IRON IN VIRGINIA

EDWIN O. GOOCH

MINERAL RESOURCES CIRCULAR NO. 1

VIRGINIA DIVISION OF GEOLOGY

Commonwealth of Virginia

Department of Conservation and Development

DIVISION OF GEOLOGY

William M. McGill, State Geologist

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I R O N I N V I R G I N I A

Edwin O. Gooch

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This is the first in a new series of publications which will be issued by the Virginia Division of Geology at irregular intervals. The aim of the mineral resources circulars is to serve the public by presenting a summary of geologic information about a specific mineral or group of minerals in language which should be readily understandable to all. Mineral resources circulars will supplement the more technical and detailed publications -- bulletins -- of the division and will be more comprehensive than the division quarterly.

C. C. Fisher
Editor

ERRATUM: Page 1, paragraph 4, line 2 should read:

from 150 to 240 million tons

IRON IN VIRGINIA

by

Edwin O. Gooch

Introduction

Although iron is one of the most abundant metals in the earth, it was not used as early as some other metals because of the character of its natural compounds. What was probably meteoric iron was known about 4000 B. C. to the Egyptian Pharaohs, who regarded it more highly than gold. Iron was first manufactured about 1200 B. C. but had no industrial use before 800 B. C., the beginning of the Age of Iron. Steel came into use about the time of Christ, but the blast furnace was not developed until the 14th century. In Great Britain, charcoal furnaces were used to smelt iron during the 16th century, and in 1710 the discovery was made that coal could be used to reduce iron ore. Bessemer discovered in 1856 a process to make steel from cast iron by forcing blasts of air through the molten metal to burn out carbon and other impurities. This discovery led to the great industrial age of iron that culminated in the steel age. In the 19th century Great Britain, with her resources of coal and iron, became the first of the modern industrial nations.

In America, iron was discovered in Virginia in 1608, and the first iron ore was mined by the Jamestown settlers in 1609. Large-scale smelting of iron ore in America began in Massachusetts in 1664 and in Pennsylvania in 1730. With the use of anthracite coal for iron-making, the iron industry centered around the anthracite coal region of Pennsylvania during the 17th century, but with the advent of coke as a fuel it moved to what is now Pittsburgh. The discovery in 1884 of the great Lake Superior iron-ore deposits ushered in the industrial age of the United States. Where coal and iron could be easily brought together, in Pennsylvania and along the Great Lakes, great industrial centers arose and a new era of United States development began.

In Virginia, during the 18th and 19th centuries, furnaces using charcoal for fuel were in operation in the Piedmont and Great Valley regions. They were of small capacity, producing only a few tons of metal per day. Coke was first used as a fuel about 1870 and this increased the capacity of the furnaces considerably. Whereas the charcoal furnaces treated from a few hundred to 2,000 tons of ore per year, the coke furnaces treated as much as 90,000 tons a year. The first furnaces used for producing iron in Virginia were scattered through the Piedmont and Great Valley, but later most of the furnaces were located west of the Blue Ridge.

World and U. S. Production

Current world production of iron ore ranges from 150 to 240 tons annually, depending upon economic conditions. The chief producing countries and their approximate normal percentages of world production are shown below. It should be noted that although Canada, Venezuela, Brazil, and Chile each produce under one per cent of the world's iron ore, Canadian, Venezuelan, and Brazilian production will increase because of recent discovery of large deposits in these countries. Moreover, production from some other countries will decrease unless their known reserve is increased by discovery of new deposits.

Country	Percentage of World Production
1. United States	50
2. France	11
3. U. S. S. R.	10
4. Sweden	8
5. Great Britain	8
6. Germany	5
7. Luxembourg	1.5
8. India	1.5
9. Spain	1.5
10. Australia	1.3
11. Algeria	1.1

The reported annual production of iron ore in the United States from 1940 through 1950 ranged from 60 to 90 million tons, divided among the producing states as follows:

State	Per cent
1. Minnesota	68
2. Michigan	10
3. Alabama	9
4. New York, Pennsylvania	5
5. Utah	1.5
6. Wisconsin	1.2

It has been estimated that Virginia has produced a total of 26,000,000 long tons of iron ore which has yielded about 11,000,000 tons of pig iron valued at approximately $200,000,000. The yearly production, beginning in 1872 and continuing through 1930, is shown in Table 1, page 2. There has been very little production of iron in Virginia since 1930.

Uses

Iron is the basis of modern civilization. Few are aware to what extent we have become dependent upon it in homes, farms, cities, machines, automobiles, etc. To enumerate the uses of iron would be to compile a history of the many creations of modern civilization and industry. When iron or steel is not suitable for a given use, it is alloyed with other substances to make it suitable.

Mineralogy

The economic iron-ore minerals are shown below.

Mineral	Composition	Approximate Per Cent Fe	Commercial Classification
Magnetite	Fe_3O_4	72	Magnetic (or black)
Hematite	Fe_2O_3	70	Red Ore
Limonite	$Fe_2O_3 \cdot H_2O$	59-63	Brown ore
Siderite	$FeCO_3$	48	Spathic, black band, clay-ironstone

Of these iron-ore minerals, magnetite is the richest but occurs in minor quantity. Hematite is the mainstay of the iron industry, yielding 94 per cent of the iron ore mined in the United States. Limonite and siderite are of minor economic importance in the United States.

TABLE 1

IRON PRODUCTION IN VIRGINIA

Year	Rank Among the Iron-producing States	Iron Ore Mined (long tons)	Pig Iron Produced (long tons)
1810	.....	.....	6,931
1840	.....	.....	18,810
1850	.....	67,319	22,163
1860	.....	23,217	9,096
1870	.....	42,114	15,387
1872	.....	.....	19,147
1873	.....	.....	23,638
1874	.....	.....	26,296
1875	.....	.....	26,772
1876	.....	.....	11,648
1877	.....	.....	11,102
1878	.....	.....	15,109
1879	.....	.....	16,851
1880	.....	162,791	26,726
1881	.....	.....	74,743
1882	.....	.....	78,331
1883	.....	.....	136,524
1884	.....	.....	140,609
1885	.....	.....	146,232
1886	.....	.....	130,580
1887	.....	.....	156,899
1888	.....	.....	176,246
1889	7	498,154	224,423
1890	7	543,583	292,779
1891	6	558,916	295,290
1892	7	741,027	342,847
1893	5	#616,965	302,856
1894	.....	600,562	298,086
1895	5	712,241	346,589
1896	4	859,466	386,277
1897	5	711,128	307,610
1898	6	557,713	283,274
1899	5	#986,476	365,491
1900	4	#921,821	490,617
1901	5	#925,394	448,662
1902	4	#987,958	537,216
1903	5	#810,161	544,034
1904	5	#550,253	310,526
1905	7	#752,045	510,210
1906	8	.....	483,525
1907	9	786,856	478,771
1908	6	692,223	320,458
1909	6	837,847	391,134
1910	6	903,377	444,976
1911	6	614,023	293,642
1912	7	446,305	256,167
1913	8	483,843	341,815
1914	7	378,520	271,228
1915	9	348,042	251,346
1916	10	440,492	399,885
1917	10	469,903	520,311
1918	9	414,048	513,737
1919	9	305,096	319,409
1920	10	320,924	429,302
1921	9	74,021	67,239
1922	12	30,971	49,024
1923	11	155,977	276,874
1924	12	89,792	.....
1925	12	96,272	125,325
1926	14	49,159	103,000
1927	13	64,592	99,197
1928	15	27,902	.....
1929	No Production	.....	.....
1930	15	19,596	.....

