	102-1/2	0	52-1/2	52-1/2	102-1/2	50	10.36	11.85	.61
W-25	8,171	1,915	681	85	0	23	23	83	60	4.03	7.39	.41
W-26	7,491	3,913	710	67-1/2	0	22-1/2	22-1/2	42-1/2	20	4.51	18.48	.71
W-27	8,155	2,355	631	20	0	5	5	17-1/2	12-1/2	3.79	6.60	.26
W-29	8,680	1,277	686	56-1/2	0	22-1/2	22-1/2	56-1/2	34	10.14	11.20	.38
W-31	8,900	2,515	720	85	0	22-1/2	22-1/2	35	12-1/2	6.51	7.92	.[illegible]5
					35	62-1/2	62-1/2	80	17-1/2	4.49	5.97	.75
W-32	8,255	2,567	674	65	0	15	15	65	50	4.85	6.82	.48
W-33	8,499	2,436	683	64	0	12	12	62-1/2	50-1/2	6.23	7.01	.40
W-34	8,546	865	704	72-1/2	0	52-1/2	52-1/2	72-1/2	20	5.14	7.28	2.43
W-35	6,902	3,014	751	48-1/2	0	20	20	45	25	5.63	10.08	.71
W-36	6,723	1,789	804	171-1/2	0	120	120	171-1/2	51-1/2	5.72	10.16	1.86
W-37	6,636	3,593	761	95	0	82-1/2	82-1/2	95	12-1/2	5.14	11.30	.41
W-39	6,428	3,930	747	80	0	57-1/2	57-1/2	80	22-1/2	16.21	12.19	.52
W-40	9,237	2,171	643	25	0	12-1/2	12-1/2	25	12-1/2	5.84	5.52	.98
W-43	5,009	5,731	700	102-1/2	0	50	50	102-1/2	52-1/2	4.30	10.99	.99
W-44	4,534	5,718	697	93	0	55	55	93	38	4.46	5.94	1.42
W-45	4,567	5,231	712	90	0	65	65	90	25	5.34	12.40	1.58
W-46	5,033	5,237	722	98	0	55	55	97-1/2	42-1/2	9.83	12.45	1.9[illegible]
W-47	4,762	5,959	691	67-1/2	0	45	45	67-1/2	22-1/2	3.93	11.71	1.91

TABLE 5. - Pertinent data on holes drilled by Westmoreland Manganese Corp. (Con.)

Hole No.	Coordinates, feet		Collar elevation, f.a.s.	Completed depth, feet	Soil, chert, clay		Manganiferous clay					
							Interval, feet		Thickness, feet	Analysis, percent		
	North	West			From-	To-	From-	To-		Mn	Fe	P
W-48	5,270	5,505	698	75	0	52-1/2	52-1/2	75	22-1/2	8.49	7.79	1.93
W-49	5,279	5,007	721	107-1/2	0	97-1/2	97-1/2	107-1/2	10	3.61	10.8	3.06
W-50	5,038	5,978	693	120	0	92-1/2	92-1/2	102-1/2	10	1.64	4.30	.93
							102-1/2	120	17-1/2	4.10	6.45	.93
W-51	5,261	5,271	724	144	0	100	100	144	44	3.81	7.93	1.82
W-53	4,283	5,429	698	70	0	62-1/2	62-1/2	70	7-1/2	3.54	8.27	2.55
W-54	4,333	5,972	649	155	0	100	100	152-1/2	52-1/2	3.30	5.50	.71
W-55	4,781	5,139	726	84	0	62-1/2	62-1/2	84	21-1/2	6.90	6.65	1.92
W-56	5,154	5,836	680	115	0	60	60	115	55	4.13	9.38	2.07
W-57	4,536	6,203	629	117-1/2	0	75	75	117-1/2	42-1/2	3.22	4.65	.85
W-58	8,691	1,909	676	45	0	22-1/2	22-1/2	45	22-1/2	6.25	10.50	.49
W-59	4,328	6,211	678	127-1/2	0	92-1/2	92-1/2	125	32-1/2	7.20	12.35	1.44
W-60	8,778	787	679	53-1/2	0	30	30	53-1/2	23-1/2	4.00	6.32	.86
W-61	8,216	931	713	62-1/2	0	25	25	62-1/2	37-1/2	4.91	10.22	.54
W-62	8,421	1,432	686	75	0	60	60	75	15	3.67	8.33	.45
W-63	8,092	1,403	712	85	0	70	70	85	15	5.54	18.37	.57
W-64	7,887	2,241	661	90	0	25	25	67-1/2	42-1/2	7.16	6.71	2.17
W-65	8,803	1,617	671	52-1/2	0	25-1/2	25-1/2	52-1/2	27	5.20	8.46	.38
W-66	8,078	2,720	684	67-1/2	0	40	40	55	15	4.00	7.20	2.17
W-68	6,715	2,789	767	90	0	35	35	90	55	7.47	10.51	.45
W-72	6,498	2,168	777	104	0	72-1/2	72-1/2	102-1/2	30	4.33	7.07	1.23
W-78	7,578	5,728	703	57-1/2	0	32-1/2	32-1/2	57-1/2	25	6.28	9.84	.69
W-79A	7,806	5,672	737	77-1/2	0	60	60	77-1/2	17-1/2	3.53	12.76	1.13
W-80	8,145	5,700	730	77-1/2	0	70	70	77-1/2	7-1/2	3.22	10.80	.31
W-81	8,173	5,452	750	55	0	42-1/2	42-1/2	55	12-1/2	4.09	10.92	.37
W-83	8,192	5,178	751	119	0	85	85	92-1/2	7-1/2	3.07	4.87	.10
W-84A	7,898	5,308	750	95	0	65	65	95	30	5.08	10.88	1.69
W-85A	7,764	5,324	743	87-1/2	0	62-1/2	62-1/2	87-1/2	25	4.03	8.72	.92
W-90	7,198	4,818	726	80	0	50	50	80	30	7.71	12.95	.45
102	6,800	4,000	-	141	0	75	75	93	18	2.40	-	-
							93	116-1/2	13-1/2	3.36	-	-
							116-1/2	141	24-1/2	1.87	-	-
104	6,600	4,400	-	131	0	97-1/2	97-1/2	131	33-1/2	6.39	-	-
105	6,600	4,600	-	106	0	55	55	106	51	6.13	-	-
123	8,860	2,414	-	86	0	65	65	85	20	6.50	-	-
126	9,067	2,090	-	50	0	15	15	40	25	4.20	-	-
132	9,357	1,919	-	45	0	20	20	45	25	3.97	-	-

TABLE 5. - Pertinent data on holes drilled by Westmoreland Manganese Corp. (Con.)

Hole No.	Coordinates, feet		Collar elevation, f.a.s.	Completed depth, feet	Soil, chert, clay		Manganiferous clay					
							Interval, feet		Thickness, feet	Analysis, percent		
	North	West			From-	To-	From-	To-		Mn	Fe	P
134	9,050	1,604	-	17-1/2	0	-	-	15	15	3.17	-	-
144	8,200	1,292	690	88	0	60	60	85	25	3.31	-	-
145	8,012	1,302	706	120	0	60	60	80	20	4.32	-	-
					80	95	95	118	23	2.43	-	-
147	8,200	1,500	694	87	0	55	55	80	25	4.44	-	-
153	8,000	2,260	667	80	0	7-1/2	7-1/2	80	72-1/2	2.26	-	-
154	8,150	2,100	659	60	0	7-1/2	7-1/2	15	7-1/2	3.03	-	-
							15	60	45	1.62	-	-
155	8,200	1,900	679	54	0	30	30	45	15	3.08	-	-
							45	54	9	1.30	-	-
156	8,000	1,700	685	105	0	47-1/2	47-1/2	105	57-1/2	2.88	-	-
158	8,363	1,700	681	55	0	15	15	40	25	3.74	-	-
							40	55	15	2.10	-	-
159	9,289	1,900	625	25	-	-	-	25	25	3.73	-	-
165	7,900	2,000	646	122-1/2	0	60	60	105	45	5.22	-	-
							105	122-1/2	17-1/2	1.90	-	-
166	9,135	1,800	655	34	0	-	-	17-1/2	17-1/2	3.62	-	-
							17-1/2	32-1/2	15	1.75	-	-
167	9,000	1,800	652	30	0	-	-	12-1/2	12-1/2	4.71	-	-
							12-1/2	30	17-1/2	1.63	-	-
171	8,600	1,300	675	50	0	15	15	37-1/2	22-1/2	4.89	-	-
172	8,400	1,300	679	87-1/2	0	30	30	47-1/2	17-1/2	1.74	-	-
							47-1/2	82-1/2	35	3.11	-	-
176	8,900	2,800	690	132-1/2	0	47-1/2	47-1/2	107-1/2	60	3.18	-	-
177	8,600	1,703	660	40	0	17-1/2	17-1/2	35	17-1/2	4.09	-	-
178	8,600	1,500	665	50	0	7-1/2	7-1/2	15	7-1/2	1.50	-	-
							15	50	35	3.00	-	-
179	8,800	1,300	672	35	0	15	15	35	20	2.87	-	-
180	5,033	5,237	722	96	0	55	55	96	41	7.30	-	-
181	5,009	5,731	700	102	0	55	55	102	47	4.19	-	-
185	9,100	2,800	619	42-1/2	0	12-1/2	12-1/2	42-1/2	30	3.22	-	-
186	8,200	1,200	666	72	0	35	35	72	37	3.71	-	-
187	8,250	1,200	-	40	0	-	-	40	40	5.41	-	-
189	8,200	1,150	-	65	0	43	43	65	22	3.58	-	-
190	8,150	1,150	-	82-1/2	0	62-1/2	62-1/2	82-1/2	20	6.19	-	-
191	8,250	1,150	-	65	0	2-1/2	2-1/2	65	62-1/2	5.39	-	-
192	8,300	1,150	-	77-1/2	0	25	25	77-1/2	52-1/2	4.69	-	-

TABLE 5. - Pertinent data on holes drilled by Westmoreland Manganese Corp. (Con.)

Hole No.	Coordinates, feet		Collar elevation, f.a.s.	Completed depth, feet	Soil, chert, clay		Manganiferous clay					
							Interval, feet		Thickness, feet	Analysis, percent		
	North	West			From-	To-	From-	To-		Mn	Fe	P
193	8,300	1,100	-	57-1/2	0	35	35	57-1/2	22-1/2	6.25	-	-
194	8,250	1,100	-	59	0	7-1/2	7-1/2	25	17-1/2	4.36	-	-
							25	59	34	1.76	-	-
195	8,200	1,100	-	47-1/2	0	30	30	47-1/2	17-1/2	3.07	-	-
196	8,500	1,200	-	45	-	10	10	45	35	4.10	-	-
197	8,450	1,200	-	40	0	30	30	40	10	3.17	-	-
198	8,350	1,200	-	57-1/2	0	-	-	57-1/2	57-1/2	2.63	-	-
199	8,200	1,700	-	143	0	95	95	105	10	3.10	-	-
							105	137-1/2	32-1/2	1.85	-	-
203	7,900	1,600	-	115	0	45	45	107-1/2	61-1/2	3.30	-	-
208	8,100	1,100	-	96-1/2	0	65	65	96-1/2	31-1/2	4.49	-	-
210	8,100	1,000	-	58	0	33	33	58	25	7.45	-	-
251	8,600	1,100	680	55	0	27-1/2	27-1/2	55	27-1/2	2.99	-	-
254	8,200	500	690	50	0	25	25	50	25	5.31	-	-
257	8,400	2,600	653	52-1/2	0	12-1/2	12-1/2	40	27-1/2	3.40	-	-
258	7,900	2,900	628	42-1/2	0	15	15	40	25	3.08	-	-
259	8,300	1,300	-	71	0	35	35	71	36	4.92	-	-
300 1/	8,500	1,300	-	40-1/2	0	23	23	33	10	3.21	-	-
							33	40-1/2	7-1/2	2.20	-	-
301 1/	8,650	1,000	-	45	0	-	-	45	45	11.23	-	-
303 1/	8,700	800	-	51	0	-	-	51	51	3.35	-	-

1/ Core-drill holes.

TABLE 6. - Reserves 1/

Type of deposit	Long dry tons	Manganese, percent (estimated)
1. Manganiferous Fernvale limestone and Cason shale	59,000,000	4.9
2. Manganiferous clay in place under chert	9,525,000	7.4
3. Manganiferous clay, talus-residual	1,550,000	5.6
4. Placer	1,270,000	4.0

1/ Indicated and inferred. Covers 25 percent of the area comprising the Batesville district.

LOGS OF BUREAU OF MINES CHURN-DRILL HOLES

Southern Mining & Manganese Co. Property
(sec. 4. T. 14 N., R. 7 W.)

BM-1

Begun: 4/5/51
Completed: 4/12/51

Elevation: 717 f.a.s.
Coordinates: 5807N-5971W

Depth, feet		
From-	To-	Formation
0	5	Topsoil.
5	50	Chert.
50	55	Clay with trace manganese.
55	75	Limestone clay and boulders.
75	85	Limestone.

BM-2

Begun: 4/6/51
Completed: 4/12/51

Elevation: 715 f.a.s.
Coordinates: 5765N-5523W

Depth, feet		
From-	To-	Formation
0	5	Topsoil.
5	40	Chert.
40	60	Manganese ore clay.
60	70	Chert, trace manganese.
70	75	Manganese ore clay.
75	78-1/2	Limestone.

From-	To-	Analysis, percent		
		Mn	Fe	P
40	42-1/2	2.86		
42-1/2	45	2.98	6.50	
45	47-1/2	2.70		
47-1/2	50	2.52	5.20	
50	52-1/2	2.61		
52-1/2	55	2.01	4.50	
55	57-1/2	3.04		
57-1/2	60	2.22	5.60	Comp.
70	72-1/2	2.52		hole
72-1/2	75	2.70	8.50	0.54

BM-3

Begun: 4/13/51
Completed: 4/16/51

Elevation: 702 f.a.s.
Coordinates: 6313N-5879W

Depth, feet		
From-	To-	Formation
0	5	Topsoil.
5	50	Chert.
50	55	Clay, trace manganese.
55	80	Clay.
80	85	Limestone.

BM-4

Begun: 4/13/51
Completed: 4/16/51

Elevation: 717 f.a.s.
Coordinates: 5912N-5586W

Depth, feet		
From-	To-	Formation
0	5	Topsoil.
5	42-1/2	Bedded chert.
42-1/2	43-1/2	Clay, trace manganese.
43-1/2	51	Manganese ore clay.
51	53-1/2	Clay, trace manganese.
53-1/2	61	Clay.
61	64	Limestone.

		Analysis, percent		
		Mn	Fe	P
43-1/2	46	3.55		Comp.
46	48-1/2	3.68		hole
48-1/2	51	4.25	11.30	1.45

BM-5

Begun: 4/17/51
Completed: 4/18/51

Elevation: 712 f.a.s.
Coordinates: 6100N-5664W

Depth, feet		
From-	To-	Formation
0	5	Topsoil.
5	38	Chert.
38	47-1/2	Manganese ore clay.
47-1/2	60	Clay.
60	65	Limestone.

		Analysis, percent		
		Mn	Fe	P
38	40	1.35		
40	42-1/2	1.60	9.00	Comp.
42-1/2	45	2.40		hole
45	47-1/2	1.87	11.80	0.77

BM-6

Begun: 4/17/51
Completed: 4/19/51

Elevation: 744 f.a.s.
Coordinates: 5488N-4474W

Depth, feet		Formation
From-	To-	
0	5	Topsoil.
5	90	Chert.
90	115	Manganese ore clay.
115	120	Clay and chert.
120	123	Limestone.

		Analysis, percent		
		Mn	Fe	P
90	93	3.80		
93	95	3.15	9.90	
95	97-1/2	1.83		
97-1/2	100	1.23	5.40	
100	102-1/2	1.31		
102-1/2	105	1.56	4.40	
105	107	1.44		
107	110	1.75	4.00	Comp.
110	112-1/2	2.11		hole
112-1/2	115	2.42	5.50	0.29

BM-7

Begun: 4/19/51
Completed: 4/20/51

Elevation: 765 f.a.s.
Coordinates: 6117N-3985W

Depth, feet		Formation
From-	To-	
0	5	Topsoil.
5	65	Chert.
65	70	Clay, trace manganese.
70	85	Manganese ore clay.
85	105	Clay and chert.
105	108	Limestone.

		Analysis, percent		
		Mn	Fe	P
70	72-1/2	4.75		
72-1/2	75	8.30	12.50	
75	77-1/2	9.75		
77-1/2	80	7.32	15.00	Comp.
80	82-1/2	6.50		hole
82-1/2	85	4.29	10.40	0.36

BM-8

Begun: 4/20/51
Completed: 4/24/51

Elevation: 744 f.a.s.
Coordinates: 5353N-4045W

Depth, feet		Formation
From-	To-	
0	5	Topsoil.
5	105	Chert.
105	110	Clay, trace manganese.
110	120	Clay.
120	123	Limestone.

BM-9

Begun: 4/23/51
Completed: 4/25/51

Elevation: 766 f.a.s.
Coordinates: 5827N-3919W

Depth, feet		Formation
From-	To-	
0	5	Topsoil.
5	80	Chert.
80	82-1/2	Clay, trace manganese.
82-1/2	100	Manganese ore clay.
100	117-1/2	Clay.
117-1/2	120	Limestone.

		Analysis, percent		
		Mn	Fe	P
82-1/2	85	10.88		
85	87-1/2	6.34	14.60	
87-1/2	90	7.36		
90	92-1/2	6.13	14.40	
92-1/2	95	4.54		Comp.
95	97-1/2	10.94		hole
97-1/2	100	4.93	11.40	1.38

BM-11

Begun 4/25/51
Completed: 4/26/51

Elevation: 763 f.a.s.
Coordinates: 5650N-3950W

Depth, feet		Formation
From-	To-	
0	5	Topsoil.
5	47-1/2	Chert.
47-1/2	50	Clay, trace manganese.
50	57-1/2	Manganese ore clay.
57-1/2	60	Clay.
60	62	Limestone.

		Analysis, percent		
		Mn	Fe	P
47-1/2	50	3.86		
50	52-1/2	3.06	14.40	Comp.
52-1/2	55	2.15		hole
55	57-1/2	2.05	7.00	2.50

BM-14

Begun: 4/28/51
Completed: 4/30/51

Elevation: 759 f.a.s.
Coordinates: 6815-3412W

Depth, feet		
From-	To-	Formation
0	5	Topsoil.
5	20	Chert.
20	22-1/2	Clay, trace manganese.
22-1/2	27-1/2	Manganese ore clay.
27-1/2	30	Clay.
30	32-1/2	Limestone.

		Analysis, percent		
		Mn	Fe	P
22-1/2	25	1.69		Comp. hole
25	27-1/2	1.62	8.00	1.11

BM-15

Begun: 4/30/51
Completed: 5/3/51

Elevation: 763 f.a.s.
Coordinates: 6276N-3908W

Depth, feet		
From-	To-	Formation
0	5	Topsoil.
5	150	Chert.
150	157-1/2	Clay, trace manganese.
157-1/2	165	Manganese ore clay.
165	168	Limestone.

		Analysis, percent		
		Mn	Fe	P
157-1/2	160	2.30		Comp.
160	162-1/2	3.00	7.80	hole
162-1/2	165	2.60	8.50	1.69

Stella Henry property

BM-10

Begun: 4/24/51
Completed: 4/27/51

Elevation: 788 f.a.s.
Coordinates: 6627N-2936W

Depth, feet		
From-	To-	Formation
0	5	Topsoil.
5	85	Chert.
85	90	Clay, trace manganese.
90	92-1/2	Manganese ore clay.
92-1/2	97-1/2	Clay.
97-1/2	99	Clay and limestone.

Depth, feet		Analysis, percent		
From-	To-	Mn	Fe	P
90	92-1/2	3.67	9.10	1.85

BM-13

Begun: 4/27/51
Completed: 4/28/51

Elevation: 791 f.a.s.
Coordinates: 6528N-3369W

Depth, feet		Formation
From-	To-	
0	5	Topsoil.
5	45	Chert.
45	50	Clay, trace manganese.
50	53	Limestone.

R. F. Wilson and R. M. Baxter property

BM-12

Begun: 4/27/51
Completed: 5/1/51

Elevation: 783 f.a.s.
Coordinates: 6335N-3353W

Depth, feet		Formation
From-	To-	
0	5	Topsoil.
5	105	Chert.
105	108-1/2	Clay, trace manganese.
108-1/2	145	Manganese ore clay.
145	147	Clay.
147	150	Limestone.

		Analysis, percent		
		Mn	Fe	P
108-1/2	111	1.99		
111	113-1/2	4.20	6.10	
113-1/2	116-1/2	4.29		
116-1/2	119-1/2	4.60	8.20	
119-1/2	122	5.52		
122	124-1/2	5.36	10.30	
127-1/2	130	4.51		
130	132-1/2	4.60	9.00	
132-1/2	135	5.00		
135	137-1/2	4.90	8.50	
137-1/2	140	4.78		Comp.
140	142-1/2	4.44		hole
142-1/2	145	4.41	8.30	1.40

BM-16

Begun: 5/1/51
Completed: 5/2/51

Elevation: 781 f.a.s.
Coordinates: 6399N-3151W

Depth, feet		
From-	To-	Formation
0	5	Topsoil.
5	40	Chert.
40	42-1/2	Clay, trace manganese.
42-1/2	52-1/2	Manganese ore clay.
52-1/2	55	Clay.
55	56	Limestone.

From-	To-	Analysis, percent Mn	Fe	P
42-1/2	45	5.36		
45	47-1/2	6.59	15.10	Comp.
47-1/2	50	3.86		hole
50	52-1/2	2.51	9.50	0.52

BM-17

Begun: 5/2/51
Completed: 5/7/51

Elevation: 778 f.a.s.
Coordinates: 6261N-3529W

Depth, feet		
From-	To-	Formation
0	5	Topsoil.
5	75	Chert.
75	80	Clay, trace manganese.
80	100	Manganese ore clay.
100	102-1/2	Clay.
102-1/2	105	Limestone.

From-	To-	Analysis, percent Mn	Fe	P
80	82-1/2	1.13		
82-1/2	85	1.04	11.20	
85	87-1/2	3.13		
87-1/2	90	4.23	11.00	
90	92-1/2	3.06		
92-1/2	95	7.05	9.70	Comp.
95	97-1/2	5.76		hole
97-1/2	100	3.89	8.70	0.71

BM-18

Begun: 5/7/51
Completed: 5/9/51

Elevation: 760 f.a.s.
Coordinates: 6012N-3549W

Depth, feet		
From-	To-	Formation
0	5	Topsoil.
5	20	Chert.
20	105	Gravel and clay.
105	110	Limestone and clay.
110	115	Limestone.

BIBLIOGRAPHY

1. MISER, HUGH D. Deposits of Manganese Ore in the Batesville District, Ark. Geol. Survey Bull. 734, 1922, 273 pp.

2. _____ . Manganese Carbonate in the Batesville District, Ark. Geol. Survey Bull. 921-A, 1941, 97 pp.

3. SHELTON, S. M., FINE, M. M., and BARDILL, J. D. Manganese Investigations - Metallurgical Division. 5. Ore-Dressing Studies of Manganese Ores. Beneficiation of Manganese Wad Ores From the Chinn Property, Batesville, Ark. Bureau of Mines Rept. of Investigations 3614, 1942, 18 pp.

4. SHELTON, S. M., FINE, M. M., and FISHER, R. B. Manganese Investigations - Metallurgical Division. 17. Ore-Dressing Studies of Manganese Ores. Concentration of Wad Ore From the Aydelotte Property, Batesville, Ark. Bureau of Mines Rept. of Investigations 3652, 1942, 17 pp.

5. STRACZEK, J. A., and KINNEY, D. M. Geologic Map of the Central Part of the Batesville Manganese District. Geol. Survey Field Studies Map MF-1, 1950.

6. RUTLEDGE, F. A., TESSMER, W. A., EWOLDT, H. B., ODER, C. R. L., LANGLEY, M. J., and BELL, J. E. Investigation of Manganese Carbonate and Wad Deposits in the Batesville Manganese District, Ark. Bureau of Mines Rept. of Investigations 4859, 1952, 180 pp.

7. FINE, M. M., and FROMMER, D. W. Mineral-Dressing Study of Manganese Ore, Cason Mine, Batesville, Ark. Bureau of Mines Rept. of Investigations 5005, 1953, 9 pp.

8. _____. Laboratory Recovery of Manganese Carbonate From the Martin Mine, Independence County, Ark. Bureau of Mines Rept. of Investigations 5086, 1954, 10 pp.

United States Bureau of Mines

Report of Investigations 5411

by

H. D. Kline and W. F. Brown

CONTENTS

ILLUSTRATIONS

Report of Investigations 5411

TABLES

MANGANESE RESOURCES OF THE BATESVILLE DISTRICT, ARKANSAS[1]

Part 2 of 3 Parts

by

H. D. Kline[2] and W. F. Brown[3]

INTRODUCTION AND SUMMARY

This interim report describes the methods and results of field investigations conducted by the Bureau of Mines on the manganese deposits of the Batesville district, Arkansas, from early 1953 until July 1956. The report embraces activities previously listed under the subheading Reconnaissance of Manganiferous Areas in Bureau of Mines Report of Investigations 5206, Manganese Resources of the Batesville District, Arkansas - Interim Report I, published in April 1956.

The Bureau's work has comprised reconnaissance sampling and exploratory drilling to estimate reserves of manganiferous deposits of various types and is part of a project begun in 1949 to evaluate the manganese potential of the district in furtherance of the Government's program of developing domestic sources of critical and strategic minerals for national defense.

Field investigations in the Batesville district have continued since July 1956. They have been concerned mainly with testing the grade and continuity of deposits of manganiferous limestone by core drilling and sampling. The results of the latest investigations will be incorporated in a final report on the manganese resources of the district.

The Batesville manganese district comprises an east-west belt 24 miles long and 4 to 8 miles wide lying principally in northwestern Independence County but extending into adjacent counties to the west and north.

The mining of manganese ores in the district was begun in 1849. To the end of 1955, production had totaled approximately 230,000 long tons of manganese ore (35 percent or more of manganese) and 236,000 tons of ferruginous manganese (10 to 35 percent of manganese).

The manganese occurs as oxide, carbonate, and silicate minerals in nearly flat-lying limestone and shale formations and as oxide in residual clays resulting from the decomposition of the shale and limestone. Most of the deposits underlie chert or chert rubble varying in thickness from a few to more than a hundred feet.

The major part of the ore shipped from the district has been produced by hand mining and sorting methods from numerous small underground and open-pit workings.

1/ Work on manuscript completed January 1958.
2/ Mining engineer, Bureau of Mines, Region IV, Batesville, Ark.
3/ Mining engineer, Bureau of Mines, Region IV, Rolla, Mo.

The use of bulldozers for uncovering deposits under shallow overburden and limited use of power shovels are virtually the only improvements that have been made in mining methods over the years. Log washers, either alone or in combination with screens, jigs, and picking belts, are used for upgrading suitable lower grade ores.

During the period covered by this report, the Bureau of Mines completed reconnaissance of areas containing manganiferous materials in 86 land sections and tested the grade and continuity of manganiferous limestone in an area of extensive occurrence, wherein its thickness was approximately 30 feet, by drilling 6 holes aggregating 1,196 feet of bore.

Inferred reserves of manganiferous materials in the Batesville district are about 166,000,000 long dry tons having an average manganese content of 5 to 6 percent. If effective and economical treatment processes can be developed, these reserves will constitute an important source of manganese.

ACKNOWLEDGMENTS

The cooperation of the various owners and lessees of manganese properties in the district is gratefully acknowledged.

Topography indicated on maps included in this report was reproduced from topographic quadrangle sheets of the Federal Geological Survey.

LOCATION AND PHYSICAL FEATURES

The Batesville manganese district comprises an east-west belt 4 to 8 miles wide and 24 miles long, lying principally in northwest Independence County in north central Arkansas. The belt extends westward from the vicinities of Pfeiffer and Hickory Valley, Independence County, into Izard and Stone Counties and includes small areas in Sharp County on the north. The southern limit of the district is about 2 miles north of Batesville, a city of about 6,500 population and the county seat of Independence County (see fig. 1).

Topographically, the district is a dissected area, with relief ranging from 100 to 500 feet, on the southern edge of the Ozark Plateau. Altitudes range from about 300 feet above sea level in stream channels to 800 feet on the highest hilltops. The principal streams and tributaries of the area from east to west are Cave Creek, Sullivan Creek, Polk Bayou, East Lafferty Creek, and West Lafferty Creek; drainage is southward into White River.

Except for small cultivated tracts, the district is covered with oak, hickory, walnut, cedar, and ash trees suitable for use as mine timber.

Spur lines of the Missouri Pacific Railroad extend from Batesville to Pfeiffer on the eastern margin of the district and to Cushman in the west central part. Hard-surface roads pass through the rail points, and branching secondary and dirt roads serve the mines.

HISTORY AND PRODUCTION

Manganese ores have been mined in the Batesville district since 1849, but most of the output was mined during two periods of activity - from 1885 to 1898 and from 1915 to the present (1958). Production through 1955 totaled approximately 230,000 long tons of manganese ore (35 or more percent manganese) and 236,000 tons of

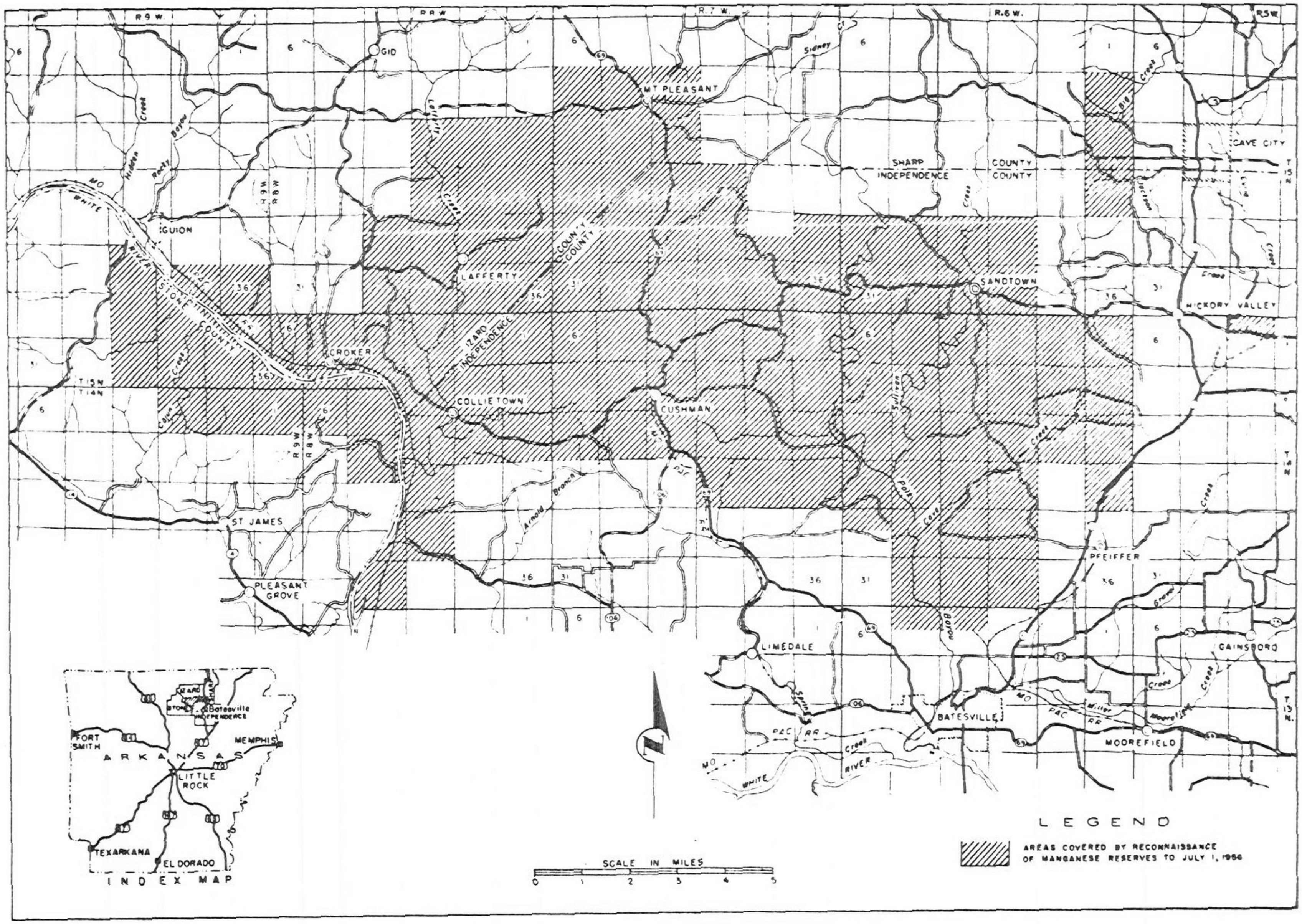


FIGURE 1. - Batesville Manganese District, Arkansas.

ferruginous manganese (10 to 35 percent manganese). Peak outputs were made during World Wars I and II, 1917-18 and 1944-45. Since 1951, the bulk of the production has been ores containing at least 40 percent manganese. A detailed description of earlier mining activity in the district is given by Miser (1,[4/] 2).

GEOLOGY AND ORE DEPOSITS (1, 2, 5, 8)

The exposed consolidated rocks of the Batesville district are sedimentary sandstones, shales, limestones, and cherts, ranging in age from Ordovician to Carboniferous. Most of the formations lie nearly horizontal, with a slight regional dip to the south. Minor folding and faulting are common locally but have not caused significant deformation or displacement of the rocks. Figure 2 shows generalized geologic section of the strata. Of the formations present, Fernvale limestone and, to a limited extent, Cason shale and St. Joe limestone are the host rocks of the primary manganese mineralization. Boone chert has served as a protective mantle in the preservation of most of the existing manganese deposits; in places, St. Clair limestone overlies the manganese-bearing formations.

Boone chert is the surface rock over most of the district. Remnants of the lower part of the formation cap most of the hills, and chert boulders comprise much of the hillside talus accumulations in the manganiferous areas. In some areas the chert lies on Devonian or Silurian rocks of local occurrence, on Fernvale limestone where the Cason shale is absent, or on residual clays resulting from weathering and decomposition of these formations.

St. Joe limestone occurs locally, principally in the western part of the district, and in places is manganiferous. Where observed during field reconnaissance, the limestone has a maximum thickness of about 10 feet, is overlain by typical Boone chert, and rests unconformably upon older formations.

Cason shale is a phosphatic, lenticular formation ranging in thickness from a feather edge to 12-1/2 feet. It occurs mainly in the eastern and western parts of the district but is absent over much of the central part.

Fernvale limestone, eroded from part of the district, crops out on hillsides in much of the manganese-bearing area. The formation, 125 feet thick in places, rests unconformably on Kimmswick limestone. In some areas the limestone is unaltered; in others it has been completely decomposed to residual clays that rest on pitted surfaces of older limestones.

Primary mineralization is ascribed to deposition of carbonates and oxides of manganese from circulating hypogene solutions in the top beds of the Fernvale limestone and in the St. Joe limestone and Cason shale. Predominant manganese minerals in the district, in order of abundance, are the oxides, carbonates, and silicates. The principal primary oxides are hausmannite and braunite. Oxides considered to be of secondary origin comprise the important minerals psilomelane and wad, together with manganite and pyrolusite which occur in relatively minor quantity. Wad is a dark-brown to black, soft, earthy mineral commonly considered to be an impure hydrous oxide of manganese often associated with iron, silica, alumina, and water. Rhodochrosite and other carbonates are widely distributed throughout the unaltered manganiferous limestone. The silicates bementite and neotocite have been identified.

4/ Underlined numbers in parentheses refer to citations in the bibliography at the end of this report.

