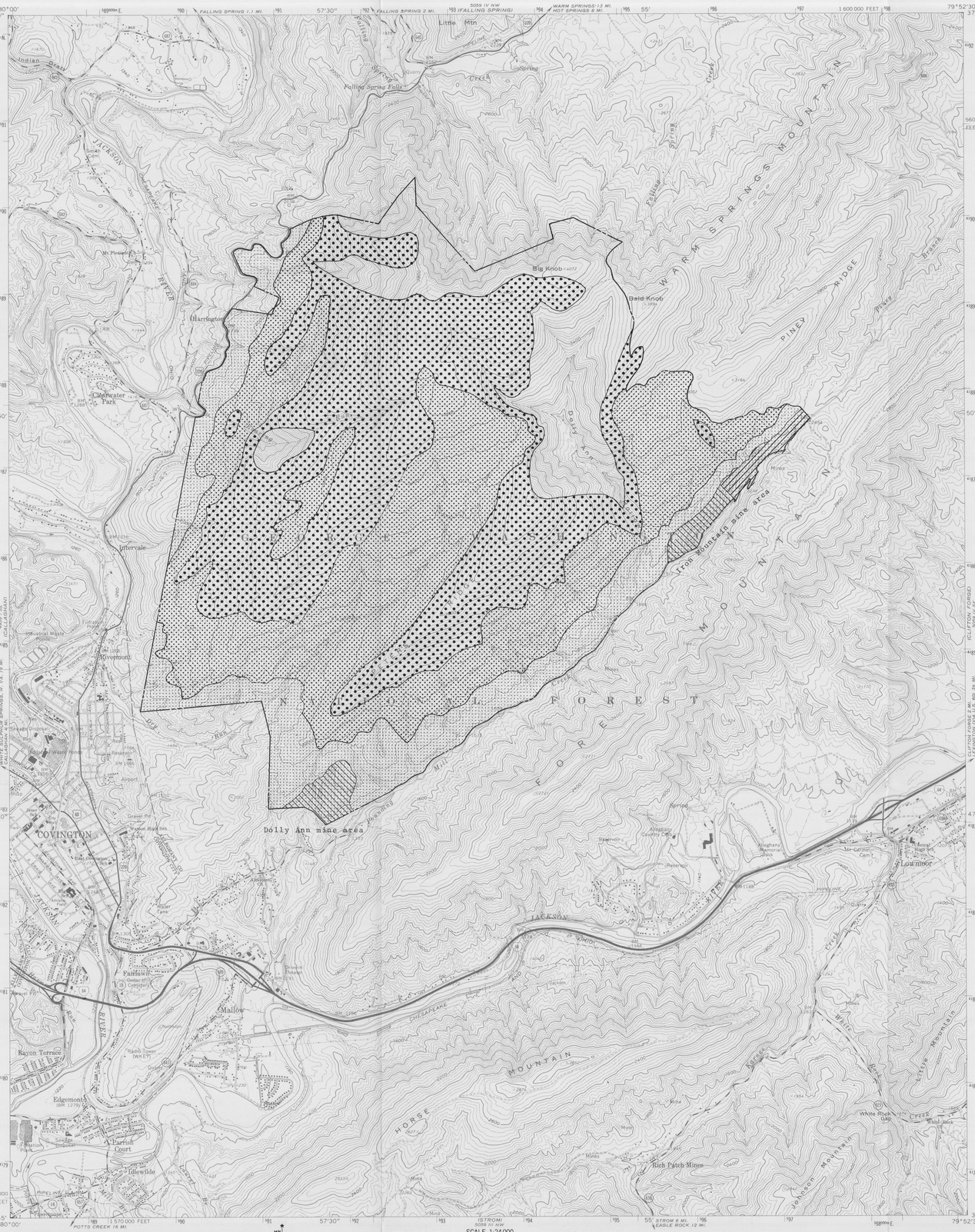

Base from U.S. Geological Survey
Covington, 1962
Photorevision as of 1969

Polyconic projection. 1927 North American datum
10,000-foot grid based on Virginia coordinate system, south zone
1,000-meter Universal Transverse Mercator grid ticks, zone 17

