Contact—Identity and existence certain, location inferred

Gradational contact--Identity and existence certain, location

-=--+-=--+

Thrust fault (1st option)/Strike-slip fault, right-lateral offset—Identity

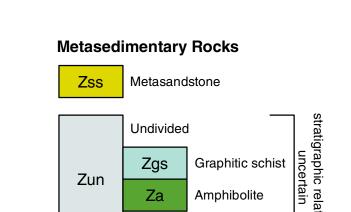
and existence certian, location approximate. Sawteeth on upper

(tectonically higher plate). Arrows show relative motion

CORRELATION OF MAP

Kenneth B. Taylor, State Geologist

DZMP Mylonite / phyllonite bzpg Porphyroclastic biotite gneiss mx Mixed gneiss



INTRODUCTION

The Old Fort 7.5-minute quadrangle lies in western North Carolina in portions of McDowell and Yancey counties. The town of Old Fort is the largest community on the quadrangle. Much of the Pisgah National Forest owned by the U.S. Forest Service. Major transportation corridors include Interstate 40, the Blue Ridge Parkway, and Highway Creek. Total elevation relief is 3,770 ft with a low of 1,330 ft along Cane Creek and a high of 5,100 ft on

GEOLOGIC OVERVIEW

Bedrock of the Old Fort quadrangle comprises the following units (from northwest to southeast): An undivided Neoproterozoic metasedimentary unit with interlayers of amphibolite and graphitic schist; a Neoproterozoic metasandstone; porphyroclastic biotite gneiss of unknown affinity; mylonite/phyllonite of the Brevard Fault Zone; and a mixed gneiss unit with several rock types including Tallulah Falls biotite gneiss, Ordovician Henderson Gneiss, and felsic gneiss.

The Brevard Zone is a prominent NE-SW-striking feature on the Old Fort quadrangle. The Brevard Zone is a linear fault zone that extends from Alabama to Virginia. It has a complex history of multiple reactivations with the earliest movement during the Neoacadian orogeny. This first movement was ductile and high-temperature with an oblique to strike-slip motion. During the Alleghanian orogeny, the Brevard fault reactivated with ductile strike-slip motion reaching greenschist-facies conditions, and later, experienced brittle dip-slip motion (Hatcher et al., 2007). In the Old Fort quadrangle, ductile shearing attributed to Brevard Zone deformation is observed in a zone up to 9 miles wide.

Stratigraphic relationships are unclear but the oldest unit on the quadrangle is interpreted to be the porphyroclastic biotite gneiss. It outcrops in the center of the Old Fort quadrangle immediately northwest of the Brevard Zone mylonite/phyllonite unit. Porphyroclasts within the unit are granule- to gravel-sized and circular, tending to be less ovoid and less elongate in the foliation plane than outcrops of the Henderson Gneiss. This unit is of unknown age and affinity but projects along strike to the northeast into Mesoproterozoic gneisses mapped by Bryant and Reed (1970).

Northwest of the porphyroclastic gneiss, the quadrangle is underlain by Neoproterozoic metasedimentary units possibly correlative with the Ashe and Alligator Back Metamorphic Suites. These rocks are thick sequences of complexly deformed and metamorphosed clastic sediments deposited in marine rift basins. Interspersed with these sediments are lesser amounts of mafic volcanic rocks and ultramafic rocks thought to have originated as oceanic crust at a spreading center (Misra and Conte, 1991; Raymond and Abbott, 1997). These metasedimentary lithologies were complexly deformed and metamorphosed to amphibolite facies conditions during Taconic orogenesis. The effects of Brevard Zone shearing increase from northwest to southeast within these units. The metasandstone unit does not contain schist, amphibolite, or garnet while the undivided unit contains schist, amphibolite, and garnet along with lithologies found in the metasandstone unit. This may represent a shift in depositional environment from shallower marine in the SE to deeper marine in the NW.

Southeast of the Brevard zone, the mixed gneiss unit contains biotite gneisses of unknown affinity and may contain the Ordovician Henderson Gneiss. Intense deformation of the Brevard zone makes delineation and identification of the protoliths of the mixed gneiss unit difficult. Biotite gneisses within the unit are heterogeneous and contain local granule- to gravel-sized porphyroclasts, ribboned quadrangle north of the town of Old Fort lies within felsic layers, boudined pegmatite layers, and granitic orthogneiss. Portions of this biotite gneiss may be correlative to the Tallulah Falls Formation mapped to the SE by Bream (1999). Possibly interlayered within the biotite gneiss are intrusions of the Ordovician Henderson Gneiss, a large granitic pluton that extends from SC to the 70. Major streams include the Catawba River and its NC piedmont. In its type locality the Henderson Gneiss is homogeneous and tributaries Curtis Creek, Cane Creek, and Mackey contains plentiful K-feldspar augens that are elongate with the foliation. Moecher et al. (2011) determined the age of the Henderson Gneiss is 447.6 Ma.

