THE MIDDLE ORDOVICIAN FINCASTLE CONGLOMERATE NORTH OF ROANOKE, VIRGINIA AND ITS IMPLICATIONS FOR BLUE RIDGE TECTONISM

by

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INTRODUCTION

The Middle Ordovician polymictic conglomerates of the Southern Appalachians are an important record of the early tectonic history of the Blue Ridge and Appalachian miogeosyncline. The Middle Ordovician conglomerates of the Southern Appalachians are located northwest of the Blue Ridge structural front and occur locally from Fincastle, Virginia to Cisco, Georgia. Most of the conglomerates are situated stratigraphically above the Athens Shale in the Tellico Sandstone (Kellberg and Grant, 1956). The conglomerates near Holston Dam and Greenville, Tennessee, are well above the base of the Tellico Sandstone, while those near Douglas Reservoir and Etowah, Tennessee, and Cisco, Georgia, occur at the base of the Tellico Sandstone (Kellberg and Grant, 1956). Tyler (1960) described conglomerates near Abingdon, Virginia, which occur high in the Knobs formation in the Pine Hills syncline. The Knobs formation is stratigraphically equivalent to the Athens Shale (Cooper, 1961).

The conglomerates, with the exception of the Fincastle conglomerate, are comprised predominantly of carbonate clasts (Kellberg and Grant, 1956). The conglomerates are evidence of contemporaneous erosion on the Blue Ridge to the southeast during Middle Ordovician time (Andrews, 1952; Kellberg and Grant, 1956; Nichol, 1959; Cooper, 1960 and 1969; Tyler, 1960; McGuire, 1970; Tillman and Lowry, 1971 and 1973; Lowry and others, 1972; Lowry, 1974; and Karpa, 1974b). The Fincastle conglomerate is of special interest in providing evidence for exposed crystalline and metamorphic rocks in the source area, and in demonstrating great structural relief between the Fincastle area and the Blue Ridge anticlinorium in Middle Ordovician time (Lowry, 1974).

Previous work on the Fincastle conglomerate was limited to description and general comments on the outcrops along U.S. Route 220, north of Fincastle, Virginia. Cooper (1960, p. 39) states that credit for the discovery of the Fincastle conglomerate belongs to M. H. Stow, but the first description of the conglomerate was by Woodward (1936a, p. 135). Other descriptions of the Fincastle conglomerate include those by Stow and Bierer (1937), Butts (1940), Andrews (1952), Decker (1952), Kellberg and Grant (1956), Nichol (1959), Cooper (1960 and 1969), McGuire (1970), Tillman and Lowry (1971 and 1973), Lowry and others (1972), Lowry (1974) and Karpa (1974b). Most of the information about Stow and Bierer's (1937) study is given in a summary of their paper by Butts (1940, p. 159), as their abstract was not published in the Virginia Academy of Science Procedures for 1937.

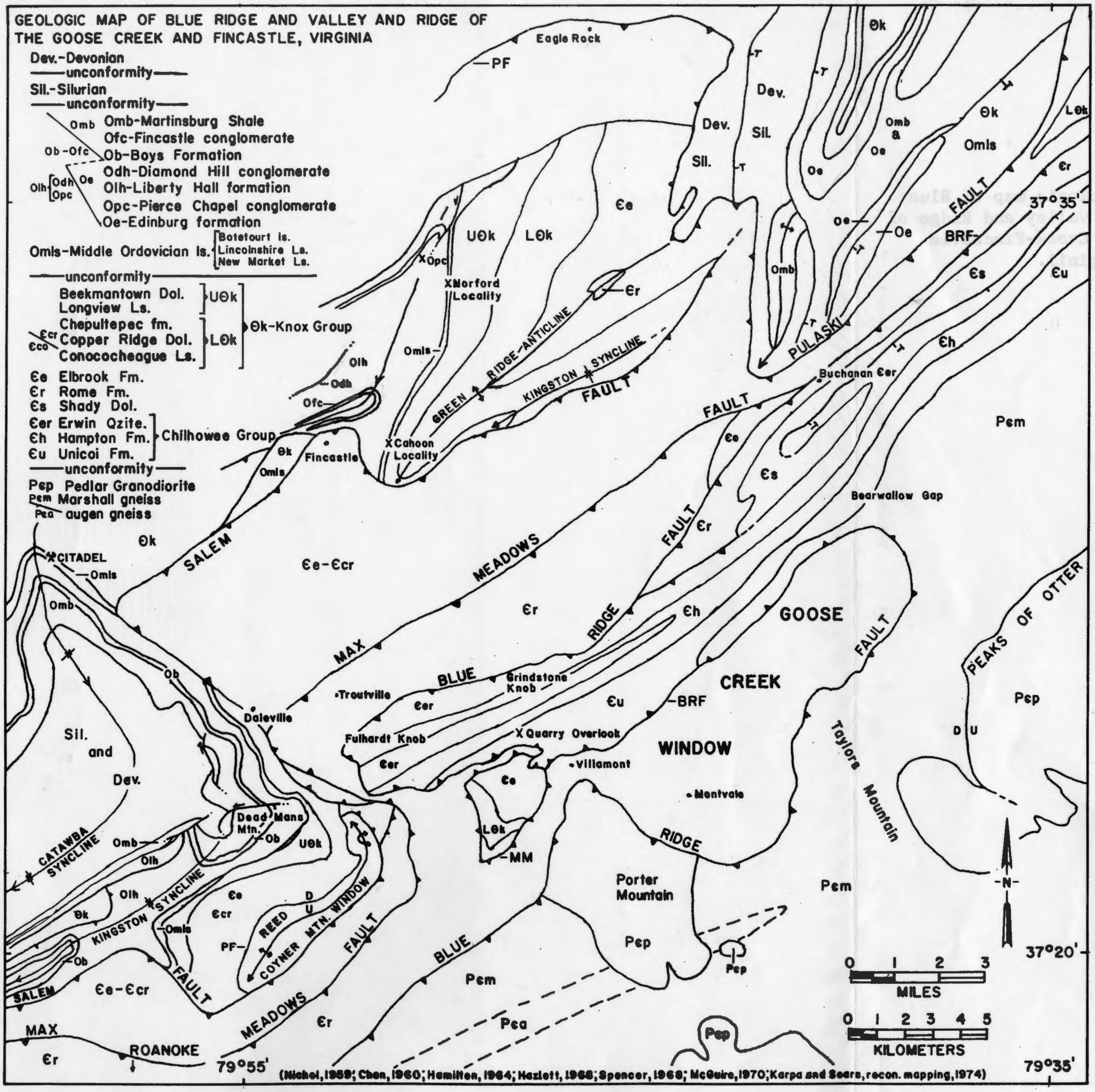
The writer appreciates the constructive criticism of his committee members: R. K. Bambach, L. Glover III, and C. G. Tillman. He also appreciates the interest and suggestions of J. F. Read. The writer is particularly indebted to W. D. Lowry for his encouragement during the investigation and writing of the paper, his lengthy discussions with the writer, and his helpful criticism of the manuscript. The writer gratefully acknowledges financial support from Sigma Xi and the Department of Geological Sciences at Virginia Polytechnic Institute and State University.

STRUCTURAL SETTING OF GOOSE CREEK-FINCASTLE AREA

Because the Fincastle conglomerate is polymictic and contains clasts derived both within the basin and from the Goose Creek area, it is important to understand both the structure of the area as it is now and the way it was in early Paleozoic time. The Fincastle conglomerate is the result of early Paleozoic tectonism within what is now the Blue Ridge and Valley and Ridge Provinces. An understanding of the tectonic history is essential to understanding the development of the depositional history of the Fincastle conglomerate.

The Fincastle area is near the northeastern end of a salient of the Pulaski overthrust belt, just south of the less faulted Central Appalachians (Fig. 1). The Goose Creek-Fincastle area consists mainly of three allochthonous structural blocks, which from southeast to northwest are the Blue Ridge, Max Meadows and Pulaski thrust sheets. The Max Meadows and the less important Salem thrusts are lesser and younger splays of the master Pulaski fault surface (Lowry, 1964, 1971a and c; and Hazlett, 1968).

The root zone of the Pulaski fault is southeast of the Read-Coyner Mountain window (Fig. 1); thus the minimum horizontal displacement is 14 mi (22.5 km). The Salem synclinorium, which comprises all of the Pulaski thrust sheet, has been thrust northwestward onto the Blacksburg synclinorium, the downwarp northwest of the Read-Coyner Mountain anticline. The Salem synclinorium consists of three major folds. From southeast to northwest these are the Kingston syncline, the Green Ridge anticline, and the Catawba syncline, the major downwarp. The sinuous


GEOLOGIC MAP OF BLUE RIDGE AND VALLEY AND RIDGE OF THE GOOSE CREEK AND FINCASTLE, VIRGINIA
Dev.-Devonian
unconformity
Sil.-Silurian
unconformity
Omb-Martinsburg Shale
Ofc-Fincastle conglomerate
Ob-Boys Formation
Odh-Diamond Hill conglomerate
Olh-Liberty Hall formation
Opc-Pierce Chapel conglomerate
Oe-Edinburg formation
Omls-Middle Ordovician ls.
Botetourt ls.
Lincolnshire Ls.
New Market Ls.
unconformity
Beekmantown Dol.
Longview Ls.
UΘk
Chepultepec fm.
Copper Ridge Dol.
Conococheague Ls.
LΘk
Θk-Knox Group
Єe Elbrook Fm.
Єr Rome Fm.
Єs Shady Dol.
Єer Erwin Qzite.
Єh Hampton Fm.
Єu Unicoi Fm.
Chilhowee Group
unconformity
Pep Pedlar Granodiorite
Pem Marshall gneiss
Pea augen gneiss
Eagle Rock
PF
Dev.
Sil.
Θk
Omb
Omls
LΘk
37°35'
BRF
Єs
Єu
Єh
Pem
UΘk
XOpc
XNorford Locality
GREEN RIDGE ANTICLINE
KINGSTON SYNCLINE
FAULT
PULASKI
FAULT
Buchanan Єer
XCahoon Locality
Fincastle
Bearwallow Gap
SALEM
MEADOWS
Єe-Єcr
XCITADEL
MAX
BLUE
RIDGE
GOOSE
CREEK
WINDOW
FAULT
PEAKS OF OTTER
Grindstone Knob
Troutville
Daleville
Fulhardt Knob
X Quarry Overlook
Villamont
Montvale
Taylors Mountain
Sil. and Dev.
Dead Mans Mtn.
CATAWBA SYNCLINE
KINGSTON SYNCLINE
REED COYNER MTN. WINDOW
MM
Porter Mountain
Pep
N
37°20'
0 1 2 3
MILES
0 1 2 3 4 5
KILOMETERS
ROANOKE
79°55'
79°35'
(Nichol, 1959; Chen, 1960; Hamilton, 1964; Hazlett, 1968; Spencer, 1968; McGuire, 1970; Karpa and Sears, recon. mapping, 1974)

EXPLANATION

MISSISSIPPIAN SYSTEM
Mp - Price Fm.

DEVONIAN SYSTEM
Dch - Chemung Fm.
Db - Brallier Fm.
Dnm - Millboro and Lower Devonian Fms.

-- unconformity --------

SILURIAN SYSTEM
Ss - Silurian sss.

-- unconformity --------

ORDOVICIAN SYSTEM
Omb - Martinsburg Shale
Ob - Bays-Moccasin Fm.
Olh - Liberty Hall fm. and Middle Ordovician limestones

-- unconformity --------

CAMBRO-ORDOVICIAN
Ꞓk - Knox Group (Lower Ordovician and Upper Cambrian carbonates)
Ꞓr - Rome Fm.
Ꞓs - Shady Dolomite
Ꞓbq - Lower Cambrian quartzites

-- unconformity --------

PreꞒ - Precambrian metamorphic rocks

Fig. 2-Geologic map of the Salem synclinorium (modified after Butts, 1933 and Tillman and Lowry, 1971).

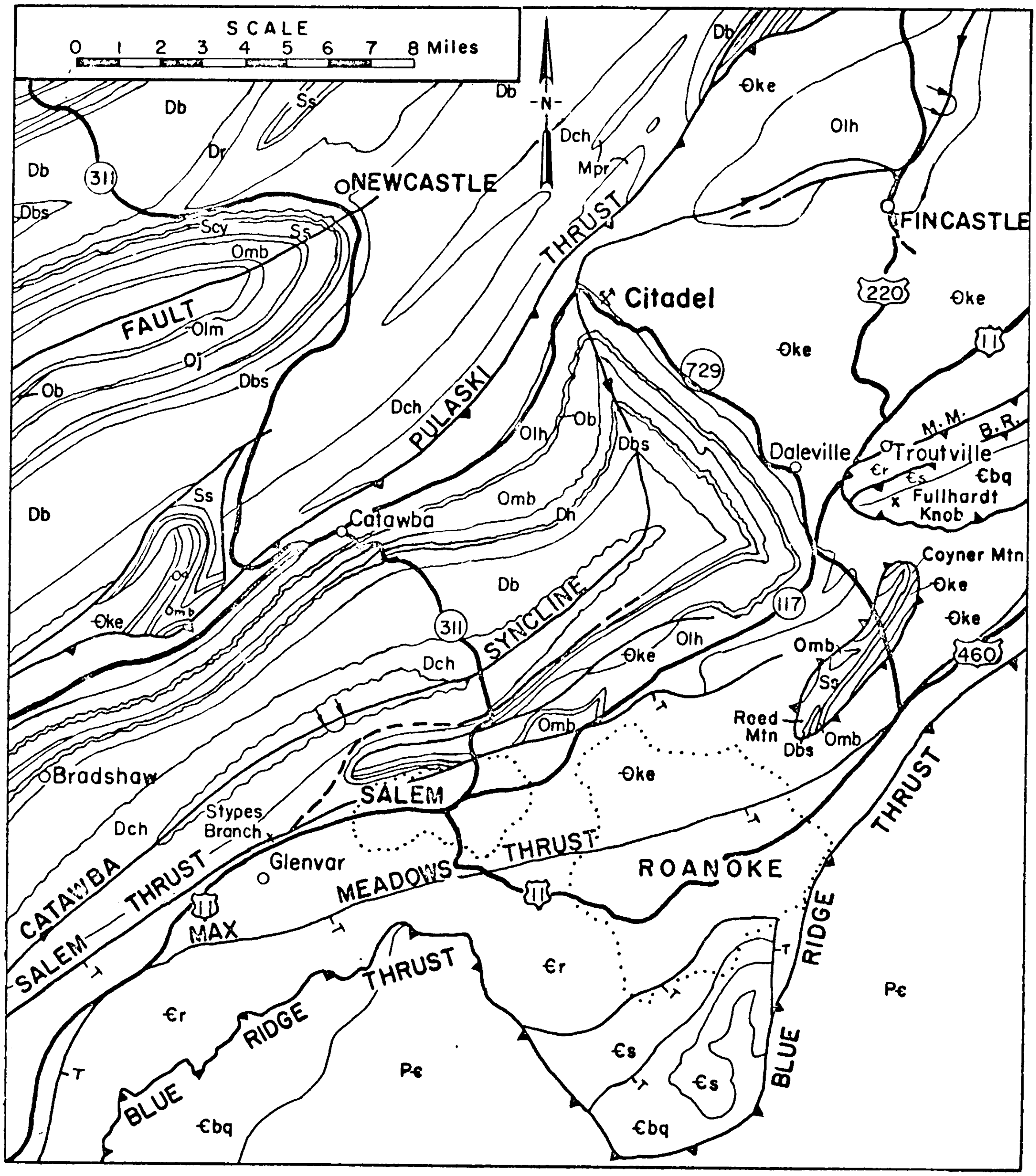


Fig. 2-Geologic Map of the Salem synclinorium (modified after Butts, 1933 and Tillman and Lowry, 1971).

axis of the Catawba syncline has a culmination and two depressions (Fig. 2). The culmination is just north of the Citadel Cement Company quarry; the major depression lies to the southwest where rocks as young as Lower Mississippian conglomerate and coal-bearing sandstone are preserved low on the southeast slope of Fort Lewis Mountain northwest of Roanoke (Campbell, 1925; Amato, 1968; and Murphy, 1968). The northeastern depression of the Catawba syncline, north of Fincastle, is known as the Pine Hills depression. The youngest rocks preserved in this part of the Salem synclinorium are Middle Ordovician shale overlying the Fincastle conglomerate. At the northeastern end of the Pine Hills the axis bends sharply to the north and plunges 7 to 11 degrees to the southwest. The Green Ridge anticline and Kingston syncline are preserved east of the Pine Hills (Fig. 1). The oldest exposed formation in the Salem synclinorium, the Rome Formation, is along the crest of the Green Ridge anticline.

Originally the rocks of the Salem and Max Meadows fault blocks were part of the southeast limb of the Salem synclinorium, or the complementary northwest limb of the Blue Ridge anticlinorium, The Salem fault is a reactivation of the older Pulaski fault (Hazlett, 1968; Lowry, 1964, 1971a and c) which surfaces again on the southeast side of the Read-Coyner Mountain window (Hazlett, 1968). Commonly the Salem thrust sheet is composed of Elbrook and lower Knox Group rocks. The salient of the Salem fault is north of Fincastle and is coincident with the axis and salient of the Salem synclinorium. The Salem fault throws Elbrook, Knox, and younger carbonates northwest over Ordovician strata of the southeast limb of the Catawba syncline in the Fincastle area. Northwest of Buchanan the Salem fault loses displacement in the Elbrook Formation and terminates before reaching the Central Appalachians (Fig. 1).

The Max Meadows thrust sheet is composed predominantly and in most places wholly of the shales and lesser carbonates of the Rome Formation, which underlie the valley of Goose Creek (Chen, 1960; and Hazlett, 1968). The minimum horizontal displacement of the Max Meadows fault in the Goose Creek area is 6 mi (9.6 km). The trace of the Max Meadows fault south of the Central Appalachians probably merges with the Blue Ridge fault southwest of Buchanan. Of the four major thrust faults of the overthrust belt, only two, the Pulaski and Blue Ridge thrusts, penetrate the Central Appalachians (Fig. 1).

The northwest part of the Blue Ridge thrust sheet is the overturned northwest limb of the Blue Ridge anticlinorium. The axis of the Blue Ridge anticlinorium is probably just southeast of Porter Mountain (Fig. 1); there the Marshall gneiss is strongly sheared and deformed (Chen, 1960; and Hamilton, 1964). The Blue Ridge thrust in the Goose Creek area is nearly horizontal (Chen, 1960) and has a minimum horizontal displacement of 7 mi (11.2 km); the root zone is southeast of the Goose Creek window.

In the Goose Creek area the Blue Ridge thrust sheet has been breached to expose the Rome Formation of the Max Meadows fault. Locally near Villamont, the Max Meadows fault has in turn been eroded through exposing the Cambrian and Ordovician carbonates of the Pulaski and Salem faults (Hazlett, 1968) (Fig. 1). The age of the rocks comprising the thrust sheets are older to the southeast. If the overthrust sheets are piled one on the other, it would make up a complete stratigraphic column from the Precambrian to the Mississippian (Lowry, 1964 and 1971a). Prior to overthrusting the positions of the major folds from southeast to northwest were: Blue Ridge anticlinorium, Salem synclinorium, Read-Coyner Mountain anticline, and Blacksburg synclinorium. If the major folds of the Goose Creek-Fincastle area are repositioned prior to overthrusting, the minimum horizontal distance between the crest of the Blue Ridge anticlinorium and the trough of the Pine Hills depression is approximately 31 mi (49.9 km).

The structure of the Goose Creek-Fincastle area is discussed in more detail by Hayes (1891), Butts (1933 and 1940), Edwards (1959), Nichol (1959), Chen (1960), Lowry (1971a), Eubank (1967), Amato (1968), Hazlett (1968), Spencer (1968), Tillman and Lowry (1968 and 1971), and McGuire (1970).

REGIONAL STRATIGRAPHY OF GOOSE CREEK-FINCASTLE AREA

Near the boundary of the Southern and Central Appalachians, the Cambrian and Ordovician stratigraphy is complex because of many facies changes along and across strike. The stratigraphy of the Goose Creek-Fincastle area is generalized in Table I. As shown, the Fincastle conglomerate is considered the most northeasterly facies of the Bays Formation.