UTM GRID AND 1969 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
DOTTED LINES REPRESENT 20-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

MINERAL RESOURCE POTENTIAL MAP OF THE DOLLY ANN ROADLESS AREA, ALLEGHANY COUNTY, VIRGINIA

By
Frank G. Lesure, U.S. Geological Survey
and
Jay G. Jones, U.S. Bureau of Mines

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EXPLANATION

Areas of iron resources

- Inferred hematitic iron resources covered by more than 200 ft (60 m) of rock. Rocks at the surface consist of the Romney Shale (Middle Devonian), sandstone and limestone formations (Lower Devonian and Upper Silurian), and landslide and colluvial material (Quaternary)
- Inferred hematitic iron resources covered by 5 to 200 ft (1.5 to 60 m) of rock. Rocks at the surface consist of the Keefer Sandstone (Middle Silurian) and landslide and colluvial material (Quaternary)
- Outcrop area of inferred hematitic iron resources. Rocks at the surface consist of the Rose Hill Formation (Middle Silurian), and landslide and colluvial material (Quaternary)
- Hematitic iron resources not present. Rocks at the surface consist of the Tuscarora Quartzite (Lower Silurian), the Juniata Formation (Upper Ordovician), and the Martinsburg Shale (Upper and Middle Ordovician)
- Inferred limonitic iron resources present in younger rocks near surface only
- Area of low potential for limonite resources

STUDIES RELATED TO WILDERNESS

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts require the U.S. Geological Survey and the U.S. Bureau of Mines to survey certain areas on Federal lands to determine their mineral resource potential. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral resource potential survey of the Dolly Ann Roadless Area in the George Washington National Forest, Alleghany County, Virginia. Dolly Ann Roadless Area (08-171) was classified as a further planning area during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

SUMMARY

The Dolly Ann Roadless Area is in the George Washington National Forest, Alleghany County, Virginia, in the Valley and Ridge physiographic province. The area, which contains folded sedimentary rocks of Paleozoic age, has extensive inferred subeconomic iron resources in low-grade hematitic sandstone and limited inferred subeconomic iron resources in medium-grade sandy limonite. Other potential mineral resources include various rocks suitable for road metal, quartzite suitable for high-silica applications, limestone suitable for agricultural uses, and clay and shale suitable for structural clay products. A potential for natural gas exists but cannot be quantified from present knowledge. Thermal springs near the area suggest a potential for geothermal energy.

The caved surface and underground workings of the Dolly Ann and Iron Mountain iron mines, developed in the late 1800s and early 1900s, are the only evidence of mining within the study area. All surface and mineral rights in the Dolly Ann Roadless Area are Federally owned, and 15 percent of the study area has been leased for oil and gas exploration.

Iron constitutes the principal mineral resource in the Dolly Ann Roadless Area. The area is estimated to contain total inferred subeconomic resources of 3 billion long tons of low-grade hematitic sandstone in the Rose Hill Formation of Middle Silurian age, containing as much as 540 million long tons of iron. Lower Devonian limestone and sandstone at the Dolly Ann and Iron Mountain mines may have total inferred subeconomic resources of 1,600,000 long tons of medium-grade sandy limonite, containing possibly as much as 700,000 long tons of iron. Because of the variable grade of iron-bearing material and present industry requirements, these iron resources in the study area probably would not compete with higher- and more uniform-grade iron resources elsewhere.

INTRODUCTION

The Dolly Ann Roadless Area comprises 7,900 acres (3,200 ha) of the George Washington National Forest, in the Valley and Ridge physiographic province of west-central Virginia. The area is at the southern end of Warm Springs Mountain in Alleghany County just northeast of Covington, the county seat (index map). U.S. Highway 220 forms part of the western boundary, and U.S. Forest Service Road 125, which parallels Pounding Mill Creek, forms the eastern boundary.