> Mylonitic and non-mylonitic foliations within the quadrangle dominantly strike NE-SW and dip to the SE. The prominent fracture set strikes NW-SE and is steeply

WHOLE ROCK ICP ANALYSIS1 OF SELECTED SAMPLES

feldspathic feldspathic mylonitic biotite metawacke metawacke granitoid gneiss MAP UNIT Zun Zun Zun Zun Zss bzpg bzpg bzpg bzpg bzpg MAJOR OXIDES IN PERCENT ELEMENTS IN PPM⁶

¹Whole Rock Inductively Coupled Plasma - Atomic Emission/Mass Spectrometer analysis conducted by Bureau Veritas, 9050 Shaughnessy St, Vancouver, BC Canada V6P 6E5. ²Sample numbers correspond to thin section and whole rock sample localities shown on geologic map ³State Plane Coordinate System ⁴LOI = loss on ignition in percent ⁵SUM = Sum total in percent

⁶PPM = parts per million. Ni analyzed by Bureau Veritas LF200 and AQ200 procedures. REFERENCES

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Cardozo, N., and Allmendinger, R.W., 2013, Spherical projections with OSXStereonet: Computers & Geosciences, v. 51, p. 193 -205, doi:10.1016/j.cageo.2012.07.021. Hatcher, R.D., Jr., Bream, B.R., and Merschat, A.J., 2007, Tectonic map of the southern and central Appalachians: A tale of three orogens and a complete Wilson cycle, in Hatcher, R.D., Jr., Carlson, M.P., McBride, J.H., and Martínez Catalán, J.R., eds., 4-D Framework of Continental Crust: Geological Society of America Memoir 200, p. 595-632, doi: 10.1130/2007.1200(29). Misra, K.C., and Conte, J.A., 1991, Amphibolites of the Ashe and Alligator Back Formations, North Carolina: Geological Society of Moecher, D., Hietpas, J., Samson, S., and Chakraborty, S., 2011, Insights into southern Appalachian tectonics from ages of detrital monazite and zircon in modern alluvium, Geosphere; v. 7; no. 2; p. 1-19; doi: 10.1130/GES00615.1

Raymond, L.A., and Abbott, R.N., 1997, Petrology and tectonic significance of ultramafic rocks near the Grandfather Mountain Window in the Blue Ridge belt, Toe terrane, western Piedmont, North Carolina, In: Paleozoic Structure, Metamorphism, and Tectonics of the Blue Ridge of Western North Carolina, Carolina Geological Society Field Trip Guidebook p. 67-85.





4000 -

Mylonite / phyllonite — Intensely deformed rocks with unknown protoliths. Tan to light-gray to dark-gray to lightolive-gray, to greenish-gray; fine- to coarse-grained; lepidoblastic to porphyroblastic; strongly foliated; mylonitic, locally ultramylonitic, locally brecciated; consists of sericite, quartz, feldspar, biotite, chlorite, and accessory graphite, garnet, sulfides, magnetite, and opaque minerals. Lenticular muscovite-aggregate porphyroblasts flattened in the mylonitic foliation planes impart a distinctive "fish scale" or "button" appearance to phyllonites. Locally interlayered with porphyroclastic biotite gneiss, granitic orthogneiss, and felsic gneiss.

DESCRIPTION OF MAP UNITS¹

Porphyroclastic biotite gneiss — Heterogeneous mix of porphyroclastic and porphyroblastic, mylonitic biotite bzpg gneiss, quartzo-feldspathic gneiss, granitic orthogneiss, felsic gneiss, phyllonite, mylonite, and amphibolite, with minor biotite metawacke and metasandstone. Protoliths unknown although tentatively correlated to Mesoproterozoic gneisses mapped along strike to the northeast. Biotite gneiss is typically light-gray to grayishblack; well foliated; locally protomylonitic to ultramylonitic; medium- to coarse-grained; inequigranular; 2-10 mm sized porphyroblasts and/or porphyroclasts; lepidoblastic; consists of quartz, plagioclase, biotite, potassium feldspar, muscovite, minor epidote, garnet, and titanite.

Mixed Gneiss — Heterogeneous unit consisting of a biotite gneiss of unknown affinity, Henderson gneiss, granitic mx orthogneiss, and mylonite.

Biotite gneiss — Dark-gray to grayish-black; fine- to coarse-grained; well foliated; protomylonitic to mylonitic; inequigranular; porphyroclastic with clasts up to 10 mm in diameter and locally porphyroblastic; layering includes ribboned felsic layers and some pegmatite boudins; consists of quartz, plagioclase feldspar, biotite, potassium feldspar, muscovite, and epidote, with minor titanite and garnet. May be correlative to the Tallulah Falls Formation.

