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GAMMA-RAY SPECTROMETRY AND GEOLOGIC MAPPING[1]

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The Division of Mineral Resources has obtained radiometric data over parts of the Valley and Ridge, Blue Ridge, and Piedmont physiographic provinces in central Virginia. These provinces are underlain by diverse types of igneous, metamorphic and sedimentary rocks (Table 1). The Valley and Ridge province has many thousands of feet of folded and faulted Paleozoic sedimentary rocks that form northeast trending linear valleys and ridges. Sandstone, which is more resistant to erosion, makes up most of the ridges, whereas the weaker shale and carbonate rocks underlie the valleys. Rocks in this province generally have low radioactivity levels. Correlation of radioactivity and lithology is used to distinguish between major rock types, such as carbonate and shale.

The Piedmont is a province of diverse rock types with variations in amount and type of radioisotopes. It is typified by 1. complex rock structure, 2. variety of metamorphic grades, and 3. deeply weathered bedrock units covered by thick saprolite. This area is excellent for correlating geologic units by use of radiometric contour patterns.

The Blue Ridge province contains deformed Precambrian plutonic, volcanic, and sedimentary rocks, which have been folded, faulted, and metamorphosed to the greenschist facies. In addition, some metamorphosed plutonic rocks have been altered retrogressively to amphibolite and granulite facies. Identification of the many lithologic types is difficult because of the similarity of mineral composition and the gradation between different formational units. In order to identify specific rock types by radioactivity, the rock must have a higher or lower feldspar and mica content than those surrounding it.

RADIOMETRIC CORRELATIONS OF GEOLOGIC UNITS

MOUNT SIDNEY QUADRANGLE LITHOLOGIC MAP

The area depicted on the Mount Sidney quadrangle (Figure 1) is located entirely within the Valley and Ridge physiographic province. Seven geologic formations (Gathright, Henika, and Sullivan, 1978) have been grouped into three units based on the lithologic similarities of the units (Figure 1). These are divided into the Upper Cambrian Elbrook and

[1]This article is related to "Radioactivity Surveys" published in the May 1979 issue of VIRGINIA MINERALS, vol. 25, no. 2.

Table 1. Geologic formations in the Mount Sidney, Waynesboro East, and Crozet quadrangles.

AGE	NAME	CHARACTER
Quaternary	Alluvium talus, terrace deposits	Clayey sand and silt, cobbles, boulders, gravel, sand, and angular blocks.
Ordovician	Martinsburg Formation	Medium-grained, metamorphosed lithic sandstone alternately interbedded with thin-bedded, calcareous black slate.
	Edinburg Formation	Fine-grained limestone with some calcareous slate.
	Lincolnshire Formation	Medium-grained, medium - to thick-bedded limestone with chert.
	New Market Limestone	Thick-bedded, massive, micritic limestone.
	Beekmantown Group	Interbedded micritic limestone and thick-bedded, fine - to medium-grained dolomite.
Cambrian	Conococheague Formation	Fine-grained algal limestone alternately interbedded with ribbon-banded silty limestone; quartz and siliceous oolitic sand interbeds present locally.
	Elbrook Formation	Fine - to medium-grained crystalline dolomite interbedded with thin algal limestone and argillite.
	Waynesboro Formation	Argillite and phyllite with interbeds of laminated to thin-bedded dolomite and limestone, fine-grained, thin - to thick-bedded sandstone.
	Antietam Formation	Massive, fine-grained vitreous metamorphosed quartzite interlayered with laminated phyllite, argillite, and sandstone.
	Harpers Formation	Phyllite with thin to massive Interbeds of metamorphosed sandstone; quartzite and ferruginous sandstone dominant locally.
	Weverton Formation	Coarse-grained ferruginous sandstone and pebbly quartzite. Thick phyllite at base.
Precambrian	Catoctin Formation	Massive schistose metabasalt and amygdaloidal metabasalt interbedded with metasediments.
	Swift Run Formation	Schistose, metamorphosed basalt and lithic sandstone.
	Mechum River Formation	Metamorphosed sandstone, graywacke, and phyllite.
	Crozet Granite	Coarse-grained, porphyritic granite.
	Pedlar Formation	Coarse-grained, massive to sheared granodiorite gneiss.
	Lovingston Formation	Massive to foliated granite gneiss and mylonitic, augen-bearing gneiss.
	Cataclastic rocks	Mylonite gneiss.

