Mineral Resources of the Rich Hole Roadless Area, Alleghany and Rockbridge Counties, Virginia

U.S. GEOLOGICAL SURVEY BULLETIN 1667

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By FRANK G. LESURE

An evaluation of the mineral potential of the Rich Hole Roadless Area

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DEPARTMENT OF THE INTERIOR
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STUDIES RELATED TO WILDERNESS

Under the provisions of the Wilderness Act (Public Law 88–577, September 3, 1964) and related acts, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System and have been studied. The act provided that areas under consideration for incorporation into the Wilderness System should be studied for suitability. The mineral surveys constitute one aspect of the suitability studies. The act directs that results of each survey are to be made available to the public and are to be submitted to the President and the Congress. This report discusses the results of a mineral survey of the Rich Hole Roadless Area (08–041), Virginia. The area, which is in the George Washington National Forest in Alleghany and Rockbridge Counties, was classified as a proposed wilderness during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979, and designated a wilderness study area by the Virginia Wilderness Act of 1984 (Public Law 98-586) October 30, 1984.

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By Frank G. Lesure

SUMMARY

Abstract

Mineral-resource surveys made in 1983 indicate that much of the Rich Hole Roadless Area (08–041) in the George Washington National Forest, Alleghany and Rockbridge Counties, Virginia, has inferred low-grade iron resources that occur in folded sedimentary rocks of Paleozoic age. The area has an estimated 170 million long tons of contained iron in hematitic sandstone and 1 million long tons of contained iron in deposits of sandy and cherty limonite. Similar deposits have been worked or prospected in a wide region outside the study area. Other mineral resources in the area include various rocks suitable for crushed stone, quartzite possibly suitable for high-silica uses, limestone suitable for agricultural uses, and shale suitable for structural clay products and can be obtained readily outside the study area. A potential for natural gas may exist but cannot be quantified from present knowledge.

Character and Setting

The Rich Hole Roadless Area (08–041) includes about 5,030 acres of the George Washington National Forest in the Valley and Ridge province in west-central Virginia. The area, which is east-northeast of Clifton Forge, spans the line between Alleghany and Rockbridge Counties and includes Brushy Mountain and the eastern flank of Mill Mountain (figs. 1, 2). The highest point is 3,570 feet above sea level on Brushy Mountain; the lowest point is 1,400 ft above sea level at the southern end along North Branch and Simpson Creek.

The Federal Government owns the surface and mineral rights of the Rich Hole Roadless Area. Oil and gas lease applications were filed for all of the study area as of February 1977 but have since been cancelled.

About 3,500–4,000 ft of folded marine sedimentary rocks of Paleozoic age are exposed in the Rich Hole Roadless Area (Lesure and Nicholson, 1985). The oldest of these rocks, interbedded shale, siltstone, and limestone of Late Ordovician age, are present along the central and northern parts of Brushy Mountain. The overlying beds of sandstone, quartzite, and hematitic sandstone of Late Ordovician to Middle Silurian age are resistant to erosion and form much of the bedrock in the roadless area. Upper Silurian to Middle Devonian formations overlying the resistant rocks are poorly exposed; they include interlayered limestone, sandstone, and shale units. A Lower Devonian limestone locally contains surficial deposits of limonite along the eastern and western parts of the area. The rocks were folded in late Paleozoic time into open upright to overturned folds. A zone of regional thrust faulting, part of the eastern overthrust belt, is buried at depths of several thousands of feet below the area.

Mineral surveys made in 1983 included geologic mapping (Lesure and Nicholson, 1985) and geochemical sampling (Lesure, 1986; Bailey and others, 1986).

Mineral Resources

The Rich Hole Roadless Area, which is in the northeastern part of the Clifton Forge iron district, contains two types of low-grade deposits–primary deposits of hematitic sandstone in the Rose Hill Formation and secondary deposits of limonite in the Licking Creek Limestone. In the primary deposits, the iron was precipitated from seawater and was concentrated as the sediments were deposited. The iron content is fairly consistent throughout any one sandstone bed and will persist to depth. In the secondary deposits, the iron minerals form discontinuous masses that cannot be projected for any extended distance. The deposits formed during weathering by acidic, iron-rich ground water that dissolved the limestone host rock and precipitated mixtures of iron oxides and hydroxides, loosely termed "limonite." The deposits are near-surface features and grade into unweathered limestone at depth. This type of deposit has been mined extensively at the Longdale and Victoria mines along the eastern edge of the roadless area and prospected in several areas in the western and northern parts of the area.

Inferred low-grade iron resources in the hematitic sandstone of the Rose Hill Formation of Middle Silurian age may total as much as 80 ft in beds 1–20 ft thick interlayered