The Federal Government owns all surface and mineral rights in the Dolly Ann Roadless Area. Oil and gas leases had been issued on approximately 1,200 acres (485 ha) in the study area as of January 1983 (fig. 1); applications for oil and gas leases for the rest of the study area are pending approval.

GEOLOGY

The rocks exposed in the Dolly Ann Roadless Area are chiefly marine clastic sedimentary rocks of Ordovician to Devonian age, which have an aggregate thickness of more than 3,500 ft (1070 m) (table 1). These strata were deformed during late Paleozoic time into a series of upright to overturned folds forming the southwest-plunging end of the Hot Springs Anticline.

Much of the area is 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 of large parts of the study area, especially where the Upper Silurian and Lower Devonian formations would otherwise be exposed (Lesure, 1981).

GEOCHEMICAL SURVEY

Iron is the only metallic mineral resource reported for the Dolly Ann area. Reconnaissance geochemical sampling in the area did not find evidence of any indistinct or unexposed metallic mineral deposits that might be recognized by their geochemical halos. Zinc is a trace constituent (0.04-0.6 percent) in the limonitic iron-ores (Lesure, 1982), and sediment samples from many streams draining areas that include the iron deposits have higher-than-background zinc content.

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 and residual clay suitable for common building brick are potential mineral resources in the Dolly Ann Roadless Area. A possibility exists for the presence of natural gas, but no drilling has been done in the area to substantiate the gas potential. Thermal springs just north of the area suggest a potential for geothermal energy.

Iron

The study area, located on the northwestern edge of the Clifton Forge iron district (Lesure, 1957, p. 61), contains two types of iron deposits, hematite and limonite. Low-grade hematitic sandstone beds and lenses in the Rose Hill Formation extend throughout most of the study area (see map). Limited areas of higher-grade limonite deposits in the Licking Creek Limestone have been largely mined out in the Dolly Ann mine at the southern end of the study area and in the Iron Mountain mine at the northeastern end of the study area (see map).

Hematite Resources

Inferred low-grade subeconomic iron resources in the Rose Hill Formation can be estimated from the weight, grade, and volume data available. The Rose Hill Formation is 250-300 ft (60-90 m) thick and is about two-thirds hematitic sandstone. Average specific gravity of this hematitic sandstone in the Dolly Ann area is 2.9 (Lesure, 1982). The weight of a cubic foot of average hematitic sandstone is the specific gravity, 2.9, multiplied by the weight of a cubic foot of water, 62.4 lbs, which equals 181 lbs/ft^3. The grade of the hematitic sandstone ranges widely from 10 to 28 percent iron and averages 18 percent iron (Lesure, 1982; Jones and others, 1982, p. 19). In the Dolly Ann Roadless Area, the Rose Hill Formation is exposed in about 2,700 acres (1,090 ha), is covered by 5-200 ft (1.5-60 m) of younger rock in 2,800 acres (1,130 ha), and is covered by more than 200 ft (60 m) in 1,300 acres (530 ha) (see maps also Lesure, 1981). Assuming an average thickness of 150 ft (45 m) of hematitic sandstone for the 4,100 acres (1660 ha) of covered Rose Hill and 75 ft (23 m) for the 2,700 acres (1,090 ha) of exposed Rose Hill, the total inferred sub-economic iron resource is about 3 billion long tons of hematitic sandstone:

Acres x 43,560 ft^2 per acre x thickness x weight per ft^3 ÷ 2240 lbs per long ton = weight of rock in place.

At an average grade of 18 percent iron, this resource could contain as much as 540 million long tons of iron. Although this material is too low in average iron content to be considered economically important now, similar material was seriously prospected in Giles County, Va., in the 1950s and 60s (Cooper, 1960; Fish, 1967; and Lesure and others, 1983).

