GEOLOGY OF THE RADFORD AREA, VIRGINIA

by

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ABSTRACT

The Radford area consists of approximately 190 square miles in the Appalachian Valley portion of Montgomery and Pulaski counties, Virginia. All of it is underlain with sedimentary rocks ranging from Early Cambrian to Early Mississippian in age, and having an aggregate thickness of at least 12,000 feet. These rock units do not represent a complete sedimentary sequence in this part of the Appalachian geosyncline because much of the Radford area is covered by three overthrust sheets which conceal formations that would otherwise be exposed in the area.

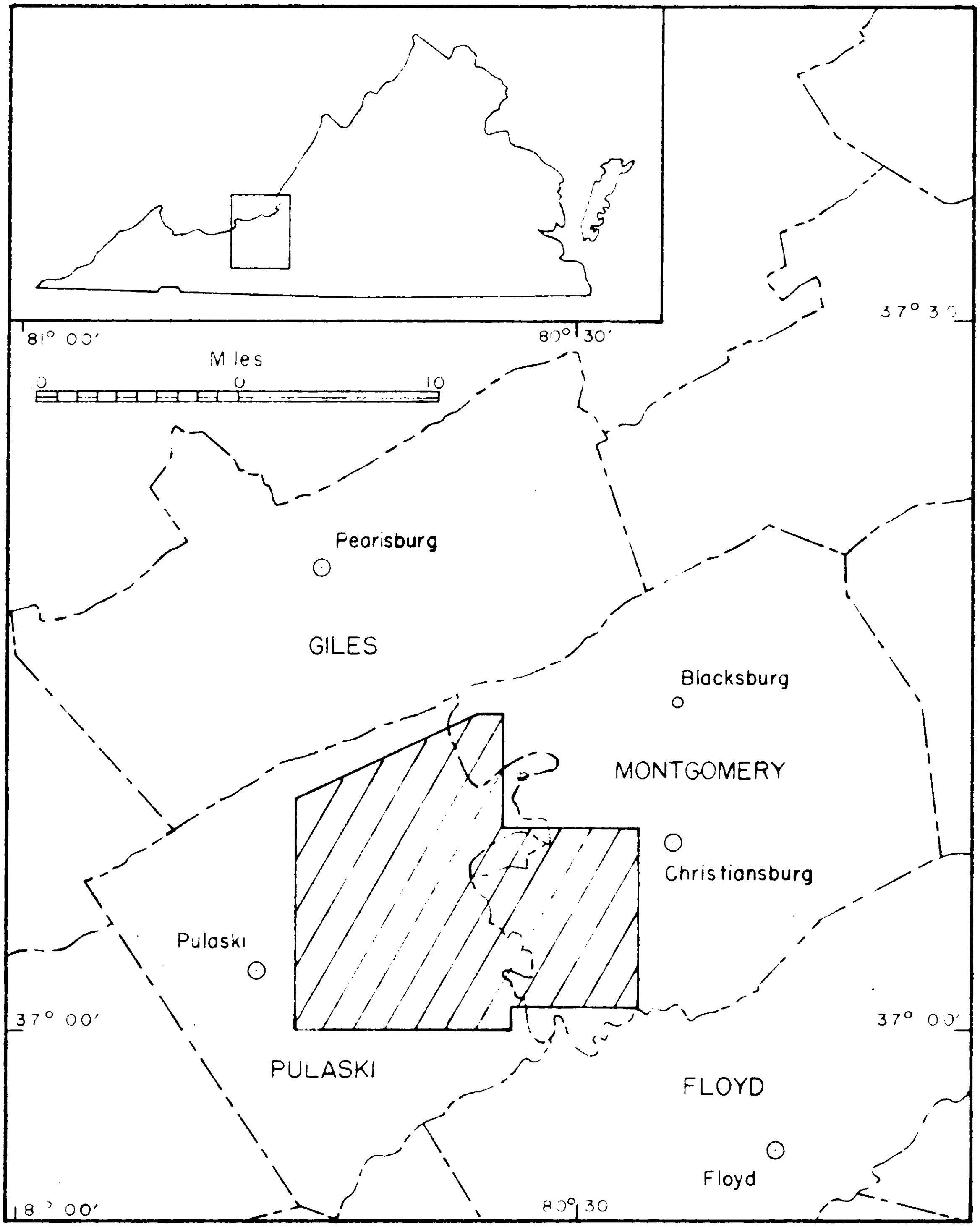
The greatest movement along these low-angle thrust faults appears to be that of the Pulaski thrust sheet. It has a horizontal displacement of at least eight miles and a minimum stratigraphic separation of 9000 feet. The Pulaski thrust sheet has been further complieated by three high-angle thrust faults which have contributed to the formation of three "windows" southeast of Radford. Two klippen that are associated with the Blue Ridge thrusts occur in the southeastern corner of the area.

INTRODUCTION

Size and location of the area. The Radford area consists of approximately 190 square miles in western Montgomery and eastern Pulaski counties, Virginia, and also includes the city of Radford, which is just northeast of the center of the area. The tract is bounded on the north by Cloyds Mountain; the foothills of the Blue Ridge roughly parallel the southern boundary. Longitude 80° 45' W. bounds the area on the west and the eastern boundary is approximately 2.25 miles east of 80° 30' West longitude. The east limit of the town of Pulaski is only a few hundred yards west of the area. Radford is situated approximately 36 miles west-southwest of Roanoke, Virginia.

U. S. Highway 11 (the Lee Highway) crosses east-west through the middle of the area and Virginia Highway 100 crosses the area north-south near the western boundary. All parts of the area are easily accessible from the many primary and secondary roads within it. The main lines of the Norfolk and Western Railway and the Virginian Railway cross the northeastern corner. The Bristol branch of the Norfolk and Western passes through Radford and closely parallels the Lee Highway across the area to Pulaski. The Galax branch of the same railroad passes through Draper in the southwestern corner of the Radford area.

Plate 3



Location of the Radford area

Purpose of investigation. The primary objective of this investigation was to map the areal and structural geology of the Radford area. The purpose of the investigation was to tie together areas of previous geologic mapping including the Draper Mountain area on the southwest, Price Mountain on the northeast, and the Pilot Mountain area on the southeast.

Method of investigation. The field work was done during the summer of 1956 and the early part of the summer of 1957. The Blacksburg and Radford 15-minute series quadrangle topographic sheets of the United States Geological Survey, which cover the entire Radford area, were used as base maps after the scale had been modified to approximately 1:30,500. Aerial photographs of part of the area were available for study. Geologic sections were measured using a Brunton compass and steel tape or pacing. Rock units were differentiated on the basis of lithology.

Previous work. Campbell (1894) many years ago recognized that the geology of Montgomery and Pulaski counties was complicated by areas in which younger rocks were completely surrounded by older rocks. Later, in his report on the Valley coal fields in Virginia, Campbell, along with Holden (1925), gave a more detailed description of the structure of part of the Radford area. The entire area was mapped in reconnaissance by Butts (1933; 1940). The southwestern portion of the area was mapped in a detailed reconnaisance by Dietrich (1954). Cooper (1939) mapped the Draper Mountain area, which adjoins the Radford area on the southwest. The area of the windows in the Pulaski thrust sheet was mapped by Cooper in 1947 for the California Company but the results were not published. Industrial limestones and dolomites in the vicinity of Miles, at the junction of Little and New rivers southwest of Radford, and also in the Radford-Peppers Ferry area, were discussed by Cooper (1944b). Cooper (1946) also made a detailed investigation of fault breccia in the vicinity of Radford.

GEOGRAPHIC FEATURES

The Radford area lies almost entirely within the Appalachian Valley of Virginia. The relief of the area ranges considerably, with the maximum relief being 1260-1300 feet. The local relief exceeds 300 feet in few places except at the southern margin of the area where the local relief ranges up to about 900 feet.

New River, which flows across the area in a northeasterly direction, is entrenched 200-300 feet below the valley floor. Its tributaries are also entrenched for varying distances away from New River. Slopes of the dissected valley floor near the river are very steep.

The highest elevation of the area concerned is 2940-2960 feet, about three miles southwest of Simpkinstown near the crest of an outlying ridge of Macks Mountain. The lowest point is along New River where it leaves the area in the vicinity of Belspring, at an altitude of 1660-1680 feet. The greater part of the area lies between 1900 and 2100 feet above sea level.

The entire area is located within the watershed of New River. Most of Claytor Lake, a reservoir built by the Appalachian Electric Power Company, lies within the area. The many tributaries of New River, of which Little River is the largest, afford good drainage. Locally the drainage is underground as would be expected in an entrenched area much of which is underlain with carbonate rocks. The average annual rainfall at Radford was 37.38 inches for the 44 year period from 1907 to 1950 (Rich and Payne, 1954, p. 7).

Much of the Radford area is grass covered. Considerable cropland and some farm woodlots are also present. The southern margin of the area and the other parts with more rugged topography are for the most part tree covered. A majority of the tree growth consists of hardwoods, although conifers flourish on the shale and sandstone terrains.

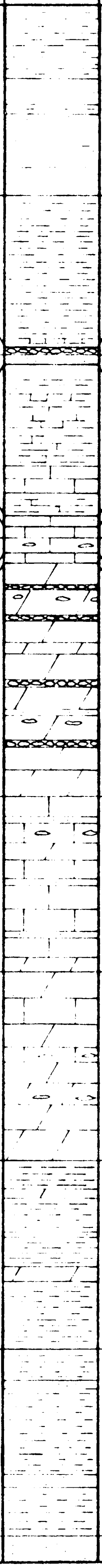
Rock exposures are quite numerous in the area mapped, especially in the southern part. Many outcrops can be seen on the banks of cuts along the roads and railways. Some of these show fresh surfaces.

DESCRIPTION OF THE ROCKS

General statement. Fourteen formations or rock units ranging in age from Early Cambrian to Early Mississippian crop out in the Radford area. These rock units are composed of sediments deposited in the Appalachian geosyncline and have an aggregate thickness of at least 12,000 feet. Several formations which are not exposed in the Radford area but crop out in adjoining areas, undoubtedly exist beneath the surface of the Radord area and are covered by the thrust sheets of Early Paleozoic rocks. These completely hidden rock units, as well as the unexposed portions of formations present, increase by several thousand feet the total thickness of sediments deposited in the Appalachian geosyncline in this region. The rock units mapped are based upon lithology and do not necessarily have any time connotation.

In rock descriptions in this report the writer has used the size terms given in the grade scale suggested by

Plate 4



System	Formation	Thickness in feet
Mississippian	Maccrady and Price formations, undifferentiated	1500+
	— major fault —	
Devonian	Black shales and brown siltstones of Hamilton and Portage ages	1200±
	Huntersville chert	8
Silurian	Clinch sandstone	30
Ordovician	Martinsburg formation	1200
	— major fault —	
	Liberty Hall formation	[illegible]
	Fetzer limestone	[illegible]
	Lenoir limestone	[illegible]
	Mosheim member	26
	Knox dolomite group	1600±
Cambrian	Knox dolomite group: Conococheague limestone (in Pulaski thrust sheet)	1400±
	Elbrook formation	1500
	— major fault —	
	Rome formation	1500+
	— major fault —	
	Hampton formation	1500
	Unicoi formation	200

Columnar section of the bedrock formations exposed in the Radford area, Virginia

Wentworth (1922a, p. 381). The writer has described bedding or stratification using a system revised from that of McKee and Weir (Pettijohn, 1957, p. 159). In this report beds less than one centimeter thick are considered as laminated; those less than two millimeters thick are thinly laminated. Layers from one to five centimeters thick are called thin bedded; those from five to 60 centimeters thick are medium bedded; those from 60 to 120 centimeters are thick bedded; and those over 120 centimeters thick are considered massive.

Unicoi Formation

The Unicoi formation was named by Campbell (1899, p. 3) for exposures in Unicoi County, Tennessee. The Unicoi crops out in the southeastern corner of the Radford area, in the vicinity of Calffe Knob.

The Unicoi in this area is predominantly composed of medium- to thick-bedded feldspathic sandstone with interbedded quartz sandstone, siltstone, and shales. The sandstones are medium to coarse-grained and locally grade into a conglomerate containing granule-size quartz grains. The sandstones are tan to light-greenish-brown on fresh surfaces, weather light gray to grayish-brown, and contain many small quartz veins. These quartz veins are indicated on weathered exposures by small angular pieces of vein quartz. A thin section of a quartz sandstone exposed south of Calffe Knob showed that the rock also contains a few microcline and hematite grains. The quartz grains are sub-angular to subrounded and some have sutured contacts. Sericite, chlorite, and a little hematite exist between some of the quartz grains. The siltstones and shales are light-tan to brownish on fresh surfaces and the weathered surfaces are only slightly darker in color.