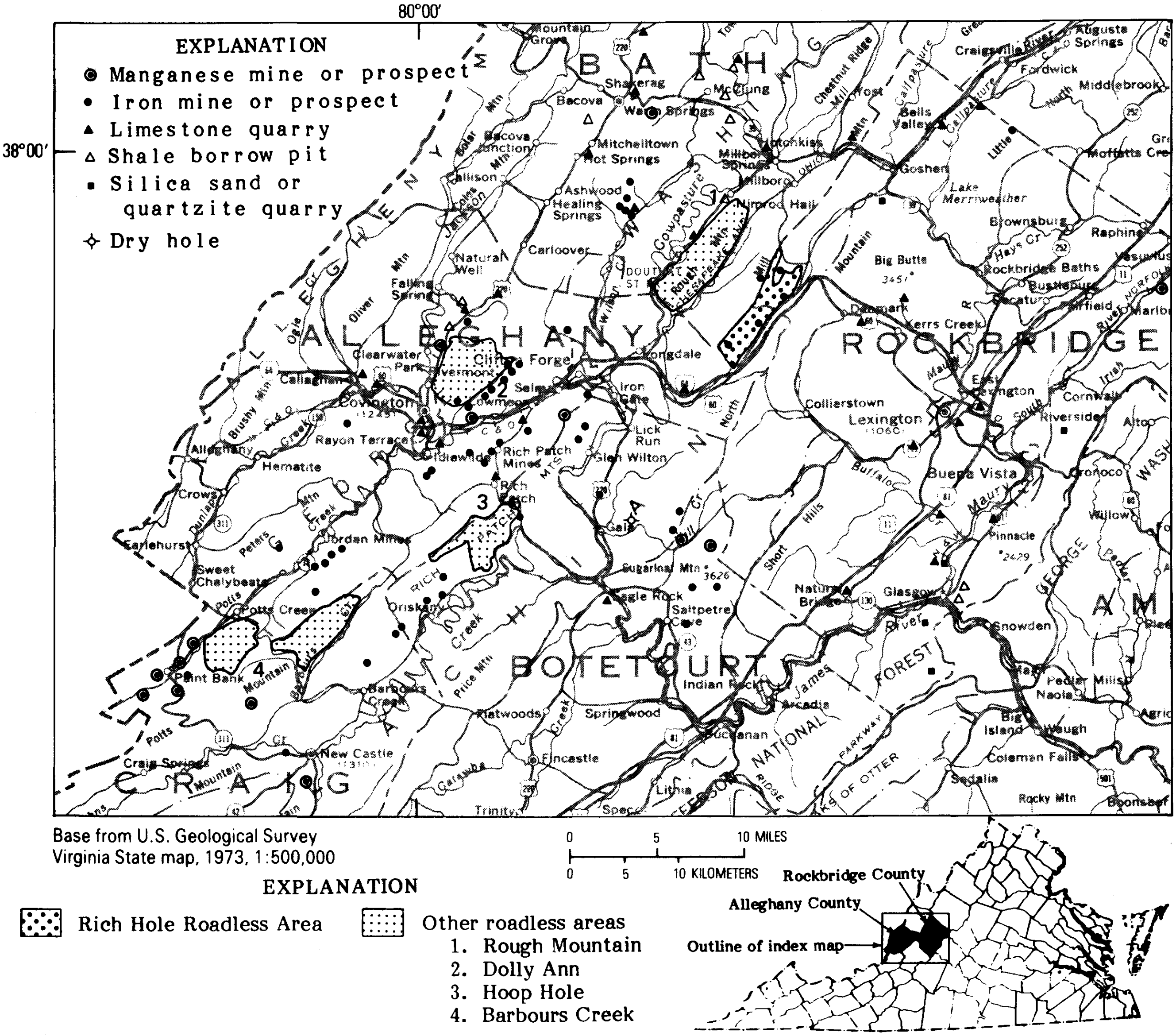
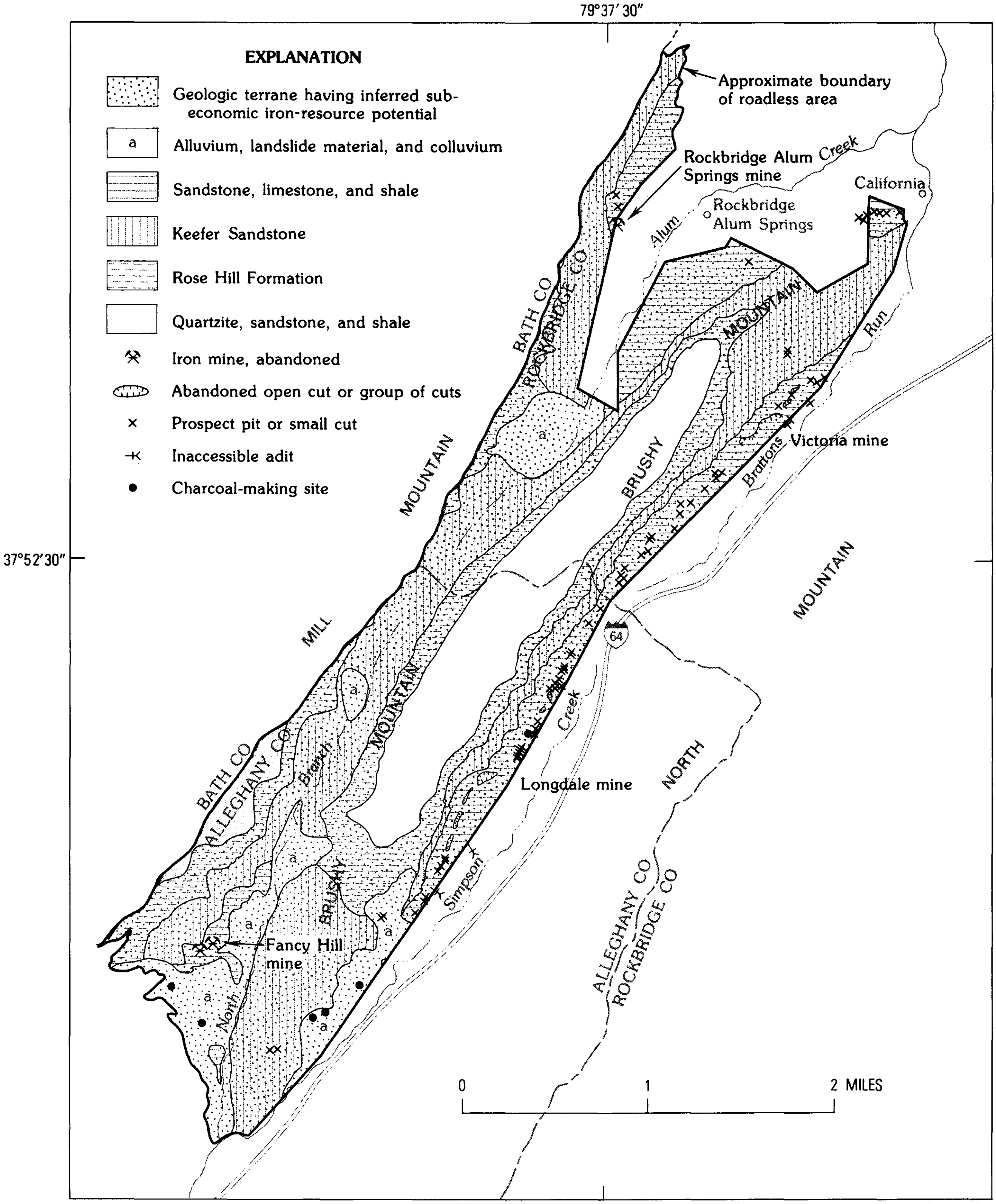


Figure 1. Location of Rich Hole and other roadless areas, and some of the mines, prospects, and quarries in Alleghany, Bath, Botetourt, Craig, and Rockbridge Counties.

in more than 200 ft of shale and nonhematitic sandstone. The hematitic beds locally contain 10–49 percent iron and average 14 percent iron in an area greater than 4,800 acres of the roadless area, either as exposed rock or covered by 5 to more than 200 ft of younger rock (fig. 2). This area of inferred low-grade iron resource could contain as much as 1.2 billion long tons of hematitic sandstone or 170 million long tons of contained iron. This iron-bearing formation, which extends from Maryland to Tennessee, is distributed widely in west-central Virginia and eastern West Virginia. It is particularly well developed in Giles County, Va., where it was prospected for iron in the 1950's and 1960's in the Mill Creek Wilderness Study Area.

Four abandoned limonite iron mines in the Rich Hole Roadless Area were worked in the 19th and early 20th centuries. Inferred iron resources at the Longdale and Victoria mines amount to 1.25 million long tons of sandy and cherty limonite having an average grade of 45 percent iron, or 560,000 long tons of contained iron, in an area of 60 acres lying between the larger workings of the two mines. The Fancy Hill mine in an area of 25 acres has inferred subeconomic iron resources of 100,000 long tons of limonite and hypothetical subeconomic iron resources of 450,000 long tons of limonite, or 250,000 long tons of contained iron. The Rockbridge Alum Springs mine is mostly outside the boundary of the roadless area, but an area adjacent to the mine of less than 5 acres within the roadless area has inferred subeconomic iron resources of 100,000 long tons of limonite, or 45,000 long tons of contained iron. Additional subeconomic iron resources of 300,000 long tons of



Base adapted from U.S. Geological Survey, 1:24,000
Collierstown, 1967 (photorevised 1978);
Longdale Furnace and Millboro, 1969
(photorevised 1978); and Nimrod Hall, 1969

Figure 2. Areas containing inferred subeconomic iron resources in the Rich Hole Roadless Area.

limonite (135,000 long tons of contained iron) are inferred for two areas totaling about 20 acres along the northwestern end of Brushy Mountain. The total limonite resources for the study area are 2.3 million long tons of limonite containing 1 million long tons of iron. These limonite deposits have not been worked for more than 50 years and have little economic potential because of sporadic distribution, relatively low grade, distance to potential users, and competition from other richer and more readily available sources.

The roadless area also contains sandstone and quartzite suitable for specialty sands, crushed rock, and building stone; limestone suitable for crushed rock and agricultural lime; and shales suitable for use in structural clay products and lightweight aggregate. These commodities, however, are abundant elsewhere in the region and can be obtained more readily outside the roadless area.