Limonite Resources

The only iron deposits mined within the study area are the secondary or supergene limonite deposits in the Lower Devonian Licking Creek Limestone (Lesure, 1957, p. 105-108). The ore mined was a sandy and clayey limonite that formed as a replacement and cavity filling in the upper sandy limestone part of the Licking Creek. In general, these limonite deposits are near-surface features that grade downward into unreplaced limestone within a hundred or a few hundred feet of the surface. The largest deposits formed where the limestone beds dip 20-75 degrees; a few deposits formed in steeper-dipping or overturned beds; and thin, sandy deposits formed where the beds are flat or only gently dipping (Lesure, 1957, p. 94).

The limonite deposits are discontinuous masses that cannot be projected for any extended distance. Thickness of a deposit is generally 10 to 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. With these restrictions in mind, we have made resource estimates based on available data.

Iron Resources at Dolly Ann Mine

Inferred subeconomic iron resources can be estimated for an area of 75 acres (30 ha) enclosed by mine workings and prospect pits in that part of the Dolly Ann mine inside the study area (see map). Little of the ore zone is presently exposed, although iron-rich Ridgeley Sandstone of the hanging wall is found in the old pits and cuts. The ore zone in the valley area west of the larger cuts must be low dipping or nearly flat, which is unfavorable for ore formation. Some of this area, therefore, may have only ferruginous sand in the ore zone. According to Weld (1911), the average thickness of ore mined at the Dolly Ann mine was 12 ft (3.6 m), but three samples collected by the U.S. Bureau of Mines from the presumed ore zone in three abandoned pits range in thickness from nearly 2 to about 5 ft (0.6-1.6 m) and in grade from 50 to 58.8 percent iron (Jones and others, 1982, p. 20). The thinness of ore in these pits may be one reason that mining here was discontinued. Harder (1909, p. 249) reported an analysis of Dolly Ann ore containing 44.32 percent iron; this is probably a realistic figure for rock in place. A tonnage factor of 13 ft^3 per long ton of ore for rock in place was estimated by Morrison and Grosh (1950, p. 13).

For that part of the Dolly Ann mine within the study area, we calculate inferred subeconomic iron resources of about 800,000 long tons of sandy limonite containing possibly as much as 350,000 long tons of iron. This tonnage is based on a mineralized area of 75 acres (30 ha), minus about 4 acres (2 ha) that have obviously been mined, an average thickness of mineralized rock of 3.5 ft (1 m), a tonnage factor of 13 ft^3 per long ton, and an average grade of 44 percent iron. The U.S. Bureau of Mines has classified 20,000 long tons of this material present within a hundred-foot (30-m) radius of the three sample sites as demonstrated subeconomic iron resources (Jones and others, 1982, p. 24).

An additional, larger tonnage of iron in the ferruginous sandstone hanging wall can also be inferred, but this material would probably be of lower grade, ranging from 10 to 40 percent iron.

Iron Resources at Iron Mountain Mine

The small part of the Iron Mountain mine in the study area includes about 50 acres (20 ha) in which are seven large cuts, several pits, and one adit, all on a small anticline in the Licking Creek Limestone and Ridgeley Sandstone. Drilling by the Low Moor Iron Company (Weld, 1926) and the U.S. Bureau of Mines (Morrison and Grosh, 1950, p. 13-14) did not show material of ore grade or minable thickness. Seven samples from the ore zone collected by the U.S. Bureau of Mines (Jones and others, 1982, p. 26) show ore-zone thicknesses of 2 to about 14 ft (0.6-4 m) and iron contents of 40 to 54 percent. The average thickness of ore is 5 ft (1.6 m) and the average grade is 48 percent iron.

