GEOLOGIC MAP OF THE ALBERENE QUADRANGLE, VIRGINIA

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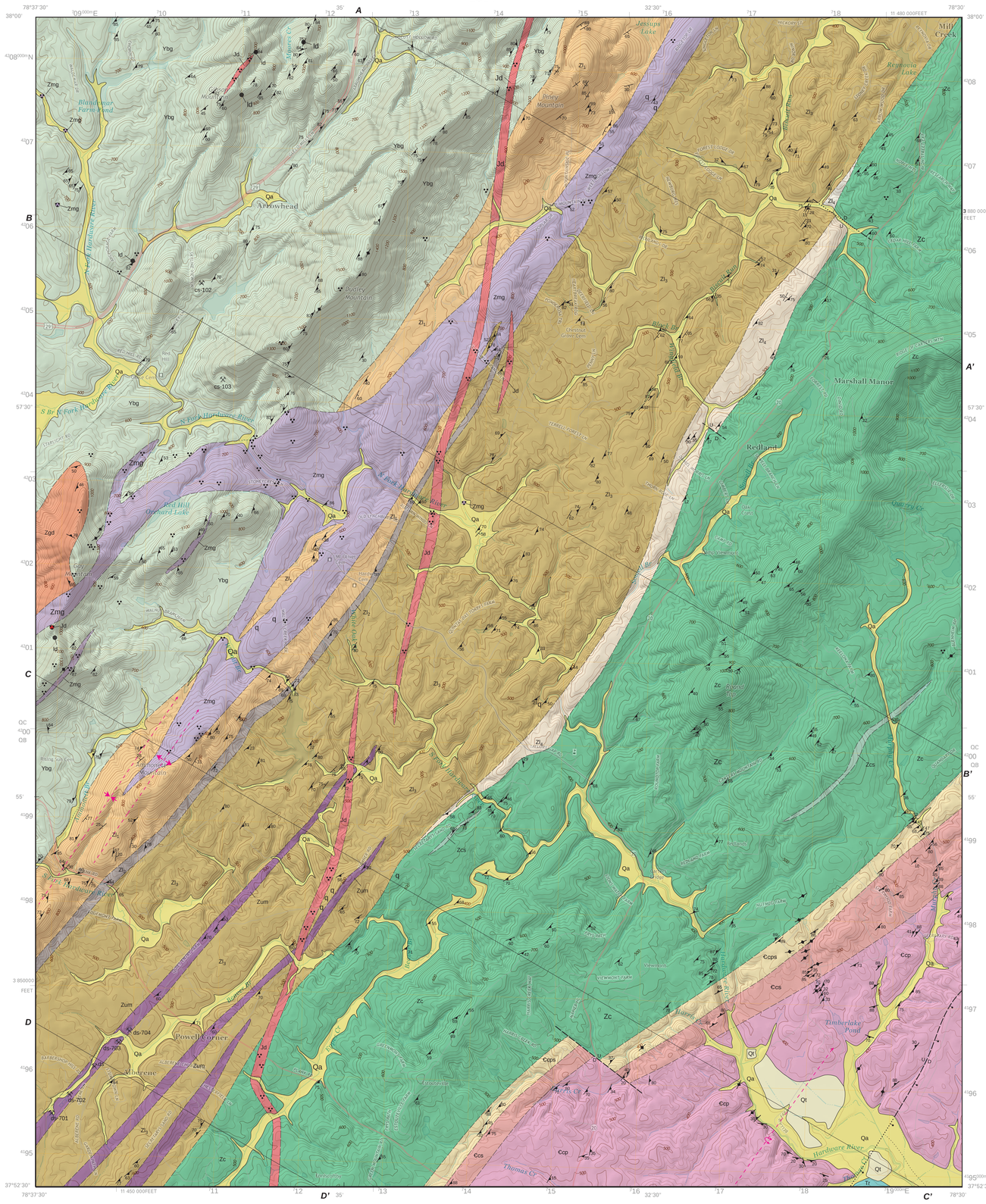