Includes a small amount produced by West Virginia.

VIRGINIA

Distribution

As shown on the map, Plate 1, the principal iron-bearing districts of Virginia are in the Piedmont, Blue Ridge, and Ridge and Valley provinces, with no deposits of commercial importance in the Coastal Plain. The major part of the iron ore produced in the state has come from the Ridge and Valley province. The Alleghany-Bath Limonite District (Plate 1) has been the largest producer.

Types of Deposits

Holden divided the iron deposits of Virginia into four main types: limonite, hematite, magnetite, and carbonate deposits. The major production of iron has been from the limonite deposits, and Virginia led all states in production of this type of ore from 1890 to 1901. The second largest production has been from the hematite deposits, with magnetite ranking third. Carbonate has been produced in small quantities only, incidental to limonite mining.

Limonite: Most of the limonite deposits can be grouped into four more or less definite types: Oriskany, shallow residual, gossan, and fault deposits.

Oriskany Deposits: The Oriskany deposits, major source of Virginia's iron, occur in the Valley Ridges section of the Ridge and Valley province and extend from one end of the state to the other; however, they are best developed in the Alleghany-Bath and Shenandoah Limonite districts (Plate 1). The ore was probably first worked about 1760 for a charcoal furnace in the Shenandoah Limonite District.

The name Oriskany was given originally to the limonite ore which occupied the position of the Oriskany sandstone. This name is now applied to all ore having a similar origin and occurring in the upper Helderberg limestone, the Oriskany sandstone, and the lower part of the Devonian shale. Characteristically the ore is found replacing the upper pure limestone of the Helderberg. According to Holden the iron was originally disseminated through the overlying Devonian shale. As the shale weathered, the iron was taken in solution, carried down and deposited in a favorable place, usually the upper portion of the Helderberg limestone.

Outcrops of Oriskany ore are most commonly found on the lower slopes of the mountains a few hundred feet above the valley bottoms, where they may appear for miles along the strike of the formation. Continuous ore bodies having a fairly constant thickness of from 8 to 25 feet have been worked for one-half mile. These ore bodies have not been deformed or fractured since they were deposited. The ore is commonly a continuous porous mass, with the openings ranging in diameter from a fraction of an inch to a foot or more. Although some openings are barren, they commonly contain water, clay, or sand.

Oriskany deposits are best developed in the Clifton Forge area of the Alleghany-Bath Limonite District, where mining began before the War Between the States and continued until around 1930. This district is credited with a production of 13,000,000 tons of iron, approximately half the total production of the state. Several mines are said to have yielded large tonnages of ore and one, the Oriskany, is reported to have produced about 2,000,000 tons.

Oriskany ores average about 43 per cent metallic iron, 21 per cent silica, 0.38 per cent phosphorus, and 1.3 per cent manganese. Mines in the Alleghany-Bath Limonite District are shown on Plate 2 and in the Shenandoah Limonite District on Plate 3.

Shallow Residual Deposits: Shallow residual limonite has long been known locally as "limonite" and "mountain ore," and is best developed in the Pulaski-Smyth Limonite District (Plate 1). According to Holden the limonite resulted chiefly from weathering of pyrite (sulfide of iron) in limestones. The limestones weathered by leaching of the soluble constitutents, the insoluble portions remaining as clay. The pyrite in the limestone altered to limonite and remained disseminated in the clay. The limonite is either pseudomorphorus after the pyrite, occurring in grains, plates, and sheets, or has been dissolved and reprecipitated in new shapes. Mountain ore is similar to limonite but is associated with clays derived from sandstone and shale rather than from limestone, is more massive, and occurs in more definite bodies than limonite ore. Mountain ores are more widely distributed than limonites but are also best developed in the Pulaski-Smyth Limonite District.

In 1880 there were twelve charcoal furnaces and forges operating in the Pulaski-Smyth Limonite District. Later, six or seven large coke furnaces used these ores, and in 1905 two trainloads of ore were being mined and shipped every day from the Cripple Creek area.

The metallic iron content of the ores in the district ranges from 35 to 45 per cent with most analyses showing between 40 and 45 per cent. The silica content may be as much as 28 per cent; however, most of the ore contains from 10 to 20 per cent silica, with some as low as 4 per cent. The combined phosphorus and manganese content is usually less than 1 per cent, although phosphorus may go as high as 2 per cent and manganese as high as 6 per cent.

The names and locations of most of the mines in the district are shown on Plate 4.

Gossan Deposits: Gossan limonite results from weathering of the iron sulfides pyrite and pyrrhotite, and such ore has been mined locally in several parts of the state. However, most gossan ore has come from the Louisa-Spotsylvania and Carroll-Grayson Limonite districts (Plate 1). Some of the earliest iron operations were in ores derived by the weathering of pyrite. These operations were in the Louisa-Spotsylvania Limonite District, but production from these mines was small and the ore was used in local furnaces.

The largest deposits of gossan limonite in Virginia, known as the "Great Gossan Lead," are in the Carroll-Grayson Limonite District, where gossan has been derived from pyrrhotite. The gossan belt is approximately 60 miles long, extending through parts of Carroll, Grayson, and Floyd counties but its best development is in Carroll County. The belt can be traced for a distance of 16.5 miles, more or less continuously, from a point approximately 2.5 miles southwest of Galax, Grayson County, to a point about 2.5 miles east of Sylvatus, Carroll County. The

deposits were worked for limonite ore from the 1890's to as late as 1908.

Analyses show the limonite in the Carroll-Grayson Limonite District contains from 35 to 45 per cent metallic iron, 16 to 23 per cent silica, 0.02 to 0.12 per cent phosphorus, and minor amounts of sulfur and manganese.

Plate 5 shows some of the mines in the Louisa-Spotsylvania Limonite District and Plate 6 shows some of the mines in the Carroll-Grayson Limonite District.

Fault Deposits: Faults are in places the loci of pyrite veins, in other places limestones along the faults have been altered to limonite. A series of fault-type deposits are along the Pulaski overthrust fault in Pulaski and Montgomery counties.

Hematite: Hematite has been produced in four districts in Virginia: the Roanoke, Iron Gate-Low Moor and Lee-Wise Hematite districts, and the Lynchburg Hematite and Magnetite District (Plate 1).

The deposits in the Lee-Wise and Iron Gate-Low Moor districts are better known as Clinton hematite, which is widespread throughout the eastern United States. Clinton ore has been mined in all the Appalachian states from New York to Alabama, and deposits in the Birmingham district in Alabama provide the basis for the iron industry in the southern Appalachian region. In Virginia, Clinton ores are meagerly developed and have been mined only in Lee, Wise, and Alleghany counties.

Clinton ore is distinctive in texture and quite unlike any other in the state in that it may be either oolitic or fossiliferous. The fossiliferous ore is composed largely of fossil fragments, such as bryozoa or crinoids, in which the hematite has replaced the original lime of the organisms. The oolitic ore is composed of rounded or flattened granules about 2 millimeters in diameter.

In the Clifton Forge area of Alleghany County, Clinton ore was mined on the north side of Jackson River at Iron Gate about 1880, and near Low Moor in the same county ore was mined in 1905 and 1906. The ore beds in this area are from 2 to 3 feet thick. In Lee and Wise counties, fossiliferous ore was mined from 1825 to about 1900. Ore beds in this district pinch and swell, being usually 2 to 3 feet thick with a maximum thickness of about 5 feet.

