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SANDY LEVEL AND CALLANDS QUADRANGLES

GEOLOGY AND MINERAL RESOURCES OF THE SANDY LEVEL AND CALLANDS QUADRANGLES, VIRGINIA

By

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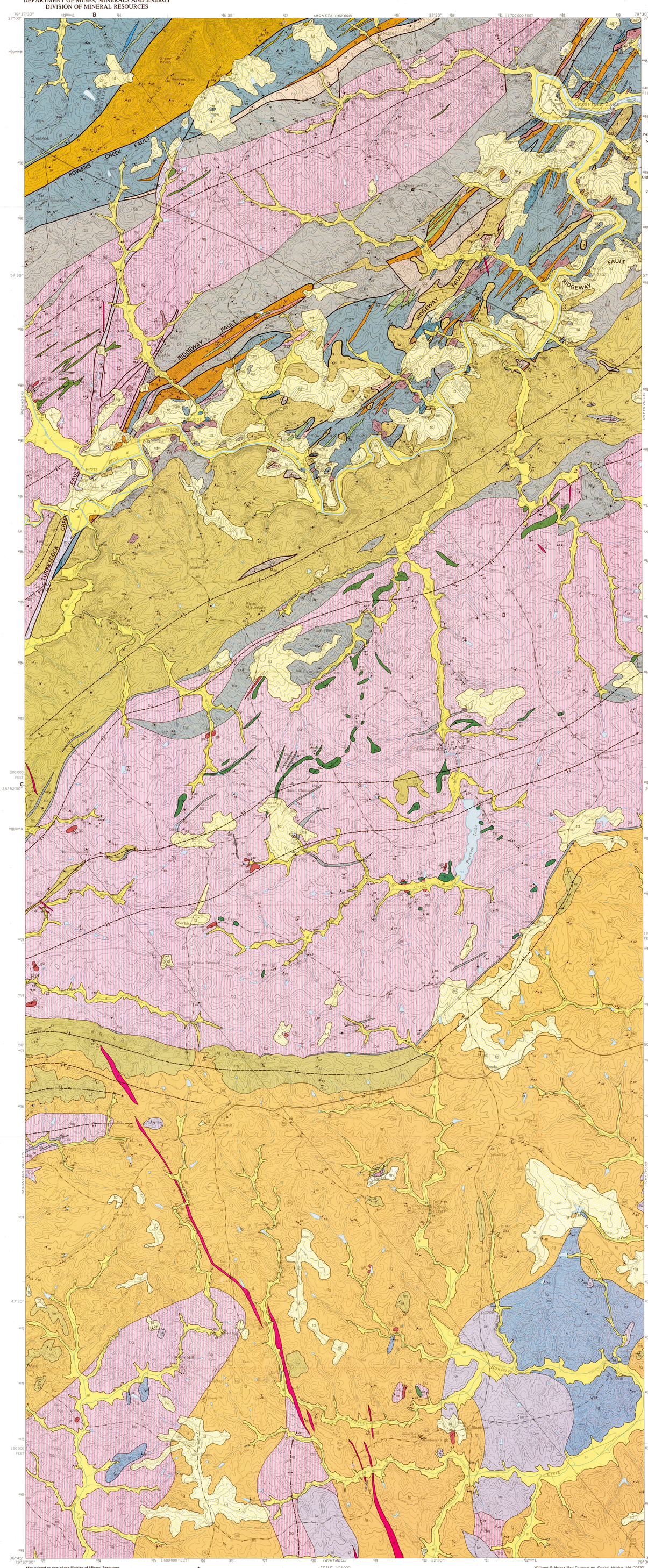

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EXPLANATION

QUATERNARY

al — Alluvium: *Organics, clay, silt, sand, gravel*

td — Terrace deposits: *Rounded pebbles and cobbles in a sandy-clay matrix*

TRIASSIC-JURASSIC

d — Diabase dikes: *Fine- to medium-grained, black diabase*

LATE PALEOZOIC-EARLY MESOZOIC

my, smy — Younger cataclastic rocks: my, *foliated mylonite; smy, angular fragments of silicified mylonite and crypto-crystalline quartz*

PALEOZOIC

tp — Younger intrusive rocks: *leucogranite and pegmatite*

c, cs, crh — Older cataclastic rocks: c, fine-grained, non-foliated cataclasite; cs, *cataclastic schist and phyllonite showing button or fish scale texture; cm, mylonite to protomylonite*

ORDOVICIAN

lw, fg — Martinsville igneous complex: lw, Leatherwood Granite, *coarse-grained granite with rapakivi texture;* lg, *leucogneiss*

