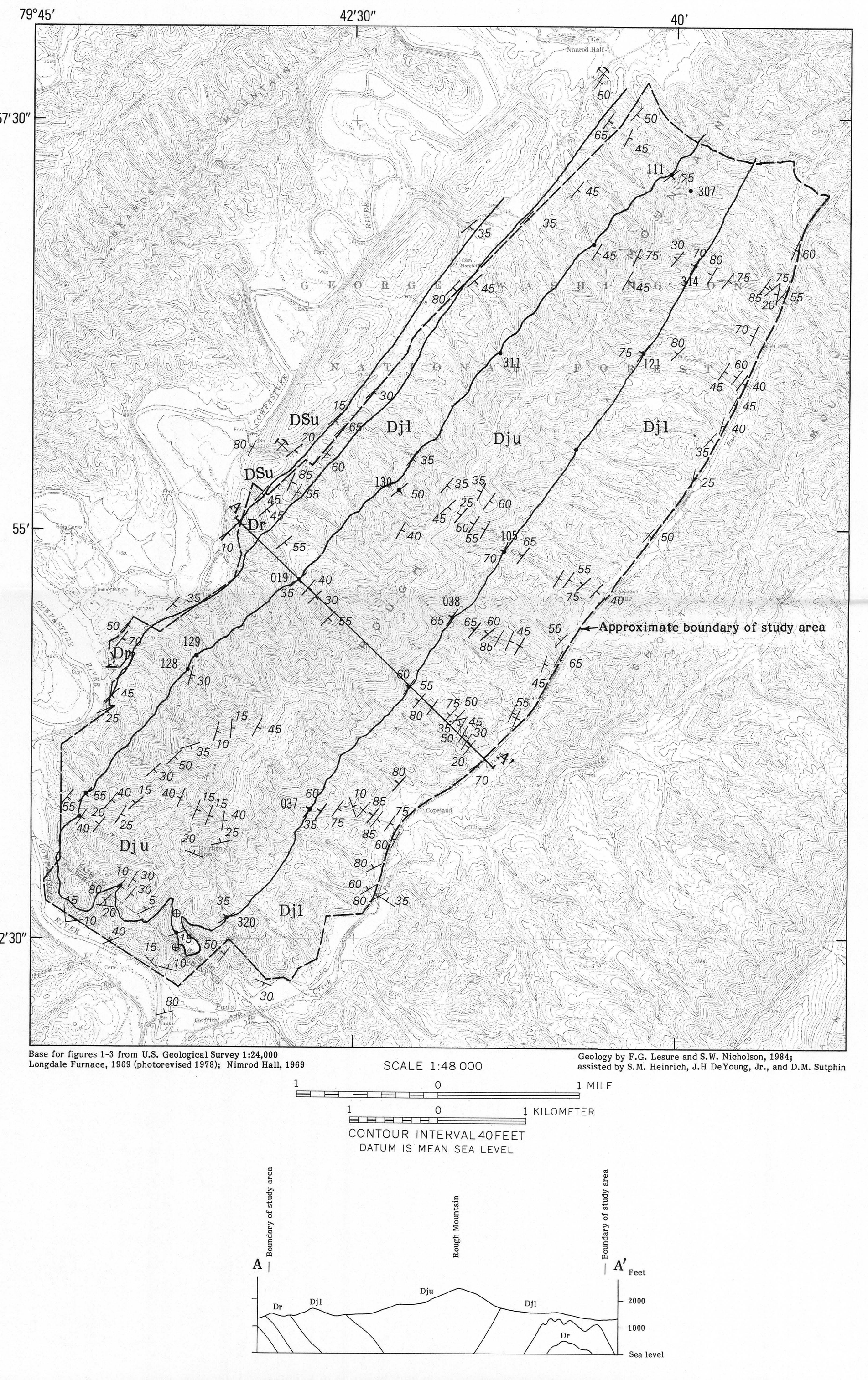


Figure 1.--Geologic map and cross section.

CORRELATION OF MAP UNITS

Unit	Series	System
Dju, Djl	Upper Devonian	Devonian
Dr	Middle Devonian	Devonian
DSu	Lower Devonian / Upper Silurian	Devonian / Silurian

DESCRIPTION OF MAP UNITS

Dju / Djl — **JENNINGS FORMATION (UPPER DEVONIAN)**--Brownish-gray to olive- or medium-gray, generally thin-bedded but locally thick-bedded, irregularly bedded, or massive, interbedded shale, siltstone, and fine-grained sandstone. Upper unit (Dju), fossiliferous beds that correlate with the Chemung Formation; lowest prominent fossiliferous bed 5-10 ft thick at base. Lower unit (Djl), nonfossiliferous beds that correlate with the Brallier Shale

Dr — **ROMNEY SHALE (MIDDLE DEVONIAN)**--Black, fissile, pyritic, sparsely fossiliferous shale. Grades into medium- to light-olive gray, calcareous, fossiliferous shale in lower 100 ft. Upper black shale correlates with the Millboro Shale and lower gray shale correlates with the Needmore Shale

DSu — **LOWER DEVONIAN AND UPPER SILURIAN ROCKS, UNDIVIDED**--Contains the following formations which are poorly exposed and were not mapped separately in this area: RIDGELEY SANDSTONE (LOWER DEVONIAN)--Medium- to coarse-grained, calcareous sandstone; LICKING CREEK LIMESTONE (LOWER DEVONIAN)--Upper part light-gray, sandy limestone. Lower part, dark- to medium-gray, cherty limestone; HEALING SPRINGS SANDSTONE (LOWER DEVONIAN)--Light gray to grayish-orange, medium- to coarse-grained, cross-bedded, calcareous sandstone. Deeply weathered and poorly exposed; NEW CREEK LIMESTONE (LOWER DEVONIAN)--Light- to medium-gray, coarse-grained, crinoidal, sandy limestone. Deeply weathered and poorly exposed; KESYER FORMATION (LOWER DEVONIAN AND UPPER SILURIAN)--Upper part calcareous sandstone and cherty limestone. Lower part coarse-grained limestone; TONOLOWAY LIMESTONE (UPPER SILURIAN)--Thin-bedded argillaceous limestone