Basemap, U.S. Geological Survey, 2013, Alberene Quadrangle, Virginia

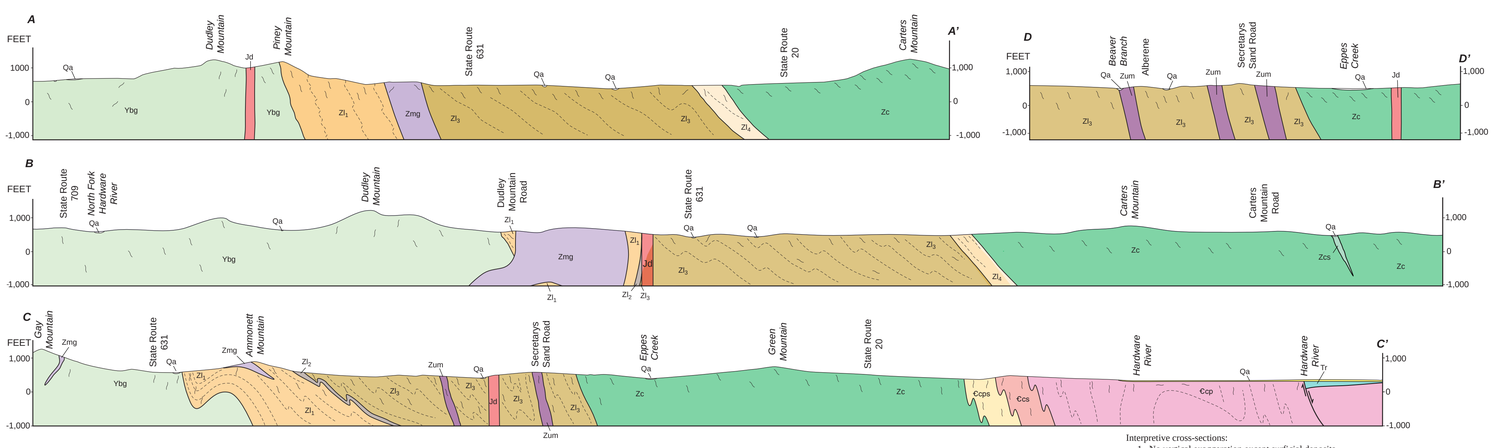
North American Datum of 1983 (NAD83)
World Geographic System of 1984 (WGS84)
Projection and 1000-meter grid: Universal Transverse Mercator, Zone 17S
10,000-foot ticks: Virginia Coordinate system of 1983 (south zone)

MN GN 9.67° 172 MILS 1°26' 25 MILS
2014 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24000
1 0.5 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 0.5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1988

Geology mapped from June 2011 to November 2013



Interpretive cross-sections:
1. No vertical exaggeration except surficial deposits
2. Subsurface structures interpreted from surface measurements

DESCRIPTION OF MAP UNITS

QUATERNARY

Qa — **Alluvium –** Clay, silt, sand, and rounded cobbles of vein quartz, greenstone, and granitoid gneiss. Occurs along modern drainages. 1-12 m (3 to 40 ft) thick.

Qt — **Terrace deposits –** Weathered cobbles and pebbles of vein quartz and greenstone in a dark reddish orange silty matrix. Terrace deposits occur at elevations from 3-5 meters (10-15 feet) above the modern floodplain of the Hardware River and are less than 3 meters (10 feet) thick.

JURASSIC

Jd — **Diabase –** Fine-grained, dark gray to black, massive diabase; weathers spheroidally to brown-orange. Composed of plagioclase, clinopyroxene, orthopyroxene, and opaque minerals. Occurs as north-striking *en echelon* dikes up to 125 m (400 ft) wide.

TRIASSIC

Tr — **Sandstone and conglomerate –** Coarse-grained, red to brown arkosic sandstone to pebble conglomerate. Thickly bedded; contains clasts of greenstone and vein quartz as well as minor granite and phyllite, with abundant iron oxide staining throughout.