CAMBRIAN

cp — Candler Formation: *phyllite with interlayers of thin quartzite*

PRECAMBRIAN TO PALEOZOIC

LATE PRECAMBRIAN

mgw, s, t, q, a, m, gq — Lynchburg Formation: *predominantly* mgw, *metagraywacke, phyllite, biotite schist and gneiss;* t, *tremolite chlorite schist;* gp, *graphitic phyllite;* ws, *white mica schist;* q, *quartzite;* a, *amphibolite;* m, *marble;* gq, *graphitic quartzite;* (No stratigraphic order implied)

SMITH RIVER ALLOCHTHON:

fm, fs, fg — Fork Mountain Formation: fs, staurolite-mica schist; fm, *garnet-sillimanite-mica schist;* fg, *garnet-biotite gneiss*

ba, bg, tts, gb — Bassett Formation: *primarily* bg, *biotite gneiss;* ba, *amphibolite;* tts, *talc-tremolite schist;* gb, *gabbro*

KEY

CONTACTS

Exposed, or approximate

Covered, or inferred

FAULTS

Black solid line where exposed or approximate; gray solid line where covered or inferred; U, upthrown side; D, downthrown side; T on overthrust block, on map only; arrows indicate relative direction of dip of fault plane; T movement toward viewer, A movement away from viewer, cross section only.

SHEAR ZONE

ATTITUDE OF ROCKS

Strike and dip of inclined beds.

FOLIATION

Strike and dip of inclined compositional layering.

Strike of vertical compositional layering.

Strike and dip of inclined schistosity.

Strike of horizontal schistosity.

Strike of vertical schistosity.

LINEATIONS

Direction and angle of plunge of inclined mineral lineation.

Direction and angle of plunge of rodding and mullion structures.

QUARTZ VEINS

FOLDS

Anticline, approximate location of axial trace and direction of plunge of axis.

Syncline, approximate location of axial trace and direction of plunge of axis.

Overturned anticline, approximate location of axial trace and direction of plunge of axis.

Overturned syncline, approximate location of axial trace and direction of plunge of axis.

Minor anticline, direction and angle of plunge of fold axis; strike and dip of axial plane.

Minor syncline, direction and angle of plunge of fold axis; strike and dip of axial plane.

Minor anticline, direction and angle of plunge of fold axis; vertical axial plane.

Minor syncline, direction and angle of plunge of fold axis; vertical axial plane.

Minor overturned anticline, direction and angle of plunge of fold axis; strike and dip of axial plane.

Minor overturned syncline, direction and angle of plunge of fold axis; strike and dip of axial plane.

LOCATION OF REPRESENTATIVE OUTCROPS

LOCATION OF MINES, QUARRIES, OR PROSPECTS

Prospect

Abandoned mine or quarry

Callands:

1. Pegmatite

Sandy Level:

1. Iron
2. Iron
3. Iron
4. Barite
5. Barite
6. Iron
7. Marble

SAMPLE LOCATIONS

R, repository number of rock sample on file at the Division of Mineral Resources.

INTRODUCTION

The Sandy Level and Callands 7.5-minute quadrangles are located approximately 25 miles northwest of Danville in western Pittsylvania and eastern Franklin counties. The area is bounded by north latitudes 37°00′ and 36°45′, and by west longitudes 79°30′ and 79°37′30″; it comprises about 119 square miles and is in the typical rolling topography of the Inner Piedmont Province. Elevations range from about 600 feet above sea level at Leesville Lake to about 1640 feet at Smith Mountain. A dendritic drainage pattern is developed in the area and is controlled partially by joints, faults, and the trend of rock units. Prior studies in the quadrangle include a report on barite by Edmundson (1938); a groundwater report by LeGrand (1960); and a field-trip guidebook on the stratigraphy of the region by Redden (1963).

Major roads servicing the region are State highways 40, 41, and 57. Use of the land in this area is chiefly agricultural; products are wheat, corn, and tobacco, with some pork and beef production. Leesville Lake is part of Appalachian Power Company's pumped-storage operation.

STRATIGRAPHY

Rocks in the report area are located within two major structures, the Smith River allochthon and the Blue Ridge anticlinorium. The allochthon is a shallow, polydeformed, rootless structure that is thrust westward over the rocks of the Blue Ridge anticlinorium.