Conococheague formations (Unit A); Middle Ordovician Beekmantown Group, New Market Limestone, and the Lincolnshire and Edinburg formations (Unit B); and Upper Ordovician Martinsburg Formation (Unit C). Quaternary alluvial deposits occur locally over all the units.

Contour patterns constructed from radiometric values obtained over this rock sequence appear to be directly related to the lithologies of the three units. The Elbrook and Conococheague formations (Figure 1, Unit A) have the highest radiometric values measured in the quadrangle. Unit A is mainly limestone and dolomite. The high counts per second may be attributed to the presence of terrigenous sediments (Figure 2A) intermixed with limestone and dolomite. Argillitic interbeds are present in the Elbrook Formation (Figure 2A) and quartz and siliceous oolite sand beds are in the Conococheague (Figure 2B). Silt layers in straticulate limestone (ribbon rock) are common to both the Conococheague and Elbrook formations (Figure 2C).

Unit B (Figure 1) has the lowest radiometric values measured in the quadrangle and is predominantly limestone and dolomite of the Beekmantown Group, the New Market Limestone, the Lincolnshire and Edinburg formations. Calcareous slate is present in the Edinburg Formation. Unit B is noted by the closed lows that dominate its contour pattern. In the central portion of the area the radiometric lows of Unit B emphasize by contrast the northeast trending linearity of Unit A. A radiometric high of 624 counts per second (northwest trend) occurs in the northeastern part of the quadrangle. This high is attributed to a middle limestone unit in the Beekmantown Group, which is spottedly exposed throughout this area.

The Martinsburg Formation (Figure 1, Unit C) displays moderate to high radiometric values when compared with units A and B. In the northwestern exposures Unit C is predominantly a slate interbedded with limestone. In the southeastern area Unit C is mainly sandstone, calcareous argillite, and slate; some interbeds of calcareous slate are present. The radiometric values displayed over the unit are related to the potassium feldspar and mica in the sandstone and heavy detrital minerals, including zircon. The northwest trend of low values in the contour pattern east of Weyers Cave occurs over alluvium in the flood plain of North River. This contour pattern is probably due to the lack of radioactive minerals in the alluvium. The closed low of 488 counts per second in the southeast occurs over a very deeply weathered area. The local high values are attributed to exposed feldspathic sandstone and argillitic beds in the Unit (Figure 2D).