Merrill (1943, p. 8) reported, however, an average of 43.27 percent iron in ore mined at the Iron Mountain mine. In the 50 acres of the Iron Mountain mine in the study area, minus about 3 acres (1 ha) that have been mined out, we calculate inferred subeconomic iron resources to total about 800,000 long tons of sandy limonite that might contain 340,000 long tons of iron. The U.S. Bureau of Mines has classified 56,000 long tons of the sandy limonite present within a hundred-foot (30-m) radius of the seven sample sites as demonstrated subeconomic iron resources (Jones and others, 1982, p. 26). In addition, as at the Dolly Ann mine, a larger amount of limonite-cemented sandstone in the hanging wall is classified as lower-grade subeconomic iron resources.

Little iron-rich material is exposed in the study area for 4,000 ft (1200 m) northeast of the workings of the Iron Mountain mine. The Licking Creek Limestone and Ridgeley Sandstone are poorly exposed in an area about 500 ft (150 m) wide along the study area boundary. Drilling southeast of U.S. Forest Service Road 125 and outside the study area by the Low Moor Iron Company and U.S. Bureau of Mines (Weld, 1926; Morrison and Grosh, 1950, p. 14) suggests the presence of some limonite on the southeast limb but none in the trough of the syncline. The small anticline present at the Iron Mountain workings in the study area probably dies out to the northeast in this covered area. Because of the low dips to be expected in the ore zone along the axis of the syncline and the lack of iron-rich material along the outcrop area of the host limestone, the possibility of significant amounts of limonite is small.

Assessment of Limonite Resources

There is little potential for the limonite resources in the Dolly Ann Roadless Area. Distribution of iron in western Virginia is sporadic, and iron resources here cannot be considered a viable commodity in the foreseeable future. The 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: competition from Great Lakes ores and from other markets, unfavorable freight rates, and 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 abundantly exposed 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 and others, 1981), 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 may be suitable for crushed stone and for agricultural uses. Both are poorly exposed, and generally deeply weathered, but are probably present locally along the western edge of the study area. The Licking Creek Limestone has been mined near Low Moor, about 3 mi (5 km) southeast of the study area. The only potential for unweathered limestone in the study area is at depth. Some boulders of New Creek Limestone are in the dump material at the Dolly Ann mine. Resources of unweathered limestone in the study area are probably not large; better and more accessible material is exposed near Low Moor.

Shale and Residual Clay

Minor amounts of shale are poorly exposed along U.S. Highway 220 on the western edge of the study area, and residual clays of limited extent are present in some of the iron mines. Tests show that some of this material is suitable for structural clay products and lightweight aggregate (Ries and Somers, 1920; Calver and others, 1964, p. 30-31; Jones and others, 1982, p. 31). Ceramic properties of this shale and clay are in no respect superior to similar material located elsewhere in the region.

Oil and Gas Potential

Although the Dolly Ann 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 structure of Warm Springs Mountain permits all of the good sandstone reservoir rocks in the near-surface clastic sequence to crop out within the Dolly Ann area. Thus, any considerable accumulation of natural gas in these rocks would have escaped to the atmosphere in the 200 million years since the rocks were folded and faulted during the Allegheny orogeny. Extensive fracture porosity, however, may be associated with buried thrust faults in the general vicinity of the Dolly Ann area (Milici, 1980; Harris and Milici, 1977, p. 8-11), and natural gas has been produced from rock having fracture porosity to the north and northwest in both the Allegheny Plateau and in the Valley and Ridge province. Because available data indicate that even if favorably developed the fractures may not be gas filled, the potential for natural gas in the Dolly Ann 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.

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, are currently 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). Leases for oil and gas have been issued for several tracts of land, parts of which lie in the study area, containing possible gas-bearing horizons (fig. 1). Applications for leases have also been filed for the rest of the study area.

Hydrocarbon potential in the Dolly Ann Roadless Area presently remains untested and speculative.