Although the Rich Hole Roadless Area contains hydrocarbon source beds and reservoir rocks, these rocks have been heated to temperatures beyond the range for oil stability and are favorable only for the occurrence of dry natural gas. Inasmuch as the better reservoir rocks are exposed at the surface, any accumulation of gas would have escaped long ago. Extensive fracture porosity associated with the zone of buried thrust faults could have formed potential reservoirs for gas accumulation, but estimation for this potential would require drilling.

The reconnaissance geochemical sampling in the roadless area did not indicate the presence of any other metallic mineral resources (Lesure, 1986). Minor amounts of zinc are present in the limonite deposits but are too low grade to be a resource. Locally, manganese is more abundant than iron in the limonite deposits, but the grade of the manganese-rich rock is too low and the size of the manganese deposits too small to constitute a resource.

INTRODUCTION

The Rich Hole Roadless Area comprises 5,030 acres of George Washington National Forest land in the Valley and Ridge physiographic province of west-central Virginia (fig. 1). The area includes Brushy Mountain and the eastern flank of Mill Mountain, north of Longdale Furnace in Alleghany County. The county line between Bath and Alleghany Counties and between Bath and Rockbridge Counties runs along the ridge line of Mill Mountain and forms the western boundary of the roadless area. The eastern boundary is the powerline that lies just to the west of old U.S. Highway 60. At the southern end, the area is bounded by the North Branch and White Rock Tower Trails. The northern boundary follows Virginia State Road 633 on Mill Mountain and the line between Forest Service and private properties west and south of Rockbridge Alum Springs.

The principal streams draining the southern part of the area are North Branch and Simpson Creek; Alum Creek and Brattons Run drain the northern part. The highest point in the area, about 3,570 ft above sea level, is along the ridge line of Brushy Mountain in the middle of the area; the lowest points are about 1,400 ft above sea level at the southern end along North Branch and Simpson Creek. In general, the slopes are steep and heavily wooded with second- or third-growth hardwoods and scattered pine and hemlock. The Rich Hole Trail starts at old Route 60 near the Alleghany-Rockbridge County line on the eastern edge of the area, climbs westward to the crest of Brushy Mountain, and joins the North Branch Trail to the southern end of the area. No other trails cross the area.

Previous Studies

W. B. Rogers, the first State Geologist of Virginia, studied the geology of the general area between 1835 and 1838. In his annual report for 1835, he described a section passing through Millboro Springs and mentioned the iron furnace at Longdale and the iron deposits on Brushy Mountain (Rogers, 1836, p. 102–105). Later, he assigned numbers to the different rock units (Rogers, 1838, p. 21–23), and his units III through VIII are exposed in the study area. Hotchkiss (1881a) briefly described the geology of the northern one-half of the study area in an article about the Victoria iron mine and furnace. N. H. Darton (1894, 1899) mapped the geology of the Staunton and the Monterey 30-minute quadrangles, which are north of the area. Numerous geologists who studied the so-called Oriskany iron ores while the deposits were being mined include Benton (1886), Lyman (1886), Pechin (1896), Chance (1900), Eckel (1906), Holden (1907, 1936), Harder (1909), and Weld (1915). The related manganese deposits were studied by Stose and Miser (1922). Mining and milling at the Longdale mine were described by Johnson (1892, 1895). The area was included by Butts (1933, 1940) in his general studies of the Appalachian Valley in Virginia. More recent work includes wartime studies of the Oriskany iron ores by the U.S. Bureau of Mines (Morrison and Grosh, 1950), a summary of iron resources in Virginia by Gooch (1954), and a study of the geology and ore deposits of the Clifton Forge iron district by Lesure (1957). Kozak (1965) mapped the Millboro 15-minute quadrangle, which includes the study area, and Bick (1960, 1962) mapped the Lexington and Williamsville 15-minute quadrangles, which are immediately to the east and north of the area.

Present Work

F. G. Lesure, assisted by S. W. Nicholson, S. M. Heinrich, and K. L. Cinsavich, mapped and sampled the area for the U.S. Geological Survey (USGS) in October 1983. Lesure, Nicholson, and Heinrich field checked the area in April 1984, assisted for 1 day by J. H. DeYoung, Jr., and D. M. Sutphin. Altogether 29 stream-sediment and 108 rock samples were collected and analyzed in the USGS laboratories, Denver, Colo. (Bailey and others, 1986). B. D. Martin (USGS) made X-ray diffraction identifications of iron and manganese minerals.

Surface- and Mineral-Rights Ownership

The Federal Government owns all surface and mineral rights in the Rich Hole Roadless Area. Oil and gas lease applications were filed for all of the study area as of February 1977 but have since been cancelled.

Acknowledgments

Palmer Sweet of the Virginia Division of Mineral Resources provided mine and prospect data and other reference material for this area in Virginia. Julett Denton, U.S. Forest Service, George Washington National Forest, and Janet Hale, Bureau of Land Management, kindly provided information regarding leasing and surface and mineral ownership.

GEOLOGY

The rocks exposed in the Rich Hole Roadless Area are chiefly marine clastic sedimentary rocks of Ordovician to Devonian age, which have an aggregate thickness of about 3,500–4,000 ft (fig. 3; table 1) (Lesure and Nicholson, 1985). The oldest formation present in outcrop is the Martinsburg Shale of Middle and Late Ordovician age, which is exposed along the eastern flank of Brushy Mountain in the central part of the study area and along the western flank of Brushy Mountain in the northern part (plate 1*A*). An overlying sequence of resistant sandstone and quartzite beds interlayered with shale, ranging in age from Late Ordovician to Middle Silurian, includes the Juniata Formation, Tuscarora Quartzite, Rose Hill Formation, and Keefer Sandstone, which forms the bedrock in most of the study area. The Upper Silurian and Lower Devonian formations overlying these resistant units are poorly exposed along the lower eastern slopes of Brushy Mountain and in two separate areas on the eastern slopes of Mill Mountain. The Middle Devonian Romney Shale is exposed along the eastern edge of the area and in the lower parts of the valleys of North Branch and Alum Creek.

The sedimentary rocks were deformed during late Paleozoic time into two upright to overturned anticlines. The older formations are exposed in the center of the Brushy Mountain anticline, and the younger units are present in the center of the syncline between the anticlines.

Parts of the area are covered by a series of landslide masses and by colluvial material consisting of boulders and cobbles of red and white sandstone from the Lower and Middle Silurian formations. This debris conceals the bedrock mostly where the Upper Silurian and Lower Devonian formations would otherwise be exposed (Lesure and Nicholson, 1985).