Table I

Regional stratigraphy of the Goose Creek-Fincastle area.

ORDOVICIAN

Martinsburg Shale
In the Fincastle area: gray to dark gray shales, brown siltstones, and gray to dark gray, thin-bedded, calcareous shale and pelite. Fincastle area, 771 ft, top eroded; Salem synclinorium, commonly 1000 to 1600 ft (Nichol, 1959; Hazlett, 1968; and Tillman and Lowry, 1971).

Bays Formation
Restricted to Southern Appalachians. Depending on the structural block; fine- to coarse-grained sandstones, subgraywackes, and siltstones and interbeds of shale; locally a vein-quartz pebble conglomerate at base; bentonites in both lower and upper part. Commonly about 150 ft thick (Hergenroder, 1966); 82 ft near Stypes Branch (Edwards, 1959); 410 ft south of Daleville.

Fincastle conglomerate facies of the Bays Formation
Several zones of massively bedded, polymictic pebble to boulder conglomerate in a graywacke matrix. Commonly grades up into thin- to thick-bedded, coarse- to fine-grained graywacke or diamictite followed by siltstone and shale. Northeastern equivalent of the Bays Formation to the southwest. Mostly 48 to 69 ft thick; maximum 302 ft in Big Gulch; absent where it fines to siltstone and shale to the southwest (McGuire, 1970).

Liberty Hall (Athens) formation
Lateral equivalent of the Edinburg formation of the Central Appalachians. Dark gray to black, thin-bedded, graptolite-bearing shale and siltstone; locally dark gray, silty or argillaceous limestones. In the Fincastle area contains the Pierce Chapel, Diamond Hill and Pine Hills conglomerate members, comprised of limestone conglomerates and calcarenites. Fincastle area, 2000 ft thick; commonly 900 to 1600 ft (Woodward, 1936a; Butts, 1940; and Hazlett, 1968).

Edinburg formation
Lateral equivalent of the Liberty Hall of the Southern Appalachians. Dense, dark gray to black, thin-bedded, fine-grained limestones and calcarenites, which may have black shale partings. In Central Appalachians northwest of the Purgatory Mountain anticline, 556 ft thick (Cooper and Cooper, 1946) to 1000 ft (Spencer, 1968).

Table I (con't)

ORDOVICIAN

MIDDLE ORDOVICIAN LIMESTONES

Botetourt limestone
Gray, massive-bedded, coarse-grained calcarenite. Commonly 3 to 29 ft thick (Eubank, 1967); Citadel quarry, 600 ft (Cooper, 1944 and 1960; Nichol, 1959; and Hazlett, 1968); Stypes Branch, 10 to 16 ft (Edwards, 1959; and Tillman and Lowry, 1968).

Lincolnshire Limestone
Dark blue to gray, medium- to thick-bedded, medium-grained limestone with black chert nodules. Fincastle area, 40 to 174 ft thick (Edmundson, 1958; and McGuire, 1970); adjacent Central Appalachians, 206 to 410 ft (Edmundson, 1958).

New Market Limestone
Gray, massive-bedded, micritic limestone with birdseye texture; basal part commonly has coarse, angular breccia with clasts of dolomite, limestone and chert. Fincastle area, 0 to 160 ft thick (J.K. Campbell, oral communication, 1974); adjacent Central Appalachians, 82 to 225 ft (Edmundson, 1958; and Spencer, 1968).

---------------------- unconformity ----------------------------

KNOX GROUP

Beekmantown Dolomite and Longview Limestone
Medium gray, thick- to massive-bedded dolomite with white chert beds and lenses, and blue-gray, fine-grained limestone much like the Conococheague Limestone. Fincastle area, 1200 ft thick (Butts, 1940; and McGuire, 1970); Central Appalachians, 1500 ft (Edmundson, 1958).

Chepultepec formation
Dark blue-gray, medium- to fine-grained limestone alternating with dolomite; limestones contain intraformational limestone conglomerates and black chert. Fincastle area, Chepultepec and Conococheague 1200 ft thick (McGuire, 1970); Central Appalachians, 456 ft (Edmundson, 1958; and Dumper, 1972).

CAMBRIAN

Conococheague Limestone
Lateral equivalent of the Copper Ridge. Mostly blue to dark blue gray limestone and quartzose limestone with common intraformational limestone conglomerates; dominant in the lower part are thin beds of dolomite, shale, impure limestone, sandy dolomite, and medium- to coarse-grained sandstone. Goose Creek area, 1500 ft thick (Chen, 1960); Central Appalachians, 2100 ft (Edmundson, 1958).

Table I (con't)

CAMBRIAN	KNOX GROUP	**Copper Ridge Dolomite** Lateral equivalent of the Conococheague. Light to dark gray, medium- to thick-bedded, fine- to medium-grained dolomite with some dark gray shale partings, white chert nodules and intraformational limestone conglomerates. Upper part: alternating limestone and dolomite. Lower part: Coarse-grained, quartzose sandstone. Fincastle area, 1100 ft thick (Hazlett, 1968; and McGuire, 1970).
		Elbrook Formation Upper part: predominantly blue-gray, thick-bedded dolomite and light gray limestone with stromatolites, intraformational limestone conglomerates and fine- to medium-grained sandstone lenses. Lower part: thin-bedded, shaly dolomite and limestone and gray shales. Fincastle area, 2000 to 2500 ft thick (McGuire, 1970); Central Appalachians, 1000 to 2000 ft (Spencer, 1968).
		Rome Formation Valley and Ridge facies: maroon and green, thin-bedded shales with less than 10 percent blue-gray, fine-grained, impure limestone and dolomite. Goose Creek area, 2000 ft thick (Hazlett, 1968). Blue Ridge facies: greater than 40 percent impure limestone and dolomite (similar to that of the Elbrook and Shady), and red, purple, green, and gray, thin-bedded shales and siltstones and interbedded sandstone lenses. East of Buchanan, 2000 ft thick (Butts, 1940; and Chen, 1960).
		Shady Dolomite Dark blue, coarse-grained, impure dolomite. Middle part is a white, fine- to medium-grained, pure dolomite. Southeast of Buchanan, 1500 ft thick (Butts, 1940; and Spencer, 1968).
	CHILHOWEE GROUP	**Erwin Quartzite** Poorly sorted, thin-bedded, silty sandstone with few occurrences of Scolithus; interbeds of siltstone and shale are common. Bearwallow Gap, 1100 ft thick (Chen, 1960); Grindstone Knob, at least 2000 ft (Chen, 1960).
		Hampton Formation Thin-bedded, sandy shale, shale, siltstone, and subgraywacke with irregular sandstone lenses and quartzite interbeds. Goose Creek area, 1200 ft thick (Chen, 1960).

Table I (con't)

CAMBRIAN(?)	CHILHOWEE GROUP	**Unicoi Formation** Primarily sandy shale, siltstone, quartzite, arkosic sandstone lenses, graywacke, subgraywacke, and oligomictic vein-quartz pebble conglomerate lenses. Goose Creek area, 2000 ft thick (Chen, 1960; and Cooper, 1960).
		---------------------- unconformity ----------------------
PRECAMBRIAN		**Marshall gneiss** Metasediment, fine- to coarse-grained biotite-quartz-feldspar, garnetiferous and sericitic quartz-feldspar gneiss. Scattered, discontinuous lenses of medium- to coarse-grained quartz-feldspar and quartzose augen gneiss, perhaps pebble conglomerate lenses. Pedlar Hypersthene Granodiorite: intrusive into the Marshall gneiss. Metaigneous, fine- to medium-grained gneissic granodiorite, equigranular hypersthene granodiorite, and porphyritic hypersthene granodiorite.

STRATIGRAPHY OF PINE HILLS DEPRESSION OF THE CATAWBA SYNCLINE

The Fincastle conglomerate is restricted to the trough of the northeastern depression of the Catawba syncline - the Pine Hills depression (Figs. 1 and 2). It lies between the shales of the Liberty Hall formation and lithologically similar shales, which herein are assigned to the Martinsburg Shale. The Liberty Hall formation contains three limestone conglomerate members - Pierce Chapel, Diamond Hill, and Pine Hills conglomerates (Figs. 1 and 4). The limestone conglomerates are comprised of several zones of conglomerates interbedded with noncalcareous shale of the Liberty Hall formation.

The Liberty Hall formation was named by Campbell (1905) from exposures near Lexington, Rockbridge County, Virginia. Cooper (1960 and 1969) first assigned the shales overlying the Middle Ordovician limestones in the Pine Hills depression to the Liberty Hall formation. Earlier Woodward (1936a), Butts (1940), Decker (1952), and Kellberg and Grant (1956) referred the shales to the Athens. The Athens Shale was named by Hayes (1894) for exposures at Athens, McMinn County, Tennessee. The Liberty Hall formation is restricted to southeastern strike belts and normally consists of dark brown to black, thin-bedded shales and siltstones and minor interbedded gray, fine-grained, limy mudstones. The Liberty Hall thins and becomes progressively more limy to the northwest. In more northwesterly strike belts its equivalent is nearly all limestone. In the Fincastle area the Liberty Hall formation is more than 2000 ft (609 m) thick and comprised of gray to black, thin-bedded siltstone and shale with little associated limestone. Its noncalcareous nature and abnormal thickness indicate a local depocenter.

In the Fincastle area approximately 300 ft (91 m) above the base occurs the Pierce Chapel conglomerate (McGuire, 1970), and about 1000 ft (305 m) above the base lies the Diamond Hill conglomerate (Lowry and others, 1972; and Lowry, 1974) (Fig. 1). Both are limestone conglomerates composed predominantly of subangular to subrounded clasts of dark gray to black, fine-grained limestone and minor calcarenites. The Pierce Chapel conglomerate is made up of two or more zones of conglomerate in a 100-ft (30-m) section which includes interbedded calcarenites and black shales (Lowry, 1974). The Diamond Hill conglomerate has 13 to 15 conglomerate zones and is about 80 ft (24 m) thick (Lowry and others, 1972; and Lowry, 1974). Between the conglomerate zones are graptolite-bearing black shales and calcareous shales with bryozoans (Prasopora), which apparently are whole and in living position. Fragments of trilobites, crinoids, and brachiopods also occur in the calcareous shale. Much higher in the section and approximately 1630 ft (497 m) above the base of the Liberty Hall and 381 ft (116 m) below the Fincastle conglomerate is a thin bentonite bed (Fig. 4). The bentonite contains euhedral apatite, biotite, sericite after biotite, quartz, K-feldspar, and minor euhedral zircons. Other bentonites may be present as much of the underlying and overlying section is not exposed. Elsewhere in the Salem synclinorium bentonites are known to occur only in the Bays Formation (Hergenroder, 1966).

Above the bentonite in the Liberty Hall formation and approximately 1900 ft (579 m) above the base of the Liberty Hall and 79 ft (24 m) below the Fincastle conglomerate is the Pine Hills conglomerate. On the southeast limb of the Catawba syncline and 23 ft (7 m) below the Fincastle conglomerate is a 1- to 2-ft (30- to 60-cm) bed of dark blue-gray, thin-bedded, fine-grained, silty limestone (Geologic Section 15, Fig. 4). Southwest of U.S. Route 220, the same limestone bed contains a limestone conglomerate with clasts of the same lithology as the enclosing limestone (Geologic Section 16, Fig. 4). These limestone beds may be part of the Pine Hills conglomerate.

The Fincastle conglomerate lies 79 ft (24 m) stratigraphically above the Pine Hills conglomerate (Geologic Section 1, Fig. 4) and approximately 2000 ft (609 m) above the base of the Liberty Hall shale. It consists of repeated sequences of polymictic conglomerate and graywacke. The conglomerates contain clasts which range in age from Precambrian, derived from the Blue Ridge anticlinorium, to Middle Orodvician, derived from within the basin. The conglomerate is absent to the southwest where it has fined to siltstone and shale (McGuire, 1970). The maximum thickness of the Fincastle conglomerate is 302 ft (92 m) where it is well developed on the northwest limb of the Catawba syncline at Big Gulch (Geologic Section 11, Fig. 4). Elsewhere the thickness of the Fincastle conglomerates ranges from 48 to 150 ft (14 to 45 m), and southwest of U.S. Route 220 where the conglomerate has fined to graywacke, the thickness is 130 ft (39 m) (Geologic Sections 17 and 20, Fig. 4).

Overlying the Fincastle conglomerate is a 771-ft (235-m) section of shales, siltstones, and gray to dark gray, thin-bedded, calcareous shale and pelite lithologically similar to both the underlying Liberty Hall formation and to the Martinsburg Shale. This sequence above the Fincastle conglomerate is believed to be a less limy equivalent of the lower Martinsburg. A fauna in this shale 2 ft (1 m) above the Fincastle conglomerate in the overturned southeastern limb of the Catawba syncline was recently collected. The brachiopod Sowerbyella cava, identified by G. A. Cooper (written communication to W. D. Lowry, 1974), indicates the shales overlying the Fincastle conglomerate may be Martinsburg in age and are tentatively assigned to the Martinsburg Shale. In the southwestern depression of the Catawba syncline the lower Martinsburg is comprised of shales and interbedded fossiliferous limestones. The top of the Martinsburg Shale in the Pine Hills depression has been eroded.

PINE HILLS CONGLOMERATE

The youngest and most significant of the conglomerates in the Liberty Hall formation in regard to the depositional history of the Fincastle area is the Pine Hills conglomerate, which crops out at the base of the northeast slope of the Pine HIlls on the southeast limb of the Catawba syncline (Fig. 4). It is especially significant in that it contains dark, fine-grained limestone clasts like those in the older Pierce Chapel and Diamond Hill conglomerates and sandstone lithologically similar to the graywacke in the Fincastle conglomerate.

The composition of the Pine Hills conglomerate implies that the source direction of the clasts in the limestone conglomerates is the same as that of the sand and gravels of the Fincastle conglomerate.

Type Locality

The type locality of the Pine Hills conglomerate member of the Liberty Hall formation is 1350 ft (411 m) N. 84° W. of the point where Virginia State Route 681 crosses Catawba Creek, Salisbury quadrangle (Fig. 4, Geologic Section 1). At the type locality the conglomerate, which occurs 79 ft (24 m) below the base of the Fincastle conglomerate, is 25 ft (7.6 m) thick. Along strike to the southwest at Geologic Section 6 the uppermost bed of the conglomerate member (sample Fc 75) lies 28 ft (8.5 m) below the base of the Fincastle conglomerate.

Lithology

The Pine Hills conglomerate interval is comprised of interbedded limestone conglomerates, calcarenites, sandy calcarenites, graywackes, siltstones, calcareous shales, and shales (Fig. 3, Geologic Sections 1 and 2). The limestone conglomerates and calcarenites thin, change grain size, and pinch out rapidly along strike. The calcarenites are dark blue-gray and fine- to coarse-grained, and consist of granules and cobbles of limestone and variable amounts of fossil detritus (brachiopods, trilobites, bryozoans, cephalopods, echnioderms, and crinoids). Generally the calcarenites are conglomeratic with the amount and size of limestone clasts differing within and between beds.

The limestone conglomerates are predominantly granule and small

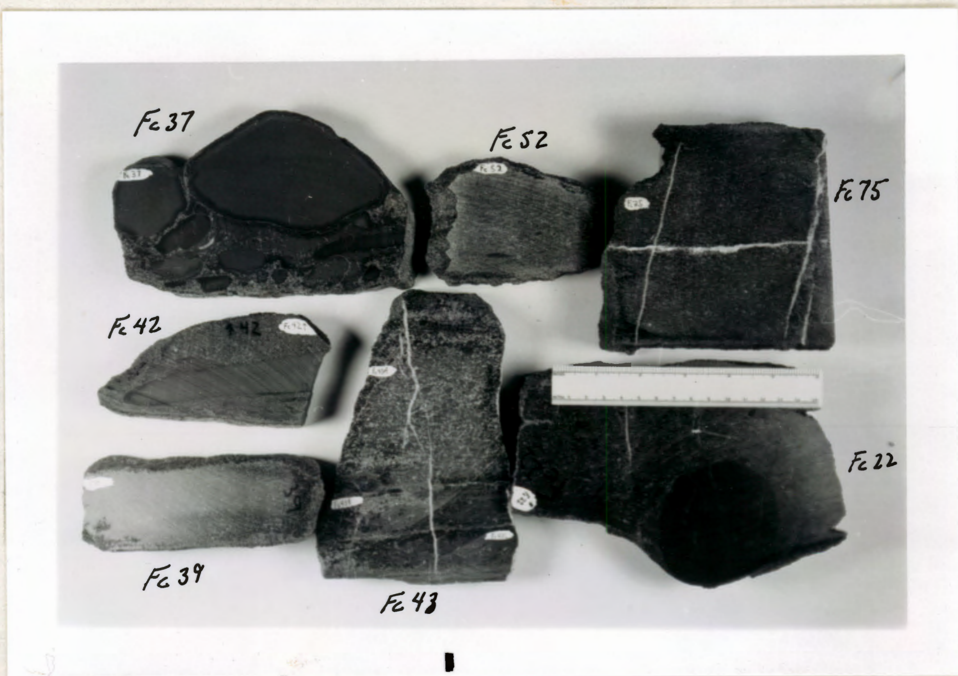


Fig. 3-Samples of the Pine Hills conglomerate.

pebble conglomerates with a matrix of calcarenite and micrite. Two cobble limestone conglomerate beds are comprised of flat, elongate limestone clasts as much as 12 in (30.5 cm) long in a granule and calcarenitic matrix (Fig. 3, units 10 and 18 of Geologic Section 1). Most limestone clasts are subrounded to rounded, but a few are well rounded. Along strike most of the limestone conglomerates lose their conglomeratic character and become a calcarenite which, lithologically and petrographically, is like the matrix of the limestone conglomerates. The clasts are dark gray to black, fine-grained limestones petrographically and lithologically similar to clasts in the Pierce Chapel and Diamond Hill conglomerates.

The graywackes of the Pine Hills conglomerate are fine- to medium-grained and less than 1.5 in (3.8 cm) thick; they consist mostly of quartz and plagioclase grains. The percentage of matrix is commonly higher than in the graywackes associated with the Fincastle conglomerate. The siltstones, calcareous shales, and shales are lithologically similar to the Liberty Hall sediments of the Fincastle area.

Petrography

Sample Fc 43 (Fig. 3) is a granule to pebble limestone conglomerate with subrounded to rounded limestone clasts as much as 1 cm in diameter. The limestone clasts are black, fine-grained micrite, pelletal limestone, and fragments of brachiopods and bryozoans. The pelletal limestone clasts consist of micrite pellets in a calcite and mud cement. Angular silt-size quartz grains in the pelletal limestone matrix range from 0 to about 20 percent, and pyrite from 0 to about 50 percent. The matrix of the rock consists predominantly of calcite and micrite cement, pyrite, quartz, and plagioclase (An 6-16; 14 counts) grains. The very angular quartz grains range from 0.5 to 1 mm in diameter. Diagenetic pyrite up to 1 mm in diameter is corroded by calcite. Some flamboidal pyrite is present. Within sample Fc 43 are layers of predominantly calcite-cemented, coarse-grained sandstone composed of quartz, plagioclase, minor chlorite, muscovite, and carbonate grains.

The coarser grained limestone conglomerates (samples Fc 22, 37, 42, and 46, Fig. 3) consist of flat and elongate, pebble- to cobble-size clasts of micrite, and granules and pebbles of pelletal limestone. The matrix ranges from a very fine- to coarse-grained, calcite-cemented graywacke to a calcarenitic, quartz-rich graywacke. The conglomerates consist of as much as 70 percent quartz and plagioclase (An 7-17; 10 counts) grains, 20 percent cement of calcite and micrite, and 10 to 90 percent clasts. The pelletal limestone consists of micrite pellets in a matrix of as much as 50 percent angular, silt-size quartz grains and various amounts of pyrite cemented by partially recrystallized micrite. The matrix of the conglomerate consists perdominantly of calcite and micrite cement, quartz, minor sericite, plagioclase, chlorite, muscovite up to 0.1 mm long, leucoxene, large grains of pyrite, and fossil detritus. The very angular to angular, very fine-grained to silt-size quartz grains are mainly supported by the calcite and micrite cement. Little or no overgrowths occur on the quartz grains, of which less than 2 percent are strained.