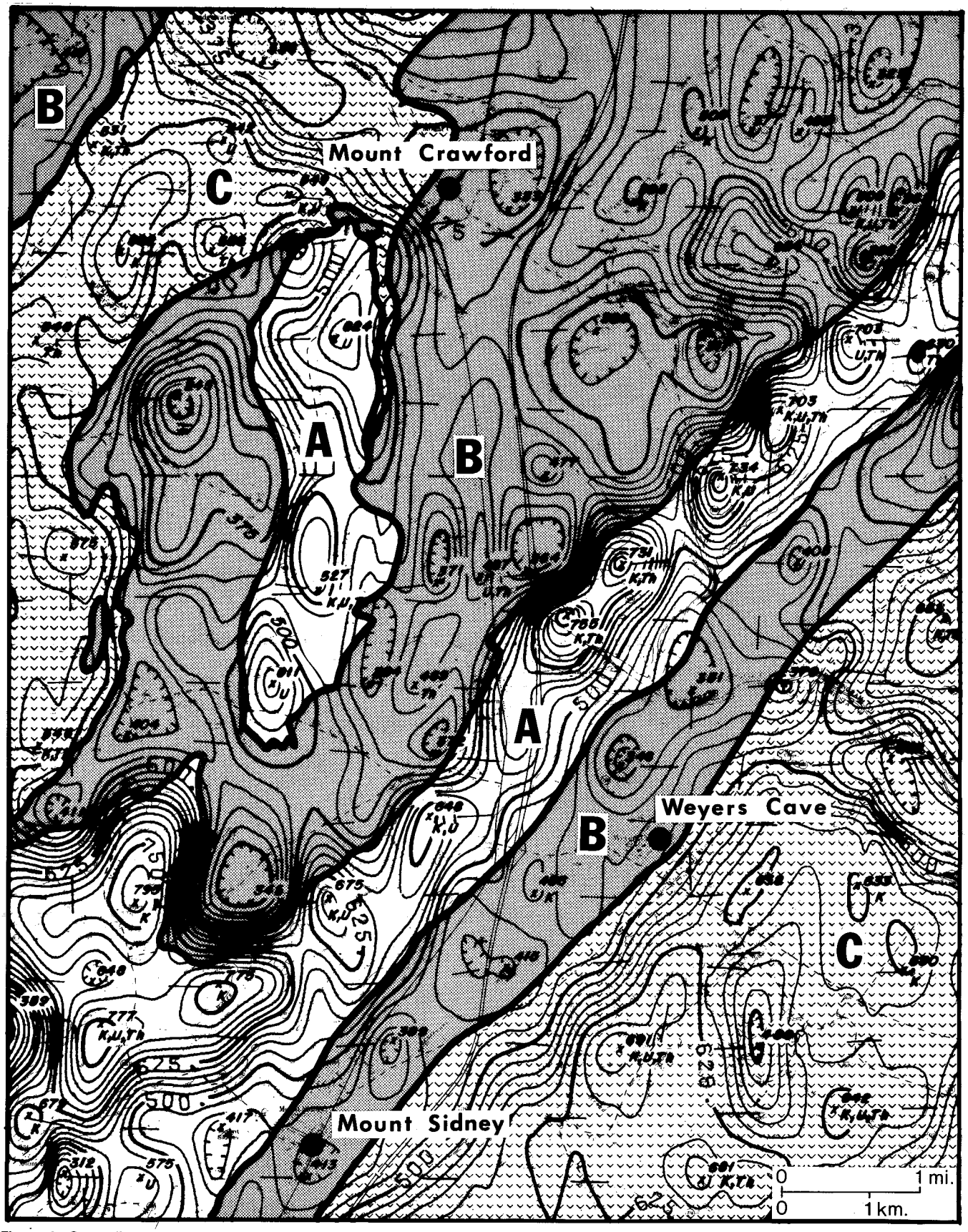

Figure 1. Generalized lithologic map of the Mount Sidney quadrangle with superposed radiometric contours. Explanation: A - Elbrook and Conococheague formations, B- Beekmantown Group, New Market Limestone, the Lincolnshire and Edinburg formations; C - Martinsburg Formation; contour interval 25 and 125 CPS; traverse spacing 0.5 mile; altitude 500 A.M.T., crystal volume 452 in³. Radionuclides: K, potassium-40; Th, thallium-208; U, bismuth-214.