Only about 200 feet of the top of the Unicoi formation is exposed in the Radford area. According to Butts (1940, p. 36) the Unicoi ranges up to about 2600 feet in thickness. The Unicoi is the basal formation of the Chilhowee group (Butts, 1940, pp. 26-36) and is generally considered as lowest Cambrian. A few consider it to possibly be pre-Cambrian (Butts, 1940, p. 36). No fossils have been reported from the Unicoi formation.

Hampton Formation

The Hampton was named by Campbell (1899, p. 3) for outcrops at Hampton, Carter County, Tennessee, which is in an area mapped by Keith. The Hampton is exposed at the southeastern corner of the Radford area and on the crests of the highest ridges along the southern boundary of the area, southwest of Simpkinstown.

The Hampton conformably overlies the Unicoi, with the contact between the two formations being indistinct in this area. In differentiating between the two formations, the writer used the method of Dietrich (1954, p. 10) who arbitrarily placed the Hampton-Unicoi contact above the highest massive arkosic conglomerate. The coarse-grained rock which Dietrich (1954, p. 13) has called "Unicoi-like sandstone" is here considered to be part of the Hampton. It is only a few feet thick and lies above a considerable thickness of shales and siltstones.

The Hampton formation in the Radford area consists mainly of shales and siltstones, with some fine-grained sandstone and coarse-grained "Unicoi-like" sandstone. The shales commonly range from light-tan or gray to reddish-brown on fresh surfaces. The shales weather light-buff to pinkish and gray. Locally, fresh surfaces of the shales have a sheen like that of a phyllite. The siltstones are light-brown and weather light-tan. Most of the siltstones are thin bedded or laminated, and locally contain cut-and fill structures, cross-bedding, and ripple marks. The fine-grained sandstones are light-gray to tan on fresh surfaces and weather light-gray. A brown rind is present just beneath weathered surfaces of many of these sandstones. In thin section the fine-grained sandstone exposed southwest of Simpkinstown is composed chiefly of subangular to subrounded quartz grains, with some opaque grains (at least some of which are hematite) and a few plagioclase and detrital mineral grains.

The actual thickness of the Hampton formation could not be measured in the Radford area. It is estimated, however, to be at least 1500 feet thick in the vicinity of Sidney Church, southeast of Calffe Knob. This does not represent the entire formation because the top has been removed by erosion. Butts (1940, p. 38) thought the Hampton to be at least 2000 feet thick at some localities.

The Hampton formation is also part of the Early Cambrian Chilhowee group (Butts, 1940, pp. 26-38). Like the Unicoi, however, the Hampton is considered by a few to be possibly pre-Cambrian. No fossils except some Scolithus tubes have been reported from Hampton strata.

Rome Formation

The Rome formation was named by Hayes, (1891, p. 143; 1892, p. 37) for exposures south of Rome, Floyd County, Georgia. Woodward (1929, pp. 592-595) has shown that, although many names have been applied to Rome strata locally, only two of these bames have appeared in the literature extensively and that "Rome" has priority over the name "Watauga", which was introduced by Keith (1903, p. 5).

The Rome crops out in a wide belt across the southern part of the Radford area.

The Rome is a quite heterogeneous and variegated formation. It is chiefly composed of red, greenish-gray, and light-brown shales. Considerable thickness of siltstone, limestone, and dolomite are also present. Though comprising considerably less than half the formation, the red shale is the most conspicuous rock type in the Rome and soil derived from weathering of the red shale has a distinctive reddish-brown color. The "red" shale is actually more nearly a reddish-brown or reddish-purple. Many of the greenish-gray shales have a silky luster. Some of the Rome shales, though having fissility, appear to be mudrocks except when viewed closely. The shales immediately above and below the carbonate rocks in the Rome are commonly calcareous and grade into thin-bedded or shaly limestone and dolomite.

The dolomite in the Rome is for the most part dark-gray to black on fresh surfaces and weathers dark-grayish-brown. It is medium to fine grained, thick bedded to massive and commonly siliceous. Much of the limestone and dolomite of the Rome contains many small calcite veins. The amount of dolomite in the Rome greatly exceeds the amount of limestone present.

The sandstones of the Rome formation are light-gray to pinkish-brown on fresh surfaces and weather yellowish-brown. They are composed chiefly of very fine sand-sized subangular quartz grains. Some hematite grains are also present. The sandstones in the Rome are thin bedded to laminated.

The Rome formation in the Radford area is repeated by tight folding and faulting. The shales and siltstones are especially folded and fractured. Many of the fractures are filled with calcite or quartz. Mudcracks and ripple-marks occur in the formation locally. Most outcrops of Rome shale are covered with shale chips and soil derived from the Rome formation typically contains many small chips of shale.

Neither the top nor the bottom of the Rome formation has been identified by the writer in the area mapped. The Rome has been thrust northwestward onto Elbrook and Knox, and it is unlikely that the fault plane occurs exactly at the bottom of the Rome. Hampton and Unicoi strata have been thrust on top of Rome in this area. An undetermined thickness of the top of the Rome may have been removed by erosion before this latter thrusting took place. Repetition of strata by extremely complicated disharmonic folds and faulting make it nearly impossible to determine accurately the actual thickness of the Rome present in the area mapped. Butts (1940, p. 63) cites a sedtion near Buchanan, Virginia, in which the Rome is about 2000 feet thick, and Cooper (1939, pl. 3) gives the thickness of the Rome in the Draper Mountain area as about 2000 feet. The Erwin and Shady formations, which normally lie between the Hampton and the Rome in the geologic column for this part of Virginia, are not exposed in the Radford area but might be present beneath the thrust sheets.

According to Butts (1940, p. 63), fossils are rather sparse in the Rome. Fossils considered as Lower Cambrian species and also some fossils considered to be Middle Cambrian species have been reported by Butts.

Elbrook Formation

The Elbrook was named by Stose (1906, p. 209) after the town of Elbrook, Franklin County, Pennsylvania, where the formation was quarried. The Elbrook crops out over an extensive part of the Radford area.

The Elbrook formation consists chiefly of thin-bedded to shaly dolomite. Considerable thicknesses of dolomitic limestone and limestone with numerous thin argillaceous laminations are also present. The shaly and thin-bedded dolomites of the Elbrook are gray on fresh surfaces and weather medium to light-grayish-brown. They are fine grained, and limy in some localities. The thin-bedded dolomite is interbedded with shaly dolomite at most exposures. The dolomitic limestones are for the most part medium to thick bedded and contain thick interbeds of dolomite at some outcrops. These rocks are dark-gray, weather medium- to dark-grayish-brown, and are fine grained. Most of the dark-bluish-gray limestone in the Elbrook contains many thin laminations of argillaceous material. The separation of these laminations ranges from about half an inch to two inches. The laminations are barely distinguishable on fresh surfaces but weather light-brown and obscure the light-gray weathered color of the limestone on surfaces exposed very long.

At least one and probably several reddish zones occur locally in the Elbrook. These zones consist of red shale, more or less calcareous, and reddish argillaceous limestone. The red color tends to be a little lighter than that of the red shales of the Rome. The red shale of the Elbrook also appears to weather into larger chips than the Rome shales. The red zones range up to about 12 feet thick and some of them have yellowish to light-brown interbeds.

The general character of the Elbrook is shown by the following section:

Geologic Section 1. - Along State Highway 100 from about .2 mile north of junction with Road 643 south to Peak Creek, Pulaski County, Virginia

		Thickness Feet
Conococheague formation (lower part)		
29.	Dolomite, shaly, with thin limestone layers	35
28.	Limestone, bluish-gray, with thin argillaceous laminations . . .	45
27.	Unexposed	200
26.	Dolomite, limy with thin argillaceous laminations, and with a two-foot interbed of sandy limestone .	50
25.	Limestone, bluish-gray, with thin argillaceous laminations, and with a two-foot interbed of sandy limestone	15
24.	Edgewise conglomerate	1
23.	Limestone, gray, with thin argillaceous laminations . . .	3
22.	Dolomite, thin-bedded to shaly, with thin bluish-gray limestone interbeds	105

	Thickness Feet
21. Unexposed, lower contact only approximately determined	65
Elbrook formation (1438 feet)	
20. Dolomite, thin-bedded to shaly, with thin bluish-gray limestone interbeds	105
19. Limestone, dark-bluish-gray, with a thin seam of black chert at top	6
18. Limestone, magnesian, with shaly and argillaceous limestone interbeds	60
17. Partly exposed, probably all thin bedded dolomite with limestone interbeds	65
16. Calcilutite, gray, with dolomite interbeds	30
15. Dolomite, shaly	20
14. Partly exposed, probably all shaly dolomite	50
13. Limestone, dark-bluish-gray, with thin argillaceous laminations and with nodules and stringers of black	

		Thickness Feet
	and tan chert	105
12.	Unexposed	25
11.	Limestone, bluish-gray, with interbeds of shaly dolomite	120
10.	Partly exposed, limestone with interbedded dolomite	100
9.	Dolomite, shaly to thin bedded . .	60
8.	Unexposed	150
7.	Shale, red, calcareous	2
6.	Dolomite, with 10 feet of limestone and a few nodules and stringers of chert	215
5.	Unexposed	60
4.	Dolomite, shaly to thin bedded . .	125
3.	Partly exposed, probably all shaly to thin bedded dolomite . . .	140
Rome formation (in fault contact with the Elbrook		
2.	Shale, red and tan	50
1.	Dolomite, dark-gray, siliceous . .	20

Most of the Elbrook formation in the area mapped is warped and fractured. It is difficult to trace a particular stratigraphic horizon for any great distance. Locally, the fractures are filled with calcite, or rarely, quartz. Small calcite vugs are numerous at some exposures. Mud-cracks, ripplemarks, and intraformational conglomerates also occur locally in the Elbrook.

The actual base of the Elbrook has not been found in the Radford area, because the Rome formation, which normally underlies the Elbrook, has been thrust over part of the Elbrook, thus obscuring the normal contact between the two formations. The top of Elbrook exists in the Radford area but was not accurately determined by the writer because many of the beds at the top of the Elbrook and near the base of the Conococheague are lithologically similar. Butts (1940, p. 77) was not certain of the exact boundary between the Elbrook and the Conococheague in the geologic section at Newbern. It is the opinion of the writer that the contact lies in the unexposed interval at the intersection of Highway 100 and Road 643, just west of Newbern. The writer would place the contact a few feet below the edgewise conglomerate (see Geologic section 1).

According to Cooper (1939, p. 12) few fossils are to be found in the Elbrook. Butts (1940, pp. 78-79) states that the Elbrook is late Middle Cambrian in age, probably extends into Late Cambrian, and correlates with the Rutledge, Rogersville, Maryville, Nolichucky, and Honaker formations of the southwestern part of the Appalachian Valley in Virginia.

Conococheague Formation

The Conococheague formation was named by Stose (1908, p. 703) for exposures along Conococheague Creek at the town of Scotland, Franklin County, Pennsylvania. The Conococheague of the Radford area crops out in an elongate oval in the vicinity of Dublin.

The Conococheague formation in this area consists chiefly of fine-grained bluish-gray limestone, most of which contains thin laminations of argillaceous material. These laminations range up to about 0.25 inch in thickness and range from 0.25 inch or less to several inches apart. The laminations in the Conococheague also stand out in the relief on weathered surfaces and the color of the weathered limestone is obscured by the light-brown weathering laminations.

Considerable amounts of gray dolomitic limestone and medium- to dark-gray limy dolomite and relatively small amounts of thin-bedded t. shaly dolomite, calcareous sandstone, coarse-grained gray limestone, and light-gray calcilutite occur in the Conococheague. A bed of calcareous red shale about one foot thick crops out several places west of Dublin. Nodules and stringers of black chert and rather thin interbeds of oolitic limestone occur locally, Edgewise conglomerate also is present in the Conococheague, in the Radford area. It is quite conspicuous on weathered surfaces but is difficult to distinguish on dry fresh surfaces. The fresh surfaces of the sandstone of the Conococheague are a gray color similar to that of many of the limestones. The sandstones weather light-brown and stand out in relief. They are composed of subrounded to rounded medium-size quartz grains in a calcareous cement. The sandstones occur only locally and do not exceed 10 feet in thickness at most occurrences.