CAMBRIAN

Ꞓcp, Ꞓcs, Ꞓcps — **Candler Formation –** Phyllite, slate, and metasiltstone to metasandstone. **Ꞓcp:** Fine-grained, tan to brownish, white-mica phyllite and laminated meta-siltstone. Weathers light brown-gray. Mineralogy dominated by muscovite, chlorite, and quartz. Bedding in laminated metasiltstone parallels foliation. Approximately 2 km (6500 ft) thick. **Ꞓcs:** Fine-grained, gray to black slate. Mineralogy includes quartz, albite, muscovite, chlorite and minor graphite. Approximately 325 m (1000 ft) thick. **Ꞓcps:** Moderate-to fine-grained, gray to green to tan metasiltstone, metasandstone and phyllite composed of albite, chlorite, and quartz. Graded laminations up to 1 cm thick. Occasional graded beds of metagraywacke up to 1 m thick. Approximately 275 m (900 ft) thick.

NEOPROTEROZOIC

Zc, Zcs — **Catoctin Formation –** Metabasalt with interlayered arkose to quartz arenite. **Zc:** Fine-grained, blue-green to gray metabasalt and light green epidosite. Weathers reddish brown creating a distinctive red soil. Primarily composed of chlorite, epidote, and actinolite with remnant albite and magnetite. Variably foliated to massive. Relict pillow structures occur in some less-deformed metabasalts. Commonly cut by white quartz and epidotized quartz veins. Approximately 3 km (10,000 ft) thick. **Zcs:** Light gray to green, epidotized arkosic sandstone to quartz arenite. Occurs as thin layers within the metabasalt. Approximately 75 m (250 ft) thick.

Zum — **Talc-chlorite schist and carbonate-chlorite-talc schist –** Medium-to coarse-grained, green to gray, talc-chlorite and carbonate-chlorite-talc schist. Weathers to distinctive orange rinds with visible carbonate grains. Talc-chlorite schist dominated by talc and chlorite with additional magnetite and tremolite. Carbonate chlorite-talc schists dominated by carbonate minerals.

Zmg — **Metagabbro –** Gray to black metagabbro to gabbronorite. Composed of abundant hornblende and white plagioclase with accessory quartz, titanite, epidote, opaques, and rare metamorphic garnet. Weakly foliated; commonly preserves a relict igneous texture. Main sill is approximately 200-500 m (350-1650 ft) thick.

LYNCHBURG GROUP

Zl_4 — **Lynchburg Group 4 –** Light gray to tan feldspathic pebble metaconglomerate and metasandstone. Weathers light brown. Composed of K-feldspar, plagioclase, and blue quartz, with biotite, white mica and rare garnet of metamorphic origin. Approximately 200 m (650 ft) thick.

Zl_3 — **Lynchburg Group 3 –** Fine-grained, light gray to tan interbedded feldspathic meta-arkosic wacke, metasiltstone, metapelite, and phyllite. Weathers light brown. Composed of blue quartz and potassium feldspar, with biotite, white mica, and occasional garnet. Graded beds are common and typically parallel to foliation. Approximately 2 km (6500 ft) thick.

Zl_2 — **Lynchburg Group 2 –** Fine-grained, gray to black graphitic schist/phyllite. Weathers grayish black. Mineralogy dominated by quartz, graphite, and opaque minerals with minor biotite. Strongly foliated. Approximately 50 m (165 ft) thick.

Zl_1 — **Lynchburg Group 1 –** Coarse-to medium-grained, light gray to tan, meta-arkose to meta-arkosic wacke with minor metaconglomerate. Weathers light brown. Composed of K-feldspar, blue quartz, plagioclase feldspar, and biotite. Graded beds are present. Up to 750 m (2460 ft) thick.

ROBERTSON RIVER INTRUSIVE SUITE

Zgd — **Granodiorite –** Porphyritic light tan to gray granodiorite. Weathers orange to gray. Mineralogy includes abundant K-feldspar, plagioclase feldspar, and quartz, with accessory biotite, muscovite, titanite, epidote, ilmenite, and magnetite. Ranges from massive to foliated in texture.

IGNEOUS ROCKS OF UNCERTAIN AGE

Id — **Lamprophyre dikes –** Fine-grained, black to dark gray biotite-rich intrusions. Mineralogy dominated by biotite with epidote, titanite, quartz, relict plagioclase, and muscovite porphyroblasts. Dikes intrude biotite-bearing granitoid gneiss. Well foliated. 1 - 5 m (3 - 16 ft) wide.