Contact

Strike and dip of bedding
- Horizontal
- Inclined
- Vertical

•311 Fossil locality. Numbered locality refers to collections identified and listed in table 1

Quarry

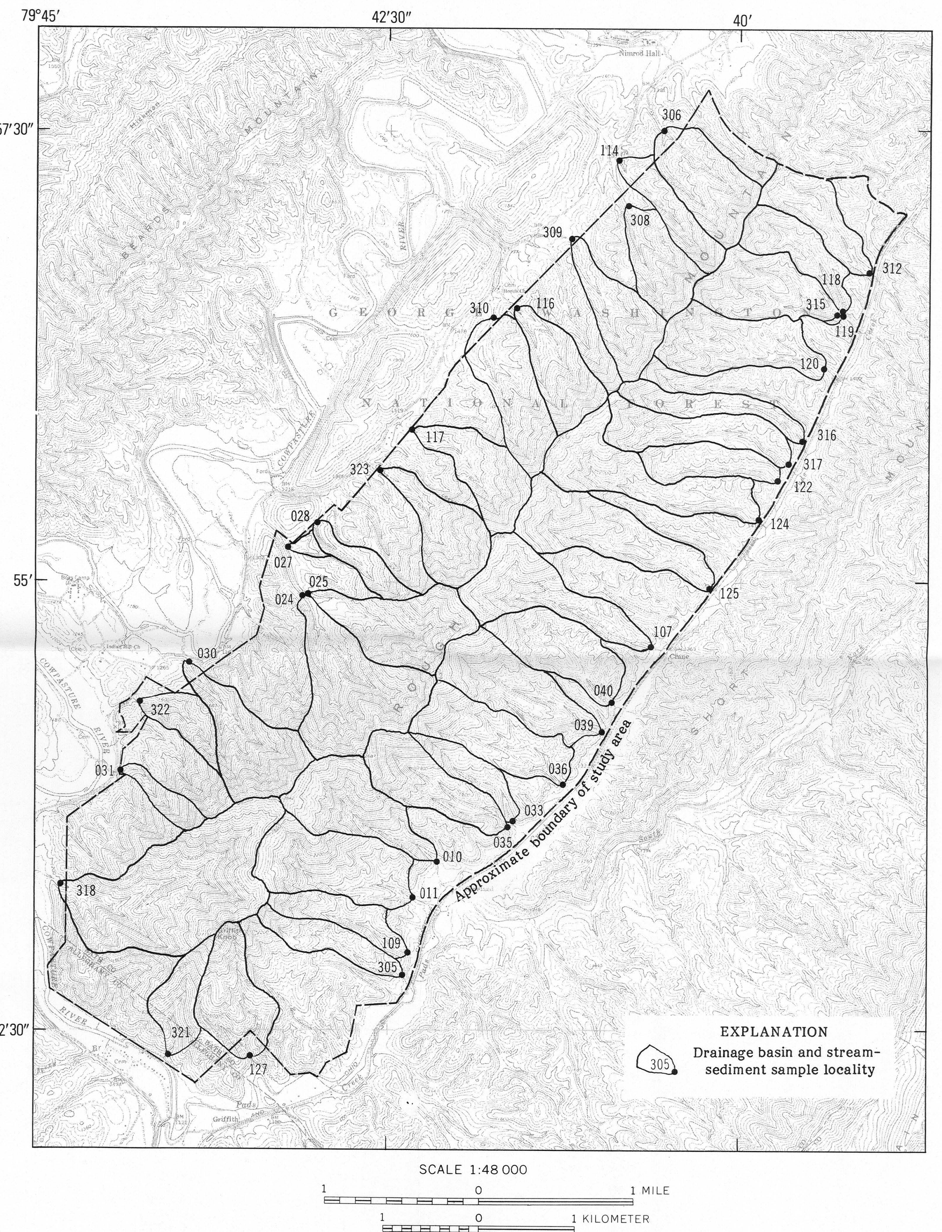


Figure 2.--Small drainage basins and localities of stream sediment samples.