The sandstones in the Conococheague indicate that the formation was deposited in relatively shallow water near shore. The presence of mudcracks and edgewise conglomerate indicate that part of the basin of deposition was exposed occasionally.

Only the lower part of the Conococheague is now present in the area. The formation occurs in the trough of a broad syncline. The top part of the formation has been removed by erosion. The lower contact of the Conococheague is present in the area. Butts (1940, p. 89) states that the thickness of the Conococheague is approximately 2000 feet throughout Virginia. Cooper (1939, p. 14) states that about 1500 feet of Conococheague is exposed in the Draper Mountain area and the lowermost part of the formation is not exposed there.

According to Butts (1940, pp. 89-90) comparatively few fossils are to be found in the Conococheague. The fossils found include poorly preserved specimens of trilobites, gastropods, and brachiopods. Cooper (1939, p. 16) reports that <u>Cryptozoon</u> sp. is the only fossil found by him in the Conococheague of the Draper Mountain area. Butts (1940, pp. 26, 90) states that the Conococheague is Late Cambrian in age and correlates with the Copper Ridge dolomite of the northwestern side of the Appalachian Valley.

Knox Dolomite Group

The Knox dolomite group was named by Safford (1869, pp. 151, 158-159, 204) for outcrops in Knox County, Tennessee. The Knox, exposed over a fairly wide belt in the east-central portion of the Radford area, includes beds ranging in age from Conococheague to Late Canadian.

The Knox group in the Radford area is composed primarily of dolomite with interbeds of chert and sandstone. Limestone and shaly to argillaceous dolomite are also present. The dolomite ranges from medium- to very dark-gray on fresh surfaces and weathers tan to dark-grayish-brown.

Locally, fresh surfaces are brownish-gray. Most of the dolomite is fine to very fine grained, and some beds are quite siliceous. A thin section of siliceous dolomite showed that it is composed chiefly of fine angular to subangular dolomite grains, a few of which are "rhombs". The grains are tightly packed together and some are interlocked. About 15 per cent of the rock is calcite, and a few very fine quartz grains are also present. Much of the Knox dolomite is thick bedded and quite compact and tough.

The limestone in the Knox is dark-gray to black and weathers gray. It is very fine grained and contains a few small white eyes and veinlets of calcite. The chert interbeds, some of which are six feet or more in thickness, range from white to reddish-gray to black in color and are more prominent in the upper part of the Knox. Beds of oolitic chert also occur in the Knox. Most of them are about one foot or less in thickness and are light-gray. They are more characteristic of the lower Knox than of the upper part, as are the sandstone interbeds. The sandstones of the Knox are similar to those found in the Conococheague but are more numerous in the Knox and range up to 20 feet in thickness. Nodules and stringers of chert occur in the Knox and a vein of bull quartz about 2.5

inches thick is exposed on the bank along Road 658, about 100 yards southeast of Bethel Church.

The sandstone and chert interbeds weather out in relief and are exposed many places where no limestone or dolomite crops out. Many knolls and low ridges in the Knox belt of outcrop are held up by the sandstone and chert interbeds. Much of the soil derived from weathering of the Knox is strewn with small blocks and angular pieces of chert.

The character of the upper part of the Knox is shown in the following section:

Geologic Section 2. - Along Road 605 at the mouth of Little River, Montgomery County, Virginia

	Thickness Feet
Elbrook formation (in fault contact with Liberty Hall)	
22. Dolomite	--
Liberty Hall limestone (15 feet)	
21. Limestone, dark-gray to black, very fine grained, thin bedded to shaly.	15

	Thickness Feet
Fetzer limestone (20 feet)	
20. Limestone, medium to dark-gray, coarse grained, argillaceous, contains fragments of trilobites	20
Lenoir limestone (281 feet)	
19. Limestone, dark-gray to black, fine grained, with thin, wavy, silty partings	80
18. Unexposed	10
17. Limestone, black, coarse grained, medium to thick bedded	56
16. Limestone, black, very fine grained, with thin, wavy, silty partings .	135
Mosheim limestone member (26 feet)	
15. Calcilutite, black, with white calcite eyes	26
Knox dolomite	
14. Dolomite, dark-gray, fine grained . .	59
13. Chert, black	2½
12. Dolomite, medium to dark-gray, fine grained siliceous, with nodules and stringers of black chert	135
11. Chert, white to gray	3

		Thickness Feet
10.	Dolomite, gray, fine grained	132
9.	Chert, gray	6
8.	Dolomite, gray, fine grained	78
7.	Chert, gray to reddish	3-6
6.	Dolomite, gray, fine grained	76
5.	Chert, gray	2
4.	Dolomite, gray, fine grained, sandy, with white chert nodules and stringers	30
3.	Unexposed	115
2.	Dolomite, gray, fine grained, siliceous	30
1.	Unexposed to base	--

The contact between the Knox group and the underlying Elbrook is not well exposed in the Radford area and has been arbitrarily placed below the owest interbeds of calcareous sandstone, as Butts (1940, p. 87) stated that no sandstone occurs in the Elbrook. Soil derived from weathering of the Elbrook is darker in color than the rather light-yellowish-orange soil of the Knox, and does not contain numerous pieces of chert that are characteristic of Knox soil. The contact between the Knox group and the overlying Mosheim limestone is well exposed at the Radford Limestone Company quarry near the junction of Little and New rivers and Claytor Dam. Lack of continuous exposures result in inaccurate measurement of the thickness of the Knox group in the Radford area. It is estimated, however, to be about 3000 feet thick in the outcrop belt extending southeast from the mouth of Little River.

Fossils are sparse in the Knox group except for a few gastropods and cephalopods. The Knox group, according to Wilmarth (1938, pp. 519, 1114), includes the Late Cambrian Copper Ridge formation and formations of Early Ordovician age. Copper Ridge is the name given to the dolomite equivalent of the Conococheague limestone (Butts, 1940, p. 91).

Lenoir Limestone

The Lenoir limestone was named by Safford and Killebrew (1876, pp. 130-131) for exposures at Lenoir Station, Loudoun County, Tennessee. The Lenoir with its basal Mosheim member crops out in a long narrow belt of vertical beds about a mile south of Ingles Mountain.

The Lenoir is composed of three distinct types of dark-gray to black limestone. The lowermost of these three types is the Mosheim limestone member. The Mosheim was originally considered a formation and was named by

Ulrich (1911, pp. 413-414) for exposures along a railroad cut at Mosheim Station, Green County, Tennessee. Cooper and Cooper (1946, pp. 51-52) point out that the type Mosheim in Tennessee occupies the same stratigraphic position as the lowest Lenoir at its type section, and therefore is probably a facies or member of the Lenoir formation. The Mosheim member in this area consists of calcilutite that ranges from light-gray to black in color and contains many small white calcite "eyes" and veinlets which stand out in relief on weathered surfaces. Locally the rock has a pinkish color on fresh surfaces. Exposed surfaces are light-gray, and commonly rough. The Mosheim is thick bedded, very dense and compact, and tends to break with a conchoidal fracture.

The most abundant type of limestone in the Lenoir is very fine grained and contains many thin, exceedingly wavy, silty partings which weather in relief on exposed surfaces and impart a honeycombed appearance and grayish-brown color to weathered exposures. Locally the laminations have a pinkish color on fresh exposures but most of them have a color simialr to the rest of the rock and are not easily distinguished. The other type of limestone of the Lenoir is coarse grained and thick bedded. Both types contain conspicuous amounts of carbonaceous material and freshly broken pieces of the rock commonly have a slight petroliferous odor. A few nodules of black chert are present locally in the Lenoir.

The formation is about 280 feet thick where the outcrop belt crosses Road 605. The Lenoir is underlain by the Knox group and is overlain by the Fetzer limestone. Numerous fossils, particularly bryozans and crinoid fragments, are to be found in the Lenoir and on exposed surfaces where they weather in relief. The fossils are especially numerous in the coarse-grained type of limestone. The Lenoir is considered to be Early Middle Ordovician in age.

Fetzer Limestone

The Fetzer limestone was named by B. N. Cooper and G. A. Cooper (Cooper, 1956, p. 64) for exposures along Ocoee River near Fetzer Creek in Polk County, Tennessee. The Fetzer is exposed in a long narrow belt of outcrop adjacent to the belt of Lenoir in the Radford area and is also exposed in the window southeast of Barringer Mountain.

The Fetzer is a medium- to dark-gray limestone that is coarse grained and thick bedded. It contains a small amount of carbonaceous material and weathers dark-gray. The rock also contains argillaceous and silty material which tends to be present in layers about one centimeter thick. These silty layers weather in relief and resemble chert stringers.

The Fetzer limestone is about 20 feet thick along Road 605 near the mouth of Little River. The Fetzer overlies the Lenoir and underlies the Liberty Hall. It is Early Middle Ordovician in age and according to Cooper (1956, p. 64) is a tongue of the Arline formation and is also virtually the same unit as the Botetourt limestone. The Fetzer is essentially equivalent to the Whitesburg limestone of Butts (B. N. Cooper, personal communication, August, 1957).

Liberty Hall Limestone

The Liberty Hall was named by Campbell (1905, pp. 445-447) for a historic ruin constructed on the limestone in the vicinity of Lexington, Rockbridge County, Virginia. Butts considered that Liberty Hall sould be abandoned (Wilmarth, 1938, p. 1179) because it was the same as the Athens, which has priority. Cooper and Cooper (1946, p. 55), however, revived Liberty Hall because they consider the name Athens to be too restricted. The Liberty Hall of the Radford area crops out in the long narrow belt of Middle Ordovician limestones southwest of Ingles Mountain and also crops out in two very small areas southeast of Barringer Mountain.

The Liberty Hall in the Radford area consists of dark-gray to black limestone that is very fine grained and thin bedded to shaly. It weathers into thin slivers and slabs that are medium-gray on exposed surfaces. Some argillaceous and carbonaceous material are present in this limestone which has a slight petroliferous odor when freshly broken.

Only about 15 feet of Liberty Hall appears to be present in the Radford area, although it is possible that more exists here. The upper limit of the Liberty Hall is a fault contact with overthrust Elbrook at the outcrop belt that crosses Road 605. Neither the upper nor the lower contact of the Liberty Hall is exposed in the outcrop areas southeast of Barringer Mountain, so no thickness determination could be made with any degree of accuracy. The Liberty Hall is underlain by Fetzer limestone and appears to be overlain by Martinsburg. According to Cooper (1956, p. 73) the Liberty Hall is a facies of the Edinburg formation which is early Middle Ordovician in age.

Martinsburg Formation

The Martinsburg shale was named by Geiger and Keith (1891, p. 161) for Martinsburg, Berkeley County, West Virginia (Keith, 1894, p. 3) which lies at the weatern edge of a large outcrop belt of the formation. The Martinsburg crops out in several small areas in the east-central portion of the Radford area.

Although the Martinsburg is exposed over a fairly extensive area, few fresh exposures are to be found. The most conspicuous characteristic of the formation is the preponderance of yellowish-brown weathering shales and siltstones. Lesser amounts of sandstone and limestone also occur. The shales are olive-drab, gray, and yellowish to reddish on fresh surfaces. Siltstones and very fine-grained sandstones are found mainly in the upper part of the Martinsburg, which is considered to be of Maysville age. They are gray or olive-drab to reddish-brown and weather yellowish-brown to dull grayish-brown. In thin section the Maysville sandstones are composed chiefly of subangular to subrounded particles of quartz. About five per cent unidentified iron-stained grains are also present. Both of these are contained in a matrix of iron oxide and sericite. The limestones are dark-gray to black, medium to fine grained, and thin bedded to slabby. Most of the shales, siltstones, and sandstones below the Maysville contain calcareous material that leaches out, giving most outcrops a soft, spongy appearance.

The Martinsburg in this area underlies the Clinch sandstone and appears to overlie the Liberty Hall limestone.

Lack of continuous exposures combined with much folding and faulting of the incompetent beds make accurate thick-ness determinations impossible in the Martinsburg. About 1000 to 12000 feet of Martinsburg is exposed on the south side of Ingles Mountain near Road 605. The bottom of the Martinsburg at this locality is covered with overthrust Elbrook. Butts (1940, p. 209) estimated the Martinsburg to be 1300 to 1600 feet thick in the middle part of the Appalachian Valley in Virginia. The Martinsburg is Middle and Late Ordovician in age and includes parts of the Trenton, Eden, and Maysville groups (Cooper, 1939, pp. 34-36).