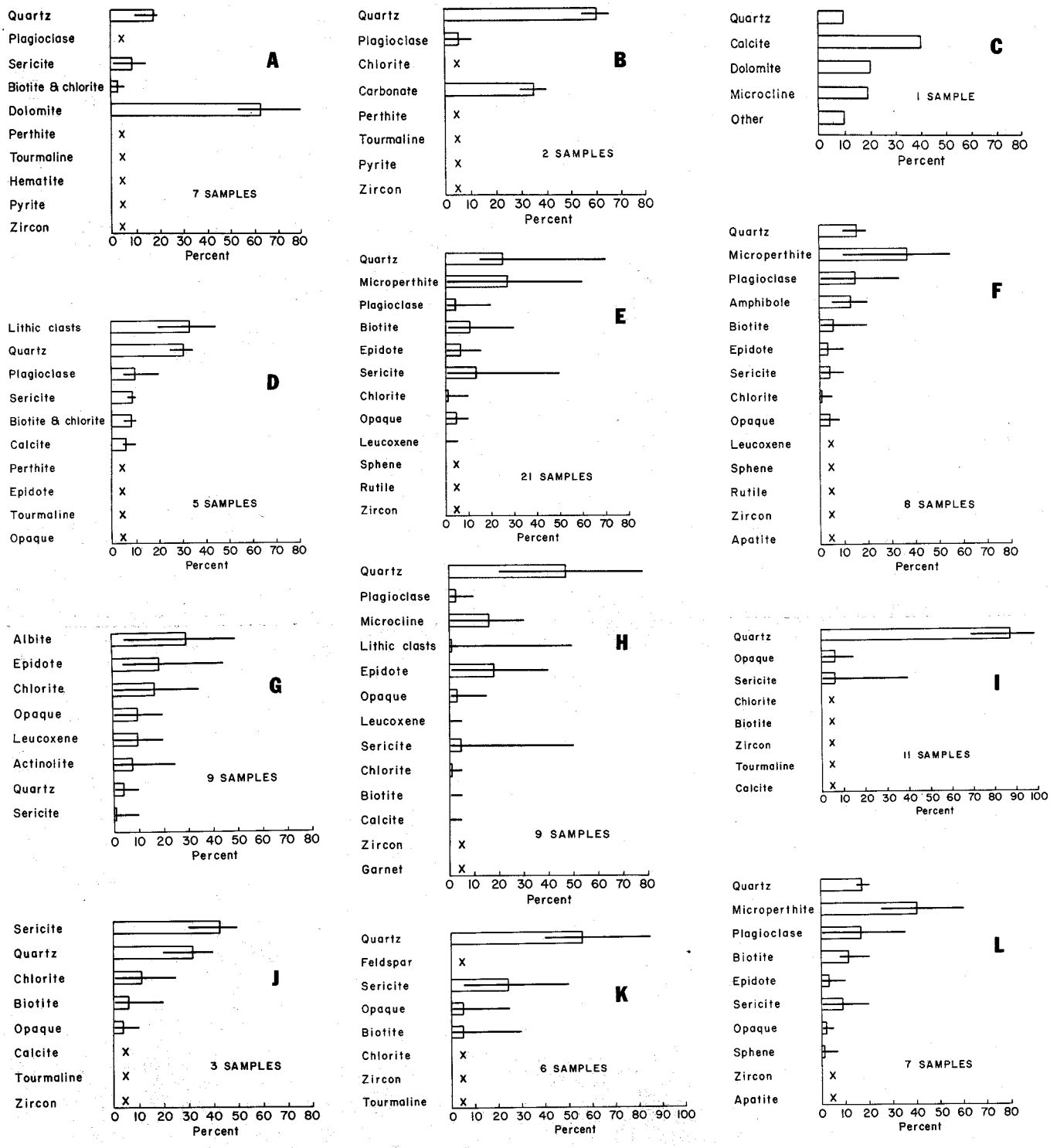

Figure 2. Mineral composition ranges (lines) and averaged estimated composition (bars) of formations in the Mount Sidney, Waynesboro East, and Crozet quadrangles. Minerals in amounts less than 5 percent indicated by X. A, argillitic interbeds - Elbrook Formation; B, sandstone interbeds - Conococheague Formation; C, silty laminae from straticulate limestone - Conococheague Formation (X-ray analyses only); D, metamorphosed lithic sandstone - Martinsburg Formation; E, cataclastic rocks; F, granodiorite gneiss - Pedlar Formation; G, metabasalt - Catoctin Formation; H, metasedimentary rocks - Catoctin Formation; I, metamorphosed sandstone - Harpers Formation; J, phyllite - Harpers Formation; K, metasedimentary rocks - Weverton Formation; L, mylonitic biotite gneiss - Lovingston Formation.

Figure 3. Generalized lithologic map of the Waynesboro East quadrangle with superposed radiometric contours. Explanation: A - Cataclastic rocks and Lovingston and Pedlar formations; B - Crozet granite; C - Swift Run and Catoctin formations; D - Weverton and Harpers formations; E - Antietam Formation; F - Elbrook Formation; contour interval 25 and 125 CPS; traverse spacing 0.5 mile; altitude 500 A.M.T.; crystal volume 452 in^3. Radionuclides: K, potassium - 40; Th, thallium-208; U, bismuth-214.

