STUDIES RELATED TO WILDERNESS

WILDERNESS AREAS

RAMSEYS DRAFT AREA, VIRGINIA

GEOLOGICAL SURVEY BULLETIN 1397-C

Mineral Resources of the Ramseys Draft Wilderness Study Area, Augusta County, Virginia

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STUDIES RELATED TO WILDERNESS—WILDERNESS AREA

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An evaluation of the mineral potential of the area

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1977

UNITED STATES DEPARTMENT OF THE INTERIOR

CECIL D. ANDRUS, *Secretary*

GEOLOGICAL SURVEY

V. E. McKelvey, *Director*

Library of Congress Cataloging in Publication Data

Mineral resources of the Ramseys Draft wilderness study area, Augusta County, Virginia.
(Geological Survey Bulletin 1397-C)
Bibliography: p. 40-42.
Supt. of Docs. no.: I 19.3:1397-C
1. Mines and mineral resources--Virginia--Ramseys Draft Wilderness Study Area. I. Lesure, Frank Gardner, 1927- II. Series: United States. Geological Survey. Bulletin 1397-C.
QE75.B9 no. 1397-C [TN24.V8] 557.3'08s
[553'.09755'916] 76-608350

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington, D. C. 20402
Stock Number 024-001-03017-9

STUDIES RELATED TO WILDERNESS

WILDERNESS AREAS

In accordance with the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and the Joint Conference Report on Senate bill 4, 88th Congress, the U.S. Geological Survey and U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Studies and reports of all primitive areas have been completed. Areas officially designated as "wilderness," "wild," or "canoe" when the Act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The Act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. This report discusses the results of a mineral survey of national forest lands in the Ramseys Draft study area, Virginia, that is being considered for wilderness designation (Public Law 93-622, January 3, 1975). The area studied is in the George Washington National Forest in Augusta County.

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By FRANK G. LESURE and PHILIP J. GERACI
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SUMMARY

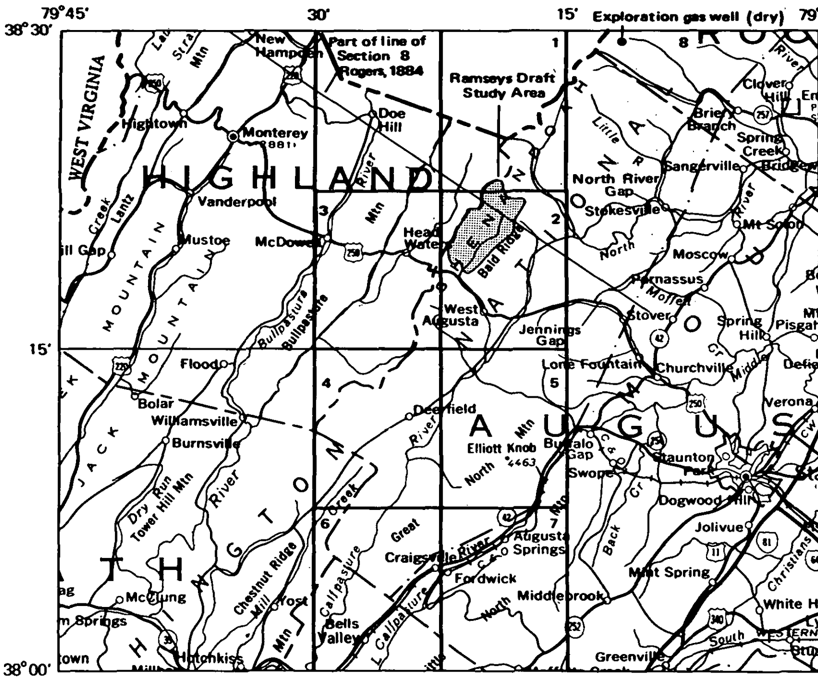
The Ramseys Draft Wilderness Study Area covers 6,700 acres (27 km^2) of steep, forested ridges in the central part of the Valley and Ridge province in Augusta County, Va. The area includes all of the upper drainage basin of Ramseys Draft in the George Washington National Forest. Bedrock is clastic, mostly nonmarine, sedimentary rocks of Late Devonian and Early Mississippian age. These are folded into a broad northeast-trending syncline. A small alkalic igneous dike of probable Jurassic age cuts the Paleozoic sedimentary rocks near the northwestern edge of the study area. No metallic mineral resources have been identified in or near the study area. A reconnaissance geochemical survey—which includes samples of stream sediments, soil, forest litter, and rock— shows no obvious anomalous values for 30 elements. Two vague northwest-trending belts of weakly anomalous copper values in stream sediments are probably related to slightly mineralized sandstone in the Hampshire Formation of Late Devonian age. Such mineralization is typical for this rock type but generally forms deposits that are too small to be economic.

No known coal beds are present in that part of the rocks of Mississippian age preserved in the area. The possibilities of oil or gas are low because of high thermal maturity and unfavorable structural position of the rock formations. The only apparent mineral resources are small amounts of sand and gravel along the main stream, abundant sandstone suitable for construction material, and abundant shale suitable for brick, tile, and other low-grade ceramic materials. Deposits of all these are readily available and more accessible in surrounding areas.

INTRODUCTION

The Ramseys Draft Wilderness Study Area constitutes about 6,700 acres (27 km^2) within the George Washington National Forest in Augusta County, Va., about 18 miles (29 km) northwest of

Staunton, Va. (fig. 1). The study area is a northeast-trending valley drained by Ramseys Draft, a tributary of the Calfpasture River which flows into the North River, all part of the James River drainage. The valley is in a syncline in Upper Devonian and Lower Mississippian sedimentary rocks in the middle part of the Valley and Ridge physiographic province. Elevations range from 2,280 feet (695 m) above sea level, where Ramseys Draft leaves the study



Base from U.S. Geological Survey, Virginia State map, 1973, 1:500,000

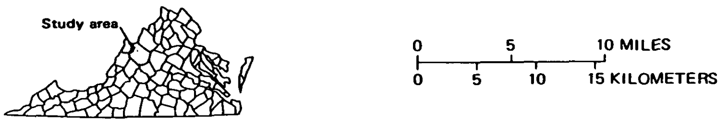


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FIGURE 1.—Index map showing Ramseys Draft Wilderness Study Area and adjacent areas of published geologic maps.

area in the south, to 4,282 feet (1,305 m) on Hardscrabble Knob in the north. The western edge of the study area follows the crest of Shenandoah Mountain, and the eastern edge follows Bald Ridge. The region (fig. 2) has steep slopes, sharp ridge crests, and narrow stream valleys. It is heavily forested by oak, hemlock, pine, and maple. Other common species include birch, beech, tulip poplar, and hickory. The underbrush is rhododendron, mountain laurel, and witch hazel.

Access to the area is good from a jeep road (U.S. Forest Service Road 68) up Ramseys Draft and a network of trails. The jeep road begins at the picnic area at the south end of the study area, just off U.S. Route 250, and goes as far as the intersection of the Left and Right Prongs of Ramseys Draft, where a trail continues to Hardscrabble Knob. The road fords the creek in 14 places, most of which require a high-clearance vehicle. The Shenandoah Mountain Trail, maintained by the Appalachian Trail Club, follows the western border of the study area. A branching trail leads to Sexton Shelter near the head of Jerrys Run and continues to the jeep road on the main stream. From the east and north, trails up Dividing Ridge from Virginia Secondary Road 715 and Forest Service Road 96 and up Springhouse Ridge from Forest Service Road 95 lead to Bald Knob. Another trail continues to Hines Spring and connects

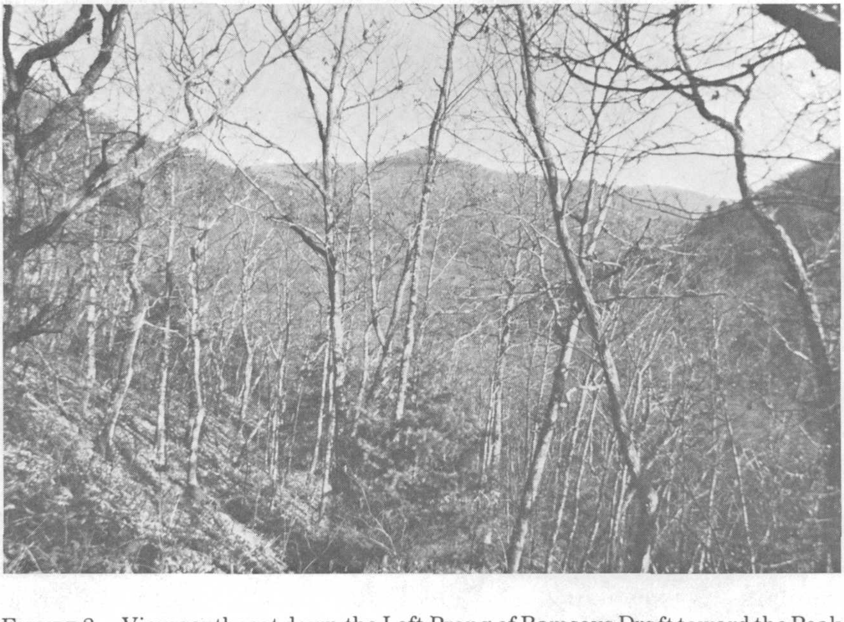

FIGURE 2.—View southeast down the Left Prong of Ramseys Draft toward the Peak on Bald Ridge in the distance. The steep slopes on either side are typical of the study area. Photograph, U.S. Bureau of Mines.

with the Ramseys Draft trail to Hardscrabble Knob; a branching trail along Tearjack Knob intersects the Shenandoah Trail. From the west along Shaws Fork, a trail goes up Sinclair Hollow to the Shenandoah Trail, and another trail about 3 miles (5 km) to the south goes to the ridge crest at the head of Jerrys Run. These trails are shown on the topographic quadrangle maps (pl. 1) and are well marked. The rest of the area has some fairly open woods but also some rather thick rhododendron and laurel patches that make hiking off trails difficult.

PRESENT STUDY

From October 15 to October 28, 1974, Lesure and Geraci, U.S. Geological Survey, mapped the geology of the study area and collected 48 rock samples, 38 soil samples, 38 forest-litter samples, and 84 stream-sediment samples for trace-element analyses. These samples were analyzed in U.S. Geological Survey laboratories, Denver, Colo. In November and December 1974, Mory and Williams, U.S. Bureau of Mines, made a reconnaissance of the mineral resources and collected 27 representative rock samples for further study. They obtained records of leasing and prospecting activities from the Bureau of Land Management in Washington, D.C., and from the U.S. Forest Service in Harrisonburg, Va., and Atlanta, Ga. Representatives from industry, state agencies, and other federal agencies were contacted for pertinent information concerning the area. Spectrographic analyses of rock samples were made by the U.S. Bureau of Mines Reno Metallurgy Research Center, Reno, Nev., and ceramic evaluations of shale samples were made by the U.S. Bureau of Mines Tuscaloosa Metallurgy Research Laboratory, Tuscaloosa, Ala.

PREVIOUS STUDIES

W. B. Rogers, the first State Geologist of Virginia, studied the geology in the general area of Ramseys Draft as early as 1835 (Rogers, 1836, p. 89-103) and assigned numbers to the different rock units (Rogers, 1838, p. 21-23). His units VIII, IX, and X are exposed in the study area. Rogers drew a cross section through the middle of the study area (Rogers, 1884, plate VII, section 8) that indicated clearly that he understood the synclinal structure of the valley.

N. H. Darton (1894) mapped the geology of the 30-minute Staunton quadrangle (fig. 1), which includes Ramseys Draft. His mapping is excellent and is modified only slightly by our work. Darton (1892) applied the names Jennings Formation to Rogers' Unit VIII and Hampshire Formation to Unit IX, and correlated the

Pocono Formation with Unit X. These names are used in this report.

Charles Butts (1933) compiled a geologic map of the Appalachian Valley in Virginia and divided the Jennings Formation of Darton into a lower unit called Brallier Shale and an upper unit called Chemung Formation. The Hampshire Formation he called Catskill Formation. Later (Butts, 1940) he used the name Hampshire in place of Catskill and gave more detailed descriptions for all the units.

Kozak (1970) mapped the Elliot Knob, Deerfield, Craigsville, and Augusta Springs quadrangles south of Ramseys Draft (fig. 1).

MINERAL OWNERSHIP

The Ramseys Draft area is part of a large tract of land acquired by the U.S. Government from Virginia Mining and Improvement Company on January 8, 1916, under authority of the Weeks Act of March 1, 1911. All mineral rights, including oil and gas, were reserved by the company and subsequently were deeded on June 14, 1917, to Girard Trust Company of Philadelphia, Pa., now known as Girard Trust Bank. The prerogative to produce minerals and mineral products, including oil and gas, is subject to the rules and regulations of the Secretary of Agriculture that are included in the original deed.

ACKNOWLEDGMENTS

We wish to thank the Crab Run Gas Company, a subsidiary of Washington Gas Light Company, Washington, D. C., for information concerning lease status and oil and gas exploration in the general area. Donald C. LeVan of the Virginia Division of Mineral Resources and Douglas G. Patchen of the West Virginia Geological and Economic Survey provided information about the natural gas fields in the general area. Harry W. Webb, Jr., Virginia Division of Mineral Resources, provided background data on the geology of the area. The friendly cooperation of Leonard J. McNeal, District Ranger, U.S. Forest Service, George Washington National Forest, greatly speeded up the mapping and sampling. Wallace de Witt, Jr., U.S. Geological Survey, supplied information on the oil and gas potential of the area.

GEOLOGY

The Ramseys Draft area is a synclinal valley in Upper Devonian and Lower Mississippian sedimentary rocks (pl. 1). The main creek follows closely the axis of this syncline through most of the area. Interlayered sandstone and shale of the Jennings Formation of

Late Devonian age are exposed along Shenandoah Mountain and the western edge of the study area. Much of the area is underlain by the distinctive reddish sandstone and shale of the younger Hampshire Formation also of Late Devonian age. The highest areas at the northeast end of the study area, including Hardscrabble, Tearjacket, and Big Bald Knobs and the isolated area around Freezland Flats, are underlain by the Pocono Formation of Early Mississippian age. The rocks are fairly well exposed in stream valleys and along ridges. The main stream flows on a thin alluvial cover of bouldery rubble (fig. 3), but the alluvium is too thin and discontinuous to be mapped separately at the scale of our geologic map.

JENNINGS FORMATION

The Jennings Formation of Late Devonian age was named by N. H. Darton (1892, p. 17) for a series of interbedded light-colored shales and sandstones that is exposed in Jennings Gap, Augusta County, Va., 8 miles (13 km) east of Ramseys Draft. Butts (1918) named the lower part of the formation, which is more shaley, the Brallier Shale after a railroad station northeast of Everett, Bedford County, Pa. He used the name Chemung for the upper or sandier part of the Jennings Formation (Butts, 1933; 1940). More recently, Dennison (1970) has divided the Chemung Formation of Butts into

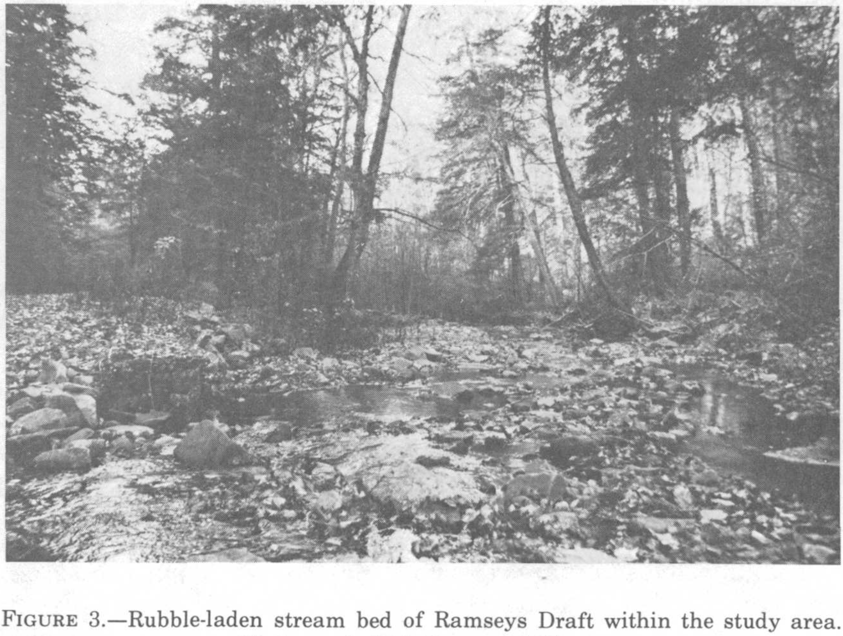

FIGURE 3.—Rubble-laden stream bed of Ramseys Draft within the study area. Photograph, U.S. Bureau of Mines.

several formations and members in the area of the Allegheny Front about 40 miles (64 km) west of Ramseys Draft. In our mapping we did not try to separate the Chemung and Brallier Formations because of a lack of exposures and the short time available for field work. Instead, we have retained the original usage of Jennings Formation as the most suitable mapping unit.

The Jennings Formation is well exposed along U.S. Route 250, where it crosses Shenandoah Mountain, and less well exposed in the western part of the study area. Butts (1940, p. 326–327) measured a section 1,935 feet (590 m) thick in the upper part of the formation (his Chemung Formation) on the southeast slope of Shenandoah Mountain. He estimated the lower part of the formation (his Brallier Shale) to be 3,000 feet (914 m) thick on the western slope of the mountain and in the valley to the west. Darton (1892, p. 13) cited thickness of 2,800–3,200 feet (840–960 m) for the Jennings.

In the Ramseys Draft area, the Jennings Formation consists largely of dusky-yellow to dark-yellowish-brown and light-olive-gray, fissile to subfissile shale and micaceous siltstone interbedded with olive-gray sandstone. The amount of sandstone increases in the upper part of the formation. Sandstone beds range in thickness from less than a centimeter to as much as a meter, but beds 10 to 30 cm thick are most common. The sandstone is mostly very fine to fine grained. It is composed predominantly of angular to subangular quartz grains and has minor amounts of feldspar and mica. Some of the sandstone beds have abundant poorly preserved fossils, generally at the base. Molds of brachiopod shells and crinoid stems are most common and establish the marine origin of these beds. Interlayered shale, mudstone, and siltstone form as much as three-fourths of the rock in the upper part of the formation exposed in road cuts along U.S. Route 250 on Shenandoah Mountain. X-ray analyses by P. J. Loferski, U.S. Geological Survey, show that these finer grained beds consist of about half clay- and silt-sized grains of quartz and minor feldspar, and about half clay minerals, mostly illite, some mixlayered clay, and a vermiculitelike mineral. Near the upper contact of the Jennings Formation are several lenses of quartz pebble conglomerate and conglomeratic sandstone. Similar but less abundant conglomeratic lenses also are present above the contact in the overlying Hampshire. The conglomerate lenses range from one to several meters in thickness and can be traced for a hundred to several hundred meters along strike. Generally, the conglomerate grades upward into conglomeratic sandstone and sandstone. The lenses are mostly quartz sand and pebbles and contain smaller quantities of accessory minerals than the average Jennings sandstone. A chemical analysis of a sample of sandstone from one of these sandstone-conglomerate lenses is given in table 1.