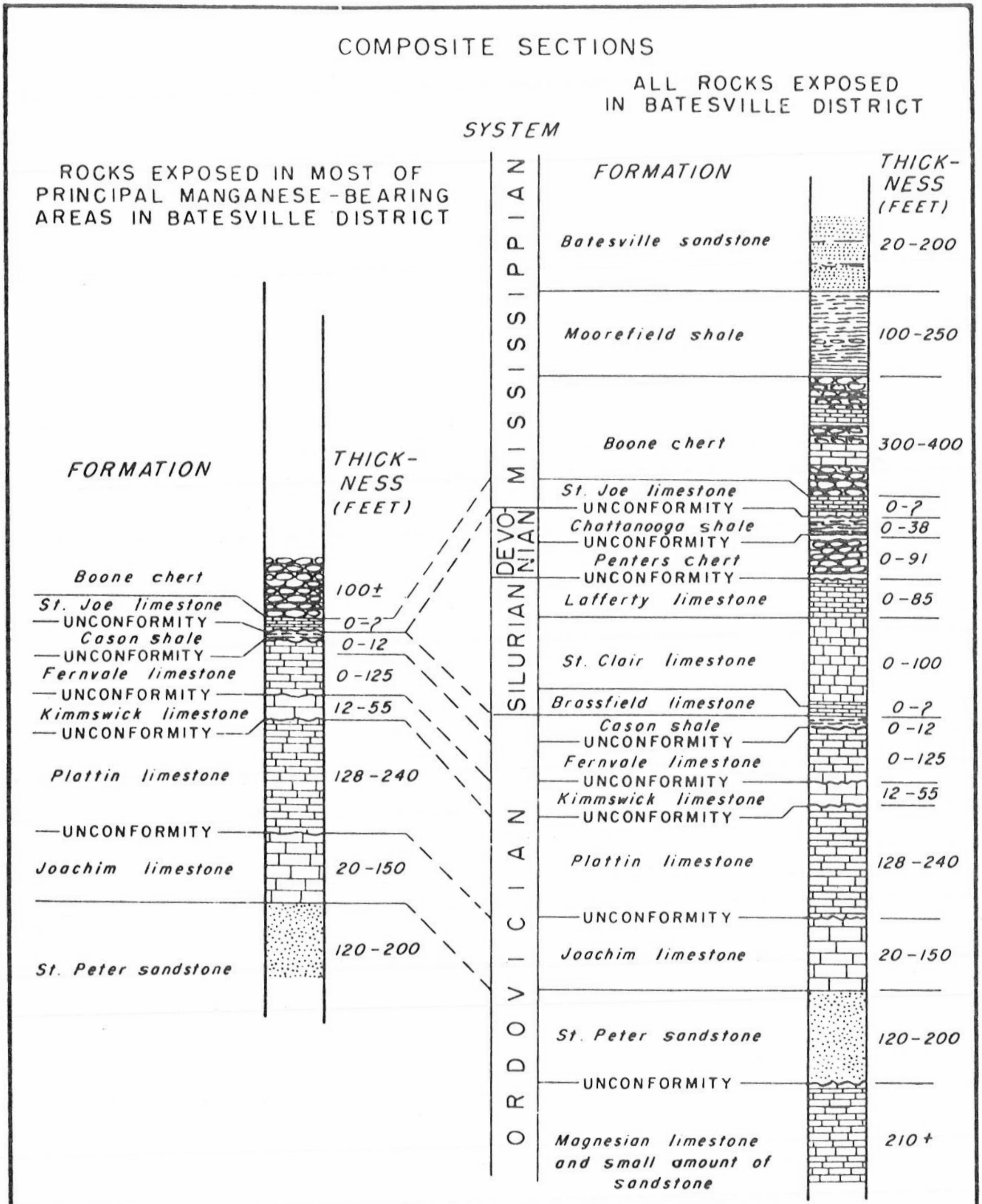


FIGURE 2. - Generalized Sections of Paleozoic Rocks Exposed in Batesville District.
(Adapted From Geol. Survey Bull. 734, Pt. IV.)

Iron oxide is associated with all the manganese oxides but is more intimately mixed with and abundant in wad.

The principal types of manganese deposits are:

1. Unaltered or slightly altered deposits of the primary minerals rhodochrosite, hausmannite, and braunite disseminated in (a) Cason shale and the upper 15 to 50 feet of the Fernvale limestone, and (b) St. Joe limestone. The deposits occur in areas where relatively undisturbed beds of dense Boone chert protect the underlying limestones and shale against weathering and consequent alteration of their primary manganese minerals. In places, St. Clair limestone, Penters chert, or Chattanooga shale immediately overlie the manganiferous formations (see fig. 3). The estimated manganese content of deposits in the eastern part of the district seldom exceeds 5 percent and in the western part 8 percent. In places, unusual concentrations of carbonate and oxide minerals occur in hard ledges of Cason shale and the upper few feet of the Fernvale limestone. Some of these minerals have been mined and marketed as carbonate ore and ledge ore. Hand-cobbed ore contained as much as 40 percent manganese.

2. Irregularly distributed deposits of secondary oxides in lumps and wad in residual clays caused by weathering and decomposition of Cason shale and Fernvale limestone and lying in place. The clays, overlain by Boone chert, rest on an irregularly eroded floor of limestone characterized by alternating pits and pinnacles. Variations in altitude from the top of a pinnacle to the bottom of a pit may be more than 100 feet in one deposit. The chert bed, shattered by subsidence, generally conforms to the irregular contour of the underlying weathered limestone surface. The clay beds range in thickness from a few feet to 60 feet in cavities in the limestone and persist over large areas. Ore occurs in the clays in irregular bodies of various dimensions and grades of manganese. The predominant manganese minerals are wad and sporadic occurrences of hard manganese oxides, the latter principally psilomelane and hausmannite in particles, chunks, and masses. Deposits in residual clays in place have been the source of much of the ferruginous- and metallurgical-grade, manganese ore mined in the district (see fig. 3).

3. Deposits in residual clays and talus, usually representing both vertical slumpage and downslope creep of deposits of type 2, from which most of the Boone chert and other rock covering has been eroded. The absence of excessive overburden makes these hillside deposits available for comparatively low cost prospecting and mining; therefore, they have accounted for much of the ore produced in the district (see fig. 3).

4. Placer deposits resulting from water transportation of type 3 deposits to other sites. The attendant washing has removed much of the clay and fine-grained manganese minerals, leaving the coarser particles and lumps of oxides in a matrix of soil, gravel, and boulders. Only a relatively small proportion of the current production is obtained from placer deposits.

DEVELOPMENT, MINING, AND BENEFICIATION

Most mining operations in the Batesville district have been conducted on a small scale, and mining practices have been essentially the same throughout the history of the district. Ore has been produced from deposits of all types, but only a minor amount of carbonate ore has been mined. Total production from the district comprises about equal quantities of manganese ore and ferruginous manganese ore; however, since 1951 marketing conditions have been unfavorable to ores containing

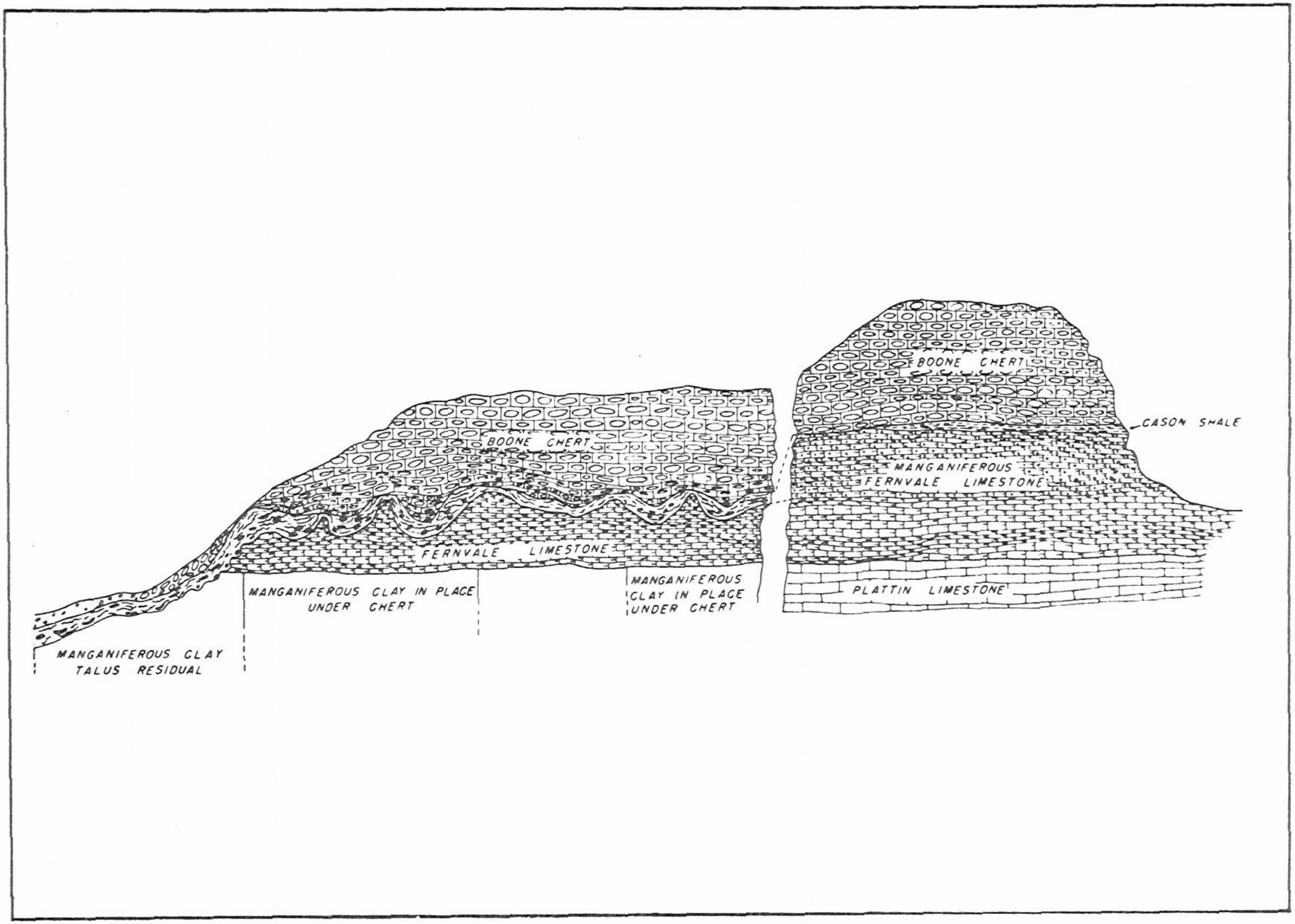


FIGURE 3. - Idealized Section Showing Modes of Occurrence of Various Types of Deposits.

less than 40 percent manganese. Most of the merchantable ore is produced from both open-pit and underground mines by selective hand-mining methods, either independent of or in conjunction with beneficiation. Such operations are restricted to the higher grade deposits containing sporadic concentrations of oxide ore in lump form. Relatively little ore is obtained from operations involving beneficiation of material from low-grade deposits mined in open pits by power shovels or from the low-grade parts of deposits mined by selective, hand-mining methods.

Prospecting for minable deposits usually is confined to known manganiferous areas. Most talus and other shallow residual deposits are explored and uncovered by bulldozers. Deposits under the tops or upper slopes of hills, where the overburden is too thick for stripping, are explored with churn drills and developed and mined through shafts and drifts.

Deposits adapted to open-pit mining by selective methods contain from a few tons to several thousand tons of ore. Overburden removed by stripping ranges from a thin layer to 50 feet and averages about 8 feet in thickness; the principal obstacle to stripping is the presence of large boulders of chert and limestone, which are common. After the overburden has been removed, two types of material - lump ore and wash dirt - are mined selectively from the deposit with pick and shovel and transported in buckets or wheelbarrows to their respective stockpiles at the workings; lower grade material is left in place or discarded as waste. Lump ore consists of chunks of hard manganese oxides which must contain at least 40 percent of manganese to be acceptable for direct shipment; wash dirt comprises fragments of ore with adhering clay or other gangue material and must be of such quality that it can be mined profitably and upgraded by log-washer treatment. The judgment of the miners is relied upon in selecting both types of material; payment for the work usually is made on the basis of a contract price per ton of salable ore.

During mining, additional stripping is sometimes necessary for the safety of miners or to facilitate their work. Water that accumulates at times of heavy rainfall is either pumped or allowed to seep out of the pits. Truck roads to the pits have natural dirt surfaces and are usable only in dry weather, but the loss of time due to rains is insufficient to justify the construction of gravel-surfaced access roads.

Churn drills are used for prospecting chert-covered deposits of type 2 by several operators in the Batesville district. Since 1953 most of the drilling has been done in areas adjacent to ore bodies drilled by Government agencies during World War II (5). These ore bodies are mined through vertical shafts 4 by 4 feet in the clear and sunk to the bottom of the indicated ore zone. The average depth of shaft is less than 80 feet; only a few exceed 130 feet. The manganiferous material is mined by hand and sorted in the same manner as in open-pit workings. Hoisting is done by hand windlass or small power units in buckets averaging 1-1/2 cubic feet in capacity. The walls of the shafts are cribbed in loose ground; drifts and stopes are timbered. Timbering of the stopes cannot be planned in advance owing to the unpredictable shape, thickness, and extent of the deposits. Vertical irregularity of the floors of the ore bodies precludes extending drifts appreciable distances from the shafts. Thickness and stability of overburden also govern the lateral extent of the workings, which normally range from 25 to 60 feet from shaft centers. It is considered more economical to sink a new shaft than to extend mining beyond these limits. In some underground operations shafts are connected to provide better ventilation.

Figure 4 shows the locations of all mines in the district that were productive within the period February 1953 to July 1956, and table 1 lists the names of the mines corresponding to the numbers shown on figure 4.

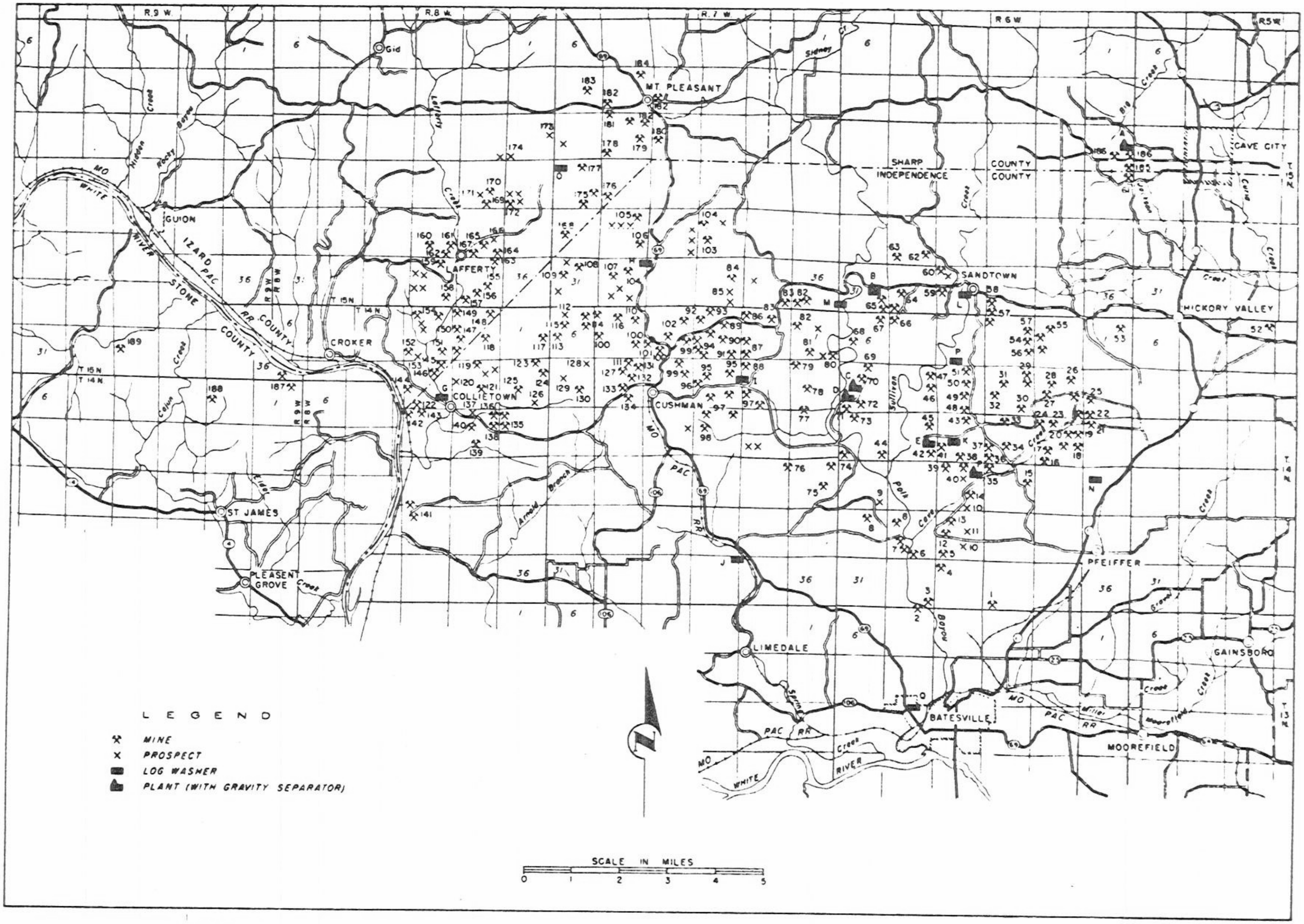


FIGURE 4. - Mines, Prospects, and Beneficiation Plants–Batesville Manganese District, Arkansas.

TABLE 1. - Mines, prospects, and beneficiation plants, Batesville manganese district

MINES AND PROSPECTS:

INDEPENDENCE COUNTY:

1. Cason
2. Champlain
3. Edgar Baker
4. Rutherford Hollow
5. Burge
6. Miller-Rinehart
7. Greenfield
8. Stark Spring
9. Crosser prospect
10. Baxter prospect
11. Collins prospect
12. Thompson
13. Churchill
14. Chinn Spring
15. Modlin Hollow
16. J. A. Reves
17. Moyer
18. Silberstein
19. Bales
20. Dunegan
21. Brokaw
22. Searcy
23. Matheny (Diener)
24. Davis Hill
25. Schlieper
26. Ozark
27. Clark
28. Searcy
29. U. S. Manganese Corp.
30. Searcy (Bill Jim)
31. Hunt Hollow
32. Wildcat
33. Albert Wilson
34. Wisdom
35. Vanemburg
36. Martha Thompson
37. Climer
38. Arkansas Mining & Exploration Corp.
39. W. A. Chinn
40. Shell-Reither prospect
41. Section 16
42. Adler
43. Adler
44. Wade
45. Herman Miller
46. Perrin
47. Kelley Hill
48. Haigwood
49. J. B. Thompson
50. Lost Forty
51. St. John
52. Ball Hill
53. Eliza Patterson
54. Gray (Hawkins area)
55. Bill Hawkins
56. McGee
57. Leo Hawkins
58. Weaver
59. Chapel Hill
60. Pool
61. Story
62. Pool
63. Adler-Southard
64. Montgomery
65. Roach Hill
66. Clark Hill (Sis Clark)
67. Galloway Hill
68. Queen Hill
69. Bell Hill
70. G. W. Patterson
71. Marshall
72. R. I. Patterson
73. Blake Hill
74. W. W. Allen
75. Button
76. Kinion
77. Shaw Hill
78. Turner
79. W. J. Hinson
80. Jackson
81. Kirby
82. Napoleon Hill
83. Johnson
84. Thirty Four
85. Friday Prospect
86. Standard
87. Blue Ridge
88. Story
89. Blue Ridge
90. Rowe Field
91. Benton
92. Polk-Southard
93. Turner
94. Wilson-Baxter
95. Rosenborough
96. Kimmer
97. Aydelotte
98. Brooks Hill
99. Wilson & Baxter
100. Page
101. Jerden
102. Southern Hill
103. Eddie Baxter
104. A. H. Dobson
105. J. R. Dobson
106. Mt. Etna
107. J. P. Barnes
108. Wolford
109. Neill
110. H. Miller
111. Martin
112. Miller prospect
113. Sterrett
114. Johnson
115. Sanders
116. Stewart Hill
117. Calaway
118. Edmundson
119. Standard
120. U. N. Dobson
121. George
122. Shaft Hill
123. Sand Field
124. Jake Cole
125. Tosh Hill
126. Frazier prospect
127. Chigger Eye
128. H. M. Tate prospect
129. R. W. Reeves prospect
130. Cole Orchard
131. Club House
132. Club House Extension
133. Meeker
134. L. Baxter
135. W. C. Collie
136. Weaver
137. Button prospect
138. F. M. Barnes
139. Kimbrough
140. Martin
141. McBride
142. Manganese Cave
143. Smith

IZARD COUNTY:

144. Penters Bluff
145. Hankins Hollow
146. T. M. Tate
147. Engles Cut
148. Cutter
149. Verna
150. Skelton
151. Pittman
152. United Phosphate
153. Casey prospect
154. Cummins Hollow
155. Adler Hollow
156. Izard
157. Pugh
158. Johnson Hill
159. Standard
160. Helm
161. E. D. Winkle
162. C. L. Sanders
163. Sand Field
164. Manganese Field
165. Ruminer Rough
166. Caraway prospect
167. Barksdale
168. Arkansas Mining & Exploration Corp.
169. Cave Hill
170. L. J. Weaver
171. Lewis prospect
172. Edwards
173. M. E. Wilson prospect
174. H. J. Ray prospect
175. McBride Bros.
176. McConnell
177. Berry Fulbright
178. Harrison Fulbright
179. Delbert Fulbright
180. W. A. King
181. Sipes
182. Younger
183. Ray
184. Shaw

SHARP COUNTY:

185. Story
186. Matlock

STONE COUNTY:

187. Logan
188. Cagens Creek
189. Alex Fults

PLANTS WITH GRAVITY SEPARATORS:

A. Matlock (Sharp County)
B. McBride (Titan Manganese Corp.)
C. Fulton
D. Buford Parse
E. Arkansas Mining & Exploration Corp.
F. Miller-McGee

LOG WASHERS:

G. Apex Mining Co.
H. R. Baxter
I. Leonard Baxter
J. J. R. Baxter
K. Arkansas Mining & Exploration Corp.
L. Titan Manganese Corp.
M. U. S. Manganese Corp.
N. Ottinger
O. Rogers
P. Kelley Hill
Q. Dunegan

In July 1956, 16 of the 17 beneficiation plants in the district were in operation (see fig. 4); 10 plants were used for upgrading selectively mined wash dirt from open-pit and underground mines, and 6 were used primarily for treating manganiferous clays mined by power shovel.

Wash dirt is beneficiated by a simple washing process using log washers alone or in conjunction with picking belts. Chert and low-grade material can be eliminated from the log-washer concentrate by handpicking on belts.

The manganiferous material mined in bulk by power shovels contains considerable coarse, porous manganese oxide with a specific gravity approximating that of chert, the common gangue mineral - a factor that contributes to low recovery by mineral-dressing processes currently used in the district. In beneficiation plants the crude material is treated in a log washer, and the resultant concentrate is sized on a revolving screen. The undersize from the screen passes to jigs, which produce a final concentrate, and the oversize discharges onto a picking belt from which pieces of coarse ore are recovered by handpicking. Low-grade material from placer deposits also is treated in plants of this type; however, the manganese occurs as hard, dense oxides, and recovery of the values is fair. It is estimated that jig and picking-belt products constitute 75 and 25 percent, respectively, of the concentrate produced from treating material loaded by power shovels. The combined capacity of the plants is about 200 tons an hour; however, the plants are operated intermittently, and their total output probably constitutes less than 10 percent of the ore shipped from the district.

No data are available on recovery of manganese contained in the feed for plants operating in the district. Extensive mineral-dressing research on the low-grade manganese ores, principally the wad ores and the manganiferous limestones, has been conducted by the Bureau of Mines laboratory at Rolla, Mo. The results of part of this work have been published as reports of investigations (3, 4, 6, 7, 10). Research is continuing, and additional information is being prepared for publication.

WORK BY THE BUREAU OF MINES

Field work during the period covered by this report - February 1953 to July 1956 - consisted essentially of reconnaissance, mapping, classification, and sampling of manganiferous areas throughout the Batesville district. Supplementary drilling was done in an area containing extensive outcrops of manganiferous limestone. The purpose of the work was to provide basic data to augment the limited data obtained from previous exploration projects, for estimating reserves and evaluating the manganese potential of the district.

Property Ownership

The tracts covered by Bureau of Mines reconnaissance are owned or controlled by various persons not listed herein. Ownership and description of the property on which churn and core drilling was done follow:

Land description, T. 14 N., R. 6 W.:	Acres	Owned or controlled by -
SE1/4SW1/4 and SW1/4SE1/4 sec. 29	80	Robert E. Purdy and John P. Metcalf.
SE1/4SE1/4 sec. 29	40	R. C. Brown.
E1/2NE1/4, SE1/4, E1/2SW1/4, and SE1/4NW1/4, sec. 32	360	Edgar Baker.
W1/2NE1/4 sec. 32	80	Westmoreland Manganese Corp.

Reconnaissance of Manganiferous Areas

Manganiferous areas in 86 land sections were surveyed and mapped; where practicable, samples were taken of the manganese deposits therein. The individual manganiferous areas were delineated by mapping outcrops, exposures in accessible mine and prospect workings, and float. In addition to the areas mapped, reconnaissance covered 38 sections that lacked evidence of potentially productive ore deposits. Figure 5 is an index map of the manganiferous areas, and figures 6 through 24 show the type and areal extent or trace of outcrops of the deposits, sample sites, and other data.

Outcrops of manganiferous limestone, exposed on steep hillsides, were sampled by cutting vertical channels across the beds; a total of 774 linear feet of 2- by 5-inch channel samples was cut.

To sample manganiferous clays, trenches and pits were dug to expose as thick a section of the residual clay as practicable, and 2- by 5-inch vertical channels were cut from faces of the trenches or sides of the pits; 74 trenches and pits totaling 635 linear feet were excavated in clays, and 965 linear feet of samples was cut. In all, 224 samples were taken from 161 separate sites; of these, 89 were manganiferous limestone and 72 were manganiferous clay. Tables 2 and 3 give pertinent data on the samples of manganiferous limestone and clays.

Churn and Core Drilling

After outcrops of manganiferous Fernvale limestone were sampled in the southern part of the Batesville district, core samples of the mineralized limestone on Reeves Hill, in secs. 29 and 32, T. 14 N., R. 6 W. (see fig. 9), were obtained for testing the grade and continuity of deposits in the area and for mineralogical study.

Six holes 6 to 8 inches in diameter were drilled through the overlying barren material, and the manganiferous limestone was cored with an NX-size diamond bit. The contractor attempted to cut the overburden in the first hole (C-1) with a roller-type bit. This drilling was successful through the tripolilike rock but not the dense flint, so the hole was completed with diamond bits. The overburden was churn drilled in the other five holes. A total of 1,196 feet was drilled in the six holes - 138 feet by roller-type bit, 811 feet by churn drilling, and 247 feet by diamond drilling. Core recovery was almost 100 percent. One hole was drilled on the flank of a fold and probably was outside the limit of the manganiferous part of the bed, but the other five holes cut manganiferous limestone of nearly uniform thickness. Figure 9 shows the locations of the holes; detailed logs are given at the end of this report. The core was split three ways; a quarter split was stored in the Bureau of Mines core-storage depot at Minneapolis, Minn., a quarter split was retained at the Bureau of Mines project office in Batesville, Ark.; and a half split was shipped to the Mississippi Valley Experiment Station of the Bureau of Mines at Rolla, Mo., for mineralogical study.

RESERVES OF MANGANIFEROUS MATERIAL

The inferred reserves of manganiferous materials shown in table 4 are based on data obtained by reconnaissance and sampling, and allowance is made for tonnage figures obtained previously in selected areas under exploratory projects (5).

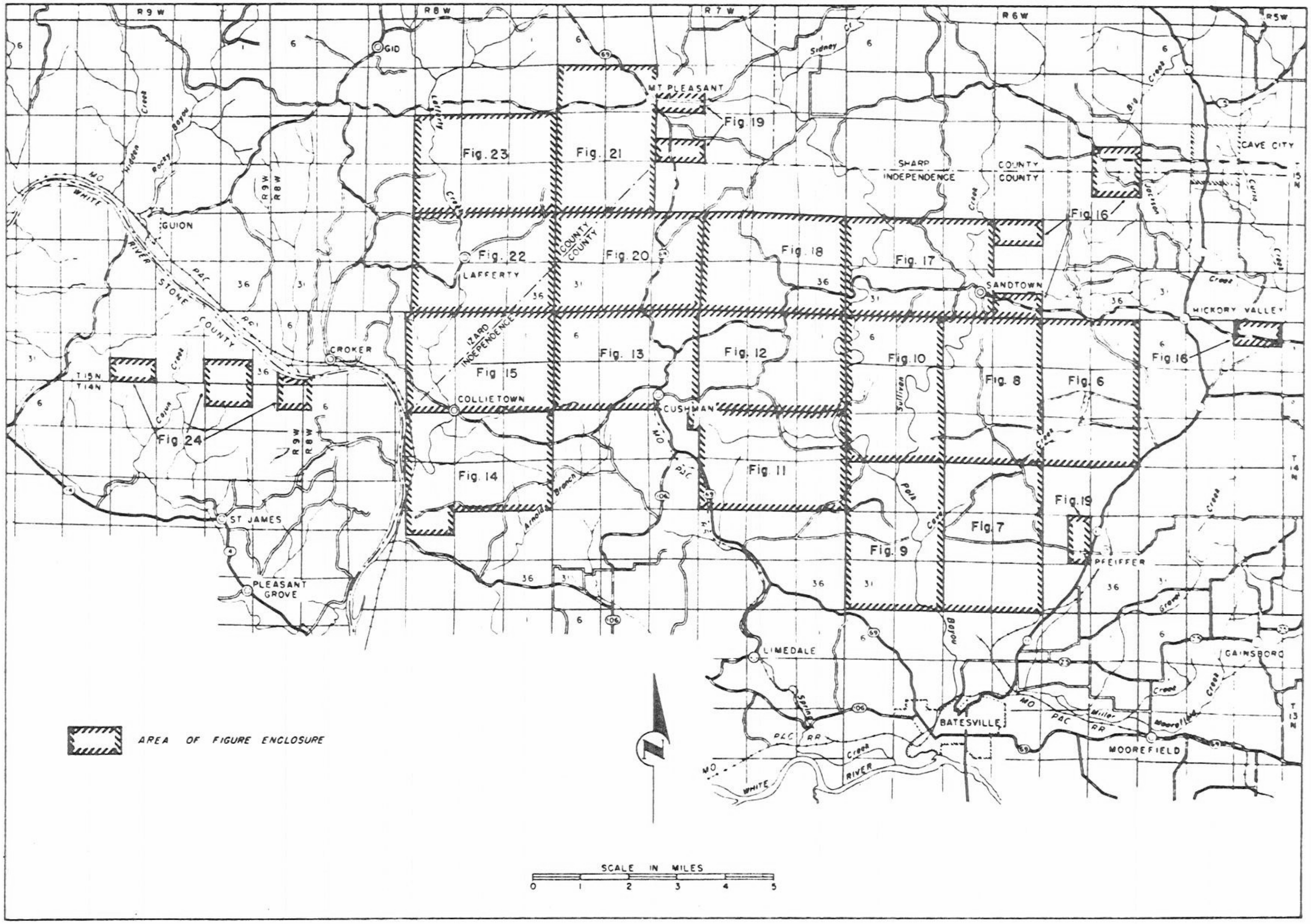


FIGURE 5. - Index Map to Figures 6-24.

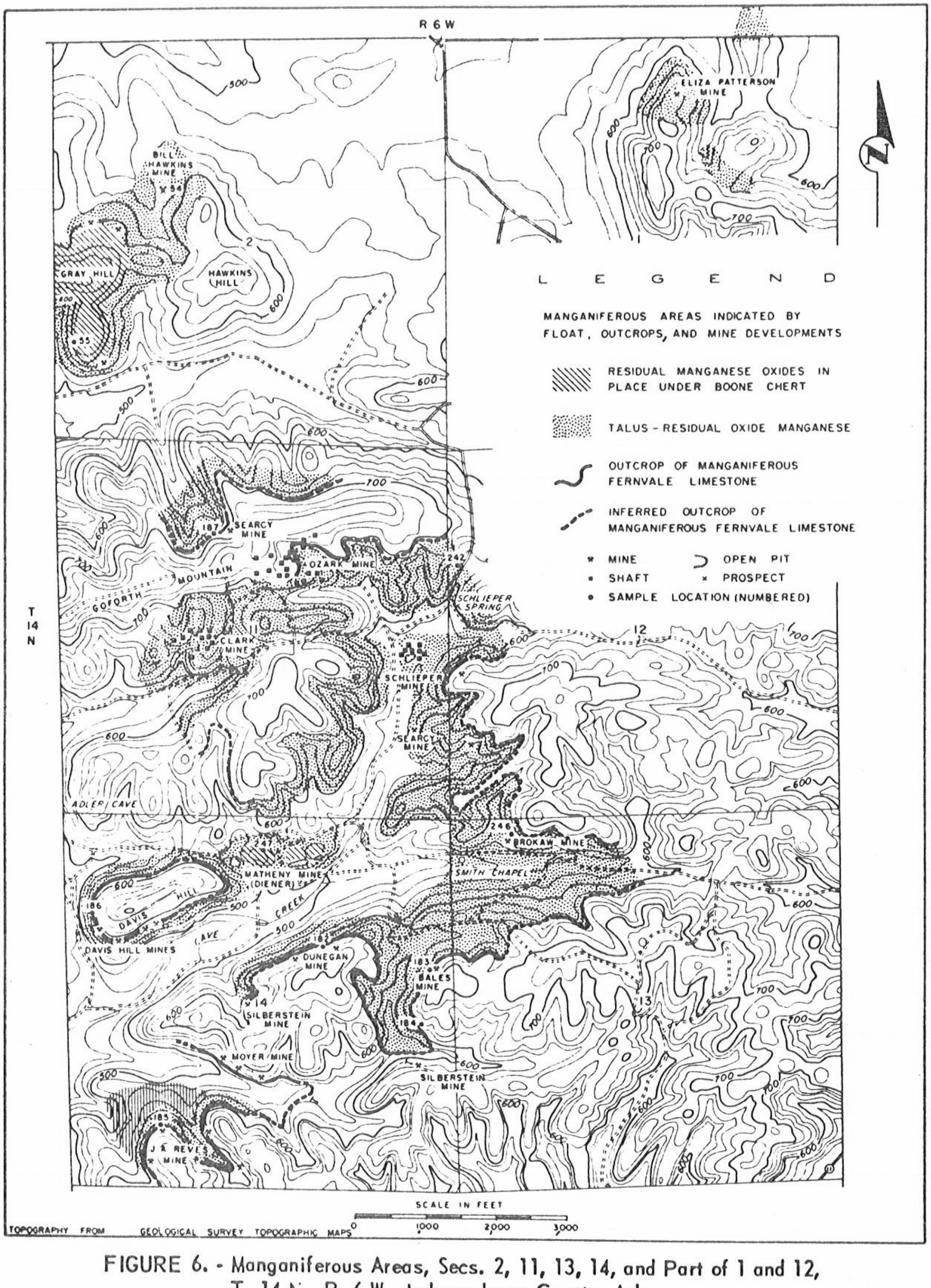


FIGURE 6. - Manganiferous Areas, Secs. 2, 11, 13, 14, and Part of 1 and 12, T. 14 N., R. 6 W., Independence County, Ark.

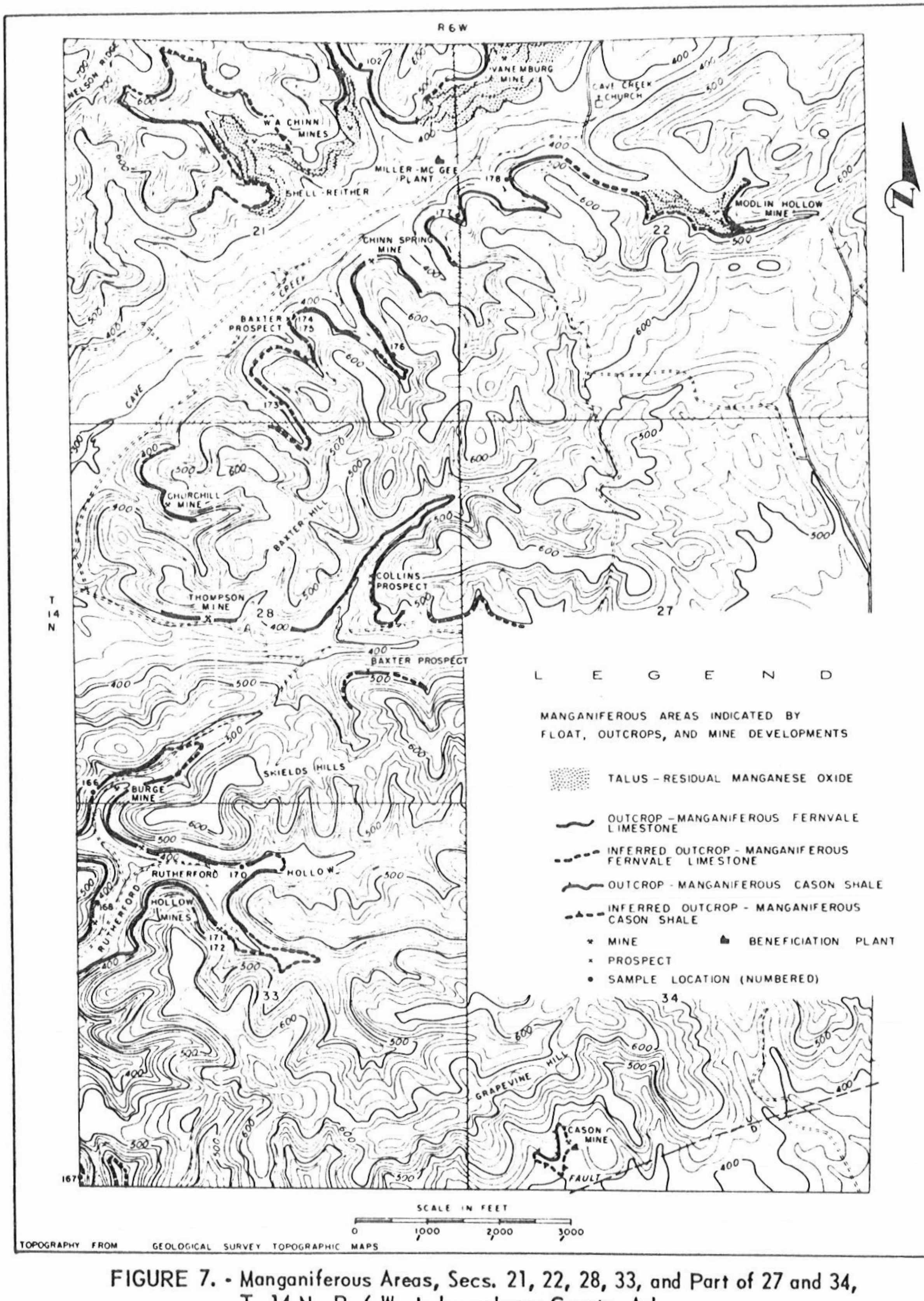


FIGURE 7. - Manganiferous Areas, Secs. 21, 22, 28, 33, and Part of 27 and 34, T. 14 N., R. 6 W., Independence County, Ark.