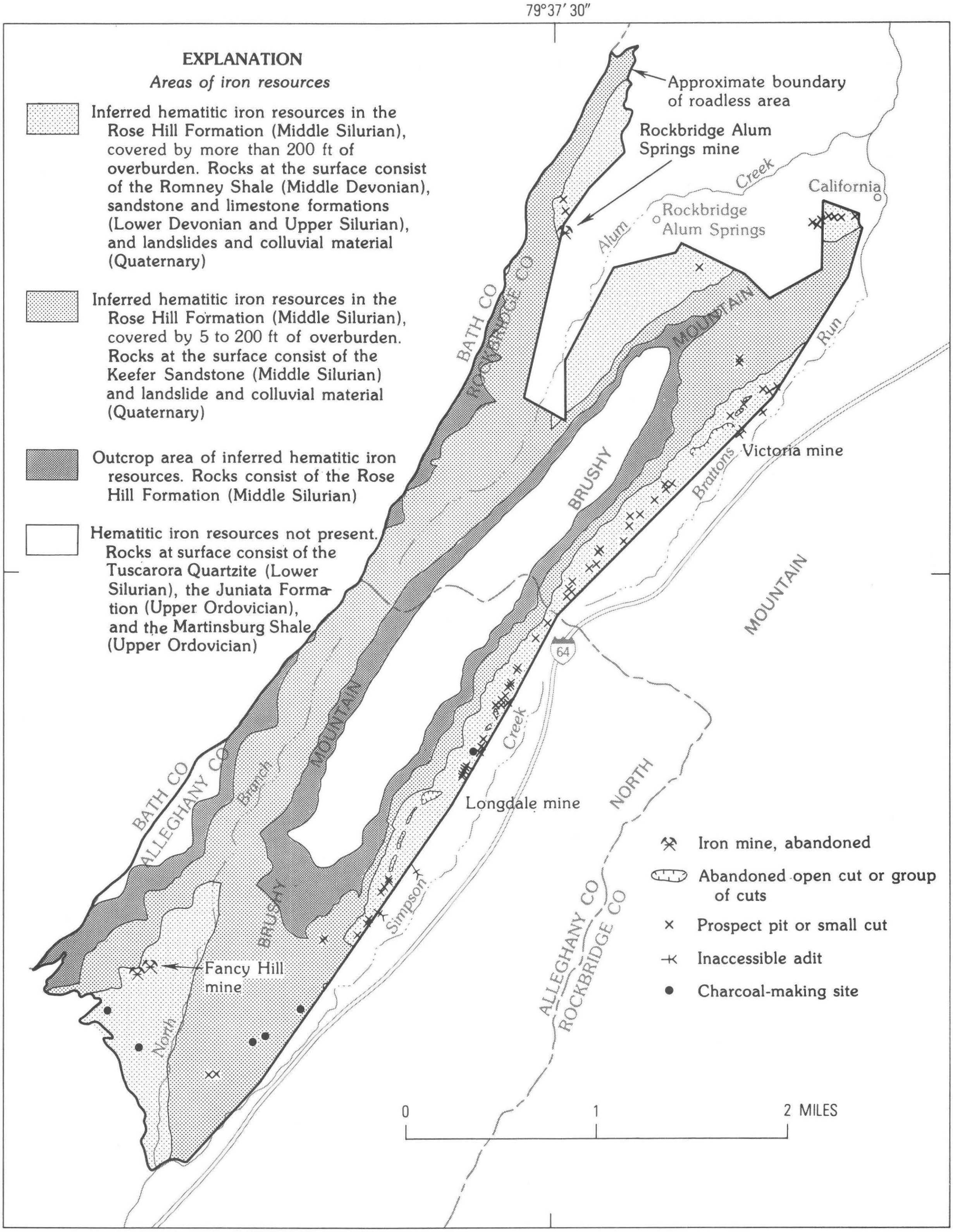
MINING ACTIVITY

Although only iron ore has been mined in the Rich Hole Roadless Area, manganese ore was mined or prospected nearby (fig. 1). Limestone, sandstone, and shale have been mined for crushed rock and fill in several small open cuts in nearby areas.

Iron Mines

The Rich Hole Roadless Area is in the northeastern part of the Clifton Forge iron district, a region of many abandoned iron mines. Iron production in the district began before 1800 (Bruce, 1931, p. 454), peaked during the period 1890–1920 when most mines in the district were in operation, and ceased by 1925 when all mining operations stopped. Production records are incomplete, but the district as a whole has been credited with a production of 13 million long tons of iron ore (Morrison and Grosh, 1950, p. 3). Total production for 11 mines in the central part of the district was more than 6 million long tons of iron ore (Lesure, 1957, p. 81–82).

Mining in the Rich Hole area began in 1827 when the Lucy Salina charcoal furnace was built on Simpson Creek west of what is now called Longdale Furnace; this was followed by the Australia charcoal furnace built in 1854 at Longdale Furnace (Lesley, 1859, p. 71). Iron ore for these furnaces came from the Longdale mine, about 4 miles northeast of Longdale Furnace. The Mount Hope (1849) and California charcoal furnaces were built along Brattons Run in Rockbridge County near the northeastern end of the study area (Lesley, 1859, p. 70–71). They utilized iron ore from what is now called the Victoria mine and possibly ore from small pits at the northern end of Brushy Mountain. Two other early charcoal furnaces near Goshen, 8 mi northeast of the study area, were the Panther Gap (abandoned in 1837) on Mill Creek and the Bath (built 1824–25) on Goshen Run (Lesley, 1859, p. 71). They probably used ore from nearby deposits. The Lucy Salina, Australia, and California furnaces supplied iron to the Tredegar Company of Richmond, which made ordnance for the Confederacy during the Civil War (Bruce, 1931, p. 455–457). After the war, more modern blast furnaces using coke were built—the Lucy Salina No. 2 at Longdale (Hotchkiss, 1881b, p. 29) and the Victoria at Goshen (Hotchkiss, 1883, p. 119). The Victoria furnace, one of the largest American blast furnaces when built, produced 25,450 tons of iron during its first year of operation from ore mined at the Victoria mine (Hotchkiss, 1884, p. 53).



Base adapted from U.S. Geological Survey, 1:24,000
Collierstown, 1967 (photorevised 1978);
Longdale Furnace and Millboro, 1969
(photorevised 1978); and Nimrod Hall, 1969

Figure 3. Areas containing inferred subeconomic hematitic iron resources in the Rich Hole Roadless Area.

Table 1.—Summary of the geologic formations in the Rich Hole Roadless Area
[Modified from Lesure, 1957, p. 20]

Age			Name	Thickness, in feet	Lithologic character
Cenozoic	Quaternary	Holocene	Alluvium	0–30	Clay, sand, and gravel on floodplains and terraces.
Cenozoic	Quaternary	Holocene	Landslide and colluvium	0–50	Angular sandstone blocks forming talus fields on higher ridges.
Paleozoic	Devonian	Middle	Romney Shale: Upper part (correlates with Millboro Shale)	600–1,000	Black fissile shale; calcareous concretions in upper part grade laterally into dark-gray calcareous beds; includes some olive-gray shale.
Paleozoic	Devonian	Early	Lower part (correlates with Needmore Shale)	100	Medium- to light- olive-gray shale; poorly exposed.
Paleozoic	Devonian	Early	Ridgeley Sandstone	10–20	Medium- to coarse-grained calcareous sandstone; where cemented with iron oxides forms hanging wall of many of the Oriskany iron deposits.
Paleozoic	Devonian	Early	Licking Creek Limestone	100–130	Upper part arenaceous limestone; where replaced by iron oxides forms Oriskany iron-ore zone. Lower part cherty limestone; forms footwall of the Oriskany iron deposits.
Paleozoic	Devonian	Early	Healing Springs Sandstone	15–25	Medium-grained calcareous sandstone; not exposed.
Paleozoic	Devonian	Early	New Creek Limestone	20	Coarse-grained crinoidal limestone; not exposed.
Paleozoic	Devonian	Early	Keyser Limestone	120	Upper part nodular limestone; lower part calcareous sandstone, poorly exposed.
Paleozoic	Silurian	Late	Tonoloway Limestone	130(?)	Thin-bedded argillaceous limestone; poorly exposed.
Paleozoic	Silurian	Late	Williamsport Sandstone(?) and (or) Wills Creek Shale(?)	50(?)	Thin-bedded calcareous sandstone and shale; poorly exposed.
Paleozoic	Silurian	Middle	Keefer Sandstone	200	Resistant quartzitic sandstone; a few thin beds of dark shale.
Paleozoic	Silurian	Middle	Rose Hill Formation	300–330	Dark-red hematitic sandstone and greenish-gray shale; some medium-gray sandstone and moderate-red shale.
Paleozoic	Silurian	Early	Tuscarora Quartzite	50–70	Resistant, quartzitic sandstone; thin lenses of pebble conglomerate.
Paleozoic	Ordovician	Late	Juniata Formation	300	Mostly yellowish-brown to olive-gray sandstone; some grayish-red sandstone and shale.
Paleozoic	Ordovician	Late	Martinsburg Shale	1,500	Medium- to light-gray calcareous shale and thin-bedded argillaceous limestone; some interbedded coarse crystalline limestone.