The contact between the Jennings and overlying Hampshire Formation is gradational, showing an interlayering of typical reddish Hampshire-type sandstone and mudstone of nonmarine origin with typical Jennings-type sandstone and shale of marine origin. In our mapping, the contact was placed above the highest beds having marine fossils and below the predominant reddish sandstone. Accordingly, a large tongue of Hampshire was mapped as extending into typical Jennings rocks near the head of Jerrys Run.

The base of the Jennings Formation is not exposed within the study area.

TABLE 1.—*Chemical composition of two rocks from Ramseys Draft Wilderness Study Area*

[Method used was a single-solution procedure described by Shapiro (1967, p. 187-191); analyses performed in the U.S. Geological Survey Rapid Rock Analysis Laboratories by Hezekiah Smith]

Sample No. (Lab)	W-185516	W-185517
Sample No. (Field)	VRD060	VRD075
	(weight percent)	(weight percent)
	Igneous dike[1]	Sandstone[2]
SiO_2	41.1	95.9
Al_2O_3	14.1	1.4
Fe_2O_3	5.6	.18
FeO	5.4	.24
MgO	8.5	.14
CaO	12.2	.16
Na_2O	2.4	.00
K_2O	2.3	.20
H_2O^+	3.0	.55
H_2O^-	.56	.05
TiO_2	1.8	.13
P_2O_5	1.3	.04
MnO	.23	.03
CO_2	.65	.03
Total	99	99

[1]Scattered chips from float of alkalic mafic igneous dike near Shenandoah Mountain trail, northwest edge of Ramseys Draft Study Area. Location shown on plate 2.

[2]Chip sample from a 1-m thick, light gray, arkosic sandstone in upper part of Jennings Formation on Shenandoah Mountain, western edge of Ramseys Draft Study Area. Location shown on plate 2.

HAMPSHIRE FORMATION

The distinctive reddish slabby sandstone of the Hampshire Formation of Late Devonian age crops out over more than half of the Ramseys Draft Study Area. The formation was named by Darton (1892, p. 17) for the dark-red sandstones above the Jennings Formation in Hampshire County, West Va., about 70 miles (112 km) northeast of Ramseys Draft. The term Catskill Formation is used in Pennsylvania for the same rocks and was used for a while in Virginia (Butts, 1933). The Hampshire Formation is well exposed along the main valley of Ramseys Draft and forms scattered cliffs 20 feet (6 m) or more high along the ridges in the area. The formation is 1,900 to 2,000 feet (570 to 600 m) thick, but no complete section has been measured in the general area. South of Ramseys Draft, the formation thins rapidly. It is not present south of Elliott Knob, according to Butts (1940, p. 334), but Woodward (1943, p. 509) reported 500 feet (150 m) of red beds as far south as northern Botetourt County, Va.

The Hampshire is composed of thin- to thick-bedded, generally crossbedded, sandstone and interlayered mudstone. Most of the sandstone is grayish red to brownish gray; some is greenish gray. Crossbedded layers that commonly are 1 to 5 cm thick are present in lenses 1 to 2 m thick. The sandstone is typically very fine to fine grained, a few beds are medium to coarse grained, and some are conglomeratic. The sand is primarily quartz, but minor amounts of feldspar and muscovite are also present. Chert, rock fragments, sericite, and clay are common accessories. Feldspar is generally altered to clay or sericite. The distinctive red color is caused by a fine coating of hematite on the sand grains. The interbedded greenish-gray sandstone commonly contains plant fragments, chiefly stems or grasslike material and irregular pieces of other plants. The plant material is now represented by thin coaly seams or iron-stained impressions, where the organic matter had been completely removed during burial. The mineral content of the greenish sandstone is similar to that of the red, but the sand grains do not have hematite coatings. The trace-element contents of the green and red beds are similar (table 2). The red beds may contain a little more iron and magnesium but less copper, manganese, and zirconium than the green beds. The differences, however, are too small to be significant.

The interbedded mudstone in the Hampshire Formation is poorly exposed but forms a distinctive dark-maroon soil. The rock is generally grayish red to brownish gray but locally is light medium gray to olive gray. Some of the thick reddish units have irregularly mottled greenish-gray areas, generally near organic remains; these are suggestive of bleached zones. One of the best exposures is along the access road in Ramseys Draft about 0.3 mile (0.5 km) from the main highway. Interlayered greenish-gray

TABLE 2.—*Trace element composition of sandstones and shales from the Ramseys and the "average"*

[N, not detected at limit given;

	Jennings Formation sandstone	Pocono Formation sandstone	Hampshire Formation		Catskill
			Green sandstone	Red sandstone	Green sandstone mineralized
Number of samples	6	6	15	17	6
Element	Median value in parts per million (ppm)				
Ag	N(0.5)	N(0.5)	N(0.5)	N(0.5)	5
B	12	15	20	20	40
Ba	125	70	150	150	400
Be	N(1)	N(1)	L(1)	L(1)	1.5
Ca	N(500)	N(500)	L(500)	L(500)	1000
Co	N(5)	N(5)	7	7	17.5
Cr	L(10)	10	15	15	100
Cu	L(5)	N(5)	5	L(5)	3000
Fe	7000	10,000	10,000	15,000	17,500
La	N(20)	L(20)	L(20)	L(20)	50
Mg	200	1000	1500	2000	7000
Mn	30	30	150	100	700
Nb	N(20)	N(20)	N(20)	N(20)	20
Ni	5	7	15	15	30
Pb	N(10)	N(10)	N(10)	N(10)	500
Sc	L(5)	5	L(5)	5	15
Ti	700	1500	1500	1500	7000
V	12	15	30	30	200
Y	L(10)	15	15	10	30
Zn	18	24	36	32	72
Zr	100	200	200	150	300
eU	L(30)	L(30)	L(30)	L(30)	60

[1]Data from Lesure, Motooka, and Weis (1977).

[2]From Pettijohn (1963, p. S11) and Turekian and Wedepohl (1961, table 2).

[3]Order of magnitude estimated by Turekian and Wedepohl (1961, table 2).

siltstone and mudstone contain a lens of hard calcareous mudstone. More massive red mudstone or siltstone mottled with green was uncovered during construction of the new bridge on U.S. Route 250 across Road Hollow, 0.1 mile (150 m) upstream from the picnic area and outside the study area.

The Hampshire Formation is overlain conformably by the Pocono Formation of Early Mississippian age. The contact is a zone probably less than 300 feet (100 m) thick, where the red and greenish thin slabby crossbedded sandstones of the Hampshire grade upward into cleaner, lighter colored, and coarser grained sandstones of the Pocono. The contact was drawn above the highest prominent red sandstone or mudstone.

The Hampshire red beds are part of a series of deltas deposited at the mouths of several rivers during Late Devonian time in an area extending from New York through Pennsylvania, Maryland, western Virginia, and eastern West Virginia. Although the formation is mostly nonmarine, some intertonguing with marine beds is shown

Draft Wilderness Study Area compared with some similar rocks from Pennsylvania sandstone

L, detected but below limit of determination]

Formation[1] Red sandstone	Green sandstone nonmineralized	"Average" sandstone[2]	Hampshire Formation Green shale		Catskill Formation[1] Green mineralized shale
4	2		Sample No. 107	Sample No. 108	6
	Average		(ppm)		range in values (ppm)
N(0.5)	N(0.5)	0.0X[3]	1	N(0.1)	0.5-10
30	45	20-30	30	30	30-50
1250	400	300	150	200	500-2000
L(1)	L(1)	2	1	1	1-1.5
5000	3000	39,100	50,000	500	700-15,000
15	15	0.3	30	30	20-30
60	60	10-20	50	100	70-150
60	25	10-20	70	50	500-3000
20,000	15,000	9800	30,000	20,000	30,000-50,000
50	50	30	30	30	30-70
7000	8500	7000	30,000	10,000	15,000-20,000
1500	3250	500	5000	200	700-3000
20	25	.0X[3]	N(20)	L(20)	L(20)-20
30	30	2	50	50	50-70
12	20	9	150	10	20-7000
10	10	1	15	15	15-20
10,000	8500	1500	2000	5000	5000-7000
100	125	10-20	1000	150	150-300
20	50	4	30	20	30-70
43	43	16	100	68	59-86
500	500	200-250	100	200	200-300
35	L(30)	0.45	30	30	30-40

by the rare occurrences of marine fossils in sandstone, especially in the lower part.

POCONO FORMATION

The Pocono Formation of Early Mississippian age, consisting of massive, light-colored, medium-grained sandstone, is exposed in two areas along the axis of the syncline at the north end of the study area. The areas mapped as Pocono are a little more extensive than the one area shown by Darton (1894) on the Staunton quadrangle map. The formation was named by J. P. Lesley (1876) for similar rocks exposed in the Pocono Mountains of Pennsylvania, and Darton (1892) extended the usage of the term into Virginia. Darton (1894, p. 3) reported a thickness for the Pocono of 750 feet (225 m) near North River Gap, 7 miles (11 km) east of Ramseys Draft, but only the lower 500 feet (150 m) or so are preserved on the higher peaks at the north end of the Ramseys Draft Study Area.

The Pocono consists of light-colored quartzitic sandstone and conglomerate that weather very pale orange to light brown. Some of the outcrops have a knobby or warty appearance owing to small bumps and depressions preserved on an iron-stained surface. The sandstone is medium to coarse grained and locally friable. Some beds grade into conglomerate containing scattered, rounded quartz pebbles. The matrix is mostly of subrounded quartz grains, some having quartz overgrowths. Feldspar and muscovite are the principal accessory minerals; locally, small grains of chert and shale are present. The Pocono sandstone is relatively pure and contains lesser amounts of trace elements than the underlying Hampshire sandstone (table 2).

Beds range from less than a foot (30 cm) to more than 3 feet (1 m) in thickness, and many of the thicker beds show crossbedding. Sandstone beds are interlayered with some light-colored shale that is poorly exposed. Locally, this shale is darker colored because of a high organic content, and thin, poor-quality coal beds have been prospected in the upper part of the formation east of the study area. No coal was seen in that part of the formation preserved in the study area.

The Pocono Formation in the Ramseys Draft area probably represents a continuation of the deltaic sedimentation that formed the Hampshire Formation, but having less iron deposited with the sand. This difference may indicate a different source area for the sediments of the two areas, as suggested by Dally (1956, p. 122). The presence of coal in the upper part of the formation establishes a nonmarine origin; the sandstone grades into marine beds containing fossils of Mississippian age to the west in West Virginia (Dally, 1956, p. 96).

IGNEOUS DIKE

A dark-gray igneous dike is poorly exposed near the trail on Shenandoah Mountain between the head of Freezland Hollow and the Left Prong of Ramseys Draft. It appears as rounded residual boulders in an area at least 250 feet (75 m) long and 5 to 15 feet (1.5 to 4.5 m) wide. The general trend is N. 75° W. across the ridge line, but the western end may swing toward the southwest. The rock is an alkalic mafic intrusive rock that has a porphyritic texture; large pyroxene crystals, 0.1–2 mm in length, are set in a fine-grained matrix of biotite and plagioclase. Magnetite is uniformly distributed throughout as 0.01 to 0.05 mm grains. The rock is composed of about 45 percent clinopyroxene, 20 percent plagioclase, 15 percent biotite, 8 percent magnetite, and 12 percent other fine-grained minerals, including calcite and probably analcite. The dike is classified as a very mafic alkali basalt or lamprophyre. Major oxides are given in table 1 and trace elements in table 5.

Similar dikes and small intrusive bodies have been described by

Johnson and others (1971) in the general area east of Ramseys Draft and by Garner (1956) in the adjacent part of Pendleton County, W. Va. More recent studies by Zartman and others (1967) indicate a Jurassic age (150 m.y.) for these dikes. A swarm of more felsic dikes, exposed 10–16 miles (16–25 km) west of the study area, has been dated by Fullagar and Bottino (1969) as Eocene (47 m.y.).

STRUCTURE

The rocks of the Ramseys Draft Wilderness Study Area have been folded into a relatively simple broad syncline that plunges gently northeast. This syncline is a broad warp in the Paleozoic sedimentary rocks that is at least 150 miles (240 km) long. From the study area, the fold extends southwest for 50 miles (80 km) nearly to Clifton Forge in Allegheny County, Va., and northeast for at least 100 miles (160 km) into Maryland. Butts (1940, p. 455) named this structure the McClung syncline after the town of McClung, Bath County, Va., 25 miles (40 km) southwest (fig. 1); it has also been called the Shenandoah Mountain syncline (Tilton and others, 1927, p. 235).

The rocks of the study area are flat-lying along the axis of the fold in the main part of Ramseys Draft. Along the ridges on either side of the valley, dips range from 5 to 45 degrees toward the axis of the syncline. Steeper dips in the Jennings Formation outside the study area are in minor second-order folds related to the major syncline. Such minor folds have amplitudes of a few tens of meters to as much as a hundred meters and are restricted to the less competent parts of the Jennings Formation. Some are overturned toward the northwest and plunge steeply northeast. Many such folds are exposed along U.S. Route 250 southeast of Ramseys Draft.

No major faults are exposed in the study area, but a large nearly flat thrust fault is probably present in Cambrian rocks about 15,000 feet (4,500 m) beneath the surface (Perry, 1964; Jacobeen and Kanes, 1974). A regional northwest-trending zone of fractures probably passes through the area and controls the location of the igneous dike (Dennison and Johnson, 1971). Such fractures are certainly not prominent in the rocks exposed.

GEOCHEMICAL SURVEY

SAMPLING AND ANALYTICAL TECHNIQUES

A reconnaissance geochemical survey of the Ramseys Draft Study Area included analyses for 32 elements, among which are the more common metals that potentially could be present in economic concentrations (tables 3, 4, 5, and 6). Samples collected included 84 stream sediments, 38 pairs of soil and forest litter, and 48 rocks (pl. 2). Twenty-seven additional rock samples, located on plate 2, were collected for physical and chemical tests by personnel of the U.S. Bureau of Mines.

All small drainage basins within the study area were sampled by collecting a few handsful of the finest sediment possible. In the tables and maps, samples from 59 flowing streams are distinguished from those from 25 dry or intermittent streams. All but a few of the small drainage basins surrounding the study area were

TABLE 3.—*Analyses of stream-sediment samples from Ramseys Draft*

[For sample localities see plate 2. Coordinates refer to Universal Transverse Mercator (UTM) grid. Six-step absorption) by G. L. Crenshaw, and equivalent uranium (eU) by Z. C. Stephenson. Results of the semiquanti- approximate midpoints of group data on a geometric scale. The assigned groups for the series will include the Letter symbols: L, detected but below limit of determination; N, not detected; G, greater than; B, not looked for; is minus 80-mesh fraction; second listing designated with "A" added to sample number is oxalic acid leachate determination (minus 80-mesh sample first, leachate second—; Ag (0.5; 1), As (200; 500), Au (10; 20), Bi (10; 20), by atomic absorption methods, but no gold was detected at a lower limit of 0.05 ppm Au]

Sample	X-coord.	Y-coord.	S-Fe percent	S-Mg percent	S-Ca percent	S-Ti percent	S-Mn	S-B	S-Ba	S-Be	S-Co
					Dry or intermittent streams						
VRD011	646350	424462	1.5	0.20	0.10	0.150	3000	20	700	3.0	15
VRD011A	646350	424462	20.0	2.00	3.00	.070	10000 G	10 L	5000	20.0	150
VRD013	646500	424460	1.0	.20	.30	.150	2000	15	300	2.0	7
VRD014	646040	424436	1.5	.20	.15	.200	1000	15	300	2.0	10
VRD014A	646040	424436	5.0	.70	1.00	.050	10000 G	20	2000	20.0	70
VRD017	644900	424371	.7	.07	.05	.300	150	15	150	1.0 N	5 N
VRD017A	644900	424371	5.0	1.50	2.00	.070	7000	70	2000	7.0	50
VRD018	644760	424344	2.0	.30	.10	.300	2000	30	500	2.0	15
VRD018A	644760	424344	15.0	1.50	2.00	.070	10000 G	30	3000	15.0	200
VRD069	645040	424457	1.5	.30	.10	.200	1500	30	500	3.0	15
VRD069A	645040	424457	15.0	2.00	2.00	.010	10000 G	20	3000	20.0	150
VRD070	644750	424477	1.0	.20	.20	.200	1500	20	500	3.0	7
VRD070A	644750	424477	10.0	2.00	1.50	.050	10000 G	30	3000	15.0	100
VRD081	643580	424460	1.5	.20	.70	.200	2000	20	500	3.0	20
VRD081A	643580	424460	15.0	1.50	1.50	.050	10000 G	30	1000	10.0	300
VRD082	643860	424457	2.0	.20	.10	.200	1000	20	300	3.0	15
VRD082A	643860	424457	15.0	1.50	1.50	.050	10000	20	1500	10.0	150
VRD209	646810	424503	1.5	.20	.10	.150	2000	20	500	3.0	10
VRD209A	646810	424503	10.0	1.50	2.00	.050	10000 G	30	5000	20.0	100
VRD210	646700	424469	1.5	.30	.30	.200	2000	20	500	3.0	15
VRD210A	646700	424469	15.0	1.50	1.50	.050	10000 G	30	2000	15.0	100
VRD212	645810	424424	1.0	.15	.10	.150	2000	20	300	2.0	7
VRD212A	645810	424424	10.0	1.50	2.00	.050	10000 G	30	5000	15.0	100
VRD214	645590	424412	1.5	.15	.07	.150	1000	20	300	3.0	10
VRD215	645100	424361	1.0	.15	.10	.200	1500	20	300	2.0	15
VRD215A	645100	424361	15.0	1.50	2.00	.070	10000 G	30	3000	10.0	300
VRD216	644950	424332	1.0	.15	.07	.200	1500	30	300	2.0	10
VRD216A	644950	424332	15.0	1.50	2.00	.070	10000 G	30	5000	30.0	100
VRD218	644400	424226	1.5	.30	.10	.200	2000	20	300	2.0	15
VRD220	647430	424653	1.5	.20	.10	.200	3000	30	500	3.0	15
VRD220A	647430	424653	15.0	.70	1.00	.015	10000 G	10 L	2000	10.0	150
VRD225	647640	424716	.5	.10	.50	.150	5000	10 L	700	2.0	5
VRD234	646390	424679	1.0	.15	.30	.150	2000	20	500	3.0	10
VRD235	646100	424673	1.0	.20	.15	.150	1500	30	500	3.0	7
VRD236	645820	424699	.7	.15	.30	.150	2000	15	200	2.0	7

sampled in the same manner. After drying in the laboratory, the samples were sieved and the minus 80 mesh fraction was used for analyses (table 3).