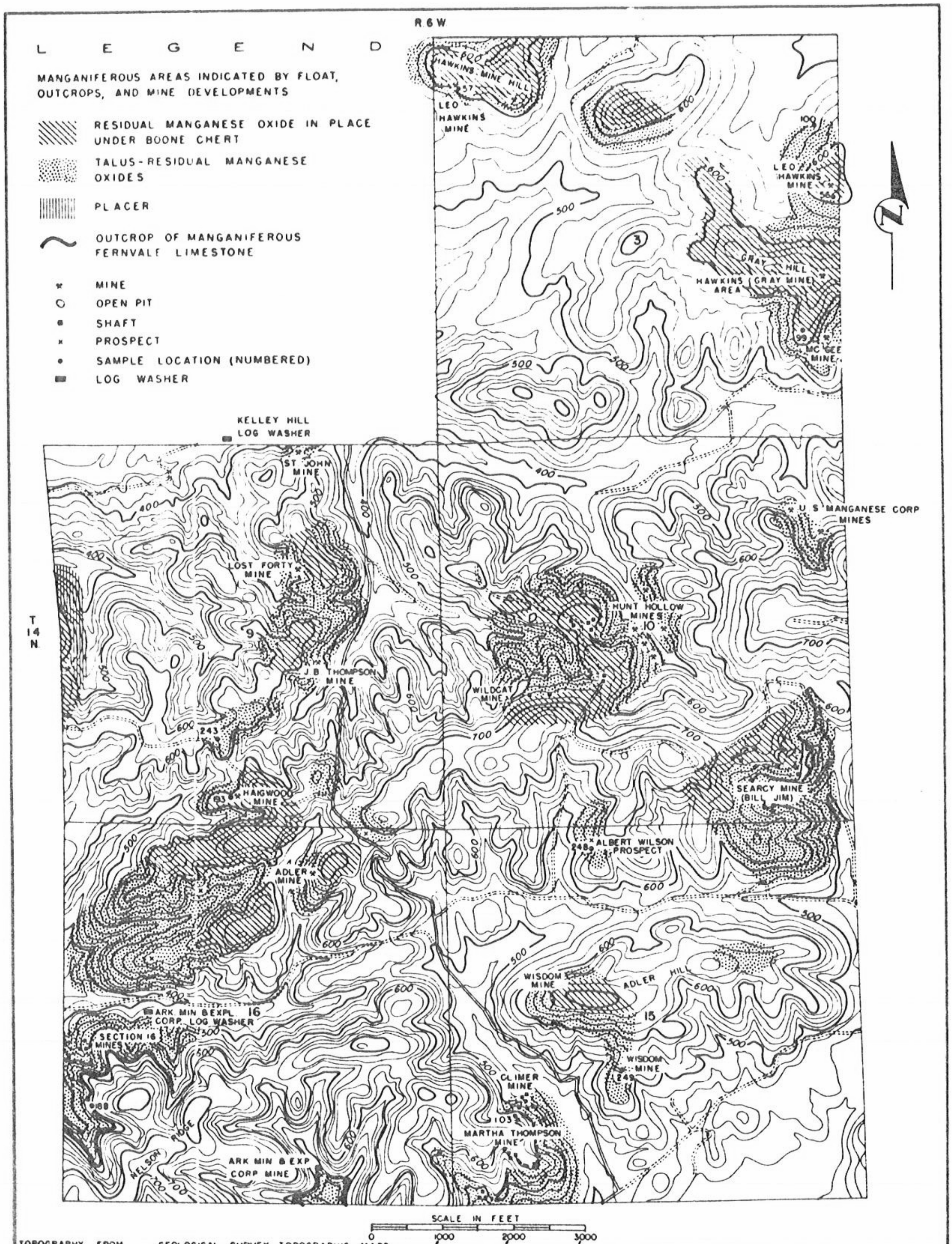


FIGURE 8. - Manganiferous Areas, Secs. 3, 9, 10, 15, and 16, T. 14 N., R. 6 W., Independence County, Ark.

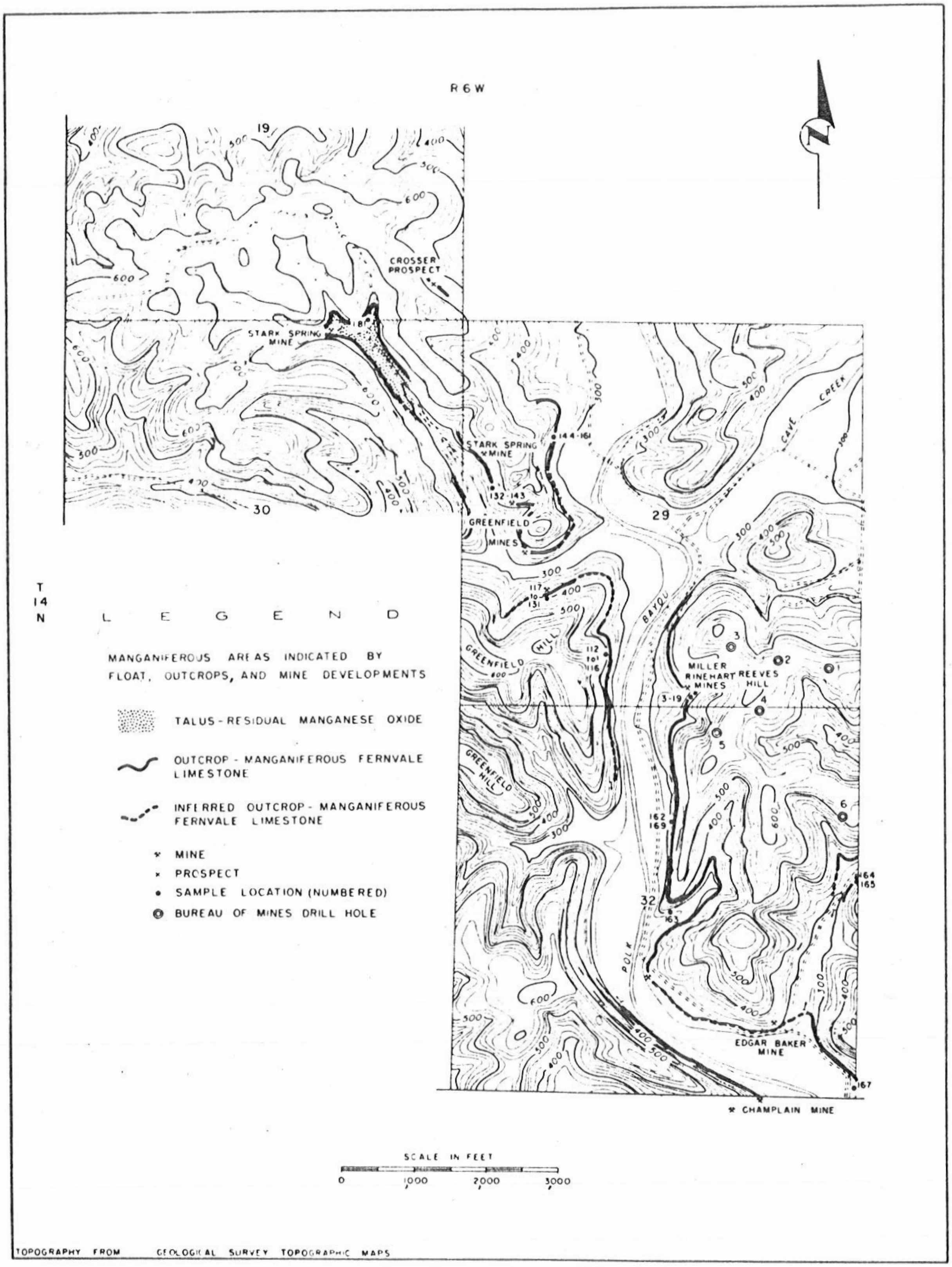


FIGURE 9. - Manganiferous Areas, Secs. 29, 32, and Part of 19 and 30, T. 14 N., R. 6 W., Independence County, Ark.

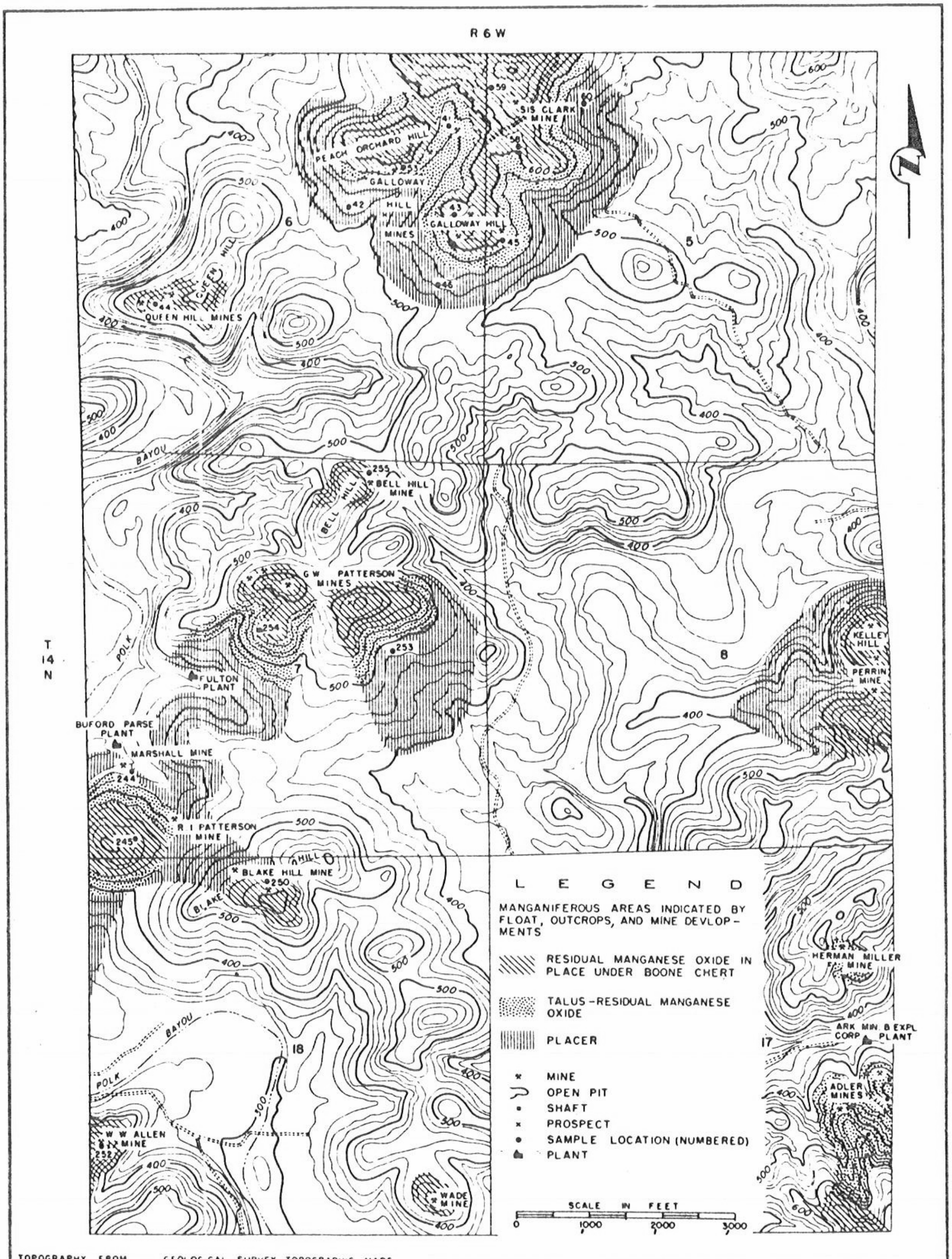


FIGURE 10. - Manganiferous Areas, Secs. 5, 6, 7, 8, 18, and Part of 17, T. 14 N., R. 6 W., Independence County, Ark.

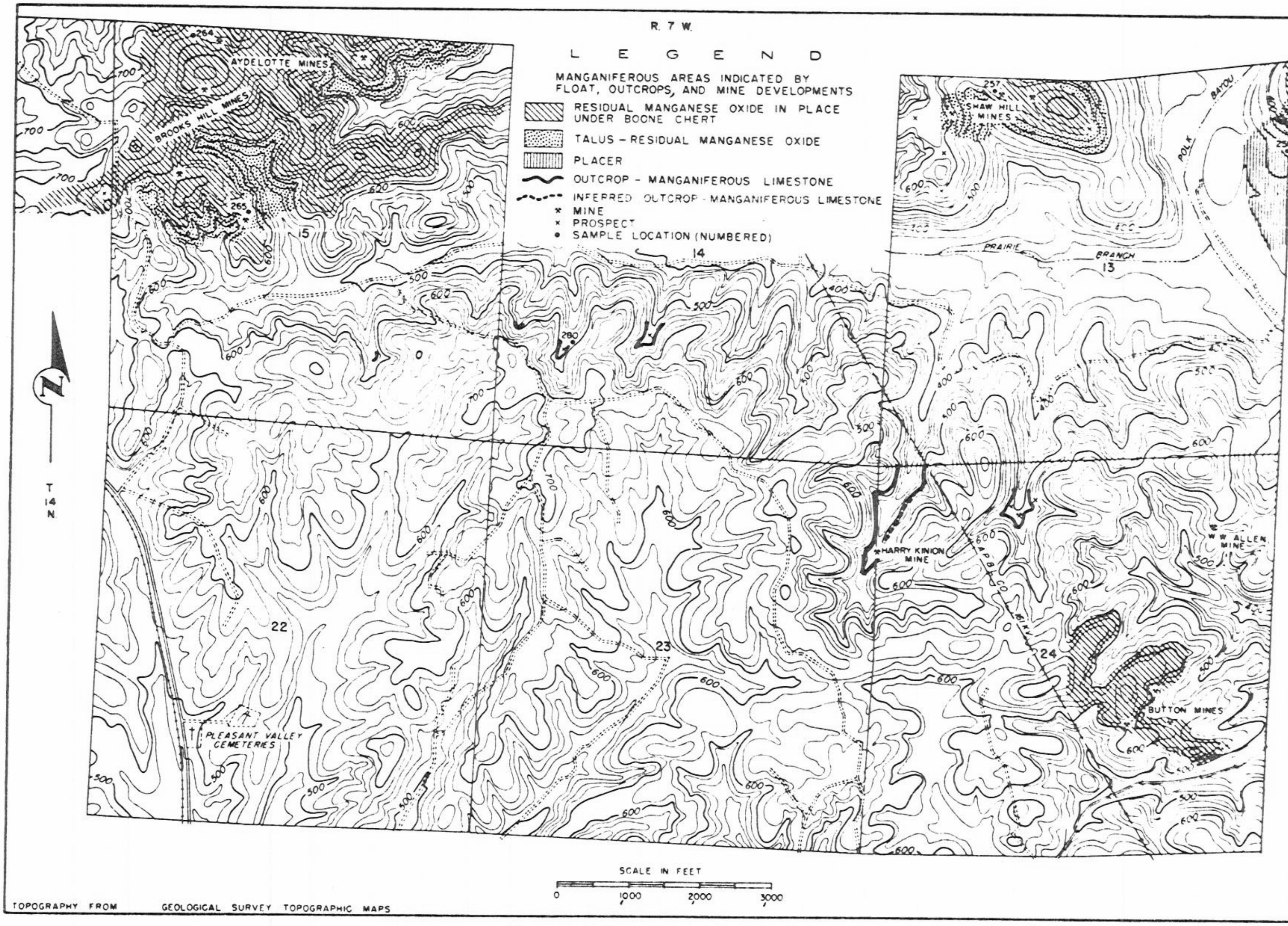


FIGURE 11. - Manganiferous Areas, Secs. 13, 15, 22, 23, 24, and Part of 14, T. 14 N., R. 7 W., Independence County, Ark.

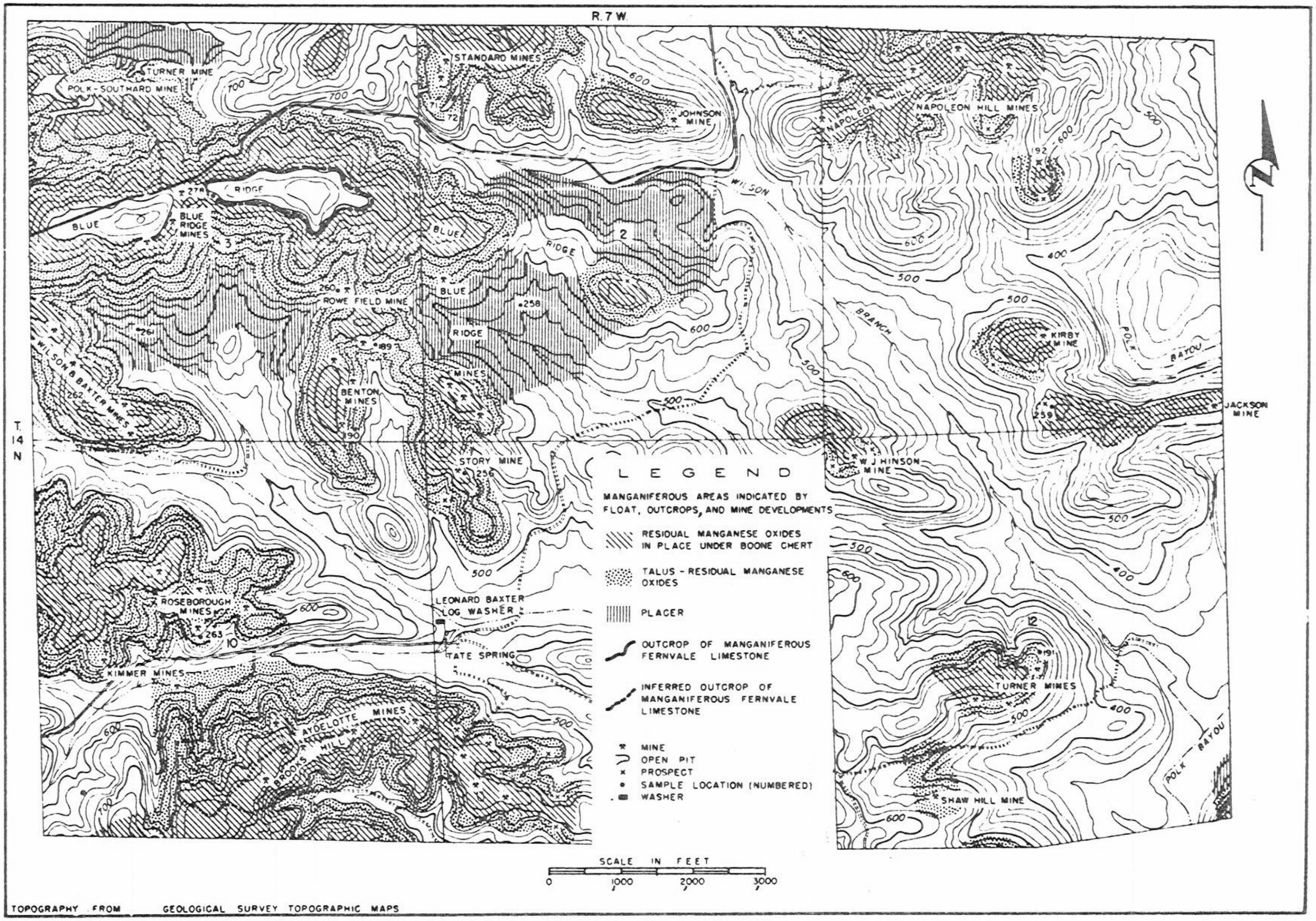


FIGURE 12. - Manganiferous Areas, Secs. 1, 2, 3, 10, 12, and Part of 11, T. 14 N., R. 7 W., Independence County, Ark.

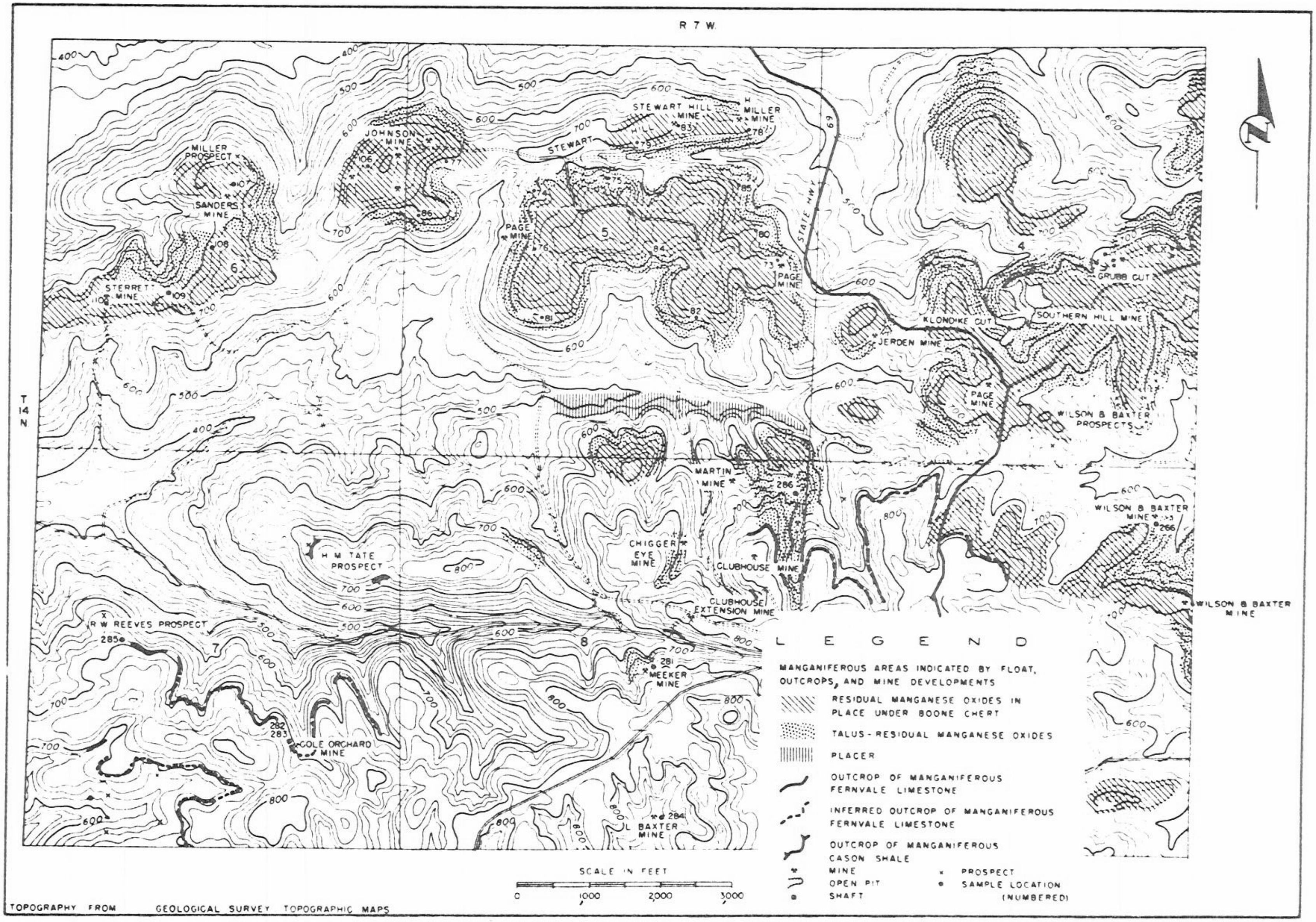


FIGURE 13. - Manganiferous Areas, Secs. 4, 5, 6, 7, and Part of 8 and 9, T. 14 N., R. 7 W., Independence County, Ark.

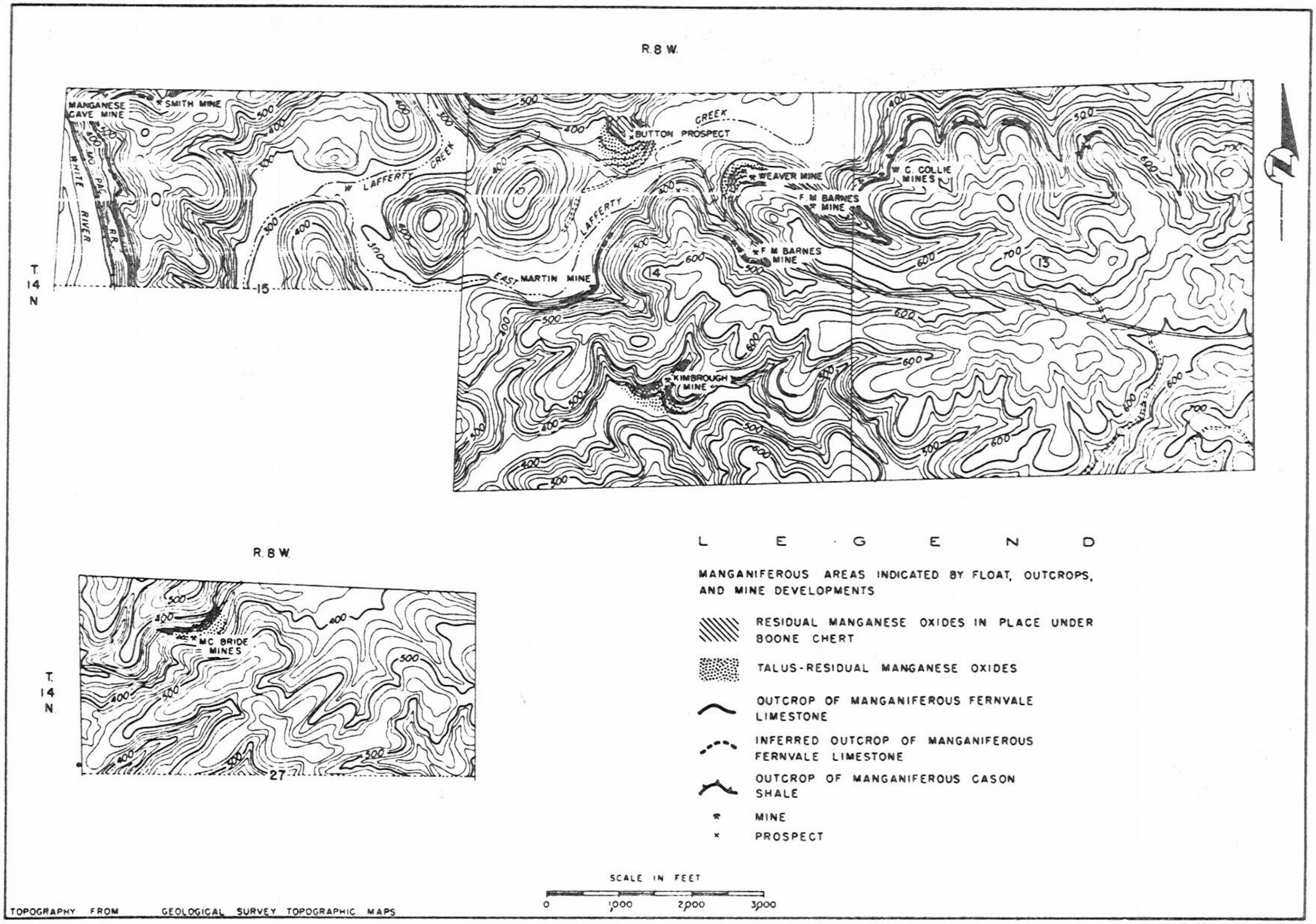


FIGURE 14. - Manganiferous Areas, Secs. 13, 14, and Part of 15 and 27, T. 14 N., R. 8 W., Independence County, Ark.

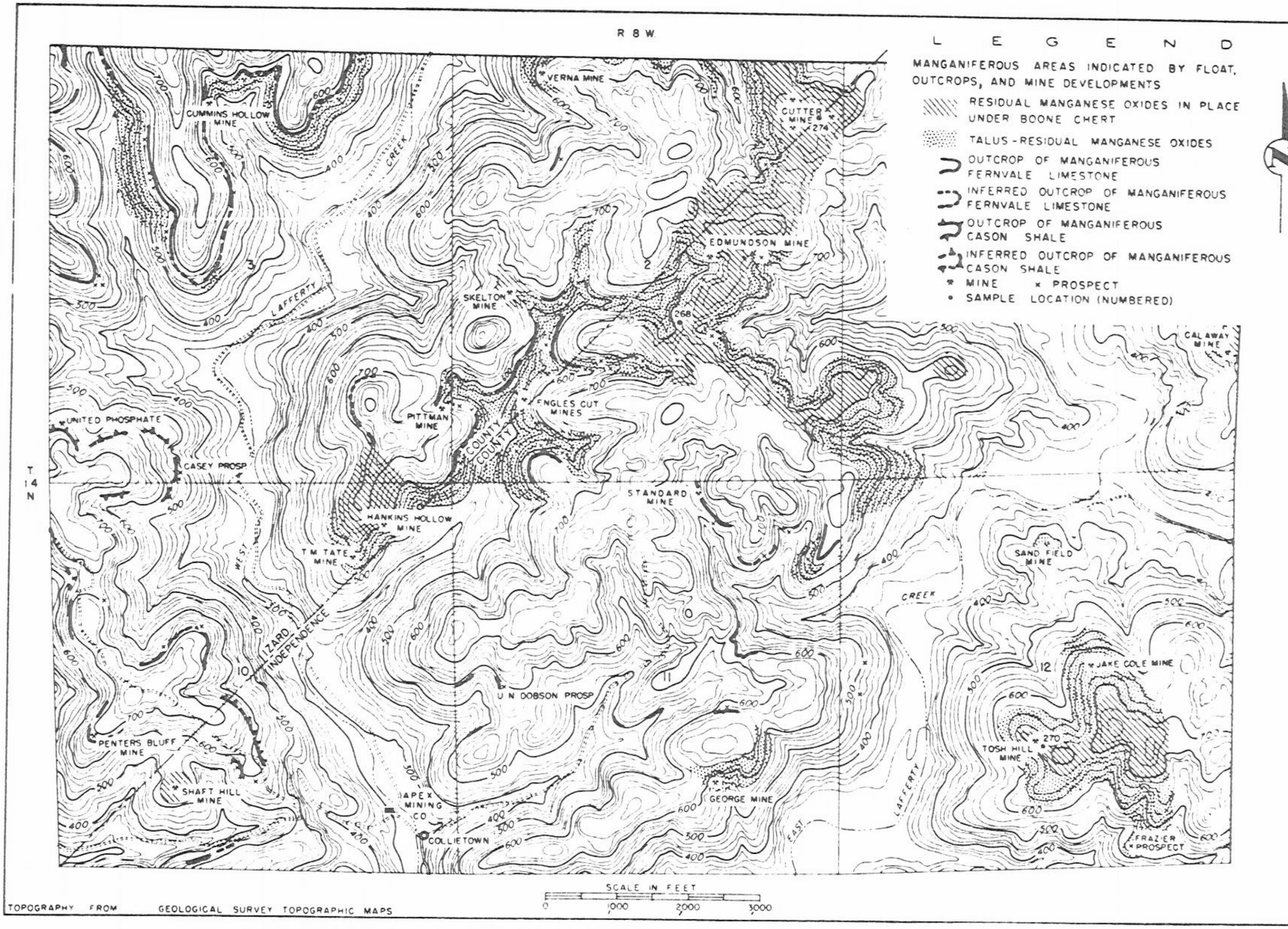


FIGURE 15. - Manganiferous Areas, Secs. 11, 12, and Part of 1, T. 14 N., R. 8 W., Independence County; Sec. 3, T. 14 N., R. 8 W., Izard County; and Secs. 2 and 10, T. 14 N., R. 8 W., Izard and Independence Counties, Ark.

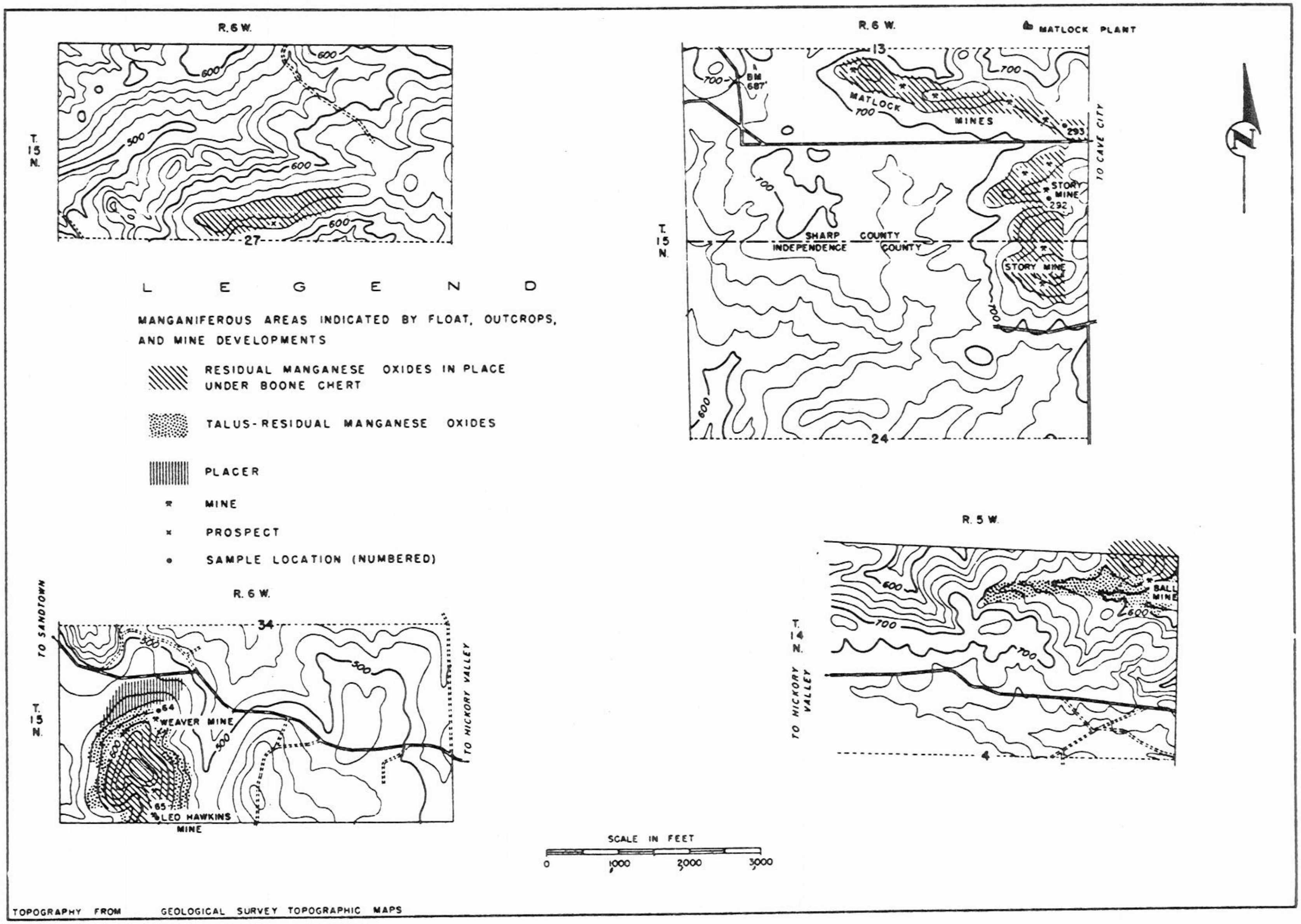


FIGURE 16. - Manganiferous Areas, Part of Sec. 13, T. 15 N., R. 6 W., Sharp County; Part of Secs. 24, 27, and 34, T. 15 N., R. 6 W., and Part of Sec. 4, T. 14 N., R. 5 W., Independence County, Ark.