Figure 4: Generalized lithologic map of the Crozet quadrangle with superposed radiometric contours. Explanation: A - Lovingston Formation; B - Mechum River Formation; C - Pedlar Formation and cataclastic rocks; D - Crozet granite; E - Swift Run and Catoctin formations; contour interval 25 and 125 CPS; traverse spacing 0.5 mile; altitude 500 A.M.T.; crystal volume 452 in.^{3} Radionuclides: K, potassium - 40; Th, thallium - 208; U, bismuth - 214.

WAYNESBORO EAST QUADRANGLE LITHOLOGIC MAP

The Waynesboro East quadrangle area is located in the Valley and Ridge, Blue Ridge, and Piedmont physiographic provinces (Figure 3). Eleven geologic formations (Gathright, Henika, and Sullivan, 1977) have been grouped into six units based on lithologic similarities of the units. These are divided into cataclastic rocks and the Lovingston and Pedlar formations, all of Precambrian age (Unit A); the Precambrian Crozet granite (Unit B); the Precambrian (?) Swift Run and Catoctin formations (Unit C); the Cambrian Weverton and Harpers formations (Unit D); the Cambrian Antietam Formation (Unit E); and the Cambrian Elbrook Formation (Unit F). Localized Quaternary alluvial deposits overlie each of the units.

The highest radiometric values in this area (Figure 3) occur over units B, D, and F; the lowest, over units C and E. Unit A is also low, but is lithologically different from units C and E. The variance in the radiometric contour patterns is attributed to the different lithologies present in the above units (Table 1). The two high value areas of cataclastic rocks in Unit A (Figure 2E) are probably composed of sheared Crozet granite (Unit B). This coarse-grained porphyritic granite has an abundance of potassium feldspar and is essentially biotite-free. Some of the Crozet granite may be intruded into the Pedlar Formation (Figure 2F; grouped in Unit A) and later both were sheared intensely.

Unit C, the Swift Run and Catoctin formations, is predominantly a metamorphosed basalt and has some of the lowest radiometric values. The small areas displaying slightly higher count rates may be due to thin, metasedimentary interbeds in the Catoctin Formation (Figure 2H) derived in part from the Precambrian granites. Unit D, the Weverton and Harpers formations, is stratigraphically higher and is a clastic sequence (Figure 2I, J, and K). The major element contributing to the radiometric values in this unit is potassium accompanied by lower values for uranium and thorium.

Unit E is composed of relatively pure quartzite of the Antietam Formation that has deeply weathered sandstone and phyllite interbeds. Detrital feldspar (less than 10 percent) and trace amounts of zircon seem to be the only radioactive-bearing minerals present and account for the low radiometric values. Talus and alluvial deposits overlie the Shady and Waynesboro formations to the west. The radioactivity of these formations is masked by the alluvial cover. The high value in the northwestern area over Unit F, the Elbrook Formation, compares favorably with the high value over the Elbrook Formation in the Mount Sidney quadrangle (Figures 1 and 2A).

CROZET QUADRANGLE RECONNAISSANCE LITHOLOGIC MAP

The Crozet quadrangle (Figure 4) has most of the lithologic units present in the adjoining Waynesboro East quadrangle. The quadrangle lies in the Blue Ridge and Piedmont physiographic provinces. The rocks mapped in reconnaissance have been grouped into five units. Those of Precambrian age are the Lovingston Formation (Unit A); the Mechum River Formation (Unit B); the Pedlar Formation and cataclastic rocks (Unit C); and the Crozet granite (Unit D). The youngest unit includes the Swift Run and Catoctin formations of Precambrian (?) age (Unit E). Localized quaternary alluvial deposits overlie each of the units. The most prominent features on the Crozet quadrangle (Figure 4) are the high radiometric values in the northwestern area of the map and the northwest trending high in the southeastern portion of the map. The highest radiometric value occurs over the Crozet Granite (Unit D), which is a coarse-grained porphyry. Unit D can almost be mapped solely on its radiometric contour pattern. The high values of Unit B occur over rocks in the Mechum River Formation, which includes metamorphosed arkosic sandstone, graywacke, and phyllite.