Clinch Sandstone

The Clinch Mountain sandstone group was named by Safford (1856, p. 157) for exposures on Clinch Mountain, Tennessee. Safford (1869, pp. 295, 297-298) then separated the Clinch sandstone from the Clinch Mountain sandstone group. Keith (1895, p. 4) restricted the Clinch to upper white massive sandstone of Saffords Clinch sandstone and applied the name Bays to the underlying red sandstone.

The Clinch crops out in the Radford area in two long, narrow discontinuous, parallel belts about a half mile apart. The southeastern most of these belts lies along the crest of Ingles and Barringer mountains. The Clinch formation consists almost entirely of well-indurated quartz sandstone and orthoquartzite. It ranges from light-gray to black on fresh surfaces and weathers light-grayish-tan to dark-grayish brown.

Most of the rock is medium- to fine-grained sandstone, although some conglomerate containing quartz granules and pebbles ranging up to about one centimeter in diameter is also present. The conglomerate is well exposed on the east side of Road 605 at the west end of Ingles Mountain. In thin section the Clinch is composed chiefly of subangular to subrounded quartz grains. A few quartz grains are rounded and others appear to have once been rounded but have been modified by outgrowths and solution cavities. About five per cent iron-stained grains, a few rounded zircons, and a little sericite are also present. Some very small opaque grains appear to be concentrated at the boundaries of the larger grains. A few small blocks of hematite-cemented sandstone are present as float near the crest and on the north side of Ingles Mountain. These float blocks may be remnants of a facies of the Clinch, or possibly of the Clinton formation, lenses of which occur in the Draper Mountain area, Cooper (1931, p. 39).

The Clinch is a very resistant rock and forms prominent ridges at nearly all occurrences except where it is very thin. The formation ranges considerably in thickness in the area mapped, and lenses out completely at several places. It is estimated to have a maximum thickness of about 30 feet in the ravine about 150 yards west of Road 787. The Clinch is Early Silurian in age (Butts, 1940, p. 229).

Huntersville Chert

The Huntersville chert was named by Price (1929, pp. 236-237) for outcrops near Huntersville, Pocohontas County, West Virginia. Exposures of the Huntersville are very limited in the Radford area. The best exposure is in the road cut on the north side of U. S. Highway 11, about one mile west of Barringer Mountain. It also crops out on the east bank of Road 787 (old 102), about 200 yards south of the intersection with Road 611, and on Road 664, at the crest of Ingles Mountain.

The Huntersville is composed chiefly of black and grayish-tan chert, some of which is slightly sandy. It is medium to thin bedded. Weathered surfaces are dull yellowish-brown to black and are rough and jagged. Outcrops are strewn with small angular blecks and fragments of chert. A glauconite bed about six inches thick is prominent near the base of the Huntersville. A glauconite bed of lesser thickness occurs locally near the top of the formation. The Huntersville is about six feet thick at the exposure along U. S. Highway 11, and appears to be about eight feet thick at the outcrop on Road 787. Exposures of Huntersville bedrock are sparse but the presence of numerous pieces of chert in soil along the Clinch outcrop belts indicate that the Huntersville was probably present at one time overlying most of the Clinch in the area.

The Huntersville directly overlies the Clinch and underlies the Devonian black shale. According to Cooper (1944a, p. 134) the Huntersville is of early Middle Devonian age and appears to correlate with the lower part of the Onondaga limestone of New York and possibly also with the underlying Schoharie formation.

Shales of Hamilton and Portage Ages

The shales of Hamilton and Portage ages crop out in a long narrow belt between the two parallel strips of Clinch sandstone in the Ingles-Barringer Mountain window, and also in a small area north of Radford. This latter exposure is the southwestern end of a large window.

The outcrop belt of Hamilton and Portage age rocks in the Ingles-Barringer window consists almost wholly of black, extremely fissle shale. A few lenses of siltstone and calcareous shale grading into shaly limestone also occur. The siltstones and calcareous shales are also dark to black.

Lenticular concretions occur in these rocks locally.

The concretions range from about one inch up to five feet in diameter, are black in color, and are essentially composed of silt-size material. They are calcareous, and according to Allen (1938, pp. 76-77) contain veins and sheet-like lenses composed of ankerite and barite. They are especially abundant where U. S. Highway 11 crosses this outcrop belt of shale.

The shales and siltstones exposed north of Radford are olive-drab to yellowish-brown and weather reddish-brown. The shale is somewhat micaceous and the bedding planes have many small warps and bumps. These shales and siltstones are believed to be stratigraphically higher than the black shales of the Ingles-Barringer window.

Outcrops of these shales are typically covered with small shale chips. The very thin soil which forms from weathering of these rocks is composed mostly of small chips of decalcified shale.

The black shale overlies the Huntersville chert in this area. Elbrook dolomite of the Pulaski thrust sheet lies over these shales and siltstones. The great amount of tight folding in these rocks of Hamilton and Portage ages makes it impossible to ascertain the thickness of the rocks present. Butts (1940, p. 312) estimated that at least 1000 feet of black shale was present in the area between Radford and Barringer Mountain. Not over 200 feet of beds are exposed in the locality north of Radford. Much of the Millboro formation and probably a lower portion of the Brallier are represented by these rocks of Hamilton and Portage age.

A considerable thickness of rocks of Devonian and Early Mississippian ages, including the main body of the Brallier, the entire Chemung and Parrott formations, and most of the Price formation, which is unexposed in the Radford area but crops out in adjoining areas, is undoubtedly present in this area but is covered by rocks of the Pulaski thrust sheet. Only a few feet of the top of the Price formation is exposed at the north edge of the Radford area but at least 1000 feet of Price is exposed in the outcrop belt extending north from this area.

Maccrady Formation

The Maccrady was named by Stose (1913, pp. 234-235) for the village of Maccrady, Smyth County, Virginia. Maccrady replaces the name "Pulaski shale" of Campbell (1894, pp. 171, 178) which was preoccupied. Butts (1939, pp. 37-38) restricted the Maccrady to shale and mudrock of pre-Warsaw age, excluding the limestone included by Stose.

The Maccrady is essentially shale and mudstone, with a few interbeds of siltstone and about 30 feet of sandstone. The shale, mudstone and siltstone are greenish-gray to reddish-brown on fresh surfaces and have a somewhat mottled appearance. The sandstone is light greenish-gray. Except for the greenish-gray shales, which weather gray, the entire formation is a dull reddish-brown on exposed surfaces. The shale is commonly lumpy and locally the shale and mudrock are quite sandy. The sandstone is micaceous, fine grained, thick bedded, and lies about 40 feet above the bottom of the formation.

The Maccrady, which overlies the Price formation, is the youngest formation present in this part of Virginia. The uppermost Maccrady present in the Radford area is overlain by the Pulaski thrust sheet. About 550 feet of Maccrady is exposed along the Virginian Railway, across the New River from Belspring. However, Maccrady which appears to be 50 to 75 feet higher stratigraphically than the top of the Maccrady exposed along the railroad, crops out about 200 yards east of the railroad in a stream bed. Campbell (1925, p. 29) estimated the Maccrady to be no less than 800 feet thick along New River.

Maccrady forms the tread of the overridden block of the Pulaski fault along Cloyds and Brush mountains in this area and comprises almost all of the exposed bedrock designated as "Maccrady and Price formations, undifferentiated" on Plate 1. The Maccrady was not separated from the Price on Plate 1 because the Price extends only a few yards into the Radford area along New River, and probably extends a few yards into the area in some of the deeper ravines on the south side of Cloyds Mountain.

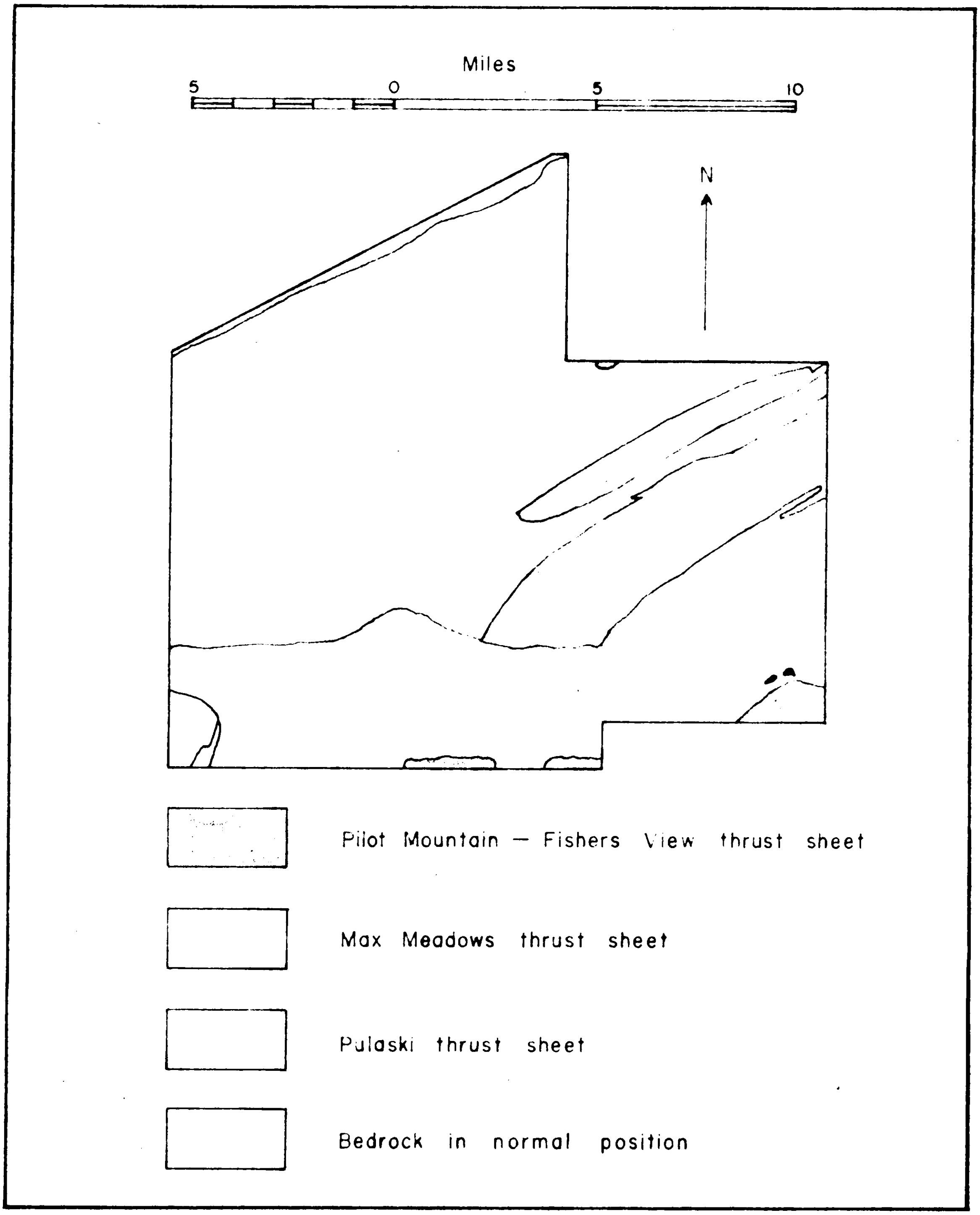
The Maccrady was thought by Butts (1940, p. 354) to be Early Mississippian Osage in age. Cooper (1944a, p. 153), however, suggests that the Maccrady may be equivalent to part of the Warsaw.

STRUCTURAL GEOLOGY

General statement. The geologic structure of the Radford area is characterized by three major low-angle overthrust faults. These thrusts almost appear to be bedding plane faults, and may well have behaved as bedding plane faults for much of the distance of the nearly horizontal displacement. The thrust sheets, which include the Pulaski, the Max Meadows, and the Blue Ridge, cover most of the Radford area (see Plates 2 and 5), and are further complicated by folds, high-angle thrusts faults, and the windows and klippen which formed where erosion has carved through the overthrust masses.

It is believed by the writer that the thrust faulting in the southeast occurred after the thrusting in the northwestern part of the Radford area. The Pulaski fault was evidently the first major fault of this area. The high-angle thrusts which cut the Pulaski fault probably formed

Plate 5



Portions of the Radford area covered by thrust sheets at the end of the Pulaski thrusting or soon after. The Max Meadows thrust sheet appears to have overridden two of the high-angle thrusts. The Blue Ridge thrusting evidently was the last major thrusting in the Radford area. This sequence of thrusting is probably the same as that of the entire region. The thrusts in the southeast are progressively younger than those to the northwest.