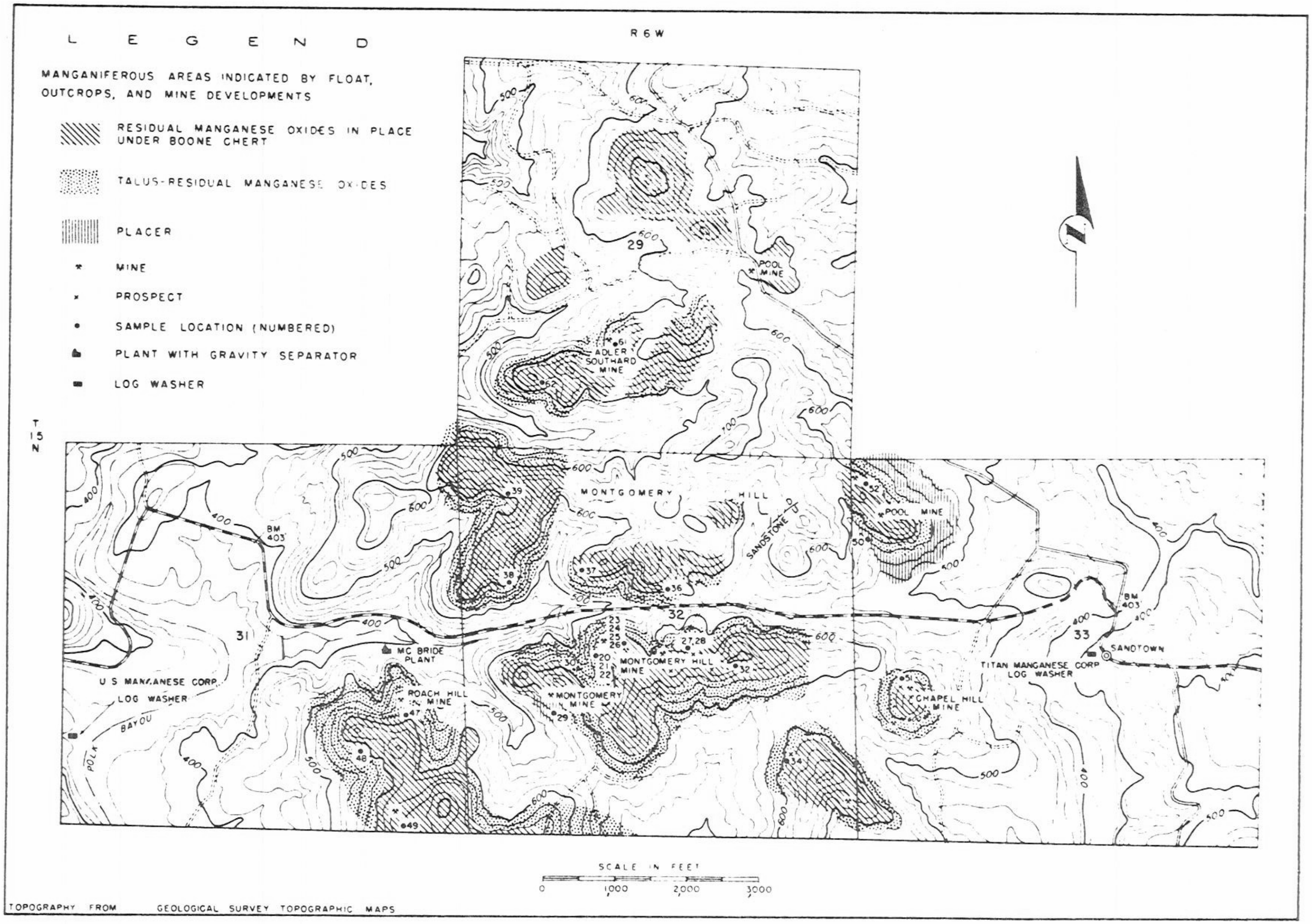


FIGURE 17. - Manganiferous Areas, Secs. 29, 31, 32, and 33, T. 15 N., R. 6 W., Independence County, Ark.

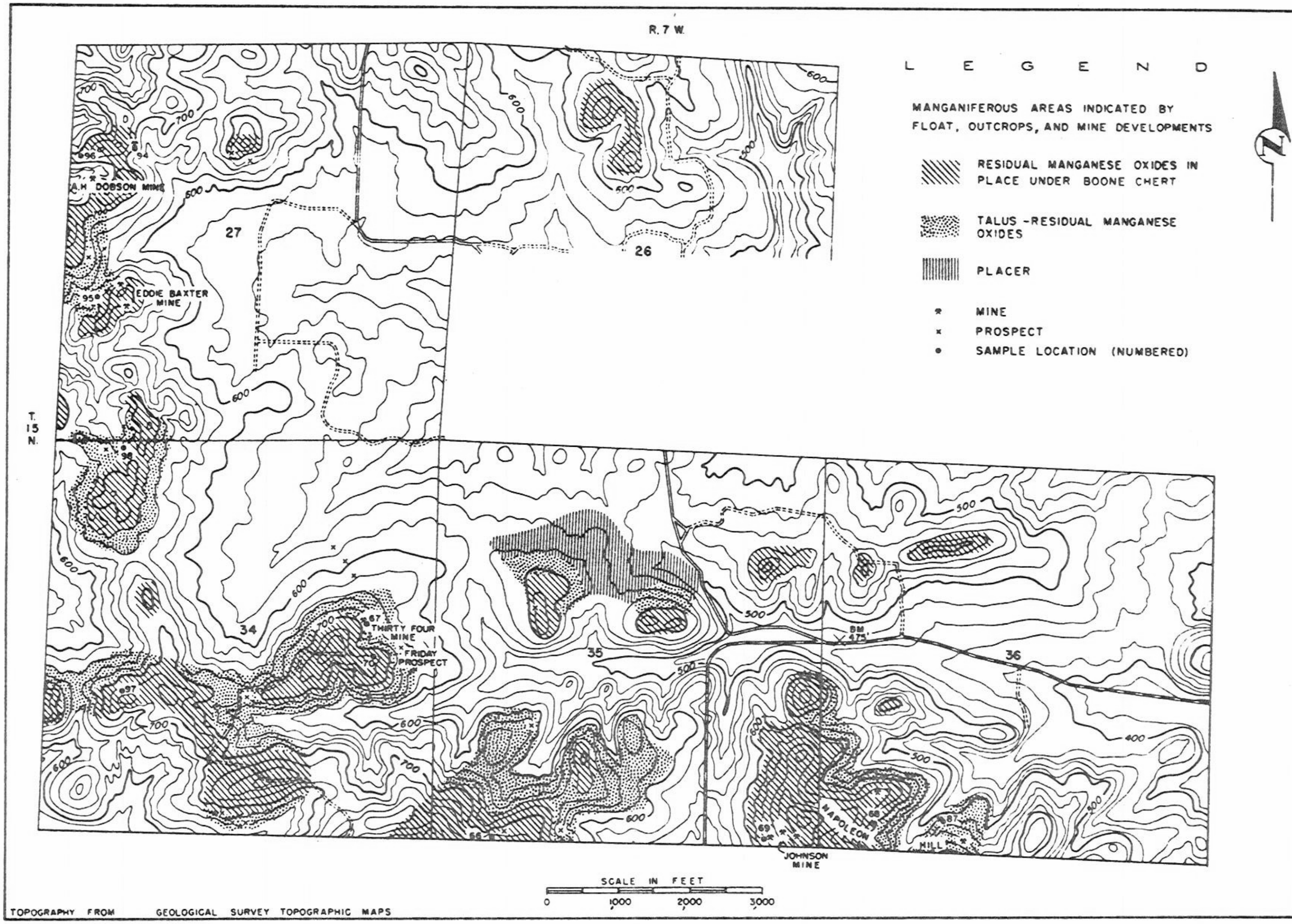


FIGURE 18. - Manganiferous Areas, Secs. 27, 34, 35, 36, and Part of 26, T. 15 N., R. 7 W., Independence County, Ark.

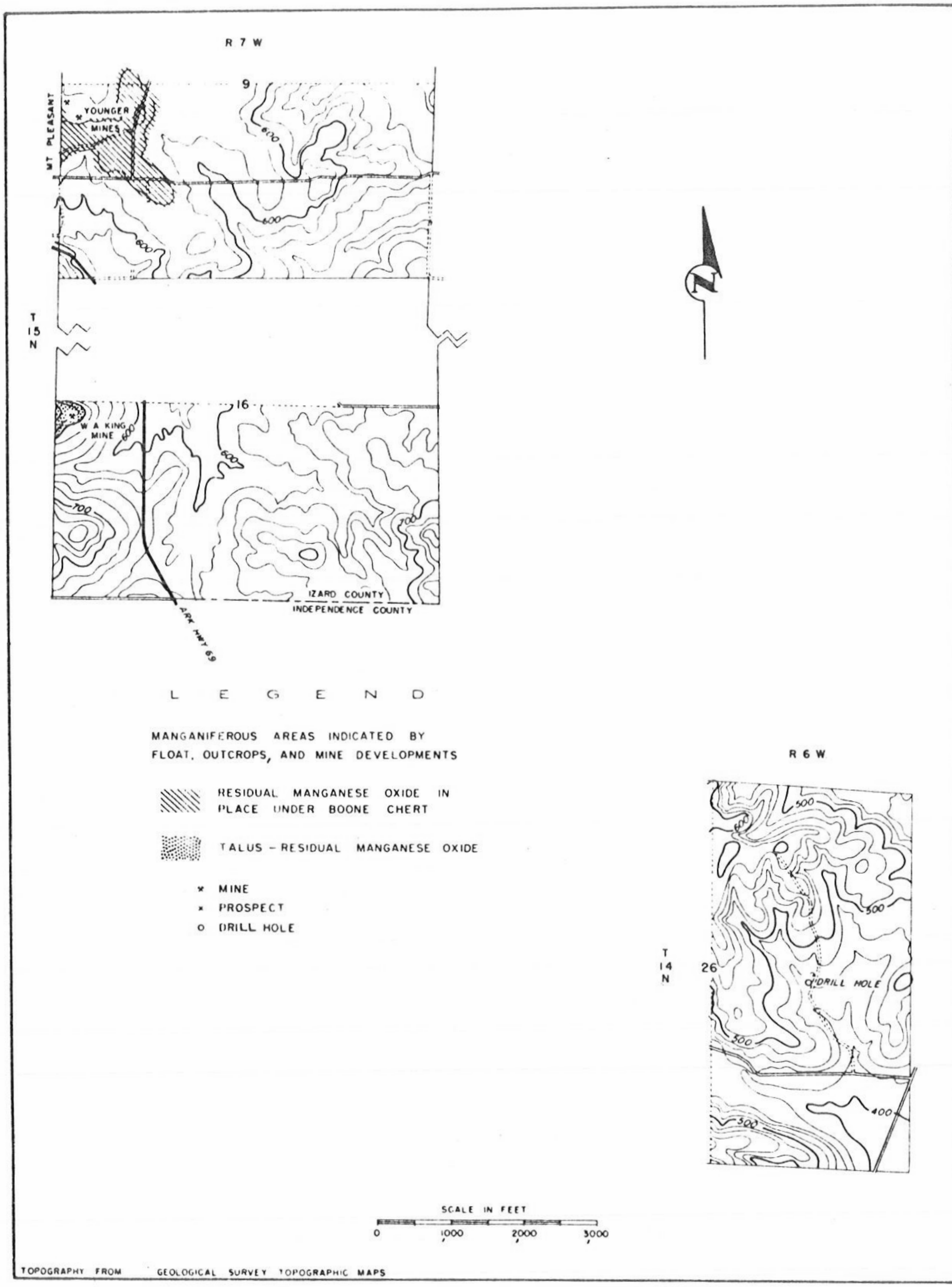


FIGURE 19. - Manganiferous Areas, Part of Secs. 9 and 16, T. 15 N., R. 7 W., Izard County, and Part of Sec. 26, T. 14 N. R. 6 W., Independence County, Ark.

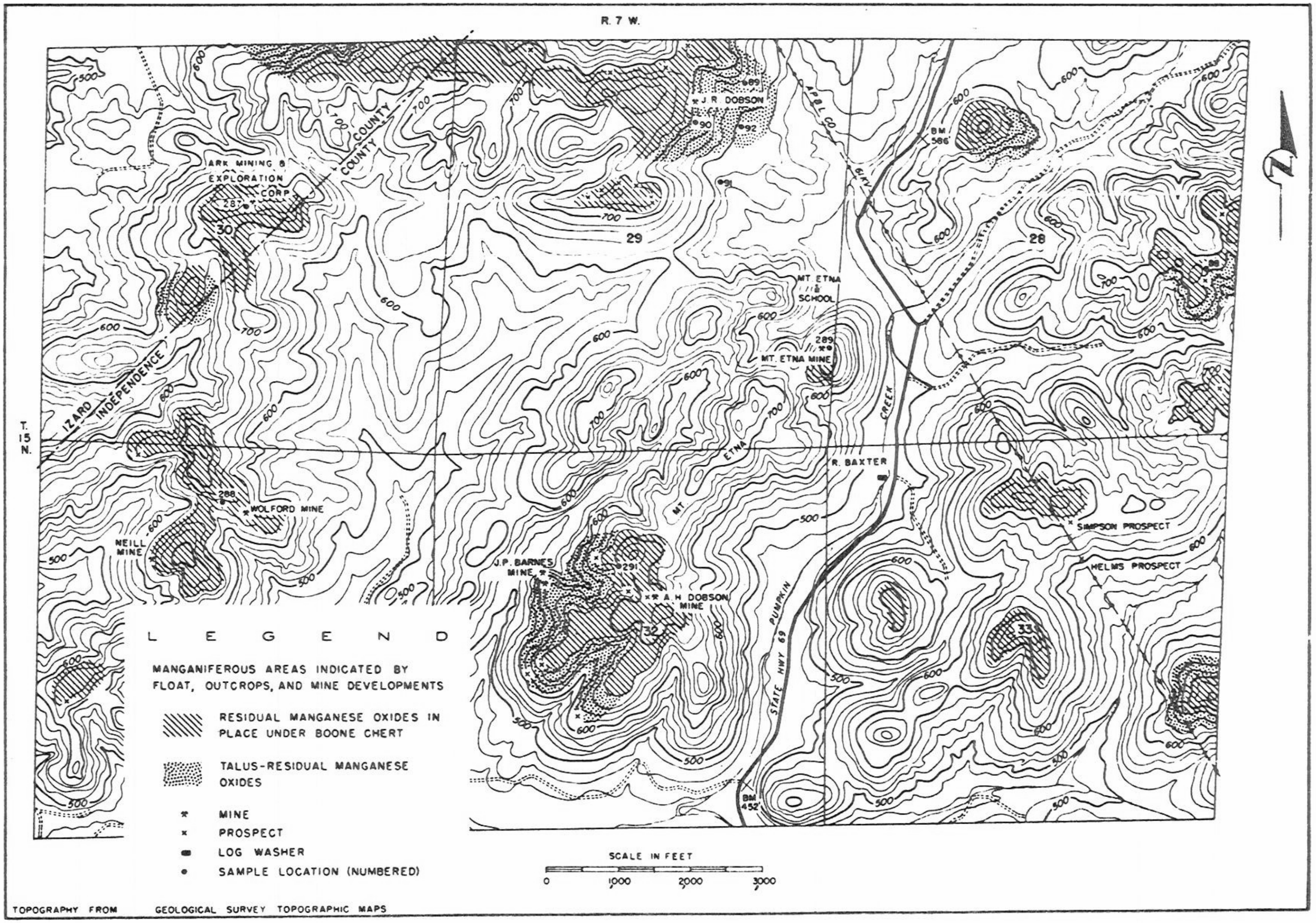


FIGURE 20. - Manganiferous Areas, Secs. 28, 29, 32, 33, and Part of 31, T. 15 N., R. 7 W., Independence County, and Sec. 30, T. 15 N., R. 7 W., Izard and Independence Counties, Ark.

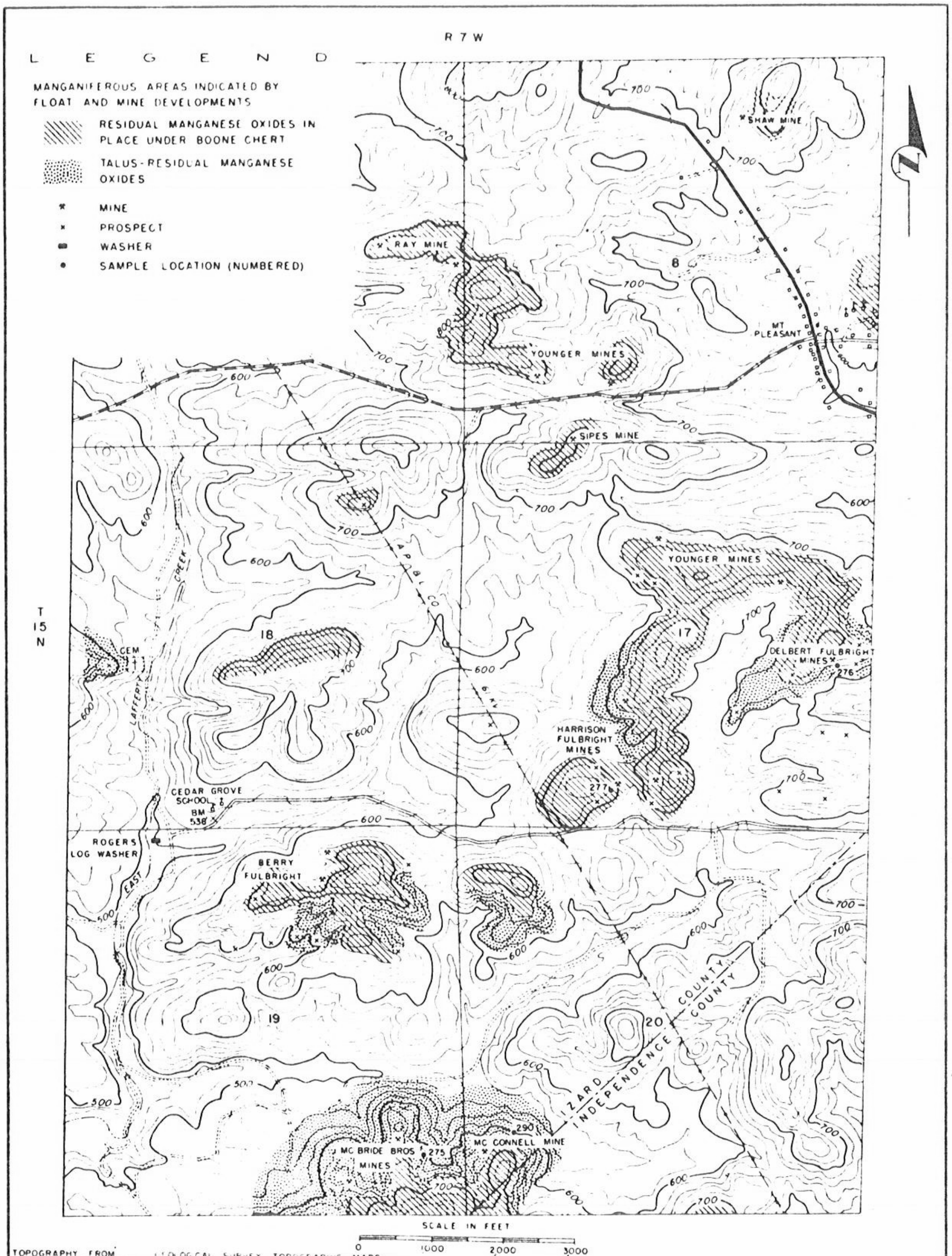


FIGURE 21. - Manganiferous Areas, Secs. 8, 17, 18, 19, and Part of 7, T. 15 N., R. 7 W., Izard County, and Sec. 20, T. 15 N., R. 7 W., Izard and Independence Counties, Ark.

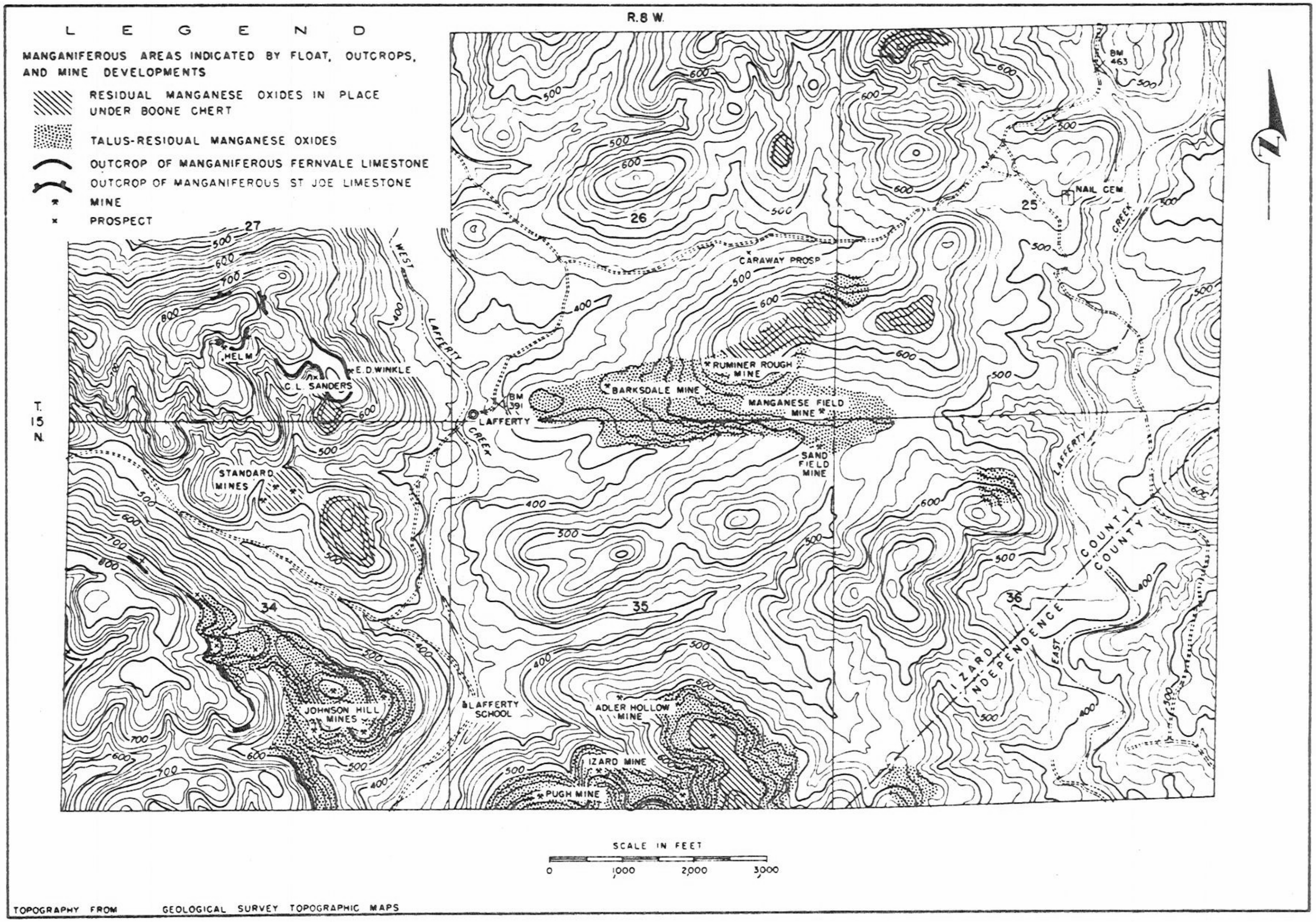


FIGURE 22. - Manganiferous Areas, Secs. 25, 26, 34, 35, and Part of 27, T. 15 N., R. 8 W., Izard County, and Sec. 36, T. 15 N., R. 8 W., Izard and Independence Counties, Ark.

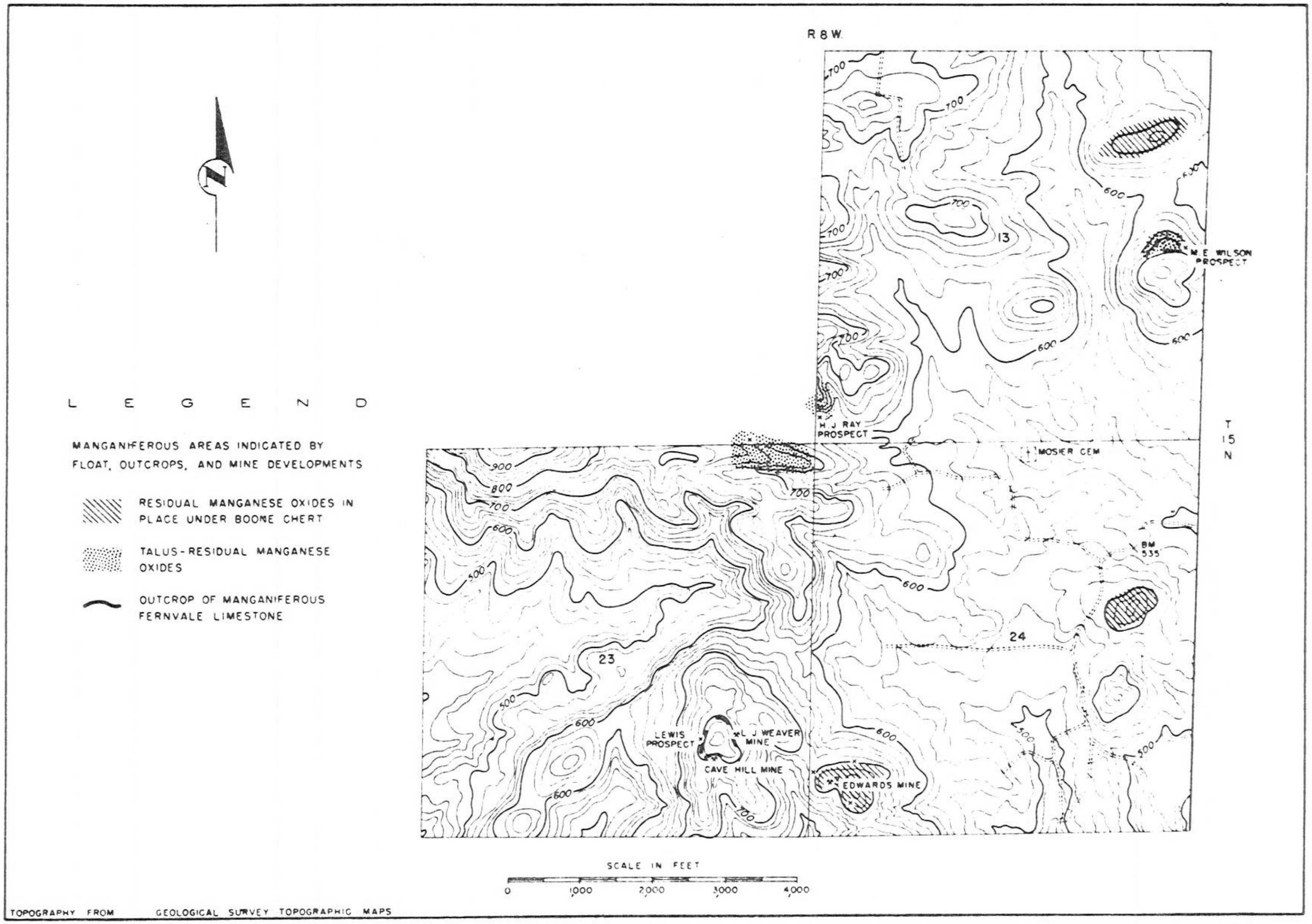


FIGURE 23. - Manganiferous Areas, Secs. 13, 23, and 24, T. 15 N., R. 8 W., Izard County, Ark.

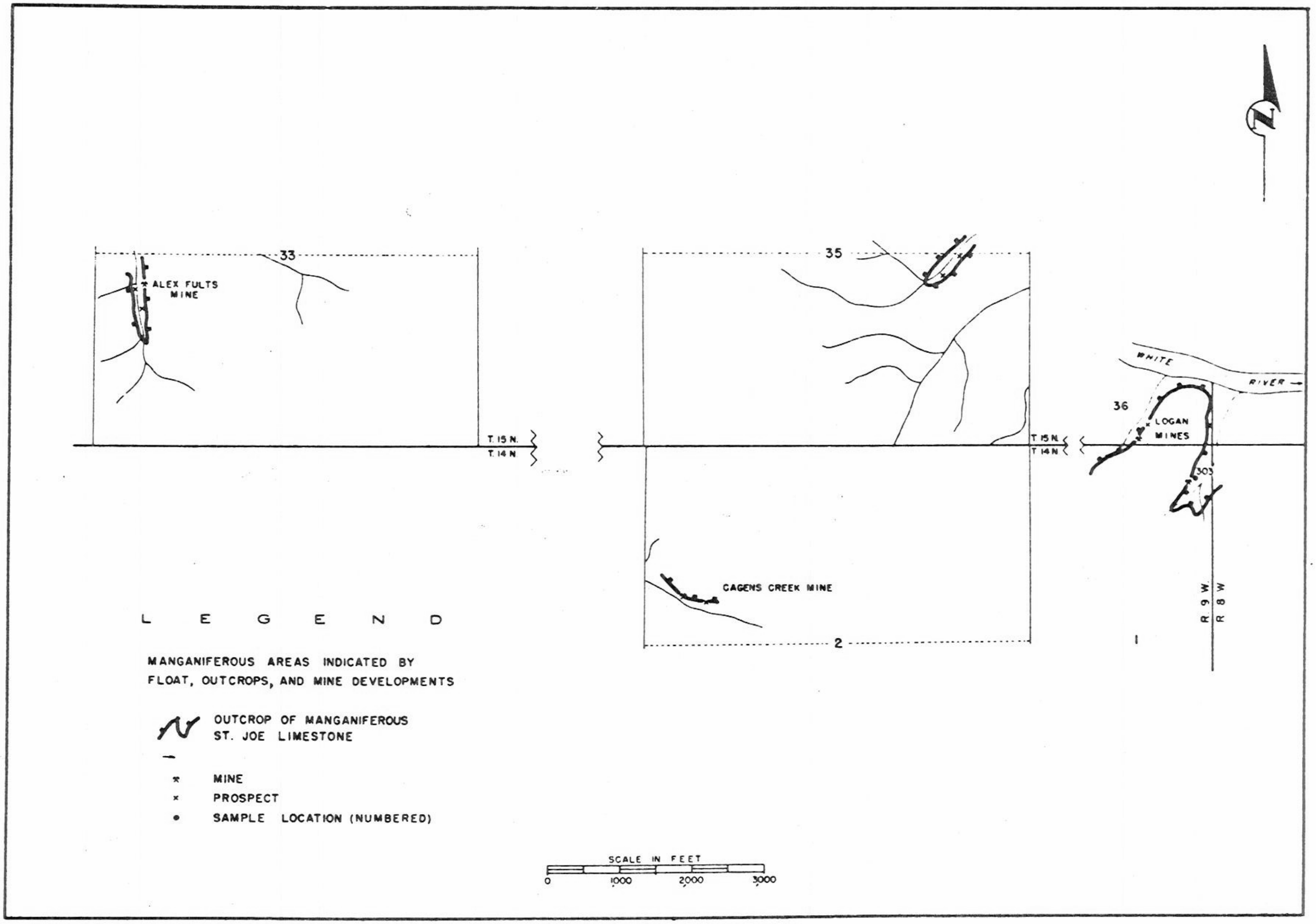


FIGURE 24. - Manganiferous Areas, Parts of Secs. 33, 35, and 36, T. 15 N., R. 9 W., and Part of Secs. 1 and 2, T. 14 N., R. 9 W., Stone County, Ark.

TABLE 2. - Pertinent data on samples of manganiferous limestone

Sample No.	Location,1/ feet from southwest corner					Thickness sampled, feet	Analysis, percent			
	North	East	Sec.	T. N.	R. W.		Mn	Fe	P	Insoluble
3- 8	130	3,170	29	14	6	15.0	3.88	2.95	) Composite	
9- 11	130	3,170	29	14	6	7.5	11.12	3.07	)0.34	1.88
12- 14	130	3,170	29	14	6	7.5	2.57	.97	)	
112	560	2,046	29	14	6	2.5	3.08	)	Composite	
113-115	560	2,046	29	14	6	7.5	12.66	)1.80	.30	.31
116	560	2,046	29	14	6	2.5	1.92	)		
117	1,452	1,188	29	14	6	2.5	1.46	)	Composite	
118-119	1,452	1,188	29	14	6	30.0	4.04	)9.30	.33	2.13
130	1,452	1,188	29	14	6	2.5	2.15	)		
131	1,452	1,188	29	14	6	2.5	.92	)		
132-143	2,902	429	29	14	6	30.0	3.41	1.80	.31	1.72
144-146	3,894	1,320	29	14	6	9.0	6.50	3.00	.41	1.38
147-158	3,894	1,320	29	14	6	30.0	3.28	3.00	.16	1.38
159-161	3,894	1,320	29	14	6	7.5	15.58	3.00	.16	1.38
162	3,960	3,102	32	14	6	40.0	3.69	2.70	.33	2.54
163	2,508	2,970	32	14	6	22.5	4.31	3.10	.33	2.30
164	2,970	5,478	32	14	6	7.5	4.00	1.70	.17	.70
165	2,970	5,478	32	14	6	27.5	5.38	2.50	.33	1.80
166	140	325	28	14	6	30.0	5.38	3.00	.40	3.12
167	75	-	33	14	6	30.0	4.31	2.25	.26	2.50
168	4,092	175	33	14	6	20.0	4.00	2.75	.29	1.84
169	3,960	3,102	32	14	6	27.5	6.61	2.35	.27	2.22
170	4,620	2,178	33	14	6	30.0	4.46	2.25	.25	2.23
171	3,498	2,112	33	14	6	10.0	3.23	2.25	.30	2.59
172	3,498	2,112	33	14	6	15.0	5.23	2.50	.32	2.43
173	335	2,895	21	14	6	30.0	5.39	2.90	.33	1.99
174	1,220	3,105	21	14	6	7.5	2.95	1.75	.25	1.90
175	1,220	3,105	21	14	6	27.5	7.91	2.37	.34	2.70
176	765	4,570	21	14	6	15.0	4.36	2.56	.27	2.64
177	2,975	70	22	14	6	30.0	4.49	2.56	.27	2.33
178	3,470	780	22	14	6	25.0	4.22	1.75	.29	2.43
179	100	4,045	32	14	6	27.5	6.38	3.11	.34	2.37
180	560	5,045	19	14	6	15.0	10.05	2.06	.31	2.86
181	115	4,165	19	14	6	30.0	4.75	2.49	.44	3.26
182	3,440	3,620	14	14	6	17.5	3.81	2.00	.36	2.74
183	2,985	5,060	14	14	6	10.0	6.47	2.00	.46	3.78
184	2,205	5,100	14	14	6	20.0	2.92	1.52	.30	1.85
185	855	1,280	14	14	6	25.0	4.99	1.52	.32	3.26
186	3,840	320	14	14	6	25.0	2.17	1.66	.31	1.45
187	4,001	2,310	11	14	6	25.0	5.15	1.57	.36	2.74
188	1,248	430	16	14	6	15.0	3.09	1.75	.23	1.77
278	3,325	2,555	3	14	7	13.0	2.82	1.15	.24	7.58
279	3,920	5,480	23	14	7	5.0	1.73	1.69	.15	1.66
280	1,570	2,225	14	14	7	15.0	3.26	2.97	.25	1.38

1/ Groups of samples from same location were taken progressively downward from top of manganiferous limestone outcrop.