The highest calcarenite, sample Fc 75 (Fig. 3), is comprised of 90 percent or more fossil fragments and minor amounts of micrite and pelletal limestone clasts and a lesser amount of quartz grains. The matrix is almost entirely calcite and micrite cement.

Graywackes interbedded with the limestone conglomerates consist of poorly sorted, very fine- to medium-grained quartz grains, in part supported by the calcite and micrite matrix. The quartz grains are very angular, extensively corroded by the calcite or dolomite, and have few overgrowths. Quartz grains comprise approximately 60 percent of the rock and, of these, greater than 90 percent are strained. Corroded grains of plagioclase (An 4-13; 10 counts) are very angular and comprise less than 5 percent of the rock; grains of biotite, muscovite, chlorite, pyrite, and carbonate comprise about 5 percent. A matrix of micrite and calcite make up about 25 percent of the rock, and sericite, hematite, chlorite, and fine muscovite and biotite comprise about 5 percent.

The limestone beds below the Fincastle conglomerate on the southeast limb of the Catawba syncline (unit 1 of both Geologic Sections 15 and 16) consist of fine-grained micrite which is petrographically similar to the micrite in the Pine Hills conglomerate. Most of the micrite is cemented by calcite. The micrite contains minor pyrite, no fossils, and minor amounts of unstrained, angular, silt-size quartz grains.

Table II

Location and lithology of samples of the Pine Hills conglomerate (8 thin sections).

Sample Fc	Location Geologic Section	Unit	Lithology
22	2	3	limestone conglomerate to calcarenite
37	1	10	limestone conglomerate
39	1	12	calcarenite
42	1	18	limestone conglomerate
43	1	14	limestone conglomerate to graywacke
46	1	18	limestone conglomerate
52	2	3	calcarenite to limestone conglomerate
75	6	1	calcarenite

Provenance

Petrographically the Pine Hills conglomerate is transitional between the older Diamond Hill and younger Fincastle conglomerate. Clasts within the Pierce Chapel, Diamond Hill, and Pine Hills conglomerates are unusual in that their black, fine-grained, silty, micritic lithology is not typical of the Middle Ordovician limestones or older carbonates. C. G. Tillman (oral communication, 1974) and Lowry (1974) have shown that microfossils recovered from Diamond Hill clasts indicate that they represent essentially contemporaneous cannibalization of a limy Liberty Hall facies.

Lithologically and petrographically the limestone clasts of the three conglomerate members of the Liberty Hall formation are similar and were probably derived from the same source area. Angular quartz and plagioclase grains, and muscovite and biotite flakes in the limestone conglomerates are similar to those in the Fincastle conglomerate and probably were derived from the southeast, as that is the logical source of the sandstone and vein quartz clasts and graywacke of the Fincastle conglomerate. The limestone clasts may have originated in the vicinity of the Citadel quarry where the lower part of the Liberty Hall is limy, but the derivation of quartz and other detrital grains would be difficult to explain. The derivation of the quartz and other detrital grains from a northwestern source is improbable as the limestone facies of the Liberty Hall formation on the northwest is largely free of quartz grains. Also, as the quartz and plagioclase grains of the older Conococheague Limestone and Copper

Ridge Dolomite are well rounded, they are not a logical source of the sand in the Pine Hills conglomerate.

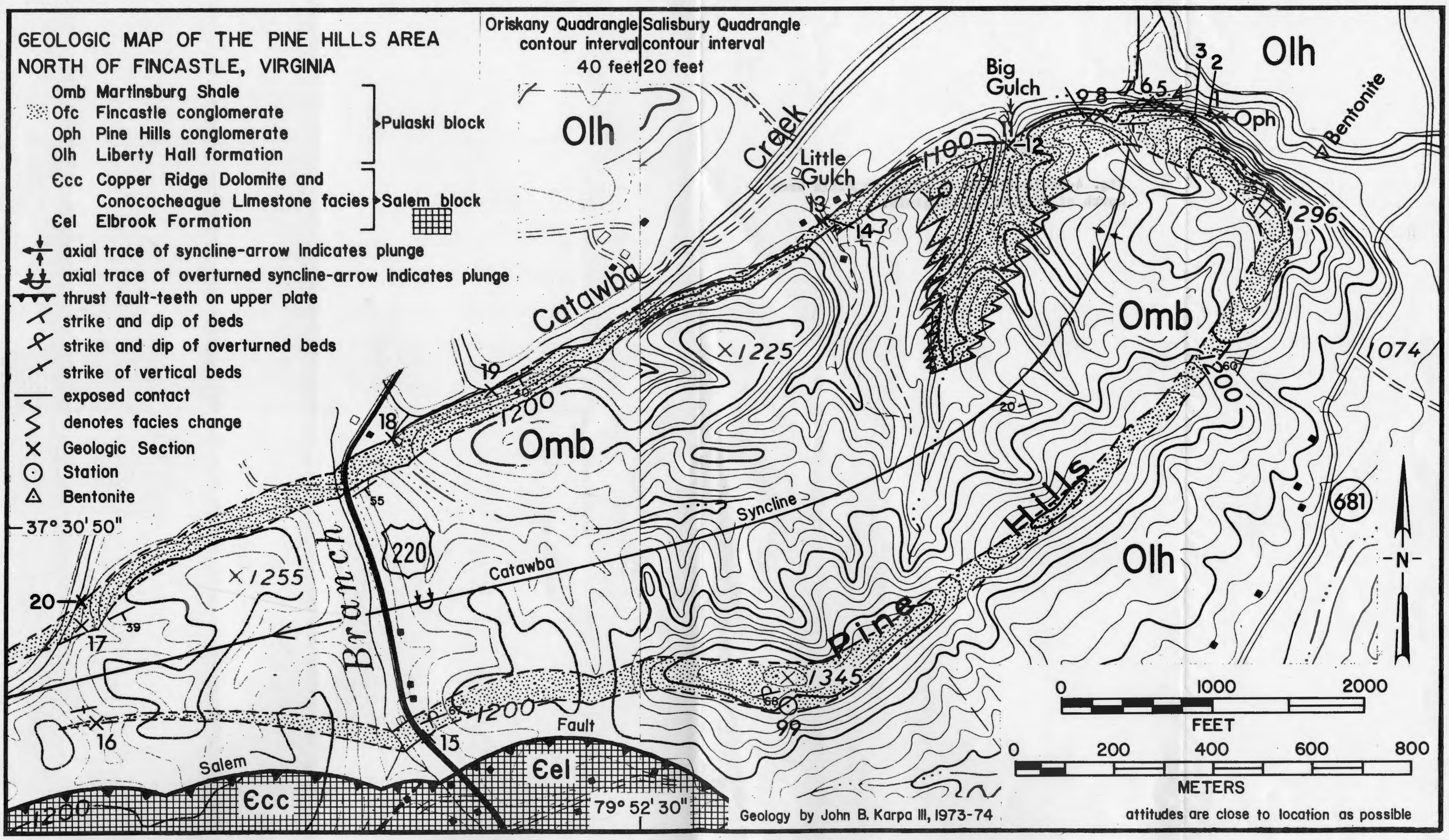
Channel geometry of the Diamond Hill conglomerate (Lowry, 1974) and the lenticular nature of the Pine Hills conglomerate indicate the limestone clasts were not deposited and later reworked _in situ_ by wave action. Lack of bioturbation and the sharp contact between the shale and overlying limestone conglomerates and calcarenites suggest that they were washed in.

The original site of deposition apparently was northwest of a positive source area of limestone and older units that was being eroded to furnish the quartz and other detritus. The Pine Hills conglomerate is viewed as being genetically related to the Fincastle conglomerate. It is the predecessor of the Fincastle conglomerate and a transitional deposit between Diamond Hill and Fincastle lithologies, and indicates a rising source area which furnished the bulk of the clasts in Fincastle time.

FINCASTLE CONGLOMERATE

Type Locality

The type locality (Geologic Section 15) of the Fincastle conglomerate is along U.S. Route 220, 0.6 mi (0.96 km) north of Fincastle, Oriskany and Salisburg quadrangles, Virginia (Fig. 4). However, better exposures occur on the northwest limb of the Catawba syncline along the northwest slope of the Pine Hills. The Fincastle conglomerate extends 1.7 mi (2.7 km) along strike. The southeast limb


GEOLOGIC MAP OF THE PINE HILLS AREA
NORTH OF FINCASTLE, VIRGINIA
Omb Martinsburg Shale
Ofc Fincastle conglomerate
Oph Pine Hills conglomerate
Olh Liberty Hall formation
Pulaski block
Ꞓcc Copper Ridge Dolomite and Conococheague Limestone facies
Ꞓel Elbrook Formation
Salem block
axial trace of syncline-arrow indicates plunge
axial trace of overturned syncline-arrow indicates plunge
thrust fault-teeth on upper plate
strike and dip of beds
strike and dip of overturned beds
strike of vertical beds
exposed contact
denotes facies change
Geologic Section
Station
Bentonite
Oriskany Quadrangle contour interval 40 feet
Salisbury Quadrangle contour interval 20 feet
37° 30' 50"
79° 52' 30"
Catawba Creek
Branch
Catawba Syncline
Pine Hills
Big Gulch
Little Gulch
Salem Fault
Bentonite
220
681
1225
1255
1345
1296
1074
1200
1100
FEET
0 1000 2000
METERS
0 200 400 600 800
N
Geology by John B. Karpa III, 1973-74
attitudes are close to location as possible

is cut off by the Salem fault (Fig. 4) whose position is indicated by a narrow, shallow valley along U.S. Route 220 and by rapids along the Town Branch of Catawba Creek. The outcrop pattern of the Fincastle conglomerate is U-shaped and open to the southwest. However, the southwestern nose of the Pine Hills depression may be the result of convergence of the graywacke and siltstone facies of the Fincastle conglomerate. Immediately southwest of U.S. Route 220 the Fincastle conglomerate does fine to graywacke (McGuire, 1970), which, in turn, rapidly grade into siltstone and shale. Weathering on the southeast limb has produced a deep residuum and the Fincastle crops out only at Station 99, and Geologic Sections 15 and 16 (Fig. 4).

Lithology

Terms used to describe the Fincastle conglomerate are defined so as to present as clear a picture as possible of the deposit. The terminology used in this report is given in Table III.

The Fincastle conglomerate is comprised of conglomerates (Fig. 5 and 6), diamictites, graywackes, siltstones, shales, and shaly mudstones. Altogether 20 geologic sections were measured and these are given in the Appendix. The lithology and relationships of those on the northwest limb are shown in Fig. 7. As shown by Fig. 7, lithology and thickness may change rapidly along strike. Likewise, sedimentary features, as well as their character, may change rapidly between outcrops.

The Fincastle conglomerate is comprised of three lithologic units: 1) conglomerate, 2) diamictite and graywacke, and 3) siltstone

Table III

Terminology.

Graywacke- a sandstone which consists of 15 percent or more interstitial matrix; comprised predominantly of quartz and feldspar and an assemblage of unstable minerals and sedimentary and metamorphic rock fragments (Krynine, 1948; Pettijohn, 1954, 1957 and 1960b; Boswell, 1960; and others).

Subgraywacke- consists of less than 15 percent interstitial matrix.

Diamictite (Flint and others, 1960a and b)- a conglomerate with an open framework fabric (clasts are matrix-supported); commonly contains clasts of many lithologies and sizes (nonsorted).

Intergradational- a layer of sediment which exhibits a graded or gradational contact with both the underlying and overlying beds.

Fig. 5-Typical weathered outcrop of the Fincastle conglomerate. Note the variety of sandstone and carbonate clasts.

Fig. 6-Unweathered samples of the Fincastle conglomerate. Sample Fc 85 occurs southwest of Geologic Section 18 where the conglomerate is becoming finer grained to the southwest. There most of the conglomerates are approaching a diamictite.

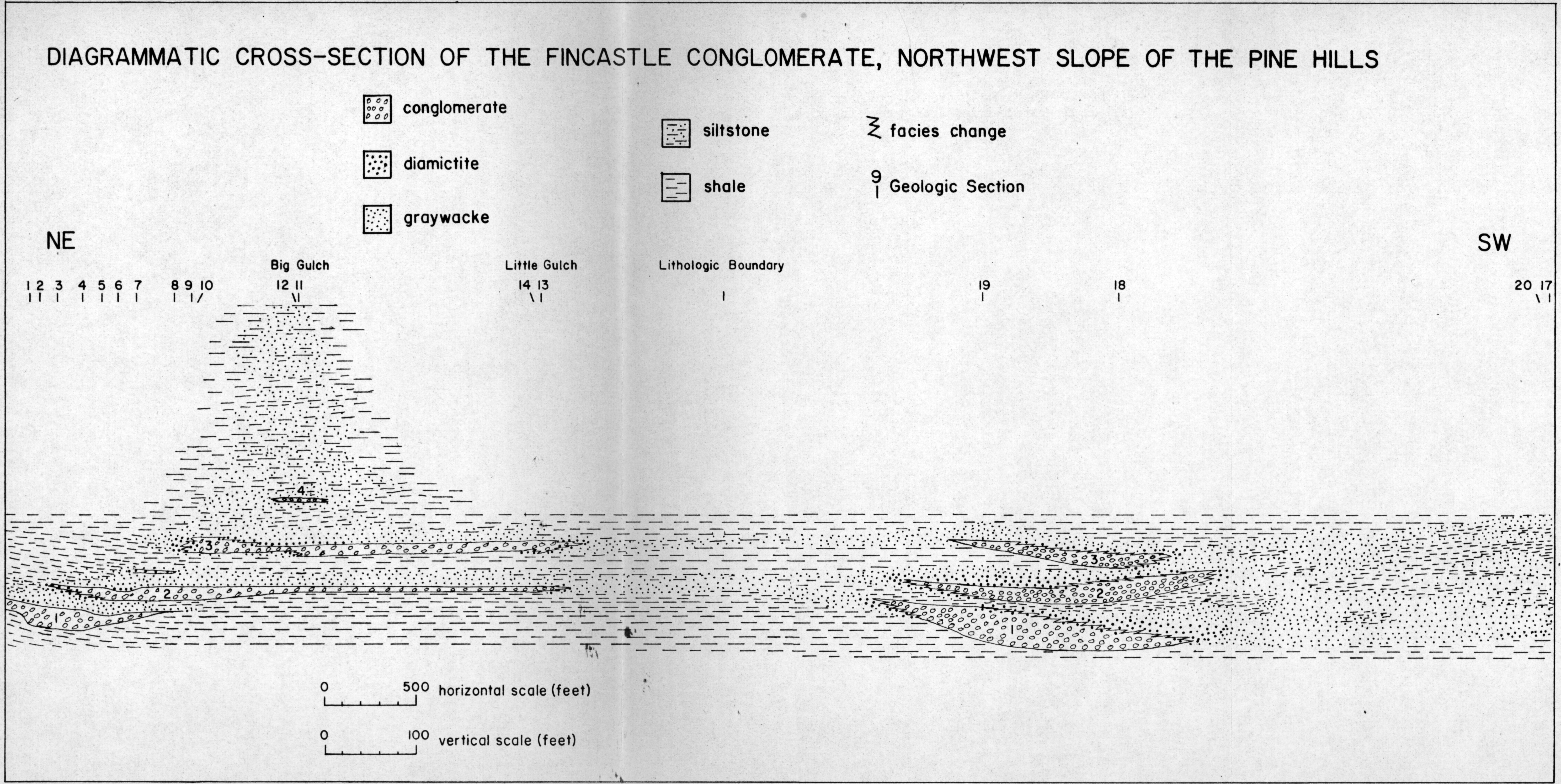
and shale. A complete depositional sequence is characterized by a bed of conglomerate which grades up into a diamictite, which, in turn, grades up into graywacke. This is well displayed at Geologic Sections 6 and 18 (Fig. 4). The graywacke may then grade up into interbedded siltstones and shales, if it is not overlain sharply by another conglomerate. There are at least four depositional sequences along the northwest limb. The four conglomerates, from oldest to youngest, are referred to as first conglomerate zone, second conglomerate zone, etc.

Conglomerate

Field Relations

A conglomerate zone commonly differs in thickness, lithologic sorting, and size of clasts along strike. Its lateral extent along strike is related to the volume of gravel introduced. The conglomerates thin and become finer grained along strike, whereas the graywacke and siltstone above the conglomerate usually thicken and, in turn, fine into shale and mudstone along strike until replaced by the next highest conglomerate zone.

At Station 99 (Fig. 4) on the southeast limb where the Fincastle conglomerate is at least 100 ft (30.5 m) thick, at least three conglomerate zones are poorly exposed. The younger conglomerates are apparently coarser with boulders of Unicoi sandstone as large as 14.5 X 8 in (37 X 20 cm). Along U.S. Route 220, both at Geologic Sections 15 and 18 (Fig. 4), the conglomerate zones contain many graywacke lenses. Most unusual at Geologic Section 18 is a very thick section of diamictite above the first and second conglomerates.



DIAGRAMMATIC CROSS-SECTION OF THE FINCASTLE CONGLOMERATE, NORTHWEST SLOPE OF THE PINE HILLS
conglomerate
diamictite
graywacke
siltstone
shale
facies change
Geologic Section
NE
SW
Big Gulch
Little Gulch
Lithologic Boundary
1 2 3 4 5 6 7 8 9 10 12 11 14 13 19 18 20 17
4
3
2
1
3
2
1
0 500 horizontal scale (feet)
0 100 vertical scale (feet)

Within a few hundred feet southwest of Geologic Section 18, the Fincastle conglomerate, for the most part, has graded into diamictite and graywacke. At Geologic Section 16 (Fig. 4) the Fincastle conglomerate has thinned to 16 ft (4.9 m) and is represented by a basal pebble conglomerate which is overlain by graywacke.

The major conglomerates along the northwest limb are the first and second conglomerates, an intermittent appearance of the third, and one outcrop of the fourth conglomerate (unit 11 of Geologic Section 11).

First conglomerate - Above Geologic Section 1 (Fig. 7) the first conglomerate thickens from 12 ft (3.6 m) to 23 ft (7 m) in less than 10 ft (3 m) along strike to the southwest. The first gravels apparently occupy a channel greater than 11 ft (3.3 m) deep in the Liberty Hall shale. The lower contact of all the conglomerates is commonly covered for long distances; thus the extent of scouring is unknown. The first conglomerate can be traced from Geologic Section 1 on the southeast limb to Geologic Section 8 on the northwest limb (Fig. 7). The maximum thickness of the first conglomerate ranges from 23 ft (7 m) above Geologic Section 1 to an exposed 2 ft (0.6 m) at Geologic Section 8. Above Geologic Section 1 the first conglomerate is a coarse pebble and cobble conglomerate which fines southwestward to a pebble and granule conglomerate at Geologic Section 8, and probably pinches out before reaching Big Gulch (Fig. 7). As the first conglomerate becomes fine grained and thinner to the southwest, there is no increase in the number of graywacke and siltstone lenses;

however, the graywacke separating the first and second conglomerates grades rapidly to siltstones and shales (Geologic Sections 5, 6, and 8). The most southwesterly known occurrence of the first conglomerate apparently has no gradational relationship with either the underlying shale or the overlying graywacke and siltstone. The southwest end of the first depositional sequence apparently terminates as a lens (Fig. 7).

Second conglomerate - The first appearance of the second conglomerate is at Geologic Section 3, where a very coarse-grained graywacke, in part diamictite 1 ft (30 cm) thick, lies 21 ft (6.4 m) above the first conglomerate (Fig. 7). The maximum thickness of the second conglomerate is 14.8 ft (4.5 m) at Geologic Section 9; from there the second conglomerate steadily thins to the southwest. At Little Gulch there are 4 to 5 ft (1.2 to 1.5 m) of second conglomerate (Geologic Sections 12 and 13), which probably grades to graywacke within 200 ft (61 m) to the southwest. Between Geologic Sections 6 and 7 the second conglomerate is abnormally thin as a result of a large channel cut into the conglomerate, which is filled with graywacke (Fig. 7). The second conglomerate zone contains the largest clast and is the most poorly sorted and variable of all the conglomerate zones. The thickness of graywacke and siltstone separating the first and second conglomerates remains fairly constant (about 20 ft; 6.1 m), where both conglomerate zones are well developed. As the first conglomerate thins, the second conglomerate thickens, and the thickness of graywacke separating the conglomerates decreases to 11 ft (3.3 m). This implies the second conglomerate thickens by the scouring of the underlying siltstone and shale. The second conglomerate becomes finer grained and thinner to both the southwest and northeast. Unlike the first conglomerate, the second conglomerate terminates at both ends by grading into and interfingering with the graywackes and siltstones of the second depositional sequence.