Smith River Allochthon

The Smith River allochthon was named by Conley and Henika (1973). Metasedimentary rocks of the Bassett Formation are structurally and probably stratigraphically overlain by the metasedimentary rocks of the Fork Mountain Formation. This Late Precambrian to Early Paleozoic sequence underwent regional prograde metamorphism to sillimanite grade followed by retrograde metamorphism to greenschist facies (Conley, 1978). The metasedimentary rocks were then intruded by rocks of the Martinsville igneous complex during the Ordovician period (Rankin, 1975; Odom and Russell, 1975; Ragland, Conley, and Odom, in preparation). Thrusting of the allochthon occurred during the Carboniferous period (Conley, 1978) followed by development of dextral transpressional faults. Three metamorphic episodes can be recognized in rocks of the allochthon, contrasting with a single prograde event in the Lynchburg and Candler formations (Conley, 1981).

Bassett Formation

The Bassett Formation is composed of biotite gneiss overlain by amphibolite. The biotite gneiss is a light-gray, equigranular, fine- to medium-grained, massive to banded rock that weathers to a moderate reddish-orange saprolite. The composition ranges from 20 to 40 percent quartz, 15 to 35 percent biotite, 5 to 10 percent plagioclase, 5 to 25 percent microcline, and 5 to 10 percent muscovite, with trace amounts of epidote, magnetite, ilmenite, apatite, and sphene. The gneiss commonly contains interlayers, up to a few feet thick, of biotite schist, chlorite schist, epidote- and feldspar-rich quartzite, and amphibolite. Within the gneiss are mappable bodies of gabbro and talc-tremolite schist. A medium- to coarse-grained pyroxene gabbro is exposed in the map area as a deeply-weathered rock or a yellowish-brown saprolite. The talc-tremolite schist is green to grayish-green, medium- to coarse-grained and is typically composed of 40 percent chlorite, 45 percent tremolite-actinolite, and 10 percent talc with accessory sphene, magnetite, and ilmenite. Talc is commonly pseudomorphous after pyroxene. The upper part of the biotite gneiss unit is biotite-rich. The contact between the biotite gneiss and the overlying amphibolite is gradational, and interlayers of amphibolite become more numerous over an interval of tens of feet. A good exposure of this sequence is in Lick Fork Creek, Sandy Level quadrangle.

The amphibolite is light green to dark-greenish-black, fine- to coarse-grained, foliated, and weathers to a yellowish-orange saprolite. Interlayers of biotite gneiss are locally present. The composition of the rock ranges from 35 to 60 percent amphibole, 15 to 30 percent epidote, up to 25 percent quartz, up to 20 percent plagioclase, and accessory amounts of ilmenite, sphene and magnetite. Major-element analysis indicates a similarity in composition to continental basalts (Conley, 1981); relict amygdaloidal texture is present but rare in the amphibolite. Lenses of light-green epidosite and massive garnet-pyroxene granofels are common. Pegmatite dikes intrude the unit.

An equigranular, compositionally layered biotite gneiss containing interlayers of coarse leucogranite, alaskite, and granite crops out in the southern half of the Callands quadrangle. This rock is in part a migmatite. Textural and compositional characteristics of this rock indicate that its paleosome was the biotite gneiss member of the Bassett Formation. Furthermore, amphibolite and ultramafic rocks that typically occur in the Bassett gneiss are also locally present.

Fork Mountain Formation

The Bassett Formation is overlain by the Fork Mountain Formation. The Fork Mountain is subdivided into garnet-sillimanite-mica schist, staurolite-mica schist, and garnet-biotite gneiss. The garnet-sillimanite-mica schist is gray, fine- to medium-grained, and contains about 10 to 50 percent sericite, up to 25 percent chloritoid, 20 percent muscovite, 15 percent quartz, 12 percent chlorite, 10 percent biotite, 30 percent sillimanite, 10 percent garnet, and accessory amounts of ilmenite, magnetite, and tourmaline. The garnet-sillimanite-mica schist and the staurolite-mica schist have undergone polymetamorphism and polydeformation. The first prograde metamorphism, which ranged from lower to upper amphibolite facies, is preserved as pseudomorphous sericite after either staurolite or sillimanite and as relict sillimanite inclusions in quartz. The sericite was produced during a second (retrograde) event. Smaller prograde sillimanite and staurolite blasts have grown within these pseudomorphs during a third (contact) metamorphic event in the vicinity of plutons of the Martinsville igneous complex. Euhedral chloritoid is post-tectonic as it has grown across the foliation. Garnets are syntectonic and post-tectonic; some are euhedral and poikiloblastic, but others contain sigmoidal trains of inclusions with euhedral overgrowths.