TABLE 3. - Pertinent data on samples of manganiferous clays

Sample No.	Location, feet from southwest corner					Thickness sampled, feet	Analysis, percent			
	North	East	Sec.	T. N.	R. W.		Mn	Fe	P	Insoluble
15-19	130	3,170	29	14	6	25.0	8.01	13.68	1.52	29.60
20-22	2,442	1,980	32	15	6	13.5	5.88	10.37	.47	-
23-26	2,640	2,376	32	15	6	17.5	11.63	11.43	.47	-
27-28	2,580	3,102	32	15	6	9.0	4.33	7.18	.47	-
29	1,584	1,122	32	15	6	5.0	3.54	6.80	.31	-
30	2,244	1,452	32	15	6	11.0	11.22	13.00	.31	-
31	1,518	1,716	32	15	6	10.0	1.69	5.00	.31	-
32	2,310	3,360	32	15	6	14.0	5.61	12.00	.31	-
33	2,640	4,356	32	15	6	18.0	5.23	6.10	.31	-
34	1,056	4,290	32	15	6	12.0	11.53	9.50	.33	-
35	528	40	33	15	6	22.0	10.61	11.61	.33	-
36	3,432	2,770	32	15	6	14.0	14.38	11.10	.37	-
37	3,564	1,584	32	15	6	12.0	4.54	7.00	.37	-
38	3,430	330	32	15	6	16.0	10.15	9.60	.37	-
39	4,686	390	32	15	6	9.0	15.38	10.38	.37	-
41	4,620	5,220	6	14	6	10.0	21.37	12.45	.30	-
42	3,630	3,640	6	14	6	4.0	6.80	5.90	.30	-
43	3,234	5,150	6	14	6	10.0	9.42	10.95	.30	-
44	1,980	1,056	6	14	6	4.0	12.07	11.95	.29	38.18
45	3,828	210	5	14	6	4.0	3.08	28.35	.30	37.17
46	2,574	4,884	6	14	6	5.0	3.87	5.15	.30	-
47	1,650	4,752	31	15	6	23.0	12.30	17.95	.30	-
48	1,122	4,092	31	15	6	5.0	13.07	10.00	.30	-
49	50	2,752	31	15	6	6.0	17.60	13.95	.30	-
50	4,092	110	33	15	6	5.0	2.46	4.85	.26	-
51	2,170	495	33	15	6	13.0	8.07	11.80	.46	48.45
52	4,818	-	33	15	6	6.0	18.11	6.25	.42	30.23
53	3,960	4,488	6	14	6	17.0	22.29	16.10	.30	-
54	3,432	1,584	2	14	6	9.0	7.69	15.15	.35	-
55	1,386	200	2	14	6	9.0	4.46	12.70	.35	-
56	3,300	5,478	3	14	6	4.0	9.38	13.85	.42	-
57	4,950	220	3	14	6	4.0	18.60	17.45	.42	-
58	4,356	400	5	14	6	12.0	13.84	12.85	.30	-
59	5,148	140	5	14	6	8.0	10.76	9.80	.79	-
60	4,884	1,386	5	14	6	10.0	5.38	9.55	.30	-
61	1,452	2,178	29	15	6	11.0	14.61	21.15	.79	-
62	930	1,188	29	15	6	4.0	12.30	24.30	.26	-
63	1,325	2,508	32	15	6	7.0	6.84	9.45	.31	-
64	1,518	1,400	34	15	6	7.0	9.53	9.90	.42	-
65	20	1,254	34	15	6	4.0	19.99	13.00	.42	-
68	390	700	36	15	7	16.0	10.92	9.70	.28	-
73	2,574	5,148	5	14	7	8.0	4.46	)		-
74	3,498	1,848	5	14	7	9.0	6.38	)		-
75	3,762	2,838	5	14	7	5.0	5.34	)		-
76	2,772	1,782	5	14	7	13.0	3.54	)		-
77	3,960	530	5	14	7	7.0	12.92	)		-
78	4,488	4,752	5	14	7	5.0	14.92	)		-
79	4,290	3,168	5	14	7	6.0	7.87	) 9.80	.44	-
80	2,970	4,884	5	14	7	7.0	15.53	)		-
81	1,790	1,914	5	14	7	6.0	3.23	)		-

TABLE 3. - Pertinent data on samples of manganiferous clays (Con.)

Sample No.	Location, feet from southwest corner					Thickness sampled, feet	Analysis, percent			
	North	East	Sec.	T. N.	R. W.		Mn	Fe	P	Insoluble
82	1,848	4,092	5	14	7	7.0	12.46	)		-
83	4,488	3,828	5	14	7	6.0	12.00	)		-
84	2,710	3,432	5	14	7	5.0	8.37	)		-
85	3,675	4,620	5	14	7	9.0	9.54	)		-
86	3,234	228	5	14	7	7.0	14.61	)		-
87	495	1,720	36	15	7	9.0	10.92	13.00	1.36	-
99	1,452	5,082	3	14	6	14.0	14.30	16.00	1.15	-
100	4,356	5,200	3	14	6	6.0	10.30	12.50	.27	-
106	3,696	4,356	6	14	7	7.5	15.38	)		-
107	3,564	2,640	6	14	7	12.0	11.53	)		-
108	2,772	2,310	6	14	7	12.0	3.84	) 3.60	.34	-
109	2,064	1,640	6	14	7	10.5	1.85	)		-
110	1,985	915	6	14	7	13.5	8.61	)		-
111	1,650	5,250	1	14	8	13.5	7.53	)		-
189	1,220	4,750	3	14	7	7.0	6.40	10.12	.24	-
190	50	4,450	3	14	7	11.0	28.81	11.80	.23	-
191	2,670	2,845	12	14	7	4.0	5.45	8.13	.23	-
192	3,530	4,585	1	14	7	14.0	22.07	10.47	.34	-
193	150	3,550	9	14	6	15.0	7.98	11.10	.32	-
242	3,612	13	12	14	6	4.0	13.99	18.06	.40	-
243	1,113	2,127	9	14	6	8.0	14.41	11.59	.25	-
244	1,393	680	7	14	3	3.0	2.84	4.18	.07	-
245	295	662	7	14	6	12.0	7.41	7.14	.43	-
246	4,924	1,505	13	14	6	4.0	14.93	11.32	.29	-
247	4,685	2,705	14	14	6	10.0	13.44	15.63	.57	-
248	5,135	1,668	15	14	6	12.0	11.95	9.77	.30	-
249	2,101	2,333	15	14	6	4.0	14.23	19.94	.54	-
250	4,909	2,501	18	14	6	4.0	6.58	14.35	.23	-
251	4,550	-	18	14	6	2.0	2.44	4.65	.09	-
252	1,442	152	18	14	6	8.0	19.90	11.86	.31	-
253	2,840	4,211	7	14	6	3.0	8.57	8.83	.40	-
254	3,214	2,422	7	14	6	4.0	4.97	16.37	.34	-
255	5,215	3,929	7	14	6	16.0	4.52	7.68	.27	-
256	5,061	44	11	14	7	8.0	4.52	9.23	.20	-
257	5,223	1,110	13	14	7	4.0	1.70	8.09	.85	-
258	1,868	1,357	2	14	7	4.0	2.01	3.91	.08	-
259	26	3,023	1	14	7	5.0	21.93	15.23	.24	-
260	2,006	4,442	3	14	7	10.0	3.06	5.27	.16	-
261	1,467	1,505	3	14	7	3.0	1.56	4.80	.17	-
262	561	706	3	14	7	4.0	11.29	16.01	.31	-
263	2,640	2,244	10	14	7	6.0	23.46	15.55	.23	-
264	5,082	1,023	15	14	7	6.0	11.22	20.62	.37	-
265	2,640	1,894	15	14	7	7.0	9.26	12.51	.91	-
266	4,620	4,917	9	14	7	9.0	20.19	14.67	.35	-
267	3,366	5,478	9	14	7	4.0	9.90	8.65	.23	-
268	2,277	3,181	2	14	8	4.0	14.40	7.91	1.44	-
269	2,772	3,498	12	14	8	4.0	17.03	10.34	.29	-
270	1,821	2,772	12	14	8	4.0	4.57	10.88	.69	-
271	4,389	2,211	35	15	7	2.0	2.30	3.65	.06	-
272	3,630	2,211	35	15	7	2.0	4.33	5.48	.56	-

TABLE 3. - Pertinent data on samples of manganiferous clays (Con.)

Sample No.	Location, feet from southwest corner: North	East	Sec.	T. N.	R. W.	Thickness sampled, feet	Analysis, percent: Mn	Fe	P	Insoluble
273	3,333	1,683	35	15	7	6.0	3.69	7.64	0.75	-
274	5,095	4,885	2	14	8	4.0	22.92	10.95	.28	-
275	963	4,884	19	15	7	4.0	22.07	11.83	.33	-
276	2,117	5,115	17	15	7	4.0	18.70	9.33	.62	-
277	790	2,181	17	15	7	6.0	8.46	9.87	.68	-
281	2,500	3,510	8	14	7	7.0	7.48	16.39	3.29	32.12
282	1,280	3,810	7	14	7	2.0	14.97	15.72	2.13	24.52
283	1,280	3,810	7	14	7	3.0	4.27	4.36	1.39	16.72
284	410	3,440	8	14	7	4.0	9.36	19.44	2.93	21.18
285	2,770	1,320	7	14	7	3.0	9.81	10.41	.47	-
286	4,950	5,305	8	14	7	4.0	11.66	10.95	.36	-
287	3,170	2,770	30	15	7	3.0	21.27	12.30	.30	-
288	4,555	2,565	31	15	7	3.0	.62	8.11	.35	-
289	1,575	5,280	29	15	7	3.0	10.25	10.28	.26	-
290	1,115	605	20	15	7	3.0	11.91	6.79	.22	-
291	3,550	2,475	32	15	7	3.0	4.82	7.61	1.22	-
292	1,860	4,455	13	15	6	4.0	15.71	10.88	.24	-
293	1,960	3,425	13	15	6	4.0	9.46	8.99	.27	-
294	645	4,950	13	15	6	8.0	15.41	9.73	.24	-
295	1,300	120	8	15	7	3.0	4.94	10.04	.79	-
297	1,200	600	1	14	7	2.0	18.84	12.91	.24	22.12
298	250	3,300	7	14	6	4.0	10.40	5.57	.10	54.66
299	1,940	600	33	15	9	6.0	18.65	5.29	.18	8.84

TABLE 4. - Inferred reserved of manganiferous materials

Type of deposit	Long dry tons	Manganese content (estimated), percent
1. Manganiferous limestone:		
(a) Fernvale limestone and Cason shale ...	140,000,000	5
(b) St. Joe limestone	1,100,000	5
2. Manganiferous clay in place under chert ...	1/ 16,600,000	1/ 9
3. Manganiferous clay, talus-residual	5,000,000	6
4. Placer	3,200,000	4

1/ Includes 700,000 long dry tons of wad ore containing 23 percent of manganese above a cutoff of 10 percent manganese (5).

Estimates of manganiferous-limestone reserves were based on the length and thickness of outcrops and the manganese content of samples taken therefrom. In estimating areas, outcrops were assumed to influence widths equal to one-half their observable lengths, and allowance was made for possible cavities and barren zones. Average measured thicknesses of 26 feet were used to calculate volume. A factor of 14 cubic feet per ton was used in calculating tonnages.

In areas inferred to contain manganiferous clays under chert, 30 percent of an area was assumed to be manganese bearing. This factor was determined by a survey of mining operations at separate sites throughout the district, by sampling, and from data published in Report of Investigations 4859, which showed that 69 percent of the 1,920 holes drilled in 13 of the most productive deposits were blank holes. A factor of 25 cubic feet per long dry ton was used in calculating tonnages.

Ten percent of an area covered by manganiferous talus and placer deposits was inferred to be manganese bearing. This factor was determined by sampling and from surveys of numerous mining operations on hillsides.

The inferred reserves were determined from data collected in the field on more than 580 separate tracts. The cutoff grades used in calculating reserves were 4 percent of manganese for clay deposits and 2 percent for manganiferous limestone.

Explorations by the Bureau of Mines in 1940 to 1942 and by American Zinc Co. in 1942 at selected sites in the district formed the basis for a reserve estimate of 1,200,000 long dry tons of wad ore containing 23 percent manganese, with cutoff grade of 10 percent (5). For inclusion in this report the tonnage figure has been reduced to 700,000, owing to subsequent mining and the resulting detriment to recovery of ore from deposits adjacent to mine excavations.

The inferred reserves of 166 million long dry tons of manganiferous materials in the Batesville district probably average 5 to 6 percent manganese. The average manganese content of individual deposits included in the reserve ranges from 4 to 30 percent. Under favorable marketing conditions, continued small-scale production of manganese ore from the manganiferous clays can be expected by methods now used. However, the significance of the aggregate reserves of the district as a future source of manganese depends upon development of efficient and economical treatment processes for recovering manganese from the several types of deposits, especially those of manganiferous limestone.

LOGS OF BUREAU OF MINES CHURN-CORE-DRILL HOLES

Reeves Hill

(Sec. 29, T. 14 N., R. 6 W.)

C-1

Begun: July 8, 1954
Completed: August 16, 1954

Elevation: 560 feet 1/

Churn and rotary drilled ...... 0-157 feet
Core drilled .... 157-195 feet
Core recovery .... 100 percent

Feet from southwest corner	
North	East
260	4840

Depth, feet		Formation
From-	To-	
0	5	Surface soil and chert rubble.
5	106	Chert.
106	118	Alternating beds of light-gray limestone and dense gray chert.
118	129	Dense chert with shale seams.
129	150-1/2	Dense chert.
150-1/2	157	Shaly limestone with minor amount of pyrite.
157	163	Limestone with iron oxides, pyrite, and glauconite.
163	195	Manganiferous limestone.

1/ Above sea level.

		Analysis, percent			
		Mn	Fe	P	Insoluble
157	160	1.12	3.18		
160	165	5.23	2.97		
165	170	4.45	1.92		
170	175	4.62	2.72		
175	180	4.54	3.14		
180	185	3.45	2.69		
185	190	4.19	2.51		
190	195	.84	.30		
157	195			0.35	2.23

C-2

Begun: July 24, 1954
Completed: August 20, 1954

Elevation: 555 feet[1/]

Churn drilled .... 0-136 feet
Core drilled .... 136-178 feet
Core recovery .... 100 percent

Feet from southwest corner	
North	East
640	4030

Depth, feet		
From-	To-	Formation
0	5	Soil and chert rubble.
5	134	Chert.
134	135-1/2	Limestone and black shale.
135-1/2	136	Shaly limestone.
136	139	Limestone with red iron oxides.
139	178	Manganiferous limestone.

		Analysis, percent			
		Mn	Fe	P	Insoluble
139	145	4.41	2.83		
145	150	4.47	2.37		
150	155	3.99	3.04		
155	160	4.45	3.25		
160	165	4.52	3.28		
165	170	4.62	1.85		
170	175	2.58	1.99		
175	178	.90	1.57		
139	178			0.30	1.74

1/ Above sea level.

C-3

Begun: August 5, 1954
Completed: August 31, 1954

Elevation: 579 feet[1/]

Churn drilled .... 0-170 feet
Core drilled .... 170-215 feet
Core recovery .... 99 percent

Feet from southwest corner	
North	East
385	3400

Depth, feet		
From-	To-	Formation
0	5	Surface soil and chert rubble.
5	140	Chert.
140	160	Light-gray chert with black shale and minor limestone seams.
160	170	Limestone with dark-gray shale.
170	215	Shattered limestone, fractures filled with calcite, pyrite, and glauconite; bedding planes cutting core at 40° angle off horizontal.

		Analysis, percent			
		Mn	Fe	P	Insoluble
170	175	0.11	0.82		
175	180	.11	1.05		
180	185	.12	1.29		
185	190	.12	1.95		
190	195	.16	1.59		
195	200	.17	.41		
200	205	.08	.21		
205	210	.08	.18		
210	215	.06	.18		
170	215			0.35	3.85

1/ Above sea level.

(Sec. 32, T. 14 N., R. 6 W.)

C-4

Begun: August 18, 1954
Completed: September 13, 1954

Elevation: 588 feet[1/]

Churn drilled .... 0-181 feet
Core drilled .... 181-211 feet
Core recovery .... 100 percent

Feet from southwest corner	
North	East
5170	4420

Depth, feet		
From-	To-	Formation
0	5	Surface chert rubble and clay.
5	145	Chert with numerous bedding planes.
145	160	Dense chert with thin, dark shale seams.
160	177-1/2	Dense chert.
177-1/2	177-3/4	Hard black shale.
177-3/4	181	Limestone and shale with iron oxides.
181	210	Manganiferous limestone.
210	211	Limestone.

1/ Above sea level.

		Analysis, percent			
		Mn	Fe	P	Insoluble
181	186	4.08	2.64		
186	190	4.30	2.61		
190	195	3.74	3.68		
195	200	4.85	2.93		
200	205	4.63	3.03		
205	210	3.98	2.86		
181	210			0.33	1.67

C-5

Begun: September 3, 1954
Completed: September 15, 1954

Elevation: 594 feet[1/]

Churn drilled .... 0-207 feet
Core drilled .... 207-245 feet
Core recovery .... 100 percent

Feet from southwest corner	
North	East
5080	3255

Depth, feet		Formation
From-	To-	
0	25	Chert rubble and clay.
25	200	Chert.
200	204-1/2	Dense chert with soft gray shale.
204-1/2	207	Brownish gray limestone with red iron oxide seams.
207	245	Manganiferous limestone.

		Analysis, percent			
		Mn	Fe	P	Insoluble
207	210	0.73	1.11		
210	215	4.37	3.03		
215	220	4.40	2.75		
220	225	3.50	3.07		
225	230	4.16	2.93		
230	235	4.35	2.93		
235	240	5.66	2.28		
240	242	1.37	1.25		
242	245	.89	.79		
207	245			0.28	1.82

1/ Above sea level.

C-6

Begun: September 16, 1954
Completed: October 12, 1954

Elevation: 506 feet[1/]

Churn drilled .... 0-118 feet
Core drilled .... 118-152-1/2 feet
Core recovery .... 100 percent

Feet from southwest corner	
North	East
4630	4730

1/ Above sea level.

Depth, feet		
From-	To-	Formation
0	4	Soil and chert rubble.
4	80	Chert.
80	116	Chert with minor blue shale seams interbedded, more than normal amount of pyrite in shales.
116	118	Brown limestone with red iron oxide seams.
118	152-1/2	Manganiferous limestones.

		Analysis, percent			
		Mn	Fe	P	Insoluble
122	125	3.70	2.32		
125	130	3.36	1.68		
130	135	4.58	2.28		
135	140	3.47	2.64		
140	145	3.46	2.78		
145	150	4.18	2.64		
150	152-1/2	2.36	1.18		
122	152-1/2			0.32	1.97

Results of Mineralogical Examinations

The results of mineralogical examinations made in the Bureau of Mines laboratory at Rolla follow:

Hole No.	Depth, feet From-	To-	Remarks
C-1	157	160	Medium-grained limestone. Some pieces of the broken core were coated with earthy hematitelike material. Other pieces were dark gray, tinged red, and yellowish brown. Calcite was the principal mineral. Occasional grains were nearly isotropic and partly altered to manganese oxide-like material. Chlorite, cryptocrystalline silica, iron silicate, and pyrite also were present. Usually manganese in various amounts was present in the earthy red areas, possibly in protoxide form combined chemically with iron and silica.
	160	165	Medium-grained, gray, fossiliferous limestone with areas and coatings along fractures of broken core pieces of admixed hematitelike material consisting of hematite and iron and manganese silicate. Calcite was the chief mineral comprising the core. Very dark-gray to black, manganese- and iron-bearing magnetic oxide material was intimately associated with calcite and in some instances with rhodochrosite and a bementitelike material, which upon digestion in hydrochloric acid left a residue of soft, nearly transparent silica having virtually the same outline as the original dark-colored grains. Carbonaceous matter and some hematite also were present in the residue. Braunite is reported in the literature as being weakly magnetic; however, the magnetic properties of the material in this and other core samples were greater than would be designated as weakly. The

Hole No.	Depth, feet From-	To-	Remarks
C-1 (Con.)			magnetic, manganese-bearing material might be a mixture of relatively soft ferrian braunite and manganamagnetite or matnetite. The magnetic material appeared to have originated from the iron-bearing bementitelike mineral, red iron oxide-like material, and iron-bearing rhodochrosite.
	165	170	Medium-grained fossiliferous limestone with small amounts of red iron oxide-like material and dark-gray to black manganese- and iron-bearing magnetic constituents previously described. Some rhodochrosite, bementitelike mineral, and clay also were present. The magnetic material was generally intimately locked with calcite, rhodochrosite, bementitelike mineral, and clay.
	170	175	Somewhat similar to the preceding samples, except that there were more dark-gray and black areas containing the magnetic material and less red iron oxide-like material and rhodochrosite. Small clay areas also were present. The dark-gray and black areas in many instances appeared to be alteration products of previously existing material in fossil molds.
	175	180	Gray, medium-grained, fossiliferous limestone. This sample was somewhat similar to the limestone previously described, except that very little red iron oxide-like material was present. The very dark gray to black magnetic areas were generally soft and wadlike. Reddish tinged material was present in some instances in these areas and carbonaceous matter. No hard manganese oxides were observed during the examination. The black magnetic material was hard to wet with water, probably owing to the presence of carbonaceous matter. Clay was also present in the core pieces. In general, the very dark gray and black areas appeared to be originally fossils.
	180	185	This sample was similar to the core samples previously described. Red iron oxide-like material, as staining and in macaceous form, was on some fractures. As in the other core samples, the manganese oxides and associations when virtually free of carbonates were quite soft and wadlike and, as usual, appreciably magnetic. The study indicated further that the magnetic materials were alterations of red iron oxide-like material, iron-bearing bementitelike mineral, rhodochrosite, and stained calcite. The study indicated also that the rhodochrosite was iron bearing.
	185	190	Medium-grained fossiliferous limestone. Appreciable red iron oxide-like material was present, some in micaceous form, confined chiefly to fractures in the rock. Only a small amount of blackish magnetic material was present. Most of the iron and manganese in the sample appeared to be in the reddish areas. Some of the red material, after treatment in boiling hydrochloric acid, left appreciable white amorphous silica.

Hole No.	Depth, feet From-	To-	Remarks
C-1 (Con.)	190	195	Coarse-grained fossiliferous limestone. Some of the core pieces contained areas in which fossils had been leached out. Others had areas showing fossil replacements with black material consisting in general of carbonaceous matter, calcite, pyrite, and small amounts of iron and manganese oxide material. Pyrite was also present on fractures. Slickenside surfaces were present, as well as claylike material and organic staining. Partly altered chocolate-colored bementite-like mineral was on and in one core piece in very thin shale-like form. The red iron oxide-like material and magnetic constituents did not appear to be in this core sample.
C-2	139	145	Medium- to coarse-grained fossiliferous limestone. Some fractures and areas of the core pieces contained the red material previously described. The dark-gray and black magnetic material also was present. Much soft silica and some hematite and carbonaceous matter remained as residue when the magnetic material was treated with boiling hydrochloric acid.
	145	150	Medium-grained fossiliferous limestone. This core sample contained the red and dard-gray to black, magnetic materials previously described.
	150	155	Medium-grained fossiliferous limestone. The magnetic material previously described was present. In addition, partly altered iron-bearing bementitelike mineral was on two pieces of the core as chocolate-colored,compact, shalelike material paralleling bedding planes. It was soluble in hydrochloric acid, giving strong tests for manganese and gelatinous silica. Before the blowpipe it yielded a magnetic black slag. A small amount of manganese carbonate also was present in the sample.
	155	160	Medium-grained fossiliferous limestone. Magnetic material was present, as well as some admixed magnetic material and red iron oxide-like material.
	160	165	Medium-grained fossiliferous limestone. Magnetic and some admixed red and magnetic materials were present. More claylike material appeared to be present in this core.
	165	170	Medium-grained fossiliferous limestone. Magnetic material was present, also the partly altered, chocolate-colored, shaly material close to bementite. Neotocite in small amount was indicated in the sample.
	170	175	Coarse-grained fossiliferous limestone. Some earthy red iron oxide-like material, partly altered earthy red material (nonmagnetic), and magnetic constituents were present.
	175	178	Coarse-grained fossiliferous limestone. Some soft red areas were present that appeared to be mainly finely micaceous hematite. Manganese oxide staining was in some of the red

Hole No.	Depth, feet From-	To-	Remarks
C-2 (Con.)			areas and along fractures. A very small amount of rhodochrosite also was present.
C-3	170	215	Medium- to coarse-grained limestones, somewhat fossiliferous and usually containing small amounts of clay and pyrite and occasionally some iron oxide staining on fracture surfaces.
C-4	181	186	Medium-grained fossiliferous limestone containing appreciable red iron oxide-like material and some wad, some of which was magnetic. Clay and small amounts of manganese carbonate and bementitelike mineral also were present.
	186	190	Medium- to coarse-grained fossiliferous limestone containing appreciable dark-gray to black areas of fairly soft manganese- and iron-bearing magnetic material. Partly altered bementitelike mineral and claylike substance also were present.
	190	195	Medium-grained fossiliferous limestone with appreciable reddish (grading into chocolate) iron- and manganese-bearing material and fairly soft, dark-gray to black, manganese- and iron-bearing magnetic material.
	195	200	Medium-grained fossiliferous limestone with appreciable dark-gray to black, relatively soft manganese- and iron-bearing magnetic material. Bementitelike mineral and manganese carbonate also were present.
	200	205	Similar to sample from 195 to 200 feet.
	205	210	Similar to sample from 195 to 200 feet except that some dark reddish, iron- and manganese-bearing material was present.
C-5	207	210	Medium-grained fossiliferous limestone containing some slickenside areas, shaly clay material, pyrite, and red iron and manganese material.
	210	215	Dark, medium-grained fossiliferous limestone with appreciable dark-red iron- and manganese-bearing material (replacing calcite) and gray to black manganese- and iron-bearing magnetic material replacing fossils. Clay also was present.
	215	220	Medium-grained fossiliferous limestone with red earthy iron- and manganese-bearing silicate and light-colored earthy collophanite. The collophanite is abundant, particularly in certain manganese-bearing zones.
	220	225	Same as sample from 215 to 220 feet with some large areas of red earthy iron oxide. Most of the manganese occurs in the magnetic material and is closely associated with collophanite.

Hole No.	Depth, feet From-	To-	Remarks
C-5 (Con.)	225	230	Medium-grained limestone with thin, irregular seams of magnetic iron- and manganese-bearing material usually intimately associated with white to bluish white, earthy calcium phosphate.
	230	235	Brown fossiliferous limestone with red seams of bementitelike material, thin irregular layers and seams of magnetic manganese-iron-bearing material, and a small amount of phosphatic fossil replacement.
	235	240	Fossiliferous limestone with relatively thick layers of red, shaly, bementitelike, iron-manganese-bearing material, thin magnetic iron-manganese seams, stylolites, and fossil replacement. Several cores showed an appreciable amount of pink rhodochrosite. One piece showed a resinous mineral tentatively identified as tephroite (2 $MnOSiO_2$) associated with black magnetic iron manganese material.
	240	242	Fossiliferous limestone with thin seams and stylolite replacement of bementitelike material and only a trace of magnetic manganese-bearing material.
	242	245	Light-colored, fossiliferous limestone with stylolites of earthy hematitic material and a few phosphatic fossils. Some areas contain an appreciable amount of carbonaceous material with admixed pyrite filling solution channels in the limestone.
C-6	122	125	Fossiliferous limestone with slickensided areas of reddish brown bementitelike mineral, gray to green shale parting, phosphatic fossil replacement, and a small amount of rhodochrosite.
	125	135	Fossiliferous limestone with stringers of red, shaly, bementitelike material and streaks and fossil replacement of magnetic iron-manganese-bearing material. A small amount of rhodochrosite also was present.
	135	140	Fossiliferous limestone with appreciable red, earthy iron oxide material as fossil replacement. Streaks of the bementitelike material with closely associated fine phosphatic fossils and a small amount of black, magnetic, manganese mineral also were present.
	140	145	Same as sample from 135 to 140 feet.
	145	150	Medium- to coarse-grained, fossiliferous limestone with numerous seams of black to brown, magnetic, manganese-bearing mineral and a small amount of red, bementitelike, manganese-bearing material. A small amount of rhodochrosite and black carbonaceous matter were associated with the magnetic manganese material.

SELECTED BIBLIOGRAPHY

1. MISER, HUGH D. Deposits of Manganese Ore in the Batesville District, Arkansas. U. S. Geol. Survey Bull. 734, 1922, 273 pp.

2. _____. Manganese Carbonate in the Batesville District, Arkansas. U. S. Geol. Survey Bull. 921-A, 1941, 97 pp.

3. SHELTON, S. M., FINE, M. M., AND BARDILL, J.D. Manganese Investigations - Metallurgical Division. 5. Ore-Dressing Studies of Manganese Ores. Beneficiation of Manganese Wad Ores From the Chinn Property, Batesville, Ark. Bureau of Mines Rept. of Investigations 3614, 1942, 18 pp.

4. SHELTON, S. M., FINE, M. M., AND FISHER, R. B. Manganese Investigations - Metallurgical Division. 17. Ore-Dressing Studies of Manganese Ores. Concentration of Wad Ore From the Aydellote Property, Batesville, Ark. Bureau of Mines Rept. of Investigations 3652, 1942, 17 pp.

5. RUTLEDGE, F. A., TESSMER, W. A., EWOLDT, HAROLD B., ODER, CHARLES R. L., LANGLEY, M. J., AND BELL, JAMES E. Investigation of Manganese Carbonate and Wad Deposits in the Batesville Manganese District, Arkansas. Bureau of Mines Rept. of Investigations 4859, 1952, 180 pp.

6. FINE, M. M., AND FROMMER, D. W. Mineral-Dressing Study of Manganese Ore, Cason Mine, Batesville, Ark. Bureau of Mines Rept. of Investigations 5005, 1953, 9 pp.

7. _____. Laboratory Recovery of Manganese Carbonate From the Martin Mine, Independence County, Ark. Bureau of Mines Rept. of Investigations 5086, 1954, 10 pp.

8. KLINE, H. D., AND RYAN, J. P. Manganese Resources of the Batesville District, Arkansas - Interim Report I, Bureau of Mines Rept. of Investigations 5206, 1956, 33 pp.

9. STRACZEK, JOHN A., AND KINNEY, DOUGLAS M. Geologic Map of the Central Part of the Batesville Manganese District. U. S. Geol. Survey Field Studies Map MF-1, 1950.

10. FINE, M. M. A Mineral-Dressing Study of Manganese Deposits of Batesville (Ark.) District. Bureau of Mines Rept. of Investigations 5301, 1957, 12 pp.

United States Bureau of Mines

Report of Investigations 6487

by

R. B. Stroud

CONTENTS

ILLUSTRATIONS

TABLES

MANGANESE RESOURCES OF THE BATESVILLE DISTRICT, ARKANSAS

(In Three Parts)

3. Field Investigations: July 1956 to June 1961

by

R. B. Stroud [1]

ABSTRACT

This report, part 3 of a series, describes and gives results of field investigations by the Bureau of Mines on manganese resources of the Batesville district, Arkansas, from July 1956 through June 1961. The purpose of the Bureau's work was to evaluate the manganese potential of the district in furtherance of the Government's program with respect to domestic resources of critical and strategic minerals. The work comprised areal reconnaissance, mapping, churn and core drilling, and sampling. In more recent years, the investigations were confined to manganiferous limestone, which constitutes a significant potential resource of manganiferous material. The resources of manganiferous material in the district are inferred to be on the order of 198 million long dry tons averaging between 4 and 5 percent manganese.

INTRODUCTION

This report presents the results of field investigations of manganese resources of the Batesville district, Ark., by the Bureau of Mines from July 1956 to June 1961. It is the third and final report of field investigations in this district from 1949 to 1961. The first, Report of Investigations 5206 (6),[2] was concerned principally with correlation of available data on mine developments and ore production, and described surveys and investigations to estimate reserves of various types of manganiferous material in the district. The report covered the period 1949 through 1952. The second publication, Report of Investigations 5411 (5), covering the period 1953 through June 1956, described field investigations concerned mainly with testing the grade and continuity of deposits of manganiferous limestone by core drilling and sampling. Not included in this series is a report on field work done in 1940-42, published as Report of Investigations 4859 (9). Results of Bureau of Mines

[1]Geologist (mineral deposits), Area IV Mineral Resource Office, Bureau of Mines, Bartlesville, Okla.

[2]Underlined numbers in parentheses refer to citations in the list of references.

Work on manuscript completed July 1963.

mineral dressing research on upgrading low-grade ores of the district are reported in other publications (1, 2, 3, 10, 11).

ACKNOWLEDGMENTS

The cooperation of the various landowners, lessees, and mine operators of manganese properties in the district is gratefully acknowledged.

LOCATION AND PHYSICAL FEATURES

The area known as the Batesville manganese district is about 4 to 8 miles wide and 24 miles long. Most of it lies in northwest Independence County, but it also extends northward and westward for short distances into Sharp, Izard, and Stone Counties. The communities of Pfeiffer and Hickory Valley are at the eastern extremities of the district; Mt. Pleasant is near the northern border; and Guion and St. James, both small villages, are near the western boundary. Batesville, the largest town and county seat of Independence County, has a population of nearly 6,500 and is about 2 miles south of the southern edge of the manganese district (fig. 1).

The district is in the eastern part of the Ozark Plateau. Altitude ranges from 250 to 800 feet. Topographically, the district consists of relatively flat-topped, steep-sloped hills with many narrow valleys and ravines. The valley floors are covered with soil and rocks from adjacent hill slopes; the hill slopes and tops exhibit occasional rock outcrops and residual soil and rock fragments. The district is drained principally by White River, and by Cave Creek, Sullivan Creek, Polk Bayou, and East and West Lafferty, which flow southward into White River.

Except for small tillable tracts, the district is covered with second growth hard woods suitable for use as mine timber.

The Missouri Pacific Railroad passes through Batesville, and spur lines connect with Pfeiffer in the eastern part of the district and Cushman in the west-central part. Hard-surface roads pass through the railheads, and a network of secondary gravel and dirt roads serve the mining area.

GEOLOGY AND ORE DEPOSITS (5, 7, 8, 9)

Sedimentary sandstones, shales, limestones, and cherts, ranging in age from Ordovician to Mississippian, are the principal rocks exposed in the district. Of lesser import are scattered outcrops of Tertiary sands and conglomerates. Quaternary alluvial fill is present in nearly every valley floor. Figure 2 shows generalized sections of the rock strata.

The rock formations in the Batesville district dip gently to the south and west, corresponding to the regional structural pattern. The dip of the beds is interrupted, however, by gentle folds and apparently normal faults. Anticlines, synclines, basins, and domes are well developed but are difficult to recognize because of mechanical weathering and a heavy growth of native grasses and trees. Folding in the district is aligned northeast, and major

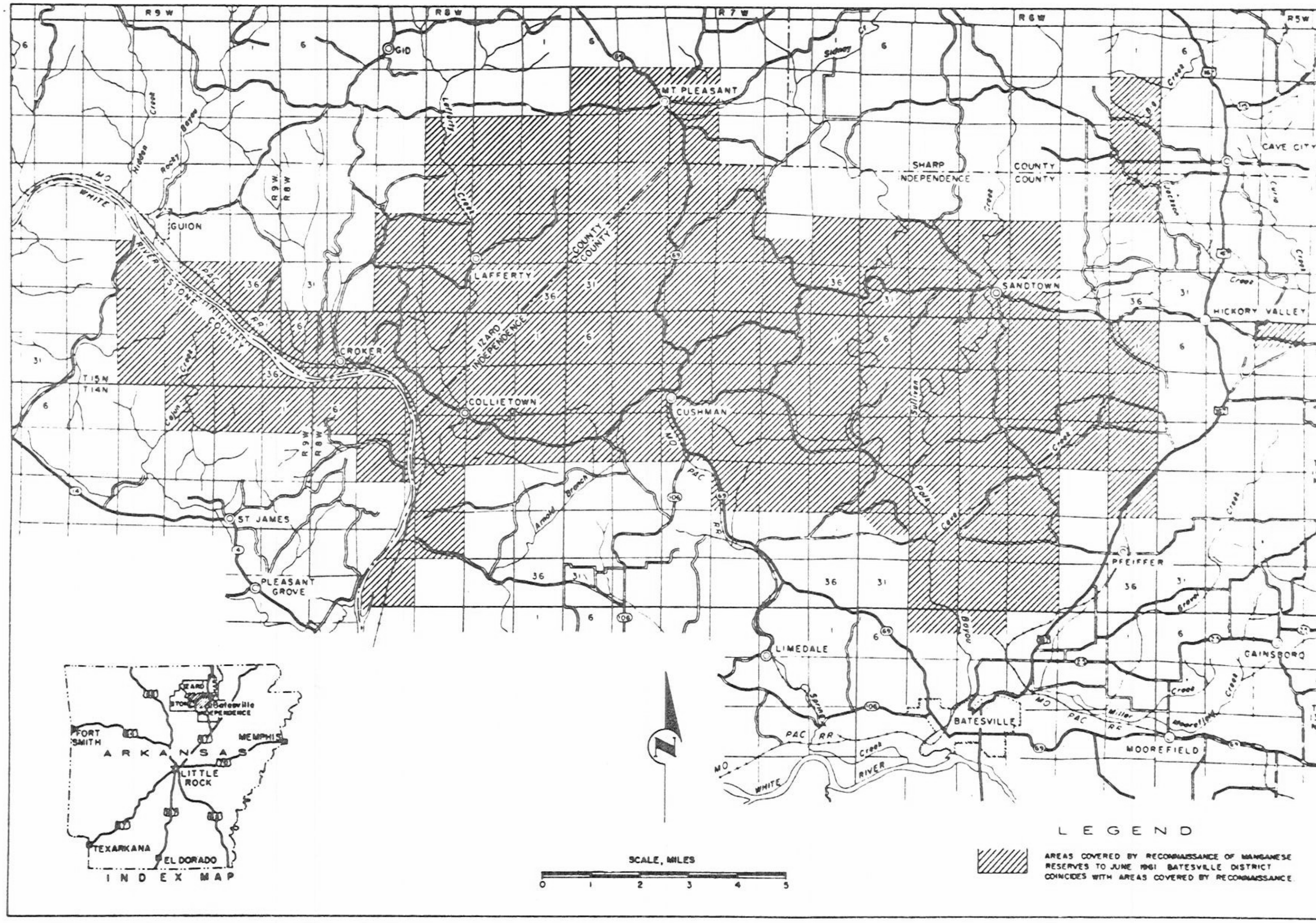


FIGURE 1. - Batesville Manganese District, Arkansas.