Third conglomerate - The third conglomerate northeast of Little Gulch occurs intermittently and consists of interbedded and cross stratified, coarse-grained graywacke with abundant lenses of diamictite and pebble and granule conglomerate. At several localities (Geologic Sections 9 to 14) the third conglomerate is a well-developed pebble and cobble conglomerate; however, numerous lenses of graywacke and diamictite comprise the majority of the zone (Fig. 7). Outcrops of the third conglomerate along the northwest limb indicate that the gravel was not deposited in the same manner as the gravels of the first and second conglomerates. The gravel of the third conglomerate appears to have been deposited intermittently with the graywacke over a large area along strike. Thus the graywacke overlying the third conglomerate may appear to be part of the second depositional sequence where no intervening gravel was deposited.

Abnormal Big Gulch deposition - The abnormal thickness (302 ft; 92 m) of the Fincastle conglomerate along Big Gulch consists predominantly of an interbedded assemblage of graywackes, subgraywackes, siltstones, shales, and pelites (Geologic Section 11) (Fig. 7). In either direction along strike the graywackes, subgraywackes, and siltstones apparently fine and grade into shales, as there is no occurrence of coarse clastics above the Fincastle conglomerate to the northeast or to the southwest (Fig. 7). The abnormal thickness of the Fincastle conglomerate along Big Gulch is interpreted as local graywacke and siltstone sedimentation which continued after Fincastle conglomerate deposition had terminated elsewhere along strike.

Correlation of conglomerate zones along strike - The area immediately southwest of Little Gulch appears to be a lithologic boundary which separates the conglomerates to the northeast from those to the southwest (Fig. 7). Correlation of conglomerate zones across the lithologic boundary was done by comparing the behavior and character of the zones to the southwest with those to the northeast. There are many similarities among the conglomerates of both areas. The conglomerate zones southwest of the boundary consist of a very thick and coarse lower and middle conglomerate, and a poorly developed and scattered occurrence of an upper conglomerate. The lowest conglomerate attains a maximum thickness of 36 ft (11 m) at Geologic Section 19 and thins to 19 ft (5.8 m) at Geologic Section 18 (Fig. 7). The middle conglomerate, which is 14 ft (4.2 m) thick at Geologic Section 19, thickens to 25 ft (7.6 m) at Geologic Section 18. The section which separates the lower and middle conglomerates ranges from less than 9 ft (2.7 m) to greater than 20 ft (6.1 m). The thicker section which separates the lower and middle conglomerates at Geologic Section 18 is comprised predominantly of polymictic diamictite (Fig. 18). The diamictite represents approximately 16 to 18 ft (4.9 to 5.5 m) of the upper part of the lower conglomerate which has fined to the southwest (Fig. 7). The thickness of the Fincastle conglomerate southwest of the lithologic boundary is consistent from Geologic Section 19 southwest to Geologic Section 17, even though the deposit is fining to the southwest.

Northeast of the lithologic boundary the first and second conglomerates are characteristically separated by a thinner section of graywacke than that between any other conglomerates. Overlying the middle conglomerate southwest of the boundary is a thick section of graywacke and siltstone, which is overlain intermittently by the upper conglomerate, whose behavior and sedimentary features are very similar to the third conglomerate zone northeast of the boundary. The behavior, character, and stratigraphic positions of the lower, middle, and upper conglomerates southwest of the boundary indicate that they represent the first, second, and third conglomerates, respectively, that occur northeast of the lithologic boundary.

Lithologic boundary - The boundary lacks outcrops or float of conglomerate; however, graywacke and siltstone float is extensive and rare outcrops of graywacke do occur. The present topography of the boundary has been eroded to a lower relief than the areas to the northeast and southwest, where conglomerate is the major ridge-maker. The conglomerate zones northeast of the lithologic boundary appear to grade to graywacke and siltstone to the southwest. Outcrops of the conglomerate zones southwest of the boundary indicate the zones grade to graywacke and become finer to the northeast. A thin sequence of interbedded graywacke and siltstone probably comprises all of the area of the lithologic boundary.

The geometry and character of the Fincastle conglomerate along the northwest limb of the Catawba syncline indicate the lithologic boundary is an area that separates, into two parts, a now eroded continuous blanket of conglomerate which lay to the southwest. The lithologic boundary apparently separates the first, second, and third conglomerates; therefore, each of the three conglomerate zones northeast and southwest of the boundary is a contemporaneous but separate conglomerate deposit. The geometry of the conglomerate zones indicates they were deposited in very broad, shallow, northwest-trending channels.

Sedimentary Features

All of the conglomerate zones are poorly sorted with respect to size; commonly the coarsest clasts are not found at the base of the conglomerate. Characteristic of all the conglomerates, regardless of grain size, are smaller clasts which always comprise part of the interstitial material. The first and second conglomerates,and in places the third conglomerate, are very poorly sorted with boulders up to 17 in (43 cm) long, cobbles, pebbles, and granules occupying the same zone (Fig. 8 and 9). Sorting appears to improve in the higher conglomerate zones. Elongated clasts in relatively unstable positions are common in the first and second conglomerates. Likewise, the sorting of clasts with respect to lithology is poor, but in a few cases carbonate, vein quartz, or sandstone clasts comprise most of

Fig. 8-All of the conglomerate zones are very poorly sorted with respect to size and lithology; many of the largest clasts are not at the base of a zone. The large clast above is sample Fc 124 and is 7 ft above the base of the first conglomerate at Geologic Section 6.

Fig. 9-Sample Fc 23 is the largest clast (11X17 in) found in the Fincastle conglomerate. It is comprised of coarse-grained sandstone and was probably derived from the Unicoi Formation. This clast occurs 7.4 ft above the base of the second conglomerate at Geologic Section 7.

an entire bed.

Locally, the first and second conglomerates and commonly the third contain scattered graywacke, granule, or pebble conglomerate lenses. The lenses may be intergradational within the conglomerate or, in the case of most graywacke lenses, gradational only at the base. The number of lenses in a conglomerate zone increases markedly as it starts to become finer. Locally a few discontinuous beds of siltstone and shale occur in the first and second conglomerates.

The first and second conglomerates are the most variable deposits with little sedimentary order, whereas the higher conglomerate zones seem to have much less change in lithology and sedimentary features along strike. The first and second conglomerates and in places the third are unstratified except for lenses of graywacke or siltstone. However, cross stratification is common in the third conglomerate as it is mostly a thinner bedded granule and pebble conglomerate with abundant graywacke lenses.

Scour channels (Fig. 10) are common within the first and second conglomerate zones and less so in the third and higher zones. The size, number, and thickness of scour channels in a conglomerate zone is directly proportional to the thickness, size of the clasts, and lateral extent of the individual zone. Small and large scale scour channels may have a basal granule or pebble conglomerate that grades upward into graywacke, which may be overlain sharply by gravel. In a few places channels are filled entirely with graywacke or gravel. The grain size of a gravel fill in a channel is usually similar in

Fig. 10-Small scour channel in graywacke lens at Geologic Section 15.

size to the enclosing conglomerate; however, it may be either finer or coarser grained.

Well-rounded to rounded, elongate clasts characterize the Fincastle conglomerate. However, large pebbles and cobbles of vein quartz are subangular to subrounded, and small pebbles of both vein quartz and black chert may be angular. Clasts derived from within the basin are usually subrounded.

In most cases a conglomerate zone consists of greater than 70 percent sandstone clasts with carbonate and vein quartz clasts comprising 0 to 16, and 10 to 20 percent, respectively. The lithologic makeup of the clasts of the first and third conglomerates in the overturned southeast limb along U.S. Route 220 is given in Table IV.

Lithologic Descriptions and Source Formations of the Clasts

Metamorphic clasts within the Fincastle conglomerate include well-foliated augen gneiss, metaquartzite, vein quartz, phyllite and slate. Other clasts include sandstone, quartzite, vein quartz conglomerate, limestone, dolomite, limestone conglomerate, chert, calcite-cemented sandstone, sandstone conglomerate, siltstone and shale. Sample location, their lithology and logical source are given in Table V.

Metamorphic clasts - Sample Fc 108, which is 5 in (12.7 cm) in diameter, grades from a well-foliated, coarse-grained augen gneiss to a completely recrystallized metaquartzite (Fig. 11). It appears to be a highly deformed and recrystallized vein-quartz pebble conglomerate. Quartz comprises about 90 percent of the rock. Grain boundaries are

Table IV

Percentage of lithologies in the Fincastle conglomerate at Geologic Section 15; overturned southeast limb, U.S. Route 220.

A. Third conglomerate; from upper 3 ft of unit 8.

percent	lithology
69	Unicoi sandstone: 66 percent fine- to medium-grained and 3 percent coarse- to very coarse-grained sandstone
10	vein quartz
8	Conococheague Limestone
6	Fairly clean quartz sandstone (Erwin or Unicoi)
3	sandy siltstone (Hampton, Unicoi or Erwin)
2	black chert (Elbrook, Knox or Middle Ordovician limestones)
2	dolomite (Shady, Elbrook or Knox)

B. Upper part of first conglomerate; unit 1b.

percent	lithology
66	Unicoi sandstone: 63 percent fine- to medium-grained and 3 percent coarse-grained sandstone
10	vein quartz
7	Conococheague Limestone
6	very fine-grained, dark gray dolomite (Shady, Elbrook or Knox)
6	fairly clean, fine-grained sandstone (Erwin or Unicoi)
3	impure, light gray, partially dolomitized limestone (Copper Ridge or Conococheague)
2	clean sandstone (Erwin?)

C. Lower part of first conglomerate; unit 1a.

percent	lithology
68	Unicoi sandstone: 59 percent fine- to medium-grained and 9 percent coarse- to very coarse-grained sandstone
20	vein quartz
4	fairly clean, fine-grained quartz sandstone (Erwin or Unicoi)
3	vein quartz pebble conglomerate (Unicoi)
3	dark gray to black chert (Elbrook, Knox or Middle Ordovician limestones)
1	white chert (Knox)
1	sandy siltstone (Hampton, Unicoi or Erwin)

Table V

Location, lithology and probable source of samples of the Fincastle conglomerate (68 thin sections).

Clasts

Sample	Location G.S.	Location unit	Lithology	Probable Source
F3AA	15	8	micritic limestone	Conococheague
F3B	15	8	micritic limestone	Conococheague
F3M	15	8	limestone conglomerate	Conococheague, Copper Ridge or Elbrook
F5a	15	1a	limestone conglomerate	Conococheague, Copper Ridge or Elbrook
F5K	15	1a	dolomite	Copper Ridge
F5L	15	1a	limestone conglomerate	Conococheague, Copper Ridge or Elbrook
F5M	15	1a	dolomite	Knox or Elbrook
F5U	15	1a	granule conglomerate	Unicoi
Fc 7	18	9	vein quartz pebble conglomerate	Unicoi
Fc 23	7	1	sandstone	Unicoi
Fc 34	13	1	sandstone	Erwin
Fc 47	15	1b	limestone conglomerate	Conococheague, Copper Ridge or Elbrook
Fc 48	15	1b	pebble conglomerate	Unicoi
Fc 49	15	1b	sandstone conglomerate	Liberty Hall
Fc 50	15	1b	quartzite	Erwin
Fc 53	4	1	calcite-cemented sandstone	Liberty Hall
Fc 54	4	1	micritic limestone	Liberty Hall
Fc 57	7	1	pebble conglomerate	Unicoi
Fc 58	4	1	calcite-cemented sandstone	Liberty Hall
Fc 69	4	1	calcite-cemented sandstone	Liberty Hall
Fc 70	4	1	limestone	Conococheague
Fc 74	6	1	calcite-cemented sandstone	Liberty Hall
Fc 79	1	1	sandstone	Unicoi
Fc 102	St.99		sandstone	Unicoi
Fc 108	15	1b	augen gneiss	Marshall
Fc 112	15	4	sandstone	Unicoi
Fc 113	15	4	limestone	Conococheague or Knox
Fc 114b	18	9	pebble conglomerate	Unicoi
Fc 122	7	1	pebble conglomerate	Unicoi
Fc 124	6	1	sandstone	Unicoi
Fc 128	15	1b	sandstone	Unicoi
Fc 131	15	1b	quartzite	Erwin

Table (con't)

Conglomerate

Sample	Location	Lithology
Fc 85	southwest of Geologic Section 18	conglomerate
Fc 111	float at Geologic Section 15	conglomerate
Fc 114	float at Geologic Section 15	conglomerate
Fc 126	float at Geologic Section 15	conglomerate-graywacke contact

Diamictite

Sample	Location	Lithology
Fc 19	unit 2 of Geologic Section 1	diamictite
Fc 83	southwest of Geologic Section 18	diamictite
Fc 84	southwest of Geologic Section 18	diamictite

Graywacke

Sample	Location	Lithology
Fc 1	unit 9 of Geologic Section 18	conglomerate-graywacke contact
Fc 27	unit 35 of Geologic Section 11	subgraywacke

Fig. 11-Well-foliated augen gneiss clast probably derived from the Precambrian Marshall gneiss. This clast appears to have been a vein-quartz pebble conglomerate (sample Fc 108).

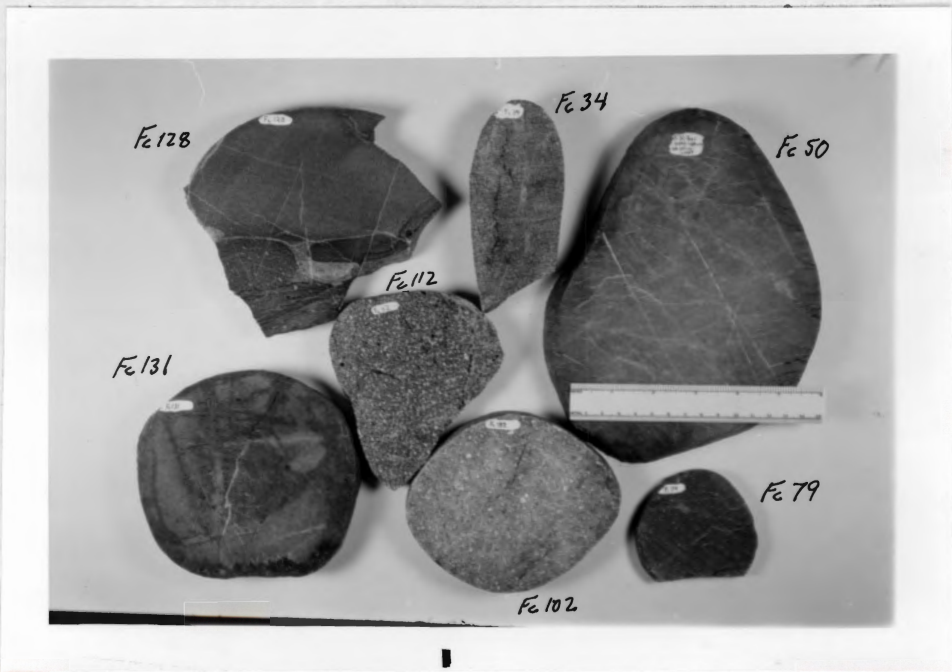


Fig. 12-Clasts of silty sandstones and fairly clean quartzites that were probably derived from the Cambrian Erwin Quartzite and Cambrian(?) Unicoi Formation.

severely sutured and commonly are separated by chlorite and sericite. Quartz grains are fractured, deformed and extremely strained. Deformed and corroded plagioclase (An 7-18; 11 counts) grains make up less than 2 percent of the rock. Plagioclase grains are up to 2.5 mm long; contain inclusions of quartz, laths of muscovite, and vermicular chlorite. Veins of chlorite and sericite appear to corrode the quartz grains by the growth of chlorite into the quartz. Inclusions of vermicular chlorite in the quartz increases in abundance toward the veins. Segregations of chlorite and epigenetic calcite are up to 15 and 6 mm, respectively, in diameter. The coarsely crystalline, untwinned calcite is severely strained and bent. Sample Fc 108 is similar texturally to the coarse-grained augen gneiss exposed on Porter Mountain in the Blue Ridge (Fig. 1), and the Precambrian Marshall gneiss exposed along the Blue Ridge Parkway 0.6 mi (0.96 m) southeast of Bearwallow Gap at the Five Oaks Overlook.

Angular fragments of fine-grained, quartz-mica augen gneiss are well-foliated and contain flat and elongated quartz porphyroblasts up to 1 mm long. Foliated phyllite and slate clasts consist of quartz, muscovite, sericite and plagioclase. Phyllites may contain quartz augen 0.1 mm long, and rotated grains of plagioclase and opaques.

Granule-size clasts of metaquartzite in the Fincastle conglomerate contain corroded plagioclase, bent and strained muscovite and chlorite, sericite, biotite, and subhedral to euhedral tourmaline crystals. These grains may comprise up to 10 percent of the rock. Quartz and plagioclase grains are strained and highly recrystallized. Metaquartzite clasts have a tectonic fabric or foliation wherein enclosing grains have been flattened and elongated. The relict texture of less deformed metaquartzites appears to represent a clean, very fine-grained sandstone comprised of angular to subangular grains of quartz and plagioclase.

Vein-quartz clasts as much as 9 in (22.8 cm) in diameter are commonly subangular to subrounded and constitute 10 to 20 percent of the Fincastle conglomerate. The milky white to light green vein quartz is highly fractured and strained. Inclusions of vermicular chlorite in the vein quartz range from 0 to greater than 90 percent.

Based on the deformation in the Unicoi Formation and in the Marshall gneiss in the Goose Creek area, there appears to be a metamorphic discontinuity across the major unconformity that separates the two rock units. Metamorphic fragments and vein quartz clasts in the Fincastle conglomerate may have been derived from the Archeozoic basement complex (Marshall gneiss) which was exposed in what is now the Blue Ridge. L. Glover (oral communication, 1974), based on work being done in the Piedmont to the southeast, has suggested that eastern metamorphosed equivalents of the Chilhowee Group in the Piedmont may have been uplifted by Middle Ordovician time. If so, some of the metamorphic clasts in the Fincastle conglomerate may be of such origin.

<u>Sandstone</u> - Rounded to well-rounded sandstone clasts (Fig. 12) comprise 66 to 69 percent of the Fincastle conglomerate. They range

in size from less than 0.5 to 17 in (1.2 to 43 cm) long (Fig. 9). The very coarse- to fine-grained sandstones consist primarily of poorly sorted, angular to subrounded grains of quartz and minor percentages of plagioclase, chlorite and perthitic plagioclase grains, and metamorphic rock fragments. The quartz grains are commonly strained and consist of vein quartz and metaquartzite. Quartz overgrowths are common but not extensive throughout the rock. The plagioclase may be strained and crenulated. Subrounded to rounded chlorite grains, which may be terrigenous, have a maximum diameter of 0.8 mm. The amount of recrystallization of grains in the sandstone clasts differ, but commonly a relict texture is preserved. The sandstone is cemented by sericite, muscovite, and chlorite, and, in part, by pressure solution. Smaller grains of quartz and plagioclase are corroded by a matrix rich in chlorite and sericite. These clasts were derived from the Lower Cambrian (?) Unicoi Formation of the Blue Ridge.

Hematite-cemented sandstone clasts, which are several inches in diameter, are rare. The hematitic sandstones consist of angular to subrounded, strained quartz grains in a hematite matrix. These were derived from hematitic sandstone beds in the Unicoi Formation.