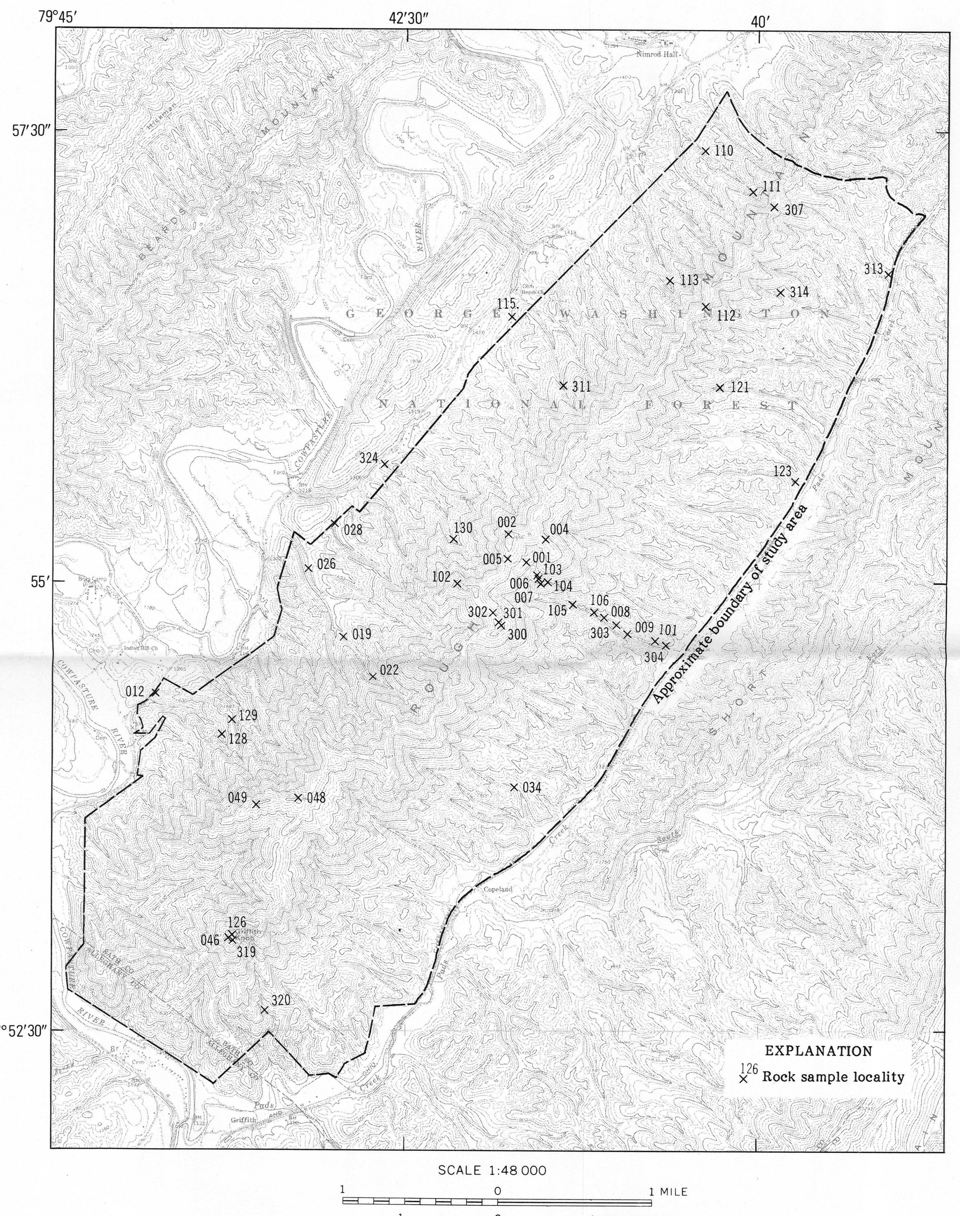


Figure 3.--Localities of rock samples.

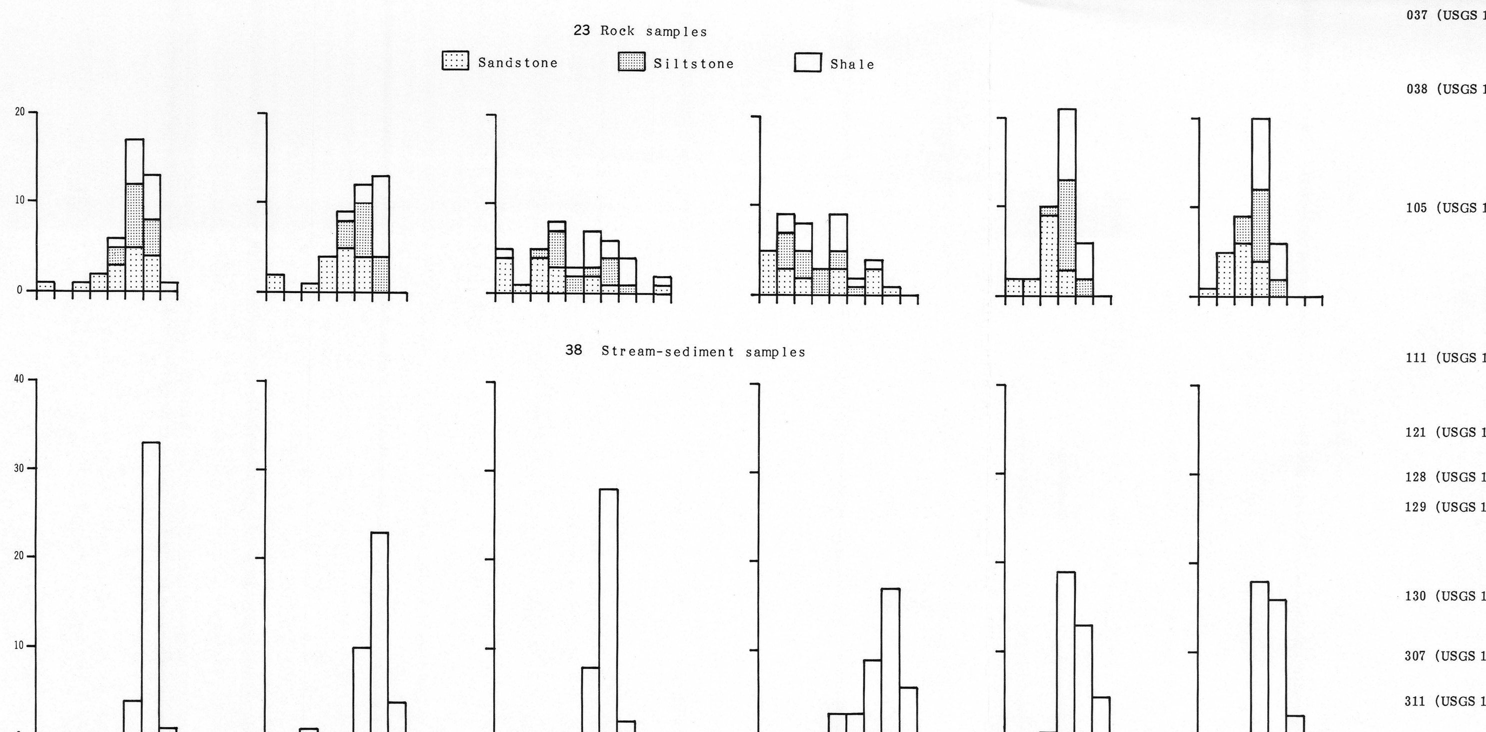


Figure 4.--Histograms showing distribution of selected elements. Data for zinc grouped in six steps per order of magnitude (Motooka and Grimes, 1976, p. 2). N, not detected; L, detected but less than limit of determination.

Table 1.--*Faunal lists of fossil collections from the Rough Mountain Roadless Area*

Sample localities shown on figure 1
Fossil identifications by J.T. Dutro, Jr., USGS, Washington, D.C.