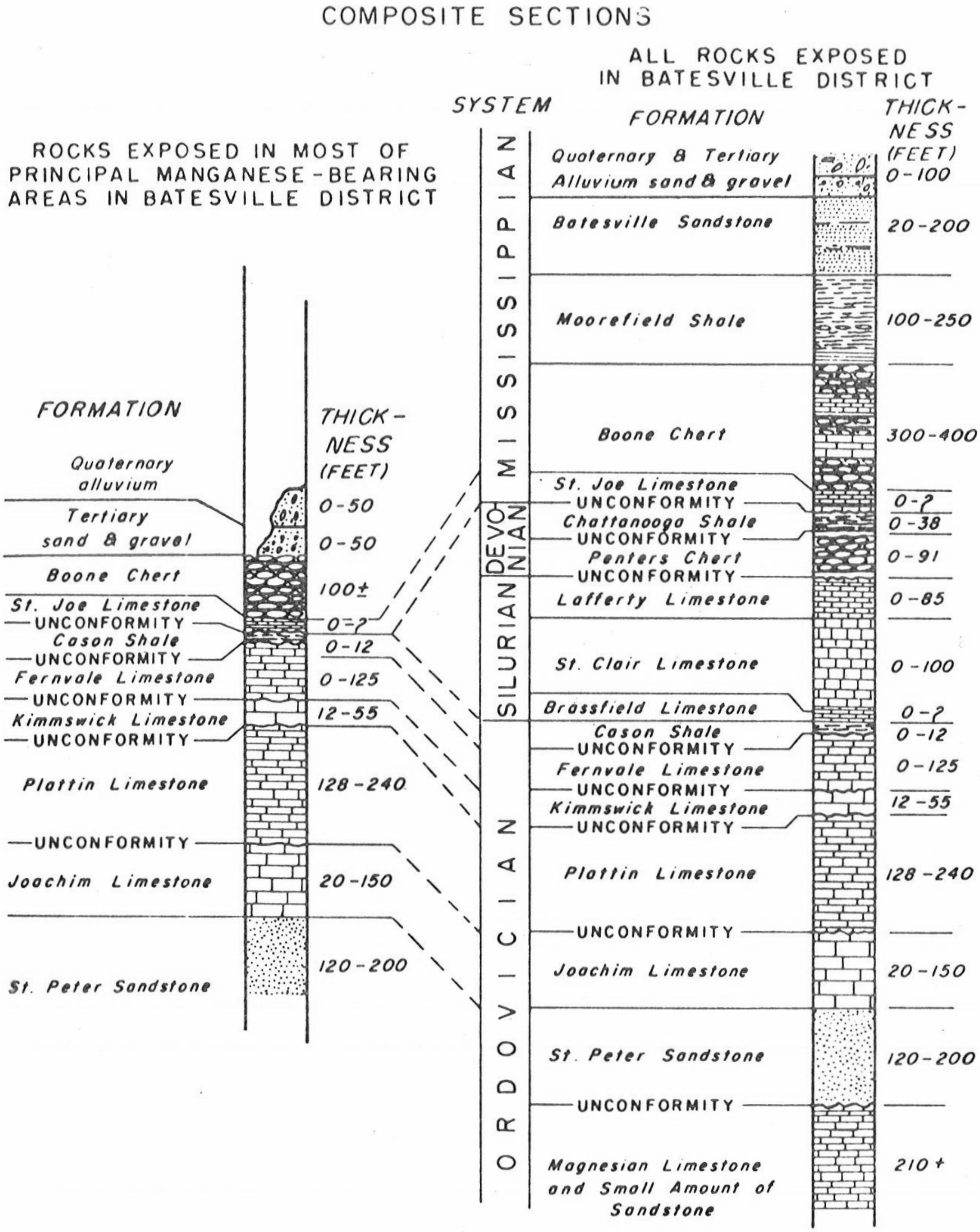


FIGURE 2. - Generalized Sections of Sedimentary Rocks Exposed in Batesville District.

faults trend east-west. Probably early folding and faulting was contemporaneous; however, some folding was followed later by faulting. Cross fracturing is common, and slumping associated with weathering of alternating layers of hard and soft rock is conspicuous at mine excavations. Recent studies of folding in the district suggest that structural lows are favorable areas for the deposition of manganese, whereas structural highs are either barren, or nearly so, of significant quantities of manganese minerals.

The Fernvale limestone and, to lesser extent, the Cason shale and St. Joe limestone were the host rocks for the primary deposition of manganese minerals. The Boone chert, which is usually more resistant, has protected much of the underlying manganese-bearing formations from excessive weathering and effectively masks many of the manganese deposits. In some places the St. Clair limestone affords a protective cover and similarly masks the manganese deposits.

The manganese occurs as oxide, carbonate, and silicate minerals in the gently folded limestone and shale formations in which structural basins have developed. Oxides also are abundant in residual clays resulting from weathering of the limestone and shale. Chert beds or chert fragments, and other detritus ranging in thickness from a few to more than 100 feet, effectively mask most of the manganese deposits.

Based on areal reconnaissance, studies of outcrops, and limited sampling of exposures, the resources of manganiferous material in the district are inferred to be on the order of 198 million long dry-tons averaging between 4 and 5 percent manganese. Of these, the manganiferous Fernvale limestone and the associated Cason shale are credited with 174 million long dry-tons, probably averaging about 4 percent manganese. This will constitute a significant source of manganese if economical recovery processes are developed.

The oldest rock exposed in the district proper is the St. Peter sandstone. It is overlain in ascending order by the Joachim, Plattin, and Kimmswick limestones.

The Fernvale limestone, eroded from much of the district, is separated from older formations by an unconformity. This limestone, the principal host rock for manganese mineralization, is distinguishable from both older and younger limestones by its grain size and, in places, a manganese content in the uppermost beds. The formation usually forms prominent outcrops on the flanks of hills and is especially conspicuous in mined areas. Normal thickness of the formation ranges from 90 to 100 feet; maximum thickness is about 125 feet. The manganiferous zone ranges in thickness from less than 10 to more than 50 feet, in places grading into barren limestone laterally.

The Cason shale is a lenticular, phosphatic formation that rests disconformably upon the Fernvale, except where removed by erosion. The shale presumably reaches a maximum thickness of about 12 feet in the district but generally is less than 5 feet thick. Although it is thin, the formation is conspicuous because of its manganese content in many places.

Where present, St. Clair limestone, Penters chert, and Chattanooga shale overlie the Cason formation in ascending order. In the Batesville district the St. Clair is completely eroded in many places, but locally it attains a maximum thickness of 100 feet. Its normal thickness is less than 5 feet. It contains sporadic concentrations of manganese minerals, although they are seldom of any consequence.

The Boone chert, or its residual products, covers most of the surface area of the district. The formation consists of shale, limestone, chert, and cherty limestone. The basal St. Joe limestone member, occurring only in the western part of the district, contains appreciable quantities of manganese. The Boone chert is gray on fresh surface and red or brown when weathered. The average thickness of the Boone chert formation is about 90 to 100 feet, but in some instances the thickness exceeds 200 feet.

Tertiary and Quaternary sands and gravel are present locally in parts of the district as thin-bedded, discontinuous, and for the most part poorly consolidated rocks. Locally some of the cementing material is manganese oxide in noncommercial quantity.

Primary deposits of manganese carbonates and oxides were formed by partial replacement of calcium carbonate in the upper beds of the Fernvale limestone, in the Cason shale, and in the St. Joe limestone member of the Boone formation. The manganese-rich solutions are believed to have been of hypogene origin. Oxides, carbonates, and silicates, in that order, are the dominant manganese minerals. Principal primary oxides are hausmannite and braunite. Psilomelane and wad, both probably of secondary origin, form important deposits, and lesser amounts of manganite and pyrolusite are also present. Significant concentrations of rhodochrosite and other carbonates have wide distribution throughout unaltered manganiferous limestone. The manganese silicates bementite and neotocite have been identified from deposits in several localities.

Iron oxide is widely distributed, but only minor quantities of barite, fluorite, arsenopyrite, and galena are associated with some of the manganese deposits. Pyrite, calcite, and gypsum are sparsely distributed.

For purposes of the reports in this series, manganese deposits in the Batesville district have been classified into four major types. In order of abundance these are (1) manganiferous limestone; (2) manganiferous clay in place under bedded chert; (3) manganiferous clay, talus-residual; and (4) placer. Figure 3 is an idealized section showing modes of occurrence of the several types of deposits.

1. Manganiferous limestone deposits. - These consist of primary minerals of rhodochrosite, hausmannite, and braunite disseminated in limy parts of the Cason shale formation, the upper 10 to 60 feet of Fernvale limestone, and in the St. Joe limestone member of the Boone formation. These deposits are relatively undisturbed and unaltered, protected from weathering largely by bedded Boone chert and occasionally by St. Clair limestone, Penters chert, or Chattanooga shale. Average manganese content of the deposits is estimated at

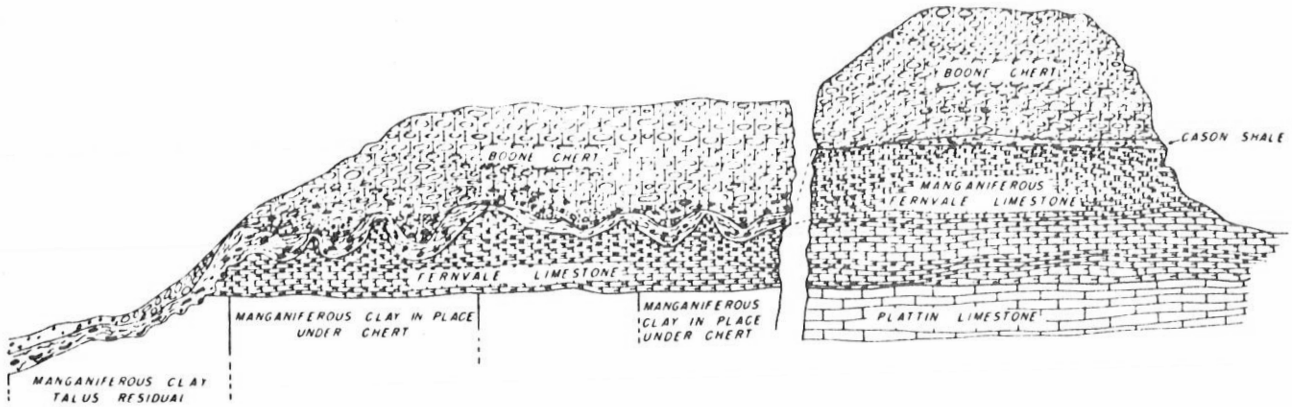


FIGURE 3. - Idealized Section Showing Modes of Occurrence of Various Types of Deposits.

4 to 5 percent. No attempt has been made to mine this low-grade material, but occasionally unusually high concentrations of manganese carbonates and oxides have been found and mined. Hand-cobbed for shipment, this "ledge" ore has contained as much as 50 percent manganese.

2. Manganiferous clay in place under bedded chert. - Deposits of primary and secondary manganese oxides in lumps and wad are irregularly distributed in residual clays formed by weathering of the Cason shale and Fernvale limestone. The clays, overlain in most cases by shattered Boone chert, rest on an unevenly eroded floor of limestone characterized by pits and pinnacles. Depressions in the bedrock caused by weathering usually contain the greatest concentrations of manganese minerals. The clay zones range in thickness from a few to more than 60 feet and, although irregularly shaped, are persistent over large areas. Variations of grade of the deposits range from the extremes of nearly barren to high grade. Dominant manganese minerals are wad, primary oxides, and secondary oxides. Deposits of this type have been a major source of both the ferruginous- and metallurgical-grade manganese ores mined in the district.

3. Manganiferous clay, talus-residual. - Closely related to type (2) are deposits of manganese oxides occurring in residual clays on hillsides from which the chert and other rock covering is eroded. A shallow overburden of soil, clay, and chert boulders makes these deposits available for comparatively low-cost prospecting and mining; therefore, they have accounted for much ore shipped from the district.

4. Placer deposits. - These represent developments from type (3) deposits in that they are outwash remnants of talus-residual occurrences. Water, the main transporting agent, has removed the finer material, leaving the coarser lumps and particles of manganese oxide mingled with soil, gravel, and boulders. There has been little sustained production of manganese from these deposits.

HISTORY OF DEVELOPMENT, MINING, AND BENEFICIATION

Manganese ores were first produced from the Batesville district in 1849, thereafter mining continued with few interruptions. However, most of the production came in two periods--from 1885 to 1898 and from 1915 to 1959. Output through 1959 totaled about 303,400 dry long tons of manganese ore (35 percent or more manganese), and 236,000 dry long tons of ferruginous manganese ore (10 to 35 percent manganese). Peaks in production were reached during World Wars I and II, 1917-18 and 1944-45. Following the Second World War, the major part of the production consisted of ores containing at least 40 percent manganese. There has been no production since termination of the Government's Domestic Manganese Purchase Program in August 1959. Early mining activities are described in detail by H. D. Miser (7).

Prospecting, ore development, mining, and mineral-dressing practices in the Batesville district have been described in detail by Kline (4). The following paragraphs give only a brief summation of information on these subjects.

Most mining operations were small scale. Mining practices remained virtually unchanged throughout the history of the district, modified only by the more recent use of bulldozers and, to lesser extent, by the use of power shovels for prospecting and stripping hillside deposits. Manganese oxides have been produced from all types of deposits, and a significant quantity of carbonate ore has been produced from the Fernvale limestone and Cason shale formations. Both manganese ore and ferruginous manganese ore have been produced, but from 1951 to the close of mining activities in 1959 the grade of shipped ore was consistently 40 percent or more manganese. During that period there was no market for ferruginous manganese ore. Most of the ore has been produced by selective hand-mining methods from both open pit and underground mines developed in residual clay deposits; a lesser quantity has been produced from operations which involved washing or other upgrading of low-grade material mined either by hand or by power shovels.

In early years deposits in residual clays and under shallow overburden were explored and mined by hand-dug pits. In recent years, bulldozers were used to remove shallow overburden and expose manganese bodies in the underlying clays. Beginning in 1942 the churn drill was used occasionally to explore residual clays overlain by medium and heavy overburden. Shafts were hand-sunk to develop and mine significant ore zones indicated by the drilling. The standard mine shaft was 4 by 4 feet in the clear, cribbed where necessary, and equipped for ventilation. Hoisting was by hand windlass or gasoline-powered machine.

All mining was by hand in open pits and in underground workings leading from pits and shafts, except for a few attempts to bulk mine low-grade material with power shovels. Mined ores were hand sorted, usually into high grade, No. 2 ore, and wash dirt, and placed in separate piles near the workings. Payment for the work usually was made on the basis of a contract price per ton of salable ore.

Figure 4 shows the approximate locations of most of the prospects, mines, and beneficiation plants that were active in recent years. Table 1 is a listing of the prospects, mines, and plants by name.

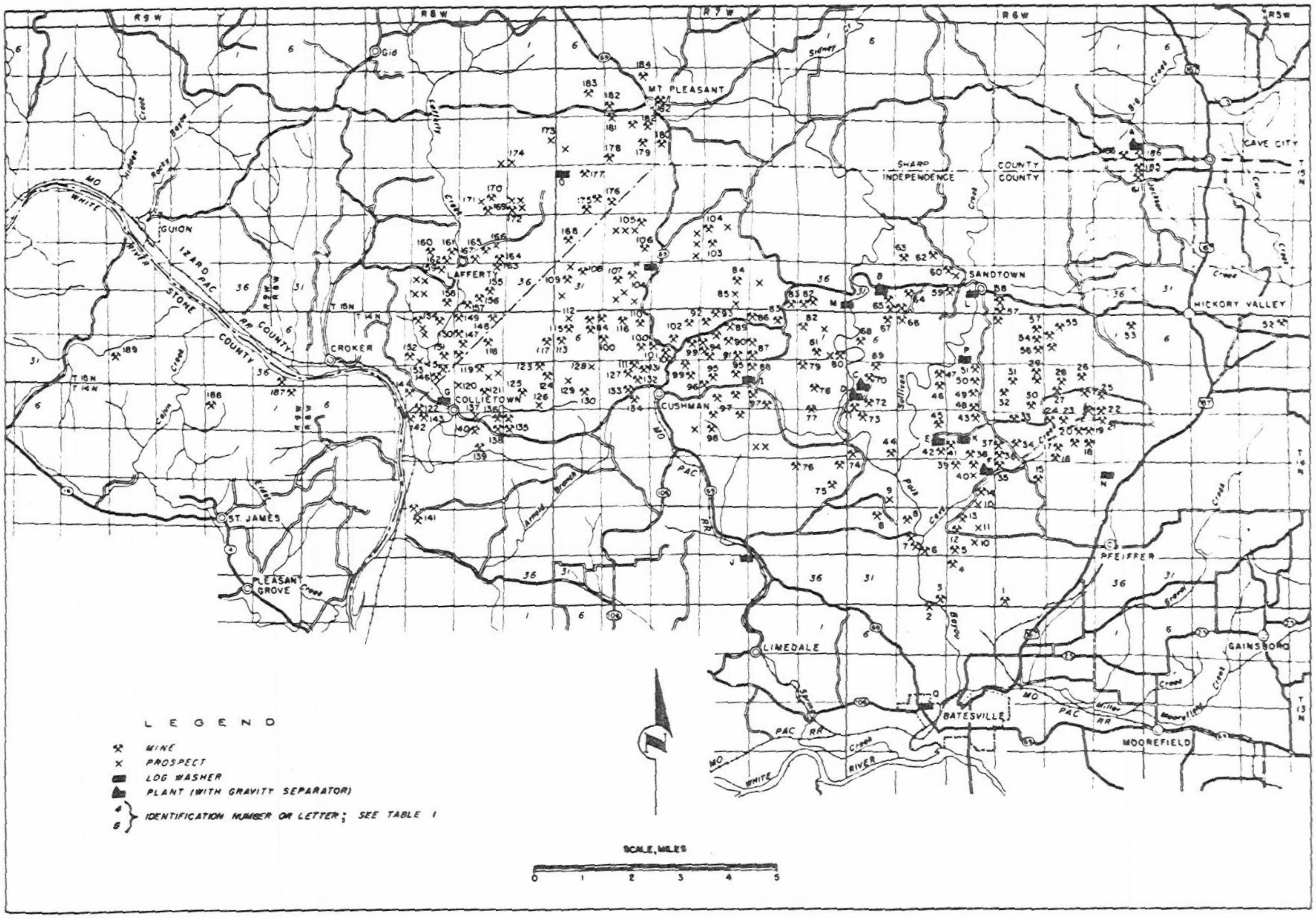


FIGURE 4. - Mines, Prospects, and Beneficiation Plants–Batesville Manganese District, Arkansas.

TABLE 1. - Mines, prospects, and beneficiation plants--Batesville manganese district

MINES AND PROSPECTS

INDEPENDENCE COUNTY

1. CASON
2. CHAMPLAIN
3. EDGAR BAKER
4. RUTHERFORD HOLLOW
5. BURGE
6. MILLER - RINEHART
7. GREENFIELD
8. STARK SPRING
9. CROSSER PROSPECT
10. BAXTER PROSPECT
11. COLLINS PROSPECT
12. THOMPSON
13. CHURCHILL
14. CHINN SPRING
15. MODLIN HOLLOW
16. J A REVES
17. MOYER
18. SILBERSTEIN
19. BALES
20. DUNEGAN
21. BROKAW
22. SEARCY
23. MATHENY (DIENER)
24. DAVIS HILL
25. SCHLIEPER
26. OZARK
27. CLARK
28. SEARCY
29. U.S. MANGANESE CORP.
30. SEARCY (BILL JIM)
31. HUNT HOLLOW
32. WILDCAT
33. ALBERT WILSON
34. WISDOM
35. VANEMBURG
36. MARTHA THOMPSON
37. CLIMER
38. ARK. MINING & EXP. CORP.
39. W. A. CHINN
40. SHELL - REITHER PROSPECT
41. SECTION 16
42. ADLER
43. ADLER
44. WADE
45. HERMAN MILLER
46. PERRIN
47. KELLEY HILL
48. HAIGWOOD
49. J. B. THOMPSON
50. LOST FORTY
51. ST. JOHN
52. BALL HILL
53. ELIZA PATTERSON
54. GRAY (HAWKINS AREA)
55. BILL HAWKINS
56. MC GEE
57. LEO HAWKINS
58. WEAVER
59. CHAPEL HILL
60. POOL
61. STORY
62. POOL
63. ADLER - SOUTHARD
64. MONTGOMERY
65. ROACH HILL
66. CLARK HILL (SIS CLARK)
67. GALLOWAY HILL
68. QUEEN HILL
69. BELL HILL
70. G. W. PATTERSON
71. MARSHALL
72. R. I. PATTERSON
73. BLAKE HILL
74. W. W. ALLEN
75. BUTTON
76. KINION
77. SHAW HILL
78. TURNER
79. W. J. HINSON
80. JACKSON
81. KIRBY
82. NAPOLEON HILL
83. JOHNSON
84. THIRTY FOUR
85. FRIDAY PROSPECT
86. STANDARD
87. BLUE RIDGE
88. STORY
89. BLUE RIDGE
90. ROWE FIELD
91. BENTON
92. POLK - SOUTHARD
93. TURNER
94. WILSON - BAXTER
95. ROSEBOROUGH
96. KIMMER
97. AYDELOTTE
98. BROOKS HILL
99. WILSON & BAXTER
100. PAGE
101. JERDEN
102. SOUTHERN HILL
103. EDDIE BAXTER
104. A. H. DOBSON
105. J. R. DOBSON
106. MT ETNA
107. J. P. BARNES
108. WOLFORD
109. NEILL
110. H. MILLER
111. MARTIN
112. MILLER PROSPECT
113. STERRETT
114. JOHNSON
115. SANDERS
116. STEWART HILL
117. CALAWAY
118. EDMUNDSON
119. STANDARD
120. U. N. DOBSON
121. GEORGE
122. SHAFT HILL
123. SAND FIELD
124. JAKE COLE
125. TOSH HILL
126. FRAZIER PROSPECT
127. CHIGGER EYE
128. H. M. TATE PROSPECT
129. R. W. REEVES PROSPECT
130. COLE ORCHARD
131. CLUB HOUSE
132. CLUB HOUSE EXTENSION
133. MEEKER
134. L. BAXTER
135. W. C. COLLIE
136. WEAVER
137. BUTTON PROSPECT
138. F. M. BARNES
139. KIMBROUGH
140. MARTIN
141. MC BRIDE
142. MANGANESE CAVE
143. SMITH

IZARD COUNTY

144. PENTERS BLUFF
145. HANKINS HOLLOW
146. T. M. TATE
147. ENGLES CUT
148. CUTTER
149. VERNA
150. SKELTON
151. PITTMAN
152. UNITED PHOSPHATE
153. CASEY PROSPECT
154. CUMMINS HOLLOW
155. ADLER HOLLOW
156. IZARD
157. PUGH
158. JOHNSON HILL
159. STANDARD
160. HELM
161. E. D. WINKLE
162. C. L. SANDERS
163. SAND FIELD
164. MANGANESE FIELD
165. RUMINER ROUGH
166. CARAWAY PROSPECT
167. BAF SDALE
168. ARK. MINING & EXP. CORP.
169. CAVE HILL
170. L. J. WEAVER
171. LEWIS PROSPECT
172. EDWARDS
173. M. E. WILSON PROSPECT
174. H. J. RAY PROSPECT
175. MC BRIDE BROS.
176. MC CONNELL
177. BERRY FULBRIGHT
178. HARRISON FULBRIGHT
179. DELBERT FULBRIGHT
180. W. A. KING
181. SIPES
182. YOUNGER
183. RAY
184. SHAW

SHARP COUNTY

185. STORY
186. MATLOCK

STONE COUNTY

187. LOGAN
188. CAGENS CREEK
189. ALEX FULTS

PLANTS WITH GRAVITY SEPARATORS

A. MATLOCK (SHARP COUNTY)
B. MC BRIDE (TITAN MANGANESE CORP.)
C. FULTON
D. BUFORD PARSE
E. ARK. MINING & EXP CORP
F. MILLER - MC GEE

LOG WASHERS

G. APEX MINING CO.
H. R. BAXTER
I. LEONARD BAXTER
J. R. BAXTER
K. ARK. MINING & EXP. CORP.
L. TITAN MANGANESE CORP.
M. U. S. MANGANESE CORP.
N. OTTINGER
O. ROGERS
P. KELLEY HILL
Q. DUNEGAN

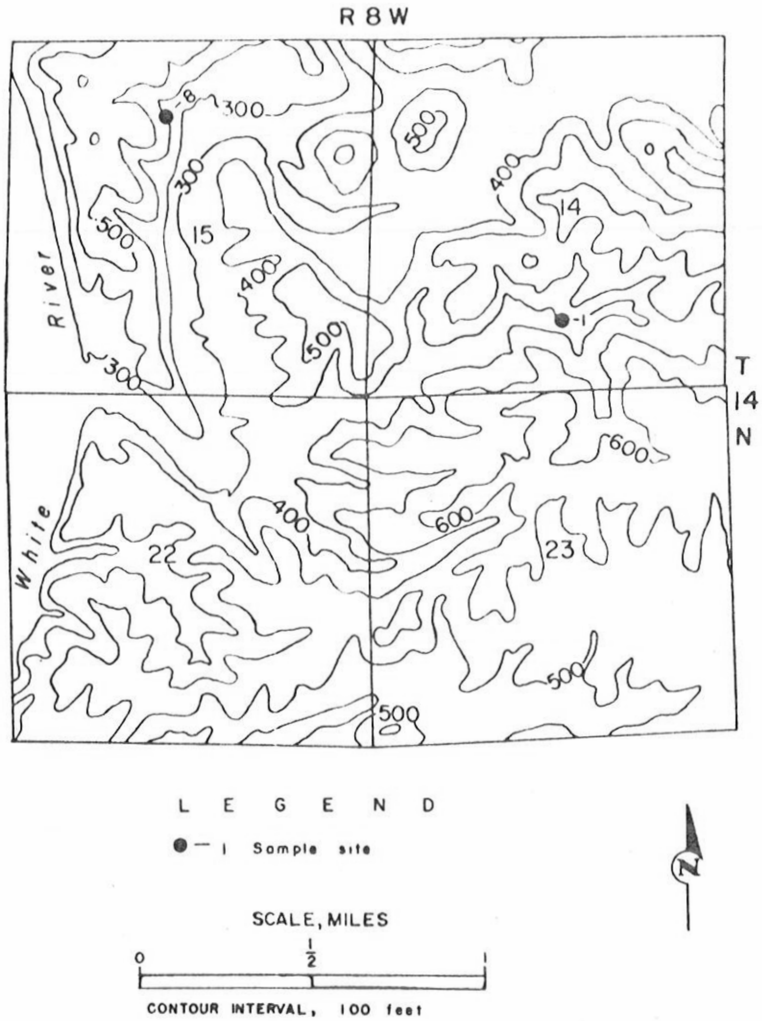


FIGURE 5. - Channel Sample Sites, Secs. 14 and 15, T 15 N, R 8 W, Independence County, Ark.

Shipping-grade ore was trucked to stockpiles in loading yards at railheads in Cushman and Pfeiffer. Wash dirt and some No. 2 ore were trucked to washers or beneficiation plants for upgrading to produce shipping-grade ore.

The typical washer plant upgraded feed material by passing it through water-immersed twin log washers to remove clay and fines, and thence over a picking belt from which chert nodules and other gangue were rejected by hand.

In the more complicated beneficiation plants, the feed material was treated in a log washer, and the resultant product was sized on a revolving screen. The undersize from the screen passed to jigs, which produced a final concentrate, and the oversize discharged onto a picking belt from which pieces of coarse ore were recovered by hand-picking. By 1957 the use of jigs had been discontinued. Thereafter, only the log washers and picking belts were used to upgrade wash dirt.

No data are available on recovery of manganese contained in the feed for plants that operated in the district.

RECONNAISSANCE OF MANGANIFEROUS AREAS

An overall field reconnaissance of the district was made to determine the effect of post-1956 mining on previously inferred quantities of manganiferous material.

Reconnaissance was made also to develop additional information on manganiferous limestones in areas previously incompletely studied in eastern Izard and western Independence Counties (figs. 5 and 6). The work included cutting 279 linear feet of vertical 2- by 5-inch channel samples on limestone outcrops at 15 sites. Table A-1 gives pertinent data on these samples.

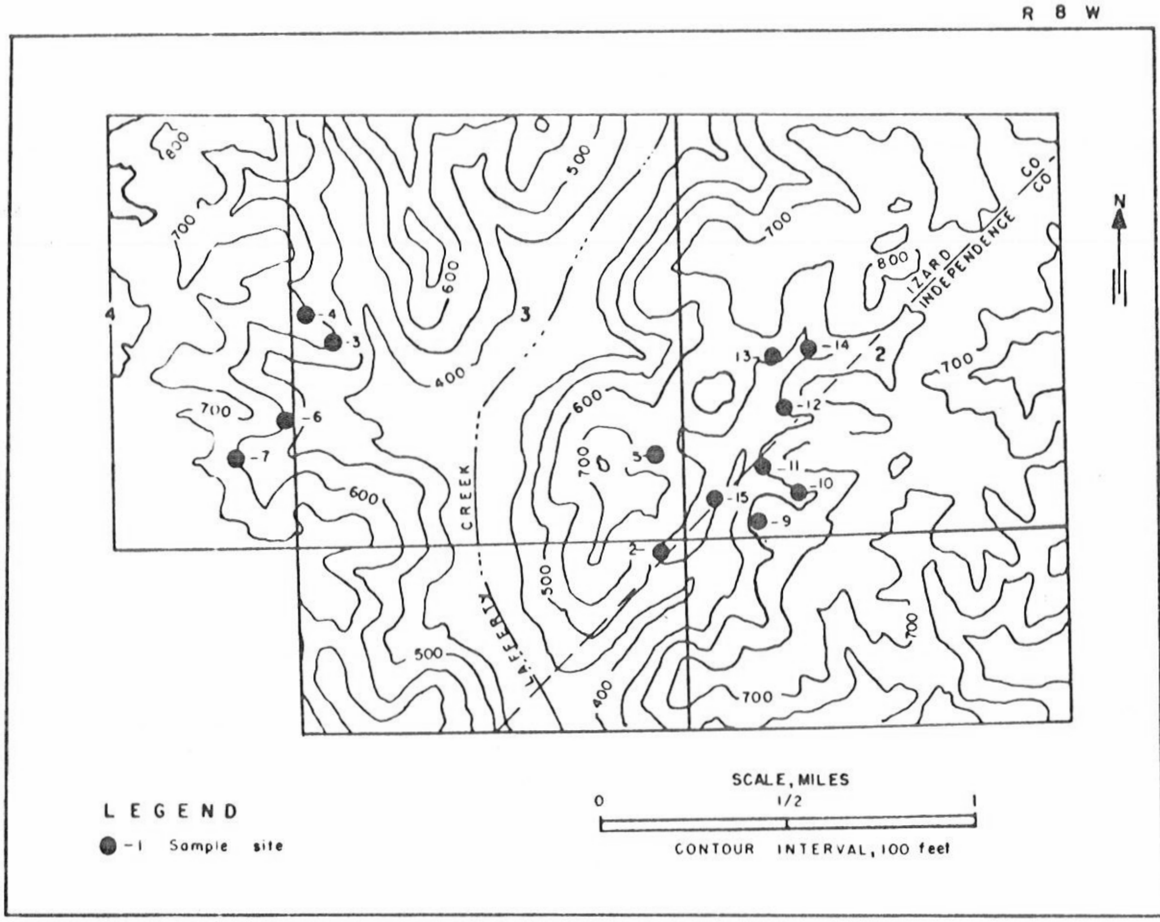


FIGURE 6. - Channel Sample Sites, Secs. 2, 3, 4, 10, and 11, T 14 N, R 8 W, Independence and Izard Counties, Ark.

CHURN AND CORE DRILLING

It is not practical to list the numerous landowners, lessees, and mine operators in the Batesville manganese district. Land ownership constantly changes as do lessees; and many mine operators have, since the end of production of manganese in 1959, turned to other work.

Location and ownership of the properties on which churn and core drilling was done follow:

Location of area, T 14 N, R 6 W	Acres	Owner or controller
S½, sec. 16....................	360	Arkansas Mining and Exploration Corp.
NE¼, sec. 21....................	40	W. A. Chinn
S½NE¼ and SE¼NW¼, sec. 22......	120	U. S. Manganese Corp.
E½SW¼ and S½SW¼SE¼, sec. 22....	100	W. W. Gibbens
Part of N½SE¼SE¼SE¼ and part of N½SW¼SE¼, sec. 22..........	117	George and Dora M. Heyde
SE¼, sec. 32....................	160	Edgar Baker
SW¼NE¼, sec. 26................	40	Earl A. Poole
SW¼NW¼, sec. 34................	40	Charles Beers

Baxter Hill (Sec. 22, T 14 N, R 6 W)

Fernvale limestone, which underlies bedded Boone chert on Baxter Hill, was tested for manganese mineralization by core drilling and sampling (fig. 7). The drilling, done in April to June 1957, was supplemental to previously reported (5) results of channel sampling of outcrops of manganiferous Fernvale on the western slopes of the hill. The purposes were to obtain information on manganese-bearing beds behind the outcrops and to procure samples of unweathered material.

Six holes, 6 to 8 inches in diameter, were churn-drilled through overlying barren chert and limestone to the top of the Fernvale limestone; the Fernvale was cored with an NX-size sawtooth bit. All drilling was done under contract. A total of 1,060½ feet was drilled in the six holes--724 feet by churn drilling, 267 feet by rotary noncore drilling, and 69½ feet by core drilling. Core recovery was only slightly more than 54 percent because of vugs in the Fernvale. Manganiferous limestone was recovered from two holes. The core was split three ways: A quarter split was stored in the Bureau of Mines core-storage depot at Minneapolis, Minn.; a quarter split was retained at the project office, Batesville, Ark.; and a half split and part of the sludge was shipped to the Bureau's Rolla Metallurgy Research Center at Rolla, Mo., for mineralogical study and chemical analyses. Logs of the holes and analyses of the samples are given in table A-2.

Section 16 Area (S½ sec. 16 and N½ sec. 21, T 14 N, R 6 W)

Churn and core drilling was done elsewhere in Independence County (fig. 8), to test the continuity and grade of deposits and to obtain samples for mineral-dressing research on recovery of manganese. The work was done from January through April 1958. Table A-2 gives the logs of the holes and the analyses of the samples.

Nine holes, 6 to 8 inches in diameter, were churn drilled through overlying barren chert, limestone and shale, to the Fernvale limestone contact. The Fernvale was cored with an NX-size sawtooth bit. A total of 1,475½ feet was drilled in the 9 holes--1,083½ feet by churn drilling and 392 feet by core drilling. Core recovery rate was nearly 97 percent. Manganiferous limestone was recovered from five of the nine holes. Thickness of manganiferous limestone ranged from 10 to 59 feet. The core was split three ways: A quarter split was stored in the Bureau's core-storage depot at Minneapolis, Minn.; a quarter split provided samples for chemical analyses; and a half split was shipped to the Rolla Metallurgy Research Center, for mineralogical study and mineral-dressing research on recovery of manganese. Chemical analyses were made by a commercial laboratory.

DETAILED STUDY OF PARTICULAR MANGANIFEROUS LIMESTONE AREAS

Beginning in 1959, a detailed study was made of the manganese-bearing limestone in Hankins Hollow, Barnes-Martin, and Cave Creek areas.