Quartzite - Fairly clean, rounded to well-rounded clasts of quartzite comprise 4 to 8 percent of the Fincastle conglomerate (Fig. 12). Quartzite clasts are fine- to coarse-grained and up to 13.5 in (34 cm) in diameter. The quartzites consist of about 85 percent vein quartz grains, some of which have vermicular chlorite inclusions.

The quartz grains are strained and overgrowths are extensive. The grains of quartz appear to be angular based on the relict texture. Plagioclase (An 3-14; 11 counts) grains constitute approximately 10 percent of the rock. Grains of plagioclase are extremely corroded and strained with bent albite twins. Rare grains of sphene and microcline occur in some samples. The matrix comprises less than 5 percent and consists of chlorite and little or no sericite. These clasts were probably derived from quartzite beds in either the Erwin Quartzite or the Unicoi Formation.

Vein quartz conglomerate - Granule to cobble-size vein quartz conglomerate clasts (Fig. 13) are subrounded to rounded and are as much as 5 in (12.7 cm) in diameter. Conglomerate consist of 65 to 75 percent quartz, 5 to 10 percent feldspar, and 20 to 30 percent matrix. Overgrowths between strained vein quartz and metaquartzite grains are common. Feldspar grains are extremely altered and some are strained and have overgrowths. Plagioclase (An 1-9; 17 counts) is the predominant feldspar. Albite and pericline twins, which may be bent, characterize the plagioclase grains. Grains of extremely corroded microcline, perthitic feldspar and orthoclase are rare. Minor amounts of rounded sphene grains and blades of muscovite (sericite) are common. The matrix of the conglomerates consists of very fine grains of quartz, feldspar, muscovite and opaques. Diagenetic chlorite is common and may have formed before transport.

Sample Fc 48 (Fig. 13) is a silty, poorly sorted, polymictic, pebble conglomerate clast which is different from the other vein

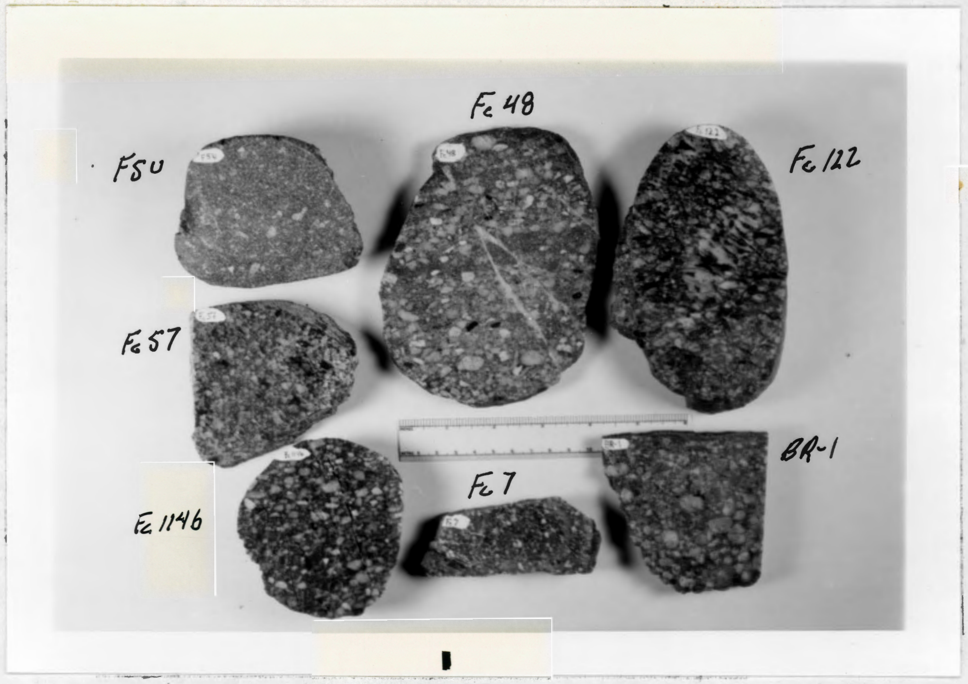


Fig. 13-Clasts of vein quartz conglomerate probably derived from the Unicoi Formation. Sample BR-1 is from one of the Unicoi conglomerate beds of the Blue Ridge.

quartz conglomerate clasts. Epigenetic calcite veins are common throughout the rock. Subrounded to rounded clasts in the conglomerate comprise approximately 70 to 80 percent of the rock. Quartz and plagioclase (An 2-14; 11 counts) comprise most of the clasts. Vein quartz, metaquartzite, and vein quartz with vermicular chlorite inclusions are all strained, and overgrowths between grains are fairly common. Angular to subrounded microcline clasts are 1 to 1.4 cm long. Plagioclase clasts with strained and bent albite and pericline twins are abundant. Small clasts of quartz and feldspar are angular. Many grains of quartz and plagioclase are extremely corroded by calcite. Other clasts include angular tourmaline up to 1.5 cm long, hematite, and bent muscovite. A rounded, elongate clast contains very angular, extremely corroded quartz and plagioclase grains which are supported in a matrix of chlorite and sericite. An angular clast of claystone is 1 cm in diameter and consists of clay and disseminated calcite, and angular to subangular, silt-size quartz grains. Clasts of phyllite up to 6 mm in diameter consist of angular, very fine-grained quartz and plagioclase. Laths of muscovite in the phyllite are small and oriented parallel to each other. The clasts in Sample Fc 48 are slightly flattened and elongated in one direction; this is suggestive of a tectonic fabric which may have been developed prior to transport or during deformation of the Catawba syncline.

Pebble and granule conglomerates presently exposed in the Blue Ridge in the Unicoi Formation consist predominantly of rounded to well-rounded vein quartz in which the original texture is preserved (Fig.

13). Few overgrowths occur between quartz clasts. The vein quartz clasts are commonly fractured and exhibit undulose extinction. Smaller granules of quartz are fractured and strained and have extensive overgrowths. Vein quartz conglomerate clasts in the Fincastle are similar in texture and composition to those of the Unicoi Formation and are probably of such origin. Sample Fc 48, although appreciably different from the typical Unicoi conglomerates, may have been derived from the Unicoi.

Carbonate clasts - Limestone clasts (Fig. 14) comprise approximately 8 percent and the majority of carbonate clasts in the Fincastle conglomerate. Limestone clasts are light gray to black, very fine- to fine-grained micrite with small segregations of microcrystalline chert. Quartz grains constitute up to 75 percent of some of the clasts. The limestones are wholly or partially silicified and dolomitized. Some hand specimens appear silicified and cherty, and commonly contain siliceous laminae. Sample Fc 70 (Fig. 14) consists of about 75 percent subrounded to rounded quartz grains 0.1 to 0.2 mm in diameter, and minor grains of sphene, tourmaline, pyrite and plagioclase (Fig. 15). The matrix consists of calcite and sericite (Fig. 15). Extensive overgrowths and a minimal amount of straining characterize the quartz grains, which are corroded by calcite or dolomite. Angular grains of plagioclase range from An 4 to 13 (10 counts). The majority of the limestone clasts were probably derived from the Cambrian Conococheague Limestone.

Sample Fc 54 (Fig. 16) is subrounded and consists of laminated

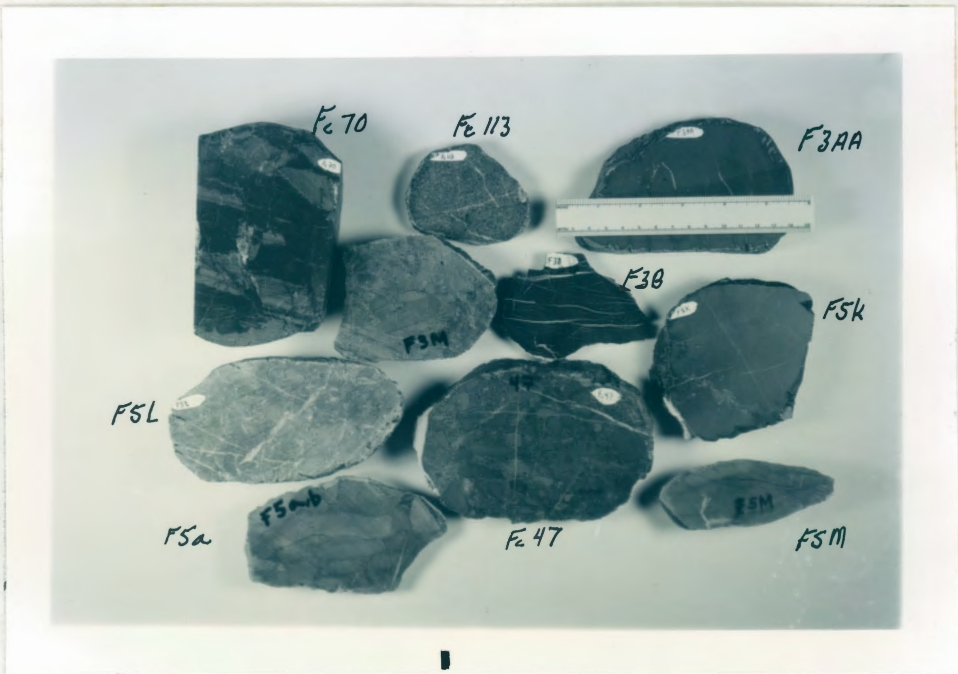
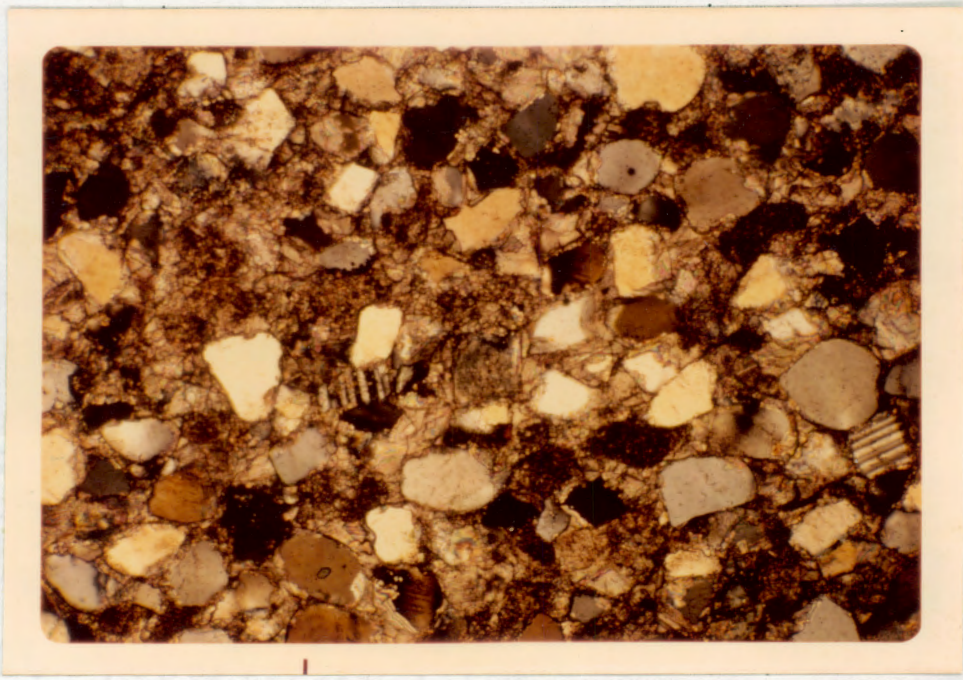


Fig. 14-Carbonate and limestone conglomerate clasts.



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mm

Fig. 15-Photomicrograph of sample Fc 70 (X nicols).

layers of pelletal limestone and micrite with pellets. The micrite and pellets are cemented by calcite. All layers contain small, inarticulate brachiopods and all elements of the multielement genus Periodon. Minor amounts of small, angular quartz grains and hematite are more abundant in the pelletal layers. The black, fine-grained micritic lithology of sample Fc 54 is similar to limestones in the Edinburg. This clast was probably derived from within the basin and may represent a southeastern limy facies of the Liberty Hall formation.

Light gray to gray, very fine-grained carbonate clasts (sample F5M, Fig. 14) are partially or wholly dolomitized. The relict texture appears to be micritic but the rock has been largely recrystallized to dolomite or calcite. Angular to subrounded quartz and minor plagioclase grains comprise from 0 to 10 percent of these clasts. Few of these grains are strained. Other micritic clasts with much diffused pyrite are darker. These clasts may have been derived from carbonates of the Knox Group and Elbrook Formation. Tillman and Lowry (1973) described several clasts comprised of dark, silty, fine-grained limestone with interbedded black chert. Based on the lithology of the clasts, Tillman and Lowry (1973) suggested they were derived from the Lincolnshire Limestone; similar microfossils as those from the clasts had not been recovered from underlying formations within or near this structure. However, recent work on microfossils from the Middle Ordovician limestones (Hight, MS.) and Knox carbonates (Tillman, oral communication, 1974) indicate that none of these units contain a similar fauna. It seems probable that the limestone clasts were derived from one of the as yet unsampled Ordovician Knox units (Tillman, oral communication, 1974).

Coarsely crystalline carbonate clasts with strained calcite are similar to those previously described, except recrystallization of the micrite to calcite has gone to completion. The clasts may contain angular to subrounded quartz and plagioclase grains, few of which are strained. Some clasts are partially silicified and may contain diffused chert and minor muscovite. Micritic clasts and coarse-grained carbonate clasts may have been derived from the carbonates of the Knox Group and Elbrook Formation.

Sample F5K (Fig. 14) is a light to dark gray, fine-grained, partially silicified dolomite clast. It consists of fine crystalline calcite and dolomite, and many angular quartz grains. Laminations within the clast consist of pelletal limestone with quartz grains. Sample F5K was probably derived from the Copper Ridge Dolomite.

Limestone conglomerate - Limestone pebble conglomerate clasts (Fig. 14) are up to 6 in (15.2 cm) long. Characteristically, they are gray to dark gray, flat, elongate limestone clasts in a light gray to gray, fine- to coarse-grained carbonate cement which may have subhedral to euhedral quartz grains (sample F3M, Fig. 14). Clasts within the limestone conglomerates are petrographically similar to Conococheague, Copper Ridge, and other carbonate clasts described above. Micritic clasts in the limestone conglomerates may contain quartz and plagioclase. Very fine to coarsely crystalline limestone clasts may contain many angular quartz and plagioclase grains up to 0.3 mm in diameter. Overgrowths between quartz grains and straining of quartz grains are minimal. Pelletal limestone clasts contain variable amounts of quartz in a cement of micrite partially recrystallized to calcite. Micrite pellets in the pelletal limestone are 0.05 to 0.1 mm in diameter. Limestone conglomerate clasts in the Fincastle conglomerate were probably derived from intraformational limestone conglomerate beds within the Elbrook Formation, Conococheague Limestone, and Copper Ridge Dolomite.

Chert - White and black chert clasts are subangular to well-rounded and consist of microcrystalline quartz. The chert may contain euhedral rhombs of zoned, saddle-shaped dolomite, which is characteristic of some cherts in the Copper Ridge Dolomite. Coarse-grained chert clasts, similar to chert found occupying vugs in the Copper Ridge Dolomite, have a colloform perimeter from which the inward growth of quartz crystals forms a tight interlocking mosaic. Some of the chert clasts were probably derived from the Elbrook Formation and Knox carbonates; some of the dark gray to black chert clasts may have been eroded from the Chepultepec formation or higher Knox limestones or Middle Ordovician limestones such as the Lincolnshire. However, the apparent absence of carbonate clasts with lithologies similar to Middle Ordovician limestones indicates that these limestones were absent in the source area. On the southeast limb of the Kingston syncline at Stypes Branch (11 mi; 17.7 km west of Roanoke, Fig. 2) 10 to 16 ft (3 to 4.9 m) of Botetourt limestone comprises the entire Middle Ordovician limestone section (Edwards, 1959; and Tillman and

Lowry, 1968). Farther southeast in the vicinity of Roanoke the Middle Ordovician limestones range in thickness from 80 ft (24 m) to a feather edge (Hazlett, 1968). Regardless of whether these limestones are thinner as a result of erosion or nondeposition, the Knox surface was relatively higher in southeastern belts than it was to the northwest. Therefore, the Middle Ordovician limestones may have never been deposited very far up the northwest limb of the Blue Ridge anticlinorium.

Calcite-cemented sandstone - These sandstone clasts (Figs. 16 and 17) are silty, poorly sorted, very fine- to coarse-grained with quartz grains up to 2.5 mm in diameter. Angular to rounded, largely unstrained quartz grains comprise 55 to 60 percent of the rock and may be matrix-supported (Fig. 17). Quartz is usually extremely corroded by calcite or dolomite. Quartz grain overgrowths are minor. Grains of biotite, muscovite, hematite, leucoxene, sphene, epidote, and tourmaline may be present, and plagioclase (An 5-16; 10 counts) and microcline are rare. The cement constitutes from 40 to 50 percent and consists of calcite and minor chlorite and sericite (Fig. 17). Macroscopic features may include worm burrows, bioturbated sediments, soft-sediment slumping, and segregations of limonite and hematite.

These sandstone clasts are not represented in the stratigraphic column of the Goose Creek area or Salem synclinorium. Petrographically and lithologically these clasts are dissimilar to the sandstones of the Chilhowee Group and those present in the lower part of the Knox Group. The sandstone beds of the Knox Group are generally very

Fig. 16-Calcite-cemented sandstone and sandstone conglomerate clasts.

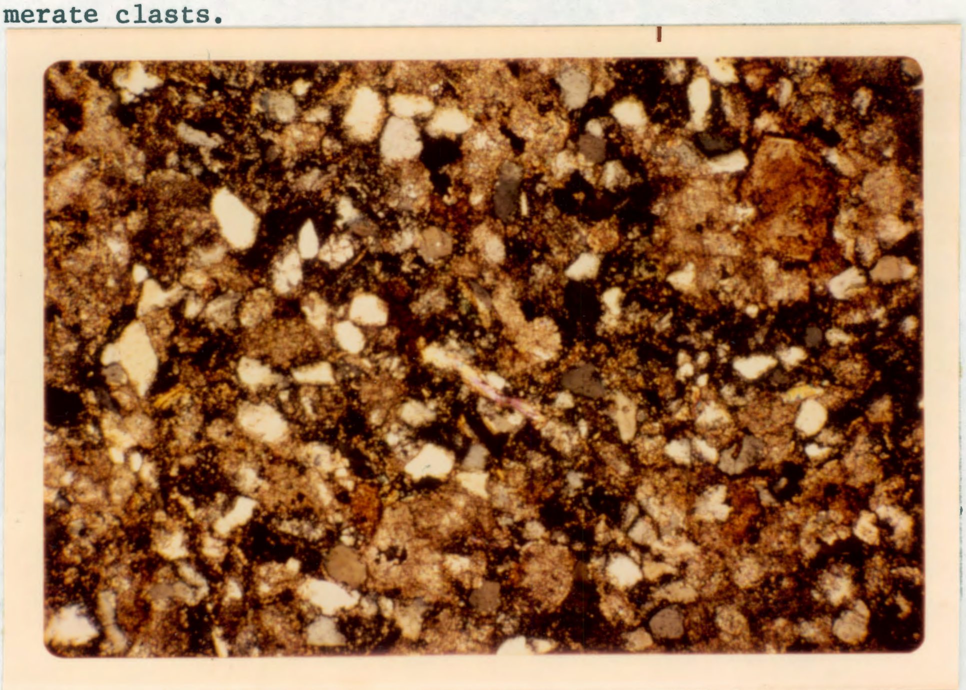

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Fig. 17-Photomicrograph of sample Fc 58. Note the corrosion of quartz grains by the calcite and dolomite cement (X nicols).

clean, well-sorted, and comprised of well-rounded quartz and microcline grains. These calcite-cemented sandstone clasts may have been derived from a southeastern sandstone facies of the Liberty Hall formation.