Field No. (Collection No.)	Collection contains:
019 (USGS 10925-SD)	*Rhipidomella* sp.; *Tropidoleptus* sp.; *Spinocyrtia* sp.; *Ambocoelia gregaria* (Hall)
037 (USGS 10926-SD)	*Rhipidomella* sp.; *Cariniferella*? sp.; *Tropidoleptus*? sp.; *Ambocoelia gregaria* (Hall)
038 (USGS 10927-SD)	echinoderm columnals, indet.; *Rhipidomella* sp.; *Schizophoria* sp.; *Tropidoleptus* cf. *T. carinatus* (Conrad); *Spinocyrtia* cf. *S. marcyi* (Hall); *Tylothyris mesacostalis* (Hall); *Spinatrypa* sp.
105 (USGS 10928-SD)	echinoderm columnals, indet.; *Rhipidomella* sp.; *Schizophoria* sp.; *Cariniferella* sp.; *Tropidoleptus* cf. *T. carinatus* (Conrad); *Tylothyris mesacostalis* (Hall); *Spinatrypa* sp.; *Ambocoelia gregaria* (Hall); proetid trilobite fragment, indet.
111 (USGS 10929-SD)	echinoderm columnals, indet.; *Rhipidomella* sp.; *Tropidoleptus* cf. *T. carinatus* (Conrad); *Tylothyris mesacostalis* (Hall)
121 (USGS 10930-SD)	echinodermal debris, indet.; *Spinocyrtia* cf. *S. marcyi* (Hall)
128 (USGS 10931-SD)	*Ambocoelia gregaria* (Hall)
129 (USGS 10932-SD)	echinoderm columnals, indet.; *Rhipidomella*? sp.; *Chonetes* sp.; *Ambocoelia gregaria* (Hall); *Lyriopecten*? sp.
130 (USGS 10933-SD)	echinoderm debris, indet.; *Cyrtospirifer chemungensis* (Conrad); *Spinatrypa* sp.
307 (USGS 10935-SD)	echinoderm debris, indet.; *Cyrtospirifer chemungensis* (Conrad)
311 (USGS 10936-SD)	*Elytha* cf. *E. fimbriata* (Conrad); *Tylothyris*? sp.; *Spinatrypa*? sp.
314 (USGS 10937-SD)	Echinoderm columnals, indet.; rhynchonelloid fragments, indet.; *Spinocyrtia* cf. *S. marcyi* (Hall); *Tylothyris mesacostalis* (Hall); *Spinatrypa* sp.
320 (USGS 10938-SD)	*Rhipidomella* sp.; *Spinocyrtia*? sp.; *Ambocoelia cregaria* (Hall); *Tylothyris*? sp.

Table 2.--Range and median values for 23 elements in stream-sediment and rock samples from the Rough Mountain Roadless Area and vicinity, compared with the median values for stream-sediment samples from the Cornplanter Roadless Area (Lesure and Day, 1984), the Allegheny Front and Hickory Creek Roadless Areas (Hickling and others, 1983a), the Clarion River Roadless Area (Hickling and others, 1983b), and Ramseys Draft Wilderness Study Area and Addition (Matooka and others, 1981)

	Stream sediments								Jennings Formation: Sandstone and conglomerate				Jennings Formation: Siltstone			Jennings Formation: Shale				Romney Shale				
	38 Samples			RD[1]	C[2]	AF[3]	HC[3]	CR[4]	16 samples			Average ss[6]	13 samples			12 samples			Average[5] Shale	3 samples			RH[8]	DA[9]
	Low	High	Median	Median	Median	Median	Median	Median	Low	High	Median		Low	High	Median	Low	High	Median		(012)	(026)	(115)	Median	Median
Percent																								
Ca (0.05)	0.05	0.3	0.13	0.07	0.2	0.07	0.05	0.05	<0.05	0.3	0.05	3.9	<0.05	0.5	0.05	<0.05	0.3	0.05	2.2	0.05	0.7	<0.05	<0.05	0.07
Fe (0.05)	1.5	7	3	2	3	3	2	3	0.3	5	3	0.98	3	7	5	.5	10	6	4.7	2	10	3	1.5	3
Mg (0.02)	.5	1	.5	.3	0.5	.3	.2	.2	0.1	1	.3	0.7	0.5	2	0.7	0.5	1.5	1	1.5	.5	2	.7	0.7	0.3
Ti (0.002)	.7	>1	1	0.5	0.5	.7	.5	.7	0.2	>1	1	0.15	.7	1	1	0.5	1	0.85	0.46	.5	.7	.5	0.7	0.3
Parts per million																								
Ag (0.5)	N	3	N	N	N	N	N	N	N	N	N	0.0X7	N	2	N	N	<.5	N	0.07	1	N	N	2	N
B (10)	150	500	300	100	70	100	100	100	50	300	175	35	200	500	300	150	500	300	100	500	500	700	700	70
Ba (20)	700	1500	1000	300	500	700	300	700	100	1000	700	300	500	1000	700	500	1500	850	580	700	1000	1000	1000	500
Be (1)	2	5	3	1.5	3	1.5	1.5	1.5	<1	3	1.3	2	1.5	5	3	2	5	3	3	5	3	3	3	3
Co (5)	5	30	20	20	15	15	15	15	N	15	10	0.3	10	20	15	10	20	15	19	5	20	10	N	10
Cr (10)	50	100	70	70	50	100	70	100	10	100	50	35	70	150	70	50	150	100	90	70	150	100	100	150
Cu (5)	20	50	30	15	20	20	15	20	<5	100	7	10-20	L	50	15	10	100	25	45	30	30	100	50	50
La (20)	N	50	30	30	50	N	N	N	N	150	30	7	N	70	30	30	70	50	39	30	50	50	50	70
Mn (10)	300	3000	2000	1000	1500	2000	1000	5000	70	1500	300	500	200	2000	300	200	1500	700	850	150	1000	200	150	300
Mo (5)	N	5	N	N	N	N	N	N	N	N	N	0.2	N	N	N	N	N	N	2.6	50	N	20	10	N
Nb (20)	N	<20	N	<20	20	N	N	N	N	20	N	0.0X7	N	20	N	N	<20	N	11	N	N	N	N	10
Ni (5)	20	70	30	50	50	30	30	30	N	50	15	2	15	50	50	30	70	50	68	70	70	70	30	50
Pb (10)	20	100	70	30	20	30	30	30	N	50	<10	7	<10	30	10	<10	70	20	20	10	10	50	100	30
Sc (5)	10	20	15	10	7	15	10	15	N	15	8.5	1	10	20	15	10	20	15	13	20	20	20	20	20
Sr (100)	<100	150	100	<100	N	<100	<100	<100	N	<100	100	20	N	100	<100	N	100	100	300	<100	<100	<100	100	100
V (10)	70	200	100	100	125	100	70	100	30	100	70	20	70	150	100	100	150	100	130	700	150	700	500	200
Y (10)	30	50	50	30	50	30	20	30	15	70	30	10	30	70	50	30	50	50	35	50	30	30	30	70
Zn (5)	70	190	85	85	70	100	60	90	20	75	48	16	40	85	70	60	90	78	95	95	60	80	5	95
Zr (10)	100	500	200	200	500	700	500	1000	100	>1000	500	200-250	100	700	200	100	700	150	160	100	100	70	70	100