Campbell (1894, pp. 280-283) advanced two explanations for the origin of the Price Mountain and Ingles-Barringer Mountain windows. He discussed the possibility that the windows were isolated masses of Devonian and Lower Carboniferous rocks (he thought that the sandstone on Ingles Mountain was part of the Price formation) that had been thrust over Early Paleozoic limestones. Campbell thought it more likely, however, that these windows were overlaps of Later Paleozoic sediments that had been uncomformably deposited on the early Paleozoic limestones, and that uplift quickly halted sedimentation in these small basins and eventually formed the anticlines now present.

Campbell and Holden (1925) later concluded that the windows were the result of thrust faulting and were composed of bedrock in place that was exposed through holes carved by erosion in the overthrust mass of Early Paleozoic rocks. Butts (1933, map; 1940, pp. 448-449, 466-467) has suggested essentially the same conclusion.

Pulaski Fault

The bedrock exposed in more than half of the Radford area constitutes part of the great Pulaski thrust sheet. The Pulaski fault was named by Campbell and Holden (1925, p. 43) for a town through which it passes, and was thought by them (Campbell and Holden, 1925, pp. 76-77) to extend from the vicinity of Timberridge, Green County, Tennessee, to a point near the James River in the vicinity of Eagle Rock, Botetourt County, Virginia. Butts (1940, p. 449) stated that the Pulaski fault extends northeastward as far as Greenville, Augusta County, Virginia. Since that time, however, Cooper (1936, p. 165, Pl. 14) has shown that the southwestern end of the Pulaski fault appears to be a few miles northwest of Marion, and stated (Cooper 1946, p. 97) that it probably extends northeastward to the vicinity of Endless Caverns in Rockingham County, Virginia, and is thus over 200 miles in length.

The Pulaski fault crosses the Radford area along the northern border. It also swings around the base of Peak Knob in the southwestern corner of the area and along the south side of the Ingles-Barringer window. According to Campbell and Holden (1925, p. 86) and Butts (1940, p. 449) the window of Devonian shale northeast of Radford is also bounded by the Pulaski fault. The Pulaski fault is also exposed between the two high-angle thrust faults south of Ingles Mountain.

The existence of the Pulaski fault and the belief that the isolated areas of young rocks completely surrounded by older rocks are windows rather than outliers, are supported by considerable field evidence in this and adjacent areas. Hayes (1891) and Rich (1934) have shown that great overthrust faults occur in other parts of the Appalachians. Campbell and Holden (1925, p. 85) determined that the Maccrady formation formed the sole of the Pulaski overthrust at the fault trace along Cloyds and Brush mountains, and also around Price Mountain, thus indicating a rather flat and shallow fault surface between. Butts (1940, p. 449) pointed out that coal mines in the Price formation at Price Mountain extend beneath Elbrook and bore holes located near New River north of Radford were started at the surface in Elbrook and encountered the coal at a depth of about 2000 feet. The Maccrady on the southeast side of Cloyds and Brush mountains dips gently to southeast beneath Elbrook and is essentially unwarped and fractured whereas the overlying Elbrook is extremely brecciated and warped in most localities. The formations in the windows, though somewhat folded, are not brecciated as is the rock of the thrust sheet immediately adjacent to the windows in many localities. Also the rocks of the thrust sheet are very brecciated at a few localities somewhat distant from the fault surface. No other explanation than that of low-angle overthrusting is conceivable to show how the Elbrook could be in contact with and appear to conformably overlie so many younger formations.

The rocks forming the sole and tread of the Pulaski fault are not the same at all localitites. Maccrady forms the tread among the fault trace at the northern limit of the thrust sheet. The thrust sheet lies on Devonian shale at the southwest end of the window north of Radford, and lies on Devonian shale, Huntersville, Clinch, and Martinsburg in the Ingles-Barringer window. The fault plane appears to lie near the bottom of the Elbrook at most places. A few blocks of Rome shale that have been extremely brecciated are present locally in the more brecciated parts of the thrust sheet. These were apparently plucked from the top of the Rome at a slight irregularity in the fault surface near the zone of rupture. Little or no brecciation of the thrust sheet appears to have taken place at some places along the fault surface whereas large masses of fault breccia are present elsewhere. The masses of breccia range up to a few hundred feet thick and grade from unbrecciated rock to extremely brecciated rock referred to by

Cooper and Haff (1940, pp. 948, 953-954) and Cooper (1946, p. 98) as "crush conglomerate". The crush conglomerate is composed chiefly of angular to subrounded grains and fragments ranging in size from less than one millimeter to several centimeters across the large diameter. The fragments consist of limestone and dolomite that have been highly crushed and broken, and a small amount of macerated shale and phyllite. Cooper (1946, p. 98) suggested that the crush conglomerate locally has been injected into dike-like masses that are enclosed in relatively unbrecciated rock.

The Pulaski thrust sheet appears to have moved northwestward a minimum of eight miles, the distance from the south side of the Ingles-Barringer window to the fault trace north of Belspring. Erosion has removed the part of the thrust sheet that at one time undoubtedly extended farther northwest than the present fault trace. It is doubtful, however, that the thrust sheet once covered the top of Cloyds and Brush mountains. The present fault trace is fairly straight for a long distance along the southeast flank of the Cloyds-Brush Mountain ridge. It is not known how far the Pulaski fault extends, or did extend, southeast of the Ingles-Barringer window and Peak Knob. The Pulaski fault probably merges with the Max Meadows fault. This merging of the two faults in the area between Claytor Lake and Peak Knob is down the dip to the south of the present Max Meadows fault trace. East of Claytor Lake the location where the Pulaski and Max Meadows faults joined is north of the Max Meadows fault trace in that locality and above the present land surface. This last area is part of a high-angle thrust block. If the above interpretation is correct the horizontal displacement of the Pulaski fault in the east side of the Radford area is a maximum of about 10 miles. The stratigraphic separation accompanying the Pulaski fault is at least 9000 feet at the localities where Elbrook lies on top of the Maccrady. This figure is most likely considerably less than the actual stratigraphic separation when one considers that the formations which do not crop out in the Radford area surely exist between the Maccrady and the Elbrook. The above figures are similar to those suggested by others who have worked in this region. Cooper (1939, p. 57) states that the Pulaski thrust sheet has moved northwestward at least 11 miles and probably much more in the Draper Mountain area, and has a stratigraphic separation of about 13,000 feet. Butts (1940, p. 451) thought 20 miles to be a conservative estimate of the horizontal displacement along the Pulaski thrust.

The over all structure of the Pulaski thrust sheet in the Radford area is that of a syncline. Butts (1940, p. 449) mentioned a syncline in the vicinity of Dublin as being a part of a long syncline in the middle of the Pulaski thrust sheet. The smaller syncline is considered as the Dublin syncline in this report. The extent of the Dublin syncline is well shown by the outcrop of the Conococheague in the Radford area. It is a very broad syncline compared to its closure, and actually is two synclines with a small anticline between. North of Radford at the edge of the area the anticline plunges northeastward and appears to die out. This anticline, however, is probably a southwestern continuation of the Price Mountain anticline.

The Pulaski fault surface probably lies at a depth of 2500 to 3000 feet beneath the earth's surface along the trough of the Dublin syncline. In determining this figure it was considered that about 1000 feet of Conococheague is present and at least 1500 feet of Elbrook lies above the fault surface. If all of the formations exposed in the Radford area are represented by their maximum thicknesses in the Dublin syncline, the basement lies at a depth of at least 15,000 feet. Some of these formations undoubtedly are not represented by their full thickness beneath the Dublin area, but 3000 to 4000 feet of strata not exposed in the Radford area are probably present and more than take the place of beds lost by thinning of strata. The basement is probably 16,000 to 18,000 feet beneath the surface in the vicinity of Dublin.

Other folds occur in the Pulaski thrust sheet of the Radford area. It is believed that these folds were formed either at the same time as the overthrusting or at a later date. The strata below the Pulaski fault surface are believed to be folded in a manner similar to that of the thrust sheet. The horizontal displacement of the Pulaski fault is much greater than the stratigraphic separation. The original characteristics of the Pulaski fault were probably those of a bedding plane fault.

The larger bodies of tectonic breccia associated with the thrust faults of the Radford area are shown on Plate 1. The contacts are gradational bedause, as mentioned before, there is no sharp contact between the breccia and unbrecciated rocks at most localities. A few large blocks of the thrust sheet that remain comparatively unbrecciated lie within the area shown as "tectonic breccia" on the map. The slivers and blocks of Rome, which are present in the breccia zones along New River at Belspring and just east of Radford, are not differentiated on the map. Some of these blocks are several feet thick and at least 25 yards across.

Max Meadows Fault

Only one overthrust was recognized in the vicinity of Draper Mountain by Campbell (1925) and Holden, and later by Butts (1940). Cooper (1939, pp. 55, 58-63, Pl. 1), however, pointed out that the so-called Pulaski fault of previous writers was actually two distinct faults. The southernmost of these two faults was then designated as the Max Meadows fault after the town of Max Meadows, Wythe County, Virginia, near which the thrust sheet of Rome has overridden Elbrook. This is the same fault referred to by Dietrich (1954, p. 20, map) in the Pilot Mountain area as the Christiansburg thrust.

The Max Meadows fault extends completely across the Radford area in a northeasterly direction from the vicinity of Peak Creek. This fault also swings around the east side of Peak Knob. The trace of the Max Meadows fault is represented by a less regular line than is the Pulaski fault.

Proof of the existence of the Max Meadows fault is not as obvious in the Radford area as that of the Pulaski fault. Although much tectonic breccia is associated with the Pulaski fault in the Radford area and with the Max Meadows fault in the Draper Mountain area immediately to the southwest (Cooper, 1939, p. 59), only a few large bodies of breccia associated with the Max Meadows fault appear to be present in the Radford area. Other evidence which supports the existence of the Max Meadows fault include the tongue of Rome at the east margin of the area that extends over Elbrook and Knox strata, the pieces of jasperoid that are locally present in soil near the fault trace, and the fact that the Claytor Dam fault ends abruptly at the Rome-Elbrook contact as if concealed by the Rome. Dietrich (1954, map) shows a small, completely isolated patch of Rome just east of the above mentioned tongue of Rome which strongly suggests an overthrust. R. V. Dietrich (personal communication, August, 1957) has found Rome strata right side up that appeared to lie on top of Elbrook. No windows are known to occur in the Max Meadows thrust sheet in this area.

The tongue of Rome extending over younger rocks suggests that the Max Meadows fault is a very low-angle thrust, at least at some localities. This idea is also supported by a rather good exposure of the Rome-Elbrook contact on the banks of an inlet on the southeast side of Claytor Lake. At this location both the Rome and the underlying Elbrook have a gentle southerly dip. Most of the strata of the overthrust sheet have relatively steep dips and are overturned to the northwest at numerous locations. This is the result, however, of complex folding and minor faulting that occurred in the incompetent Rome formation as it overrode the Elbrook.

The horizontal displacement of the Max Meadows thrust is unknown but is probably much less than that of the Pulaski thrust. The displacement is at least four miles, however, in the vicinity of Peak Knob. The stratigraphic separation associated with the Max Meadows fault appears to be about 3500 to 4000 feet in the Radford area. The sole of the overthrust block appears to be near the bottom of the Rome formation. The thrust sheet has overridden the Elbrook and the lower part of the Knox. As mentioned in the description of the Pulaski fault, it is probable that the Max Meadows and Pulaski faults merge down the dip to form a single fault.

The Rome shales forming the Max Meadows thrust sheet are extremely folded and somewhat faulted. Many of the folds are overturned to the northwest and rather closely parallel the local trend of the Max Meadows fault trace. The overall dip of the Rome of the Max Meadows thrust sheet appears to by under the Blue Ridge thrusts.

The Max Meadows fault breccia is somewhat similar to the breccia of the Pulaski fault that contains blocks and slivers of Rome. A small amount of crush conglomerate is present where dolomites of the Rome are associated with the fault surface. A complete description of breccia associated with the Max Meadows fault in the Draper Mountain area has been given by Cooper and Haff (1940, pp. 945-947).

Blue Ridge Faults

The Blue Ridge faults have been recognized by several writers. Stose (1928) and Butts (1933; 1940) have recognized several distinct faults along the Blue Ridge front in Virginia. Ver Wiebe (1936, pp. 910-938), speaks of one "great boundary fault" along the northwest side of the Blue Ridge. Dietrich (1954, pp. 20-22, map) shows two distinct thrusts along the Blue Ridge front in Montgomery County.