MESOPROTEROZOIC

Ybg — **Biotite-bearing granitoid gneiss –** Medium-to coarse-grained, light tan to dark gray biotite-bearing granitoid gneiss. Weathers orange to dark gray. Composed of plagioclase, K-feldspar, quartz, and biotite with minor white mica, titanite, epidote, and opaque minerals. Much of the plagioclase feldspar is saussuritized, altered to epidote, sericite, and zoisite. Ranges from massive to foliated to weakly mylonitic in texture.

MAP SYMBOLS

For all contact and fold symbols: lines are solid where the location is exact; long-dashed where the location is approximate; short-dashed where the location is inferred; dotted where the location is concealed. Queries added where identity or existence may be questionable. For geologic observation symbols, observation sites are centered on the strike bar or at the intersection point of multiple symbols.

Contacts

Fault Contacts

Normal - ball and bar on downthrown block

Transverse - U - upthrown block, D - downthrown block

Folds - showing direction of plunge where appropriate

Anticline

Syncline

Overturned anticline

Geologic Observations

Strike and dip of inclined beds

Strike of vertical bedding

Strike and dip of overturned bedding

Massive rock (no penetrative fabric)

Strike and dip of greenschist foliation

Strike of vertical foliation

Abundant quartz veins

Mineral Resources - identification numbers are preceded by "154A-" in the Mineral Resources of Virginia database.

Mine or quarry (cs-crushed stone)

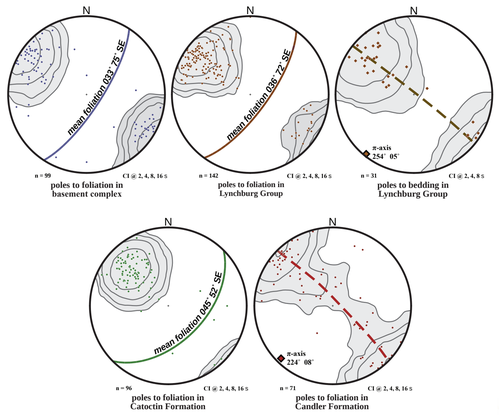
Abandoned mine or quarry (cs-crushed stone, ds-dimension stone)

Symbols used in cross-section

Bedding

Foliation

STEREOGRAMS OF STRUCTURAL ELEMENTS



GEOLOGY OF THE ALBERENE QUADRANGLE

The Alberene 7.5 minute quadrangle encompasses approximately 60 square miles in Albemarle County, Virginia, southwest of Charlottesville. The quadrangle is located among the western foothills and uplands of the Piedmont physiographic province, but straddles the boundary between the Blue Ridge and Piedmont geologic provinces.

Little geologic work has been completed in the area since it was mapped by Nelson (1962) as part of a 1:62,500 scale map of Albemarle County. Few modern 1:24,000 maps exist for the eastern Blue Ridge in central Virginia (see, however: Rossman, 1991; Evans, 1994; Carter, 2008). Evans (1984), as part of his doctoral thesis, mapped in the southeast part of the Alberene quadrangle.

The Alberene quadrangle is underlain by four major bedrock geologic units: 1) Mesoproterozoic-Neoproterozoic granitoid basement rocks; 2) Neoproterozoic Lynchburg Group; 3) Neoproterozoic Catoctin Formation; and 4) Cambrian Candler Formation. Rocks of the Blue Ridge basement complex are intruded by a series of lamprophyre dikes. Both the basement complex and cover rocks of the lower Lynchburg Group are intruded by a set of Neoproterozoic mafic-ultramafic dikes and sills emplaced prior to the extrusion of the Catoctin Formation. A small area of Triassic rocks occurs near the southeastern boundary of the quadrangle at the north end of the Scottsville basin. Proterozoic to Triassic units are crosscut by a number of north-striking Jurassic diabase dikes. The Alberene quadrangle is located along the eastern limb of the Blue Ridge anticlinorium, a regional-scale structure that extends from central Virginia to south-central Pennsylvania. Most of the pre-Mesozoic rock units are penetratively deformed and fractured.