[1] RD-median values for 42 stream sediment samples, Ramseys Draft Wilderness Study Area and additions, Va.(Lesure and others, 1977; Motooka and others, 1981).

[2] C-median values for 22 stream sediment samples, Cornplanter Roadless Area, Pa. (Lesure and Day, 1984).

[3] AF-median values for 21 stream sediment samples, Allegheny Front Roadless area, Pa.; HC-median values for of 23 stream sediment samples, Hickory Creek Roadless area, Pa.(Hickling and others, 1983a).

[4] CR-median values for 9 stream sediment samples, Clarion River Roadless area, Elk County, Pa.(Hickling and others, 1983b).

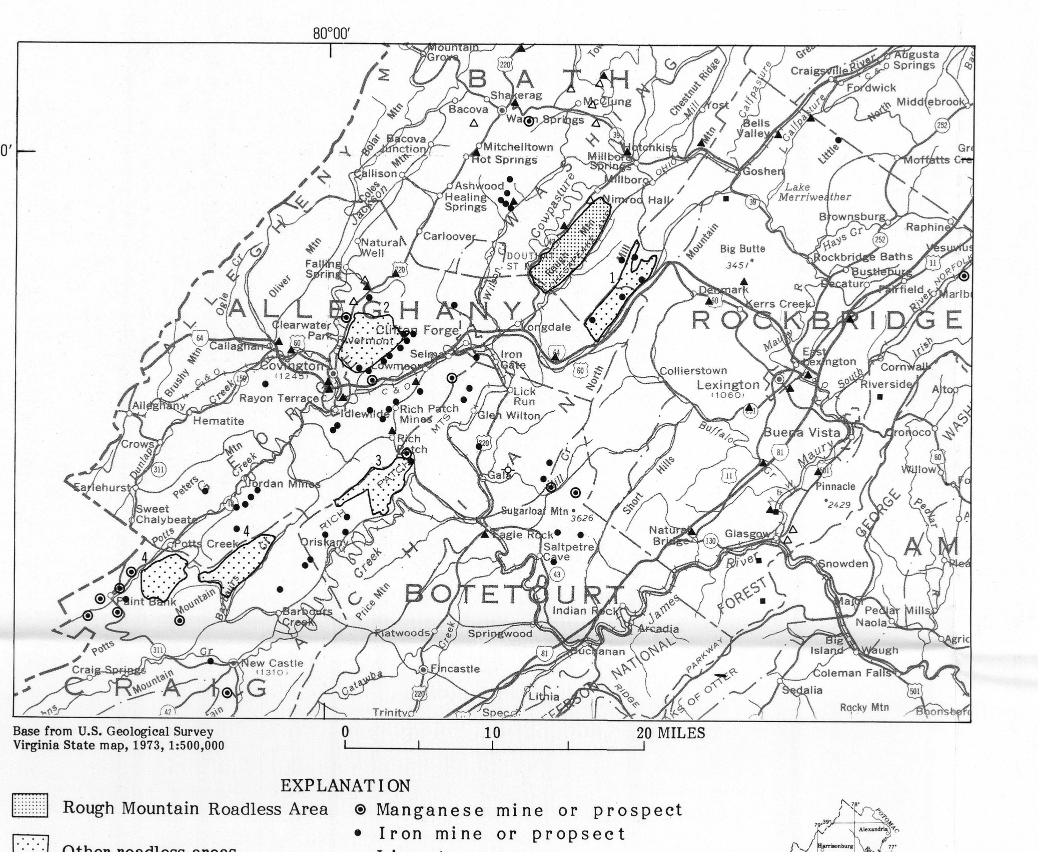
[5] Turekian (1977).

[6] Pettijohn (1963, s11).

[7] Order of magnitude estimated by Turekian (1977).

[8] RH- median values for 9 samples, Rich Hole Roadless Area, Va.(Lesure, in press).

[9] DA- median values for 7 samples, Dolly Ann Roadless Area, Va.(Lesure, 1982).



Index map showing the location of the Rough Mountain Roadless Area, other nearby roadless areas, and some mines and prospects in neighboring areas.

Studies Related To Wilderness

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts require the U.S. Geological Survey to survey certain areas on Federal lands to determine their mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a geological, geochemical, and mineral survey of the Rough Mountain Roadless Area (08-040) in the George Washington National Forest, Alleghany and Bath Counties, Virginia. This area was classified as a proposed wilderness during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979 and designated a wilderness study area by the Virginia Wilderness Act of 1984, Public Law 98-586, October 30, 1984.

SUMMARY

The Rough Mountain Roadless Area comprises 9,300 acres of the George Washington National Forest in the Valley and Ridge physiographic province of west-central Virginia. The area contains folded clastic sedimentary rocks of Devonian age. These form a gently plunging, broad syncline that has numerous minor folds, especially on the eastern limb. The only apparent mineral resources are sandstone suitable for use as rough construction material and shale probably suitable for use in making brick and tile. A small area on the western edge of the study area contains limestone suitable for use as construction materials and agricultural lime. Deposits of all of these materials are readily available and more accessible in the surrounding region.