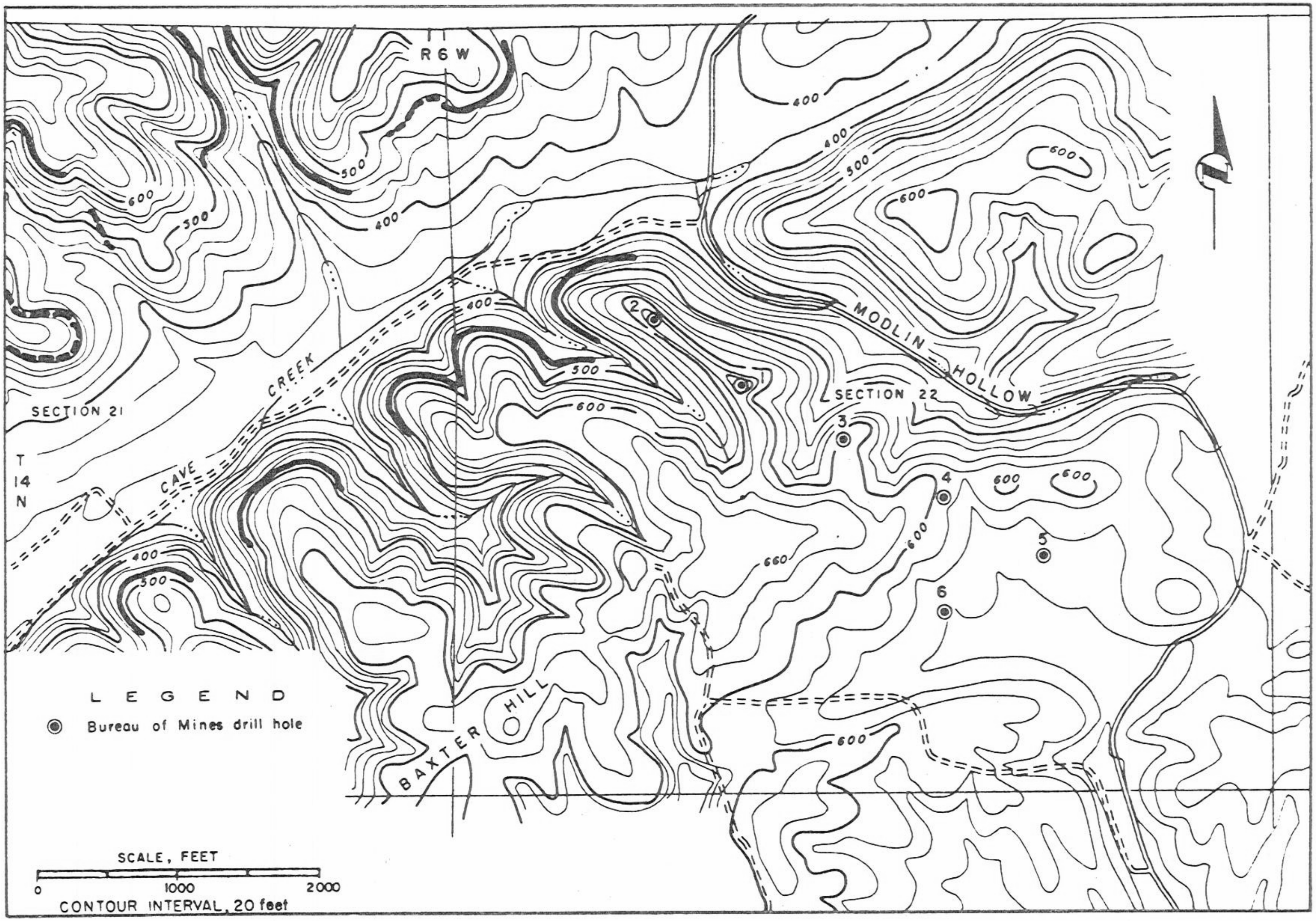


FIGURE 7. - Bureau of Mines Drill Holes, Baxter Hill, Sec. 22, T 14 N, R 6 W, Independence County, Ark.

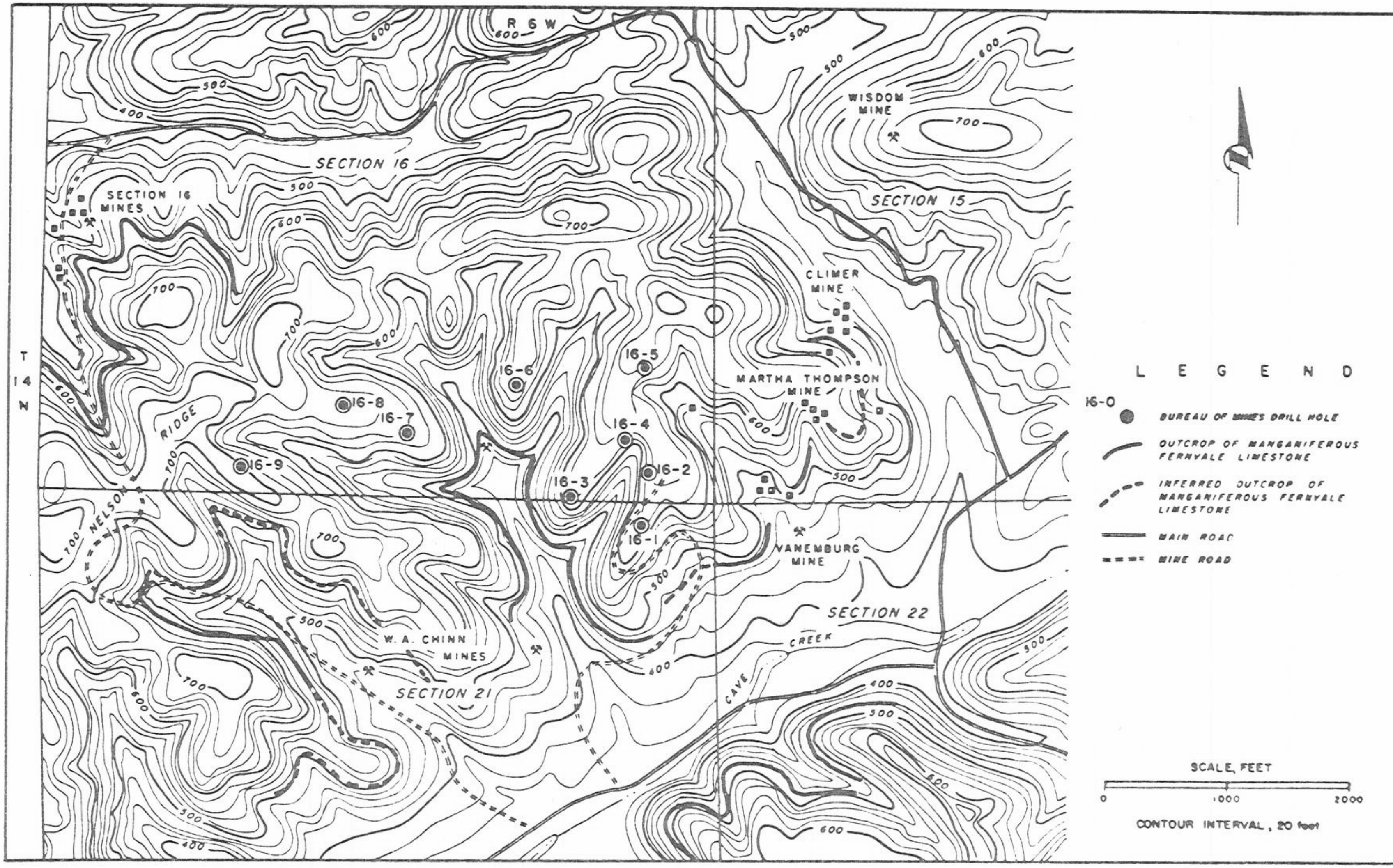


FIGURE 8. - Bureau of Mines Drill Holes, Secs. 16 and 21, T 14 N, R 6 W, Independence County, Ark.

Mapping and drilling suggested that folding and faulting influenced the localization of manganese deposition, and that the manganese-bearing limestone deposits are best developed in structural lows. A detailed reconnaissance study was made of selected areas to determine the continuity of manganiferous limestone outcrops with respect to thickness and probable lateral extent. Evidence of structural features was noted. The areas were then mapped by plane table methods using a telescopic alidade, table, tripod, and stadia rod. Field mapping was on a scale of 1 inch equal to 200 feet and a contour interval of 10 feet. Particular attention was given to the geologic contact of manganiferous Fernvale limestone and overlying formations. The thickness of the mineralized zone was measured where exposed.

Hankins Hollow Area

In the Hankins Hollow area the rock strata are folded into a relatively shallow, elliptically shaped structural basin (fig. 9). The long axis, trending northeast, was mapped for more than 3,500 feet. Cross sections A-A', B-B', and C-C' depict the attitude of the ore-bearing strata of the Fernvale limestone. Maximum dips appear to be about 5 to 7 degrees. Cross-fracturing has developed obliquely to the long axis of the fold, and erosion has resulted in the development of the main hollow and several smaller ravines and gullies. The thickness and linear extent of the exposures of the manganiferous beds are dependent upon the degree of erosion and the magnitude of past mining operations. Measured thicknesses of manganese-bearing shale and limestone range from about 20 to more than 40 feet.

Barnes-Martin Area

In the Barnes-Martin area, manganese appears to be concentrated in two structural lows (fig. 10), one in the vicinity of the Martin mine and the other centered at the Barnes mine. A fault just north of the Button prospect and readily recognizable in the field is probably post-mineralization. Another, of greater displacement but not readily discernible in the field, is south of the Button prospect. A splinter fault branches northwest from the latter fault. Dips of the beds range from gentle to 5 to 10 degrees, but cross-bedding and erosional factors affect the reliability of dip measurements. Cross fracturing, prominent in local areas, coupled with folding, controls the erosional characteristics of the Barnes-Martin area.

Cross sections (fig. 10) show the attitude of the beds as related to structural features. At no place in the area is the entire thickness of the manganiferous zone well exposed; however, it is possible to infer a minimum thickness of 10 feet.

Cave Creek Area

Although lack of bore holes, outcrops, or other serviceable criteria north and south of the extensive manganiferous Fernvale limestone outcrops on the sides of Cave Creek Valley make interpretation difficult, examination of the geologic map of the area indicates that the strata have been folded to produce an elongated structural low flanked on either side by modified

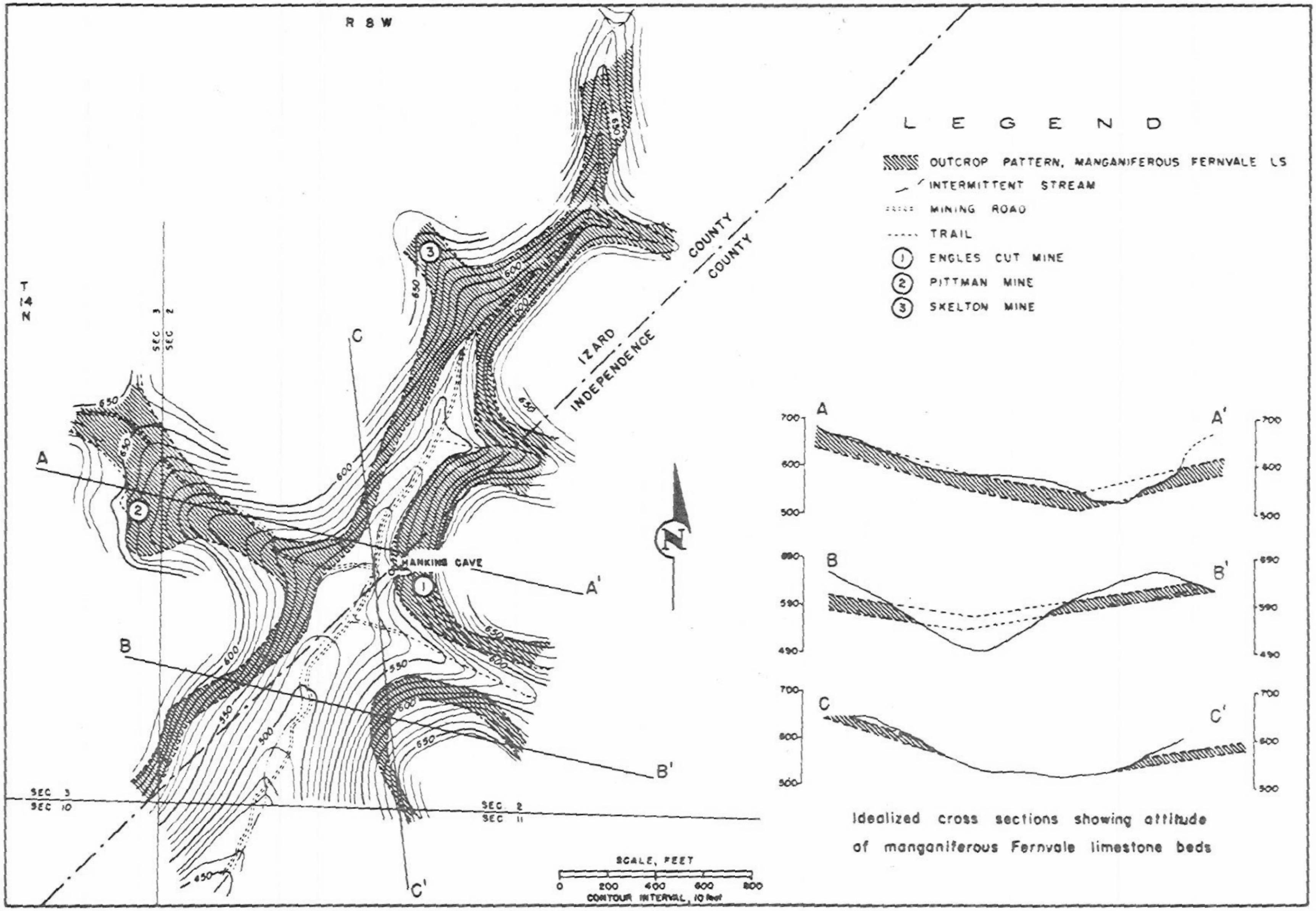


FIGURE 9. - Geologic Map and Cross Sections, Hankins Hollow Area.

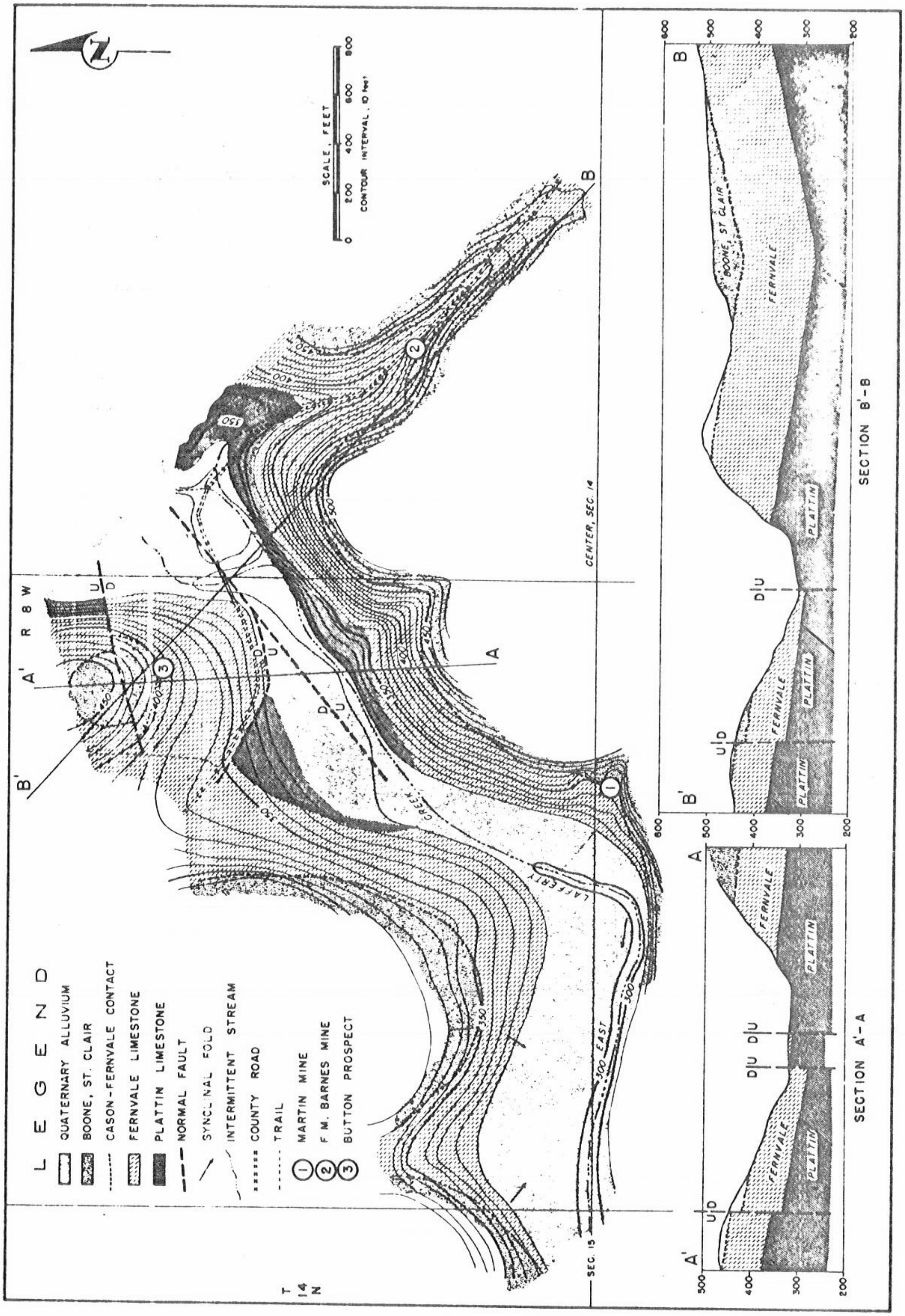


FIGURE 10. - Geologic Map and Cross Sections, Barnes-Martin Area.

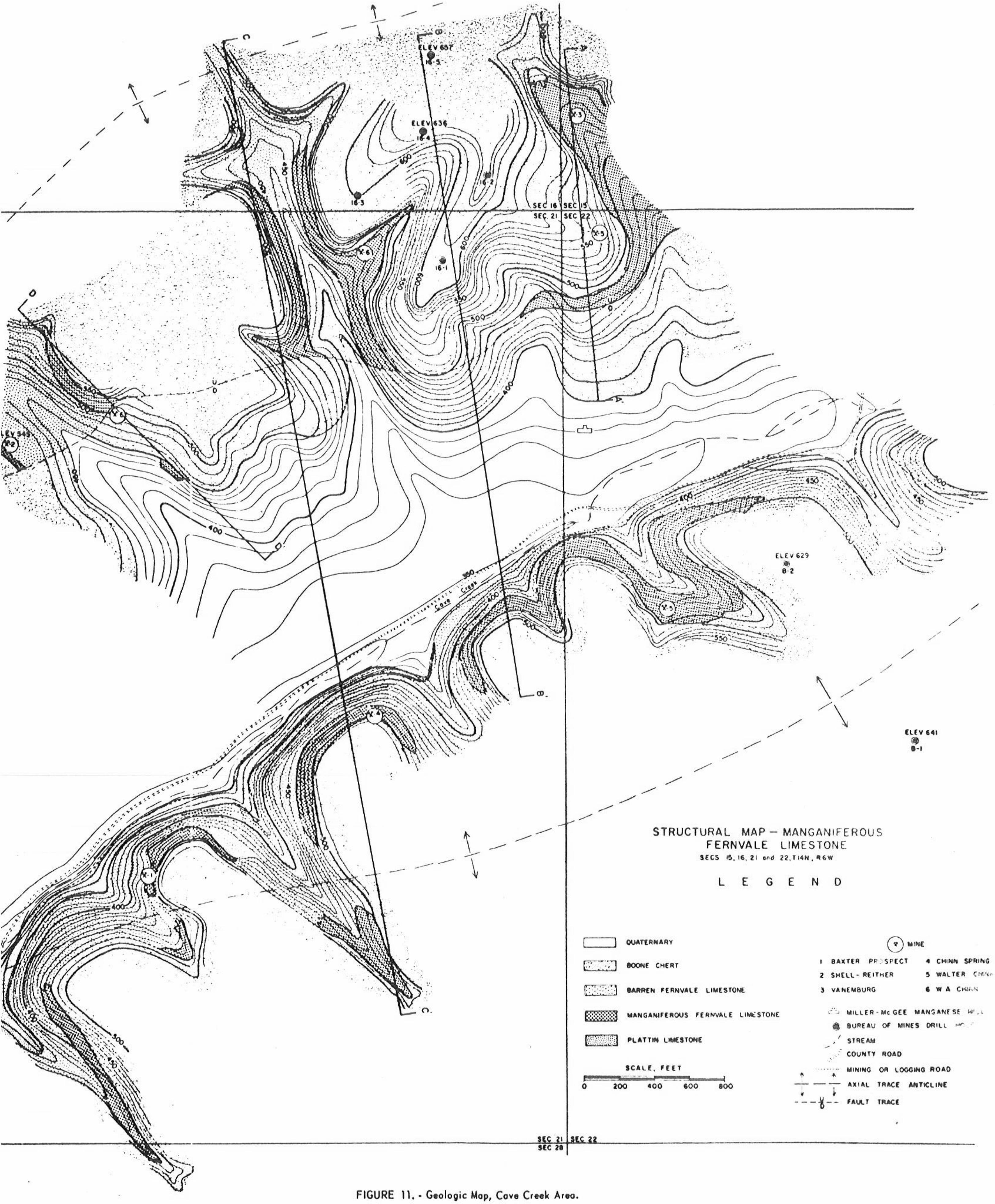


FIGURE 11. - Geologic Map, Cave Creek Area.

anticlines (fig. 11). The long axis of this low trends northeastward, but its exact placement must remain questionable until additional test holes have been drilled. As a result of erosion the fold is open at either end.

A major fault passes east to west near the center of secs. 15 and 16, immediately north of the mapped area. The fault extends for about 9 miles, and the beds are downthrown on the south. Maximum displacement along this fault is about 500 feet; however, near the mapped area the displacement may not exceed 100 feet. The latest movement apparently occurred in upper Mississippian time and is post-mineralization. A second fault (figs. 11 and 12) trends about N 70 degrees E, 1,000 to 1,500 feet northwest of Cave Creek. The beds are downthrown on the south; maximum displacement appears to be about 50 feet. Weathering along this fault has altered the beds of manganiferous limestone over much of its exposed length, and in the fault zone manganese minerals, settled into slump areas, have formed wad-type deposits. A possible third fault (not shown on fig. 11) may trend parallel to and coincide with Cave Creek, its trace obscured by valley fill. Measured dips and location of the creek seem to indicate this fault, but its existence has not been proven. Dips of the rock strata in the area are normally less than 10 degrees; however, measurable dips of 10 to 18 degrees were observed locally.

Polk Bayou and Other Areas

In the last half of 1960 and the first half of 1961 additional field investigations, including detailed reconnaissance studies, detailed plane table mapping, and two drilling projects, were carried out. This work was done in the eastern part of the Batesville district in secs. 4 and 5, T 13 N, R 6 W, and in secs. 26, 32, 33, and 34, T 14 N, R 6 W.

Before plane table mapping, a detailed reconnaissance was made of the areas. Land ties were located, mappable rock units were defined, and the geology was noted. Tenative drill-hole sites were selected. A detailed plane table map was made of parts of secs. 4 and 5, T 13 N, R 6 W, and secs. 32 and 33, T 14 N, R 6 W. This area was designated as the Polk Bayou area (fig. 13).

The Plattin limestone is the oldest rock in the area. It is exposed only in the southernmost part, and it is overlain by the Fernvale limestone, which has a maximum exposed thickness exceeding 100 feet. Manganese occurs in the oxide and carbonate forms in the upper 50 feet of the limestone, but the manganiferous zone is not consistently this thick. The St. Clair limestone is less than 20 feet thick. Where not removed by erosion or missing because of nondeposition, the St. Clair limestone overlies the Fernvale limestone. Locally, the Penters chert (up to 33 feet thick) and the Chattanooga shale (up to 9 feet thick) overlie the St. Clair limestone. Normally, however, the Boone chert directly overlies the Fernvale limestone in the Polk Bayou area. Here the Boone chert formation attains a maximum thickness of about 350 feet.

Within the area, the sediments have been folded into alternating structural highs and lows following the pattern of the whole Batesville district. The outcrops of the Fernvale limestone suggests the presence of two synclinal basins separated by a structural high. A major normal fault passes east to west near the southern border of the mapped area (figs. 13 and 14).

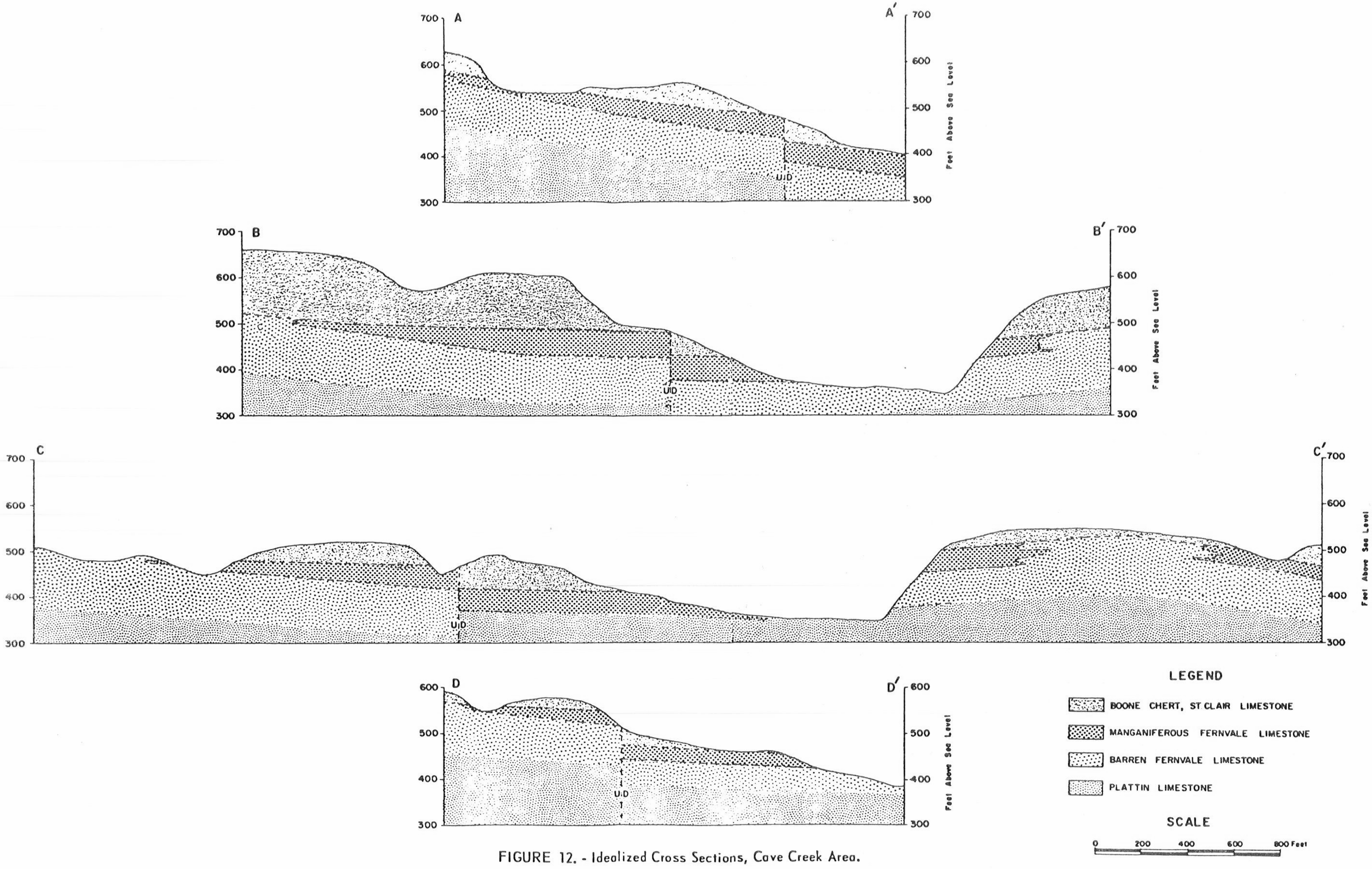


FIGURE 12. - Idealized Cross Sections, Cave Creek Area.

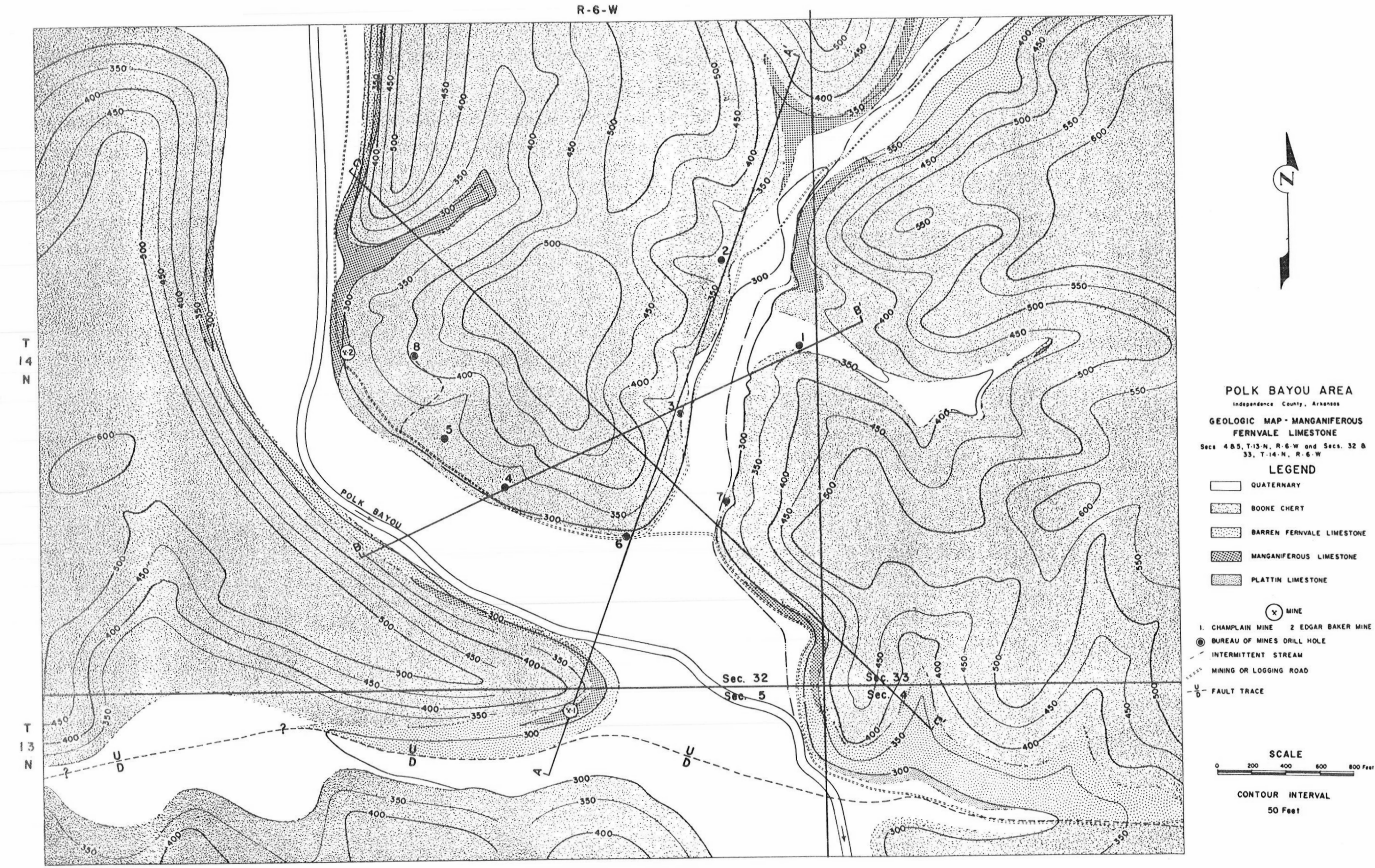


FIGURE 13. - Geologic Map, Polk Bayou Area.

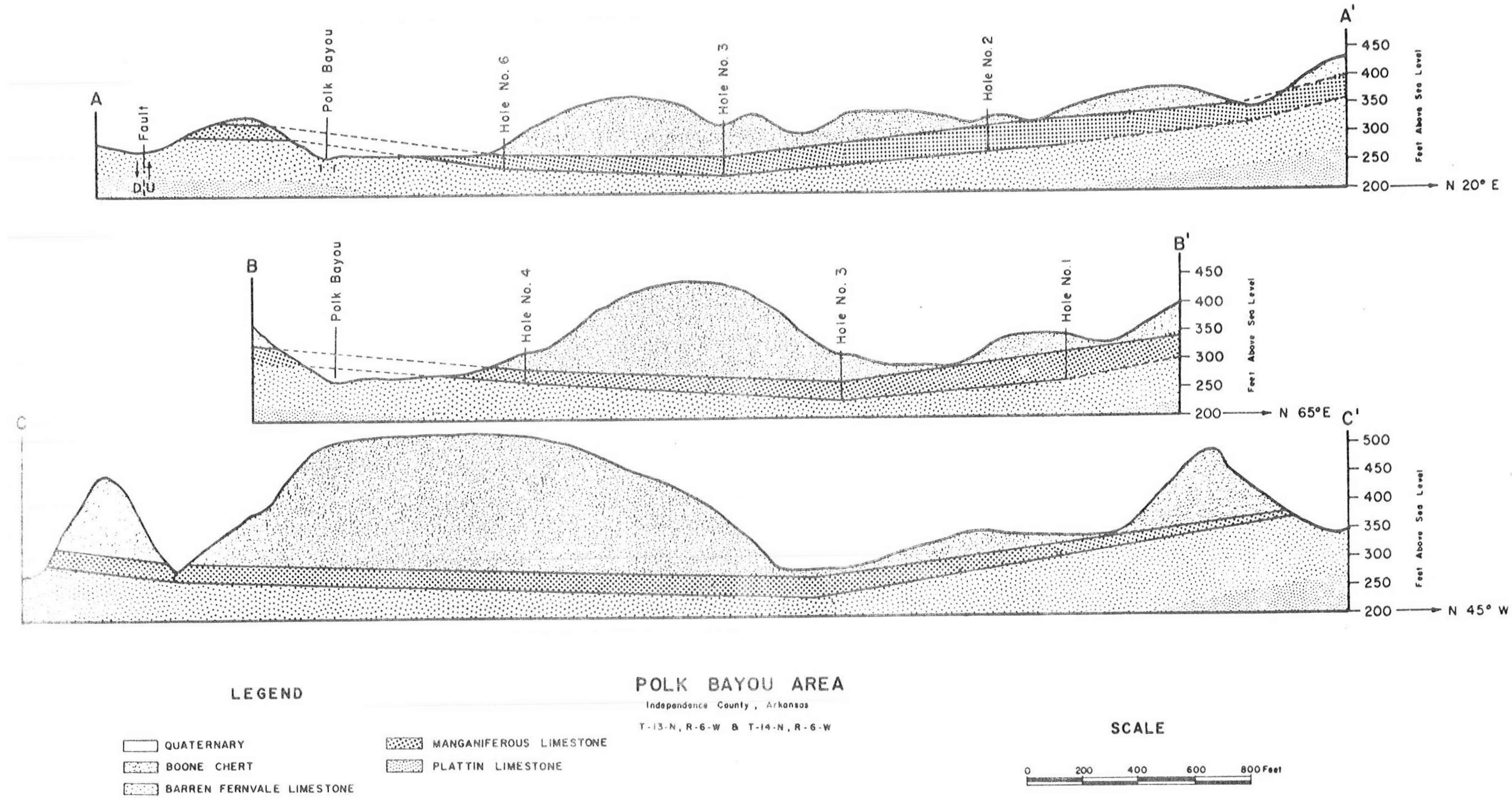


FIGURE 14. - Idealized Cross Sections, Polk Bayou Area.