The Lovingston Formation (Unit A) is mainly a medium-to coarse-grained granite gneiss with some mylonitic, augen-bearing biotite gneiss. The radiometric values over this formation are variable with local highs and lows (Figure 2L). Cataclastic rocks (Unit C) are largely derived from the shearing and deformation of the Lovingston Formation. Undeformed gneiss (Unit A) of the Lovingston Formation is difficult to distinguish from the cataclastic rock because of similarity in mineral composition. Unit E, the Catoctin Formation displays the same low values as discussed in the Waynesboro East quadrangle.

The contrast between radiometric values of rock types provides a means to correlate these types in much of the study area. From this study it was determined that radioactivity data is a useful aid to geologic mapping in the Valley and Ridge and Piedmont provinces in Virginia.

REFERENCES

Gathright, T. M., II, Henika, W. S., and Sullivan, J. L., III, 1977, Geology of the Waynesboro East and Waynesboro West quadrangles, Virginia: Virginia Division of Mineral Resources Publication 3, 53p.

_____, 1978, Geology of the Mount Sidney quadrangle, Virginia: Virginia Division of Mineral Resources Publication 11, 1 sheet-text and 1:24,000 scale map.

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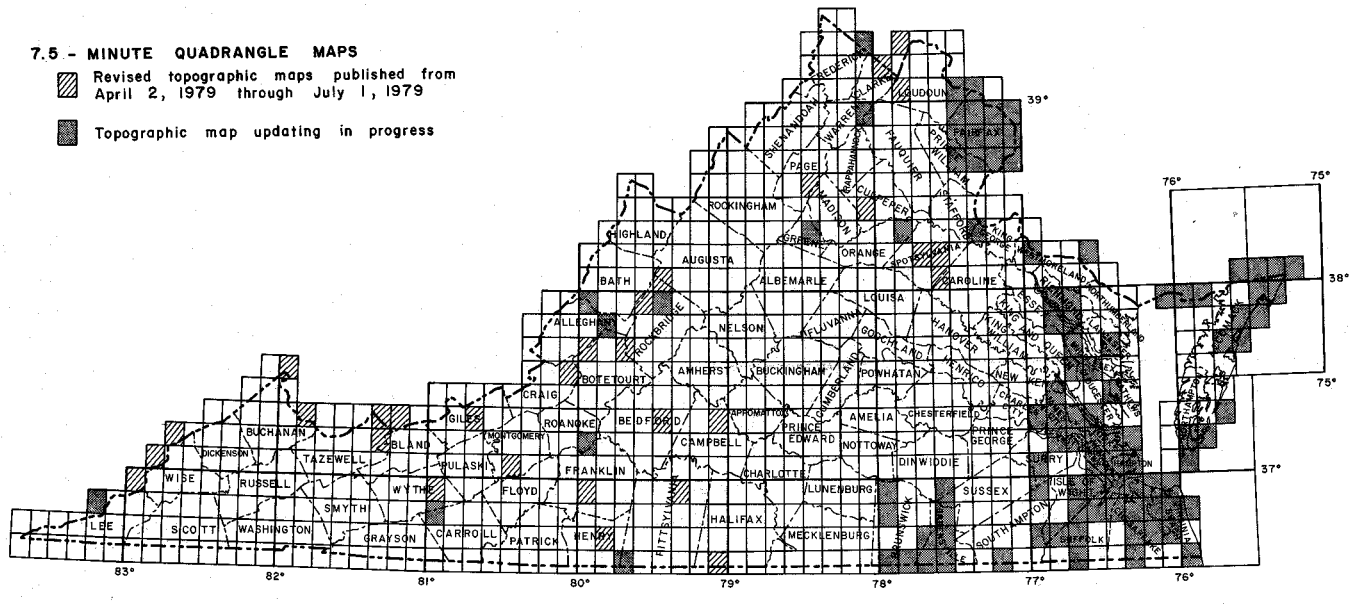

Revised 7.5 - minute quadrangle maps published from April 2, 1979 through July 1, 1979. Each map available folded for $1.30 ($1.25 plus $0.05 State sales tax); if desired unfolded add $2.00 for orders of ten or fewer maps.

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