No evidence of a potential for metallic mineral resources was found in or near the study area. Reconnaissance geochemical sampling indicates normal concentrations in the rock types sampled of 31 elements for which analyses were made.

Although the area has both source beds and reservoir rocks, the possibilities of oil occurences are low because of the high thermal maturity of the rocks. Structural conditions are probably fair to poor for gas accumulation, but no drilling has been done in or near the study area to evaluate gas potential.

INTRODUCTION

The Rough Mountain Roadless Area comprises about 9,300 acres of George Washington National Forest land in the Valley and Ridge province in west-central Virginia. The area, which is about 6 mi long and 2 mi wide, is in Bath and Alleghany Counties, about 3 mi south of Millboro Springs, Va. (Index Map). State Route 42 forms part of the western boundary of the area, the Cowpasture River forms part of the southern boundary, and the Chesapeake and Ohio Railroad and Pads Creek form the eastern boundary. The northern boundary follows the crests of two small ridges that lead east and west from the main ridgeline of Rough Mountain.

Rough Mountain is the major topographic feature. Drainages along the eastern flank of the mountain flow eastward into Pads Creek, which is a tributary of the Cowpasture River. Along the western and southern flanks, drainages flow directly into the Cowpasture River. The highest point in the area is 2,842 ft along the ridgeline at the southern end of Rough Mountain, just north of Griffith Knob. The lowest elevations are about 1,150 ft along the Cowpasture River at the southern end of the area. In general, the slopes are steep and heavily wooded with second- or third-growth hardwoods and scattered pine and hemlock. The Crane Trail, which is the only trail maintained within the area, begins on Virginia State Route 42 about 7 mi south of Millboro Springs, ascends eastward to the crest of Rough Mountain, and then descends to the railroad switching station at Crane on the eastern side of Rough Mountain. Relief along the trail is about 1,200 ft. Access to the Crane switching station is from a dirt road that leaves the maintained gravel road along South Fork Creek at Copeland, another railroad switching station. The South Fork Creek road goes south from State Route 633 about 3 mi south of the town of Millboro.

Previous Studies

The earliest geologic work in the area was done by W.B. Rogers, the first State Geologist of Virginia, who described a geological traverse passing through Millboro Springs just north of the study area (Rogers, 1836, p. 96-105). N.H. Darton (1894, 1899) mapped the Monterey and Staunton 30-minute quadrangles just north of the area and described rock units that extend into the Rough Mountain area (Darton, 1892). The first comprehensive stratigraphic and structural framework for the Valley and Ridge province of Virginia was established by Charles Butts (1933). Later he provided a detailed discussion of the stratigraphy and geologic structures of the valley (Butts, 1940). Perry (1978) gives an updated discussion of structural features in this region of the central Appalachians. Work which is more specific to the Rough Mountain area includes a measured section of Upper Silurian and Lower Devonian limestones and sandstones in and near a quarry on Virginia State Route 42 about 7 mi south of Millboro Springs (Edmundson, 1958, p. 74-75) and a geologic map of the Millboro, Virginia 15-minute quadrangle (Kozak, 1965).

Present Work

Field work for the present study was done in April 1984 by F.G. Lesure, S.W. Nicholson, and S.M. Heinrich. J. Thomas Dutro, Jr., U.S. Geological Survey (USGS), provided identification of fossil assemblages from the Jennings Formation. All geochemical samples were analyzed by E.A. Bailey, J.D. Sharkey, and Marianne Walter in USGS laboratories, Denver, Colo.

Acknowledgments

Palmer Sweet of the Virginia Division of Mineral Resources provided mine and prospect data and other reference material for this area in Virginia.

GEOLOGY

Stratigraphy

The rocks exposed in the Rough Mountain study area are interbedded Middle and Upper Devonian sandstones and shales of the Romney Shale and Jennings Formation, although Upper Silurian and Lower Devonian rocks are exposed along the western side of the study area (fig. 1). A brief description of each unit is presented here; more detailed discussions can be found in Butts (1940, p. 261-333), Lesure (1957, p. 41-60), and Kozak (1965, p. 9-12).

Along the western margin of the Rough Mountain Roadless Area lies a series of thin limestones and sandstones of Late Silurian and Early Devonian age, which form a low, doubly plunging anticlinal ridge west of State Route 42. These formations, which are poorly exposed and lie mostly outside the boundaries of the study area, are shown on the map as one undivided Lower Devonian-Upper Silurian unit, DSu. In ascending stratigraphic order this unit includes the Tonoloway Limestone, Keyser Formation, New Creek Limestone, Healing Springs Sandstone, Licking Creek Limestone and Ridgeley Sandstone. The New Creek, Healing Springs, and Licking Creek were included in the Helderberg Group by Swartz (1930, p. 27), Edmundson (1958, p. 74-75) and Kozak (1965, p. 10).

The Tonoloway Limestone is characteristically a thin-bedded, laminated, impure, and argillaceous limestone that commonly contains mudcracks. About 30 ft of the formation are exposed in the creek and lower slopes in the middle of the gap through which Virginia Highway 42 passes near the southern end of the anticline.

The overlying lower limestone member of the Keyser Formation is light-gray, coarse-grained, and crinoidal. It is well exposed in the small quarry north of the road in the gap where Edmundson (1958, p. 75) measured a thickness of 50 ft. The upper sandstone member of the Keyser is gray, medium bedded, and calcareous and contains some cherty limestone beds. About 68 ft of the upper member are exposed in and east of the quarry (Edmundson, 1958, p. 75). West of the quarry the Tonoloway and Keyser are thrust over steeply dipping Licking Creek Limestone and Ridgeley Sandstone on the west limb of this small anticline (Rader and Gathright, 1984, p. 37-38).

The New Creek Limestone, formerly called the Coeymans Limestone (Butts, 1940, p. 274; Lesure, 1957, p. 46-47; Kozak, 1965, p. 10), is a coarsely crystalline, light-gray to pink limestone, commonly containing large crinoid columns. Edmundson (1958, p. 74-75) measured a thickness of 12-15 ft where the formation is exposed outside the roadless area east and north of the small quarry along route 42.