Sandstone conglomerate - Sample Fc 49 is a granule to pebble sandstone conglomerate (Fig. 16) comprised of about 10 percent clasts, 10 to 15 percent cement and matrix, and 75 to 80 percent quartz grains. Fine-grained sandstone clasts within the sandstone conglomerate are subangular to subrounded and consist of angular, unstrained quartz grains perdominantly supported by a calcite and sericite matrix. Other grains include muscovite up to 0.5 mm long, leucoxene, tourmaline, hematite, and rare grains of rounded epidote. Angular micritic limestone clasts contain less than 5 percent angular quartz grains. Rounded, very fine-grained calcareous shale clasts are rare and contain angular quartz grains and minor amounts of muscovite and sericite. Clasts within the sandstone conglomerate are supported by a matrix petrographically similar to the calcite-cemented sandstone clasts described above. The matrix consists perdominantly of a poorly sorted, very fine-grained to granule-size quartzose sandstone with minor muscovite and no feldspar. Quartz grains are extremely corroded by the calcite or dolomite cement. Clasts within sample Fc 49 are similar to clasts which occur in the Fincastle conglomerate but are granular or smaller in size. Sample Fc 49 may be part of a sandstone facies of the Liberty Hall Formation.

Siltstone and shale - Shale and siltstone clasts are very fine-grained and contain angular quartz grains up to 0.05 mm in diameter. Most are very angular and were probably ripped up from the Liberty Hall formation during deposition of the Fincastle conglomerate. However, some may have been derived from the siltstone and shale beds of the Chilhowee Group or Cambrian Rome Formation.

Matrix of the Conglomerate Zones

The matrix of the conglomerate zones consists of graywacke. The percentage of graywacke in the matrix is variable and dependent on the size of the clasts in the conglomerate. The finer a conglomerate zone becomes, the higher the percentage of graywacke in the matrix until the zone becomes a diamictite. Nowhere was a mud or siltstone matrix observed in a conglomerate zone.

The matrix in which clasts of the Fincastle conglomerate occur is petrographically similar to the graywacke which lies above the conglomerate zones (Figs. 19 and 20). Generally the matrix is blue-gray to gray when fresh and weathers to a dark yellowish-brown. The matrix is a very poorly sorted, medium- to coarse-grained graywacke consisting of mostly vein quartz and smaller grains of all the larger clasts described above. Small, angular metamorphic rock fragments in the graywacke matrix are abundant. Angular, tightly packed quartz and plagioclase grains comprise most of the matrix. Some of the quartz grains are strained. Overgrowths between quartz grains are common and form part of the cement along with calcite, chlorite, and sericite. Other fragments include muscovite, pyrite, biotite, chlorite, twinned and untwinned plagioclase up to 2 mm long, subhedral tourmaline, rounded leucoxene up to 2 mm long, and well-foliated quartz-muscovite-sericite phyllite. Veins of calcite commonly contain inclusions of matrix material. Calcite in the veins is subhedral, strained, and usually the twinning is well developed.

Diamictite

The graywackes may contain scattered discontinuous zones of diamictite. They are common and characteristic of the graywacke associated with the third and higher conglomerates. The diamictites are commonly intergradational, within graywacke, but in a few places they are part of a scour channel fill. The majority of diamictites consist of subangular to subrounded vein quartz pebbles and granules less than 0.5 in (1.3 cm) in diameter. Although most of the diamictites are discontinuous, they may represent the appearance of a major conglomerate deposit along strike as in the case of the second and third conglomerates (Geologic Sections 3, 4, 18, 19, and 20). As a diamictite grades laterally into a conglomerate, it first will become a polymictic diamictite. The concentration of clasts steadily increases until the clasts are grain-supported, at which point the diamictite becomes a conglomerate. The concentration of vein quartz in a diamictite may increase until it becomes a conglomeratic lens. Rare cobble polymictic diamictites occur in graywacke beds above two major conglomerates. At Geologic Section 10 (unit 2) a cobble diamictite overlies the third conglomerate. This is the only locality where clasts were found in a siltstone matrix. At Geologic Section

19 (unit 4) another cobble diamictite consists of widely scattered pebbles and cobbles of vein quartz and Unicoi sandstone in a dark brown, coarse-grained graywacke matrix. Overlying the first conglomerate at Geologic Section 18 (unit 3) is an 18 ft (5.5 m) section of diamictite with clasts up to 3 in (7 cm) in diameter in a silty, pelitic graywacke matrix (Fig. 18). The cobble diamictites are interpreted as scattered and intermittent gravel influxes during graywacke deposition. The cobbles are probably lag deposits left behind during or after the initial influx of gravel. All the cobbles are rounded to well-rounded except for clasts of subangular to subrounded vein quartz. The youngest polymictic diamictites above the third conglomerate contain a relatively higher percentage of metamorphic fragments than the older diamictites.

Petrography - The diamictites (Fig. 19) are similar to the conglomerate zones in that the types of clasts are similar. Vein quartz comprises the majority of clasts in the diamictites. Completely recrystallized metaquartzite clasts are fine- to coarse-grained, rather well foliated and some contain muscovite, as much as 2 percent plagioclase, sericite, chlorite and leucoxene. Clasts of Unicoi sandstone are very fine- to fine-grained, moderately sorted and consist of slightly strained, angular quartz and plagioclase grains, sericite, chlorite, biotite and muscovite grains. Clasts of graywacke in the diamictites above the third conglomerate are very similar to the graywackes that overlie the first and second conglomerate zones. Clasts of graywacke are fine-grained, poorly sorted

Fig. 18-The upper 18 ft of the first conglomerate which has become a diamictite at Geologic Section 18.

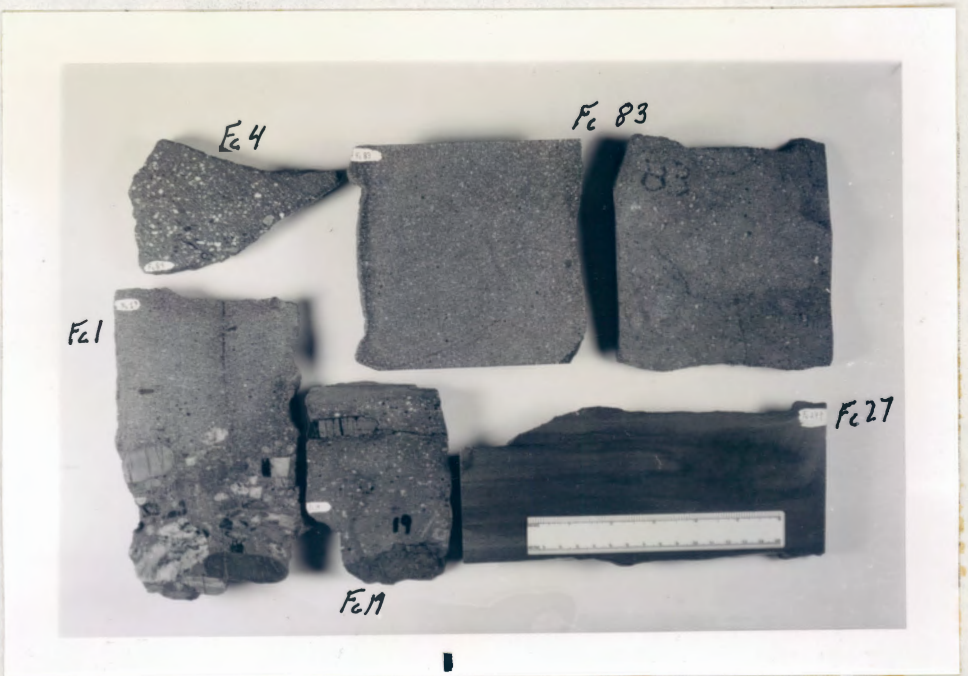

Fig. 19-Samples of diamictite and graywacke of the Fincastle conglomerate.

and consist of angular to subrounded quartz grains, and minor biotite and muscovite in a chlorite and sericite matrix. Clasts of diamictite within the diamictites are comprised of angular and subangular, medium-grained quartz and plagioclase grains. Other clasts in the diamictites include chert, shale, angular micritic limestone, and smaller grains of chlorite, muscovite and biotite. A flat, elongate, calcarenitic limestone clast similar to those in the Pine Hills conglomerate is in sample Fc 19 (Fig. 19). Metamorphic fragments include slate or phyllite up to 2.5 mm long, quartz-biotite schist, and well-foliated quartz-chlorite-sericite schist.

Diamictites have a very fine- to coarse-grained, poorly sorted graywacke matrix comprised predominantly of angular to subangular quartz grains and a fine groundmass of quartz, plagioclase, carbonate, chlorite, muscovite, biotite and metamorphic rock fragments. Overgrowths on small quartz grains are common. Other grains include muscovite, biotite, and chlorite in a groundmass of sericite and chlorite. Angular to subangular plagioclase (An 0-18; 11 counts) grains comprise approximately 2 percent of the rock. The matrix of some diamictites contains up to 15 percent hematite and fine grains of sericite, muscovite, chlorite, quartz, plagioclase and carbonate.

Graywacke

Graywacke (Fig. 19) characteristically overlies and grades laterally into conglomerate, and above the uppermost conglomerate zone, is interbedded with siltstones and shales (Geologic Section 11, Fig. 7). The graywacke of the first and second depositional sequences, like the first and second conglomerates, changes rapidly in character and grain size along strike; however the grain size of the higher graywacke beds are more consistent. As the Fincastle conglomerate becomes finer grained to the southwest, the thickness of graywacke and the abundance of intergradational diamictites increase. Southwest of U.S. Route 220, the number of diamictites decreases as the graywacke grades into siltstone and shale.

Contact between conglomerate and graywacke - The contact between a conglomerate zone and the overlying graywacke ranges from sharp as the result of scouring of the underlying gravel prior to deposition of the graywacke to a gradational contact. The gradational contact can range from a graded bed to a zone consisting of conglomerate grading to diamictite in turn grading to graywacke. The thickness of the graded bed or zone of gradation can range from 6 in to more than 18 ft (15 cm to 5.5 m). In places the graywacke cuts a deep scour channel in the underlying gravel, such as bed 2 of Geologic Section 6 (Fig. 7). In Fig. 7 the graywacke overlying the first conglomerate is part of a large scour channel. If scouring of the conglomerate had not occured, it would grade upward into poorly sorted, polymictic diamictite which, in turn, would grade up into graywacke, siltstone, and shale. This implies the graywacke in Fig. 7 is a separate influx of sand that occurred after the deposition of the gravel. The first conglomerate along the northwest limb of the syncline originally may have been graded, but scouring has removed the overlying sequence. The first and second conglomerates are characteristically separated by a thinner section of finer sediment than that which separates other conglomerate zones. This suggests a relatively short time interval between the deposition of the first and second gravels.

Sedimentary features of graywacke - The graywacke of each depositional sequence is distinguishable by the character of its bedding and sedimentary features. Generally the graywacke southwest of U.S. Route 220 is featureless compared with that to the northeast. The graywacke overlying the first conglomerate zone is massive-bedded and may contain some graded beds; otherwise, it is generally featureless. The graywacke immediately overlying a conglomerate zone is not necessarily as coarse as that higher up. This is common in the graywacke overlying the first and second conglomerates where graded beds of variable grain size are interbedded with each other. Near Geologic Section 7 the lower half of the second conglomerate consists of many alternating conglomerate beds grading up into graywacke, which is overlain sharply by another conglomerate. The upper part is comprised of an intergradational graywacke lens about 5 ft (1.5 m) thick within the conglomerate.

The most diverse graywacke is that overlying the second conglomerate, which represents the last major influx of gravel. This graywacke is in most places massive-bedded and overlain by a distinctive marker zone (Geologic Sections 7, 8, 11, 12, and 13). The marker zone ranges in thickness from 5.5 to 13 ft (1.7 to 3.9 m) and consists of alternating graywackes, siltstones, and shales, all thin-bedded and fine- to medium-grained. Siltstones and shales commonly overlie the marker zone and are, in turn, overlain sharply by the third conglomerate. The sequence of beds which overlie both the third and fourth conglomerates where they are well developed up Big Gulch (Geologic Section 11) is similar but thicker than that above the second conglomerate.

Northeast of Little Gulch the graywacke overlying the third conglomerate is thick- to massive-bedded with no sedimentary features; in this respect it is similar to that above the first and second conglomerates. However, sharply overlying the massive-bedded graywacke is cross-stratified graywacke with scour channels. Cross-stratified layers may have an angle of inclination greater than 20°.

The graywacke of the third and fourth depositional sequences is interbedded with siltstones and shales and is generally medium- to thin-bedded and better sorted with respect to grain size than lower graywackes. The graywacke overlying the third conglomerate is commonly thin-bedded, with a few medium-bedded, coarse-grained, gritty graywackes. These graywackes contain granules of vein quartz and resemble a diamictite (unit 7 of Geologic Section 11). Some of the graywacke beds which are underlain by shale have sole markings. In a few places where a conglomerate zone becomes finer grained along the strike, the overlying graywacke may contain abundant interbeds of siltstone and minor shale, especially where the next higher conglomerate is becoming thicker and coarser.

The graywacke overlying the fourth conglomerate is thicker and generally finer grained than any of the graywackes of the other depositional sequences. Graywacke and subgraywacke are interbedded with siltstones and shales and are commonly thin- to medium-bedded, but in places thick-bedded (Geologic Section 11). The graywackes are commonly sole-marked. Sole marks are oriented within 20° of an east-west trend and indicate sediment transport within the basin was toward the west. Most markings are flute casts, groove casts, or prod casts. Flute casts are the most abundant and most are poorly preserved due to loading of the overlying sediment. All three types of casts are well developed on the base of bed 35 of Geologic Section 11.

The graywacke associated with the third and higher conglomerates contains abundant scour channels or lenses of granule polymictic conglomerate and vein quartz conglomerate, whereas older graywackes rarely contain zones of diamictites and lenses of conglomerate. Commonly as a conglomerate zone fines along strike to graywacke, these lithologies become interbedded. As a result, the graywacke contains many lenses and scour channels filled with pebbles and in a few places cobble conglomerates (compare horizon 7 of Geologic Section 13 and 1 of Geologic Section 14). The graywacke, in turn, grades laterally and vertically into siltstones and shales. In a few places the vertical gradation may be interrupted by another influx of gravel, in which case the depositional sequence begins again.

Petrography - The silt-size to very coarse-grained, very poorly sorted graywackes (Figs. 19 and 20) are comprised of 65 to 80 percent

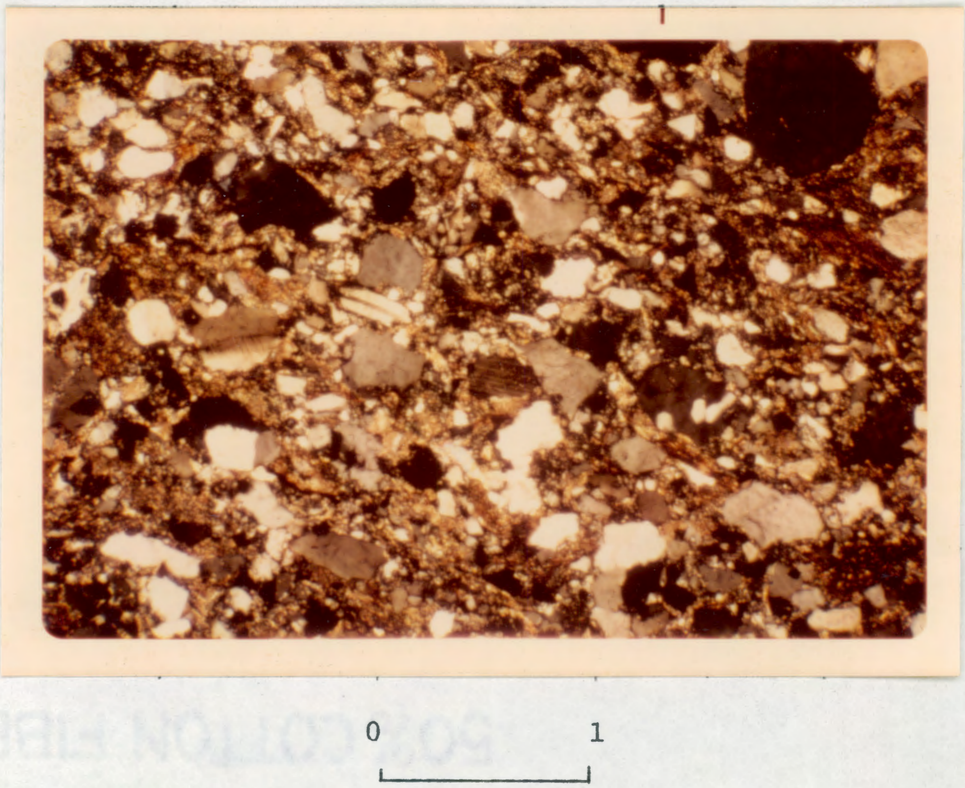

Fig. 20-Photomicrograph of graywacke (sample Fc 126) of the Fincastle conglomerate (X nicols).

quartz, less than 5 percent feldspar, and 20 to 30 percent matrix. Grains of extremely strained metaquartzite and vein quartz with vermicular chlorite inclusions are subrounded to rounded if they are 1.5 to 2 m in diameter and very angular if they are less than 1 mm in diameter. The amount of overgrowths between quartz grains differs among samples. The twins of angular plagioclase (An 5-17; 15 counts) grains are strained and bent. Highly corroded microcline grains are rare. Corrosion of quartz and plagioclase grains by the matrix of mica and calcite is common. Other grains include large blades of biotite and muscovite, angular fine-grained carbonate and micritic limestone, sphene, leucoxene, chlorite, pyrite, shale fragments (with soft-sediment deformation), ilmenite, zircon, and calcite. The matrix and cement is predominantly a groundmass of altered muscovite (sericite) and biotite with minor calcite, chlorite, quartz, and plagioclase (Fig. 20). Some samples are partially cemented by hematite.

Sample Fc 126 (Figs. 19 and 20) has a distinct foliation parallel to bedding imparted by the orientation of elongate grains and by the rotation of calcite, quartz, and chlorite grains along bedding planes. Strained euhedral quartz crystals within fractures indicate the straining of quartz in the Fincastle conglomerate was, in part, caused by the deformation of the Catawba syncline.

Younger graywackes such as sample Fc 27 (Fig. 19) contain less matrix and more plagioclase, and are better sorted than older graywackes. The very fine- to medium-grained, poorly sorted graywackes contain about 15 percent, or less, matrix, 65 to 70 percent quartz grains, 5 to 10 percent hematite, and about 3 percent plagioclase. Angular quartz and plagioclase (An 4-17; 10 counts) grains are corroded by the matrix. Because of less matrix, quartz overgrowths are more abundant. Other grains include biotite, muscovite, chlorite, zircon and fine-grained carbonate. The cement is predominantly very fine sericite, muscovite, chlorite, hematite and minor calcite.

Provenance

Apparently clasts of vein quartz, sandstone and quartzite, and metamorphic fragments were derived from what is now the Blue Ridge, as this is the nearest source of these clasts. The Fincastle conglomerate is not preserved to the northeast or southeast; however, the Bays Formation on the southwest lacks conglomerate beds. It is probable that the Blue Ridge could have supplied these clasts either from the southeast in the vicinity of the Goose Creek window or from the northeast. Carbonate clasts from the Elbrook Formation and Knox Group were probably derived from the Blue Ridge, although they could have originated from within the basin.

Correlation

Since Woodward (1936a) first described the Fincastle conglomerate, it has been considered a conglomerate member of the Liberty Hall, Edinburg formation or the Athens Shale. Stow and Bierer (1937), Butts (1940) and Decker (1952) agreed with Woodward's original stratigraphic assignment of the Fincastle conglomerate. Decker (1952) misinterpreted the structure of the Pine Hills as an overturned anticline, and he also mistook sedimentary rock clasts for granite and metamorphic rocks; these misinterpretations were later pointed out by Cooper (1960 and 1969). The assignment of the Fincastle conglomerate to the Liberty Hall formation was due to the fact that the shales which overlie the deposit are lithologically similar to the underlying Liberty Hall shales, and also because similar coarse clastics occur elsewhere in the Southern Appalachians in relatively similar stratigraphic position (Kellberg and Grant, 1956). Cooper (1960 and 1969) stated the Fincastle conglomerate was an intraformational conglomerate within the Liberty Hall formation.