Geothermal Resources

Thermal springs in Warm Springs Valley northeast of the Dolly Ann area have been used as medicinal and recreational attractions for two hundred years (Hobbs and others, 1979, p. E3). Falling Spring, the southernmost thermal spring in Warm Springs Valley, is less than one mile north of the study area (see map). This spring discharges 65° to 74° F water at a rate of 6,000 to 7,000 gallons per minute (Reeves, 1932, p. 16). Studies of water chemistry in Warm Springs Valley indicate a geothermal resource of approximately 250° to 300° F (Dean Pilkington, AMAX Exploration, Inc., oral commun., 1981).

The principal aquifer for the thermal springs is Middle Ordovician limestone, which is present only at depth in the study area. A geothermal lease on 4,928 acres less than a mile north of the Dolly Ann area was allowed to terminate in 1980 after geophysical studies were performed. Previous studies indicate that warm springs in the area may constitute a geothermal resource for low-temperature application such as space heating (Costain, 1976). Additional data, however, would be required to determine geothermal-energy potential for the study area.

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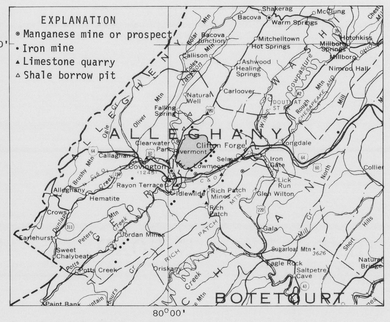

Base from U.S. Geological Survey Virginia State map, 1973

0 5 10 MILES
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Dolly Ann Roadless Area

Index map showing location of Dolly Ann Roadless Area and some of the mines, prospects, and quarries in Alleghany County.

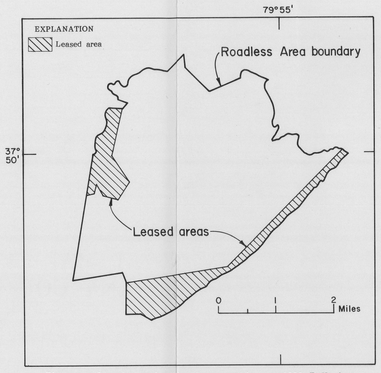

Figure 1.—Land leased for oil and gas as of January 1983, Dolly Ann Roadless Area.

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

Age		Name	Thickness in feet	Lithologic character
CENOZOIC	QUATERNARY	Alluvium	0-30	Clay, sand, and gravel on floodplains and terraces
	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)	600-1150	Black fissile shale; calcareous concretions in upper part grade laterally into dark-gray calcareous beds; includes some olive-gray shale
		Lower part (correlates with Needmore Shale)	15-100	Medium to light olive-gray shale; poorly exposed
	DEVONIAN, Lower	Ridgeley Sandstone	20	Medium- to coarse-grained calcareous sandstone; where cemented with iron oxides forms hanging wall of many of the Oriskany iron deposits
		Licking Creek Limestone	105	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
		Healing Springs Sandstone	20	Medium-grained calcareous sandstone
		New Creek Limestone	20	Coarse-grained crinoidal limestone
	SILURIAN, Upper?	Keyser Limestone	100	Upper part nodular limestone; lower part calcareous sandstone
		Tonoloway Limestone	150	Thin-bedded argillaceous limestone
		Williamsport Sandstone(?) or Wills Creek Shale (?)	50	Thin-bedded argillaceous limestone and shale; poorly exposed
	SILURIAN, Middle	Keefer Sandstone	250	Resistant quartzitic sandstone; a few thin beds of dark shale
		Rose Hill Formation	250-300	Dark-red hematitic sandstone and greenish-gray shale; some medium-gray sandstone and red shale
	SILURIAN, Lower	Tuscarora Quartzite	100	Resistant quartzitic sandstone; thin lenses of pebble conglomerate
	ORDOVICIAN, Middle and Upper	Juniata Formation	250	Grayish-red sandstone and shale; some medium-gray to greenish-gray sandstone and shale in the east
		Martinsburg Shale	1200	Dark-gray calcareous shale and thin-bedded argillaceous limestone; some interbedded coarse crystalline limestone

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