The basement complex crops out in the northwestern part of the quadrangle and includes a Mesoproterozoic biotite-bearing granitoid gneiss (Ybg) that is intruded by a Neoproterozoic granodioritic pluton (Zgd). The biotite-bearing granitoid gneiss consists of saussuritized plagioclase feldspar, K-feldspar, recrystallized quartz, and metamorphic biotite with minor white mica, titanite, epidote, and opaque minerals. The unit is of Grenvillian age. Southworth *et al.* (2010) report a U-Pb zircon age of 1040 ± 9 Ma for this lithology in Madison County, 50 km north of the Alberene quadrangle. The granodioritic pluton is likely a southern equivalent to the 700 - 730 Ma Robertson River Igneous Suite in Northern Virginia. The rock is composed of plagioclase feldspar, K-feldspar, quartz, biotite, epidote, magnetite, and rare fluorite.

A series of well-foliated lamprophyre dikes (Id) intrude both the Mesoproterozoic biotite-bearing granitoid gneiss and the Neoproterozoic granodiorite. Dike rocks are dominated by biotite and also contain hornblende, titanite, epidote, quartz, and relict plagioclase feldspar. In some samples, large muscovite porphyroblasts (0.4-1.0 mm) and rare twinned calcite occur. Dikes vary from 1-4 m in thickness.

The basement complex is nonconformably overlain by the Lynchburg Group, a metasedimentary sequence that records sedimentation associated with continental rifting during the Neoproterozoic. In the Alberene quadrangle, the Lynchburg Group is divided into four subunits. From stratigraphic bottom-to-top, these include Zl_1, a metamorphosed coarse-grained meta-arkose to meta-arkosic wacke; Zl_2, a graphitic schist/phyllite formally known as the Johnson's Mill Formation; Zl_3, a metamorphosed micaceous siltstone to fine-grained sandstone; and Zl_4, a feldspathic pebbly meta-conglomerate and meta-sandstone with abundant blue quartz. In aggregate these four units are approximately 3 kilometers thick. The Lynchburg Group is composed of sediment derived from the Proterozoic basement complex and was deposited in a marine setting during Late Neoproterozoic continental rifting (Wehr and Glover, 1985).

Both the basement complex and the Lynchburg Group are intruded by a suite of Neoproterozoic metagabbro sills and dikes (Zmg). The largest body is commonly referred to as the University Amphibolite (Nelson, 1962) as it underlies much of the University of Virginia campus. The metagabbro is composed of equal parts hornblende and plagioclase feldspar with minor quartz, sphene, epidote, opaque minerals, and rare garnet. The large metagabbro body has a hook-shaped map pattern linked to a tabular sill-like body in the Lynchburg Group. The hook-shaped feature is the dike-like conduit through which magma intruded the lower strata of the Lynchburg Group. The main sill body is locally 200-600 m thick. The gabbroic body has previously been hypothesized by Nelson (1962) to represent a deeper equivalent to Catoctin Formation metabasalts. However, with an absence of definitive evidence for this correlation, including the lack of discernible feeder dikes connecting the two units within the quadrangle, the relationship between the metagabbro and metabasalts of the Catoctin Formation remains inconclusive.

A series of Neoproterozoic northeast-southwest trending ultramafic dikes/sills also cuts the Lynchburg Group. These dikes are either talc-chlorite schist or carbonate-talc-chlorite schist (Zum). The age of intrusion is uncertain, however these mafic to ultramafic rocks may be the result of bimodal magmatism associated with the emplacement of the Robertson River Igneous Suite around 730-700 Ma (Weiss, 1999) or may be the ultramafic component of a fractionated picritic magma emplaced as part of a plutonic-volcanic sequence during a period of late Neoproterozoic rifting (Jensen, 2012). These ultramafic dikes/sills were once quarried for commerical soapstone near Alberene.

The Catoctin Formation overlies the Lynchburg Group and includes metamorphosed basaltic lava flows/greenstone (Zc) interlayered with a series of feldspathic metasandstones and phyllite (Zcs). Metabasalts are interpreted as a flood-basalt sequence that was extruded during Neoproterozoic continental rifting and opening of the Iapetus Ocean ~570-550 Ma (Aleinikoff *et al.*, 1995; Badger and Sinha, 1988). Basalts have since been metamorphosed to greenstone composed of epidote, chlorite, actinoline, albite, and limited magnetite. The Catoctin Formation reaches a maximum thickness of approximately 3 km in the Alberene quadrangle. Although primary structures are rarely preserved, relict pillow structures occur in some locations (Kline *et al.*, 1990). The Lynchburg-Catoctin contact is interpreted to be a nonconformity, and is offset by a number of subparallel northwest-southeast striking dip-slip faults.