The presence of several polymictic conglomerate zones in the Fincastle conglomerate probably discouraged correlation with the Bays Formation. However, Andrews (1952) and Nichol (1959) correlated the Fincastle with the Bays. Nichol (1959) recognized the similarity between the matrix of the Fincastle conglomerate and the sediments of the Bays Formation in the southwest depression of the Catawba syncline, and he also suggested that the sediments that overlie the Fincastle conglomerate may be a northeasterly facies of the Martinsburg Shale in the Catawba syncline. Edmundson (1958) and McGuire (1970) considered the Fincastle to be a conglomerate bed of the Edinburg formation.

Fossils collected in 1958 from the lower part of the overlying shale on the southeast limb (unit 2 of Geologic Section 15) and identified by G. A. Cooper (written communication to Lowry, 1958) include <u>Sowerbyella</u>, <u>Orthambonites</u> and <u>Calliops</u>. Because of the poor preservation of specimens, a reliable correlation was not made. In 1974 a new roadcut permitted the collection of well-preserved specimens from the same horizon. G. A. Cooper identified the new specimens as Sowerbyella cava (written communication to Lowry, 1974). He noted that this species occurs in the Orando formation and the overlying Martinsburg Shale in the Central Appalachians. Cooper stated: "On the basis of these Sowerbyellas I would not want the enclosing rocks in the Liberty Hall." The shale overlying the Fincastle conglomerate is lithologically similar to part of the Martinsburg Shale of southeastern belts and along strike to the southwest, which is generally unfossiliferous and less calcareous.

The best criteria for correlating the Fincastle conglomerate is its lithology. The major lithologies that comprise the Fincastle are graywacke and siltstone. Conglomerates comprise a relatively small percentage of the entire deposit. The composition and texture of the graywacke and siltstone in the Fincastle are similar to the subgraywacke and siltstone of the Bays Formation (Hergenroder, 1966) in the southwestern depression of the Catawba syncline, even though they are better sorted and rounded.

Based on the lithology of the Fincastle conglomerate, it is logical to correlate it with the Bays Formation. It is easier to explain Fincastle sedimentation during Bays rather than Liberty Hall deposition. Evidence indicates the Fincastle conglomerate is a northeastern lithofacies of the Bays Formation and that the overlying shale is a northeastern facies of the Martinsburg.

Depositional Environment

Many sedimentary features in the Fincastle conglomerate are characteristic of both submarine channel fills and massively transported sediments (mass flowage, slumps, slides) and stream deposits (alluvial, fluvial). Sedimentary structures such as graded beds, sole marks, fining-upward sequences and contorted beds occur in both deep water sediments like turbidites and submarine channels, and shallow water deposits like those of fluvial origin (Dott, 1963 and 1966; and Stanley, 1968). Stanley (1969a) has shown some submarine channel fills and their sedimentary features are similar to fluvial channels and can be distinguished only by associated facies changes.

The massively bedded, poorly sorted conglomerates, and graded beds, diamictites, fining-upward sequences and clasts in unstable positions, and the lack of cross stratification in the Fincastle suggest emplacement by mass movement. However, typical features indicative of these types of deposits are absent in the Fincastle sediments. Commonly such deposits incorporate and deform much of the underlying mud during emplacement (Crowell, 1957; Dott, 1963; Stanley, 1969b; and Hubert and others, 1970). The contact between the Liberty Hall shale and Fincastle conglomerate, where exposed, is always sharp; the underlying shale is undeformed and relatively few shale chips are present in the conglomerate. Commonly an irregular scour surface marks the contact between submarine channels filled with gravel and the underlying mud (Stanley, 1969b); the contact between the Liberty Hall shale and Fincastle conglomerate is always sharp and smooth. Also absent in the Fincastle sediments are sequences displaying convolute lamination, current ripple lamination and repetitive graded beds that are typically found in submarine sediments emplaced by mass transport (Kuenen, 1953a; Bouma, 1962; Walker, 1965; and others). Hubert and others (1970) have described conglomerates and finer grained sediments similar to the Fincastle sediments that occur in the Middle Ordovician Quebec Supergroup. They have proposed that these deposits were emplaced by mass transport; sedimentary features absent in the Fincastle are present in the Quebec deposits.

Stream deposits of fluvial and alluvial origin are commonly fining-upward sequences (Allen, 1965b; McCave, 1968; and Nilsen, 1968a), and exhibit abundant large and small-scale cross stratification (Allen, 1965b; Dott, 1966; Allen and Friend, 1968; Buttner, 1968; McCave, 1968; and Nilsen, 1968a). Buttner (1968) has described fluvial channels of the Devonian Genesee Group of New York that contain repetitive sequences of granule to boulder polymictic conglomerates and diamictites that fine upward to subgraywacke, which, in turn, grade up into siltstone and mudstone. He proposed each sequence represents the beginning and waning phases of a fluvial system.

The fining-upward sequences of the Devonian Solund conglomerate of Norway is a poorly sorted, massively bedded, polymictic conglomerate with diamictites that grade up into massive-bedded, horizontally stratified sandstones (Nilsen, 1968a). Nilsen (1968a) has proposed these deposits are an upper flow regime, stream channel deposit of alluvial origin. Similar conglomerate deposits of fluvial origin have been described by Stanley (1968).

The Fincastle sediments are underlain and overlain by marine shales, and the presence of fossil detritus in the graywacke (between the second and third conglomerates near Geologic Section 18), indicates the Fincastle sediments were deposited in a marine environment. The Fincastle conglomerates apparently occupy very broad, shallow marine channels from which relatively little of the underlying Liberty Hall shale was scoured. The textural and compositional immaturity of the Fincastle sediments indicates very little or no reworking in a nearshore environment. However, the rounded clasts in the conglomerates indicate a significant abrasion history. The minimum distance of transport is about 31 mi (49.9 km), as this is the minimum distance between the axis of the Blue Ridge anticlinorium and the trough of the Pine Hills depression. Marginal marine channel fills are commonly moderately sorted and display cyclic sedimentation, ripple marks and large-scale cross stratification (McCave, 1968).

Indications are that the Fincastle sediments are a product of resedimentation of an original stream or river deposit to an offshore, probably shallow, marine channel deposit. McBride (1966) has shown that some marine conglomerates are a product of resedimentation from an original fluvial deposit. Fincastle sedimentation was rapid enough for the finer grained sediments to largely escape reworking in a nearshore environment and to prevent the formation of cross stratified beds in the graywackes. The prevalence of horizontal stratification in many channel deposits has been shown to be the result of sedimentation during high velocity flow (Allen, 1965a; Harms and Fahnestock, 1965; Simons and others, 1965; Nilsen, 1968a; Stanley, 1968; and Visher, 1972). Before sedimentation the Fincastle sediments may have occupied the deeper parts of the stream as channel lag deposits (Happ and others, 1940; Lattman, 1960; and Allen, 1965a) and been transported into the marine environment during floods or high river stages. The broad, shallow channels occupied by the conglomerates suggest the conglomerates were washed in as thin, broad sheets.

The lateral grading and interfingering of each conglomerate zone with graywacke and siltstone indicates that the rate of deposition may have decreased toward the edges of the channels. The third and fourth depositional sequences appear to represent the end of gravel deposition and a depletion of gravel in the source area, although in a few places granules and pebbles continued to be washed in until Martinsburg time (Geologic Sections 15 and 18).

The now eroded northwesterly occurrence of the lithologic boundary was probably much wider than what is presently southwest of Little Gulch. The conglomerate zones probably thinned by grading laterally to graywacke to the northwest. There the graywacke would separate the Liberty Hall formation and Martinsburg Shale as the Bays Formation does in the southwesterly depression of the Catawba syncline. The present extent of the Fincastle conglomerate appears to be only part and probably the salient of a much larger conglomerate and graywacke deposit.

The lithology of the overlying Martinsburg suggest the reestablishment of an environment similar to that prior to Fincastle time. The end of coarse detrital sedimentation can be explained either by depletion of coarse material at the source or a rise in sea level, or both. The correlative Bays sediments farther southwest in the Catawba syncline were probably deposited in mostly a shallow marine environment (Hergenroder, 1966). The sandstones of the Bays are moderately well sorted and contain subrounded to rounded quartz grains. Graywackes and subgraywackes of the Bays Formation may represent nearshore river mouth deposits (Hergenroder, 1966).

PALEOGEOGRAPHY AND BLUE RIDGE TECTONISM

The Fincastle conglomerate attests to greater than 15,000 ft (4600 m) of structural relief between the crest of the Blue Ridge anticlinorium and the trough of the Pine Hills depression by Middle Ordovician time; that is, the equivalent Precambrian basement of Marshall gneiss was buried in the Pine Hills depression by at least 15,000 ft (4600 m) of Cambrian, Lower and Middle Ordovician sediment while erosion of gneiss was occurring within the Blue Ridge during Fincastle time. Conservatively, greater than 8000 ft (2500 m) of uplift of the Blue Ridge was required to allow erosion of sediments of the Knox Group and older formations down to the Marshall gneiss by Middle Ordovician time. Likewise, a significant amount of protracted subsidence in the adjacent Salem synclinorium must have taken place to account for the abnormalities in thickness and lithology of sediments accumulating there.

The Blue Ridge may have been positive at times prior to Middle Ordovician time in view of an intraformational conglomerate comprised of large, angular carbonate blocks in the Cambrian Shady Dolomite in the southeasterly part of the Austinville syncline near Austinville, Virginia (Lowry, 1974). The Austinville syncline is the adjacent downwarp northwest of the Blue Ridge anticlinorium.

Southeast of the Pine Hills at the Cahoon locality (Fig. 1) the Middle Ordovician limestones contain a basal conglomerate above the surface of unconformity on the Knox carbonates. The conglomerate is 10 ft (3 m) thick and consists of abraded boulders of limestone and dolomite that range up to 3 ft (1 m) in diameter. The conglomerate, which thins to the northeast and southwest, appears to be a channel fill; the channel trends across strike and is at least 150 ft (46 m) deep and approximately 500 ft (152 m) wide. A detailed study of the clasts in the conglomerate should show whether all the clasts were locally derived or if some of the clasts originated from an area to the southeast that provided the detritus of the Pine Hills and Fincastle conglomerates.

The lack of clasts with lithologies similar to the Middle Ordovician limestones in the Fincastle conglomerate also suggests that the Blue Ridge was emergent prior to Middle Ordovician time. Also, in order to account for the relatively small percentage of carbonate clasts in the Fincastle conglomerate, much of the Knox, Elbrook and Shady must have been deeply weathered on the Blue Ridge. The relatively small percentage of clasts in the Fincastle conglomerate sediments and the local abundance of vein quartz and angular chert clasts in the Fincastle sediments also indicates deep weathering on the Blue Ridge. The Liberty Hall shales and mica-bearing siltstones may represent the erosion of Rome shales on the Blue Ridge as well as other micaceous terranes farther southeast. The Rome Formation alone probably could not have supplied all the terrigenous sediment of the Liberty Hall.

The uplift of the Blue Ridge may have been accomplished either by gentle folding and the formation of a geanticlinal upwarp or by faulting. These two alternatives were proposed by Cooper (1960 and 1969). As the Fincastle conglomerate is probably a product of resedimentation, neither type of uplift can be determined with certainty. If the high on the Blue Ridge was due to a fault, it would have had to have been a high-angle fault in order to expose greater than 8000 ft (2500 m) of section and also to have minimized the amount of horizontal displacement. The Rome Formation and Chilhowee Group of the Blue Ridge block in the Goose Creek area are asymmetrically folded, and the Blue Ridge thrust sheet is nearly horizontal. Thus it is apparent that most of the folding in the Blue Ridge took place prior to any movement on the Blue Ridge fault. Blue Ridge thrusting appears to post-date folding within the Blue Ridge.

CONCLUSIONS

The lithology and petrography of the Fincastle conglomerate show it to be a northeasterly lithofacies of the Bays Formation. Except for the absence of conglomerates, the Bays sediments are not unlike the Fincastle sediments. The Bays and Fincastle sediments are comparable in that they are similar in lithology and environment of deposition.

The Fincastle conglomerate was deposited in very broad, shallow marine channels as thin, sheet-like deposits. The Fincastle sediments were originally stream deposits which were resedimented during flooding or high river stages. The texture and composition of the Fincastle sediments indicate that they essentially bypassed the nearshore environment. Quartz and plagioclase grains are angular and most are unaltered.

More than 8000 ft (2500 m) of sediment was eroded off the Blue Ridge by Middle Ordovician time assuming the Middle Ordovician limestones were never deposited there. Emergence of the Blue Ridge after deposition of Middle Ordovician limestone would require excessively rapid uplift of 8000 ft (2500 m) or more during Liberty Hall time. On the other hand, protracted rising of the Blue Ridge since Early Ordovician or Late Cambrian time seems much more reasonable in view of the evidence presented by the Fincastle conglomerate. The relatively small percentage of metamorphic rock fragments and clasts suggests that the Chilhowee Group was the major source of clasts, quartz and plagioclase grains, and finer detritus of the Fincastle conglomerate. The rarity of basement clasts of Marshall gneiss suggests that only a limited amount was exposed to erosion.

More detailed study of the rocks of southeasterly belts and especially the rocks of the Blue Ridge block will add to the significance of the Fincastle conglomerate and an even better understanding of its tectonic significance.

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APPENDIX

Geologic Sections

Geologic Section 1. Section begins at base of Liberty Hall formation; location on Fig. 4.

	Thickness
Fincastle conglomerate (25+ feet)	
2. Pebble diamictite (sample Fc 19); overlain by dark yellowish-brown, coarse-grained graywacke; probably fines upward into siltstones and shales; mostly covered; upper contact not exposed	2 ft
1. First conglomerate; thins rapidly to 12 ft to northeast against the side of a channel; sample Fc 79	23 ft
Liberty Hall formation (2011 feet)	
21. Gray to dark gray shales and brown siltstones	79 ft
20. Pine Hills conglomerate member (25 feet)	
19. Gray shale with light brown graywacke interbeds less than 1 in thick; includes medium dark gray, coarse-grained calcarenite 1.5 in thick	2.2 ft
18. Pebble and cobble limestone conglomerate in a very fine-grained, conglomeratic, calcite-cemented sandstone matrix, sample Fc 42 and 46	3 in
17. Light brown siltstones and gray shales	1.2 ft
16. Medium dark gray, very coarse-grained calcarenite with small limestone pebbles; bed pinches out 8 ft to southwest	5 in
15. Brown shale; small ripple marks of one bed trend N.20°W.	10 in
14. Granule and pebble limestone conglomerate in a calcarenitic matrix; thins to 3 in, 5 ft to northeast; sample Fc 43; same unit as 1 of Geologic Section 2	7 in
13. Light brown siltstones and gray shales	9.1 ft
12. Dark gray, fine-grained calcarenite; thins to northeast; sample Fc 39	4.5 in
11. Gray shale and abundant interbeds of dark yellowish-brown graywacke less than 1.5 in thick; one interbed is calcareous with angular quartz and plagioclase grains	3.2 ft
10. Pebble and cobble limestone conglomerate with little calcarenitic matrix; thins to northeast to 1 in; clasts are flat and elongate from 0.5 to more than 12 in long; sample Fc 37	5 in
9. Dark gray to black graptolite-bearing shale; graptolites are oriented N.75°W.	2.6 ft
8. Dark gray, fine-grained calcarenite	1 in
7. Dark gray to black shale	2 ft

		Thickness
6.	Medium dark gray, medium- to coarse-grained calcarenite with some small limestone clasts; bed thins to southwest	2 in
5.	Dark gray to black shale	1.5 ft
4.	Dark gray, fine-grained calcarenite	1.5 in
3.	Dark gray to black shales and siltstones; mostly covered	277 ft
2.	Yellowish-gray, coarse-grained bentonite with grains of biotite, feldspar, quartz, apatite and zircon	1.5 in
1.	Brown, dark gray and black shale; mostly covered	1630 ft

Lincolnshire Limestone

Geologic Section 2. Location is 50 ft southwest of unit 14 of Geologic Section 1 (Fig. 4).

		Thickness
	Pine Hills conglomerate member of the Liberty Hall formation; lower contact not exposed (6.1+ feet)	
9.	Dark gray, very fine-grained calcarenite; abundant brachiopods, cephalopods and trilobite fragments	2 in
8.	Dark gray to black, graptolite-bearing shale	2 in
7.	Medium gray, fossiliferous limestone bed with brachiopods and trilobites; thins to 0.5 in to northeast and thickens to southwest	2 in
6.	Dark gray shale	6 in
5.	Dark gray, fine-grained calcarenite with pebble-size limestone clasts; pinches out 3 ft to northeast	3.5 in
4.	Light brown siltstones and dark gray shales	1.5 ft
3.	Grayish-black, coarse-grained calcarenite with small black limestone clasts up to 3 in in diameter (samples Fc 22 and 52); pinches out 11 ft to southwest	4 in
2.	Brown shale	2.2 ft
1.	Granule and pebble limestone conglomerate in a calcarenite matrix; thickens to southwest; same unit as 14 of Geologic Section 1	10 in

Geologic Section 3. Located about halfway between Geologic Sections 1 and 4; location on Fig. 4.

	Thickness (feet)
Martinsburg Shale	
Fincastle conglomerate (49 feet)	
4. Dark yellowish-brown graywacke with some interbedded brown siltstones; grades up into light gray to gray shale..	4
3. Brown, very coarse-grained graywacke, in part diamictite; probably the second conglomerate..............	1
2. Dark yellowish-brown graywacke with some interbedded brown siltstones.......................................	21
1. First conglomerate......................................	23
Liberty Hall formation	

Geologic Section 4. Location on Fig. 4.

	Thickness (feet)
Fincastle conglomerate (46+ feet)	
3. Second conglomerate; upper contact not exposed.........	2
2. Dark yellowish-brown graywacke with interbedded brown siltstones and gray to dark gray shale...........	21
1. First conglomerate; samples Fc 53, 54, 58, 69 and 70; about 15 ft above base is large scour channel filled with conglomerate overlain by dark yellowish-brown graywacke..	23
Liberty Hall formation	

Geologic Section 5. Location on Fig. 4.

	Thickness (feet)
Martinsburg Shale	
Fincastle conglomerate (48 feet)	
4. Dark yellowish-brown graywacke grading upward into brown siltstones and light gray to gray shales.........	6
3. Second conglomerate; coarse pebble and cobble conglomerate..	14
2. Dark yellowish-brown graywacke with some interbedded brown siltstones and gray shales......................	18
1. First conglomerate; coarse pebble conglomerate and some cobbles.....................................	10

Liberty Hall formation

Geologic Section 6. Location on Fig. 4.

		Thickness
Martinsburg Shale		
Fincastle conglomerate (54 feet)		
11.	Dark yellowish-brown graywacke grading upward into brown siltstones and gray shales........................	11 ft
10.	Dark yellowish-brown graywacke..........................	5.6 ft
9.	Intergradational, coarse-grained diamictite............	6 in
8.	Dark yellowish-brown graywacke..........................	1.4 ft
7.	Diamictite grading upward to brown graywacke...........	6 in
6.	Second conglomerate....................................	9 ft
5.	Dark gray shale and interbedded brown graywacke........	11 ft
4.	Dark yellowish-brown graywacke..........................	4.3 ft
3.	Pebble conglomerate lens; thickens northeast and thins to southwest................................	6 in
2.	Dark yellowish-brown graywacke; thickens to 2 ft, 7 ft to northeast in a scour channel with a basal pebble conglomerate...	5 in
1.	First conglomerate; sample Fc 74 and 124...............	9.8 ft
Liberty Hall formation (28+ feet)		
2.	Brown and gray to dark gray shale......................	27.8 ft
1.	Medium dark gray, coarse-grained calcarenite (sample Fc 75); highest bed of Pine Hills conglomerate member..	3 in

Geologic Section 7. Location on Fig. 4.

		Thickness (feet)
Fincastle conglomerate (30+ feet)		
4.	Polymictic pebble diamictite with abundant vein quartz pebbles; intergradational within graywacke.............	3
3.	Alternating dark yellowish-brown graywacke, brown siltstone and gray shale; all thin-bedded; marker zone between second and third conglomerates................	6
2.	Dark yellowish-brown graywacke.........................	8.5
1.	Second conglomerate (sample Fc 122); contains three large scour channels filled with pebble conglomerate grading upward to dark yellowish-brown graywacke overlain sharply by conglomerate. An 11X17-in, well-rounded, very coarse-grained Unicoi sandstone clast (sample Fc 23) is 7.4 ft above the base; sample Fc 57 is 6 ft above the base................................	12.5

Geologic Section 8. Location on Fig. 4.