The southwesternmost of these, called the Pilot Mountain-Fishers View thrust by Dietrich, is between the Rome and Hampton formations in the southeast corner of the Radford area. The fault on the two outlying ridges of Macks Mountain southwest of Simpkinstown, may well be a continuation of the Pilot Mountain-Fishers View thrust. Hampton has also been thrust over Rome strata south of Simpkinstown. The Pilot Mountain-Fishers View fault also bounds Calffe Knob and a smaller klippe to the southwest. Limonite-cemented breccia occurs at numerous places along the fault in the Radford area, for example, 0.2 mile north of Sidney Church on Road 606, on Calffe Knob and the klippe to the southwest, and on the north flanks of the two ridges of Hampton southwest of Simpkinstown.

Calffe Knob and the related klippe are thought to be remnants of the overturned anticline, called the Pilot Mountain fold by Dietrich (1954, p. 24), which is situated immediately to the south. Much Unicoi sandstone is among the float on the sides of the two hills east of Calffe Knob and indicates that these hills also were likely former klippen. The above interpretation of the structure in the vicinity of Calffe Knob is in accord with that given by Dietrich (1954, pp. 21-22). The writer found no indication that the two small patches of Unicoi between Calffe Knob and the Pilot Mountain fold have been thrust to their present location. Evidently they are erosional remnants of the northwest flank of the overturned anticline.

The horizontal displacement of the Pilot Mountain-Fishers View fault is indeterminable in the Radford area. Dietrich (1954, p. 22) states that the movement was at least one mile in the Pilot Mountain area to the east. The stratigraphic separation is not completely shown in the Radford area. The tread of the thrust appears to be near the middle of the Rome. Unicoi, probably near the top of the formation, forms the thrust sheet on Calffe Knob. The Hampton, Erwin, and Shady formations are also included in the stratigraphic separation. The Shady and Erwin formations, though not exposed in the Radford area, crop out in the Pilot Mountain and the Draper Mountain areas (Dietrich, 1954, map; Cooper, 1939, Pl. 1) and are probably present beneath the thrust sheet in this area.

High-Angle Thrust Faults

Three high-angle thrust faults occur in the Radford area and further complicate the Pulaski fault. The most extensive of the high-angle thrusts is the Salem fault. According to Butts (1940, p. 448) the Salem fault extends from the vicinity of Cloverdale, Botetourt County, southwestward to a point between Radford and Christiansburg where it merges with the Pulaski fault around the Ingles-Barringer window. It is now believed, however, that the Salem fault extends along the north side of the Ingles-Barringer window and apparently terminates a short distance northwest of Claytor Dam. The Salem fault is displaced a few hundred yards by a cross-fault at the northeast end of Barringer Mountain. Two nearly parallel high-angle thrusts occur just south of the Ingles-Barringer window. The southeasternmost of these two faults passes beneath Claytor Dam and is here referred to as the Claytor Dam fault. The other fault is here called the Shrouds Creek fault after a small tributary of New River that has been influenced by the fault. Shrouds Creek is located on the south side of Ingles Mountain and not on the north side as shown on Plate 1.

These three high-angle faults cut the Pulaski fault. In each case the upthrown block lies on the southeast side of the fault trace and has been thrust northwestward. The Pulaski fault surface has been elevated by these thrusts so that it apparently has been eroded from the area between the Claytor Dam and Max Meadows faults. The Ingles-Barringer window probably would not exist had it not been elevated to its present position as part of the Salem fault block. The two outcrop belts of Martinsburg shale south of the Ingles-Barringer window also would not exist were it not for the Shrouds Creek and Claytor Dam faults.

Windows in the Pulaski Thrust Sheet

The exposure of Devonian shale north of Radford is part of a large window. The tract of Devonian shale, Huntersville, Clinch, and Martinsburg, in the vicinity of Ingles and Barringer mountains also resembles a window. The Ingles-Barringer area is not a true window because its existence at least partially results from the high-angle Salem fault.

The structure of the strata within the window north of Radford appears to be that of a southwest plunging anticline that extends beneath the Pulaski thrust sheet. The structure of the rocks within the Ingles-Barringer window, however, is more complicated. The two parallel discontinuous ridges along each side of the window are the flanks of a syncline. The most prominent of these two ridges is the one on the south and consists of Ingles and Barringer mountains. Barringer Mountain is a northwest dipping hogback. Ingles Mountain, however, is more complicated. The eastern end is a simple anticline but the western end appears to be an anticline and a very tight syncline adjacent on the southeast. The syncline has been overturned to the northwest. Many tight folds occur in the Devonian shales in the trough of the large syncline. The "windows" of Martinsburg south of the Ingles-Barringer window are actually high-angle fault blocks.

GEOMORPHOLOGY

General statement. Almost all of the Radford area lies within the Ridge and Valley physiographic province. The northern boundary of the area is located near the base of the southeasternmost ridge of the Valley Ridges. The Blue Ridge front at the southeast corner of the area lies along the north side of the Pilot Mountain anticline. Calffe Knob and a neighboring klippe now lie within the Appalachian

Valley, although the Blue Ridge front at one time undoubtedly lay northwest of these knobs.

Drainage Development

New River and its tributaries, including Little River, Back Creek, and Peak Creek, drain the Radford area. Some of the tributaries do not appear to be subsequent streams but most of them either follow the strike of the strata or are influenced by fault zones. Most of the streams within the Rome outcrop belt trend in the same direction as the folds. Shrouds Creek and Back Creek are good examples of fault-controlled streams. New River also flows along a fault zone from Claytor Lake State Park to the mouth of Little River. A karst topography has developed on much of the Pulaski thrust sheet west of New River. It is particularly evident in the outcrop area of the Conococheague limestone;

The expanse bounded by Peak Creek, New River, and Cloyds Mountain, and extending a few miles westward from the edge of the Radford area, is a broad, slightly dissected area that Butts (1940, p. 7) referred to as the Dublin plain, and was considered part of the Valley peneplain by Fenneman (1938, p. 249). The city of Radford is built upon an extension of this plain that lies between New River and Ingles Mountain. The elevations of the tops of the hills representing the level of the Dublin plain range from 2200 feet on the west down to about 2000 feet near New River. Although the river is now entrenched 200 to 300 feet below the level of the upland plain, the occurrence of stream-rounded cobbles and terrace gravel on many of the hills within two miles of New River indicates that the river once meandered on the eastern part of the Dublin upland plain. Cobbles are present on the top of a hill about 1.25 miles northwest of Claytor Dam at an elevation exceeding 2140 feet. This is about 400 feet above New River at the base of Claytor Dam. Much of the surface within the city of Radford and the area between Ingles Mountain and the Radford city limit is covered with quartzite cobbles and gravelly alluvium.

The writer broke about 50 cobbles found in the vicinity of Radford and determined that fully half of them were either vein quartz or quartzite from the Blue Ridge. Some of the cobbles were composed of sandstone from Silurian and Cambrian formations. Ingles Mountain was undoubtedly the source of many of the cobbles of Clinch. The source of the Blue Ridge cobbles is less definite. New River leaves the Blue Ridge province and enters the Great Valley in the vicinity of Austinville, a distance of approximately 30 miles from Radford. It is more likely that those cobbles were carried from the Blue Ridge by either Little River or a former tributary of the New River that no longer exists. This shorter distance via Little River to the Blue Ridge is about 10 air miles. Wentworth (1922b) has shown that cobbles may become fairly rounded while being transported only a few miles by vigorous streams. Many of the cobbles described above are only slightly weathered.

A few cobbles were found in a saddle on top of Ingles Mountain at an altitude slightly above 2160 feet. Many of these cobbles are more friable and were likely deposited long before the cobbles at the lower elevations north of Ingles Mountain.

The Land Forms

Almost all of the topographic features of the Radford area resulted directly from the relative resistance to erosion of the strata and seondarily result from the stratigraphy and structure. The most prominent feature of the Radford area, is Peak Knob at the east end of Draper Mountain. It is held up by steeply dipping Clinch sandstone just as are many of the more prominent ridges of the Ridge and Valley province. The most prominent topographic feature entirely within the Radford area is Calffe Knob. It, the klippe just to the southwest, and the highest hills south of Calffe Knob are capped with coarse Unicoi sandstone.

The two parallel discontinuous ridges of Clinch sandstone lying within the Ingles-Barringer Mountain window are also prominent topographic features in the Radford area. Ingles Mountain is a doubly plunging anticline held up by the very resistant Clinch. The hill of Clinch and Huntersville that is exposed on Highway 11 west of Barringer Mountain is also an anticline, probably a low continuation of the Ingles Mountain anticline. Barringer Mountain and the other Clinch-capped hills and ridges in the Ingles-Barringer window are hogbacks dipping toward the trough of the syncline. The Clinch ranges greatly in thickness with a result that saddles and stream valleys have developed where the Clinch is either thin or nonexistent.

The entire Rome outcrop belt is marked by very distinctive elongate hills, most of which parallel each other and trend in the same direction as folds in the formation. These elongate hills are very distinct on topographic maps, and the Rome contacts can be placed on the map with reasonable accuracy by observing the contour lines. The east-west valleys tend to develop along the axes of synclines and along the outcrop of less resistant strata. Many of the north-south valleys in this belt have probably been influenced by minor cross faults in the Rome.

Elongate hills are conspicuous in the outcrop of the

Knox dolomite. Most of these hills are held up by the thick chert beds and sandstone interbeds in the Knox. Only the thicker sandstone interbeds and those containing less calcareous material have resisted erosion sufficiently well to form topographic highs. Slump blocks of chert as much as five-feet thick, six feet wide, and ten feet long, occur on hillsides within the Knox outcrop belt.

Most of the hills and local divides within the Dublin plain are believed to have resulted from less brecciated and broken masses within the Pulaski thrust sheet and from the occurrence of sandstone interbeds in the Conococheague. The valleys and the many sinkholes have likely developed where the thrust sheet was more broken and brecciated. The great number of cobbles which cover some of the higher hills and knobs in the Dublin plain have evidently somewhat protected the underlying soil and rock from erosion. The structure of the rocks within the Pulaski thrust sheet is also important.

ECONOMIC GEOLOGY

General statement. The Radford area is predominantly rural. Except within Radford, Dublin, and the Radford Arsenal, most of the area is devoted to agriculture and lumbering. The fertile soil that develops upon most of the carbonate rocks of the area produce good yields of alfalfa, corn, and the small grains. Soil derived from Knox strata with sandstone and chert interbeds is generally thin and more suited to grazing. The less rugged topography in the Rome outcrop belt is suitable for cropping and grazing. Soil developed on Rome shale is thin at most localities except where a cover of cobbles and gravelly alluvium is present and has facilitated deep weathering. The more steep Rome terrain is more adaptable to grazing and lumbering, as are the other soils derived from shales and sandstones in the Radford area. Soil derived from the Devonian shales is exceptionally infertile and supports little vegetation other than scrub trees and weeds.

Ample water supplies exist in most parts of the Radford area and some mineral resources are also present. Large supplies of water for industrial uses may be obtained from New River. An analysis of water from Radford as given by Lohr and Love (1954, p. 581) is shown in figure 1.

Radford, because of a good supply of water, a large source of labor, and excellent rail facilities, is an ideal location for industries. Much of Radford, especially near New River, has a thick cover of cobbles and gravelly alluvium which minimizes the formation and existence of underground solution cavities. The Lynchburg Foundry in Radford and the

Table 1. - Analyses of water supply at Radford, Virginia

(Analyses, in parts per million, by U.S. Geological Survey)

	Raw water[a]	Finished water
Silica (SiO_2)	9.8	7.7
Iron (Fe)	.13	.05
Manganese (Mn) . . .	---	---
Calcium (Ca)	8.9	12
Magnesium (mg) . . .	3.6	4.6
Sodium (Na).	2.4	2.0
Potassium (K)		1.3
Carbonate (CO_3) . . .	0	0
Bicarbonate (HCO_3) .	41	45
Sulfate (SO_4)	5.0	11
Chloride (Cl)	1.4	2.8
Fluoride (F)	.2	.2
Nitrate (NO_3)	1.2	.7
Dissolved solids . .	55	74
Hardness as $CaCO_3$:		
Total	37	49
Noncarbonate . . .	3	12
Color	8	0
pH	7.3	7.6

Table 1. - (continued)

	Raw water[a]	Finished water
Specific conductance (micromhos at 25° C.)	81	109
Turbidity	---	0.5
Date of collection . .	Sept. 11-20 1950	Sept. 12 1951

[a] Composite of 10 daily samples from the New River at Radford from September 11 through 20, 1950.