The staurolite-mica schist is fine-grained, gray, and contains porphyroblasts of magnetite, garnet, and chloritoid. Sericite pseudomorphs after first-prograde staurolite porphyroblasts (up to 2 inches in length) are characteristic of this unit; otherwise the unit is similar to the garnet-sillimanite-mica schist. Rocks of the two schist units differ mainly in metamorphic grade and probably share an origin from the same sediments. The contact between the rocks is therefore a relict regional metamorphic isograd. The regional metamorphic grade increases to the southeast. Both schist members commonly contain interlayers of thin (2 ft) light-greenish-gray epidote quartzite and thicker (10 to 15 ft) micaceous quartzite; quartz may also occur as inch-thick lenses; pegmatites locally intrude the schists. The contact with the gneiss member is generally gradational over several feet.

The garnet-biotite gneiss is a medium- to coarse-grained, light- to dark-gray rock composed of alternating biotite-rich and quartzofeldspathic layers. The gneiss contains epidote-rich quartzite interlayers up to 3 feet thick. The composition of the garnet-biotite gneiss ranges from 15 to 50 percent biotite, 15 to 40 percent quartz, 5 to 30 percent microcline, and approximately 10 percent muscovite, 5 percent plagioclase, and 15 percent garnet with accessory amounts of sillimanite, sphene, epidote, and opaque minerals. Sillimanite occurs both as fibrolite produced during regional metamorphism (now partially to totally altered to sericite) and as post-tectonic euhedral crystals produced during later contact metamorphism. Post-tectonic sillimanite and muscovite porphyroblasts commonly are not oriented and grow across the foliation, indicating growth under non-stress conditions.

Blue Ridge Anticlinorium

Lynchburg Formation

The Lynchburg Formation is characterized by a heterogeneous assemblage of metasedimentary and metavolcanic rocks. It is recognized that these rocks may also be equivalent to the lower Ashe and upper Alligator Back formations, but this report will use the Lynchburg Formation terminology. Within the map area the Lynchburg is subdivided into eight units; folds and/or unmapped faults have caused repetition of units.

The Lynchburg is predominantly a metagraywacke with chlorite phyllite, schist and gneiss, and gneiss. The chlorite phyllite is a lustrous, light-grayish-green to gray, chlorite-quartz rock that contains lens-shaped layers of quartzite and graphitic phyllite and schist up to several feet thick. Foliation is well developed. Randomly oriented late- or post-tectonic chloritoid porphyroblasts have grown across the foliation. Euhedral magnetite and pyrite are common. Although most of the rocks of this unit are bounded on the northwest and southeast by faults and are exposed between the Candler and Bassett formations, some chlorite phyllite is found west of the Candler Formation. The schist and gneiss unit is a dark-green to light-brown, fine- to medium-grained biotite schist that grades into a gray to olive, fine- to medim-grained biotite gneiss. Granule- to sand-sized clasts of quartz and feldspar are common. Mica schist, which comprises part of the schist and gneiss unit, contains 10 to 45 percent quartz, 15 to 40 percent biotite, 5 to 30 percent muscovite, 15 percent microcline, 5 to 10 percent garnet, 5 percent plagioclase, and accessory amounts of zircon, sphene, magnetite, illmenite, and zoisite. The associated gneiss is observed only as saprolite in the map area. Thin, lens-shaped, discontinuous altered ultramafic rocks and interbeds of quartzite, marble, amphibolite, graphitic schist and siltstone, and conglomerate are common and were mapped as a separate unit where possible.

Rocks northwest of the Candler Formation in the northwest corner of the Sandy Level quadrangle are predominantly gneissic and commonly contain interbeds of quartzite and graphite schist. The gneiss is a medium- to fine-grained, light- to dark-gray, quartz-biotite metagraywacke that contains relict sedimentary clasts. It is composed of about 40 percent quartz, 30 percent muscovite, 15 percent biotite, and 5 percent plagioclase with accessory amounts of magnetite, epidote, sphene, and zircon. The rock has interbeds up to a few feet thick of metagraywacke conglomerate, amphibolite, white-mica schist, talc-tremolite schist, graphite schist, chlorite phyllite, and chlorite schist.

The following units occur as lenses or as fairly continuous interbeds throughout the Lynchburg metagraywacke. The graphitic phyllite is a dark-gray, quartz-chlorite-graphite rock with thin (up to 1.5 in thick) quartzite and chloritic phyllite interlayers. Amphibolite is a fine-grained, thinly laminated, fissile, light-greenish-gray to greenish-gray, quartz-biotite rock that commonly contains interbeds of biotite gneiss, hornblende gneiss, quartzite, and schist. Trace-element distributions indicate that these rocks originated as ocean-floor basalts (Conley, 1981). The white-mica schist is a yellowish-gray to light-greenish-brown, quartz-muscovite schist containing chloritoid and magnetite porphyroblasts.