		Thickness (feet)
Fincastle conglomerate (42+ feet)		
6.	Polymictic pebble diamictite with abundant vein quartz pebbles; intergradational within graywacke; grades upward into coarse-grained, massively bedded, brown graywacke	3
5.	Alternating dark yellowish-brown graywacke (maximum 4 in thick), brown siltstone and gray shale; all thin-bedded; marker zone between second and third conglomerates	5.5
4.	Dark yellowish-brown graywacke	7
3.	Second conglomerate; contains lenses of dark yellowish-brown graywacke and scour channels	13.5
2.	Covered, probably graywacke grading upward to siltstones	11
1.	First conglomerate; a coarse pebble conglomerate	2

Liberty Hall formation

Geologic Section 9. Location on Fig. 4.

			Thickness (feet)
Fincastle conglomerate (69.2+ feet)			
6.	Third conglomerate; characteristically comes and goes; thickness changes rapidly along strike; consists of two conglomerate zones		16.9
d.	Zone grades from pebble conglomerate to diamictite to graywacke	7.3	
c.	Coarse pebble conglomerate with some cobbles; same unit as 1b of Geologic Section 10	4	
b.	Zone grades from pebble conglomerate to diamictite to graywacke; overlain sharply by a coarse pebble conglomerate	3.6	
a.	Cobble conglomerate with many lenses of pebble conglomerate consisting mainly of vein quartz clasts	2	
5.	Brown, coarse-grained, silty graywacke overlain by coarser grained graywacke		4
4.	Dark gray shale with some interbedded brown, fine-grained graywacke		11.2
3.	Brown, well-bedded, medium-grained subgraywacke beds less than 5 in thick, interbedded with dark gray shale.		6
2.	Brown, massive- to medium-bedded, coarse-grained graywacke		16.3

	Thickness (feet)
1. Second conglomerate; contains abundant graywacke lenses and only the basal part is coarse cobble conglomerate; remainder is coarse pebble conglomerate with minor cobbles; first conglomerate has fined to siltstones and shales..	14.8

Liberty Hall formation

Geologic Section 10. Location about 25 ft southwest of Geologic Section 9 (Fig. 4).

		Thickness (feet)
Martinsburg Shale		
Fincastle conglomerate (21+ feet)		
2. Brown, thin-bedded, coarse-grained, silty graywacke and siltstone beds; contains clasts of rounded to well-rounded vein quartz, carbonate and Unicoi sandstone up to 3X4 in in diameter; average is 0.5 to 1 in; all matrix supported......................................		2
1. Third conglomerate; characteristically comes and goes; consists of two conglomerate zones....................		19
c. Dark yellowish-brown, thin-bedded, coarse-grained graywacke; many scour channels and cross-stratified beds.....................	9.8	
b. Pebble conglomerate; entirely vein quartz clasts; appears to become finer grained to southwest; same unit as 6c of Geologic Section 9................................	4.2	
a. Lowest conglomerate grades upward to diamictite which grades up into graywacke; overlain sharply by pebble conglomerate....	5	

Geologic Section 11. Big Gulch; location on Fig. 4.

	Thickness (feet)
Martinsburg Shale (50+ feet)	
3. Brown to gray shale...................................	10
2. Brown to gray shale and interbedded brown sandstone beds less than 4 in thick.............................	5
1. Brown to gray shale...................................	35

		Thickness (feet)
Fincastle conglomerate (302.5 feet)		
36.	Alternating brown, thin-bedded, silty sandstones and brown siltstones; sole markings on sandstones trend about east-west from the east	19
35.	Brown, thick-bedded, medium-grained subgraywacke with sole markings; trend N.88°E. and N.82°W., from the east ; sample Fc 27	5.2
34.	Gray shale	0.5
33.	Dark yellowish-brown, thick-bedded, coarse- to medium-grained graywacke	2.6
32.	Alternating brown siltstones, gray shales and dark yellowish-brown graywacke beds 2 to 3 in thick	3.8
31.	Dark yellowish-brown, thick-bedded, coarse- to medium-grained graywacke	1.3
30.	Brown siltstones and gray shales	13.4
29.	Alternating dark yellowish-brown graywacke beds and brown siltstones	5.4
28.	Brown siltstones and gray shales	41.4
27.	Brown siltstones and brown, silty graywacke beds 4 to 6 in thick	1.6
26.	Brown siltstones and a few brown, thin-bedded graywacke beds; axis of local anticline	3
25.	Alternating dark yellowish-brown graywacke beds and brown siltstones; one graywacke bed is 2 ft thick; set of joints trend N.60°E.; axis of local syncline	7
24.	Brown siltstones and a few thin interbeds of brown graywacke	13.8
23.	Dark yellowish-brown, medium-grained graywacke	2.3
22.	Alternating brown siltstones and brown graywacke beds less than 1 in thick	13.8
21.	Brown siltstones	23
20.	Dark yellowish-brown graywacke and a few interbeds of brown siltstone	11
19.	Dark yellowish-brown, medium-grained graywacke with sole markings trending N.70°E., from the east	1.5
18.	Alternating gray shales and dark yellowish-brown graywackes	7
17.	Dark yellowish-brown, medium-grained graywacke	0.7
16.	Light gray to gray, sandy shale	5.1
15.	Brown siltstones	6.5
14.	Dark yellowish-brown, thin-bedded, medium- to fine-grained graywackes and interbedded brown siltstones and gray shales; set of joints about 2 in apart, trend N.70°W.	13
13.	Brown siltstones	6.4
12.	Dark yellowish-brown, coarse-grained graywacke	1.5
11.	Fourth conglomerate; a coarse pebble to small cobble conglomerate	2.2

			Thickness (feet)
10.	Brown siltstones and some brown, thin-bedded graywacke beds		19.3
9.	Alternating dark yellowish-brown, medium-grained graywacke (1 in thick beds), brown siltstones and gray shales		11.8
8.	Gray to dark gray shale		1.7
7.	Dark yellowish-brown, very coarse-grained graywacke with vein quartz grit about 0.1 in in diameter		2.7
6.	Gray to dark gray shales and brown siltstones		7
5.	Coarse-grained diamictite in a graywacke matrix; contains a pebble conglomerate lens 6 in thick		2.6
4.	Third conglomerate		10.5
	d. Pebble and cobble conglomerate	2.2	
	c. Cobble conglomerate with medium-grained graywacke lenses	1.9	
	b. Pebble and cobble conglomerate with graywacke lenses	1.9	
	a. Pebble and cobble conglomerate; coarsens to northeast	4.5	
3.	Gray to dark gray shale		18
2.	Alternating dark yellowish-brown graywacke, brown siltstone and gray to dark gray shale; all thin-bedded; marker zone between second and third conglomerates; sole markings of one graywacke bed trend east-west, from the east		13
1.	Second conglomerate; coarse pebble and cobble conglomerate; first conglomerate has fined to siltstones and shales		3.9

Liberty Hall formation

Geologic Section 12. Location about 20 ft northeast of Geologic Section 11 (Fig. 4).

		Thickness (feet)
Fincastle conglomerate (37.2+ feet)		
7.	Third conglomerate; mainly a pebble conglomerate with a few cobbles	3.6
6.	Gray to dark gray shale	6.9
5.	Alternating dark yellowish-brown graywacke, brown siltstone and gray to dark gray shale; all thin-bedded; marker zone between second and third conglomerates	5.7
4.	Brown siltstones	2.4
3.	Dark yellowish-brown, medium-grained graywacke	1.4
2.	Brown siltstones and interbedded gray to dark gray shales	12.9

	Thickness (feet)
1. Second conglomerate; first conglomerate has fined to siltstones and shales	4.3

Liberty Hall formation

Geologic Section 13. Little Gulch, location on Fig. 4.

		Thickness (feet)
Martinsburg Shale		
Fincastle conglomerate (60 feet)		
7. Third conglomerate; dark yellowish-brown, massively bedded, coarse-grained graywacke with many lenses of pebble and coarse pebble conglomerate; changes thickness and coarseness rapidly along strike; same unit as 1 of Geologic Section 14		16.7
i. Dark yellowish-brown graywacke grading up into brown siltstones and gray shales	4.7	
h. Very coarse pebble conglomerate	1.3	
g. Dark yellowish-brown graywacke	1.5	
f. Pebble conglomerate	1	
e. Dark yellowish-brown graywacke	1.3	
d. Pebble conglomerate; thins rapidly to southwest	3.3	
c. Dark yellowish-brown graywacke	1.3	
b. Coarse pebble conglomerate	1	
a. Dark yellowish-brown graywacke	1.3	
6. Alternating dark yellowish-brown graywacke, brown siltstone and gray shale; all thin-bedded; marker zone between second and third conglomerates; mostly covered.		12.7
5. Dark yellowish-brown, medium-bedded, coarse-grained graywacke		1.3
4. Brown siltstones and interbedded light gray shales and brown mudstones		3.3
3. Dark yellowish-brown, massively bedded, coarse-grained graywacke; becomes finer grained and thin-bedded to southwest		4
2. Mostly covered, probably siltstones		16.5
1. Second conglomerate (sample Fc 34); largest clasts are 2 to 3 in in diameter; abundant carbonate clasts		5.5

Liberty Hall formation

Geologic Section 14. Location about 45 ft northeast of Geologic Section 13 (Fig. 4); measured up from unit 7 of Geologic Section 13.

	Thickness (feet)
Martinsburg Shale	
Fincastle conglomerate (62.8+ feet)	
4. Dark yellowish-brown graywacke, overlain sharply by Martinsburg Shale	1
3. Light gray to gray shale and interbedded brown graywacke and brown siltstone beds less than 2 in thick	28.7
2. Brown siltstone	23.1
1. Third conglomerate; massively bedded, coarse pebble and cobble conglomerate with clasts up to 7 in in diameter; same unit as 7 of Geologic Section 13	10

Geologic Section 15. Overturned southeast limb of Catawba syncline along U.S. Route 220; measured before new roadcut was made, location on Fig. 4.

	Thickness (feet)
Martinsburg Shale (780.5+ feet)	
3. Mainly calcareous gray shale and dark gray, thin-bedded, silty limestones and pelite which weathers rapidly; upper part has been eroded; *Sowerbyella* occurs in a layer 31.5 ft above unit 2	771
2. Brown mudstone and gray shale; some layers contain granules and pebbles of vein quartz and Unicoi sandstone; fossils occur throughout this interval; most fossiliferous layer is 2 ft thick and occurs 5.5 ft above unit 1; fossils include *Sowerbyella cava*, *Orthambonites* and *Calliops*	7.5
1. Gray shale	2
Fincastle conglomerate (83.8 feet)	
9. Dark yellowish-brown graywacke and some interbedded gray, calcareous shale	17
8. Third conglomerate(?); pebble and cobble conglomerate with clasts up to 7 in in diameter; samples F3AA, F3B and F3M	14.5
7. Dark yellowish-brown graywacke	2.1
6. Dark yellowish-brown, massively bedded graywacke with intergradational lenses of polymictic diamictite; dominant clast is carbonate	9.8
5. Sheared brown siltstones	9

			Thickness (feet)
4.	Second conglomerate(?); pebble and cobble conglomerate with some cobbles up to 6X7 in in diameter; samples Fc 113 and 112; zone contains abundant graywacke lenses...		4.4
3.	Dark gray shale; local tectonic thickening to 3 ft.....		1
2.	Dark yellowish-brown graywacke with lenses of intergradational, poorly sorted, polymictic diamictite......		10.5
1.	First conglomerate(?)................................		15.5
	b. Upper part is mostly massively bedded, coarse-grained graywacke; lower part (samples Fc 47-49, 108, 128 and 131) is pebble and boulder conglomerate with clasts up to 13.5 in (Fc 50) in diameter................	3	
	a. Pebble and cobble conglomerate with a 1-ft graywacke lens 2.5 ft above base; samples F5a, F5K, F5L, F5M and F5U.................	12.5	

Liberty Hall formation (24.5+ feet)

2.	Gray shale; overlain sharply by Fincastle conglomerate.	23
1.	Dark blue-gray, thin-bedded, fine-grained limestone; same unit as 1 of Geologic Section 16.................	1.5

Geologic Section 16. Location on Fig. 4.

		Thickness (feet)

Martinsburg Shale

Fincastle conglomerate (16.3 feet)

1.	Pebble and cobble conglomerate with clasts up to 3 in in diameter; grades up into dark yellowish-brown, coarse-grained graywacke which is overlain by brown siltstones and gray to dark gray shales...............	16.3

Liberty Hall formation (24.5+ feet)

2.	Gray shale; overlain sharply by Fincastle conglomerate.	23
1.	Dark blue-gray, thin-bedded, fine-grained limestone with a bed of limestone conglomerate of same lithology as the limestone; same unit as 1 of Geologic Section 15..	1.5

Geologic Section 17. Location on Fig. 4.

	Thickness (feet)
Martinsburg Shale	
Fincastle conglomerate (83+ feet)	
15. Dark gray graywacke	0.5
14. Gray shale	17.3
13. Dark gray graywacke	0.5
12. Gray shale	6.2
11. Gray graywacke	1.6
10. Gray shale	6.2
9. Gray graywacke	1.2
8. Alternating gray, silty shale, light gray to gray siltstone and gray graywacke beds less than 2 in thick	5.6
7. Gray, medium-bedded graywacke with scour channels filled at base with graywacke; top is same unit as 8 of Geologic Section 20	4.2
6. Alternating gray, silty shale, light gray to gray siltstone and gray graywacke beds less than 2 in thick	8.4
5. Gray, massive-bedded graywacke	2.9
4. Gray shale	7.2
3. Gray graywacke	2.5
2. Sheared gray siltstones and shales	5.1
1. Gray, medium- to coarse-grained graywacke; base not exposed	13.5

Geologic Section 18. Location on Fig. 4.

	Thickness (feet)
Martinsburg Shale (77.8+ feet)	
2. Severely slumped and contorted, fossiliferous, brown mudstone; slumped penecontemporaneous; one layer contains granules and pebbles of vein quartz and Unicoi sandstone	34
1. Olive-gray to gray shale	43.8
Fincastle conglomerate (149.8 feet)	
15. Gray, fine- to medium-grained graywacke with small-scale scouring; current ripple lamination and parallel lamination at base	10.9
14. Covered	10.9
13. Dark yellowish-brown graywacke	1
12. Gray shale with interbeds of gray siltstone	12.6
11. Dark yellowish-brown, medium- to coarse-grained graywacke	5
10. Gray shale	2.5

			Thickness (feet)
9.	Third conglomerate; base is a pebble and cobble conglomerate, samples Fc 1, 7 and 114b; rest is pebble conglomerate with abundant shale chips and carbonate clasts; grades upward to 6 in of brown graywacke which, in turn, grades upward to shale.................		13.5
8.	Gray shale and reddish-brown siltstone.................		5
7.	Pebble conglomerate lens which grades upward to diamictite..		1
6.	Dark yellowish-brown graywacke and interbedded brown siltstone...		5.9
5.	Second conglomerate; pebble and cobble conglomerate with abundant shale chips................................		25.2
4.	Mostly covered; probably diamictite fining to siltstone and shale..................................		10.9
3.	Diamictite with clasts up to 3 in in diameter; matrix is dark gray, silty, pelitic graywacke.................		18.1
2.	Dark yellowish-brown graywacke; base is the scoured underlying conglomerate and top is scoured by the overlying diamictite..................................		8
1.	First conglomerate......................................		19.3
	d. Pebble and cobble conglomerate with lenses of dark yellowish-brown graywacke..........	9.2	
	c. Pebble conglomerate with minor cobbles and abundant graywacke lenses..............	7.3	
	b. Dark brown graywacke and diamictite with clasts up to 2 in in diameter..............	0.7	
	a. Pebble and cobble conglomerate with abundant shale chips.......................	2.1	

Liberty Hall formation

Geologic Section 19. Location on Fig. 4, basal contact of Fincastle conglomerate is in Catawba Creek.

Martinsburg Shale

Fincastle conglomerate (138.4 feet)

		Thickness (feet)
8.	Predominantly brown siltstone grading upward to shale; interbeds of dark yellowish-brown graywacke which grade upward to brown siltstone, which, in turn, grade up into gray shale.............................	30.7
7.	Dark yellowish-brown graywacke; grades up to brown siltstone...	3.6

			Thickness (feet)
6.	Third conglomerate		3.9
	c. Pebble conglomerate of mainly vein quartz and minor Unicoi sandstone pebbles	1.6	
	b. Dark yellowish-brown, coarse-grained graywacke lens	0.7	
	a. Vein quartz pebble conglomerate; base is predominantly ripped-up shale chips	1.6	
5.	Gray shale and gray to reddish-brown siltstones		23.8
4.	Polymictic diamictite with clasts up to 9 in in diameter; matrix is dark brown, coarse-grained graywacke		16.9
3.	Second conglomerate; cobble and boulder conglomerate which grades upward to diamictite; less matrix and more abundant boulders than first conglomerate		13.9
2.	Gray, silty shale overlain by second conglomerate		9.9
1.	First conglomerate; cobble and boulder conglomerate overlain sharply by shale; many clasts are in relatively unstable positions; percentage of silty graywacke matrix is high; approaches appearance of diamictite; local scouring of underlying shale		35.7

Liberty Hall formation

Geologic Section 20. Located 102 ft N.13°E. of Geologic Section 17 (Fig. 4).

Fincastle conglomerate (100.6+ feet)

		Thickness (feet)
9.	Gray shale; 8 ft to northeast the shale is scoured and filled with 10 ft of graywacke; top not measured	10
8.	Gray, medium- to thick-bedded graywacke; top is same unit as 7 of Geologic Section 17	37.7
7.	Gray siltstones	7.1
6.	Gray, massive-bedded graywacke with vein quartz granules and gray shale chips	5.5
5.	Gray, silty shale and graywacke beds less than 8 in thick	9.4
4.	Gray, medium-bedded graywacke	2
3.	Gray, cross-stratified graywacke with vein quartz pebbles at top	3.8
2.	Gray, massive-bedded graywacke and minor gray shale partings	20.1
1.	Diamictite; predominantly granules and pebbles of vein quartz and minor clasts up to 3 in in diameter	5

Liberty Hall formation

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THE MIDDLE ORDOVICIAN FINCASTLE CONGLOMERATE

NORTH OF ROANOKE, VIRGINIA AND ITS

IMPLICATIONS FOR BLUE RIDGE TECTONISM

by

John B. Karpa III

(ABSTRACT)

Clasts within the Fincastle conglomerate indicate that more than 15,000 ft of structural relief had developed between the axis of the Blue Ridge anticlinorium and the trough of the Salem synclinorium by Middle Ordovician time. The Fincastle conglomerate is restricted to the northeast depression of the Salem synclinorium, south of the Southern and Central Appalachian boundary. Evidence indicates the Fincastle conglomerate is a northeastern lithofacies of the Bays Formation. The Fincastle has an average thickness of 48 to 69 ft, a maximum thickness of 300 ft, and is absent to the southwest where it has fined to siltstone and shale. Each conglomerate zone may grade up into diamictite or graywacke which, in turn, grades upward into shale. Clasts of well-foliated basement gneiss, vein quartz, quartz pebble conglomerate, sandstone and carbonate clasts were derived from the complementary Blue Ridge anticlinorium and perhaps the Piedmont. Calcite-cemented sandstone, sandstone conglomerate and micritic, black limestone clasts were probably derived from within the basin. The deposit is characterized by subrounded to rounded, elongate clasts (up to 17 in long) in a graywacke matrix. The Fincastle conglomerate was deposited in broad, shallow, marine channels. Sedimentary features indicate it was resedimented from a stream environment during flooding or high river stages. The textural

and compositional immaturity of the Fincastle sediments indicate they bypassed the nearshore marine environment. The Fincastle conglomerate indicates erosion of a local culmination on the Blue Ridge anticlinorium or a geanticline in Middle Ordovician time to the southeast in the vicinity of the Goose Creek window.