Soil samples and forest-litter samples were collected in the areas of little or poor outcrop, mainly in flat areas on drainage divides or along ridge lines. The soil samples were collected below most of the coarse organic matter but include some humus. The samples were dried and sieved; the minus 80-mesh fraction was used for analysis. Leaves, twigs, and humus above mineral soil constitute a

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semiquantitative spectrographic analyses (S) were made by J. M. Motooka, chemical analyses (AA, atomic tative analyses are reported to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.15, and 0.1, which represent quantitative value about 30 percent of the time. The data should not be quoted without stating these limitations. P, partial digestion. Values in parts per million (ppm) except where indicated in percent. First listing of sample of minus 80-mesh fraction. Elements looked for spectrographically bot not found and their lower limits of Cd (20; 50), Sb (100; 200), Sn (10; 20), W (50; 100). All minus 80-mesh fraction samples were also tested for gold

S-Cr	S-Cu	S-La	S-Mo	S-Nb	S-Ni	S-Pb	S-Sc	S-Sr	S-V	S-Y	S-Zn	S-Zr	AA-Zn P	eU
Dry or intermittent streams														
30	30	20	5 N	20 N	50	15	10	100 N	100	30	200 N	100	146	0 B
150	300	50	20	50 N	500	200	15	300	200	150	500 N	150	0 B	0 B
15	30	20 L	5 N	20 N	20	10 L	7	100 N	30	20	200 N	200	75	0 B
15	10	20 L	5 N	20 N	15	10 L	7	100 N	50	15	200 N	150	48	30 L
50	70	50 N	10	50 N	150	70	10 L	300	70	20 L	500 N	50	0 B	0 B
15	5	20 L	5 N	20 N	5	10 N	5	100 N	30	15	200 N	300	18	30 L
50	100	50 N	15	50 N	100	150	10 L	500	100	20	500 L	70	0 B	0 B
30	15	20 L	5 N	20 N	20	10	10	100 N	100	20	200 N	150	50	30 L
150	100	50 N	15	50 N	150	150	20	300	200	100	500 L	150	0 B	0 B
30	50	20 L	5 N	20 N	30	10	10	100 N	100	30	200 N	200	52	30 L
150	300	50	10	50 N	200	150	20	300	200	150	500 L	150	0 B	0 B
15	20	20 L	5 N	20 N	20	10 L	7	100 N	50	20	200 N	70	77	0 B
100	200	50 N	10 L	50 N	200	150	10	300	150	20 L	500 L	100	0 B	0 B
50	20	20	5 N	20 N	70	20	10	100 N	100	20	200 N	100	146	0 B
100	200	70	10 L	50 N	700	200	10	200	150	100	500	100	0 B	0 B
50	15	20	5 N	20 N	30	15	10	100 N	100	20	200 N	150	86	0 B
150	150	50 N	10	50 N	200	150	10	200	200	70	500 L	150	0 B	0 B
30	15	20	5 N	20 N	20	30	7	100 N	70	15	200 N	100	50	30 L
150	150	50 N	10	50 N	200	200	10	150	150	70	500 L	100	0 B	0 B
70	20	20	5 N	20 N	30	15	7	100 N	70	30	200 N	150	67	30 L
150	150	50 N	10 L	50 N	200	150	10	150	200	20	500 L	100	0 B	0 B
20	10	20 L	5 N	20 N	15	10	5	100 N	50	10	200 N	100	64	30 L
150	150	50 N	10	50 N	150	200	15	500	200	70	500 L	100	0 B	0 B
30	15	20 L	5 N	20 N	20	15	5	100 N	70	20	200 N	150	129	30 L
20	15	20 L	5 N	20 N	20	10 L	7	100 N	50	20	200 N	100	95	0 B
150	150	50 N	15	50 N	200	150	20	300	300	70	500 L	150	0 B	0 B
20	15	20 L	5 N	20 N	20	10	7	100 N	50	20	200 N	200	60	0 B
100	150	50 N	10	50 N	300	150	15	300	150	70	500 L	100	0 B	0 B
70	30	20 L	5 N	20 N	30	20	7	100 N	70	20	200 N	150	79	0 B
30	20	20	5 N	20 N	70	15	10	100 N	100	20	200 N	200	165	0 B
100	150	50	10	50 N	300	200	15	200	150	70	500	100	0 B	0 B
15	15	20 L	5 N	20 N	30	30	5	100 N	20	10 N	200	30	550	0 B
20	30	20 L	5 N	20 N	30	15	7	100 N	50	20	200 N	50	125	0 B
50	10	20 L	5 N	20 N	20	10	5	100 N	50	15	200 N	300	62	30 L
70	15	20 L	5 N	20 N	15	20	5	100 N	30	20	200 N	70	79	0 B

TABLE 3.—*Analyses of stream-sediment samples from Ramseys Draft Wilder-*

Sample	X-coord.	Y-coord.	S-Fe percent	S-Mg percent	S-Ca percent	S-Ti percent	S-Mn	S-B	S-Ba	S-Be	S-Co
					Dry or intermittent streams—*Continued*						
VRD236A	645820	424699	20.0	2.00	2.00	0.070	10000 G	50	2000	10.0	300
VRD241	647030	424590	1.5	.20	.30	.200	5000	30	700	3.0	15
VRD241A	647030	424590	15.0	1.50	2.00	.050	10000 G	30	3000	10.0	200
VRD272	643450	424119	2.0	.30	.10	.200	1500	30	300	2.0	15
VRD272A	643450	424119	15.0	1.50	1.50	.070	10000 G	30	2000	10.0	150
VRD273	642990	424113	1.5	.30	.10	.300	1500	50	300	2.0	15
VRD279	643630	424121	1.5	.30	.07	.200	1000	20	200	1.5	15
VRD279A	643630	424121	20.0	1.50	1.50	.100	10000 G	20 L	1500	7.0	200
					Flowing streams						
VRD002	643830	424190	1.5	0.30	0.15	0.200	1000	20	300	1.5	15
VRD002A	643830	424190	30.0	5.00	2.00	.050	10000 G	20 L	2000	3.0	200
VRD005	640540	424212	2.0	.30	.05	.300	1000	30	500	1.5	20
VRD005A	640540	424212	30.0	5.00	1.00	.050	10000	20 L	2000	3.0	300
VRD006	644940	424854	1.0	.15	.05	.200	1000	15	200	1.0	10
VRD006A	644940	424854	30.0	5.00	2.00	.050	10000	20 L	2000	3.0	300
VRD007	644960	424852	1.5	.20	.05	.200	700	30	300	1.5	15
VRD007A	644960	424852	30.0	7.00	1.50	.050	10000	20 L	2000	3.0	300
VRD008	645130	424945	2.0	.30	.05	.200	1000	30	300	1.5	20
VRD008A	645130	424945	30.0	7.00	.70	.020	10000	20 L	2000	2.0	300
VRD009	643590	424894	2.0	.30	.05 L	.200	700	20	300	1.0	15
VRD009A	643590	424894	50.0	7.00	.70	.030	10000	20 L	2000	2.0	300
VRD016	645270	424413	1.5	.20	.05 L	.200	500	30	150	1.0	10
VRD016A	645270	424413	50.0	7.00	1.50	.070	10000	20 L	2000	5.0	300
VRD019	644540	424304	1.0	.15	.05 L	.150	500	15	150	1.0 L	10
VRD021	644640	424272	.7	.15	.05	.150	700	10	200	1.0	7
VRD021A	644640	424272	30.0	7.00	3.00	.070	10000 G	20	3000	7.0	300
VRD022	644200	424228	.5	.10	.05	.150	700	15	150	1.5	7
VRD022A	644200	424228	30.0	7.00	3.00	.070	10000 G	20	3000	10.0	300
VRD046	645720	424721	1.0	.15	.05	.200	700	20	150	1.0	10
VRD046A	645720	424721	30.0	7.00	2.00	.070	10000 G	20	3000	5.0	300
VRD047	645800	424730	1.5	.20	.07	.150	1000	15	300	2.0	10
VRD048	645530	424744	1.0	.20	.05 L	.200	300	20	150	1.0	10
VRD048A	645530	424744	30.0	7.00	1.50	.070	10000	20 L	2000	3.0	300
VRD055	644490	424480	1.0	.20	.05 L	.200	700	20	150	1.0	10
VRD055A	644490	424480	50.0	7.00	2.00	.070	10000 G	20 L	2000	3.0	300
VRD056	644670	424616	1.0	.20	.05	.200	700	20	150	1.0 L	10
VRD056A	644670	424616	50.0	7.00	3.00	.070	10000 G	20 L	3000	5.0	300
VRD071	644120	424490	1.5	.30	.05	.300	700	20	200	1.0 L	15
VRD071A	644120	424490	50.0	7.00	1.50	.070	10000 G	20 L	2000	3.0	300
VRD079	643190	424428	1.5	.20	.05 L	.300	500	20	150	1.0	10
VRD079A	643190	424428	50.0	7.00	.70	.070	10000	20 L	1500	3.0	200
VRD080	643090	424436	1.5	.20	.05 L	.300	700	20	200	1.0	20
VRD080A	643090	424436	50.0	3.00	.70	.070	10000	20 L	2000	5.0	500
VRD109	646250	423939	2.0	.30	.05 L	.300	700	30	300	1.0	15
VRD109A	646250	423939	50.0	5.00	.70	.050	10000	20 L	2000	2.0	300
VRD114	643030	424746	1.5	.20	.05 L	.200	500	20	150	1.0 L	10
VRD114A	643030	424746	50.0	7.00	.70	.050	10000	20 L	2000	2.0	300
VRD115	642970	424636	1.5	.20	.05 L	.150	700	20	150	1.0	10
VRD115A	642970	424636	30.0	7.00	.50	.020	10000	20 L	2000	2.0	300
VRD116	642230	424560	1.5	.30	.05	.200	700	20	300	1.0	15
VRD116A	642230	424560	30.0	7.00	.70	.050	10000	20 L	2000	3.0	300
VRD117	641150	424473	1.5	.30	.05	.200	700	30	300	1.0	15
VRD117A	641150	424473	30.0	7.00	2.00	.050	1000	20 L	2000	3.0	200
VRD118	641140	424428	2.0	.50	.05 L	.200	500	30	200	1.0	15
VRD118A	641140	424428	30.0	7.00	.70	.050	7000	20 L	1500	3.0	200
VRD203	643850	424026	1.5	.20	.05 L	.150	500	30	150	1.0	10
VRD203A	643850	424026	30.0	5.00	2.00	.070	10000	20 L	1500	3.0	200
VRD204	644220	423929	1.5	.20	.05 L	.150	700	20	150	1.0 L	10
VRD204A	644220	423929	30.0	5.00	2.00	.070	10000 G	20 L	2000	5.0	300

ness Study Area and vicinity, Augusta and Highland Counties, Va.—Continued

S-Cr	S-Cu	S-La	S-Mo	S-Nb	S-Ni	S-Pb	S-Sc	S-Sr	S-V	S-Y	S-Zn	S-Zr	AA-Zn P	eU
						Dry or intermittent streams—*Continued*								
200	200	50 N	15	50 N	300	200	15	300	300	70	500 L	150	0 B	0 B
30	30	20 L	5 N	20 N	30	20	10	100 N	70	20	200 N	150	94	30 L
100	150	50 N	15	50 N	300	150	15	300	200	50	500 L	150	0 B	0 B
70	20	20 L	5 N	20 N	30	15	7	100 N	70	20	200 N	200	64	0 B
150	150	50 L	15	50 N	300	150	15	300	150	150	500 L	150	0 B	0 B
50	15	20	5 N	20 N	30	10	10	100 N	70	30	200 N	300	69	0 B
30	15	20	5 N	20 N	30	10	7	100 N	70	20	200 N	150	80	0 B
150	200	50 L	10	50 N	300	70	20	200	200	100	500 L	150	0 B	0 B
						Flowing Streams								
50	20	30	5 N	20 N	30	15	10	100 N	100	30	200 N	200	78	30 L
300	200	50 N	15	50 N	300	200	50	200	300	30	500	150	0 B	0 B
70	20	50	5 N	20 L	50	20	15	100 L	150	30	200 N	200	135	30 L
300	150	50	10	50 N	300	200	50	200	300	100	700	150	0 B	0 B
30	10	30	5 N	20 N	30	15	10	100 N	100	20	200 N	150	93	0 B
700	200	50	20	50 N	300	200	50	300	300	150	500 L	150	0 B	0 B
50	20	30	5 N	20 N	30	20	10	100 L	100	20	200 N	150	94	30 L
700	200	50	15	50 N	300	150	50	300	300	150	500 L	150	0 B	0 B
70	15	50	5 N	20 L	50	20	15	100 L	100	30	200 N	200	85	0 B
500	200	50 L	10	50 N	300	150	50	200 N	300	100	500 L	150	0 B	0 B
70	15	20	5 N	20 N	30	15	10	100 N	100	20	200 N	150	77	0 B
700	300	50 L	15	50 N	300	150	50	200 L	300	70	500 L	150	0 B	0 B
30	7	30	5 N	20 L	20	10	10	100 N	70	30	200 N	300	48	30 L
700	300	50 L	15	50 N	500	200	50	200 L	300	100	500	150	0 B	0 B
50	7	20	5 N	20 N	20	10 N	7	100 N	50	15	200 N	300	230	30 L
20	15	20	5 N	20 N	30	10	5	100 N	50	15	200 N	200	63	0 B
500	300	50 L	20	50 N	700	150	50	300	300	50	500 L	150	0 B	0 B
10	5	20 N	5 N	20 N	15	10 N	5	100 N	30	15	200 N	70	40	30 L
700	300	50 L	20	50 N	700	200	30	300	300	70	500 L	100	0 B	0 B
20	7	20	5 N	20 N	20	10 L	7	100 N	50	20	200 N	300	58	30 L
500	300	50 L	10	50 N	300	200	50	200	300	70	500	150	0 B	0 B
30	20	20	5 N	20 N	20	10	10	100 N	70	20	200 N	70	97	0 B
50	10	30	5 N	20 N	30	10 L	7	100 N	70	20	200 N	150	51	30 L
300	200	50	15	50 N	300	200	50	200 L	300	100	500	150	0 B	0 B
20	7	30	5 N	20 L	20	10	7	100 N	70	20	200 N	200	68	30 L
300	200	50 N	10	50 N	500	150	50	200 L	300	70	500	150	0 B	0 B
30	15	30	5 N	20 N	20	15	7	100 N	50	15	200 N	300	57	30 L
500	300	50 N	15	50 N	500	200	50	200	300	70	500	150	0 B	0 B
70	20	30	5 N	20 N	50	15	10	100 N	100	20	200 N	200	85	0 B
300	300	50	15	50 N	700	200	50	200	300	100	500	150	0 B	0 B
20	7	30	5 N	20 L	20	10 L	7	100 N	70	15	200 N	300	70	30 L
700	200	50	10	50 N	300	200	50	200 N	300	70	500	150	0 B	0 B
50	10	30	5 N	20 L	50	10	10	100 N	100	20	200 N	200	122	30 L
700	200	50	10	50 N	700	200	50	200 N	500	70	700	150	0 B	0 B
70	15	30	5 N	20 L	30	20	10	100 N	100	20	200 N	200	86	30 L
300	200	50	10	50 N	300	150	50	200 L	300	70	500	150	0 B	0 B
30	10	30	5 N	20 N	20	10 L	7	100 N	70	15	200 N	150	72	30 L
500	200	50	15	50 N	300	150	50	200 L	300	70	500 L	150	0 B	0 B
30	10	30	5 N	20 N	20	10 L	7	100 N	70	20	200 N	70	95	0 B
700	150	50	15	50 N	300	150	30	200	300	70	500 L	100	0 B	0 B
70	15	30	5 N	20 N	30	15	10	100 N	100	20	200 N	100	89	30 L
500	150	50	10	50 N	300	150	30	200	300	70	500	150	0 B	0 B
70	15	30	5 N	20 N	30	15	10	100 L	100	20	200 N	100	100	30 L
700	200	50	20	50 N	300	200	30	300	500	150	500 L	150	0 B	0 B
70	15	30	5 N	20 N	30	10 L	10	100 L	100	20	200 N	150	78	30 L
700	200	50	20	50 N	300	200	30	200 L	500	100	500	150	0 B	0 B
30	7	20	5 N	20 N	20	10	7	100 N	70	20	200 N	300	56	30 L
700	200	50	20	50 N	300	200	30	200	500	150	500 N	200	0 B	0 B
50	15	20	5 N	20 N	30	15	7	100 N	70	15	200 N	150	71	30 L
700	200	50	20	50 N	300	200	30	200 L	500	150	500 L	200	0 B	0 B

TABLE 3.—*Analyses of stream-sediment samples from Ramseys Draft Wilder*

Sample	X-coord.	Y-coord.	S-Fe percent	S-Mg percent	S-Ca percent	S-Ti percent	S-Mn	S-B	S-Ba	S-Be	S-Co
						Flowing streams—*Continued*					
VRD205	644890	424855	1.5	0.30	0.05	0.300	700	30	300	1.5	15
VRD206	645160	424963	1.5	.30	.05	.300	700	30	200	1.5	15
VRD206A	645160	424963	30.0	5.00	1.00	.050	7000	20 L	2000	3.0	200
VRD207	643960	424964	3.0	.50	.05 L	.300	700	30	200	1.5	20
VRD207A	643960	424964	30.0	5.00	.50	.020	10000	20 L	1500	2.0	150
VRD208	643150	424827	1.5	.20	.05 L	.200	700	30	150	1.5	15
VRD208A	643150	424827	30.0	5.00	.70	.050	10000	20 L	2000	5.0	300
VRD219	644290	424205	1.0	.15	.05	.150	1000	20	150	1.0	10
VRD219A	644290	424205	30.0	3.00	2.00	.100	10000 G	20 L	2000	7.0	200
VRD221	647670	424690	1.5	.10	.05	.150	2000	20	150	3.0	20
VRD221A	647670	424690	30.0	1.50	.70	.070	10000 G	20 L	3000	20.0	700
VRD226	647930	424750	.7	.05	.05 L	.150	1000	20	100	1.0	15
VRD226A	647930	424750	30.0	1.50	.50	.070	10000 G	20 L	2000	15.0	700
VRD230	647060	424643	1.0	.10	.05 L	.200	2000	20	150	2.0	15
VRD231	646760	424637	1.5	.20	.05 L	.200	700	30	150	1.5	10
VRD232	646740	424648	1.0	.15	.05 L	.200	2000	20	150	1.0	15
VRD232A	646740	424648	30.0	2.00	1.00	.070	10000 G	20 L	2000	7.0	300
VRD237	645570	424775	1.5	.30	.05 L	.200	1500	30	150	1.0	15
VRD237A	645570	424775	30.0	3.00	1.50	.070	10000	20 L	1500	3.0	200
VRD238	645590	424848	.7	.10	.05 L	.150	300	15	100	1.0	7
VRD238A	645590	424848	30.0	5.00	1.50	.150	10000	20 L	1500	5.0	200
VRD239	646770	424564	1.5	.15	.05 L	.200	1500	20	150	1.0	15
VRD242	646890	424525	.7	.07	.05	.100	700	10	150	1.5	5
VRD242A	646890	424525	30.0	3.00	2.00	.070	10000	30	3000	10.0	200
VRD243	646680	424525	1.0	.10	.05 L	.150	1000	15	150	1.0	10
VRD269	642020	424074	1.0	.20	.05 L	.200	500	20	150	1.0	10
VRD269A	642020	424074	30.0	5.00	1.00	.050	10000	20 L	1500	3.0	200
VRD270	642200	424156	1.5	.30	.05 L	.200	700	30	150	1.0	15
VRD270A	642200	424156	30.0	3.00	1.00	.050	10000	20 L	1500	3.0	200
VRD274	642860	424259	1.5	.30	.05 L	.150	500	30	150	1.0	10
VRD274A	642860	424259	30.0	7.00	2.00	.070	10000	20 L	1500	5.0	150
VRD278	643640	424202	1.5	.30	.07	.200	700	30	200	1.0	10
VRD278A	643640	424202	20.0	5.00	2.00	.070	10000	20 L	1500	5.0	150
VRD280	646550	423957	1.5	.30	.05 L	.200	700	30	200	1.0	15
VRD280A	646550	423957	20.0	5.00	2.00	.050	7000	20 L	1500	3.0	200
VRD281	648410	424859	1.5	.15	.05 L	.150	1500	15	200	1.5	15
VRD281A	648410	424859	20.0	2.00	1.00	.070	10000 G	20 L	2000	5.0	200
VRD282	648420	424852	1.5	.10	.05 L	.150	1000	20	150	1.5	15
VRD282A	648420	424852	20.0	1.50	.70	.050	10000	20 L	1500	7.0	200
VRD283	649880	424883	1.5	.15	.05 L	.150	1500	20	150	1.0	15
VRD283A	649880	424883	20.0	2.00	.70	.070	10000	20 L	1500	7.0	300
VRD284	650620	424750	1.5	.15	.05 L	.150	1500	20	150	1.5	15
VRD284A	650620	424750	20.0	2.00	1.00	.070	10000	20 L	2000	7.0	300
VRD285	650880	424682	1.0	.15	.05 L	.150	700	20	150	1.0	10
VRD285A	650880	424682	20.0	3.00	1.50	.070	10000	20	1500	7.0	200
VRD286	649170	424522	1.5	.20	.05 L	.150	1000	20	200	1.5	10
VRD286A	649170	424522	30.0	5.00	2.00	.100	10000	20	2000	7.0	100
VRD287	648480	424380	2.0	.30	.05	.200	700	30	150	1.0	10
VRD288	648370	424309	1.5	.20	.05 L	.200	700	30	150	1.5	10
VRD290	647080	424125	1.5	.20	.05 L	.200	700	30	150	1.0	15
VRD290A	647080	424125	30.0	3.00	1.00	.070	7000	20 L	1500	3.0	100
VRD291	647150	424140	1.5	.30	.05 L	.200	700	30	150	1.0	15
VRD291A	647150	424140	30.0	5.00	1.00	.070	10000	20 L	1500	2.0	150
VRD292	643280	424697	1.5	.30	.05 L	.200	700	20	200	1.0	15
VRD292A	643280	424697	15.0	3.00	.70	.020	7000	20 L	1500	5.0	100
VRD293	642650	424580	1.5	.20	.05 L	.200	700	20	300	1.0	15
VRD293A	642650	424580	20.0	3.00	.70	.020	7000	20 L	1500	2.0	150
VRD294	642060	424542	1.5	.15	.05	.150	700	20	150	1.0	10
VRD294A	642060	424542	15.0	5.00	.70	.020	10000	20 L	1500	2.0	150