Ownership: Municipal

Source: New River

Treatment: Prechlorination, coagulation with alum, sedimentation, rapid sand filtration, and adjustment of pH with lime.

Rated capacity of treatment plant: 2,000,000 gpd.

Finished water storage: 1,600,000 gal.

Celanese plant near Pearisburg are examples of large industrial plants located on alluvial material along the banks of New River.

Limestone and Dolomite

Limestone and dolomite have been quarried at many locations in the Radford area but only one quarry is being actively worked at the present time. Many small pits can be found where limestone and dolomite were once calcined for agricultural purposes. An abandoned quarry is located about 0.25 mile northwest of Childress where dolomite and dolomitic limestone of the Rome formation were once obtained for ballast and fill used in construction. Another old quarry is located in Conococheague along U.S. Highway 11 about three miles west of Radford. The Virginia Department of Highways recently abandoned a quarry on Virginia Highway 100 south of Newbern. This quarry is located in limestone of the Elbrook formation. A quarry now being worked intermittently is located south of Ingles Mountain and west of Road 664 at the end of an outcrop belt of Martinsburg. Somewhat brecciated Martinsburg limestone and fault breccia occur in this quarry.

A large quarry and processing plant owned by the Radford Limestone Company is located between the mouth of Little River and Claytor Dam. Knox dolomite and a little Lenoir and Mosheim limestones are crushed at this quarry and used for concrete aggregate, ballast and fill, aggregate for black topping highways, and agricultural lime. Many truck loads of stone are hauled from this plant daily and several car loads are shipped out each day via the Norfolk and Western's spur line from Radford. A description of this quarry and the rock quarried is given by Cooper (1944b, pp. 48-51).

The dolomite of the upper Knox, is quite compact and tough and thus is well suited for use as crushed stone. The Mosheim though generally considered as a high-grade limestone, is not particularly high in calcium carbonate in this area. Here the Mosheim probably does not exceed 30 feet in thickness and the strata are nearly vertical. Thus the Mosheim limestone is not well suited for industrial use within the Radford area. A chemical analysis of the "Mosheim" in the vicinity of Miles as given by Cooper (1944b, p. 50) is as follows:

$CaCO_3$	84.30%
$MgCO_3$	8.99
SiO_2	3.39
Al_2O_3	1.98
Fe_2O_3	0.74
Total	99.40

Iron

Secondary residual concentrations of limonite and limonite-cemented breccia occur locally along the Max Meadows and Blue Ridge faults. The old iron mines on Peak Knob have been discussed by Cooper (1939, pp. 85-86). These mines were situated near the Max Meadows fault trace on the east side of Peak Knob. A few traces of limonite-cemented breccia occur along the Max Meadows fault trace near Claytor Lake but have no economic value. Limonite cemented breccia occurs at many places along the Blue Ridge faults, for example in the vicinity of Calffe Knob and on the ridges south of Simpkinstown. A few small prospect pits ave been dug at both localities. It is very doubtful, however, that commercial quantities or commercial grades of the iron exists here.

Coal

Coal beds occur in the Price formation and several active and several abandoned mines are located just north of the Radford area along the south slope of Cloyds and Brush mountains. These beds of semi-anthracite coal dip beneath the Radford area but lie at too great a depth to be economically important at the present time.

Local residents have reported that coal has been dug from the north side of Barringer Mountain. However, no coal beds have been found to occur in that area. It is presumed that the residents referred to carbonaceous shale of Devonian age which will burn slightly.

Sulfides

An exploratory hole was drilled in Elbrook dolomite on the north side of Claytor Lake, southeast of Newbern, during the summer of 1956. It was rumored that zinc was the object of the prospecting. The writer examined the part of the core which was left lying near the test hole and found only a few traces of pyrite. R. V. Dietrich (personal communication, August, 1957) examined the remainder of the core and found only pyrite. Small amounts of pyrite have been found elsewhere in the Elbrook but it is very doubtful that commercial quantities of any sulfide mineral occurs in this locality.

Sphalerite has been found in Rome dolomite on the Palmer property on Road 631, approximately four miles west of Snowville. The sphalerite occurs as fracture-filling in the dolomite. Traces of galena, smithsonite, hemimorphite, cuprite, and malachite have also been identified at this locality. The sphalerite was discovered in a shallow pit in which dolomite was obtained for burning. No core drilling has been done to determine the extent of the deposit but it is rather doubtful that it has commercial possibilities. Traces of "zinc ore" have been reported elsewhere in the dolomites of the Rome in this and near by areas. Dietrich (1954, p. 28) mentions the occurrence of sulfides near Boneys Run, in the Pilot Mountain area, in which sphalerite, galena, smithsonite, and hemimorphite have been identified. Sears (1950; and personal communication, July, 1957) mentioned an old mine situated in Rome dolomite about two miles south of Christiansburg, Virginia, in which sulfides of iron and copper have altered to limonite and malachite.

Clays

A brick plant which manufactured common brick was once located at the southwest end of Radford. Two clay deposits have been mentioned by Ries (1920, pp. 76-77, 112-113) as being in that vicinity and having high plasticity, high tensile strength, low air shrinkage, comparatively low absorption, and burn to a fine buff brick. These clay deposits have a thin cover of sandy to gravelly alluvial material. The location of these deposits was vaguely described but is probably now within the city limit of Radford and now beneath a residential district.

Other Resources

Terrace gravel and cobbles have been used locally for fill and surfacing driveways. Cobbles and boulders have been used in a few instances to build houses, stone fences, and for similar ornamental purposes.

Rome shale has been used for surfacing secondary roads and driveways at numerous places in the Rome outcrop belt. Less fissile shales of the Rome are reasonably satisfactory for this purpose if the road or driveway is not heavily traveled. Vast quantities of the shale are readily available for this use, but the actual commercial value is slight, if any.

Rome shale is being quarried near Elliston for making brick. Some of the Rome shale in the Radford area is believed to be suitable for this purpose. Especially suitable deposits occur where a cover of alluvial material is present and has facilitated deep weathering of the Rome shales. Such deposits occur near the Norfolk and Western Railway in the vicinity of Peak Knob. Similar deep weathered shale is likely present beneath the alluvium south of Radford in the belt of Devonian rocks.

The writer bloated cubic chips of red Rome shale and Devonian black shale in order to find a possible source of material for making light-weight aggregate. The shale chips were preheated to release moisture and were then exposed to a temperature of 1250° C. for 30 minutes. The Rome chips after bloating would not float on water. The Devonian black shale chips did float on water after bloating, and apparently have an impermeable outer layer. A wide belt of this shale crops out southeast of Radford and is close to rail facilities. A more detailed investigation should be made to determine whether or not the high fissility of the Devonian black shale is an undesirable characteristic.

ACKNOWLEDGMENTS

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Appreciation must also be extended to the writer's wife, , who typed the preliminary drafts of this report.

Plate 6

A. Hampton shale along Road 672 south of Calffe Knob.

B. Rome shale along Road 787 near Laurel Hill Church.

Plate 6

A

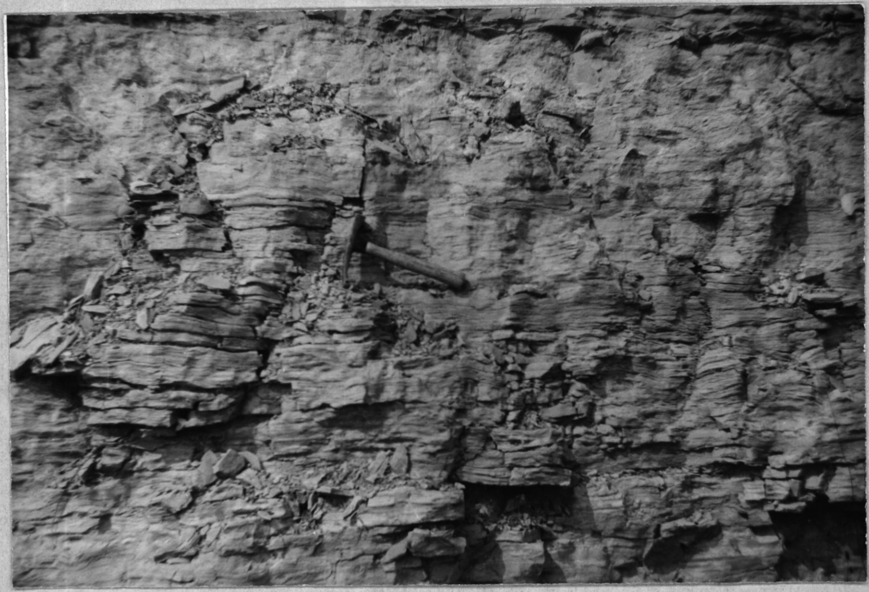
B

Plate 7

A. Thin-bedded Elbrook dolomite on State Highway 100 near Newbern.

B. Conococheague limestone with thin argillaceous laminations, on State Highway 100 near Newbern.

Plate 7



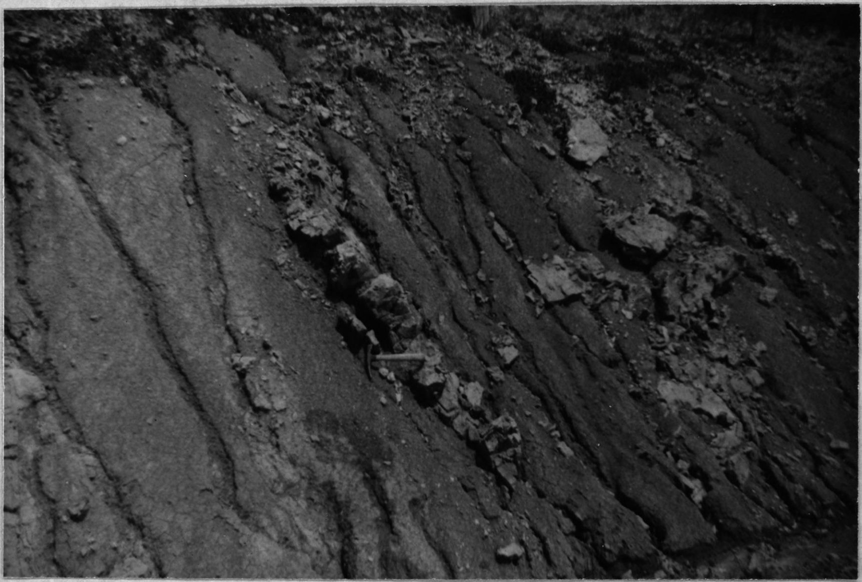
A

B

Plate 8

A. Chert and Sandstone interbeds in the Knox dolomite weather in relief at many localities. This picture shows chert interbeds along Road 787 near the junction with Road 664.

B. En echelon calcite veins in steeply-dipping Liberty Hall limestone, approximately one mile south of Barringer Mountain.



A

B

Plate 9

A. Martinsburg limestone along U. S. Highway 11 southeast of Barringer Mountain.

B. Extremely fissle black shale of Devonian age. The concretion is approximately five feet in diameter. This picture was taken along U. S. Highway 11 about one mile west of Barringer Mountain.

A

B

Plate 10

A. Crush conglomerate exposed along U. S. Highway 11 just east of Radford.

B. Drag fold in "Unicoi-like" sandstone approximately one mile south of Calffe Knob. This is the same picture which has been printed backwards on page 24 of the report on the Pilot Mountain area by Dietrich (1954).

Plate 10

A

B

Plate 11

A. Alluvial cobbles and gravels occur in many localities in the Radford area. This picture shows cobbles between Radford and Ingles Mountain at an elevation slightly above 2000 feet.

B. Looking southeast from Road 658 towards a low ridge held up by a comparatively thick sandstone interbed in the Knox dolomite.

Plate 11

A

B

Plate 12

A. Looking south across an area underlain with Rome towards Macks Mountain and the Blue Ridge front. This picture was taken on Road 605 near Corner View Church.

B. Looking towards the Dublin plain from near Calffe Knob.

A

B

REFERENCES CITED

Allen, R.M. (1938), Septaria in the Romney Shale in Virginia, abstract, Virginia Academy of Science Proceedings for the Year 1937-1938, pp. 76-77.

Butts, Charles (1933), Geologic Map of the Appalachian Valley of Virginia with Explanatory Text, Virginia Geol. Survey Bull. 42, 56 p., map.