The metallic iron content of deposits in the Lee-Wise District ranges from 34 to 50 per cent, with an average of around 40 per cent. The silica content varies from 6.6 to 35 per cent, with most analyses showing between 10 to 20 per cent. Phosphorus runs from about 0.16 to 0.58 per cent. The metallic iron content of the hematite in the Iron Gate-Low Moor District is about 45 per cent, with the silica content varying from 15 to 20 per cent.

Mines in the Lee-Wise District are shown on Plate 7 and in the Iron Gate-Low Moor District on Plate 8.

The deposits in the Roanoke Hematite District, often referred to as Blue Ridge Hematite, are bedded deposits associated with lower Cambrian shales and quartzites. South of Roanoke the ore bed is about 18 inches thick; to the north around Blue Ridge Station it thickens to about 3 feet; farther to the northeast it thickens to 7 feet and then, in the vicinity of Arcadia, thins to 3 feet. So between Blue Ridge Station and Arcadia the ore-body apparently is lens-shaped. At depth the ore is dense and hard and usually deep bluish-green in color, but near the surface it weathers to a dark red and in places is altered to limonite.

Hematite ore in the Roanoke district was first mined about 1880, and operations continued for approximately 50 years. This ore is siliceous and low grade, with an average content of 35 to 40 per cent iron and 30 to 40 per cent silica. The combined percentages of phosphorus and manganese seldom exceed 1 per cent. Mines in the Roanoke district are shown on Plate 9.

In the Lynchburg Hematite and Magnetite District deposits of hematite and magnetite occur along the James River from Norwood to Lynchburg. These deposits are in the form of beds, lenses, and disseminations and occur in the Mount Athos quartzite. The beds and lenses dip at high angles, parallel to the schistosity of the enclosing rocks, whereas the disseminations occur as zones in the schists and quartzites. According to Furcron, the ore-bearing zones vary from a few inches to more than 10 feet in thickness, with the veins in the principal mines averaging from 1 to 3 feet, including the schist partings.

For several years after 1880, the date of first exploitation, the Lynchburg district was the largest iron-producing region in the state. Most of the mines and prospects in the district are shown on Plate 10.

Magnetite: The main occurrences of magnetite in Virginia are in the Pittsylvania, Franklin-Patrick, and Carroll-Grayson Magnetite districts and and the Lynchburg Hematite and Magnetite District (Plate 1).

One of the largest magnetite deposits that has been worked in Virginia is near Pittsville, Pittsylvania County. The ore-body, which lies between schist and limestone, is in the form of a lens that pinches and swells both horizontally and vertically. This lens has an average thickness of 3 feet, but according to Holden it locally reaches a thickness of 7 feet. The deposit has been worked for more than one-half mile along the strike and to a depth of about 175 feet. The Pittsville mine (Plate 11) was worked at various times between 1880 and 1906 and later and is credited with a production of over 100,000 tons of ore.

Ore from the Pittsville mine contains about 60 per cent metallic iron and 0.09 per cent phosphorus.

In the Franklin-Patrick Magnetite District, the ore deposits occur as lenses in hornblende schists and dip to the southeast parallel to the schistosity. Mines at Rocky Mount were worked for many years for local furnaces, and ore was mined for shipment about 1880. According to Holden, some cuts are 10 to 20 feet wide, indicating an ore-body of unusual width. The Hairston mine, near Stewart's Knob in Patrick County, produced magnetite for shipment about 1906 from an ore-body similar to that at Rocky Mount but occurring as narrower lenses.

Ore from the mines in the Franklin-Patrick District, Plate 11, has a metallic iron content ranging from 53 to 60 per cent, with the silica varying from

7 to 15 per cent and a combined phosphorus and manganese content of less than 1 per cent.

In the Carroll-Grayson Magnetite District discontinuous showings of magnetite extend in a northeast-southwest belt from North Carolina to some distance beyond Fries, Grayson County. Ore occurs as lenses or veins in schists and apparently has been worked to some extent for local forges. Most analyses of ore from this district show titanium.

The metallic iron content of magnetite in the Carroll-Grayson District averages approximately 50 per cent, with silica approximately 10 per cent, and titanium oxide as high as 4.2 per cent. The mines and prospects in the district are shown on Plate 12.

Carbonate Deposits: Although iron carbonate has been found in a number of mines, it has not been an important ore. No mines have been worked for iron carbonate alone, but it has been produced in commercial quantities from deeper workings of mines on other types of ore: for example, from Oriskany ore in the Longdale mine and from fault deposits in the Indian Camp and Grubb mines.

Possible Future of the Industry

To predict the possible future of the iron industry in Virginia, it is necessary to examine the past and see why production of iron ceased. Until about 1925 the industry profitably served a restricted local market. However, after 1920, competition from Great Lakes ore, unfavorable freight rates, and more modern furnace practices made it increasingly difficult for Virginia mines to operate. Production finally ceased about 1930 because of economic problems rather than exhaustion of ore reserves. The future of the industry depends largely upon the depletion of Great Lakes ore, the development of new deposits in Labrador, Brazil, and Venezuela, and possible relocation of steel mills.

An article by Professor Marvin Barloon in the August 1947 issue of Harper's Magazine discusses the thesis that with the dwindling and ultimate exhaustion of ore from the Great Lakes region there will be increased importation of iron from foreign sources, mainly Labrador, Brazil, and Venezuela. Such importation could ultimately lead to the migration of the entire steel industry to the Atlantic Coast where ports of unloading ore are located. The Hampton Roads area would undoubtedly be one of these ports. If such a trend materializes there might be an increased economic incentive for the redevelopment of the as yet unexhausted iron ore deposits of Virginia.