ness Study Area and vicinity, Augusta and Highland Counties, Va.—Continued

S-Cr	S-Cu	S-La	S-Mo	S-Nb	S-Ni	S-Pb	S-Sc	S-Sr	S-V	S-Y	S-Zn	S-Zr	AA-Zn P	eU
						Flowing streams—*Continued*								
70	15	30	5 N	20 N	20	10	10	100 L	100	20	200 N	150	75	0 B
70	15	30	5 N	20 L	30	15	10	100 L	100	20	200 N	200	69	0 B
500	200	50	15	50 N	300	200	30	200 L	500	150	500 L	150	0 B	0 B
70	15	30	5 N	20 L	50	15	10	100 N	150	30	200 N	150	96	0 B
500	150	50 N	15	50 N	200	150	30	200 N	500	70	500 L	100	0 B	0 B
50	7	30	5 N	20 L	20	10 L	10	100 N	100	20	200 N	150	79	30 L
700	200	50 L	20	50 N	300	200	30	200 L	500	100	500 L	200	0 B	0 B
15	7	20	5 N	20 N	15	10 L	7	100 N	50	15	200 N	150	44	0 B
500	150	50	15	50 N	300	150	30	300	500	150	500 N	150	0 B	0 B
15	7	20	5 N	20 N	70	30	7	100 N	50	20	200 L	150	192	0 B
700	200	50	20	50 N	2000	2000	30	200 L	500	100	1500	150	0 B	0 B
20	5 L	20 L	5 N	20 N	30	10 L	5 L	100 N	30	10 L	200 N	150	104	30 L
700	150	50 L	20	50 N	1000	700	30	200 N	500	70	1000	150	0 B	0 B
20	10	20	5 N	20 L	70	20	7	100 N	50	10	200 L	200	240	0 B
30	10	30	5 N	20 L	30	10	7	100 N	70	20	200 N	200	64	0 B
15	10	30	5 N	20 N	70	10	7	100 N	70	20	200 N	150	147	0 B
700	200	50	30	50 N	1000	200	30	200	500	150	500	150	0 B	0 B
70	15	30	5 N	20 N	30	10	10	100 N	100	20	200 N	150	88	0 B
500	200	50 L	15	50 N	300	200	30	200 L	300	100	500 L	150	0 B	0 B
15	5	20	5 N	20 N	15	10 L	5	100 N	30	10	200 N	150	62	30 L
700	200	50 L	20	50 N	300	200	30	200 L	500	100	500 N	200	0 B	0 B
20	10	20 L	5 N	20 L	30	10 L	7	100 N	70	20	200 N	200	57	0 B
20	15	20 L	5 N	20 N	20	10 L	5	100 N	30	15	200 N	100	46	30 L
500	200	50 L	20	50 N	300	150	20	300	500	100	500 N	150	0 B	0 B
15	7	20	5 N	20 N	20	10 L	5	100 N	50	15	200 N	200	42	30 L
50	15	20	5 N	20 N	20	10	7	100 N	70	20	200 N	200	76	30 L
300	150	50 L	15	50 N	300	150	20	200 L	300	100	500 N	150	0 B	0 B
50	15	30	5 N	20 L	30	15	10	100 N	70	20	200 N	150	72	30 L
700	150	50 L	15	50 N	300	150	20	200 L	300	100	500 N	150	0 B	0 B
50	10	20	5 N	20 N	20	10	7	100 N	70	15	200 N	150	73	30 L
700	200	50 L	20	50 N	300	200	20	200 L	300	100	500 L	200	0 B	0 B
70	15	30	5 N	20 N	20	10	7	100 N	70	20	200 N	200	85	0 B
1000	150	50 L	20	50 N	300	150	20	200	300	150	500 N	150	0 B	0 B
70	15	30	5 N	20 L	30	20	10	100 N	100	20	200 N	150	83	30 L
1500	150	50 L	20	50 N	300	150	20	200	300	150	500 L	150	0 B	0 B
30	10	20	5 N	20 L	70	15	7	100 N	70	15	200 N	100	124	0 B
1000	150	50 L	50	50	500	200	20	200	300	100	500	150	0 B	0 B
30	10	30	5 N	20 N	30	10	7	100 N	70	15	200 N	100	96	0 B
2000	150	50 L	30	50 N	500	200	20	200	300	100	500 L	150	0 B	0 B
30	15	20	5 N	20 N	50	15	7	100 N	70	15	200 N	150	136	30 L
1000	150	50 L	20	50 N	500	200	20	200 L	300	100	700	150	0 B	0 B
50	15	20	5 N	20 N	50	15	7	100 N	70	15	200 N	200	85	30 L
700	150	50 L	30	70	300	200	20	200	300	100	500	200	0 B	0 B
20	10	20	5 N	20 N	30	10	7	100 N	70	20	200 N	150	60	0 B
1000	150	50 L	30	20 N	300	200	20	200	300	100	500 L	150	0 B	0 B
30	10	30	5 N	20 N	50	15	7	100 N	70	15	200 N	200	66	30 L
700	150	50 L	30	50 N	300	200	20	300	300	100	500 N	150	0 B	0 B
70	15	30	5 N	20 N	30	15	7	100 N	100	15	200 N	100	60	0 B
30	15	30	5 N	20 L	20	15	7	100 N	70	15	200 N	150	55	0 B
70	15	30	5 N	20 L	30	15	7	100 N	100	15	200 N	150	64	0 B
700	150	50 L	15	50 N	200	150	20	200 L	300	100	500 N	150	0 B	0 B
50	15	30	5 N	20 N	30	15	7	100 N	70	15	200 N	150	78	30 L
700	200	50 L	15	50 N	300	200	30	200 L	300	100	500 N	150	0 B	0 B
70	15	30	5 N	20 L	30	15	10	100 N	100	20	200 N	150	79	30 L
200	70	50 N	10 N	50 N	150	100	20	200 L	200	70	500 N	100	0 B	0 B
50	10	30	5 N	20 L	30	10	10	100 L	70	30	200 N	150	111	0 B
500	150	50 N	10	50 N	300	150	20	200 L	300	70	500 L	100	0 B	0 B
50	15	30	5 N	20 N	20	15	7	100 N	70	20	200 N	70	116	30 L
700	70	50 N	15	50 N	300	150	20	200 L	300	70	500 L	100	0 B	0 B

forest-litter sample. These were ashed, and percent ash was determined. All subsequent analyses were made on the ash.

The rock samples are representative of all the major rock types that are well exposed in the study area. No obviously mineralized rock was found. The one poorly exposed igneous rock is not altered or mineralized (sample no. VRD 060, tables 1 and 6; sample no. VRD 321, table 8); no mineralized veins should be expected with this type of igneous rock, and none was seen.

All samples were analyzed spectrographically for 30 elements

TABLE 4.—*Analyses of forest litter from Ramseys Draft Wilderness*

[For sample localities see plate 2. Coordinates refer to Universal Transverse Mercator (UTM) grid. Six-step absorption) and percent ash were made by G. L. Crenshaw. Results of the semiquantitative analyses are points of group data on a geometric scale. The assigned groups for the series will include the quantitative value per million (ppm) except where indicated as percent. Letter symbols: L, detected but below limit of determina- and lower limit of determination: Au (2), Nb (20), Sb (50), Sc (5), W (50)]

Sample	X-coord.	Y-coord.	S-Fe percent	S-Mg percent	S-Ti percent	S-Mn	S-Ag	S-As	S-B	S-Ba	S-Be	S-Bi	S-Cd
						Forest litter							
VRD025	647960	424602	2.0	0.2	0.10	10000 G	0.50	200N	150	500	2	1.0N	20
VRD027	648690	424642	2.0	.2	.20	10000 G	.30	200L	150	700	3	1.0L	30
VRD029	648540	424764	2.0	.2	.30	10000 G	.30	500	150	3000	20	1.0N	15
VRD032	647740	424792	2.0	.3	.30	10000 G	.30	200	200	1500	5	1.0	10
VRD034	646710	424833	1.5	.3	.10	10000 G	.20	200N	150	1500	2	1.0N	30
VRD038	645940	424814	3.0	.3	.20	10000 G	.30	200	200	2000	5	1.0	20
VRD040	646780	424768	1.5	1.0	.10	10000 G	.70	200L	200	1500	2	1.0N	30
VRD043	646560	424683	2.0	.3	.20	10000 G	.20	300	200	3000	7	1.0N	20
VRD050	645240	424778	2.0	.3	.30	10000 G	.70	200	150	2000	5	1.5	20
VRD052	646060	424900	2.0	.3	.10	10000 G	.30	200	150	3000	7	1.0N	20
VRD059	644390	424630	2.0	1.0	.10	10000 G	.30	200	150	5000	5	1.0N	15
VRD062	645440	424692	2.0	1.0	.10	10000 G	.30	300	200	3000	5	1.0N	30
VRD064	645170	424583	1.5	.2	.15	10000 G	.10	200N	200	1000	3	1.0N	7
VRD066	645870	424528	2.0	.5	.15	10000 G	.70	200L	200	1500	5	2.0	20
VRD068	645510	424457	2.0	.3	.20	10000 G	.20	200L	150	3000	5	1.0N	10
VRD074	644190	424562	3.0	.5	.50	10000 G	.30	300	150	3000	10	1.0N	10
VRD078	643730	424500	3.0	.3	.30	10000 G	.30	200L	200	2000	3	1.0N	15
VRD084	644350	424428	3.0	.3	.20	10000 G	.50	200L	200	1500	5	1.0	15
VRD086	643880	424390	2.0	.5	.15	10000 G	.50	300	200	5000	10	1.0L	30
VRD088	643480	424329	3.0	.5	.20	10000 G	.50	200	300	3000	5	1.0N	30
VRD090	644070	424274	3.0	1.0	.20	10000 G	.50	200L	300	3000	3	1.0N	20
VRD092	642020	424296	3.0	1.0	.15	10000 G	.30	300	200	10000	10	1.0N	20
VRD095	642700	424403	3.0	1.5	.15	10000 G	.70	500	300	5000	15	1.0	30
VRD098	643040	424354	2.0	1.5	.20	10000 G	.15	200	300	3000	5	1.0L	7
VRD100	642600	424295	3.0	.7	.30	10000 G	.50	200	200	3000	3	1.0N	20
VRD103	642650	424186	2.0	1.0	.15	10000 G	.50	200	200	5000	5	1.0N	20
VRD105	643110	424190	3.0	.2	.50	10000 G	.15	200L	150	2000	5	1.0L	15
VRD113	644340	424176	1.5	.3	.15	10000 G	.10	200L	200	3000	3	1.0N	10
VRD227	647110	424864	2.0	1.5	.20	10000 G	.50	200L	300	2000	3	1.0N	15
VRD247	648090	424556	2.0	.3	.15	10000 G	.20	200N	150	3000	3	1.0N	15
VRD250	647820	424490	3.0	1.0	.30	10000 G	.50	200	200	3000	5	1.0	20
VRD252	647540	424426	3.0	1.5	.15	10000 G	.50	200L	300	3000	2	1.0N	30
VRD254	648750	424361	2.0	.3	.30	10000 G	.20	200N	150	1500	3	1.0N	7
VRD256	648270	424612	3.0	.3	.20	10000 G	.30	200L	150	3000	3	1.0L	15
VRD258	645030	424300	1.5	.7	.10	10000 G	.15	300	200	5000	7	1.0N	10
VRD260	645900	424274	2.0	.3	.15	10000 G	.30	200N	200	2000	3	1.0N	10
VRD262	645480	424221	2.0	1.0	.10	10000 G	.50	200L	200	3000	5	1.0N	15
VRD267	645030	424121	1.5	2.0	.10	10000 G	.30	300	200	7000	5	1.0N	10

and chemically for gold in the U.S. Geological Survey laboratories, Denver, Colo. All except the forest-litter samples were analyzed chemically for zinc and were scanned for radioactivity, reported as eU or equivalent uranium. Selected samples were also analyzed for thorium and uranium by delayed neutron methods (table 7). In addition, the rock samples were analyzed for mercury. Because of the general low value of most trace elements, the stream sediment and soil samples were leached using oxalic acid, and the leachate was analyzed spectrographically.

Study Area and vicinity, Augusta and Highland Counties, Va.

semiquantitative spectrographic analyses (S) were made by J. M. Motooka; chemical analyses (AA, atomic
reported to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.15, and 0.1, which represent approximate mid-
about 30 percent of the time. The data should not be quoted without stating these limitations. All data in parts
tion: N, not detected; G, greater than; B, not looked for. Elements looked for spectrographically but not found

S-Co	S-Cr	S-Cu	S-La	S-Mo	S-Ni	S-Pb	S-Sn	S-Sr	S-V	S-Y	S-Zn	S-Zr	Ash percent
						Forest litter							
10 N	50	100	20 N	5	70	200	15	200	70	10	700	500	10.0
10 N	50	100	20 N	7	50	200	15	300	70	10	700	200	17.3
100	30	100	50	5	150	150	10	150	70	50	700	300	13.2
20	70	150	20	5	50	200	15	300	100	30	700	500	12.9
10 N	20	150	20 N	2	50	200	7	300	70	10	1500	150	7.4
10 N	70	150	20 N	5	100	200	15	300	100	20	1000	200	14.0
10 N	50	200	20 N	5	70	300	7	300	100	10	1000	100	5.2
10 N	70	150	20 N	20	100	200	7	700	70	20	700	150	7.5
10 N	70	200	20 N	10	70	500	15	700	100	20	700	150	6.6
10 N	50	150	20 N	5	100	300	15	300	70	20	700	200	10.2
10 N	50	150	20 N	2	100	200	10	700	70	20	700	100	9.7
10 N	30	200	20 N	2	100	200	7	500	70	50	1500	150	11.2
10 N	20	70	20 N	2 L	30	100	5	200	50	15	500	500	19.6
10 N	50	300	20 N	7	70	500	15	500	100	15	1000	150	7.9
10 N	50	100	20 N	2	70	150	7	500	70	15	500	150	12.9
30	70	100	20	2	100	150	10	500	70	50	700	200	20.4
10 N	30	150	20 N	5	100	300	15	500	70	20	700	300	6.5
10 N	50	150	20 N	7	70	200	15	500	70	15	700	200	9.4
10 N	70	150	20 N	2	100	200	15	700	100	20	500	200	12.7
10 N	100	300	20 N	7	100	500	15	700	150	20	700	200	8.4
150	70	200	20 N	2	100	500	15	700	100	20	300	300	9.6
10 N	100	150	20 N	2	150	300	15	700	70	30	500	150	11.8
70	100	300	20 N	10	150	500	15	700	100	50	500	200	5.2
10 N	100	150	20 N	2	100	200	10	700	70	20	200	150	15.1
10 N	100	700	20 N	2	100	300	7	700	70	20	300	200	11.5
10 N	100	200	20 N	2	100	300	15	700	100	20	300	100	8.0
10 N	100	150	20 N	2 L	70	200	10	500	70	30	200	300	14.0
000	50	150	20 N	2 N	150	200	5 L	700	50	10	200	500	13.6
10 N	100	200	20 N	2	100	200	7	700	100	15	300	100	7.0
10 N	70	200	20 N	2 L	70	300	10	500	70	20	300	150	9.6
10 N	100	300	20 N	7	70	700	15	700	100	20	700	300	8.2
10 N	150	200	20 N	3	70	500	7	700	150	10	500	100	7.4
10 N	30	100	20 N	2	30	150	7	300	70	15	300	300	16.6
10 N	70	150	20 N	2	100	300	10	500	100	20	300	200	8.7
10 N	70	200	20 N	2 N	100	200	7	1000	70	20	300	200	9.6
10 N	50	150	20 N	5	70	200	10	500	70	15	300	150	-
10 N	70	200	20 N	2	70	300	15	700	100	20	300	100	3
10 N	70	200	20 N	2 N	100	300	7	700	100	20	300	150	4
													5

RESULTS

No well-defined anomalous areas obviously related to potentially economic mineral deposits are apparent in the analytical

TABLE 5.—*Analyses of soil samples from Ramseys Draft Wilderness*

[For sample localities see plate 2. Coordinates refer to Universal Transverse Mercator (UTM) grid. Semi-tion) by G. L. Crenshaw, and equivalent uranium (eU) by instrument by Z. C. Stephenson. Results of the represent approximate midpoints of group data on a geometric scale. The assigned groups for the series will limitations. All data in parts per million (ppm) except where indicated as percent. Letter symbols: L, detected listing of soil samples is for minus 80-mesh fraction; second listing designated "A" is oxalic acid leachate of (minus 80-mesh sample first, leachate second): As (200; 500), Au (10; 20), Bi (10;20), Cd (20; 50), Sb (100; 200),