_______________ (1940), Geologic Map of the Appalachian Valley in Virginia, Virginia Geol. Surv. Bull. 52, 568 p.

Campbell, H.D. (1905), The Cambro-Ordovician Limestones of The Middle Portion of the Valley of Virginia, Am. Jour. Sci., 4th ser., vol. 20, pp. 445-447.

Campbell, M.A. (1894), Paleozoic Overlaps in Montgomery and Pulaski Counties, Virginia. Bull. Geol. Soc. America, Vol. 5, pp. 171-190.

_______________ (1899), Description of the Bristol Quadrangle, Virginia-Tennessee, U.S. Geol. Surv. Geologic Atlas, Bristol Folio, No. 59, 8 p.

_______________, and Holden, R.J. (1925), Geologic Structure, in The Valley Coal Fields of Virginia, by Campbell and others, Virginia Geol. Surv. Bull. 25, pp. 30-96.

Cooper, B.N. (1936), Stratigraphy and Structure of the Marion Area, Virginia, Virginia Geol. Surv. Bull. 46-L, pp. 125-166.

____________ (1939), Geology of the Draper Mountain Area, Virginia, Virginia Geol. Surv. Bull. 55, 98 p.

____________ (1944a), Geology and Mineral Resources of the Burkes Garden Quadrangle, Virginia, Virginia Geol. Surv. Bull. 60, 299 p.

____________ (1944b), Industrial Limestones and Dolomites in Virginia: New River-Roanoke River District, Virginia Geol. Surv. Bull. 62, 98 p.

____________ (1946), Metamorphism Along the "Pulaski" Fault in the Appalachian Valley in Virginia, Am. Jour. Sci., Vol. 244, pp. 95-104.

____________, and Cooper, G.A. (1946), Lower Middle Ordovician Stratigraphy of the Shenandoah Valley, Virginia, Bull. Geol. Soc. America, Vol. 57, pp. 35-113.

____________, and Haff, J.C. (1940), Max Meadows Fault Breccia, Jour. Geology, Vol. 48, pp. 945-974.

Cooper, G.A. (1956), Chazyan and Related Brachiopods, Smithsonian Miscellaneous Collections, Vol. 127, pt. I, 1024 p.

Dietrich, R.V. (1954), Geology of the Pilot Mountain Area, Virginia, Bull. Virginia Polytechnic Institute, Engineering Experiment Station Series No. 91, 32 p.

Fenneman, N.M. (1938), Physiography of Eastern United States, McGraw-Hill Book Company, Inc., New York, 714 p.

Geiger, H.R., and Keith, Arthur, (1891), The Structure of the Blue Ridge near Harpers Ferry, Bull. Geol. Soc. America, Vol. 2, pp. 155-164.

Hayes, C.W. (1891), The Overthrust Faults of the Southern Appalachians, Bull. Geol. Soc. America, Vol. 2, pp. 141-154.

__________ (1892), Geology of North-Eastern Alabama and Adjacent Portions of Georgia and Tennessee, Geol. Surv. Alabama Bull. No. 4, 85 p.

Keith, Arthur (1894), Description of the Harpers Ferry Quadrangle, Maryland-Virginia, U.S. Geol. Surv. Geologic Atlas, Harpers Ferry Folio, No. 10, 5 p.

__________ (1895), Description of the Knoxville Quadrangle, Tennessee, U.S. Geol. Surv. Geologic Atlas, Knoxville Folio, No. 16, 6 p.

__________ (1903), Description of the Cranberry Quadrangle, North Carolina-Tennessee, U.S. Geol. Surv. Geologic Atlas, Cranberry Folio, No. 90, 9 p.

Lohr, E.W., and Love, S.K. (1954), The Industrial Utility of Public Water Supplies in the United States, 1952, Part I, U.S. Geol. Surv. Water Supply Paper 1299, 639 p.

Pettijohn, F.D. (1957), Sedimentary Rocks, Harper & Brothers, New York, 718 p.

Price, P.H. (1929), Pocahontas County, West Virginia Geol. Surv., County Reports, 531 p.

Rich, J.L. (1934), Mechanics of Low-Angle Overthrust Faulting as Illustrated by Cumberland Thrust Block, Virginia, Kentucky, and Tennessee, Am. Assoc. Petroleum Geologists Bull., Vol. 18, pp. 1584-1596.

Rich, L.G. (1954), Hydrology of Virginia: Part III, Bull. Virginia Polytechnic Institute, Engineering Experiment Station Series No. 92, 30 p.

Ries, Heinrich, and Somers, R.E. (1920), The Clays and Shales of Virginia West of the Blue Ridge, Virginia Geol. Surv. Bull. 20, 118 p.

Safford, J.M. (1856), A Geological Reconnaissance of the State of Tennessee, 1st Bien. Rept., Nashville, p. 157.

______________ (1869), Geology of Tennessee, Nashville, 550 p.

______________, and Killebrew, J.M. (1876), The Elements of the Geology of Tennessee, Nashville, pp. 130-131.

Sears, C.E. Jr. (1950, Occurrence and Origin of Limonite and Malachite in Montgomery County, Virginia, abstract, Virginia Jour. Sci., Vol. 7, new series, No. 4, p. 380.

Stose, G.W. (1906), The Sedimentary Rocks of South Mountain, Pennsylvania, Jour. Geology, Vol. 14, pp. 201-220.

__________ (1908), The Cambro-Ordovician Limestones of the Appalachian Valley in Southern Pennsylvania, Jour. Geology, Vol. 16, pp. 698-714.

__________ (1913), Geology of the Salt and Gypsum Deposits of Southwestern Virginia, from Contributions to Economic Geology, U.S. Geol. Surv. Bull. 530, pp. 232-255.

__________ (1928), supervisor of preparation, Geologic Map of Virginia, Virginia Geol. Surv., map.

Ulrich, E.O. (1911), Revision of Paleozoic Systems, Bull. Geol. Soc. America, Vol. 22, pp. 281-680.

Ver Wiebe, W.A. (1936), Geosynclinal Boundary Faults, Am. Assoc. Petroleum Geologists, Bull., Vol. 20, pp. 910-938.

Wentworth, C.K. (1922a), A Scale of Grade and Class Terms for Clastic Sediments, Jour. Geology, Vol. 30, pp. 377-392.

__________ (1922b), A Field Study of the Shapes of River Pebbles, From The Shapes of Pebbles, U.S. Geol. Surv. Bull. 730-C, pp. 103-114.

Wilmarth, M.G. (1938), Lexicon of Geologic Names of the United States, U.S. Geol. Surv. Bull. 896, 2396 p.

Woodward, H.P. (1929), The Age and Nomenclature of the Rome ("Watauga") Formation of the Appalachian Valley, Jour. Geology, Vol. 37, pp. 592-602.

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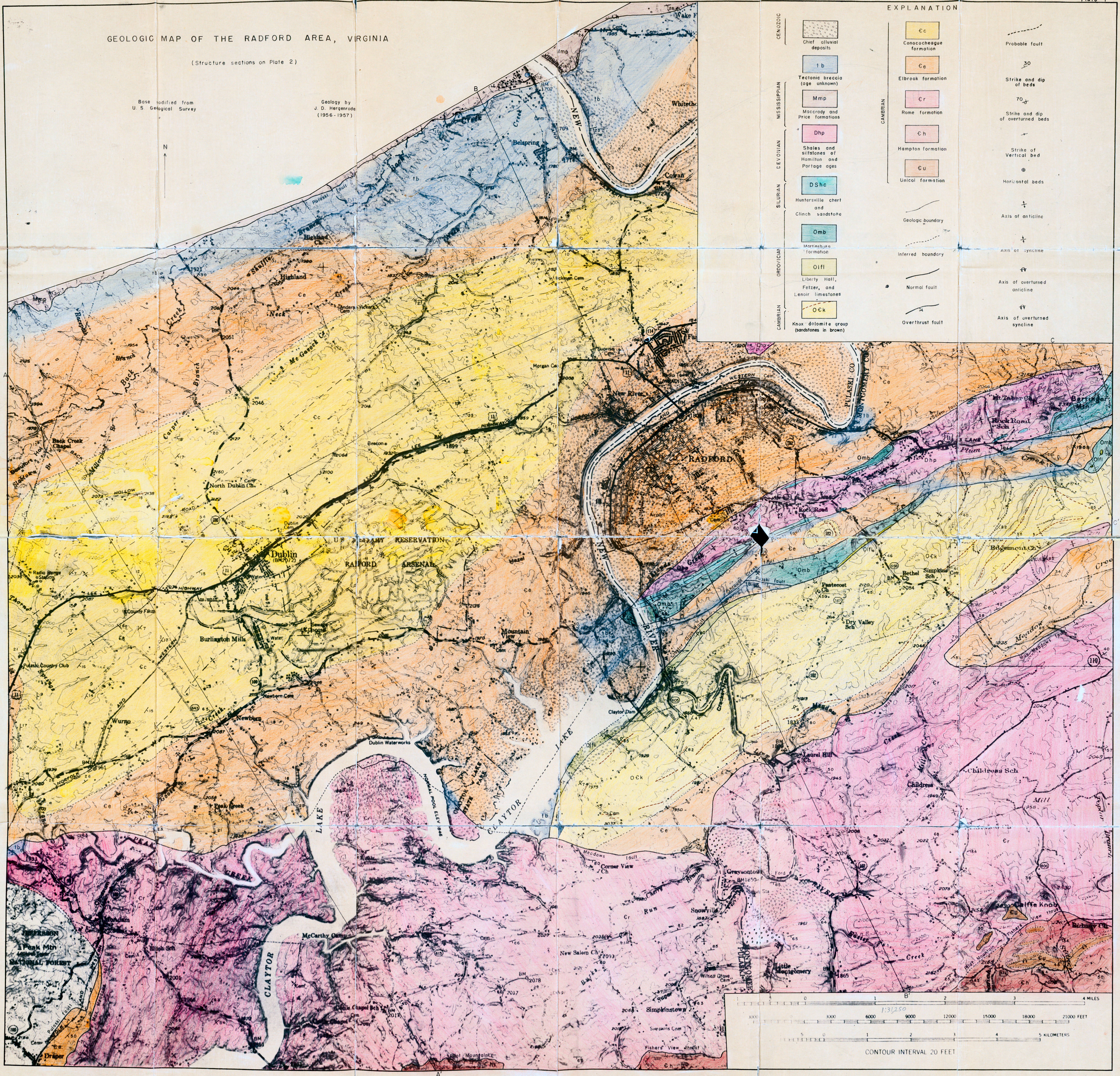
GEOLOGIC MAP OF THE RADFORD AREA, VIRGINIA
(Structure sections on Plate 2)
Base modified from U. S. Geological Survey
Geology by J. D. Hergenroder (1956-1957)
N
EXPLANATION
CENOZOIC
Chief alluvial deposits
tb
Tectonic breccia (age unknown)
MISSISSIPPIAN
Mmp
Maccrady and Price formations
DEVONIAN
Dhp
Shales and siltstones of Hamilton and Portage ages
SILURIAN
DShc
Huntersville chert and Clinch sandstone
ORDOVICIAN
Omb
Martinsburg formation
Olfl
Liberty Hall, Fetzer, and Lenoir limestones
CAMBRIAN
OЄk
Knox dolomite group (sandstones in brown)
CAMBRIAN
Єc
Conococheague formation
Єe
Elbrook formation
Єr
Rome formation
Єh
Hampton formation
Єu
Unicoi formation
Geologic boundary
Inferred boundary
Normal fault
Overthrust fault
Probable fault
Strike and dip of beds
Strike and dip of overturned beds
Strike of Vertical bed
Horizontal beds
Axis of anticline
Axis of syncline
Axis of overturned anticline
Axis of overturned syncline
RADFORD
Dublin
U. S. ARMY RESERVATION
RADFORD ARSENAL
CLAYTOR LAKE
NEW RIVER
Belspring
Highland
North Dublin Ch.
Burlington Mills
Newbern
Dublin Waterworks
Claytor Dam
Snowville
Little Montgomery
Childress
Bethel
Dry Valley Sch
Simpkinstown
1 0 1 2 3 4 MILES
1:31,250
3000 0 3000 6000 9000 12000 15000 18000 21000 FEET
5 0 1 2 3 4 5 KILOMETERS
CONTOUR INTERVAL 20 FEET

J. D. Hergenroder

STRUCTURE SECTIONS OF THE RADFORD AREA, VIRGINIA

(Explanation of symbols on Plate 1)

1660