Espenshade (1954) and Brown (1958) mapped continuous marble beds and assigned them to various formations. This was not possible in the study area because stratigraphic relationships are not clear and structural relationship are more complicated than thought by previous investigators. The marble that occurs in the Sandy Level quadrangle is quite variable in color, composition, and texture. It is a light-bluish-gray to white, massive but commonly foliated, fine- to coarse-grained rock that ranges in composition from a pure calcite marble containing minor tremolite and pyrite to an impure mica-quartz marble. Saprolite is grayish-orange in color. The marble at the intersection of State roads 949 and 626 is intruded by granite and pegmatite, and wollastonite is developed by contact metamorphism of the marble. In a quarry 0.25-mile to the northeast, the marble is coarser grained (0.75 in) due to increased metamorphic grade caused by local igneous intrusions.

Quartzites are generally white to light-gray micaceous rocks containing interbeds of gray micaceous metaconglomerates. Reddish-brown, iron-rich quartzites are present but rare. The metaconglomerates commonly contain granules and pebbles of feldspar, and clear and blue quartz. Muscovite, biotite, euhedral magnetite, and epidote are common accessory minerals in the quartzites. Itacolumite occurs on State Road 782 0.5-mile northwest of Canada Bridge (Sandy Level quadrangle). Graphitic quartzites are light- to dark-gray, massive to laminated, fine-grained graphite-rich rocks that are composed of particles that range from fine-sand to silt size. Interlayers of mica schist are common to all quartzite units.

Tremolite-chlorite schist is a grayish-green, medium- to coarse-grained rock containing variable amounts of chlorite, pyroxene, tremolite-actinolite, and talc. This metapyroxenite may be related to the sequence of ophiolites that are on strike with it to the southwest (Conley, 1981).

Candler Formation

The Candler Formation is a light-greenish-gray to light-gray, lustrous, fine-grained phyllite that is commonly composed of interlayers of thin (0.5 in) quartzite and thicker (1 in) phyllite. Lens-shaped quartzite layers up to several inches thick, interbedded granule conglomerates up to 0.5 inch thick and calcite zones are common. The Candler Formation in this area is devoid of graphite interbeds in contrast to the Lynchburg Formation rocks, which commonly contain graphite. The Candler contains chlorite, quartz, sericite, and randomly oriented post-tectonic and syntectonic chloritoid porphroblasts up to 0.5 inch in size; accessory minerals are tourmaline, feldspar, muscovite, ilmenite, and magnetite.

Tertiary-Quaternary Deposits

Alluvial terrace deposits are composed of white sand and clay or mottled red and gray clay with lenses of rounded boulders, cobbles, and pebbles. These deposits, found at nearly any elevation, were deposited in the Tertiary and Quaternary periods by rivers and streams flowing across the Piedmont. They are now highly dissected.

Alluvium consists of unconsolidated light-brown sand, silt, and gravel and is confined to present stream valleys and floodplains. Isolated lenses of organic material and brown to gray clay are also common.

IGNEOUS ROCKS

Martinsville Igneous Complex

Rocks of the Martinsville igneous complex intruded the metasedimentary rocks that compose the Smith River allochthon during the Ordovician period. Because the allochthon was not emplaced until the Carboniferous period, these intrusive rocks are restricted to the allochthon (Conley, 1978). The only rocks of this complex exposed in the report area are the Leatherwood Granite and a leucogneiss. The Leatherwood is a light- to dark-gray, coarse-grained porphyritic granite, commonly showing rapakivi texture (plagioclase overgrowths on microcline phenocrysts). It is composed of about 30 percent quartz, 20 percent microcline, 0 to 15 percent plagioclase, 15 percent biotite, 10 percent muscovite, and accessory epidote, zircon, sphene, and apatite. The rock is cut by alaskite dikes and pegmatites.

The leucogneiss is a light-gray segregation banded gneiss that is associated with the Leatherwood Granite. The rock contains about 40 percent quartz, 30 percent muscovite, 15 percent plagioclase, and 0 to 15 percent orthoclase. Banding is produced primarily by quartz-muscovite-rich layers alternating with quartzofeldspathic layers. Some muscovite has grown across the foliation; nearly all plagioclase contains myrmekitic intergrowths.

Diabase Dikes

North- to northwest-trending subvertical diabase dikes are common in the region. They are fine- to coarse-grained, dark gray to black with ophitic texture and are composed of plagioclase laths with interstitial augite, olivene, and accessory magnetite.