Sample	X-coord.	Y-coord.	S-Fe percent	S-Mg percent	S-Ti percent	S-Mn	S-Ag	S-B	S-Ba	S-Be	S-Co	S-Cr
						Soil						
VRD024	647960	424602	1.0	0.05	0.30	100	0.5 N	15	100	1.0 N	5 N	20
VRD024A	647960	424602	50.0 G	.00 B	.00 B	10000	2.0	200	3000	2.0	30	500
VRD026	648690	424642	.3	.02	.20	70	.5 N	10	70	1.0 N	5 N	10 L
VRD026A	648690	424642	7.0	.00 B	.00 B	1500	1.0 N	150	1000	2.0 N	10	200
VRD028	648540	424764	1.5	.15	.50	200	.5 N	30	200	1.0	15	70
VRD028A	648540	424764	30.0	.00 B	.00 B	10000	1.0 N	70	2000	15.0	200	700
VRD031	647740	424792	.7	.10	.50	70	.5 N	20	150	1.0 L	5 L	50
VRD031A	647740	424792	50.0	.00 B	.00 B	5000	1.0 N	100	2000	7.0	20	700
VRD033	646710	424833	1.0	.07	.20	500	.5 N	10	150	1.0 L	5 L	15
VRD033A	646710	424833	30.0	.00 B	.00 B	10000 G	1.0 N	100	1500	5.0	30	300
VRD037	645940	424814	1.5	.15	.30	300	.5 N	20	150	1.0 L	5 L	50
VRD037A	645940	424814	30.0	.00 B	.00 B	10000 G	1.0 N	100	3000	7.0	100	500
VRD039	646780	424768	.5	.02 L	.20	50	.5 N	10	50	1.0 N	5 N	10
VRD039A	646780	424768	30.0	.00 B	.00 B	5000	5.0	100	3000	5.0	30	700
VRD042	646560	424683	1.0	.10	.50	70	.5 N	15	150	1.0 N	5 L	30
VRD042A	646560	424683	30.0	.00 B	.00 B	1500	1.0 N	70	2000	3.0	50	500
VRD049	645240	424778	1.0	.15	.50	50	.5 N	30	200	1.0 L	5 N	50
VRD049A	645240	424778	50.0	.00 B	.00 B	700	1.0 N	70	1500	3.0	20	500
VRD051	646060	424900	1.5	.15	.30	1000	.5 N	20	200	1.0 L	7	50
VRD051A	646060	424900	20.0	.00 B	.00 B	10000 G	1.0 N	20	3000	10.0	70	200
VRD058	644390	424630	1.5	.20	.30	1500	.5 N	20	300	1.0	10	70
VRD058A	644390	424630	30.0	.00 B	.00 B	10000 G	1.0 N	20 L	5000	10.0	100	300
VRD061	645440	424692	.5	.02 L	1.50	200	.5 N	15	100	1.0 L	5 N	50
VRD061A	645440	424692	30.0	.00 B	.00 B	10000 G	1.5	100	5000	15.0	50	700
VRD063	645170	424583	.7	.07	.50	70	.5 N	15	150	1.0 N	5 N	20
VRD063A	645170	424583	30.0	.00 B	.00 B	10000	3.0	1000	10000	7.0	30	500
VRD065	645870	424528	.2	.02 L	.30	30	.5 N	15	70	1.0 N	5 N	10 L
VRD065A	645870	424528	30.0	.00 B	.00 B	10000	5.0	700	10000 G	7.0	30	300
VRD067	645510	424457	1.5	.10	.30	150	.5 N	15	100	1.0 N	5	15
VRD067A	645510	424457	30.0	.00 B	.00 B	10000	1.0 N	30	3000	5.0	50	500
VRD073	644190	424562	.5	.07	.30	70	.5 N	15	150	1.0 L	5 L	30
VRD073A	644190	424562	30.0	.00 B	.00 B	7000	1.0 N	30	5000	10.0	70	500
VRD077	643730	424500	.7	.07	.30	30	.5 N	20	100	1.0 L	5 L	20
VRD077A	643730	424500	30.0	.00 B	.00 B	10000	1.0 N	50	2000	5.0	20	300
VRD083	644350	424428	.7	.07	.30	50	.5 N	20	100	1.0 N	5 L	20
VRD083A	644350	424428	30.0	.00 B	.00 B	3000	1.0 N	70	1500	10.0	20	500
VRD085	643880	424390	1.5	.20	.30	200	.5 N	20	150	1.0 L	5	30
VRD085A	643880	424390	30.0	.00 B	.00 B	10000 G	10.0	30	2000	10.0	100	300
VRD087	643480	424329	.7	.07	.20	50	.5 N	20	100	1.0 L	5 L	15
VRD087A	643480	424329	30.0	.00 B	.00 B	5000	1.0 N	50	2000	7.0	30	300
VRD089	644070	424274	.7	.05	.50	30	.5 N	30	100	1.0 N	5 L	15
VRD089A	644070	424274	50.0 G	.00 B	.00 B	2000	1.0 L	200	3000	2.0	50	500
VRD091	642020	424296	1.0	.10	.30	2000	.5 N	15	500	1.5	10	20
VRD091A	642020	424296	30.0	.00 B	.00 B	10000 G	1.0 N	30	10000 G	20.0	300	500
VRD094	642700	424403	1.5	.15	.50	700	.5 N	20	200	1.0	15	50

results. Two vague northwest-trending lines of higher copper values in stream sediments are in the northern half of the area, and an area of higher lead and zinc values is at the north end (pl. 3).

Study Area and vicinity, Augusta and Highland Counties, Va.

quantitative spectrographic analyses (S) were made by J. M. Motooka, chemical analyses (AA, atomic absorp-
semiquantitative analyses are reported to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.15, and 0.1, which
include the quantitative value about 30 percent of the time. The data should not be quoted without stating these
but below limit of determination; N, not detected; G, greater than; B, not looked for; P, partial digestion. First
minus 80-mesh fraction. Elements looked for spectrographically but not found and lower limit of determination
W (50; 100)]

S-Cu	S-La	S-Mo	S-Nb	S-Ni	S-Pb	S-Sc	S-Sn	S-Sr	S-V	S-Y	S-Zn	S-Zr	AA-Zn P	eU
							Soil							
5	20 L	5 N	20 L	5	10 N	5	10 N	100 N	50	10	200 N	200	27	30 L
200	0 B	50	50 L	150	3000	0 B	100	300	0 B	0 B	1500	0 B	0 B	0 B
5	20 L	5 N	20 N	5	10 N	5 L	10 N	100 N	20	10	200 N	100	21	30 L
70	0 B	15	100	70	200	0 B	20 N	300	0 B	0 B	500 N	0 B	0 B	0 B
10	20	5 N	20 L	15	10	7	10 N	100 L	70	20	200 N	200	51	30 L
100	0 B	15	50 N	150	300	0 B	20 N	200 N	0 B	0 B	500	0 B	0 B	0 B
7	20	5 N	20 L	7	10	7	10 N	100 N	100	30	200 N	200	25	30 L
150	0 B	50	50 N	50	700	0 B	20	200 N	0 B	0 B	500 N	0 B	0 B	0 B
10	20 N	5 N	20 N	7	10 L	5 L	10 N	100 N	50	10	200 N	100	40	30 L
200	0 B	20	50 N	100	500	0 B	20 L	200	0 B	0 B	500	0 B	0 B	0 B
10	30	5 N	20 N	10	10 L	7	10 N	100 L	70	20	200 N	100	54	30 L
100	0 B	15	50 L	150	500	0 B	20	200 L	0 B	0 B	1000	0 B	0 B	0 B
5	20 N	5 N	20 N	5 L	10 N	5 L	10 N	100 N	10	10 L	200 N	70	43	30 L
500	0 B	100	50 N	150	1000	0 B	50	700	0 B	0 B	1500	0 B	0 B	0 B
5	20	5 N	20 L	5	10 N	7	10 N	100 L	50	20	200 N	500	29	30 L
70	0 B	10	50 L	150	500	0 B	20 N	200 N	0 B	0 B	500 L	0 B	0 B	0 B
10	20	5 N	20 L	5	10	7	10 N	100 N	70	20	200 N	300	31	30 L
100	0 B	15	50 N	100	300	0 B	20	200 N	0 B	0 B	500 N	0 B	0 B	0 B
15	20	5 N	20 L	15	10	5	10 N	100 N	70	20	200 N	150	85	30 L
70	0 B	10	50 N	150	100	0 B	20 N	200 N	0 B	0 B	500 N	0 B	0 B	0 B
15	20	5 N	20 L	20	10 L	10	10 N	100 N	70	30	200 N	200	158	30 L
70	0 B	10 N	50 N	150	150	0 B	20 N	200 N	0 B	0 B	500 N	0 B	0 B	0 B
5 N	20 L	5 N	20 N	5	10 N	5	10 N	100 N	10	10 L	200 N	100	28	30 L
100	0 B	20	50	150	300	0 B	20	200	0 B	0 B	500 N	0 B	0 B	0 B
10	20	5 N	20 L	5	10 N	5	10 N	100 N	20	15	200 N	300	20	30 L
500	0 B	30	50 N	150	1000	0 B	150	500	0 B	0 B	1500	0 B	0 B	0 B
5	20 L	5 N	20 N	5	10 N	5 L	10 N	100 N	10	15	200 N	200	26	0 B
500	0 B	70	50 N	150	1000	0 B	50	3000	0 B	0 B	1000	0 B	0 B	0 B
7	20 L	5 N	20 L	7	10 N	5	10 N	100 N	30	15	200 N	200	38	30 L
50	0 B	20	50	150	200	0 B	20 L	200 L	0 B	0 B	500 N	0 B	0 B	0 B
5 L	20	5 N	20 L	7	10 N	7	10 N	100 N	30	20	200 N	200	116	30 L
100	0 B	20	50 N	150	200	0 B	20 L	200 N	0 B	0 B	700	0 B	0 B	0 B
7	20	5 N	20 L	7	10 N	7	10 N	100 N	30	20	200 N	300	30	30 L
100	0 B	20	50 N	100	200	0 B	20 L	200 N	0 B	0 B	500 N	0 B	0 B	0 B
7	20 L	5 N	20 L	5 L	10 N	5	10 N	100 N	30	15	200 N	500	20	30 L
50	0 B	15	50 N	70	300	0 B	20 L	200 N	0 B	0 B	500 N	0 B	0 B	0 B
15	30	5 N	20 L	7	10 L	7	10 N	100 N	50	20	200 N	200	92	30 L
100	0 B	20	50 N	150	200	0 B	20 L	200 N	0 B	0 B	500 L	0 B	0 B	0 B
5	20 L	5 N	20 N	5	10 N	5	10 N	100 N	20	15	200 N	100	22	30 L
150	0 B	15	50 N	70	200	0 B	20 L	200 N	0 B	0 B	500 N	0 B	0 B	0 B
5	20	5 N	20 L	5	10 N	5	10 N	100 N	30	20	200 N	700	16	30 L
100	0 B	20	50	100	700	0 B	50	300	0 B	0 B	500 N	0 B	0 B	0 B
10	20	5 N	20 L	20	20	10	10 N	100 N	30	20	200 N	100	170	0 B
150	0 B	10	50 N	150	700	0 B	20 N	200 L	0 B	0 B	500 N	0 B	0 B	0 B
7	20	5 N	20 L	15	10	10	10 N	100 N	70	20	200 N	300	50	30 L

TABLE 5.—*Analyses of soil samples from Ramseys Draft Wilderness Study*

Sample	X-coord.	Y-coord.	S-Fe percent	S-Mg percent	S-Ti percent	S-Mn	S-Ag	S-B	S-Ba	S-Be	S-Co	S-Cr
						Soil—*Continued*						
VRD094A	642700	424403	50.0	0.00 B	0.00 B	10000 G	1.0 N	20	2000	15.0	300	700
VRD097	643040	424354	1.5	.20	.30	1500	.5 N	20	300	1.0	7	7
VRD097A	643040	424354	50.0	.00 B	.00 B	10000 G	1.0 N	20	5000	20.0	300	700
VRD099	642600	424295	1.5	.20	.50	700	.5 N	20	300	1.0 L	20	7
VRD099A	642600	424295	50.0	.00 B	.00 B	10000 G	1.0 N	20	3000	10.0	500	500
VRD102	642650	424186	1.0	.15	.50	700	.5 N	30	300	1.0	10	50
VRD102A	642650	424186	50.0	.00 B	.00 B	10000 G	1.0 N	20	2000	10.0	200	300
VRD104	643110	424190	1.0	.10	.50	300	.5 N	30	200	1.0 L	7	30
VRD104A	643110	424190	50.0	.00 B	.00 B	10000 G	1.0 N	50	2000	10.0	200	1000
VRD112	644340	424176	.3	.02	.50	30	.5 N	20	70	1.0 N	5 L	30
VRD112A	644340	424176	30.0	.00 B	.00 B	7000	5.0	1000	3000	7.0	300	700
VRD228	647110	424864	1.0	.15	.50	1000	.5 N	20	300	1.0	5 L	50
VRD228A	647110	424864	50.0	.00 B	.00 B	10000 G	1.0 N	50	3000	10.0	100	500
VRD246	648090	424556	.7	.02 L	.15	500	.5 N	10 L	70	1.0 N	5 N	10 L
VRD246A	648090	424556	30.0	.00 B	.00 B	10000 G	1.0 N	20	1500	2.0	20	200
VRD251	647820	424490	1.0	.03	.20	30	.5 N	15	100	1.0 N	5 N	15
VRD251A	647820	424490	50.0	.00 B	.00 B	3000	1.0 N	50	1500	2.0	15	300
VRD253	647540	424426	.3	.02 L	.15	20	.5 N	10	70	1.0 N	5 N	10 L
VRD253A	647540	424426	50.0	.00 B	.00 B	7000	1.5	700	10000	10.0	30	700
VRD255	646750	424361	1.0	.10	.30	150	.5 N	20	150	1.0 N	5 N	30
VRD255A	646750	424361	30.0	.00 B	.00 B	10000	1.0 N	100	7000	10.0	20	300
VRD257	646270	424612	1.5	.10	.70	70	.5 N	20	150	1.0 L	5 L	30
VRD257A	646270	424612	50.0 G	.00 B	.00 B	5000	1.0 N	50	3000	2.0	30	1000
VRD259	645030	424300	.3	.02	.50	50	.5 N	20	100	1.0 N	5 N	15
VRD259A	645030	424300	15.0	.00 B	.00 B	10000	1.5	300	5000	15.0	50	300
VRD261	645900	424274	.7	.05	.50	70	.5 N	20	100	1.0 N	5 N	20
VRD261A	645900	424274	50.0	.00 B	.00 B	10000	1.0	100	3000	3.0	20	500
VRD263	645480	424221	.5	.02	.15	200	.5 N	15	100	1.0 N	5 N	10
VRD263A	645480	424221	20.0	.00 B	.00 B	10000 G	1.0 N	70	2000	10.0	30	100
VRD268	645030	424121	1.0	.20	.30	2000	.5 N	20	700	1.0 L	7	50
VRD268A	645030	424121	30.0	.00 B	.00 B	10000 G	1.0 N	70	10000 G	20.0	150	500

Twelve of the 16 drainage basins that contain 20 ppm or more copper are along the two northwest-trending lines; 7 of the 12 basins head in the Pocono Formation, 3 head in the Jennings Formation, and the other 2 in the Hampshire Formation. Eleven of the samples with 20 ppm or more copper are from intermittent or dry streams (fig. 4).

The Pocono Formation may have thin seams of organic-rich shale or poor-quality coal not exposed but containing enough sulfide minerals to produce higher values of copper in stream sediments. The area of higher lead and zinc content in stream sediments is also in an area of Pocono Formation, but this area does not correspond to the higher copper values. Rock samples from the Pocono Formation contain little metal (tables 2 and 6), but the oxalic acid leachates of soil samples in the general area of the two higher copper trends have more copper than the untreated samples (pl. 3).

Area and vicinity, Augusta and Highland Counties, Va.—Continued

S-Cu	S-La	S-Mo	S-Nb	S-Ni	S-Pb	S-Sc	S-Sn	S-Sr	S-V	S-Y	S-Zn	S-Zr	AA-Zn P	eU
							Soil—*Continued*							
100	0 B	30	50 N	150	300	0 B	20 L	200 N	0 B	0 B	500 N	0 B	0 B	0 B
15	20	5 N	20 L	20	10 L	10	10 N	100 N	70	20	200 N	200	117	30 L
200	0 B	15	50 N	300	150	0 B	20 N	300	0 B	0 B	500	0 B	0 B	0 B
10	20	5 N	20 L	20	10	10	10 N	100 L	100	30	200 N	200	84	30 L
100	0 B	15	50 N	150	300	0 B	20 N	200 N	0 B	0 B	500 L	0 B	0 B	0 B
7	30	5 N	20 L	20	10 L	10	10 N	100 L	70	30	200 N	500	150	30 L
100	0 B	15	50 N	150	150	0 B	20 N	200 N	0 B	0 B	700	0 B	0 B	0 B
7	20	5 N	20 L	5	10 N	10	10 N	100 L	50	30	200 N	300	22	30 L
100	0 B	10	50 N	150	150	0 B	20 L	200 N	0 B	0 B	500 N	0 B	0 B	0 B
5 L	20 N	5 N	20 L	5 L	10 N	5 L	10 N	100 N	20	15	200 N	500	8	30 L
200	0 B	50	70	200	5000	0 B	150	300	0 B	0 B	500	0 B	0 B	0 B
30	20	5 N	20 L	10	10	7	10 N	100 N	70	20	200 N	150	42	30 L
200	0 B	20	50 N	150	200	0 B	20 N	200 N	0 B	0 B	500	0 B	0 B	0 B
5 L	20 L	5 N	20 N	5	10 N	5 L	10 N	100 N	20	10 L	200 N	100	30	30 L
70	0 B	15	50	100	150	0 B	20 N	200 N	0 B	0 B	500 N	0 B	0 B	0 B
7	20 L	5 N	20 N	5 L	10 L	5	10 N	100 N	50	15	200 N	500	20	30 L
70	0 B	15	50 L	50	200	0 B	20	200 N	0 B	0 B	500 N	0 B	0 B	0 B
5	20 N	5 N	20 N	5 L	10 N	5 L	10 N	100 N	10	10	200 N	100	19	30 L
500	0 B	100	50 L	200	5000	0 B	70	1000	0 B	0 B	1500	0 B	0 B	0 B
15	20	5 N	20 N	7	10	5	10 N	100 N	50	20	200 N	300	30	30 L
200	0 B	20	50 N	150	700	0 B	50	500	0 B	0 B	1000	0 B	0 B	0 B
15	30	5 N	20 L	5	10 L	7	10 N	100 N	50	30	200 N	500	15	30 L
100	0 B	15	50	150	200	0 B	20 N	200 N	0 B	0 B	500 N	0 B	0 B	0 B
5 L	20	5 N	20 N	5 L	10 N	5 L	10 N	100 N	15	15	200 N	500	18	30 L
100	0 B	50	50 N	150	700	0 B	50	500	0 B	0 B	700	0 B	0 B	0 B
10	20	5 N	20 L	5 L	10 L	5 L	10 N	100 N	30	15	200 N	200	18	30 L
150	0 B	30	50	100	700	0 B	70	200	0 B	0 B	700	0 B	0 B	0 B
10	20 L	5 N	20 N	5	10	5 L	10 N	100 N	20	10	200 N	200	40	30 L
200	0 B	20	50 N	100	700	0 B	50	300	0 B	0 B	700	0 B	0 B	0 B
15	20	5 N	20 L	15	15	5	10 N	100 N	70	20	200 L	150	136	30 L
200	0 B	15	50 L	150	150	0 B	20 N	700	0 B	0 B	1000	0 B	0 B	0 B

The higher copper values may be related to small dikes not found in outcrop but related to the dike swarm discussed previously. The trend of the higher copper values is approximately the same as the trend of the one dike found, but stream-sediment samples from drainage basins heading into the area of the known dike contain only 7-10 ppm copper, which are background values.