The principal mining in the Rich Hole Roadless Area was along the lower eastern slopes of Brushy Mountain where the abandoned workings extend for 4.5 mi just within the southeastern boundary of the roadless area. The southwestern part of these workings in Alleghany County form the Longdale iron mine (plate *1B*); the workings to the northeast in Rockbridge County are the Victoria mine (plate *1C*). The Longdale mine was worked in a series of open cuts for a strike length of 2 mi and a depth of 100 ft or more. Underground workings below the larger cuts in the southern one-half of the mine area reached to depths of 500–700 ft down dip (Holden, 1907, p. 439; 1936, p. 31; Johnson, 1892, p. 97–98, 106–107; Pechin, 1891, p. 1020) and, judging by the presence today of caving ground, extended at least 4,000–5,000 ft along strike. Access to these underground workings was by a series of long adits, which are now caved and inaccessible. Holden (1907, p. 439) reported a production for the Longdale mine of 1.5 million long tons of ore from 1869 to 1907. Mining was continued by the Longdale Iron Company until 1911, but production from this work is not recorded. The Low Moor Iron Company (1923) leased the mine from 1914 to 1919 and produced 101,432 tons of ore according to unpublished company records.

The workings of the Victoria mine are similar to those of the Longdale. Small cuts, prospect pits, and trenches are present along strike for 2 mi, but the large cuts and caving undergound workings are restricted to an area about 3,000 ft long near the northeastern end of the mine. No production records have been found for the Victoria mine. The intensively worked area of the Victoria mine, however, is about two-thirds as large as that of the intensively worked part of the Longdale mine, and production of 1 million tons of ore would appear to be a reasonable assumption.

The Fancy Hill mine (Holden, 1907, p. 440) consists of an open cut 150 ft long, 100 ft wide, and 20 ft deep, several trenches 50–200 ft long on one spur of Mill Mountain, and another pit 50 ft long on another spur 500 ft to the southwest (plate *1D*). The small size of the workings suggests a production of only 10,000-20,000 tons of ore, which was sent to the Longdale furnaces.

The Rockbridge Alum Springs iron mine (Holden, 1907, p. 436) consists of one large cut about 150 ft long, 100 ft wide, and 20–30 ft deep and numerous trenches and pits 10-50 ft long that are scattered for 1,500 ft along the hill slope across several spurs of Mill Mountain (plate *1E*). The small size of the workings suggests a production of only 10,000–20,000 tons of ore, presumably sent to the Victoria furnace at Goshen. The larger workings are just outside the boundary of the study area.

The northeastern end of Brushy Mountain contains numerous prospect trenches and pits over a distance of 1,500 ft (fig. 3). The trenches are 50–100 ft long, 10–20 ft wide, and 5–10 ft deep. Most of them are just inside the boundary of the study area. Production, if any, was probably small. Some of these pits might have supplied ore for the California and Mount Hope charcoal furnaces, which were on Brattons Run within one-half mile to the north of the pits.

In the study area, other prospect pits, widely scattered on the middle or upper southeastern slopes of Brushy Mountain, are in the Keefer Sandstone or Rose Hill Formation, where minor faulting or fracturing has produced open spaces now partly filled with secondary iron and manganese oxides. None of these pits suggest significant mineralization.

Manganese Mines

Only minor evidence of manganese mineralization was found in the study area. Nearby manganese localities in Alleghany, Bath, and Botetourt Counties are small, low-grade deposits (Stose and Miser, 1922, p. 101–112).

GEOCHEMICAL SURVEY

A reconnaissance geochemical survey was made of the Rich Hole Roadless Area based on analyses of stream-sediment and rock samples (Lesure, 1986; Bailey and others, 1986). Most of the small drainage basins in the study area and a few adjacent to it were sampled by collecting a few handfuls of the finest grained sediment available. The major rock types exposed in the area were sampled by taking several small chips from beds of one lithology and across a known thickness. All samples were scanned spectrographically for 31 elements and analyzed by atomic absorption for zinc (Bailey and others, 1986). The iron- and manganese-rich rocks also were analyzed by induction-coupled plasma methods for iron, manganese, phosphorus, barium, cobalt, lead, nickel, and zinc.

The analytical data for samples from the Rich Hole Roadless Area compare closely with analyses on similar samples collected in the Dolly Ann Roadless Area, Alleghany County (Lesure, 1982), and in the Mill Creek, Mountain Lake, and Peters Mountain Wilderness Study Areas, Craig and Giles Counties, Va., and Monroe County, W. Va. (Lesure and others, 1982). These four study areas, which are between 15 and 60 mi to the southwest, have the same rock formations exposed as in Rich Hole. The median concentrations of many elements for samples from each formation in Rich Hole are as similar to those from Dolly Ann, Mill Creek, Mountain Lake, and Peters Mountain as can be expected, considering that the data are semiquantitative and that the analyses were done by different analysts using different machines and techniques. The median values are also similar to the average for comparable rock types (Lesure, 1986). The analytical data indicate areas rich in iron and manganese; they do not indicate any other well-defined anomalous areas obviously related to other types of mineralized rock.

Iron is the only metallic mineral resource reported for the Rich Hole Roadless Area. Zinc is a trace constituent (0.005–1.0 percent) in the limonitic iron ores (Lesure, 1982, 1986), and sediment samples from many streams draining areas that include the iron deposits have higher-than-background zinc content. Barium (220–5,000 parts per million), cobalt (<20–3,300 ppm), lead (<20–1,600 ppm), manganese (0.005–16 percent), and nickel (47–4,000 ppm) also occur in anomalously high trace amounts in the limonite deposits in the Lower Devonian formations. Locally small deposits in which manganese is more abundant than iron are present in the Clifton Forge Sandstone Member of the Keyser Limestone stratigraphically below the iron deposits but topographically above them because of the geologic structure. Such deposits were found near the Fancy Hill (plate 1*D*) and Rockbridge Alum Springs (plate 1*E*) iron mines and others may exist. They contain sandstone partly cemented with such manganese minerals as lithiophorite and cryptomelane. The reconnaissance geochemical sampling in the area did not find evidence of any other indistinct or unexposed metallic mineral deposits that might be recognized by their geochemical halos.

ASSESSMENT OF MINERAL-RESOURCE POTENTIAL

Low-grade iron deposits, abundant rock for common building stone and crushed rock, limestone and quartzite for special uses, and limited amounts of shale suitable for common building brick are potential mineral resources in the Rich Hole Roadless Area. A possibility exists for the presence of natural gas, but no drilling has been done in the area to substantiate such potential.