Other Intrusive Rocks

Within the Sandy Level quadrangle, leucogranite and pegmatites intrude both the Lynchburg Formation and the Smith River allochthon and are concentrated in the Ridgeway and normal fault zones separating these units. The rock is light-gray to white, medium- to coarse-grained leucogranite with associated pegmatites. The pegmatites contain fractured and randomly oriented tourmaline; both pegmatites and leucogranite contain, in increasing order of abundance: muscovite, tourmaline, plagioclase, microcline, and quartz. Perthitic feldspar and myrmekite are common. Age dates have not been determined for these rocks.

CATACLASTIC ROCKS

Fault movement resulted in the formation of a variety of cataclastic rocks along the Bowens Creek fault and other contemporaneous fault zones. Cataclasite is a very fine-grained rock that is possibly derived from micaceous quartzite, marble, and graphitic quartzite. The rock is usually nonfoliated and structureless. The cataclastic schist and phyllonite unit is a light-brown to greenish-gray rock which commonly shows button or fish-scale texture. The rock also contains interlayers of light-green to black chlorite-graphite phyllonite. Mylonite ranges from a light bluish-gray, fine-grained mylonite to medium-gray granitic protomylonite.

Two other types of cataclastic rocks were formed after development of the Bowens Creek fault; mylonites and silicified mylonites define high angle faults that offset the thrust faults. Mylonite is a foliated, very fine-grained, light-brown to light-gray rock and consists of muscovite, amphibole, quartz, and feldspar in a fine-grained, quartz-rich matrix. Porphyroclasts of quartz and feldspar up to 0.125 inch in size are common. Silicified mylonite is massive and light gray with fragments of angular silicified mylonite and cryptocrystalline quartz up to 2 inches long. These fragments are bonded in a matrix of iron-stained cryptocrystalline quartz. Quartz veins showing comb structure commonly crosscut the silicified mylonite.

STRUCTURE

Faults

Ridgeway Fault

A subhorizontal fault zone of cataclastic rock with numerous reentrants and klippen is exposed throughout the central part of the Sandy Level quadrangle. This fault is believed to be the re-emerged Ridgeway fault, previously defined on the southeast edge of the Smith River allochthon by Conley and Henika (1973). The map pattern suggests that the fault plane has been folded. The best exposure of the Ridgeway fault is in the northwestern part of the Pittsville quadrangle (Marr, 1984). About 0.1 mile north of the intersection of State roads 771 and 672, the garnet-sillimanite schist of the Fork Mountain Formation overlies graphitic siltstones of the Lynchburg Formation; at this place, rocks from both units are cataclastically deformed in the narrow (1 to 3 ft) fault zone.

Bowens Creek Fault

The leading (northwest) edge of the Smith River allochthon is marked by the Bowens Creek fault from the North Carolina boundary to the Penhook quadrangle (Conley, in preparation). This fault continues further to the southwest into the Brevard zone in North Carolina (Rankin and others, 1972; Espenshade and others, 1975). The Bowens Creek fault continues to the northeast (Penhook quadrangle) through the Lynchburg Formation where two faults join; these faults form the boundaries of the Candler Formation in Penhook and Sandy Level quadrangles. The fault on the east side of the Candler is most likely the Bowens Creek fault, and probably continues into the Mountain Run fault (J. F. Conley, personal communication). The relationship of the fault on the west side of the Candler Formation to the Bowens Creek fault is unknown. Movement on the Bowens Creek fault is dextral transpressional; that is, a right lateral fault with a thrust component (Conley and Henika, 1973).

As previously mentioned, both the eastern and western boundaries of the Candler Formation are in fault contact with the Lynchburg Formation. Along strike to the southwest the Candler Formation is truncated by one or both of these faults; there, the Lynchburg Formation appears to be thrust over itself toward the west. The contact of the Candler with the Lynchburg to the east is the Bowens Creek fault where the older Lynchburg is thrust over the younger Candler.

Turkeycock Creek Fault

Numerous normal and reverse faults in the Sandy Level quadrangle were formed subsequent to thrusting of the allochthon. A zone of mylonite and silicified mylonite is herein named the Turkeycock Creek fault for exposures along Smith Mountain to the east of Turkeycock Mountain, in the Mountain Valley 7.5-minute quadrangle (Conley, in preparation). This high-angle normal fault, similar to faults that bound the Danville Triassic basin, may have developed during the Late Permian or Triassic periods.

Other Faults

The western Candler Formation contact with the Lynchburg Formation may be interpreted in several different ways until more data become available. The western Candler boundary could be a gravity or listric normal fault. The Candler is on the down-dropped block as shown in cross section B-B′. For a listric normal fault, the fault plane would dip more gently to the southeast with increasing depth.