Some of the apparent higher copper trends may be due to differences in copper accumulation in flowing and in intermittent streams. The only apparent difference between the two types is a greater organic content in the intermittent-stream sediment, which is more nearly a soil sample than a stream sediment. However, the soil samples have a copper content similar to that of sediments from flowing streams (tables 3 and 5).

The most likely explanation for the alined higher copper values is the presence of small areas of copper mineralization in the Hampshire Formation. The Hampshire is similar in lithology, origin,. and age to the Catskill Formation in Pennsylvania. The possibility of copper-uranium deposits in the Hampshire Formation similar to those described by McCauley (1961) and Klemic (1962) in the Catskill Formation has been speculated on by Stow

TABLE 6.—*Analyses of rock samples from Ramseys Draft Wilderness*

[For sample localities see plate 2. Coordinates refer to Universal Transverse Mercator (UTM grid. Six-step atomic absorption) and mercury by instrument by G. L. Crenshaw, and equivalent uranium (eU) by instrument 0.7, 0.5, 0.3, 0.2, 0.15, and 0.1, which represent approximate midpoints of group data on a geometric scale. The not be quoted without stating these limitations. Letter symbols: L, detected but below limit of determination; where indicated in percent. Elements looked for spectrographically but not detected except where noted below Zn (200). Exceptions: Sample VRD107 also contained 1 ppm Ag, 5 ppm Mo, L(50) W, and 500 ppm Zn. Other atomic absorption methods for gold, but no gold was detected at a lower limit of 0.05 ppm Au]

Sample	X-coord.	Y-coord.	S-Fe percent	S-Mg percent	S-Ca percent	S-Ti percent	S-Mn	S-B	S-Ba	S-Be	S-Co
Sandstone and siltstone, Jennings Formation											
VRD057	644700	424628	3.00	2.00	1.00	0.20	1000	30	200	1L	15
VRD075	643870	424611	.05L	.02L	.05N	.03	10N	10L	20N	1N	5N
VRD076	643590	424511	.70	.02L	.05N	.03	30	10L	20L	1N	5N
VRD093	642780	424386	1.50	.10	.05N	.15	30	15	70	1N	5
VRD096	642000	424356	1.00	.10	.05L	.30	30	30	70	1N	5N
VRD271	642220	424153	1.50	.20	.05L	.30	200	20	70	1L	10
Grayish-red sandstone, Hampshire Formation											
VRD003	643540	424147	1.50	0.20	0.05L	0.20	100	20	100	1L	7
VRD010	646480	424473	1.50	.15	.05N	.15	100	15	100	1L	7
VRD015	645900	424433	2.00	.20	.05L	.20	150	20	150	1L	7
VRD036	645890	424811	1.50	.20	.05L	.20	150	30	150	1L	5
VRD045	646570	424720	2.00	.20	.05L	.20	100	15	150	1L	7
VRD054	644840	424471	2.00	.50	.05L	.20	150	20	200	1L	10
VRD201	643050	424096	1.50	.20	.05L	.15	100	20	150	1	10
VRD213	645700	424422	2.00	.30	.05L	.20	100	20	150	1L	10
VRD217	644460	424236	1.50	.20	.05L	.20	70	20	150	1L	10
VRD229	647050	424894	1.00	.05	.05L	.10	70	10	150	1N	5N
VRD233	646670	424653	1.50	.10	.05L	.15	50	20	100	1L	5L
VRD240	646830	424599	1.00	.07	.05N	.10	30	10	200	1N	5L
VRD244	646720	424522	1.50	.30	.05L	.20	100	30	150	1	10
VRD245	647620	424549	1.00	.15	.05L	.15	200	15	300	1L	5
VRD248	648050	424538	.70	.03	.05N	.10	20	10	100	1N	5N
VRD264	645290	424195	2.00	.20	.05L	.15	100	20	200	1L	5
VRD275	642910	424249	1.50	.15	.05L	.15	70	20	70	1L	5
Greenish-gray sandstone, Hampshire Formation											
VRD001	643830	424190	1.00	0.20	0.05L	0.15	150	15	100	1L	7
VRD004	642840	424098	1.00	.15	.05L	.15	700	20	150	1L	10
VRD012	646590	424473	.70	.15	.05	.15	700	20	150	1L	7
VRD044	646570	424720	.30	.07	.05L	.15	100	15	150	1N	5L
VRD053	644840	424471	1.00	.30	.05L	.20	300	20	200	1L	10
VRD072	643980	424510	.70	.15	.05L	.15	150	15	70	1N	5
VRD101	642720	424226	.30	.02L	.05N	.03	10L	10L	20L	1N	5N
VRD106	643440	424128	2.00	.70	.05L	.30	300	20	150	1	15
VRD110	648740	424856	1.50	.20	.05N	.30	100	20	150	1L	10
VRD111	645290	424059	.70	.10	.05N	.15	10L	20	70	1N	5N
VRD200	643050	424096	1.50	.20	.05L	.15	700	30	150	1	10
VRD202	643690	424030	.70	.15	.05L	.15	70	20	150	1L	5
VRD211	646580	424473	1.00	.15	.05L	.15	150	15	150	1L	10
VRD266	645030	424121	1.00	.15	.05L	.20	100	20	150	1L	5
VRD277	643250	424229	1.50	.50	.05	.30	150	20	300	1L	15
Red siltstone, Hampshire Formation											
VRD020	644460	424308	3.00	0.70	0.05L	0.50	150	50	200	1	15
Greenish-gray siltstone, Hampshire Formation											
VRD107	643440	424128	3.00	3.00	5.00	0.20	5000	30	150	1	30
VRD108	643440	424128	2.00	1.00	.05	.50	200	30	200	1	30

(1955), Dennison (1973), and Dennison and Wheeler (1975). For comparison, stream-sediment and rock samples were collected from eight areas of small uneconomic deposits of copper-uranium in red and green sedimentary rocks of the Catskill Formation in

Study Area and vicinity, Augusta County, Va.

semiquantitative spectrographic analyses (S) are by J. M. Motooka and R. T. Hopkins, chemical analyses (AA, by Z. C. Stephenson. Results of the semiquantitative analyses are reported to the nearest number in the series 1, assigned groups for the series will include the quantitative value about 30 percent of the time. The data should N, not detected; G, greater than; B, not looked for; P, partial digestion. All data in parts per million (ppm) except and lower limit of determination: Ag (0.5), As (200), Au (10), Bi (10), Cd (20), Mo (5), Sb (100), Sn (10), W (50), samples containing L(50) W were: VRD015, VRD020, VRD054, VRD213. In addition all samples were tested by

S-Cr	S-Cu	S-La	S-Nb	S-Ni	S-Pb	S-Sc	S-Sr	S-V	S-Y	S-Zr	INST-Hg	AA-Zn P	eU
Sandstone and siltstone, Jennings Formation													
70	20	20	20 N	30	10	10	100 N	150	20	70	0.02	67	30 L
10 L	5 N	20 N	20 N	5 L	10 N	5 N	100 N	10 N	10 N	50	.02 N	10	30 L
10 L	5 L	20 N	20 N	5 L	10 N	5 N	100 N	10 N	10 N	150	.02 N	18	30 L
10	5 N	20 L	20 N	10	10 N	5	100 N	15	15	200	.02 N	66	30 L
20·	5 N	20 L	20 N	7	10 N	5	100 N	20	15	500	.02 N	24	30 L
20	5	20	20 L	15	15	7	100 N	50	30	500	.02	42	30 L
Grayish-red sandstone, Hampshire Formation													
15	5 L	20 L	20 N	20	10 N	5	100 N	50	15	300	.02 N	40	30 L
15	5 L	20 N	20 N	20	10 N	5 L	100 N	30	10 L	100	.02 N	48	30 L
15	5	20 L	20 N	15	10 N	7	100 N	30	10	100	.02 N	32	30 L
20	5 L	20	20 L	15	10 N	5	100 L	50	20	200	.02 N	32	30 L
15	5 L	20 L	20 N	15	10 N	5	100 N	50	15	200	.02 N	28	30 L
30	5 L	20 L	20 N	20	10 N	5	100 N	70	20	300	.02 N	31	30 L
30	5 L	20	20 N	20	10 N	5	100 N	70	20	200	.02	36	30 L
30	5	20	20 N	15	10 L	10	100 N	100	30	150	.02	29	30 L
20	5 L	20 L	20 N	15	10 L	10	100 N	50	20	150	.02 N	40	30 L
10 L	5 N	20 N	20 N	5	10 N	5 L	100 N	15	10 N	70	.02 N	14	30 L
15	5 N	20 N	20 N	5	10 N	5 L	100 N	30	10 L	200	.02 N	18	30 L
10	5 L	20 N	20 N	5	10 N	5 L	100 N	20	10 L	70	.02	16	30 L
50	7	20	20 L	20	10 L	10	100 N	70	20	200	.02	46	30 L
15	5 L	20	20 N	15	10 N	5	100 N	30	10 L	100	.02 N	30	30 L
10 L	5 L	20 N	20 N	5 L	10 N	5 L	100 N	10	10 L	70	.02 N	23	30 L
15	5 L	20 N	20 N	10	10 N	5	100 N	30	10	70	.02 N	35	30 L
15	5 N	20 L	20 N	10	10 N	5	100 N	30	10 L	200	.02 N	35	30 L
Greenish-gray sandstone, Hampshire Formation													
10	5 L	20 N	20 L	20	10 N	5	100 N	50	15	300	.02 N	30	30 L
15	5	20	20 N	20	10	5 L	100 N	30	20	300	.02 N	36	30 L
10	20	20 N	20 N	15	10 N	5 L	100 N	30	50	70	.02	25	30 L
10	5 L	20 N	20 N	7	10 N	5 N	100 N	15	10 L	50	.02 N	19	30 L
20	30	20 L	20 N	15	10 N	5	100 N	70	15	150	.02 N	35	30 L
15	5	20 L	20 N	20	10 N	5 L	100 N	20	10 L	200	.02 N	48	30 L
10 L	5 N	20 N	20 N	5	10 N	5 N	100 N	10 N	10 N	100	.02	56	30 L
50	20	30	20 L	30	10	15	100 N	100	20	300	.02	60	30 L
50	5	50	20 L	20	10 L	10	100 N	100	50	300	.02 N	32	30 L
10	5 N	20 N	20 N	5	10 N	5 L	100 N	30	10	100	.02 N	19	30 L
30	15	20 L	20 N	20	10 N	5	100 N	70	20	100	.02 N	36	30 L
15	5 L	20	20 N	10	10	5	100 N	30	10	200	.02 N	43	30 L
15	5 L	20 N	20 N	10	10 N	5 L	100 N	30	10	200	.02	39	30 L
15	5 N	50	20 N	10	10 N	5 L	100 N	30	10	300	.02 N	26	30 L
50	20	30	20 L	20	10 L	10	100 L	100	20	300	.02 N	39	30 L
Red siltstone, Hampshire Formation													
70	7	30	20 L	50	10	15	100	150	30	300	0.02 N	75	30 L
Greenish-gray siltstone, Hampshire Formation													
50	70	30	20 N	50	150	15	100 L	100	30	100	0.02 N	100	30
100	50	30	20 L	50	10	15	100 L	150	20	200	.02	68	30

TABLE 6.—*Analyses of rock samples from Ramseys Draft Wilderness*

Sample	X-coord.	Y-coord.	S-Fe percent	S-Mg percent	S-Ca percent	S-Ti percent	S-Mn	S-B	S-Ba	S-Be	S-Co
					Sandstone, Pocono Formation						
VRD023	647810	424597	0.70	0.02	0.05N	0.05	10	10	150	1N	5N
VRD030	648310	424770	1.00	.02L	.05N	.10	50	15	30	1N	5N
VRD035	646740	424769	.70	.02L	.05N	.03	10	10L	20	1N	5N
VRD041	647140	424667	.70	.10	.05L	.15	200	15	150	1L	7
VRD222	647670	424690	1.00	.15	.05L	.30	50	10	150	1L	7
VRD224	647690	424712	.30	.02	.05N	.03	20	10L	100	1N	5N
					Igneous dike						
VRD060	645210	424721	7.00	5.00	5.00	0.50	1000	10N	1500	1L	30

Pennsylvania (Lesure, Motooka, and Weis, 1977). Geochemical anomalies related to these small deposits are small as well. The highest copper values (30–50 ppm) in the Ramseys Draft stream sediments compare well with values of 30–150 ppm copper found in stream sediments near the copper showings in Pennsylvania, but no rock samples from the Hampshire Formation contain much copper. Fifteen samples of greenish-gray sandstone from the Hampshire lithologically similar to the copper-bearing sandstone in the Catskill were analyzed (tables 2 and 6). Most of these contain organic remains as do many of the copper-bearing sandstones in Pennsylvania, but the highest copper value in the Ramseys Draft samples was 30 ppm, which is about the value of copper for unmineralized sandstone in the Catskill Formation.

One shale sample from the Ramseys Draft area (VRD 107, table 2, and pl. 2) contains a little more copper than do the sandstone samples and has a trace of silver similar to that in analyses of

TABLE 7.—*Delayed neutron determinations of uranium and thorium for selected rock samples from Ramseys Draft Wilderness Study Area*

[Analyses by H. T. Millard and D. A. Bickford, U.S. Geological Survey, Denver, Colo.]

Sample No.	Th (ppm)	U (ppm)	Th/U
VRD012	7.2	2.2	3.3
VRD015	9.5	1.4	6.7
VRD020	15.6	3.3	4.7
VRD053	8.4	3.1	2.7
VRD054	9.6	2.3	4.1
VRD057	15.5	2.2	7.0
VRD106	14.7	5.1	2.9
VRD107	9.9	7.3	1.3
VRD108	18.6	4.8	3.9
VRD110	12.5	3.2	3.9
VRD200	8.1	2	4.0
VRD213	8.6	1.9	4.5
VRD222	7.8	1.9	4.1
VRD277	10.9	2.3	4.7

Study Area and vicinity, Augusta County, Va.—Continued

S-Cr	S-Cu	S-La	S-Nb	S-Ni	S-Pb	S-Sc	S-Sr	S-V	S-Y	S-Zr	INST-Hg	AA-Zn P	eU
Sandstone, Pocono Formation													
10 L	5 L	20 N	20 N	5 L	10 N	5 L	100 N	15	10 L	70	0.02 N	12	30 L
10 L	5 L	20 N	20 N	5	10 N	5 L	100 N	10	10 L	150	.02 N	36	30 L
10 L	5 L	20 N	20 N	5 L	10 N	5 N	100 N	10 N	10 N	30	.02 N	10	30 L
10	5 L	20 N	20 N	10	10 N	5 L	100 N	30	10	150	.02 N	23	30 L
20	5	20 L	20 L	10	10 N	10	100 N	70	20	300	.02	28	30 L
10 L	5 N	20 N	20 N	5	10 N	5 N	100 N	10 L	10 N	50	.02 N	13	30 L
Igneous dike													
200	30	100	30	70	10	15	1500	200	30	70	0.02 N	66	30 L

mineralized shale in the Catskill Formation. Shale beds were not seen on the steep hillsides near the site of the higher copper trends, but if present, shales like sample VRD 107 could be the cause of

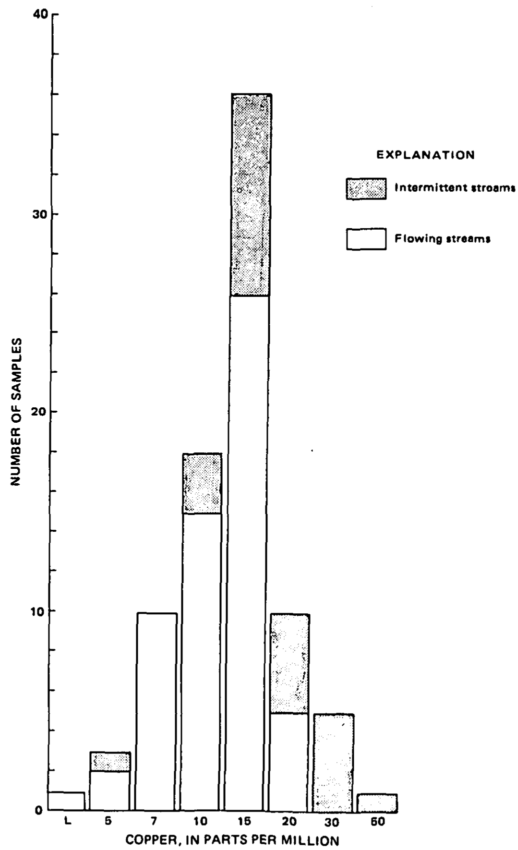

FIGURE 4.—Histogram of copper content of stream-sediment samples from flowing and intermittent streams, Ramseys Draft and vicinity, Augusta County, Va. (L, detected but below limit of determination.)

higher copper values in stream sediments, where the drainage basin is mostly in the Hampshire Formation.

In October 1975 we collected 219 more soil samples from 110 sample sites in an area bounded by Bald Knob, Hardscrabble Knob, Freezland Flat, Jerrys Run, and the Pinnacle in order to evaluate the higher copper values in stream sediments. Two samples were collected at each site. Sample A was from the surface and contained abundant organic material. Sample B was taken below a sharp change in color and contained less organic material. All but two samples contained 15 ppm or less copper, similar to the soil samples listed in table 5. The two exceptions were collected at the same site (pl. 3); sample A contains 500 ppm Cu, 2 ppm Ag, 2 ppm Be, 10 ppm Co, 7 ppm Ni, and 2,000 ppm Mn. Sample B contains 3,000 ppm Cu, 2 ppm Ag, 700 ppm As, 100 ppm Co, and 70 ppm Ni; Fe (5 percent) and Mn (greater than 5,000 ppm) are also higher than average. These samples are probably derived from mineralized sandstone in the Hampshire Formation. No outcrops

TABLE 8.—*Analyses of some shale and miscellaneous rock samples from the*

[Symbols used: —, not detected; >, greater than; <,less than; M, major component; *, atomic absorption
As, Au, Be, Bi, Cd, Ga, Hf, In, Li, Mo,

	General spectrographic analyses (percent)											
Sample No.	Al	Ag	B	Ba	Ca	Co	Cr	Cu	Fe	Mg	Mn	Na	Ni
VRD301	> 5.0	<0.001	0.03	—	<0.02	—	0.003	0.003	2.0	0.4	0.01	0.5	0.002
VRD302	> 5	—	.03	—	< .02	—	.003	.003	1	.4	.01	.5	.002
VRD303	> 5	—	.03	—	.02	—	.003	.003	2	.4	.01	.5	.002
VRD304	> 5	—	.03	—	< .02	—	.003	.003	2	.4	.02	.5	.002
VRD305	> 5	—	.03	—	< .02	—	.003	.003	2	.4	.02	.5	.002
VRD306	> 5	—	.03	—	< .02	—	.003	.003	2	.4	.02	.5	.002
VRD307	3	< .001	.03	—	< .02	—	.003	.003	2	.4	.02	.5	.002
VRD308	> 5	—	.03	—	< .02	—	.003	.003	2	.4	.02	.5	.002
VRD309	3	—	.03	—	—	—	.003	.003	2	.4	.02	.5	.002
VRD310	4	—	.03	—	< .02	—	.003	.003	2	.4	.02	.5	.002
VRD311	> 5	—	.03	—	< .02	—	.003	.003	2	.8	.05	.5	.002
VRD312	3	—	.03	—	.1	—	.003	.003	2	.8	.05	.5	.002
VRD313	5	< .001	.03	—	.02	—	.003	.003	2	.4	.02	.5	.002
VRD314	3	—	.03	—	.02	—	.003	.003	1	.4	.02	.5	.002
VRD315	3	—	.03	—	.02	—	.003	.003	2	.4	.02	.5	.002
VRD316	3	—	.03	—	.03	—	.003	.003	2	.4	.02	.5	.002
VRD317	5	—	.03	—	.02	—	.003	.003	2	.4	.02	.5	.002
VRD318	5	—	.03	—	.02	—	.003	.003	2	.4	.02	.5	.002
VRD319	4	—	.03	—	—	—	.003	.003	2	.4	.02	.5	.002
VRD320	3	—	.03	—	.02	—	.003	.003	1	.4	.02	.5	.002
VRD321	M	<.001	—	0.1	M	0.004	.02	.01	7	6	.2	2	.01
VRD322	1	—	—	—	—	—	—	.003	.6	.02	.003	—	—
VRD323	1	—	<.01	—	—	—	—	.003	.6	.02	.003	—	—
VRD324	3	—	.01	—	.02	—	—	.003	1	.4	.006	.5	< .002
VRD325	3	—	.02	—	.03	—	—	.003	2	.2	.02	1	< .002
VRD326	3	—	.02	—	.06	—	—	.003	2	.6	.05	1	< .002
VRD327	2	—	.01	—	.2	—	—	.003	1	.6	.05	.5	< .002

General spectrographic analyses by U.S. Bureau of Mines, Reno Metallurgy Research Center, Reno, Nev.

were seen, but thin sections of several rock chips in the soil sample suggest that the rock contained sulfides that are now altered to iron hydroxides. No copper minerals were seen. This one sample site with abnormally high copper values is on the divide between drainage areas sampled by stream sediments VRD 069, which has 50 ppm Cu, and VRD 070, which has 30 ppm Cu.