The overlying Healing Springs Sandstone is not exposed within the Rough Mountain Roadless Area, but Edmundson (1958, p. 75) reports its thickness west of the quarry as 15 ft. The formation is a calcite-cemented quartz sandstone, which is generally deeply weathered.

The Licking Creek Limestone consists of a lower, dark gray, cherty limestone and an upper, massive, sandy limestone. The limestone is also exposed along Route 42 immediately west of the study area, where it is 150 ft thick (Edmundson, 1958, p. 74-75), and also just within the study area in the stream valley 0.3 mi south of the quarry.

Overlying the Licking Creek Limestone is the Ridgeley Sandstone, a calcite-cemented quartz sandstone, which correlates with the Oriskany Sandstone of New York. The Ridgeley, which is about 15 ft thick in this area (Edmundson, 1958, p. 74), forms the hanging wall of the so-called Oriskany iron deposits in the Clifton Forge and Longdale areas 5 mi to the southwest and southeast, respectively. In the Rough Mountain area, there is little secondary iron cement in the sandstone and no iron workings are present.

The Romney Shale of Middle Devonian age overlies the Lower Devonian Ridgeley Sandstone. N.H. Darton (1892, p. 17-18) first defined the Romney Shale as those dark shales which lie above the Oriskany Sandstone (or Ridgeley in this area) and below the light-colored shales of the Jennings Formation. Kindle (1912, p. 14) and Butts (1940, p. 294-305) separated a lower green shale member from Darton's Romney Shale and called it the Onondaga Shale. Woodward (1943, p. 278) suggested, however, that the correlation of this shale with the Needmore Shale in Pennsylvania was more appropriate, and the latter name was adopted for these rocks. Butts (1940, p. 308-309) called the fissile black shale of the Romney the Millboro Shale after exposures near Millboro Springs 4 mi north of the study area. Because the exposures are generally poor in this area, the Needmore and Millboro have been mapped as a single unit called the Romney Shale, which conforms to Darton's original definition (1892, p. 17). In the Rough Mountain area, the Romney Shale is well exposed in a small quarry at the north end of the study area as well as in the lower reaches of several creeks which drain the west side of Rough Mountain (fig. 1). Based on our mapping, the Romney Shale is at least 700 ft thick in this area. Hasson (1977, p. 37-39) reports a thickness of 1,800 ft for the Millboro and 100 ft for the Needmore at Millboro Springs about 3 mi northeast of the Rough Mountain area. The formation is generally structurally incompetent and may be thinned tectonically along the western edge of Rough Mountain. Exposures are inadequate to determine the true thickness of the Romney.

The rocks that make up the high ground of Rough Mountain are part of the Upper Devonian Jennings Formation. N.H. Darton (1892, p. 17) originally defined the Jennings Formation as the light-colored shales and sandstones which overlie the Romney Shale and included those rocks which contain Chemung- and Portage-type fossils. Butts (1940, p. 317) subdivided the formation by recognizing a lower, generally non-fossiliferous, greenish-gray shale which he called the Brallier Shale, and an upper fossiliferous sandy unit containing a Chemung fauna which he called the Chemung Formation. More recently, Dennison (1970) has divided the Chemung Formation of Butts into two formations and several members in the area of the Allegheny Front, 35 mi and more north of Rough Mountain.

In the Rough Mountain area the uper part of the Jennings is similar lithologically to the lower part, and we have, therefore, mapped these rocks as a single formation. A particularly fossiliferous bed, the first one encountered upsection after passing through a monotonous sequence of unfossiliferous interlayered shales, siltstones, and sandstones in the lower part of the Jennings, forms the base of the upper unit. Both lower and upper units contain light-olive-gray, olive-gray, and yellowish-brown shales and siltstones. Beds of fine-grained sandstone increase in thickness and abundance vertically in the sequence, and locally these contain abundant Chemung-type fossils. Brownish-gray and grayish-brown, almost red shale and sandstone beds and thin pebble conglomerate beds also become more common upsection near the top of the mountain.

We collected fossiliferous material at 13 places (fig. 1). Eleven of the samples came from what is probably the same stratigraphic horizon, which we have shown as the base of the upper unit of the Jennings Formation (table 1).

According to J.T. Dutro, Jr., (written commun., 1984):

"These collections probably represent about the same time interval, the "Chemung" or Cohocton Stage of the Late Devonian, approximately the *Cyrtospirifer chemungensis* Assemblage Zone (Dutro, 1981). The occurrences of the named species, in addition to *Tropidoleptus* cf. *T. carinatus* (Conrad), *Tylothyris mesacostalis* (Hall), *Cariniferella* sp., and *Spinocyrtia* cf. *S. marcyi* (Hall), support this late Frasnian age.

This relationship was noted by Butts (1940, p. 331-333) who discussed the fossils from "the lower 200 feet of the Chemung on Little Back Creek...1-1/2 miles northwest of Mountain Grove, Bath County..." Butts indicated that the occurrence of *Cyrtospirifer* (*Spirifer disjunctus* of his usage) is slightly higher than the fauna with *Tropidoleptus*. And so it would appear from these collections, although the differences could simply be due to local facies control."

Rocks above this fossiliferous bed correlate with the Chemung Formation of Butts (1940, p. 322-333) and possibly with the Scherr Formation of Dennison (1970, p. 64-66). Rocks below the fossil bed correlate with the Brallier Shale.

Based on our mapping and structural interpretations (fig. 1), the thickness of the Jennings Formation in this area is at least 3,800 ft; the lower part, below the fossiliferous bed, is at least 1,600 ft thick, and the upper part is at least 2,200 ft thick. The top of the formation is not preserved in the area.

Structure

The Rough Mountain area is a syncline that is a minor structure near the southwest end of the larger Broadtop Synclinorium of Jacobeen and Kanes (1975, p. 1137). The principal fold axis of the Rough Mountain syncline lies approximately along the crest of Rough Mountain, striking generally S 35°W and plunging less than 1° to the southwest. The major fold is open and asymmetric (fig. 1); numerous minor folds are present, especially in the shaly beds on the eastern limb of the main syncline. Some of these minor folds can be traced for half a mile or more. No surface faults with major displacements were recognized during mapping in the area, although at depth there may be nearly flat thrust faults (Perry, 1975; 1978). The flat-lying thrust fault exposed in the small anticline west of the study area may be a splay from a major fault at depth similar to those shown by Perry (1978, p. 520) in an area of the Broadtop Synclinorium about 30 mi to the northeast.