Another interpretation is that the Candler and Lynchburg formations were first folded into an overturned syncline, with subsequent thrusting of the eastern (overturned) limb of this structure over its western limb (Berquist, 1979). In this case, the fault is a thrust similar to section B-B′ but the relative fault movement would be reversed.

A structural style of low-angle ramped thrust faults allows for nearly any combination of units to be in fault contact. Although good exposures are lacking, this style of deformation is probably responsible for the lens-shaped minor units in the Lynchburg Formation and for repetitive slices of Lynchburg rocks. Undulation of the subhorizontal Ridgeway fault may be the result of tectonic thickening in the subsurface (Harris and Milici, 1977) causing folding of the overlying flat Smith River allochthon. In other words, the Ridgeway fault is a folded thrust fault.

A fault along the leading (western) edge of the allochthon is marked by a zone of cataclastic rock. The fault plane is steeply inclined and dips to the southeast. This fault can be traced along strike to the southwest where it may possibly join and be a splay off the Bowens Creek fault. This possible splay fault is well exposed in Lick Fork Creek, 0.6 mile northwest of the intersection of Lick Fork Creek and State Road 777 (Sandy Level quadrangle).

Folds

Within the Smith River allochthon, four generations of folds are evident. The first deformational event is represented by rare, sheared-out isoclinal folds (F_1) the limbs of which are coplanar with regional foliation and the hinges V-shaped. F_2 folds are upright to overturned isoclines, commonly with U-shaped hinges. The relationship between F_2 and F_3 is evident where the F_3 folds have been deformed into hook-shaped folds by the F_2 generation. Major foliation is now coplanar to the F_3 axial planes. Both generations are mesoscopic, whereas the F_3 and F_4 generation folds are rare in exposure but generally apparent at map scale. F_3 structures are broad open folds that deform the foliation and trend northeastward. F_2-F_3 interference patterns form broad domes, antiforms, and synforms. The expression of the Bassett Formation in the northwestern part of Sandy Level quadrangle is produced by an F_3 antiform, for example. F_4 folds are broad, northwest-trending, upright, and open structures. They are conspicuous on a regional scale, and have deformed the northeastward trend of the F_3 structures.

There are at least three fold systems within the Candler and Lynchburg formations in the mapped area. F_1 folds are attenuated isoclines within the major foliation. F_2 folds range from open to closed isoclinal and are axial planar to the northeast-trending, southeast-dipping foliation. Within the Candler Formation, low-angle thrust faults with associated drag folds and a subhorizontal crenulation foliation indicate a third generation of deformation. F_3 folds are open; within the Candler axial planes are parallel to the crenulation foliation. Northwest-trending F_4 folds are apparent in the region (Conley, 1981) but are not within this map area.

ECONOMIC GEOLOGY

Barite was mined in the Sandy Level quadrangle from 1874 (Watson, 1907) through the 1930s (Edmundson, 1938). Marr (1979, 1984) found that barite mineralization is concentrated in high-angle fault zones that cut rocks of the Lynchburg Formation, or both the Smith River allochthon and the Lynchburg, and that it is also associated with the quartzite and marble beds in the Lynchburg. He concludes that the barite was originally associated with these quartzites and marbles and was later mobilized and redeposited in rocks of the Smith River allochthon by hydrothermal solutions.

In addition, small secondary deposits of wad are associated with the barite. The manganese probably precipitated from ground water; the weathering of barite and marble may have produced a suitable chemical environment for manganese precipitation. A trend of manganese soil concretions occurs about 0.6 mile east of Sandy Level Church and was discussed by Redden (1962).

Iron ore was mined in the Sandy Level quadrangle from about 1870 through 1900 (Watson, 1907). Numerous small mines and prospects were worked for limonite; specularite float was found in the vicinity of unnamed abandoned mine #3 (Sandy Level quadrangle). One of these iron occurrences is in the Fork Mountain Formation, and all others are found in the Lynchburg Formation. Espenshade (1954) thought that the iron deposits in the Lynchburg were originally iron-rich sediments that were later altered by metamorphic processes.

Soapstone was supposedly quarried from Cedar Creek. An area was found which contained talc-tremolite schist of the Bassett Formation, but no evidence of quarrying was discovered. A small prospect for mica was located in a pegmatite in the southwest quadrant of Callands quadrangle (Prospect #1).