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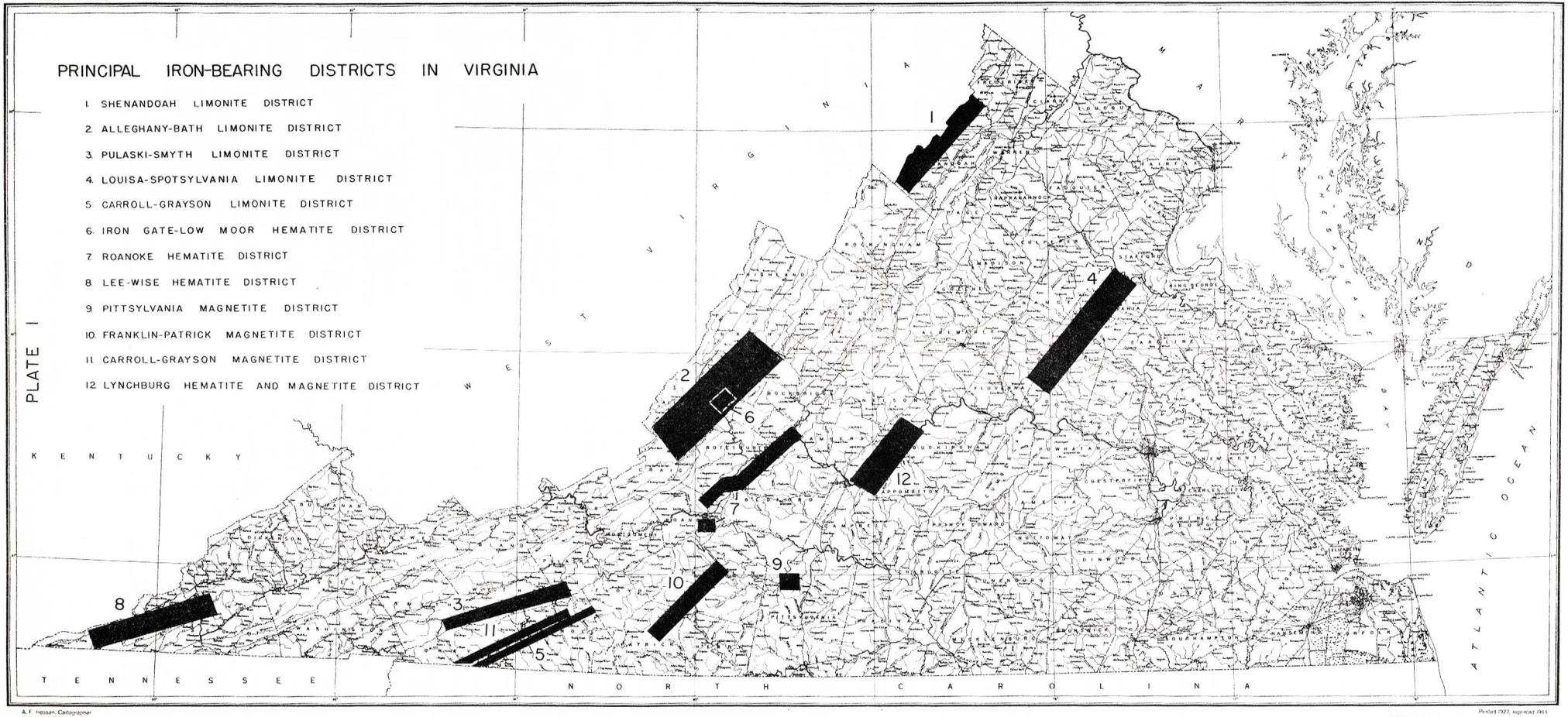
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

VIRGINIA

PRINCIPAL IRON-BEARING DISTRICTS IN VIRGINIA

1. SHENANDOAH LIMONITE DISTRICT
2. ALLEGHANY-BATH LIMONITE DISTRICT
3. PULASKI-SMYTH LIMONITE DISTRICT
4. LOUISA-SPOTSYLVANIA LIMONITE DISTRICT
5. CARROLL-GRAYSON LIMONITE DISTRICT
6. IRON GATE-LOW MOOR HEMATITE DISTRICT
7. ROANOKE HEMATITE DISTRICT
8. LEE-WISE HEMATITE DISTRICT
9. PITTSYLVANIA MAGNETITE DISTRICT
10. FRANKLIN-PATRICK MAGNETITE DISTRICT
11. CARROLL-GRAYSON MAGNETITE DISTRICT
12. LYNCHBURG HEMATITE AND MAGNETITE DISTRICT

PLATE I

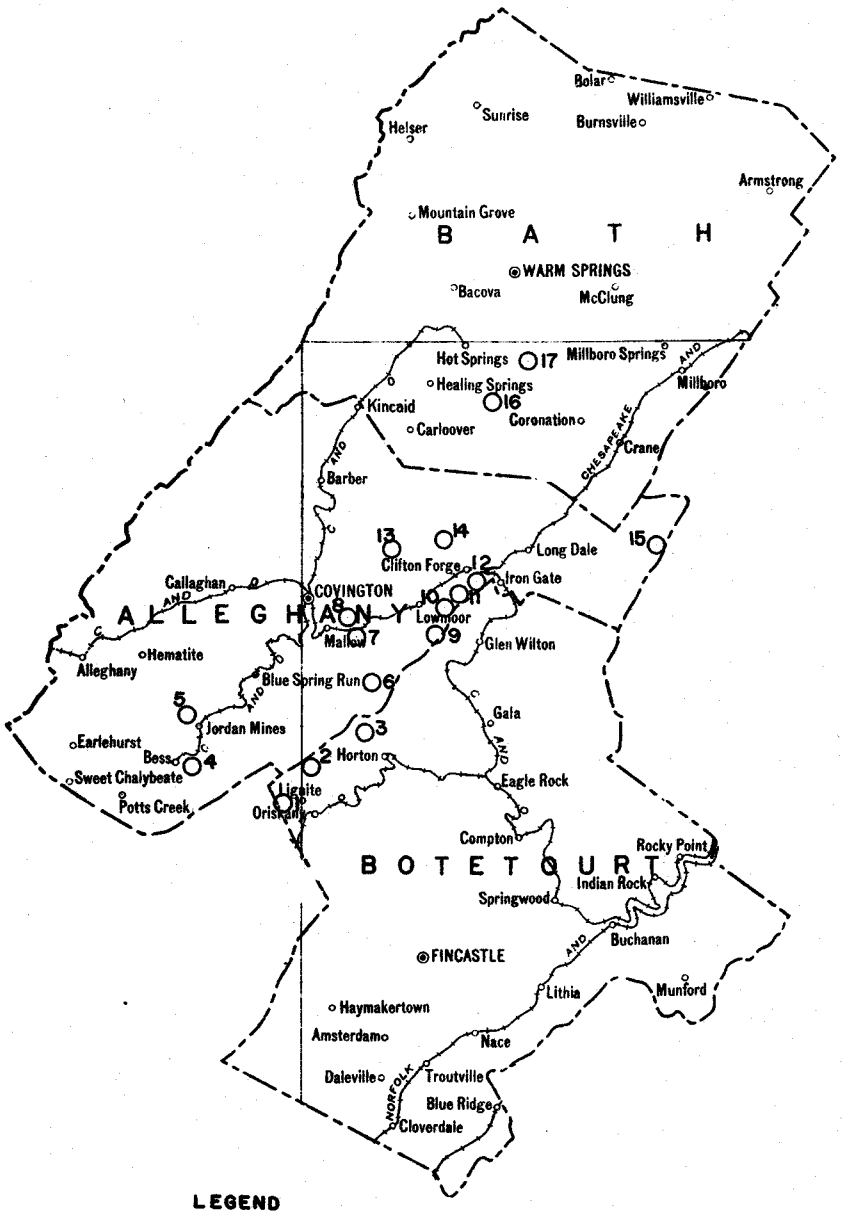


A. F. Hassan, Cartographer
Compiled in 1914
Revised in 1929

Printed 1927, reprinted 1931
Lambert conformal conic projection. North American datum

PLATE 2

ALLEGHANY-BATH LIMONITE DISTRICT



LEGEND

○ MINES, PROSPECTS

1. LIGNITE	10. GLEN WILTON
2. TREDEGAR	11. COLLIE NO. 1 & 2
3. ROARING RUN	12. CHARTER OAK
4. GIVEN	13. IRON MOUNTAIN
5. JORDAN	14. MOORE AND HAYNES
6. RICHPATCH	15. LONGDALE
7. LOWMOOR	16. DOUTHAT SURVEY
8. DOLLY ANN	17. DOUTHAT SURVEY
9. CIRCLE	