GEOCHEMICAL SURVEY

Concurrent with the geologic mapping, we made a reconnaissance geochemical survey of the Rough Mountain Roadless Area. Thirty-eight stream sediment and 45 rock samples were collected in and near the area to test for indistinct or unexposed mineral deposits that might be recognized by their geochemical halos.

Most of the small drainage basins in the study area and a few adjacent to it were sampled by collecting a few handfuls of the finest-grained sediment available from each locality (fig. 2). After drying in the laboratory, the samples were sieved and the minus 80-mesh (0.177 mm) fraction was analyzed.

The rock samples (fig. 3) consist of a few small chips taken from beds of mostly one lithology and of known thickness. The samples are representative of the major rock types exposed in the area and are described in detail by Bailey and others (1985). Most are samples of siltstone, shale and sandstone from the Jennings Formation of Late Devonian age.

All samples were scanned spectrographically for 31 elements and analyzed chemically for zinc in the USGS laboratories, Denver, Colo. The complete analytical data and rock sample descriptions are given in Bailey and others (1985).

Results

The analytical data do not outline any areas having a potential for metallic mineral resources in the Rough Mountain Roadless Area. The distribution of six elements (barium, cobalt, copper, lead, vanadium, and zinc) which are economically important as ore deposits in sedimentary rocks are shown as representative of the entire set of analyzed samples (fig. 4). The histograms for rock samples clearly illustrate the chemical differences between sandstone, siltstone, and shale; these differences are also shown in table 2. The finer-grained shale and siltstone tend to have greater amounts of the trace elements than the coarser-grained sandstones. Stream sediment analyses form expected distribution patterns and are similar to analyses of samples from other areas containing Upper Devonian clastic sedimentary rocks (table 2).

Of the six elements chosen, only barium is unusually greater in concentration compared with the average rock. Isolated high concentrations of barium are common in Middle and Upper Devonian shales from western New York to Virginia (Pepper and others, 1985; Lesure, 1957, p. 55-57). In general, these high barium concentrations are in the form of barite concretions, but locally barite forms small secondary veins, replaces fossil material, or forms some of the cementing agent in sandstone. Barite concretions were not found in the Rough Mountain area; however, a zone in the lower part of the Romney Shale contains some barite concretions in nearby areas (Lesure, 1957, p. 55-57; Clark, 1983). The potential for economic deposits of barite in the Rough Mountain Roadless Area is low.

MINERAL RESOURCES

No evidence of mining or prospecting was found during field work in the Rough Mountain Roadless Area, but small quarries in the Lower Devonian limestones and the Romney Shale are located just west of the roadless area. This limestone has been used for road ballast (Edmundson, 1958, p. 74)

The Rough Mountain Roadless Area contains abundant rock suitable for use as crushed stone or rough building stone. A small area along the west side underlain by the Licking Creek Limestone contains limestone resources. Some shale beds in the Romney Shale and Jennings Formation from nearby areas are suitable for the manufacture of brick and tile (Calver and others, 1964, p. 16-35, 80-88), but similar shales in the roadless area have not been tested. No evidence of a potential for the occurrence of metallic mineral resources was found or is reported in the literature.

Oil and Gas Potential

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

Although the Rough Mountain Roadless Area contains both source beds and reservoir rocks, it has a low potential for natural gas and no potential for commercial accumulations of oil. The degree of thermal maturation, the temperature to which the source beds have been heated, is too great for the presence of oil; however, the rocks are within the temperature range favorable for the presence of dry natural gas (Harris and others, 1978). Hydrocarbon potential in the Rough Mountain Roadless Area presently remains untested and speculative.

The synclinal structure of the mountain is not favorable for the accumulation of natural gas but the minor folds on the eastern side may reflect structural complications at depth which might contain small traps. Extensive fracture porosity may also be associated with buried thrust faults in the general vicinity of the Rough Mountain area (Milici, 1980; Harris and Milici, 1977, p. 8-11). Natural gas has been produced from rocks having fracture porosity to the north and northwest in both the Allegheny Plateau and in the Valley and Ridge province. A test well drilled in 1981 by Columbia Gas Transmisssion Corporation in Botetourt County about 12 mi south of Rough Mountain was plugged and abandoned. Gas shows were encountered in fractured zones in Middle Ordovician limestone but the well is listed as dry (Patchen and others, 1983, p. 1573-1586). Because available data indicate that even if favorably developed the fractures may not be gas filled, the potential for natural gas in the Rough Mountain area must be rated as low. The area is certainly one of high-risk drilling, but it cannot be excluded from the list of possible gas-producing areas.

Uranium

Marine black shales, which may contain more uranium than other types of shale, have been studied extensively as possible sources of uranium (Swanson, 1961). Several traverses across the outcrop belts of the Romney Shale and the Jennings Formation using a four-channel gamma-ray spectrometer indicate that in the Rough Mountain area the black shale of the Romney is only slightly more radioactive than the lighter-colored shales of the Jennings. Two samples of black shale collected along the western margin of the study area were analyzed for uranium by T.A. Roemer, USGS Laboratories, Denver, Colo., using fluorometric methods. Sample 012 contains 4.3 ppm uranium and sample 026 contains 0.55 uranium (fig. 3). Samples of black shale collected from the Romney Shale in areas surrounding Rough Mountain from 4 to 25 mi away contain from less than 1 to as much as 14 ppm uranium (Hasson, 1977, appendix III; Lesure, 1982). We agree with Hasson (1977, p. 41) who concluded that "the Millboro Shale of Virginia contains too little uranium to be a potential source."

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MAPS SHOWING GEOLOGY, GEOCHEMISTRY, AND MINERAL RESOURCE ASSESSMENT OF THE ROUGH MOUNTAIN ROADLESS AREA, ALLEGHANY AND BATH COUNTIES, VIRGINIA

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