Iron Deposits

The study area contains two types of iron deposits, hematite and limonite (table 2). Low-grade hematitic sandstone beds and lenses in the Rose Hill Formation extend throughout most of the study area (fig. 3). Limited areas of higher grade limonite deposits in the Licking Creek Limestone have been largely mined out in the Longdale and Victoria mines along the southeastern border of the study area. Similar deposits have been mined and prospected at the Fancy Hill and Rockbridge Alum Springs mines along the western border.

Hematite Deposits

Deposits of hematite, an iron oxide (Fe_2O_3) mineral, are distributed widely in sedimentary rocks of Silurian age from central New York to Alabama. They have been called Clinton iron ores or Clinton-type ores after typical exposures near Clinton, Oneida County, N.Y. These deposits were mined extensively near Birmingham, Ala., and, to a lesser extent, in Georgia, Tennessee, and New York. Small amounts also were mined in Pennsylvania, Maryland, Virginia, and West Virginia (Wright and others, 1968, p. 409). In Virginia, these deposits are in the Rose Hill Formation.

The hematite in the Clinton-type iron ores generally occurs in the following three forms: as flattened spheroids, called oolites; as replacements of fossil remains that preserve the shape of the original calcareous shells; and as cementing material coating and filling in around original sand grains, oolites, and fossils (Wright and others, 1968, p. 407). The principal ores are either oolitic or fossil, and some are combinations of the two types.

The unweathered ore is hard and calcareous, whereas the weathered ore is soft and less calcareous. Iron content of

Table 2. Summary of iron resources in the Rich Hole Roadless Area

[See sections on hematite and limonite resources for explanation of calculations and discussion. Outline of areas containing resources shown in figures 3 and 4. All tonnages rounded]

Type of deposit	Approximate area, in acres	Inferred subeconomic resources, in long tons		Hypothetical resources, in long tons	
		Rock in place	Contained iron	Rock in place	Contained iron
Hematitic sandstone in Rose Hill Formation:					
Outcrop	1,000	140,000,000	20,000,000	—	—
Covered, 5–200 ft	2,600	710,000,000	100,000,000	—	—
Covered, more than 200 ft	1,285	350,000,000	50,000,000	—	—
Total	4,885	1,200,000,000	170,000,000	—	—
Limonite deposits:					
Longdale and Victoria mines	60	1,250,000	560,000	—	—
Fancy Hill mine	5	100,000	45,000	—	—
Area NE and SW of Fancy Hill Mine	20	—	—	450,000	200,000
North Branch area	5	100,000	45,000	—	—
Rockbridge Alum Springs mine	5	100,000	45,000	—	—
Brushy Mountain area	20	300,000	135,000	—	—
Total	115	1,850,000	830,000	450,000	200,000

the hard ore ranges from 20 to 47 percent, and calcium carbonate content, from 10 to 50 percent. Iron content of the soft or leached ore ranges from 40 to 60 percent, and calcium carbonate is generally less than 1 percent (Whitlow, 1962). The ore-grade material commonly is enclosed in or grades into hematitic sandstone or shale. Hematitic sandstone associated with the fossil and oolitic ores of the Birmingham, Ala., district contains 15-30 percent iron and less than 10 percent calcium carbonate (Crane, 1926, p. 31).

The Clinton-type iron ores and associated hematitic sandstone are a primary type of sedimentary iron deposit. The iron was precipitated from seawater and was concentrated as the sediments were deposited. In the Birmingham area, the oolitic and fossil ores probably were deposited as lagoonal sediments and the hematitic sandstone as a barrier island (Sheldon, 1970, p. 110). In the Rich Hole Roadless Area, the Rose Hill Formation also probably was deposited in a shallow marine environment (Diecchio, 1973, p. 57–62). Amorphous iron oxides and hydroxides deposited with the sediments formed the mineral hematite during compaction and lithification of the rocks. The primary deposition of the iron as a component of the sediments is of significance because it suggests that the iron content of an ore bed or hematitic sandstone bed will be areally widespread throughout the bed and will persist down its dip.

Oolitic and fossil ore beds have been found in the Rose Hill Formation in Lee and Wise Counties, in the far southwestern part of Virginia, and near Iron Gate and Low Moor in Alleghany County (Gooch, 1954, p. 4; Lesure, 1957, p. 121); these ore beds have never been important economically. Thin beds of fossil ore 1–2 ft thick containing 40-57 percent iron have been mined on the southeastern side of Horse Mountain near Low Moor, 14 mi southwest of the Rich Hole area, and near Iron Gate, 7 mi to the southwest (Lyman, 1886, p. 808; Harder, 1909, p. 228–233).

No oolitic or fossil ore beds were found in the Rose Hill Formation in the Rich Hole Roadless Area, but hematitic sandstone similar to that associated with the ore beds in Alabama is common. The beds of hematitic sandstone range in iron content from less than 10 to as much as 49 percent but average only 14 percent (Lesure, 1986). The phosphorus content ranges from 0.05 to 0.43 percent. Where exposed at Iron Gate, the Rose Hill Formation is about two-thirds red hematitic sandstone interlayered with red and green shale (Lesure, 1957, p. 36), but, in the section exposed along the Rich Hole Trail (fig. 3), the formation is only one-quarter hematitic sandstone (Lesure, 1986). The formation is 300–320 ft thick, and the total thickness of hematitic sandstone is probably about 80 ft in beds 1–20 ft thick interlayered with shale and nonhematitic sandstone. The low grade of this material would not normally warrant economic consideration, but, because a large volume is present, a significant low-grade iron resource can be inferred. Recent studies suggest that economical methods of recovery of high-quality concentrates are possible from the low-grade hematitic sandstone (Hanna and Rampacek, 1982).

Hematite Resources

Inferred low-grade subeconomic iron resources in the Rose Hill Formation can be estimated from available density, grade, and volume data. The average specific gravity of 37 samples of hematitic sandstone representing 157 ft of rock from the Rich Hole Roadless Area is 2.8 (Lesure, 1986). The grade of the hematitic sandstone ranges widely from 10 to 49 percent iron, but a weighted average for all samples is about 14 percent iron (Lesure, 1986), which is less than the average of 18 percent for similar rock from the Dolly Ann Roadless Area, Alleghany County (Lesure and Jones, 1983), and less than the 18-22 percent iron in similar rocks from Giles County, Va. (Fish, 1967, p. 10; Lesure and others, 1982, p. 42). Using the geologic map of the Rich Hole Roadless Area (fig. 3), we can estimate by planimetric measurement that the Rose Hill is exposed in about 1,000 acres, is covered by 5–200 ft of younger rock in 2,600 acres, and is covered by more than 200 ft in 1,285 acres (fig. 3). Assuming an average thickness of 80 ft of hematitic sandstone for the 3,885 acres of covered Rose Hill and 40 ft (as one-half is eroded) for the 1,000 acres of exposed Rose Hill, and an average specific gravity of 2.8 (175 pounds per cubic foot), the total inferred subeconomic iron resource is about 1.2 billion long tons of hematitic sandstone:

Weight of rock in place (long tons) = Acres × 43,560 square feet per acre × thickness in feet × weight of rock per cubic foot ÷ 2,240 pounds per long ton.

At an average grade of 14 percent iron, this resource could contain as much as 170 million long tons of iron. Although this material is too low in average iron content to be considered economically important now, similar material was prospected seriously in Giles County, Va., in the 1950's and 1960's (Cooper, 1960; Fish, 1967; Lesure and others, 1982, p. 43–53).