GEOLOGIC FACTORS AFFECTING LAND USE

The types of rock, saprolite, soil, and topography greatly affect land use. A geologic map shows, among other things, the type and areal extent of the rocks from which the land surface is formed. It should be noted that this map is only a general guide for land use; specific local conditions may exist which might alter the interpretations at any given locality. It is recommended that additional information be collected on a specific site during project design. Detailed information on soils may be obtained from the county agricultural agent.

The following information on broad characteristics of the rock, saprolite, and soil is summarized from field observations and may be useful as a general guide in planning prior to altering present land use. Clay-rich soils and saprolite have formed from diabase, amphibolite, marble, ultramafic rock, gabbro, and to lesser extent from phyllite and schist. Problems may be encountered during construction on these materials because the soils are commonly thin, have low percolation rates, and have a high shrink-swell potential. Sandy, well-drained soil and saprolite are commonly derived from gneiss, quartzite, and granite. In some places sandy, well-drained soil is formed from terrace deposits or alluvium. Saprolite from gneiss and granite may be tens of feet thick and quite porous.

Several examples may help describe how land use is affected by geology. The presence and quantity of groundwater is directly related to the capacity of the underlying soil and rock materials to absorb, retain, and release water. In this area, groundwater is stored in jointed rocks and in permeable saprolite. Areas underlain by rocks with widely spaced joints, thin saprolite, and clay-rich soils would be the least likely to produce groundwater in large quantities (units ba and a for example). Terrain underlain by the Bassett gneiss is usually much more productive because this gneiss weathers to a thick, porous, and permeable saprolite that is overlain by soils containing small amounts of clay. This allows the rainwater to be absorbed by the saprolite and rock fractures and to be stored rather than becoming surface runoff. The location of septic drainage fields is subject to the same factors; construction on amphibolites (a, ba), diabase dikes (d), or some mafic and ultramafic intrusive rocks (t, tts) may not be advisable because of thin, clay-rich soils which have low percolation rates or shallow depths to bedrock.

Mass wasting and movement of material occurs naturally but may be accelerated by man's intervention. Removal of protective vegetative cover may enhance soil erosion. Over-steepening of slopes or removal of material at the base of slopes may result in slumping, particularly if the excavation is in alluvium, terrace deposits, or saprolite. Such unconsolidated, saturated, porous, and permeable material usually lacks cohesive strength, and failure of slopes in such excavations is common. Rock slides or falls may be common in areas of steep slopes, especially those underlain by well-jointed or foliated rocks or by crushed rocks along fault zones. Rock slides may occur on slopes if the angle of inclination of bedding or foliation is less than, and in the same direction as, the angle of the excavated surface.

Foundation failures are more common in areas where structures overlie soil or saprolite that contain high shrink-swell clays. Clay-rich soils and saprolites may also become plastic and extrude under load after repeated saturation with water. On weathering, amphibolites, diabase dikes, and talc-tremolite schists produce very clay-rich soils. Load-bearing capacity may be estimated by considering the slope, drainage capacity, and composition of the soil and saprolite; areas of flat topography and well-drained soils may have few restrictions in supporting heavy structures.

Finally, certain features may be associated with particular rock units. Caverns and sinkholes may develop in areas underlain by marble. Alluvium is commonly subject to slumping, periodic flooding, and severe erosion. Recent movement along fault zones is unknown in the area; however, areas underlain by faults and cataclastic rocks might best be avoided for construction of permanent structures.

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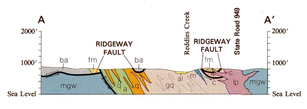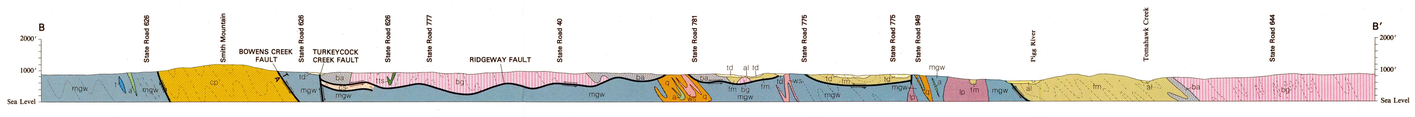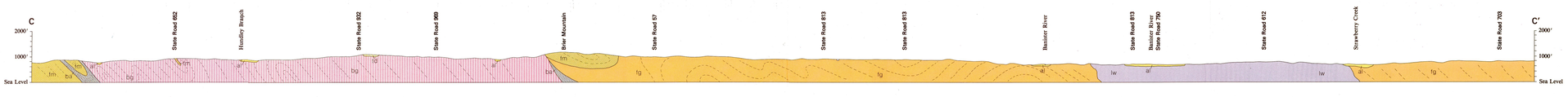
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