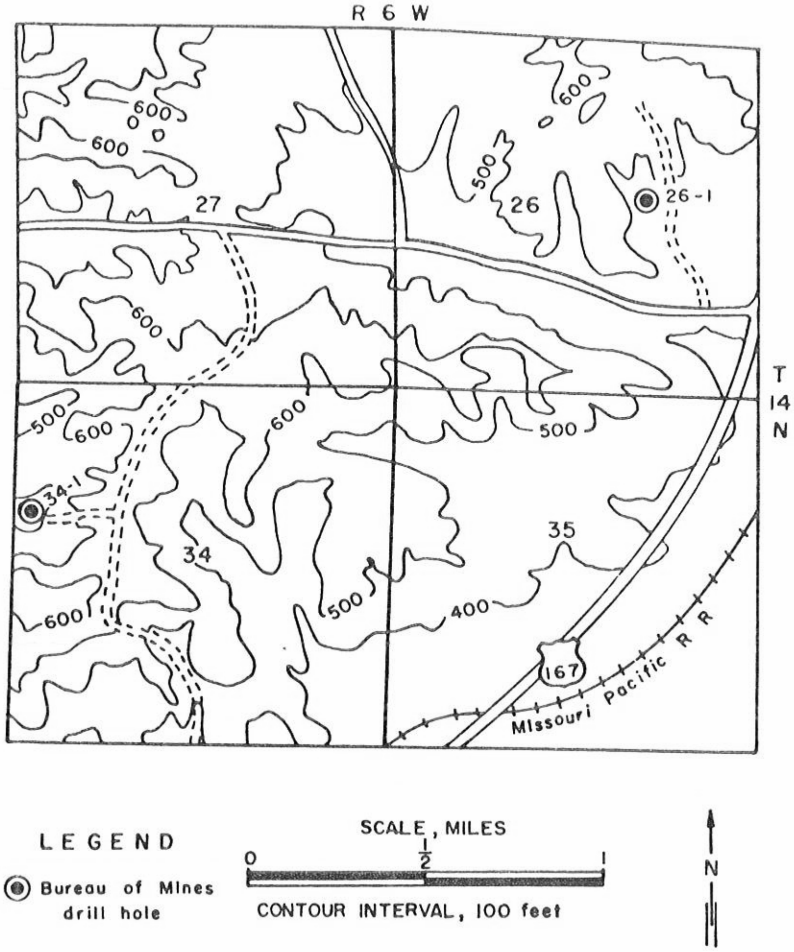


FIGURE 15. - Bureau of Mines Drill Holes, Secs. 26 and 34, T 14 N, R 6 W, Independence County, Ark.

To supplement the mapping data, churn drilling was begun in December 1960, and completed in March 1961. Hole locations are shown on figure 13. Assay results of samples obtained during the course of the drilling and logs of the holes are given in table A-2.

Eight holes, 8 to 10 inches in diameter, were churn drilled through barren chert or other rock formations to firm bedrock. Six-inch-ID casing was set and drilling continued. Samples of manganiferous Fernvale were taken at 2.5 foot intervals. Aggregate footage drilled was 571.0 feet. Manganiferous limestone was found in all holes in thicknesses ranging from 12.5 feet to 50.0 feet. Average thickness of manganese-bearing limestone penetrated in all holes was 32.9 feet.

Upon completion of reconnaissance studies in secs. 26 and 34, T 14 N, R 6 W, a second drilling program was begun in March and completed in April 1961. Two holes were drilled, one each in secs. 26 and 34, the sites being based upon geological criteria. Hole locations are shown on figure 15. Assay results of samples obtained by churn drilling and logs of the holes are given in table A-2.

The churn-drill hole in sec. 34, in the SW¼NW¼, is on the eastern flank of a synclinal basin, the major portion of which lies in the NE¼ of sec. 33. The long axis of the basin trends northeast, and the basin is flanked on the northwest by a dome which is essentially in the central part of sec. 27. An elongated, anticlinal fold flanks the basin on the southeast and plunges southwest. The Fernvale is barren of manganese where it crops out on the north and south ends of this anticline, but the limestone is manganiferous on the eastern limb where it begins to form a synclinal structure. The structural basin, probably underlain by manganese-bearing limestone, exceeds 2,000 feet in length and is about 1,500 feet at its maximum width. Estimated average thickness of the overburden, consisting of soil, Boone chert, and shale, is about 50 feet.

The other churn-drill hole was drilled in the SW¼NE¼, sec. 26, not far from an old hole which was drilled in 1918 in the NW¼SE¼ sec. 26 (8). The purpose of the new hole was to check the stratigraphic column and to assist in determining the thickness, lithologic character, grade, and extent of manganiferous Fernvale limestone underlying the area. Thickness and grade of the manganiferous zone in the limestone appears to be marginal, as indicated in table A-2; however, the lithologic character of the material recovered in the churn-drill cuttings is similar to the cuttings of manganiferous limestone obtained from drill holes located near the outer limits of this type of deposit. Insufficient exploration in the area of the occurrence prevents a good estimate of the manganese potential.

MANGANIFEROUS RESOURCES

Table 2 gives the inferred resources of the four types of manganiferous materials. These estimates are based upon data obtained by reconnaissance, detailed mapping, churn and core drilling, and sampling. Due allowance is made for tonnage figures gathered under previous exploratory projects. Mining operations and attendant production of manganese ore since 1956 have resulted in an estimated reduction of 7 percent of inferred resources in deposits classified as types (2) and (3), as compared to the quantities given in Report of Investigations 5411 (5).

TABLE 2. - Inferred manganiferous resources

Type of deposit	Manganiferous resources, long dry tons	Estimated, percent manganese content
1. Manganiferous limestone:		
(a) Fernvale limestone and Cason shale.......	174,000,000	4
(b) St. Joe limestone........................	1,000,000	4
2. Manganiferous clay in place under chert........	[1] 16,000,000	[1] 9
3. Manganiferous clay, talus-residual............	4,000,000	6
4. Placer.......................................	3,000,000	4
Total..................................	198,000,000	-

[1] Includes 700,000 long dry tons of wad ore containing an average of 23 percent manganese (9).

Estimates of manganiferous limestone tonnages and grades were based on the length and thickness of outcrops, drill hole intersections, and the manganese content of samples. In determining the size of areas believed to be underlain by manganiferous limestone, exposures were assumed to influence widths equal to one-half their observable lengths, except in instances where plane table mapping and drill hole data permitted the use of more exact information. Revisions in estimates were made for areas where barren zones were found by post-1956 churn and core drilling. Average measured thicknesses were used to calculate volume. A factor of 14 cubic feet per long dry ton was used in calculating tonnages (5).

Thirty percent of an area inferred to contain manganese oxides in residual clays was assumed to be manganese bearing. This factor was determined by a survey of mining operations at separate sites throughout the district, by sampling, and from data contained in Report of Investigations 4859 (9). A factor of 25 cubic feet per long dry ton was used in calculating tonnages (5).

Calculations of reserves of manganiferous talus and placer deposits were based upon a factor of 10 percent of the deposit areas. This factor was determined by surveys of mining operations.

The inferred resources were based upon data gathered in the field on more than 580 separate tracts, using manganese cut-off grades of 4 percent for clay deposits and 2 percent for manganiferous limestone.

LIST OF REFERENCES

1. Fine, M. M. A Mineral Dressing Study of Manganese Deposits of Batesville (Ark.) District. BuMines Rept. of Inv. 5301, 1957, 12 pp.

2. Fine, M. M., and D. W. Frommer. Laboratory Recovery of Manganese Carbonate From the Martin Mine, Independence County, Ark. BuMines Rept. of Inv. 5086, 1954, 10 pp.

3. _____. Mineral Dressing Study of Manganese Ore, Cason Mine, Batesville, Ark. BuMines Rept. of Inv. 5005, 1953, 9 pp.

4. Kline, H. D. Methods and Costs of Mining and Washing Manganese Ore, Batesville District, Ark. BuMines Inf. Circ. 8095, 1962, 22 pp.

5. Kline, H. D., and W. F. Brown. Manganese Resources of the Batesville District, Arkansas. Part 2 of 3 Parts. BuMines Rept. of Inv. 5411, 1958, 46 pp.

6. Kline, H. D., and J. P. Ryan. Manganese Resources of the Batesville District, Ark.: Interim Report 1. BuMines Rept. of Inv. 5206, 1956, 33 pp.

7. Miser Hugh D. Deposits of Manganese Ore in the Batesville District, Arkansas. U.S. Geol. Survey Bull. 734, 1922, 273 pp.

8. _____. Manganese Carbonate in the Batesville District, Arkansas. U.S. Geol. Survey Bull. 921-A, 1941, 97 pp.

9. Rutledge, F. A., W. A. Tessmer, Harold B. Ewaldt, Charles R. L. Oder, M. J. Langley, and James E. Bell. Investigation of Manganese Carbonate and Wad Deposits in the Batesville Manganese District, Arkansas. BuMines Rept. of Inv. 4859, 1952, 180 pp.

10. Shelton, S. M., M. M. Fine, and J. D. Bardell. Manganese Investigations-Metallurgical Division. 5. Ore-Dressing Studies of Manganese Ores. Beneficiation of Manganese Wad Ores From the Chinn Property, Batesville, Ark. BuMines Rept. of Inv. 3614, 1942, 18 pp.

11. Shelton, S. M., M. M. Fine, and R. B. Fisher. Manganese Investigations-Metallurgical Division. 17. Ore-Dressing Studies of Manganese Ores. Concentration of Wad Ore From the Aydellote Property, Batesville, Ark. BuMines Rept. of Inv. 3652, 1942, 17 pp.

12. Straczek, John A., and Douglas M. Kinney. Geologic Map of the Central Part of the Batesville Manganese District. U.S. Geol. Survey Field Studies Map MF-1, 1950.

APPENDIX

TABLE A-1. - Data on channel samples of manganiferous material

Sample site	Location					Rock formation	Sample number	Interval, feet	Analysis	
	Quarter	Quarter	Sec.	T N	R W				Mn, percent	P, percent
1	SW¼	SW¼	14	14	8	Cason shale.......	35	0 - 5	7.07	3.83
						Fernvale limestone	36	5 - 7	4.61	0.60 Composite
						........do........	37	7 - 9	5.07	
						........do........	38	9 -11	4.15	
						........do........	39	11 -15	2.17	
						........do........	40	15 -17	1.23	
2	NE¼	NE¼	10	14	8	........do........	45	0 - 2½	4.77	0.34 Composite
						........do........	46	2½- 5	6.46	
						........do........	47	5 - 7½	2.46	
						........do........	48	7½-10	5.38	
						........do........	49	10 -12½	3.69	0.33 Composite
						........do........	50	12½-15	6.00	
						........do........	51	15 -17½	4.77	
						........do........	52	17½-20	3.54	
						........do........	53	20 -22½	1.54	0.16 Composite
						........do........	54	22½-25	1.69	
						........do........	55	25 -27½	1.54	
						........do........	56	27½-30	1.69	
						........do........	57	30 -32½	1.54	0.11 Composite
						........do........	58	32½-35	.92	
						........do........	59	35 -37½	.77	
						........do........	60	37½-40	.92	
3	SW¼	NW¼	3	14	8	........do........	61	0 - 2½	3.38	0.14 Composite
						........do........	62	2½- 5	1.54	
						........do........	63	5 - 7½	1.69	
						........do........	64	7½-10	2.15	
						........do........	65	10 -12½	4.77	0.11 Composite
						........do........	66	12½-15	2.00	
						........do........	67	15 -17½	3.23	
						........do........	68	17½-20	1.54	
4	SW¼	NW¼	3	14	8	St. Joe limestone.	69	0 - 2½	5.07	0.03 Composite
						........do........	70	2½- 5	1.85	
						........do........	71	5 - 7½	1.54	
						........do........	72	7½-10	1.54	
						........do........	73	10 -12½	2.00	0.03 Composite
						........do........	74	12½-15	1.38	
						........do........	75	15 -17½	1.54	
						........do........	76	17½-20	1.38	0.04 Composite
						........do........	77	20 -22½	2.15	
						........do........	78	22½-25½	1.38	

TABLE A-1. - Data on channel samples of manganiferous material (Con.)

Sample site	Location: Quarter	Location: Quarter	Location: Sec.	Location: T N	Location: R W	Rock formation	Sample number	Interval, feet	Analysis: Mn, percent	Analysis: P, percent
5	SE¼	SE¼	3	14	8	Cason shale.......	80	0 - 2½	15.38	2.34
						Fernvale limestone	81	2½- 5	7.38	0.35 Composite
						........do........	82	5 - 7½	10.76	
						........do........	83	7½-10	6.15	0.23 Composite
						........do........	84	10 -12½	6.77	
6	NE¼	SE¼	4	14	8	........do........	85	0 - 2½	4.92	0.11 Composite
						........do........	86	2½- 5	3.08	
						........do........	87	5 - 7½	3.69	
						........do........	88	7½-10	4.92	0.14 Composite
						........do........	89	10 -12½	3.54	
						........do........	90	12½-15	2.77	
						........do........	91	15 -17½	3.08	0.15 Composite
						........do........	92	17½-20	1.69	
						........do........	93	20 -22½	1.54	
7	SE¼	SE¼	4	14	8	........do........	96	0 - 2½	.77	0.11 Composite
						........do........	97	2½- 5	2.31	
						........do........	98	5 - 7½	3.69	0.12 Composite
						........do........	99	7½-10	1.69	
						........do........	100	10 -12½	2.00	0.15 Composite
						........do........	101	12½-15	3.84	
8	NE¼	NW¼	15	14	8	........do........	107	0 - 2½	1.38	
						........do........	108	2½- 5	1.30	
						........do........	109	5 - 7½	5.20	
						........do........	110	7½-10	3.60	
						........do........	111	10 -11½	3.21	
9	SW¼	SW¼	2	14	8	........do........	112	0 - 2½	2.75	
						........do........	113	2½- 5	5.05	
						........do........	114	5 - 7½	5.20	
						........do........	115	7½-10	4.44	
						........do........	116	10 -12½	2.14	
10	SE¼	SW¼	2	14	8	........do........	117	0 - 2½	4.90	
						........do........	118	2½- 5	5.81	
						........do........	119	5 - 7½	3.37	
						........do........	120	7½-10	4.28	
						........do........	121	10 -12½	4.28	
						........do........	122	12½-15	4.28	
						........do........	123	15 -17½	5.81	
						........do........	124	17½-20	3.67	
						........do........	125	20 -22	1.84	
11	SE¼	SW¼	2	14	8	........do........	126	0 - 2½	3.21	
						........do........	127	2½- 5	4.13	
						........do........	128	5 - 7½	4.28	
						........do........	129	7½-10	3.67	
						........do........	130	10 -12½	2.60	
						........do........	131	12½-15	3.06	

TABLE A-1. - Data on channel samples of manganiferous material (Con.)

Sample site	Location					Rock formation	Sample number	Interval, feet	Analysis	
	Quarter	Quarter	Sec.	T N	R W				Mn, percent	P, percent
12	NE¼	SW¼	2	14	8	Fernvale limestone	132	0 - 2½	5.20	
						........do........	133	2½- 5	4.13	
						........do........	134	5 - 7½	3.52	
						........do........	135	7½-10	3.67	
						........do........	136	10 -12½	3.37	
						........do........	137	12½-15	2.60	
						........do........	138	15 -17½	1.53	
						........do........	139	17½-20	1.22	
13	NW¼	SW¼	2	14	8	........do........	140	0 - 2½	10.71	
						........do........	141	2½- 5	10.40	
						........do........	142	5 - 7½	6.27	
						........do........	143	7½-10	4.90	
14	NE¼	SW¼	2	14	8	........do........	144	0 - 2½	5.36	
						........do........	145	2½- 5	3.83	
						........do........	146	5 - 7½	3.67	
						........do........	147	7½-10	5.20	
						........do........	148	10 -12½	7.50	
						........do........	149	12½-15	3.37	
15	SW¼	SW¼	2	14	8	........do........	150	0 - 2½	3.21	
						........do........	151	2½- 5	4.59	
						........do........	152	5 - 7½	3.37	
						........do........	153	7½-10	1.38	
						........do........	154	10 -12½	1.84	
						........do........	155	12½-15	2.30	
						........do........	156	15 -17½	1.84	
						........do........	157	17½-20½	1.22	

TABLE A-2. - Logs of Bureau of Mines drill holes

Baxter Hill

(Sec. 22, T 14 N, R 6 W)

B-1

Begun: April 26, 1957 Elevation above sea level: 641 feet
Completed: May 29, 1957

Churn Drill

Depth, feet		Formation
From-	To-	
0	5	Soil, clay, and chert.
5	70	Chert and clay.
70	80	Chert and limestone.
80	94	Open cave.
94	102	Fernvale limestone.
		Core Drill
102	117	Barren Fernvale limestone (partially decomposed). Bottom at 117.

B-2

Begun: May 3, 1957 Elevation above sea level: 629 feet
Completed: May 27, 1957

Churn Drill

Depth, feet		Formation
From-	To-	
0	5	Chert rubble and surface soil.
5	65	Boone chert.
65	110	Mixed chert and limestone.
110	125	Alternating thin-bedded chert and limestone with minor pyrite.
125	135	Alternating thin-bedded chert and limestone.
135	145	Chert-limestone-sandstone and clay.
145	150	Chert.
150	160	Alternating thin-bedded limestone and chert.
160	195	Barren Fernvale limestone.
		Core Drill
195	205	Barren and partially decomposed Fernvale limestone. Bottom at 205 feet.

B-3

Begun: May 10, 1957 — Elevation above sea level: 630 feet
Completed: June 12, 1957

Depth, feet		
From-	To-	Formation
		Churn Drill
0	5	Topsoil and chert.
5	20	Chert and red clay.
20	35	Chert rubble.
35	70	Chert.
70	75	Chert with thin-bedded limestone.
75	80	Chert with thin-bedded limestone.
80	90	Intrabedded chert and limestone.
90	109	St. Clair limestone--minor shale.
		Tricone Rotary Bit
109	115	St. Clair limestone and Cason shale.
		NX Core Bit
115	122	Manganiferous limestone.
122	125	Fernvale limestone--baren. Bottom at 125 feet.

From-	To-	Analysis, percent			
		Mn	Fe	P	Insoluble
115	122	0.26	3.10	0.31	1.50

B-4

Begun: May 15, 1957 — Elevation above sea level: 550 feet
Completed: June 7, 1957

Depth, feet		
From-	To-	Formation
		Churn Drill
0	20	Red clay.
20	45	Light gray clay (no chert).
45	120	Red clay.
120	129	Chert and clay.
129	182	Broken light gray chert--clay-filled crack, churn drill unable to clean hole, rock caving from sides.
		Rotary Tricone Bit
182	271	Broken chert and clay-filled seams. Hole stopped in material inferred to be residual clay in broken chert. Bottom at 271 feet.

B-5

Begun: May 20, 1957
Completed: June 4, 1957

Elevation above sea level: 595 feet

Churn Drill

Depth, feet		
From-	To-	Formation
0	5	Surface soil and chert rubble.
5	70	Chert, iron stained.
70	85	Chert, light gray.
85	100	Chert, light yellow.
100	135	Chert, light gray.
135	141	Chert and red limestone.

Core Drill

141	167	Manganiferous limestone.
167	176½	Manganiferous clay with chert.
		Bottom at 176½ feet.

		Analysis, percent			
		Mn	Fe	P	Insoluble
153	161½	4.13	-	-	-
161½	166½	3.21	-	-	-
166½	171½	8.99	-	-	-

B-6

Begun: June 7, 1957
Completed: June 11, 1957

Elevation above sea level: 555 feet

All With Tricone Bit

Depth, feet		
From-	To-	Formation
0	8	Surface soil and clay.
8	16	Light gray shale and minor chert.
16	46	Red clay and minor chert.
46	81	Pink clay.
81	111	Red clay and minor chert.
111	121	Chert--porous.
121	126	Chert and sand.
126	156	Light gray porous chert and some clay.
156	166	Unconsolidated finely brecciated porous chert.

No radioactivity indicated by geiger counter.

Bottom at 166 feet.

TABLE A-2. - Logs of Bureau of Mines drill holes (Con.)

Section 16 Area

(S½ sec. 16 and N½ sec. 21, T 14 N, R 6 W)

Hole 16-1

Begun: January 3, 1958 Elevation above sea level: 620 feet
Completed: March 6, 1958

Churn Drill

Depth, feet		Formation
From-	To-	
0	5	Surface soil, chert rubble and clay.
5	40	Light gray chert with clay seams.
40	60	Light to dark gray thin-bedded chert.
60	75	Dark gray chert.
75	80	Light gray chert.
80	100	Dark gray chert.
100	105	Gray chert with thin-bedded limestone.
105	116	Dark gray chert.
116	116½	Cason shale.

Core Drill

116½	117½	White manganiferous limestone.
117½	121	Red manganiferous limestone.
121	165	Dark gray manganiferous limestone.
165	174	Light gray manganiferous limestone.
174	175	Barren limestone.

		Analysis, percent	
		Mn	P
116½	120	2.00	0.43
120	125	3.23	.35
125	130	4.00	.35
130	135	2.46	.26
135	140	3.54	.29
140	145	3.84	.20
145	150	3.23	.23
150	155	3.38	.22
155	160	5.54	.19
160	165	2.61	.27
165	170	3.84	.12
170	174	2.46	.14
174	175	.92	.10

TABLE A-2. - Logs of Bureau of Mines drill holes (Con.)

Hole 16-2

Begun: January 22, 1958
Completed: March 7, 1958

Elevation above sea level: 650 feet

Churn Drill

Depth, feet		Formation
From-	To-	
0	5	Surface soil, chert and clay.
5	40	Chert rubble and clay.
40	82	Broken chert with clay seams.
82	100	Light gray chert.
100	110	Dark gray chert.
110	117	Alternating thin beds of limestone and chert.

Core Drill

From-	To-	Formation
117	119	Manganiferous Cason shale.
119	173	Manganiferous Fernvale limestone--high-grade seam 125½ to 126 feet.
173	175	Barren Fernvale limestone.

From-	To-	Analysis, percent	
		Mn	P
117	119	7.84	2.01
119	125	3.23	.48
125	130	6.30	.33
130	135	2.46	.31
135	140	2.92	.36
140	145	5.07	.27
145	150	4.77	.23
150	155	4.92	.22
155	160	4.77	.20
160	165	3.08	.18
165	170	2.92	.23
170	175	1.23	.17

No radioactivity found.

TABLE A-2. - Logs of Bureau of Mines drill holes (Con.)

Hole 16-3

Begun: January 27, 1958 Elevation above sea level: 618 feet
Completed: March 11, 1958

Churn Drill

Depth, feet From-	To-	Formation
0	10	Surface soil, chert and clay.
10	65	Light gray chert with clay seams.
65	87½	Light gray chert.
87½	90	Dark gray chert.
90	105	Dark gray chert with minor limestone seams.
105	109	Barren limestone.

Core Drill

Depth, feet From-	To-	Formation
109	110	Cason shale.
110	169	Manganiferous Fernvale limestone.
169	172	Barren Fernvale limestone.

From-	To-	Analysis, percent Mn	P
109	115	9.07	0.45
115	120	3.84	.36
120	125	2.61	.31
125	130	4.61	.37
130	135	5.69	.27
135	140	5.07	.25
140	145	5.54	.28
145	150	6.46	.35
150	155	3.69	.22
155	160	7.38	.21
160	165	5.38	.21
165	170	2.31	.19
170	172	1.38	.20

No radiactivity found.

TABLE A-2. - Logs of Bureau of Mines drill holes (Con.)

Hole 16-4

Begun: January 31, 1958
Completed: March 12, 1958

Elevation above sea level: 645 feet

Churn Drill

Depth, feet		Formation
From-	To-	
0	15	Surface soil, chert and clay.
15	75	Light gray chert, brown clay seams.
75	90	Dark gray chert.
90	115	Dark gray chert with intrabedded limestone.
115	118½	Light gray limestone, probably St. Clair formation.

Core Drill

From-	To-	Formation
118½	126½	St. Clair limestone.
126½	138	Cason shale.
138	160	Manganiferous Fernvale limestone.
160	165	Barren Fernvale limestone.

From-	To-	Analysis, percent Mn	P	
115	119	0.77	0.55	(Churn Drill Sludge)
119	130	.30	.08	(Core)
130	137	.31	.08	Do.
137	140	8.15	.62	Do.
140	145	7.38	.22	Do.
145	150	4.77	.29	Do.
150	155	5.69	.21	Do.
155	160	3.69	.19	Do.
160	162	.46	.11	Do.

No radioactivity found.

TABLE A-2. - Logs of Bureau of Mines drill holes (Con.)

Hole 16-5

Begun: February 10, 1958 Elevation above sea level: 675 feet
Completed: March 14, 1958

Churn Drill

Depth, feet		Formation
From-	To-	
0	5	Surface soil, chert and clay.
5	15	Light gray chert and red clay.
15	77½	Light gray shale with brown clay.
77½	82½	Light gray chert.
82½	105	Dark gray chert.
105	121	Dark gray chert with intrabedded limestone, minor pyrite.
121	125	Dark gray limestone, St. Clair formation, minor pyrite.

Core Drill

125	131	St. Clair limestone.
131	145	Cason shale.
145	165	Fernvale limestone, with pyrite and minor manganese mineralization.

		Analysis, percent	
		Mn	P
131	135	0.45	0.08
135	140	.31	.06
140	145	.30	1.71
145	150	.92	.42
150	155	.46	.35
155	160	.45	.17
160	165	Not analyzed.	

TABLE A-2. - Logs of Bureau of Mines drill holes (Con.)

Hole 16-6

Begun: February 20, 1958 Elevation above sea level: 650 feet
Completed: March 4, 1958

Churn Drill

Depth, feet		Formation
From-	To-	
0	5	Surface soil, chert and clay.
5	15	Chert rubble and red clay.
15	87½	Light gray chert with brown clay seams.
87½	125	Light gray chert with limestone seams, minor pyrite and glauconite.
125	128½	Light gray St. Clair limestone, some shale.

Core Drill

128½	129	Cason shale.
129	153	Manganiferous limestone.
153	157	Barren limestone.

		Analysis, percent	
		Mn	P
128½	135	0.46	0.42
135	140	.92	.33
140	145	1.23	.31
145	150	1.54	.28
150	155	.92	.37

No radioactivity found.

Hole 16-7

Begun: March 19, 1958 Elevation above sea level: 640 feet
Completed: April 16, 1958

Churn Drill

Depth, feet From-	To-	Formation
0	10	Surface soil, chert rubble and clay.
10	25	Broken chert and red clay.
25	90	Light gray chert with clay seams.
90	95	Dark gray chert, minor pyrite.
95	105	Light gray chert.
105	120	Dark gray chert, minor pyrite.
120	125	Dark gray limestone, minor pyrite.
125	130	Light gray limestone, minor pyrite.

Core Drill

130	155	Pyritic limestone.
		Bottom of hole.

Top of Fernvale above sea level: 520 feet

		Analysis, percent Mn	P
129½	135	0.62	0.49
135	140	.46	.37
140	145	.45	.36
145	150	.31	.23

No radioactivity found.

TABLE A-2. - Logs of Bureau of Mines drill holes (Con.)

Hole 16-8

Begun: March 28, 1958
Completed: April 17, 1958

Elevation above sea level: 670 feet

Churn Drill

Depth, feet		Formation
From-	To-	
0	5	Surface soil, chert and clay.
5	97	Light gray chert with clay seams.
97	100	Dark gray chert with thin limestone and clay seams.
100	105	Light gray chert.
105	120	Thin-bedded light and dark gray chert and limestone; minor pyrite.
120	133½	Light gray St. Clair limestone with minor pyrite.

Core Drill

From-	To-	Formation
133½	135½	Pyritic limestone.
135½	136	Dark gray shale.
136	138	Pyritic limestone.
138	138½	Dark gray shale.
138½	140	Pyritic limestone.
140	140-2/3	Dark gray shale.
140-2/3	150	Pyritic limestone.
150	165	Iron-stained limestone.
		Bottom of hole.

From-	To-	Analysis, percent Mn	P
134	140	0.30	0.48
140	145	.28	.80
145	150	.30	.41
150	155	.31	.14

No radioactivity found.

TABLE A-2. - Logs of Bureau of Mines drill holes (Con.)

Hole 16-9

Begun: April 6, 1958 Elevation above sea level: 700 feet
Completed: April 18, 1958

Churn Drill

Depth, feet		Formation
From-	To-	
0	10	Surface soil, chert rubble and clay.
10	80	Light gray shale with clay seams.
80	100	Thin-bedded dark gray chert and limestone.
100	106	Light gray limestone.

Core Drill

106	140	Manganiferous limestone.
140	145	Barren limestone.
		Bottom of hole.

Top of Fernvale above sea level: 597 feet

		Analysis, percent	
		Mn	P
106	110	0.29	0.55
110	115	.30	.44
115	120	.46	.31
120	125	4.61	.29
125	130	2.92	.26
130	135	.62	.11
135	140	.92	.28

No radioactivity found.

TABLE A-2. - Logs of Bureau of Mines drill holes (Con.)

Polk Bayou

(Sec. 32, T 14 N, R 6 W)

Hole 1

Begun: December 27, 1960 Elevation above sea level: 332 feet
Completed: January 9, 1961

Churn drilled: 0 - 75 feet
Sampled interval: 22½ - 72½ feet

Depth, feet		Formation
From-	To-	
0	5	Surface soil, brown and gray chert with red clay.
5	11½	Light gray chert.
11½	22½	Pink, gray and white coarse-grained limestone.
22½	72½	Manganiferous limestone.
72½	75	Pink and gray limestone.

		Analysis, percent		
		Mn	Fe	P
22½	27½	2.07	-	-
27½	32½	4.13	-	-
32½	37½	4.36	-	-
37½	42½	2.37	-	-
42½	47½	3.82	-	-
47½	52½	1.99	-	-
52½	57½	2.22	-	-
57½	62½	2.37	-	-
62½	67½	5.05	-	-
67½	72½	2.14	-	-
Composite				
22½	72½		1.42	0.19

TABLE A-2. - Logs of Bureau of Mines drill holes (Con.)

Hole 2

Begun: January 19, 1961 Elevation above sea level: 334 feet
Completed: January 25, 1961

Churn drilled: 0 - 70 feet
Sampled interval: 20 - 67½ feet

Depth, feet		Formation
From-	To-	
0	7½	Surface soil, light gray and brown chert, brown clay.
7½	20	Brown clay, light gray chert, brown chert fragments.
20	67½	Manganiferous limestone.
67½	70	Pink and gray limestone.

Depth, feet		Analysis, percent		
From-	To-	Mn	Fe	P
20	25	2.22	-	-
25	30	3.21	-	-
30	35	4.21	-	-
35	40	4.44	-	-
40	45	4.90	-	-
45	50	4.90	-	-
50	55	3.06	-	-
55	60	2.45	-	-
60	67½	2.45	-	-
Composite				
20	67½		2.02	0.25

TABLE A-2. - Logs of Bureau of Mines drill holes (Con.)

Hole 3

Begun: January 12, 1961 Elevation above sea level: 308 feet
Completed: January 18, 1961

Churn drilled: 0 - 80 feet
Sampled interval: 42½ - 77½ feet

Depth, feet		Formation
From-	To-	
0	5	Surface soil, light gray chert, hard blue-gray chert.
5	15	Hard blue-gray chert.
15	27½	Light to dark limy chert.
27½	42½	Light gray, pink and white coarse-grained limestone.
42½	77½	Manganiferous limestone.
77½	80	White, pink and gray coarse-grained limestone.

From-	To-	Analysis, percent		
		Mn	Fe	P
42½	47½	1.42	-	-
47½	52½	4.13	-	-
52½	57½	2.37	-	-
57½	62½	4.90	-	-
62½	67½	4.44	-	-
67½	72½	1.22	-	-
72½	77½	.99	-	-
Composite				
42½	77½		2.08	0.58

TABLE A-2. - Logs of Bureau of Mines drill holes (Con.)

Hole 4

Begun: January 10, 1961
Completed: January 12, 1961

Elevation above sea level: 317 feet

Churn drilled: 0 - 55 feet
Sampled interval: 27½ - 47½ feet

Depth, feet		
From-	To-	Formation
0	5	Surface soil, red clay, chert fragments.
5	27½	Chert fragments, red clay.
27½	32½	Pink, white, light gray limestone, little manganese oxide, and manganiferous clay.
32½	47½	Manganiferous limestone.
47½	55	Pink, white, brown limestone, slightly manganiferous, little manganiferous clay.

Depth, feet		Analysis, percent		
From-	To-	Mn	Fe	P
27½	32½	1.15	-	-
32½	37½	2.90	-	-
37½	42½	9.03	-	-
42½	47½	5.13	-	-
Composite				
27½	47½		2.78	0.31

TABLE A-2. - Logs of Bureau of Mines drill holes (Con.)

Hole 5

Begun: January 25, 1961 — Elevation above sea level: 326 feet
Completed: February 3, 1961

Churn drilled: 0 - 47½ feet
Sampled interval: 37 - 47½ feet

Depth, feet		Formation
From-	To-	
0	5	Surface soil, light to dark brown chert fragments, brown clay.
5	34	Dark brown clay, light to dark gray chert; some blue-gray chert.
34	37	Light gray, pink, white limestone.
37	45	Light to dark gray manganiferous limestone.
45	47½	Light gray, pink and white coarse-grained limestone.

		Analysis, percent		
		Mn	Fe	P
37	42½	0.77	-	-
42½	47½	.92	-	-
Composite				
37	47½		3.64	0.40

TABLE A-2. - Logs of Bureau of Mines drill holes (Con.)

Hole 6

Begun: February 3, 1961 Elevation above sea level: 290 feet
Completed: February 9, 1961

Churn drilled: 0 - 47½ feet
Sampled interval: 20 - 45 feet

Depth, feet		
From-	To-	Formation
0	5	Surface soil, brown, light to dark chert, brown clay.
5	20	Brown chert, light gray chert, dark brown clay.
20	45	Manganiferous limestone.
45	47½	White and pink, coarse-grained limestone.

Depth, feet		Analysis, percent		
From-	To-	Mn	Fe	P
20	25	8.72	-	-
25	30	5.36	-	-
30	35	5.51	-	-
35	40	4.90	-	-
40	45	3.67	-	-
Composite				
20	45		4.68	0.37

TABLE A-2. - Logs of Bureau of Mines drill holes (Con.)

Hole 7

Begun: February 9, 1961
Completed: February 14, 1961

Elevation above sea level: 284 feet

Churn drilled: 0 - 45 feet
Sampled interval: 5 - 42½ feet

Depth, feet From-	To-	Formation		
0	5	Surface soil, brown clay, light to dark gray chert.		
5	42½	Manganiferous limestone and shale.		
42½	45	Slightly manganiferous limestone.		
		Analysis, percent		
		Mn	Fe	P
5	10	3.98	-	-
10	15	3.21	-	-
15	20	2.91	-	-
20	25	3.83	-	-
25	30	4.28	-	-
30	35	2.75	-	-
35	40	2.60	-	-
40	45	2.07	-	-
Composite				
5	42½		3.34	0.35

TABLE A-2. - Logs of Bureau of Mines drill holes (Con.)

Hole 8

Begun: February 14, 1961 Elevation above sea level: 412 feet
Completed: March 8, 1961

Churn drilled: 0 - 151 feet
Sampled interval: 116 - 150 feet

Depth, feet		
From-	To-	Formation
0	5	Surface soil, brown and gray chert, red clay.
5	36	Light to dark blue chert, brown clay.
36	52½	Light gray limy chert, very hard.
52½	72½	Dark gray chert, some pyrite, glauconite.
72½	81½	Blue-gray shale; minor pyrite.
81½	106	Dark gray chert.
106	114	Light gray, limy chert.
114	116	Light gray, pink and white fine grained limestone.
116	150	Manganiferous limestone and shale.
150	151	Pink to white limestone, shale, slightly manganiferous.

		Analysis, percent		
		Mn	Fe	P
116	122½	2.68	-	-
122½	127½	4.67	-	-
127½	132½	4.51	-	-
132½	137½	4.44	-	-
137½	142½	4.47	-	-
142½	147½	5.13	-	-
147½	150	4.28	-	-
Composite				
116	150		3.34	0.58

TABLE A-2. - Logs of Bureau of Mines drill holes (Con.)

Hole 34-1

(Sec. 34, T 14 N, R 6 W)

Begun: March 21, 1961 — Elevation above sea level: 475 feet
Completed: March 29, 1961

Churn drilled: 0 - 47 feet
Sampled interval: 20 - 45 feet

Depth, feet		
From-	To-	Formation
0	6	Surface soil, brown chert and clay.
6	17½	Light to dark gray limy chert.
17½	47½	Light to dark gray, coarse-grained limestone, in part manganiferous.

From-	To-	Analysis percent Mn
20	25	4.44
25	30	4.59
30	35	2.92
35	40	2.14
40	45	3.59

TABLE A-2. - Logs of Bureau of Mines drill holes (Con.)

Hole 26-1

(Sec. 26, T 14 N, R 6 W)

Begun: April 3, 1961
Completed: April 27, 1961

Elevation above sea level: 460 feet

Churn drilled: 0 - 250 feet
Sampled interval: 212½ - 240 feet

Depth, feet		
From-	To-	Formation
0	5	Surface soil, brown clay, light gray to white chert.
5	103½	Thin-bedded limy chert.
103½	143½	Black, hard shale, slightly pyritic.
143½	204	Dark gray, limy chert.
204	250	Light to dark gray, coarse-grained limestone, in part manganiferous.

		Analysis, percent
		Mn
212½	217½	3.30
217½	225	3.75
225	230	.46
230	235	.31
235	240	.30