Limonite Deposits

The only iron deposits mined within the study area are the secondary, or supergene, limonite deposits in the Lower Devonian Licking Creek Limestone. The ore mined was a sandy, cherty, and clayey limonite that formed as a replacement and cavity filling in the upper sandy limestone part of the Licking Creek. During weathering, ground water moving through black shale in the Romney Shale dissolved iron from disseminated iron sulfides and became acidic and iron rich (Holden, 1907, p. 408–410; Lesure, 1957, p. 102–103). This acidic ground water dissolved the calcium carbonate of the underlying rocks. As the ground water became less acidic, iron was precipitated as mixtures of iron oxides and iron hydroxides, commonly called limonite. The lower cherty part of the Licking Creek is generally less permeable during weathering and forms the footwall of the deposits. The calcareous cement of the overlying Ridgeley Sandstone also generally is replaced by iron minerals during weathering, and the resulting iron-cemented and brecciated sandstone forms the hanging wall of the deposits. In general, these limonite deposits are near-surface features that grade downward into unreplaced limestone within 100 ft or more of the surface. The largest deposits formed where the limestone beds dip 20–75 degrees; only a few deposits form in more steeply dipping or overturned beds, and thin sandy deposits form where the beds are flat or only gently dipping (Lesure, 1957, p. 94).

These ores have been called Oriskany iron ore for many years because of the correlation of the Licking Creek Limestone and Ridgeley Sandstone with the Oriskany Sandstone of Early Devonian age in New York State. A more complete discussion of the origin of the ores is given in Lesure (1957, p. 82–105).

Limonite Resources

Resource estimates for limonite, which is a secondary ore, are not made as easily as resource estimates of primary or bedded deposits because the limonite deposits are discontinuous masses that cannot be projected for any extended distance. Thickness of the mineralized zone is generally 10–35 ft, much less than the 50–60 ft of the unweathered upper part of the Licking Creek Limestone, and the iron content is highly variable within the deposit. The depth to which the limonite can be projected is also variable but generally not by more than a few hundred feet. The resource estimates given for each mining area are based on an assumed average thickness and grade and projection of 100 ft below existing outcrops or bottom of workings. These constitute inferred subeconomic resources as defined in USGS Circular 831 (U.S. Bureau of Mines and U.S. Geological Survey, 1980).

Longdale and Victoria mines.—The Longdale and Victoria mines have been mined extensively and are reported to be largely worked out (Merrill, 1943, p. 3). Limonite-cemented brecciated sandstone of the hanging wall and limonite-cemented chert breccia of the lower part of the ore zone or of the footwall zone crop out in some of the cuts, and large dumps of sandy and cherty limonite are present. This material might be amenable to modern beneficiation methods and, if so, would constitute a low-grade iron resource. The larger pits and caving ground of the southern part of the Longdale mine cover an area of 75 acres or more within the boundary of the study area (plate 1*B*). An area of similar large cuts and caving underground workings covers about 40 acres inside the study area at the northern end of the Victoria mine (plate 1*C*). These areas probably are worked out. Any iron resources remaining at depth would be difficult to recover because of the dangerous ground. Between these two areas are 60 acres within the study area containing smaller cuts, trenches, and prospect pits that extend for 2.5 mi along the strike of the ore zone (fig. 4). Inferred subeconomic iron resources of 1.25 million long tons are estimated for this area, assuming a mineralized zone 12,500 ft long, 100 ft wide down the dip below the bottom of present workings, a thickness of 13 ft of mineralized rock, and a tonnage factor of 13 cubic feet per long ton of rock in place as estimated by Morrison and Grosh (1950, p. 13) for this type of ore.

The average grade of ore from the Victoria mine was 47 percent iron according to furnace returns (Holden, 1907, p. 436). Analyses of ore from the Longdale mine range from 47.47 to 51.66 percent iron (Benton, 1886, p. 279–280; Holden, 1907, p. 439), and the average grade was probably similar to that of the Victoria mine. Using 45 percent iron as a conservative estimate, the iron content of the inferred subeconomic iron resources is about 560,000 long tons.

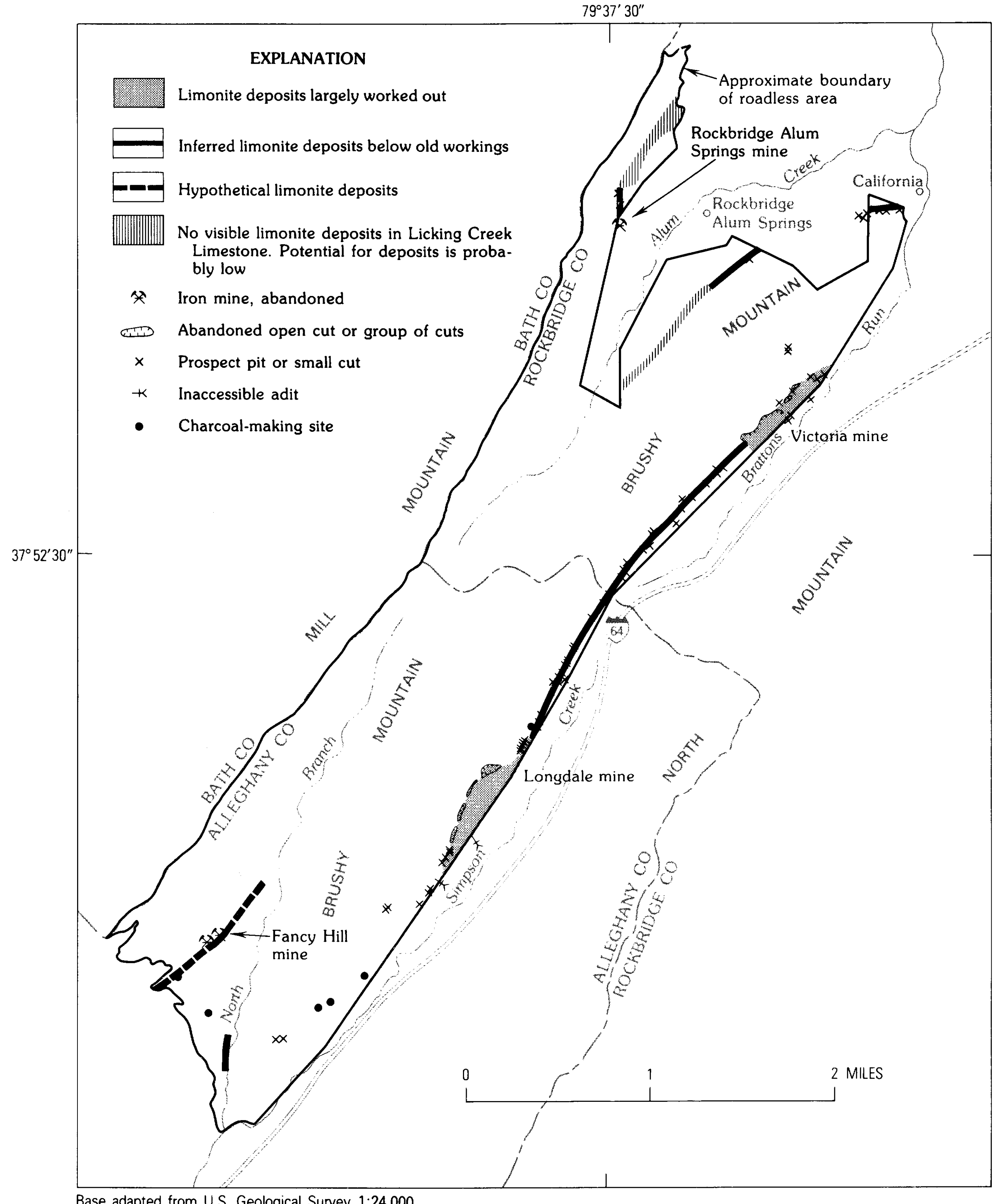
Fancy Hill mine.—The strike length of the ore zone at the Fancy Hill mine is about 1,000 ft (plate 1*D*). The ore zone is covered to the northeast for approximately 2,500 ft and to the southwest for 2,000 ft (fig. 4). Using the same methods of resource calculation as before, 100,000 long tons of inferred subeconomic iron resources are 100 ft down dip below the workings of the Fancy Hill mine, and 450,000 long tons of hypothetical subeconomic iron resources are in the covered areas northeast and southwest of the mine area. An additional 100,000 long tons of inferred subeconomic iron resources may be present below the workings on the northwestern bank of North Branch south of the Fancy Hill mine (fig. 4).