In summary, the stream-sediment data suggest a nonrandom distribution for copper and also another nonrandom distribution for lead and zinc. At least two of the high copper values seem to be related to mineralized sandstone in the Hampshire Formation. This mineralized rock is probably not extensive because only one sample site out of 20 within a radius of 2,500 feet (700 m) contained anomalous material.

The area of higher lead and zinc values seems restricted to the Pocono Formation. Minor concentrations of lead and zinc have been reported in the Pocono of southwestern Pennsylvania (Stevenson, 1878, p. 240-241), but none was seen in Ramseys Draft.

Ramseys Draft Wilderness Study Area and vicinity, Augusta County, Va.[1]

analyses not performed; CC, continuous chip; RC, random chip; C, chip. Elements tested for but not detected Nb, P, Pt, Re, Sb, Sn, Ta, Te, Tl, W. Zn]

	General spectrographic analyses—Continued (percent)						Atomic absorption analyses (percent)		Sample thickness		
Sample No.	Pb	Si	Sr	Ti	V	Zr	Fe	Sample type	(ft)	(m)	Sample description
VRD301	<0.01	M	—	0.2	<0.01	0.007	*	CC	26.2	7.86	Shale
VRD302	< .01	M	—	.2	<.01	.007	*	CC	25.7	7.71	Do.
VRD303	< .01	M	—	.2	<.01	.007	*	CC	29	8.7	Do.
VRD304	—	M	—	.2	<.01	.007	*	CC	48.3	14.49	Do.
VRD305	—	M	—	.2	<.01	.007	*	CC	34.7	10.41	Do.
VRD306	< .01	M	—	.2	< .01	.007	*	CC	33.7	10.11	Do.
VRD307	< .01	M	—	.2	< .01	.007	*	CC	34	10.2	Do.
VRD308	< .01	M	—	.2	< .01	.007	*	CC	17.3	5.19	Do.
VRD309	< .01	M	—	.1	< .01	.007	*	CC	25.8	7.74	Do.
VRD310	< .01	M	—	.2	< .01	.007	*	CC	22.8	6.84	Do.
VRD311	< .01	M	—	.2	< .01	.007	*	CC	17.5	5.25	Do.
VRD312	< .01	M	—	.2	< .01	.007	*	CC	23.5	7.05	Do.
VRD313	.01	M	—	.2	< .01	< .007	*	CC	22	6.6	Do.
VRD314	—	M	—	.2	< .01	< .007	*	CC	40	12.0	Do.
VRD315	—	M	—	.2	< .01	< .007	*	CC	58	17.4	Do.
VRD316	—	M	—	.2	< .01	< .007	*	CC	29.9	8.97	Do.
VRD317	—	M	—	.2	< .01	< .007	*	CC	20	6.0	Do.
VRD318	—	M	—	.2	< .01	< .007	*	CC	20.5	6.15	Do.
VRD319	<.01	M	—	.2	< .01	< .007	*	CC	22	6.6	Do.
VRD320	—	M	—	.2	< .01	< .007	*	CC	23.2	6.96	Do.
VRD321	.1	M	0.1	.4	.006	.007	7.8	RC	10	3.0	Igneous intrusive
VRD322	—	M	—	.02	—	—	1.4	C	40	12.0	Sandstone
VRD323	—	M	—	.02	—	—	0.77	C	18	5.4	Do.
VRD324	<.01	M	—	.1	< .006	<.007	1.4	C	25.5	7.65	Do.
VRD325	.01	M	—	.1	< .006	<.007	2.1	C	17.5	5.25	Do.
VRD326	.02	M	—	.1	< .006	<.007	1.8	C	27	8.1	Do.
VRD327	.01	M	—	.05	< .006	<.007	2	C	16	4.8	Do.

MINERAL RESOURCES

SETTING

The relatively simple stratigraphy of the siliceous clastic sedimentary rocks and the simple structure that has no major faulting in the Ramseys Draft study area limit the possible mineral resources to nonmetallic resources, construction materials, and fuels. No known metallic mineral resources are present in the rocks exposed in the study area, and, except for a remote possibility for the copper-uranium occurrences already discussed, no metallic resources are to be expected in the rocks that are exposed or that are present within several thousand feet of the surface. Although iron, manganese, lead, and zinc have been produced in nearby areas of Virginia, the geologic conditions are not favorable for the occurrence of ore-grade deposits of those metals in the study area. Two types of iron ore, sedimentary hematite in the Rose Hill Formation of Middle Silurian age and supergene limonite in the Oriskany Sandstone of Early Devonian age, have been mined at various places within 50 miles (80 km) of the study area (Darton, 1894, 1896; Gooch, 1954; Lesure, 1957). The Rose Hill Formation probably contains iron-rich beds in the study area, but these are buried at least 7,500 feet (2,250 m), too deep for mining. The supergene iron ores in the Oriskany Sandstone formed only near the surface and should not be expected where the formation is buried as much as 6,500 feet (2,000 m), as it is in the study area.

Although the largest manganese mines in the East were operated in Augusta County, Va. (Dorr and Sweeney, 1968, p. 419), approximately 28 miles (45 km) southeast of Ramseys Draft, the lower Paleozoic formations in which they are present are more than 10,000 feet (several thousand meters) deep in the study area. Likewise, lead and zinc deposits are found in a district 25–40 miles (40–65 km) northeast of Ramseys Draft (Herbert and Young, 1956) in lower Paleozoic sedimentary rocks that probably are at depths of 10,000 feet (3,000 m) or more in the study area. Minor occurrences of zinc sulfides have been reported in Devonian shales and sandstones in unspecified parts of the Shenandoah Valley area, probably north of the study area (Herbert and Young, 1956, p. 21), and lead and zinc sulfides are reported in the Pocono Formation in Fayette County, Pa. (Stevenson, 1878, p. 240–241). Similar occurrences were not found in the Ramseys Draft Study Area.

MINES, PROSPECTS, AND LEASES

On the basis of available information, there has been no commercial mineral production from within or near the Ramseys

Draft Wilderness Study Area. A small pit (plate 2) furnished sand, gravel, and shale as road metal for U.S. Forest Service Road 68. No other pits, mines, or prospects are known to be within a 2-mile (3-km) radius of the study area.

Federal oil and gas leases were issued to Washington Gas Light Company in 1970 on a block of land 1 mile (1.6 km) southeast of Ramseys Draft. The same lessee held an oil and gas lease on the entire study area between November 1970 and October 1972.

NONMETALLIC RESOURCES AND CONSTRUCTION MATERIALS

HIGH-SILICA SAND

Several Paleozoic sandstones in western Virginia have been considered as possible sources of high-silica sand (Lowry, 1954, p. 9), but among these only the Pocono Formation crops out within the study area. Chip samples VRD 322 and VRD 323 (plate 2) were taken across two exposures of sandstone of the Pocono, 40 and 18 feet (12.2 and 5.5 m) thick, respectively. Analyses (table 8) show that the sandstone contains higher percentages of aluminum (Al), iron (Fe), magnesium (Mg), and titanium (Ti) than are considered suitable for high-silica sand. The rock might be used as low-quality glass sand. Additional analyses of Pocono sandstones are included in table 6, and all indicate too much iron for most uses of silica sand. A bed of clean sand in the Jennings Formation (table 1, sample no. VRD 075) is also not pure enough for glass sand; furthermore, the bed is limited in extent.

SHALE

Within the study area, the Jennings and Hampshire Formations contain beds of shale, which are best exposed along the southeast flank of Shenandoah Mountain. Twenty continuous chip samples (VRD 301-320, pl. 2) were collected from within and near the study area. Samples were taken across the thickness of the shale units after removing weathered material at the surface. These samples were submitted for preliminary ceramic tests and property determinations to evaluate their economic potential. Results are reported in table 9; partial analyses are given in table 8.

Preliminary tests indicate that these shales are suitable for the manufacture of building brick, floor brick, sewer pipe, and quarry tile. None of the samples expanded during the fast-fire bloating test, eliminating the shales from consideration as lightweight aggregate. Until the early 1960's, brick plants operated in both Buffalo Gap, 10 miles (16 km) southeast, and Staunton, 18 miles (29 km) southeast. The nearest operating plants are in Glasgow, Rock-

TABLE 9.—*Evaluation of shales*

Sample No.	Sample interval (ft)	Sample interval (m)	Raw properties[1]	Slow firing test: Temperature[2] (°F)	Munsell color	Mohs' hardness	Total shrinkage (percent)	Absorption (percent)	Apparent porosity (percent)	Bulk density (g/cm³)	Potential use
VRD301	27.0	8.1	Water of plasticity: 18.7 percent	1,800	5 YR 7/8	3	2.5	16.1	29.8	1.85	Building brick and floor brick.
			Dry strength: fair	1,900	5 YR 7/10	3	2.5	14.0	26.9	1.92	
			pH: 6.3	2,000	5 YR 5/8	3	5.0	10.9	22.0	2.02	
				2,100	2.5 YR 4/6	4	5.0	7.9	16.9	2.14	
				2,200	2.5 YR 4/4	5	7.5	5.6	12.5	2.21	
				2,300	2.5 YR 3/4	5	7.5	4.1	9.2	2.25	
VRD302	25.7	7.71	Water of plasticity: 21.2 percent	1,800	5 YR 7/8	2	2.5	16.8	30.8	1.83	Do.
			Dry strength: fair	1,900	5 YR 7/8	3	2.5	15.8	29.4	1.86	
			pH: 6.2	2,000	2.5 YR 5/8	3	5.0	11.7	23.4	1.99	
				2,100	2.5 YR 4/6	4	7.5	7.4	16.0	2.16	
				2,200	2.5 YR 4/4	5	10.0	5.0	11.2	2.25	
				2,300	2.5 YR 3/4	6	10.0	3.6	8.2	2.26	
VRD303	29.5	8.85	Water of plasticity: 20.1 percent	1,800	5 YR 7/8	2	2.5	15.9	29.6	1.86	Do.
			Dry strength: fair	1,900	5 YR 7/10	3	2.5	15.0	28.3	1.89	
			pH: 6.3	2,000	2.5 YR 5/8	3	5.0	11.5	23.1	2.01	
				2,100	2.5 YR 4/8	4	7.5	7.4	16.1	2.16	
				2,200	2.5 YR 4/4	5	7.5	4.8	10.8	2.26	
				2,300	2.5 YR 3/4	6	10.0	3.4	7.8	2.29	
VRD304	48.3	14.49	Water of plasticity: 19.6 percent	1,800	5 YR 7/8	3	2.5	16.0	29.7	1.86	Do.
			Dry strength: fair	1,900	5 YR 6/8	3	2.5	13.8	26.7	1.94	
			pH: 5.9	2,000	2.5 YR 5/8	3	5.0	9.9	20.5	2.07	
				2,100	2.5 YR 4/6	4	7.5	6.8	14.8	2.19	
				2,200	2.5 YR 4/4	6	10.0	4.5	10.0	2.25	
				2,300	2.5 YR 3/4	6	10.0	2.6	5.9	2.30	
VRD305	34.7	10.41	Water of plasticity: 17.2 percent	1,800	5 YR 7/8	2	2.5	14.2	27.4	1.93	Do.
			Dry strength: good	1,900	5 YR 6/8	3	2.5	12.8	25.3	1.97	
			pH: 6.8	2,000	2.5 YR 5/8	3	5.0	9.3	19.5	2.10	
				2,100	2.5 YR 4/6	4	7.5	7.1	15.5	2.18	
				2,200	2.5 YR 3/4	7	10.0	4.6	10.4	2.25	
				2,300	2.5 YR 3/4	7	10.0	3.6	8.1	2.24	
VRD306	33.7	10.11	Water of plasticity: 22.0 percent	1,800	5 YR 7/8	2	2.5	15.8	29.6	1.87	Building brick and quarry tile.
			Dry strength: good	1,900	5 YR 6/8	3	2.5	13.8	26.7	1.93	
			pH: 5.6	2,000	2.5 YR 5/8	5	5.0	7.9	17.0	2.15	
				2,100	2.5 YR 4/6	6.5	7.5	4.9	11.0	2.27	
				2,200	2.5 YR 4/4	7	10.0	1.9	4.4	2.34	
				2,300	2.5 YR 3/4	8	10.0	1.5	3.6	2.35	

VRD307	34.0	10.2	Water of plasticity:	17.5	1,800	2.5 YR 6/8	3	2.5	12.6	24.5	1.94	Building brick and
			Dry strength: fair	percent	1,900	2.5 YR 6/10	3	2.5	10.4	21.0	2.01	floor brick.
			pH: 6.7		2,000	2.5 YR 5/8	3	5.0	7.9	16.7	2.11	
					2,100	2.5 YR 4/8	4	5.0	4.9	11.0	2.23	
					2,200	2.5 YR 4/4	7	10.0	2.4	5.5	2.30	
					2,300*	—	—	Expanded	—	—	—	
VRD308	17.3	5.19	Water of plasticity:	17.5	1,800	2.5 YR 6/8	3	2.5	12.1	23.8	1.96	Do.
			Dry strength: fair	percent	1,900	2.5 YR 6/10	3	2.5	8.9	18.4	2.08	
			pH: 6.0		2,000	2.5 YR 5/8	5	5.0	6.5	14.1	2.17	
					2,100	2.5 YR 4/6	7	5.0	2.4	5.7	2.34	
					2,200	2.5 YR 4/4	8	10.0	1.2	2.8	2.34	
					2,300*	—	—	Expanded	—	—	—	
VRD309	25.8	7.74	Water of plasticity:	20.0	1,800	5 YR 7/8	2	2.5	14.5	27.0	1.85	Do.
			Dry strength: fair	percent	1,900	2.5 YR 6/10	3	2.5	12.4	23.6	1.89	
			pH: 6.0		2,000	2.5 YR 5/10	3	5.0	10.2	20.5	2.00	
					2,100	2.5 YR 4/8	5	10.0	5.9	12.7	2.15	
					2,200	2.5 YR 4/4	8	10.0	1.4	3.2	2.32	
					2,300*	—	—	Expanded	—	—	—	
VRD310	22.8	6.84	Water of plasticity:	17.5	1,800	5 YR 7/8	3	2.5	12.4	23.8	1.92	Do.
			Dry strength: fair	percent	1,900	2.5 YR 6/10	3	2.5	9.9	19.7	2.00	
			pH: 6.3		2,000	2.5 YR 5/10	3	5.0	7.7	16.0	2.09	
					2,100	2.5 YR 4/8	7	5.0	3.8	8.4	2.25	
					2,200	2.5 YR 4/6	7	7.5	1.9	4.5	2.31	
					2,300*	—	—	Expanded	—	—	—	
VRD311	17.5	5.25	Water of plasticity:	18.5	1,800	5 YR 7/8	2	2.5	13.3	25.3	1.90	Building brick.
			Dry strength: fair	percent	1,900	2.5 YR 6/10	3	2.5	9.6	19.5	2.03	
			pH: 5.6		2,000	2.5 YR 5/10	4	5.0	6.9	14.8	2.14	
					2,100	2.5 YR 4/6	6	7.5	2.3	5.4	2.33	
					2,200	2.5 YR 3/4	7	10.0	.8	1.9	2.35	
					2,300*	—	—	Expanded	—	—	—	
VRD312	23.5	7.05	Water of plasticity:	15.1	1,800	5 YR 7/6	2	2.5	11.2	22.3	1.99	Sewer pipe and
			Dry strength: fair	percent	1,900	2.5 YR 6/10	3	2.5	8.8	18.3	2.08	quarry tile.
			pH: 6.4		2,000	2.5 YR 5/8	3	5.0	7.1	15.1	2.13	
					2,100	10 R 4/6	6	7.5	2.9	6.6	2.29	
					2,200	10 R 4/4	8	7.5	1.0	2.4	2.33	
					2,300*	—	—	Expanded	—	—	—	
VRD313	22.0	6.6	Water of plasticity:	18.3	1,800	5 YR 7/8	2	2.5	14.7	27.0	1.83	Building brick and
			Dry strength: fair	percent	1,900	2.5 YR 6/10	3	2.5	13.2	25.1	1.89	sewer pipe.
			pH: 5.2		2,000	2.5 YR 5/10	3	2.5	11.1	21.7	1.96	
					2,100	2.5 YR 4/8	3	5.0	8.1	16.7	2.07	
					2,200	10 R 4/6	6	7.5	5.1	11.0	2.16	
					2,300	10 R 3/4	7	7.5	1.7	3.9	2.28	