PLATE 3

SHENANDOAH LIMONITE DISTRICT

LEGEND

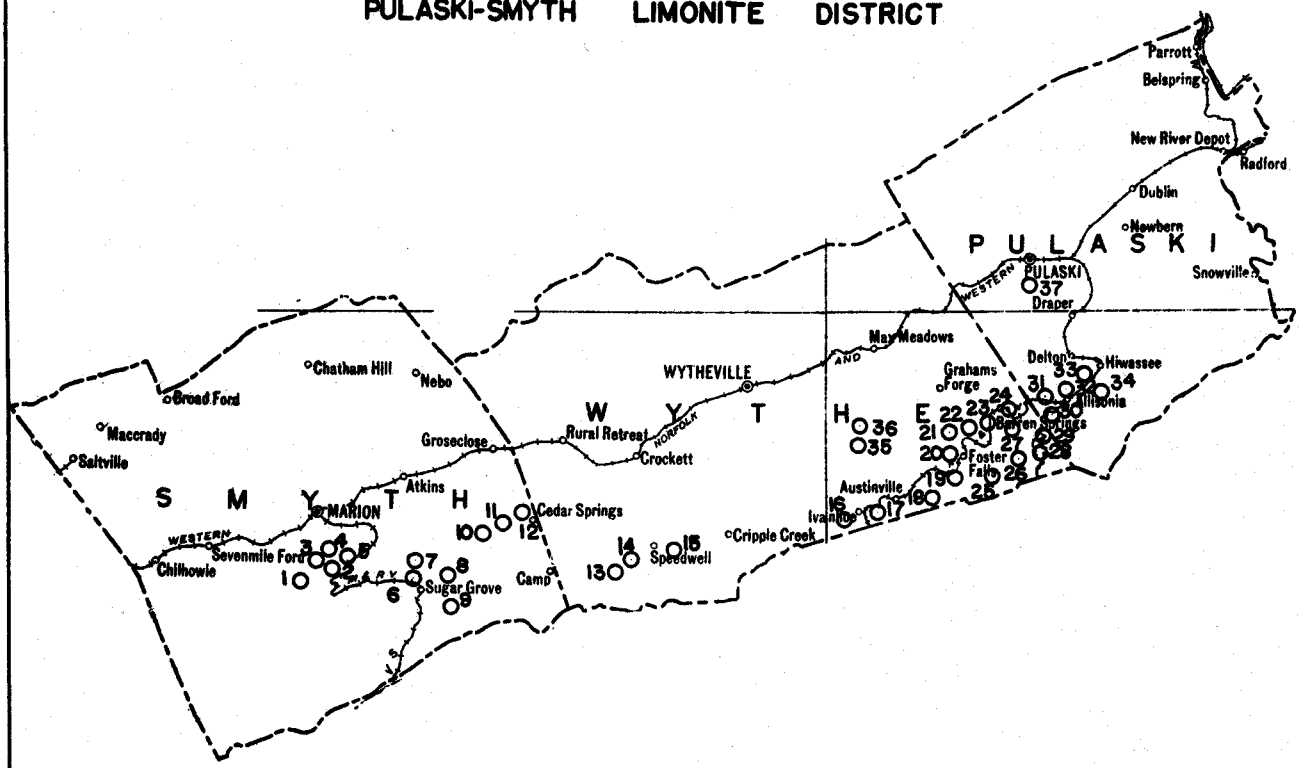
○ MINES

1. LIBERTY FURNACE MINES

2. VAN BUREN FURNACE MINES

PLATE 4

PULASKI-SMYTH LIMONITE DISTRICT



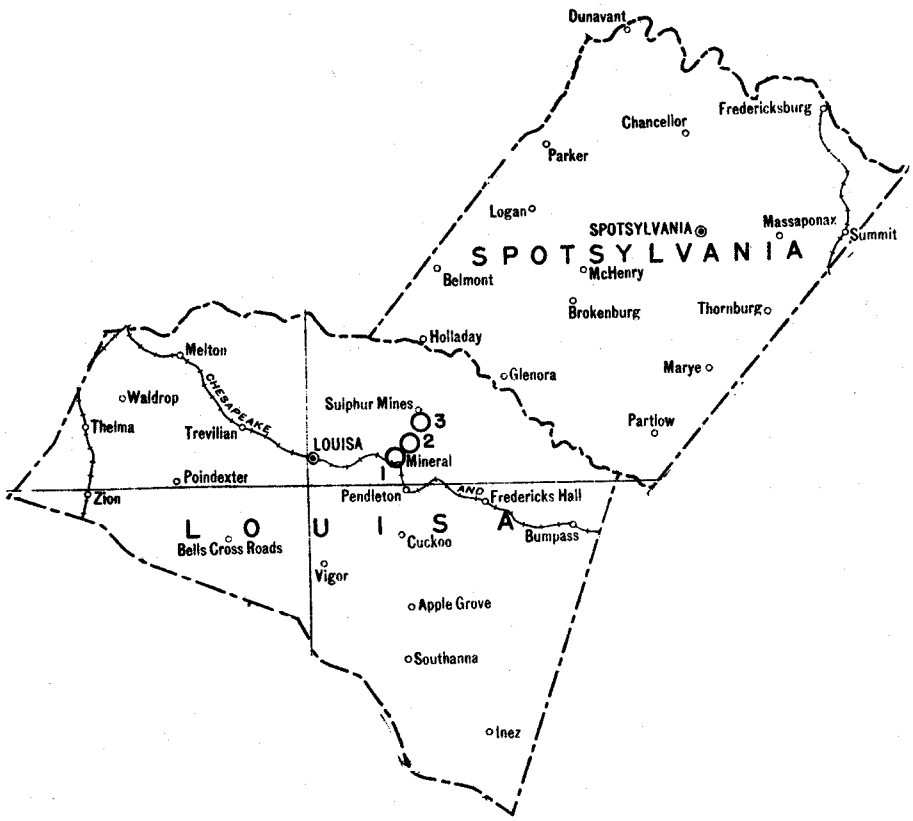
LEGEND

○ MINES

1. CURRIN VALLEY MINE NO. 4
2. CURRIN VALLEY MINE NO. 3
3. CURRIN VALLEY MINE NO. 5
4. CURRIN VALLEY MINE NO. 2
5. CURRIN VALLEY MINE NO. 1
6. BISHOP MINE
7. WRIGHT BANK MINE
8. PORTER BANK MINE
9. UMBARGER MINE
10. 11. 12. → WHITE ROCK MINES
13. ANDIS MINE
14. PERCIVAL MINE
15. GANAWAY MINE
16. IVANHOE MINE
17. SIMMERMAN MINES
18. INDIAN CAMP MINES
19. POPLAR CAMP MINE
20. HEMATITE MINE
21. WALTON MINE
22. CEDAR RUN MINE
23. CARTER BANK MINE
24. BARREN SPRINGS MINE
25. TIPTON MINE
26. CRAWFORD MINE
27. BERTHA MINE
28. PATTERSON MINE
29. HURST MINE
30. FARRIS MINE
31. RICH HILL. MINE
32. CLARK'S BANK MINE
33. RADFORD FURNANCE MINE
34. TASHER MINE
35. LOCUST HILL MINE
36. HENSON MINE
37. CLAYTON MINE