The Catoctin Formation is conformably overlain by the siliciclastic Candler Formation, a Cambrian metasedimentary unit characterized by three subunits from stratigraphic bottom-to-top: phyllite and laminated meta-siltstone (Ꞓcp); a graphitic slate (Ꞓcs); and a package of moderate- to fine-grained laminated metasiltstone, metasandstone, and phyllite (Ꞓcps). The mineralogy of the rocks in this unit is dominated by muscovite, chlorite, and quartz with accessory zircon, tourmaline, magnetite, and graphite. The Candler Formation locally is 2.5 km thick. Rocks in the Candler Formation are interpreted to be distal submarine fan sedimentary sequences deposited during the drift phase after the opening of the Iapetus Ocean (Wehr and Glover, 1985). The conformable nature of the contact between the Candler and the Catoctin is evidenced by the occurence of interbedded metabasalt and chlorite-rich sedimentary greenstone that were deposited in periods between volcanic flows and chemically altered by fluid flow, along the contact trace (Evans and Milici, 1994).

Triassic rocks of the Scottsville Basin (Tr) occur in the southeastern corner of the quadrangle and are bound on the northwest by a normal fault. These rocks include a sequence of thickly-bedded cobble conglomerate to coarse arkosic sandstone composed of clasts of greenstone, vein quartz, granite, phyllite, and other metasedimentary rocks in an iron-rich sandy-clay matrix (Quinlan and Bailey, 2012).

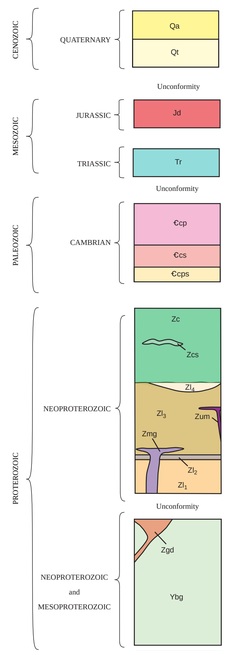
A series of near vertical, north-northeast striking en-echelon Jurassic diabase dikes (Jd) crosscuts older rocks in the quadrangle. Unweathered diabase is dark gray, massive, and weathers to rounded boulders. Diabase is composed of plagioclase feldspar, orthopyroxene, clinopyroxene, and opaque minerals. Dikes range from 10 cm to ~120 m in width.

Surficial deposits, primarily alluvium, are common adjacent to most streams (Qa). Alluvium includes clay, silt, sand, and rounded cobbles of vein quartz, greenstone, and sub-angular sedimentary lithics. In some areas vein quartz boulders up to 2 m in diameter occur as massive pieces of float within streams and on the surface (q).

A distinctive northeast- to southwest-striking foliation is variably present in both the basement complex and cover rocks. Foliation in the basement complex dips steeply both to the northwest and southeast. Foliation in the Neoproterozoic cover sequence typically dips moderately to the southeast. Foliation in the Candler Formation is folded and crenulated. The penetrative foliation is likely the result of greenschist facies regional metamorphism in the mid- to late Paleozoic (Jenkins *et al.*, 2012). Beds in the Lynchburg Group are folded. Outcrop-scale folds are gently plunging, typically asymmetric, and verge to the northwest. The orientations of these structural elements are consistent with a northwest-southeast contractional deformation.

A series of steeply dipping subparallel localized northwest- to southeast-striking transverse faults occur in the Alberene quadrangle. These steeply dipping faults cut both the Neoproterozoic and Cambrian cover units. In map view these faults displace geologic contacts by up to 450 m, however the actual displacement along these faults is likely dip-slip with a maximum displacement of ~200 m. Transverse faults post-date the folding of the cover sequence.

CORRELATION OF MAP UNITS



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SUGGESTED REFERENCE

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