TABLE 9.—*Evaluation of shales—Continued*

Sample No.	Sample interval (ft)	Sample interval (m)	Raw properties[1]	Slow firing test: Temperature[2] (°F)	Munsell color	Mohs' hardness	Total shrinkage (percent)	Absorption (percent)	Apparent porosity (percent)	Bulk density (g/cm³)	Potential use
VRD314	40.0	12.0	Water of plasticity: 18.2 percent	1,800	5 YR 7/8	2	2.5	14.6	27.1	1.86	Sewer pipe and quarry tile.
			Dry strength: fair	1,900	2.5 YR 6/10	3	2.5	11.8	23.1	1.96	
			pH: 5.3	2,000	2.5 YR 5/10	3	5.0	9.7	19.6	2.02	
				2,100	2.5 YR 4/10	7	5.0	5.6	12.2	2.18	
				2,200	10 R 4/6	7	10.0	3.2	7.2	2.24	
				2,300	10 R 3/6	7	10.0	1.6	3.6	2.27	
VRD315	58.0	17.4	Water of plasticity: 17.2 percent	1,800	5 YR 7/8	2	2.5	12.9	24.6	1.91	Do.
			Dry strength: fair	1,900	2.5 YR 6/10	3	2.5	10.6	21.1	1.99	
			pH: 6.3	2,000	2.5 YR 5/8	3	5.0	7.7	16.1	2.11	
				2,100	2.5 YR 4/8	5	5.0	4.8	10.5	2.20	
				2,200	10 R 4/6	9	7.5	2.5	5.6	2.27	
				2,300	10 R 3/4	9	7.5	1.5	3.4	2.24	
VRD316	29.9	8.97	Water of plasticity: 16.4 percent	1,800	5 YR 6/8	2	2.5	13.1	25.1	1.91	Building brick and quarry tile.
			Dry strength: fair	1,900	2.5 YR 6/10	3	2.5	10.9	21.6	1.99	
			pH: 6.0	2,000	2.5 YR 5/10	3	5.0	8.0	16.8	2.10	
				2,100	2.5 YR 4/8	6	5.0	4.8	10.6	2.21	
				2,200	2.5 YR 4/6	7	7.5	2.8	6.3	2.28	
				2,300	2.5 YR 3/4	7	10.0	1.4	3.1	2.27	
VRD317	20.0	6.0	Water of plasticity: 17.0 percent	1,800	5 YR 7/8	2	2.5	13.9	26.1	1.88	Building brick and sewer pipe.
			Dry strength: fair	1,900	2.5 YR 6/10	3	2.5	11.1	22.0	1.98	
			pH: 5.7	2,000	2.5 YR 5/10	3	2.5	9.3	19.0	2.04	
				2,100	2.5 YR 4/8	5	5.0	6.1	13.2	2.15	
				2,200	10 R 4/6	6	5.0	3.8	8.5	2.23	
				2,300	10 R 3/4	7	7.5	1.9	4.2	2.24	
VRD318	21.0	6.3	Water of plasticity: 17.2 percent	1,800	5 YR 6/8	3	2.5	12.1	23.4	1.93	Building brick and floor brick.
			Dry strength: fair	1,900	2.5 YR 5/10	3	2.5	9.0	18.5	2.05	
			pH: 7.1	2,000	2.5 YR 5/8	4	5.0	6.9	14.6	2.12	
				2,100	2.5 YR 4/6	7	5.0	2.6	5.9	2.29	
				2,200	2.5 YR 3/4	8	7.5	.3	.7	2.28	
				2,300 *	—	—	Expanded	—	—	—	

VRD319	22.0	6.6	Water of plasticity:	18.2	1,800	5 YR 6/8	2	2.5	13.4	25.3	1.89	Sewer pipe and
			Dry strength: fair	percent	1,900	2.5 YR 6/10	3	2.5	10.6	21.2	2.00	floor brick.
			pH: 6.4		2,000	2.5 YR 5/10	3	5.0	8.0	16.6	2.09	
					2,100	2.5 YR 4/8	4	7.5	4.2	9.3	2.23	
					2,200	10 R 4/6	7	7.5	1.8	4.2	2.30	
					2,300*	—	—	Expanded	—	—	—	
VRD320	23.2	6.96	Water of plasticity:	15.6	1,800	5 YR 6/8	2	2.5	10.4	20.8	2.00	Building brick.
			Dry strength: fair	percent	1,900	2.5 YR 6/10	3	2.5	7.9	16.5	2.08	
			pH: 7.7		2,000	2.5 YR 4/8	6	5.0	4.7	10.5	2.24	
					2,100	2.5 YR 4/4	7	7.5	1.1	2.5	2.36	
					2,200	—	—	Expanded	—	—	—	
					2,300*	—	—	—	—	—	—	

[1]Tests indicate the following for all samples: Working properties-short; Drying defects-none; Drying shrinkage-2.5 percent; Bloating tests-negative; no effervescence with HCl.
[2]Asterisk denotes abrupt vitrification prior to temperature noted.

VRD301 Roadcut, 26.2 feet (7.86 m) olive-gray shale with interbedded 0.8 foot (0.2 m) siltstone layer excluded; Jennings Formation.
VRD302 Roadcut, 25.5 feet (7.65 m) olive-gray and grayish-red fissile shale with interbedded 0.2 foot (0.06 m) sandstone layer included; Jennings Formation.
VRD303 Roadcut, 29.0 feet (8.7 m) olive-gray and yellow shale with interbedded 0.5 foot (0.15 m) sandstone layer excluded; Jennings Formation.
VRD304 Roadcut, 48.3 feet (14.49 m) gray and olive shale; Jennings Formation.
VRD305 Roadcut, 34.5 feet (10.35 m) light-brown and olive shale with interbedded 0.2 foot (0.06 m) sandstone layer included; Jennings Formation.
VRD306 Roadcut, 33.7 feet (10.11 m) olive and light-brown shale; Jennings Formation.
VRD307 Roadcut, 33.9 feet (10.17 m) olive and dark-brown shale with interbedded 0.1 foot (0.03 m) sandstone layer included; Jennings Formation.
VRD308 Roadcut, 17.3 feet (5.19 m) dark-brown and red shale; Jennings Formation.
VRD309 Roadcut, 25.8 feet (7.74 m) olive-green shale; Jennings Formation.
VRD310 Roadcut, 22.7 feet (6.81 m) green-brown shale with interbedded 0.1 foot (0.03 m) sandstone layer included; Jennings Formation.
VRD311 Roadcut, 17.5 feet (5.25 m) olive-green shale; Jennings Formation.
VRD312 Outcrop, 23.5 feet (7.05 m) green and brown shale; Jennings Formation.
VRD313 Outcrop, 21.5 feet (6.45 m) olive-brown shale with interbedded 0.5 foot (0.15 m) sandstone layer included; Jennings Formation.
VRD314 Outcrop, 39.8 feet (11.94 m) light-brown and green shale with interbedded 0.2 foot (0.06 m) sandstone layer included; Jennings Formation.
VRD315 Outcrop, 58.0 feet (17.4 m) olive and brown shale; Jennings Formation.
VRD316 Outcrop, 29.8 feet (8.94 m) green and brown shale with interbedded 0.1 foot (0.3 m) sandstone layer included; Jennings Formation.
VRD317 Outcrop, 20.0 feet (6.0 m) green and brown shale; Jennings Formation.
VRD318 Stream cut, 20.5 feet (6.15 m) olive and reddish-brown shale with interbedded 0.5 foot (0.15 m) sandstone layer excluded; Hampshire Formation.
VRD319 Stream cut, 22.0 feet (6.6 m) green and dark-brown shale; Jennings Formation.
VRD320 Stream cut, 23.2 feet (6.96 m) red and olive hard shale; Hampshire Formation.

bridge County, and Somerset, Orange County, Va. (Le Van, 1974, p. 6–7), both over 50 miles (80 km) from the study area. The shale within the study area is considered to be too far from marketing areas to compete economically with more readily available material.

STONE, SAND, AND GRAVEL

Sandstone suitable for crushed stone, riprap, or possibly dimension stone is the principal mineral resource in the study area. Commercial potential is low because of the distance to market and the ready availability of similar material nearer to markets.

Small deposits of sand and gravel are present along the valley floor of Ramseys Draft, but production has been limited to use as road metal in local construction. Because quantities are small and more accessible construction materials are available in the larger river valleys of the region, sand and gravel deposits within the study area are deemed of little economic value.

FUELS

COAL

Semianthracite coal has been mined near North River Gap, approximately 8 miles (13 km) east of the study area (Darton, 1894). This coal was examined as early as 1835 by W. B. Rogers (1836, p. 99), and the area has been known as the North River coal field for many years (Watson, 1907, p. 348). The coal is present as thin beds in the upper section of the Pocono Formation on Narrow Back Mountain from Stokesville in Augusta County northeastward to Rawley Springs in Rockingham County (Howell, 1925, p. 283). Several small mines have supplied local needs in the past, but no production has been reported in many years (Howell, 1925, p. 283). Only the lower part of the Pocono is preserved in the study area, and no coal was found during the course of our field investigations.

OIL AND GAS

Only small quantities of oil and natural gas have been produced from the folded rocks of the Valley and Ridge physiographic province in the Eastern United States (Meyer and Edgerton, 1968, p. 153).

No tests wells have been drilled in the Ramseys Draft area, and the possibility of finding oil or natural gas is remote. The Pocono, Hampshire, and Jennings Formations have petroliferous equivalents deeply buried under the Appalachian Plateau to the west in West Virginia, but in the study area the thermal maturity of these rocks, the combined effects of heat and pressure to which the strata have been subjected since their deposition, exceeds the temperature at which oil is decomposed and expelled from source or reservoir rocks (Wallace de Witt, written commun., 1975).

The more deeply buried Cambrian to Middle Devonian sedimentary rocks, at least to the depth of a major detachment thrust fault zone, the Broadtop décollement (Jacobeen and Kanes, 1974), are within the thermal range for rocks capable of containing natural gas. They lie, however, in the bottom of a large syncline, which is most unfavorable for the accumulation and retention of natural gas. The absence of structural traps, minor anticlines, or high-angle faults in the syncline indicates that natural gas will not be found in the rocks underlying the Ramseys Draft area.

Relatively little is known about the rocks below the major detachment zone, about 15,000 feet (4,500 m) below Ramseys Draft. Scant drilling on anticlines to the west in the Valley and Ridge province has shown complexly folded and faulted rocks at depth (Perry, 1964). Near-surface anticlines and synclines have been displaced westward several miles along the major detachment thrust fault, and these surface structures cannot be projected accurately across the fault without abundant geophysical data. The few wells that have been drilled through the major detachment fault have not found oil or gas below the detachment zone.

Two minor gas fields have been partly defined in the general area of Ramseys Draft: the Thornwood field, 22 miles (35 km) northwest in Pocahontas County, West Va. (Patchen, 1968, p. 19-20) and the Bergton field, 34 miles (55 km) northeast in Rockingham County, Va. (Young and Harnsberger, 1955, p. 317). In both gas fields, the Oriskany Sandstone of Early Devonian age is the major gas-bearing horizon, and minor shows were reported in the overlying formations. Patchen (1968, p. 19-20) indicated that the Thornwood field is along the surface axis of the Horton anticline; the Bergton field is along the axis of the Bergton-Crab Run anticline (Young and Harnsberger, 1955, p. 320-326). These gas fields are shut-in and neither has had commercial production.

The nearest known exploratory gas well was drilled on Hone Quarry Run in Rockingham County, 10 miles (16 km) northeast of Ramseys Draft (lat 38°29′16″ N.; long 79°10′34″ E.) on the Bergton-Crab Run anticline (fig. 1). It proved to be dry.

Crab Run Gas Company conducted seismic investigations along U.S. Route 250 from just south of the study area to a point east of West Augusta. On the basis of the interpretation of these data, the company is of the opinion that the wilderness study area, because of its synclinal position, has no potential for the accumulation of oil or gas. If oil or gas accumulation exists this far south along the

Bergton-Crab Run anticline, it will be to the east of Bald Ridge, the southeastern boundary of the study area (F. H. Jacobeen, Jr., Crab Run Gas Company, February 1975, written commun.).

REFERENCES CITED

Butts, Charles, 1918, Geologic section of Blair and Hunting Counties, central Pennsylvania: Am. Jour. Sci., 4th ser., v. 46, p. 523-537.

——— 1933, Geologic map of the Appalachian Valley of Virginia, with explanatory text: Virginia Geol. Survey Bull. no. 42, 56 p.

——— 1940, Geology of the Appalachian Valley in Virginia: Virginia Geol. Survey Bull. no. 52, 568 p.

Dally, J. C., 1956, The stratigraphy and paleontology of the Pocono Group in West Virginia: New York, Columbia Univ., unpub. Ph.D. dissert., 237 p. (Univ. Microfilms, Ann Arbor, Mich., Doctoral dissert. series pub. no. 19).

Darton, N. H., 1892, Notes on the stratigraphy of a portion of central Appalachian Virginia: Am. Geologist, v. 10, p. 10-18.

——— 1894, Description of the Staunton quadrangle [Virginia-West Virginia]: U.S. Geol. Survey Geol. Atlas, Folio 14, 4 p.

——— 1896, Description of the Franklin quadrangle [West Virginia-Virginia]: U.S. Geol. Survey Geol. Atlas, Folio 32, 6 p.

Dennison, J. M., 1970, Stratigraphic divisions of Upper Devonian Greenland Gap Group ("Chemung Formation") along Allegheny Front in West Virginia, Maryland, and Highland County, Virginia: Southeastern Geology, v. 12, no. 1, p. 53-82.

——— 1973, Appalachian energy resources for the future: West Virginia Acad. Sci. Proc., v. 45, no. 3, p. 235-243.

Dennison, J. M., and Johnson, R. W., Jr., 1971, Tertiary intrusions and associated phenomena near the thirty-eighth parallel fracture zone in Virginia and West Virginia: Geol. Soc. America Bull., v. 82, no. 2, p. 501-508.

Dennison, J. M., and Wheeler, W. H., 1975, Stratigraphy of Precambrian through Cretaceous strata of probable fluvial origin in Southeastern United States and their potential as uranium host rocks: Southeastern Geology Spec. Pub. 5, 210 p.

Dorr, J. V. N., 2d, and Sweeney, J. W., 1968, Manganese, *in* Mineral resources of the Appalachian region: U.S. Geol. Survey Prof. Paper 580, p. 416-425.

Fullagar, P. D., and Bottino, M. L., 1969, Tertiary felsite intrusions in the Valley and Ridge province, Virginia: Geol. Soc. America Bull., v. 80, no. 9, p. 1853-1857.

Garner, T. E., Jr., 1956, The igneous rocks of Pendleton County, West Virginia: West Virginia Geol. Survey Rept. Inv. 12, 31 p.

Gooch, E. O., 1954, Iron in Virginia: Virginia Div. Geology, Mineral Resources Circ. 1, 17 p.

Herbert, Paul, Jr., and Young, R. S., 1956, Sulfide mineralization in the Shenandoah Valley of Virginia: Virginia Div. Geology Bull. 70, 58 p.

Howell, R. W., 1925, Fields of Augusta and Rockingham Counties, *in* Campbell, M. R., and others, The valley coal fields of Virginia: Virginia Geol. Survey Bull. 25, p. 283-294.

Jacobeen, F. H., Jr., and Kanes, W. H., 1974, Structure of the Broadtop synclinorium and its implications for Appalachian structural style: Am. Assoc. Petroleum Geologists Bull., v. 58, no. 3, p. 361-375.

Johnson, R. W., Jr., Milton, Charles, and Dennison, J. M., 1971, Field trip to the igneous rocks of Augusta, Rockingham, Highland, and Bath Counties, Virginia: Virginia Div. Mineral Resources Inf. Circ. 16, 68 p.

Klemic, Harry, 1962, Uranium occurrences in sedimentary rocks of Pennsylvania: U.S. Geol. Survey Bull. 1107-D, p. 243-288.

Kozak, S. J., 1970, Geology of the Elliott Knob, Deerfield, Craigsville, and Augusta Springs quadrangles, Virginia: Virginia Div. Mineral Resources Rep. Inv. 21, 23 p.

Lesley, J. P., 1876, The Boyd's Hill gas well at Pittsburgh: Pennsylvania Geol. Survey, 2d, Report L, Appendix E, p. L.217-L.237.

Lesure, F. G., 1957, Geology of the Clifton Forge iron district, Virginia: Virginia Polytech. Inst. Bull., Eng. Expt. Sta. Ser. no. 118, 130 p.

Lesure, F. G., Motooka, J. M., and Weis, P. L., 1977, Geochemical studies of some sandstone copper-uranium deposits, Bradford, Columbia, and Lycoming Counties, Pennsylvania: U.S. Geol. Survey Jour. Research, v. 5, no. 5 (in press).

Le Van, D. C., 1974, Directory of the mineral industry in Virginia: Charlottesville, Va., Virginia Div. Mineral Resources, 56 p.

Lowry, W. D., 1954, Silica sand resources of western Virginia: Virginia Polytech. Inst. Bull., Eng. Expt. Sta. Ser. no. 96, 62 p.

McCauley, J. F., 1961, Uranium in Pennsylvania: Pennsylvania Geol. Survey, 4th Ser., Bull. M43, 71 p.

Meyer, R. F., and Edgerton, C. D., Jr., 1968, Petroleum and natural gas, *in* Mineral resources of the Appalachian region: U.S. Geol. Survey Prof. Paper 580, p. 145-163.

Patchen, D. G., 1968, Oriskany Sandstone—Huntersville Chert gas production in the eastern half of West Virginia: West Virginia Geol. and Econ. Survey, Circ. 9, 30 p.

Perry, W. J., Jr., 1964, Geology of Ray Sponaugle well, Pendleton County, West Virginia: Am. Assoc. Petroleum Geologists Bull., v. 48, no. 5, p. 659-669.

Pettijohn, F. J., 1963, Chapter 5. Chemical composition of sandstones—excluding carbonate and volcanic sands, *in* Fleischer, Michael, ed., Data of geochemistry 6th ed.: U.S. Geol. Survey Prof. Paper 440-S, 21 p.

Rogers, W. B., 1836, Report of the geological reconnaissance of the State of Virginia: Philadelphia, Desilver, Thomas and Co., 143 p.

——— 1838, Report of the progress of the Geological Survey of the State of Virginia for the year 1837: Philadelphia, S. Shepherd and Co., 24 p.

——— 1884, A reprint of annual reports and other papers on the geology of the Virginias: New York, D. Appleton and Co., 832 p.

Shapiro, Leonard, 1967, Rapid analysis of rocks and minerals by a single-solution method, *in* Geological Survey research 1967: U.S. Geol. Survey Prof. Paper 575-B, p. B187-B191.

Stevenson, J. J., 1878, Report of progress in the Fayette and Westmoreland district of the bituminous coal fields of western Pennsylvania, Part 2, the Ligonier Valley: Pennsylvania Geol. Survey, 2d, Rept. KKK, 331 p.

Stow, M. H., 1955, Report of radiometric reconnaissance in Virginia, North Carolina, eastern Tennessee, and parts of South Carolina, Georgia, and Alabama: U.S. Atomic Energy Comm. [Rept.], RME 3107, 33 p.

Tilton, J. L., Prouty, W. F., and Price, P. H., 1927, Pendleton County: West Virginia Geol. Survey [County Report], 384 p.

Turekian, K. K., and Wedepohl, K. H., 1961, Distribution of the elements in some major units of the earth's crust: Geol. Soc. America Bull., v. 72, no. 2, p. 175-191.

Watson, T. L., 1907, Mineral resources of Virginia: Lynchburg, Va., Virginia Jamestown Exposition Comm., 618 p.

Woodward, H. P., 1943, Devonian system of West Virginia: West Virginia Geol. Survey [Rept.] v. 15, 655 p.

Young, R. S., and Harnsberger, W. T., 1955, Geology of Bergton gas field, Rockingham County, Virginia: Am. Assoc. Petroleum Geol. Bull., v. 39, no. 3, p. 317–328.

Zartman, R. E., Brock, M. R., Heyl, A. V., and Thomas, H. H., 1967, K-Ar and Rb-Sr ages of some alkalic intrusive rocks from central and eastern United States: Am. Jour. Sci., v. 265, no. 10, p. 848-870.