PLATE 5

LOUISA-SPOTSYLVANIA LIMONITE DISTRICT



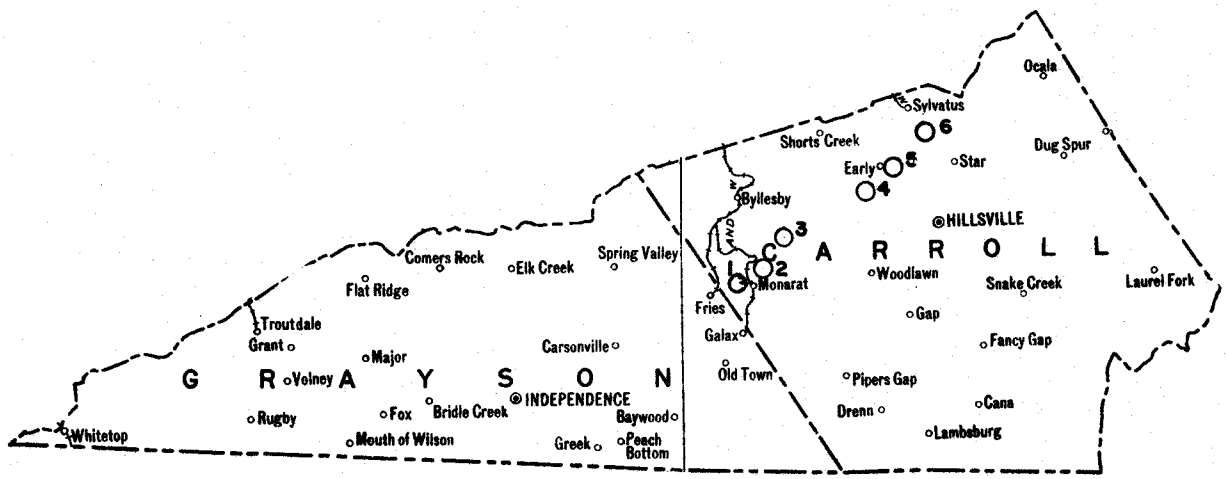
LEGEND

○ MINES

1. ARMINIUS MINE
2. SMITH MINE
3. SULPHUR MINES

PLATE 6

CARROLL-GRAYSON LIMONITE DISTRICT



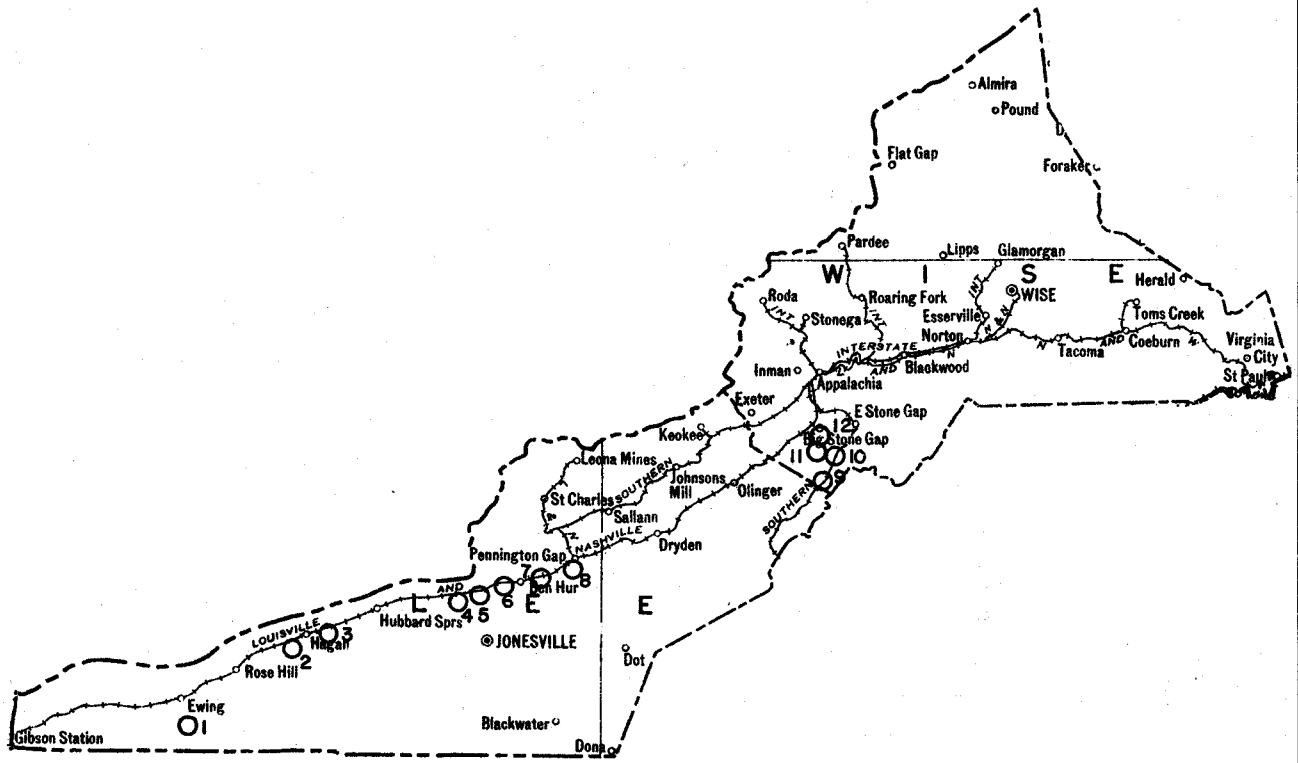
LEGEND

○ MINES

1. IRON RIDGE MINES
2. LINEBERRY MINE
3. COPPERAS HILL MINES
4. WILD CAT MINE
5. CRANBERRY MINE
6. BETTY BAKER MINES

PLATE 7

LEE-WISE HEMATITE DISTRICT



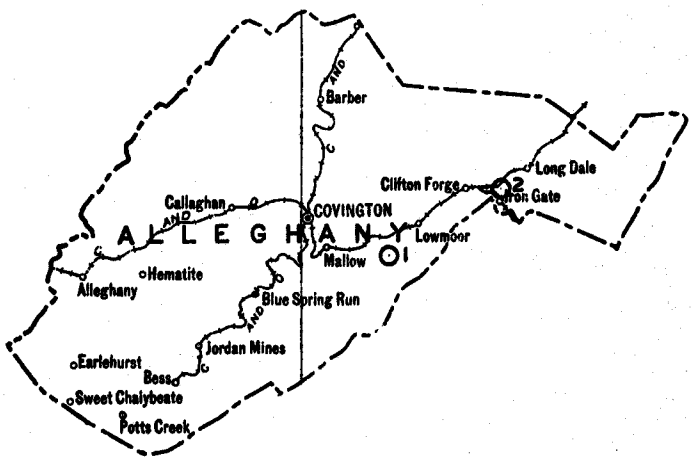
LEGEND

○ MINES

1. EWING MINE
2. BOONES PATH MINES
3. GRABILL MINE
4. NOES SIDING MINE
5. TRURO MINE
6. BEN HUR MINE
7. LAVINE MINE
8. PENNINGTON MINE
9. ORETON MINES
10. KEYSTONE MINE
11. IRONDALE MINES
12. YEARY OR BUNN MINES