Rockbridge Alum Springs mine.—The strike length of the ore zone at the Rockbridge Alum Springs mine inside the study area boundary is about 1,000 ft. The inferred subeconomic iron resources are, therefore, about 100,000 long tons. No evidence of mineralized rock was seen along strike 3,500 ft northeast of the mine area near the boundary along the State road.

North end of Brushy Mountain.—The strike length of the ore zone containing prospect pits and mineralized rock within the study area boundary at the northern end of Brushy Mountain is 1,000 ft near California and 2,000 ft in an area southeast of Rockbridge Alum Springs. Inferred subeconomic iron resources may amount to 300,000 long tons in these areas. The ore zone is present for an additional 5,000 ft southwest of Rockbridge Alum Springs, but the formations become steeply dipping to overturned in this area and may not be mineralized. No mineralized float or prospect pits were seen in this area.

Economic Assessment of Limonite Resources

Economic potential is small for the limonite resources in the Rich Hole Roadless Area. Because distribution of iron in western Virginia is sporadic, iron resources cannot be



Base adapted from U.S. Geological Survey, 1:24,000
Collierstown, 1967 (photorevised 1978);
Longdale Furnace and Millboro, 1969
(photorevised 1978); and Nimrod Hall, 1969

Figure 4. Distribution of inferred subeconomic limonitic iron resources in the Rich Hole Roadless Area.

considered a viable commodity in the foreseeable future. The following reasons for the decline and eventual demise of iron mining in Virginia, as pointed out by Morrison and Grosh (1950, p. 4), are still applicable in dismissing any present-day potential: (1) competition from Great Lakes ores and from other markets, (2) unfavorable freight rates, and (3) more stringent iron-ore requirements for modern furnaces.

Stone

The Juniata Formation, Tuscarora Quartzite, Rose Hill Formation, and Keefer Sandstone contain abundant rock suitable for crushed rock and rough building stone. Similar rock is exposed abundantly throughout the general region, and the rocks of the study area have no special properties that could increase their value.

The Tuscarora Quartzite and Keefer Sandstone contain silica-rich sandstone that may be suitable for use in various sand products. Chemical analyses indicate that contaminants, especially iron (Lesure, 1986), limit the commercial potential for glass sand and other high-silica sand products. Some of this sandstone, however, may be suitable for use as furnace, molding, engine, and construction sand and for the manufacture of ganister and abrasives. Similar quality and more accessible materials are widely available elsewhere in the region.

Limestone

The New Creek and Licking Creek Limestones are relatively clean limestones that could be suitable for crushed stone and for agricultural uses. Both are poorly exposed and generally deeply weathered but are probably present at depth along the western edge of the study area. The Licking Creek has been mined near Low Moor, about 11 mi southwest of the study area. The only potential for unweathered limestone in the study area is at depth. Resources of unweathered limestone in the study area are probably not large; better and more accessible material is exposed along the highway south of Longdale Furnace.

Shale and Residual Clay

Minor amounts of shale are poorly exposed along old U.S. Highway 60 on the eastern edge of the study area, and residual clays of limited extent are present in some of the iron mines. Tests show that similar material from adjacent areas is suitable for structural clay products and lightweight aggregate (Ries and Somers, 1920, p. 78–82; Calver and others, 1964, p. 35, 84-85, 217–221.) Ceramic properties of shale and clay from the study area are untested but should not differ greatly from similar material located in greater abundance elsewhere in the region.

Oil and Gas Potential

Recently, major petroleum companies and independent operators have become interested in the possibility of new gas discoveries in the eastern overthrust belt of the Appalachian Mountains from New York to Alabama. Geologic and geophysical exploration, including seismic work, currently is being conducted in the Valley and Ridge province of Virginia. Cambrian to Mississippian strata underlying the province may contain potential natural gas reservoirs, with a lesser possibility for large-scale petroleum reserves (LeVan, 1981).

Although the Rich Hole Roadless Area contains both source beds and reservoir rocks, it has a low potential for natural gas and no potential for commercial accumulations of oil (Wallace de Witt, Jr., U.S. Geological Survey, written commun., 1981). The degree of thermal maturation, the temperature to which the source beds have been heated, is too great for the presence of oil; however, the rocks are within the temperature range favorable for the presence of dry natural gas (Harris and others, 1978). The anticlinal structures of Brushy and Mill Mountains permit the good sandstone reservoir rocks in the near-surface clastic sequence to crop out within the Rich Hole area. Thus, any considerable accumulation of natural gas in these rocks would have escaped to the atmosphere in the 250 million years since the rocks were folded and faulted during the Alleghenian orogeny. Extensive fracture porosity, however, may be associated with buried thrust faults in the general vicinity of the Rich Hole area (Milici, 1980; Harris and Milici, 1977, p. 8–11), and natural gas has been produced from rocks having fracture porosity to the north and northwest in the Allegheny Plateau and in the Valley and Ridge province. A test hole drilled in 1981 by Columbia Gas Transmission Corporation in Botetourt County about 10 mi south of Rich Hole and on a continuation of the anticlinal structure was plugged and abandoned. Only gas shows were encountered in fractured zones in Middle Ordovician limestone, and the hole is listed as dry (Patchen and others, 1983, p. 1573–1586). Because available data indicate that even favorably developed fractures may not be gas filled, the potential for natural gas in the Rich Hole Roadless Area must be rated as low. The area is certainly one of high-risk drilling, but it cannot be excluded from the list of possible gas-producing areas. Hydrocarbon potential in the Rich Hole Roadless Area presently remains untested and speculative.

Uranium

Marine black shales, which may contain more uranium than other types of shale, have been studied extensively as possible sources of uranium (Swanson, 1961). Several traverses across the outcrop belts of the Romney Shale using a four-channel gamma-ray spectrometer indicate that, in the Rich Hole Roadless Area, the black shale of the Romney is only a little more radioactive than the lighter colored shales of other formations. Six samples of black shale collected from the Romney Shale in the Rich Hole area contain 0.15–24 ppm uranium (Bailey and others, 1985, p. 3), and similar samples from 4 to 25 mi away contain from less than 1 to as much as 14 ppm uranium (Hasson, 1977, appendix III; Lesure, 1982). These findings support Hasson (1977, p. 41), who concluded "the Millboro (upper Romney) Shale of Virginia contains too little uranium to be a potential source."

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