PLATE 8

IRON GATE-LOW MOOR HEMATITE DISTRICT



LEGEND

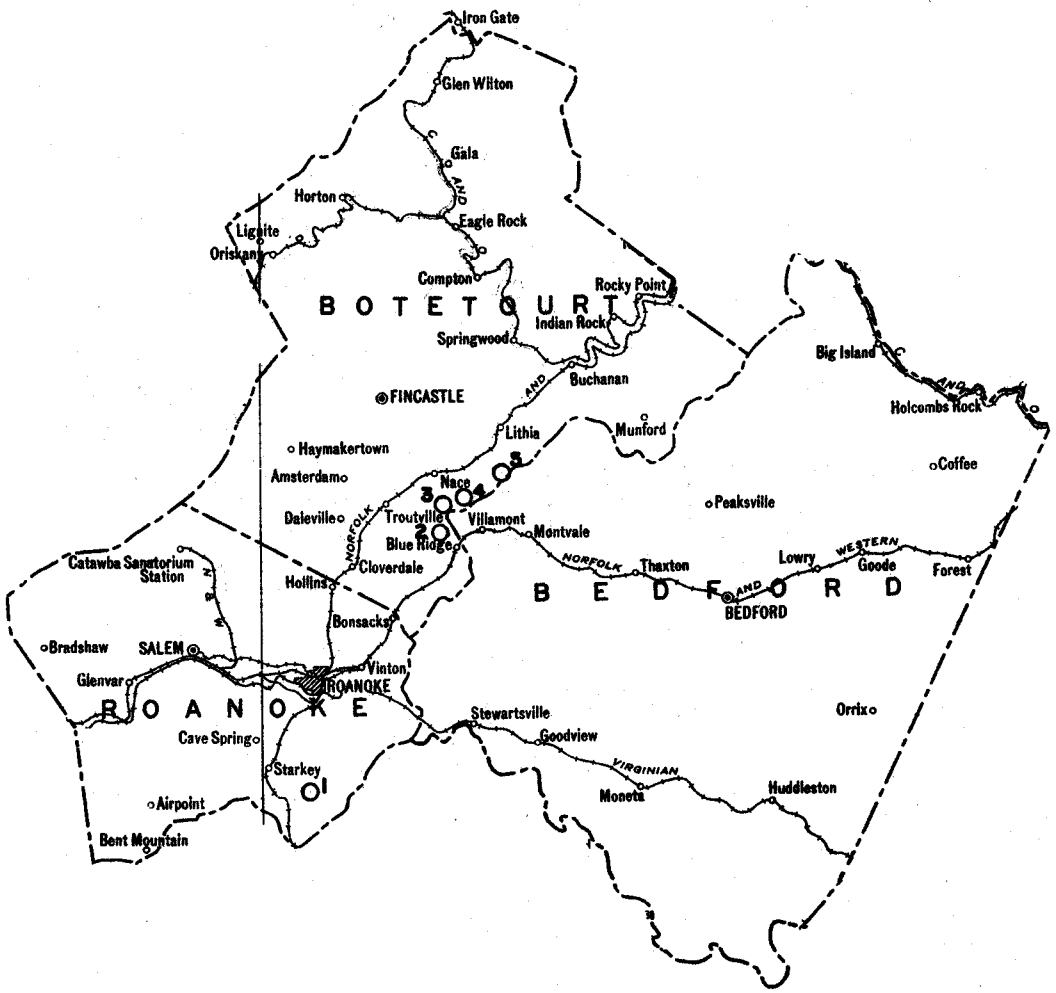
○ MINES

1. HORSE MOUNTAIN MINE

2. IRON GATE MINE

PLATE 9

ROANOKE HEMATITE DISTRICT



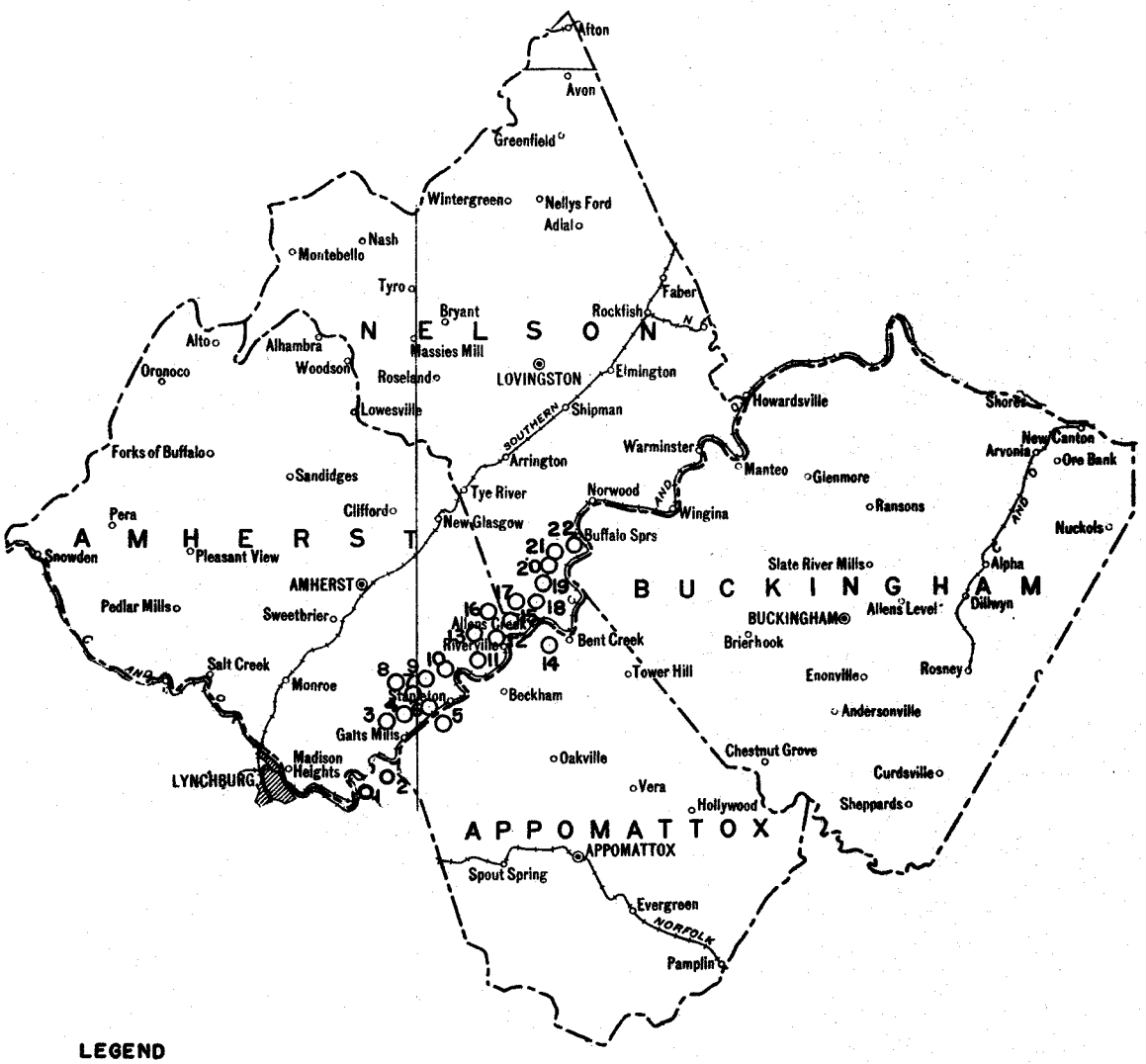
LEGEND

○ MINES

1. GRIFFIN SPECULAR MINE
2. CUNDIFF AND DEWEY MINES
3. GRUBB SPECULAR MINE
4. EDITH MINE
5. LEMON MINE

PLATE 10

LYNCHBURG HEMATITE AND MAGNETITE DISTRICT



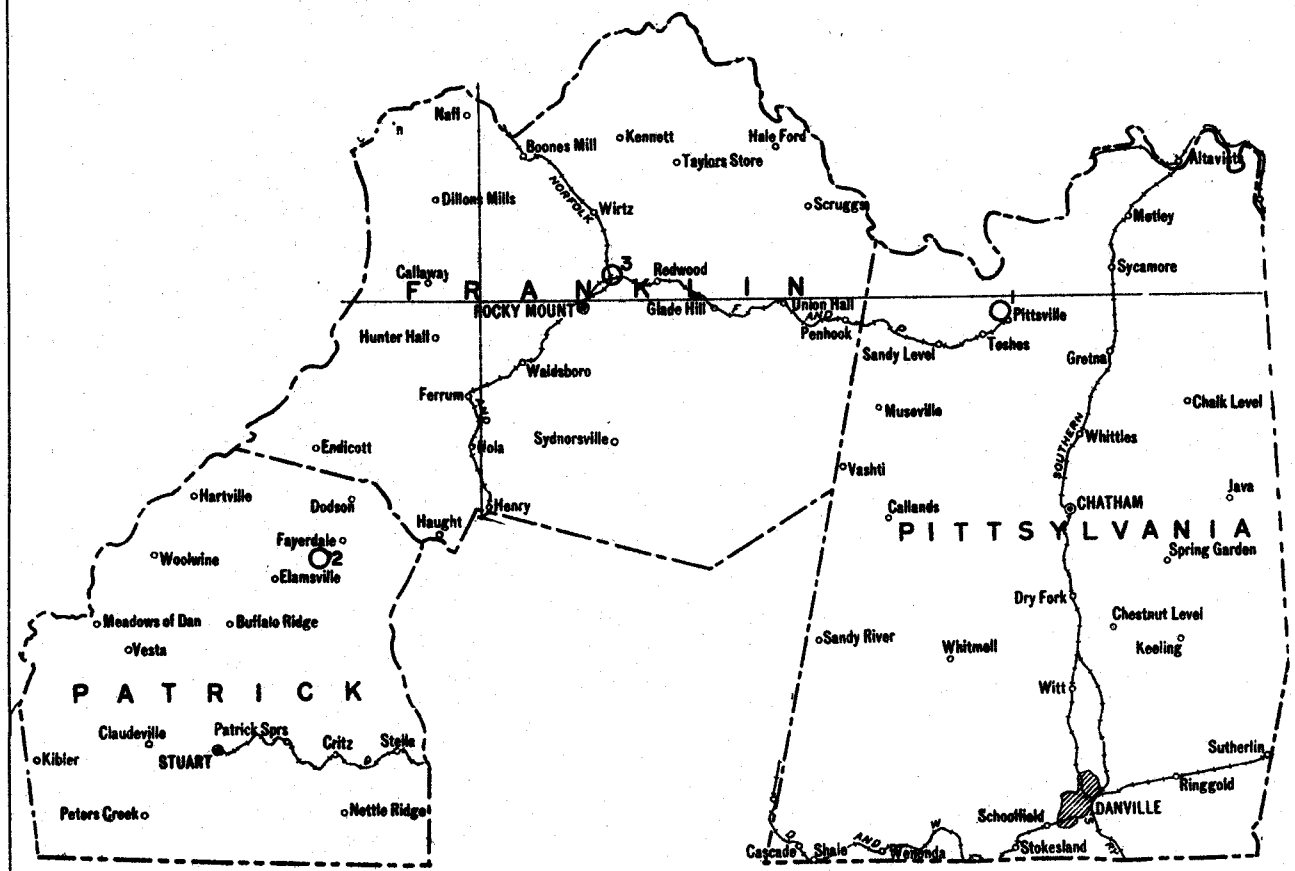
LEGEND

○ MINES AND PROSPECTS

1. IRON MINES
2. PROSPECT
3. LONE PINE MINE
4. ROUND TOP SHAFT
5. FERGUSON AND ISBELL PROPERTIES
6. BEULAH TUNNEL
7. MATTHEWS TUNNEL
8. MAUD MINES
9. ICE CLIFF TUNNEL
10. OLD SHAFT
11. HART TUNNEL
12. CANAL TUNNEL
13. AMES TUNNEL
14. KIRBY SMITH PROSPECT
15. TUNNELS, OPEN CUTS, AND SHAFTS
16. GARDENFIELD TUNNEL
17. KIMBALL TUNNEL
18. 19. 20. GREENWAY MINES AND CHURCH TUNNEL
21. LEWIS TUNNEL AND PRICE SHAFT
22. GAY PROSPECT

PLATE 11

FRANKLIN-PATRICK AND PITTSYLVANIA MAGNETITE DISTRICTS



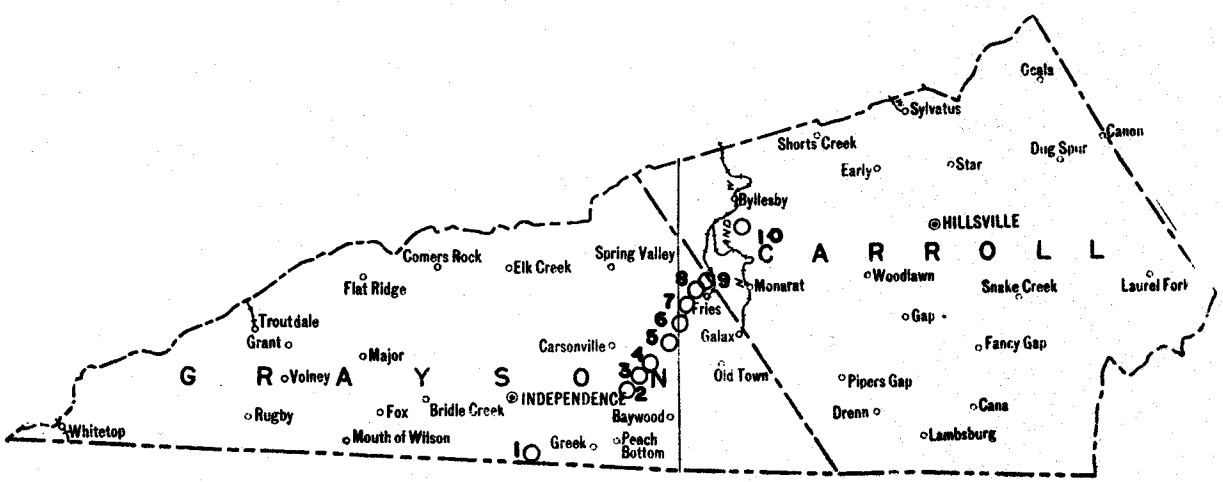
LEGEND

○ MINES

1. PITTSVILLE MINE
2. HAIRSTON MINE
3. ROCKY MOUNT MINE

PLATE 12

CARROLL-GRAYSON MAGNETITE DISTRICT



LEGEND

○ MINES, PROSPECTS

1. REEVES PROSPECT
2. FOREST COX PROSPECT
3. CLAUDE EDWARDS PROSPECT
4. COY DIAMOND PROSPECT
5. JOHN DICKERSON PROSPECT
6. JAMES TAYLOR PROSPECT
7. FRED WHITTAKER PROSPECT
8. 9. WASHINGTON MILLS
10. JERRY JENNINGS PROSPECT