Henderson Gneiss — Medium-gray to medium-bluish-gray to mottled black and white; inequigranular; medium- to coarse-grained matrix with distinctive megacrysts (augen) of microcline variable in size and abundance; typically protomylonitic to mylonitic, to granoblastic to lepidoblastic; massive to well foliated; dominantly biotite granite that ranges to tonalite; consists of potassium feldspar, plagioclase, quartz, biotite, muscovite and sericite, epidote group minerals, opaque minerals, and trace amounts of titanite, zircon, and apatite; locally pegmatitic and migmatitic. Locally microcline augen exceed 2.5 cm in length. The augen structures are produced by a high

metawacke, and quartzite. Tan to medium-gray to light-green; fine- to medium-grained; foliated to locally mylonitic;

This individed — Heterogeneous unit consisting of interlayered layers and lenses of laterally and vertically grading

to mylonitic; equigranular to inequigranular; granoblastic to lepidoblastic; locally migmatitic; consists of quartz, plagioclase feldspar, biotite, muscovite, garnet, epidote, sillimanite and/or kyanite, staurolite, chlorite, opaque

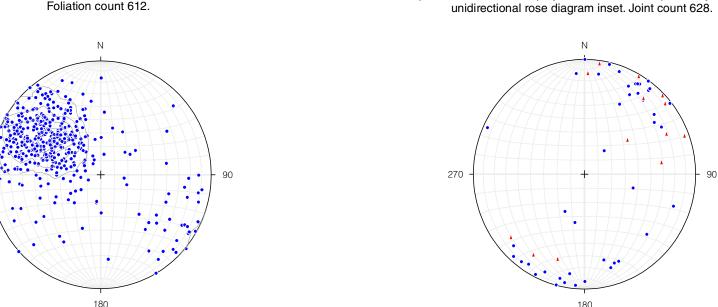
Arkosic meta-arenite — Tan to medium-light-gray to gray; medium-grained, equigranular to inequigranular,

of muscovite, biotite, garnet, quartz, plagioclase feldspar, potassium feldspar, and minor accessory minerals;

Graphitic schist — Dark-gray to greenish-gray to medium-gray; fine- to medium-grained; well foliated to mylonitic; equigranular to inequigranular; lepidoblastic to porphyroblastic; consists of muscovite, biotite, garnet, sericite, quartz, graphite, feldspar, chlorite, pyrite, and accessory minerals; interlayered with lesser amounts of metaarkose,

¹Mineral abundances are listed in decreasing order of abundance based upon visual estimates of hand samples and thin-sections.

SCHMIDT EQUAL AREA STEREONET DATA



Equal area Schmidt Net projection of contoured poles to mylonitic foliation.

Mylonitic foliation count 468.

arrows indicate relative motion along faul

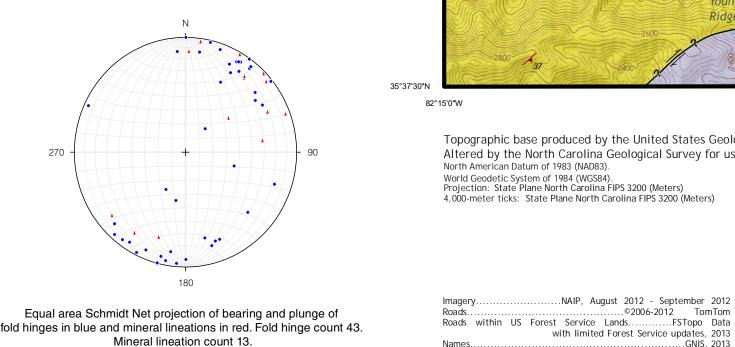
Research supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program under STATEMAP (award number - G18AC00205, 2018). The views and conclusions

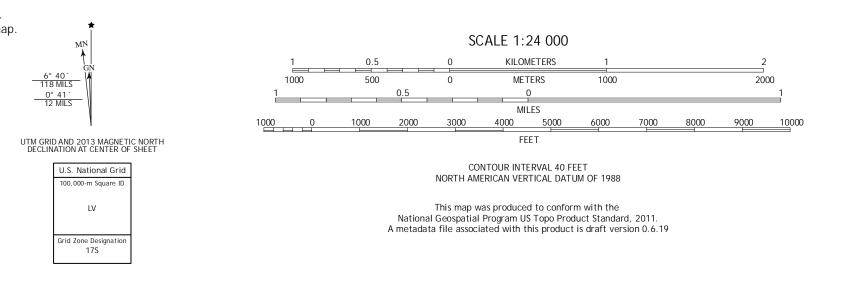
contained in this document are those of the authors and should not be interpreted as

necessarily representing the official policies, either expressed or implied, of the U.S.

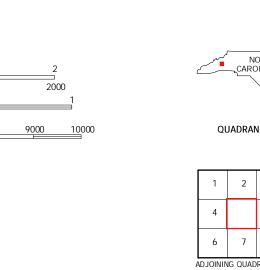
T indicates motion toward viewer A indicates motion away from viewer

Form Lines ------ interpretive patterns of subsurface foliation orientations based upon surficial structural measurements



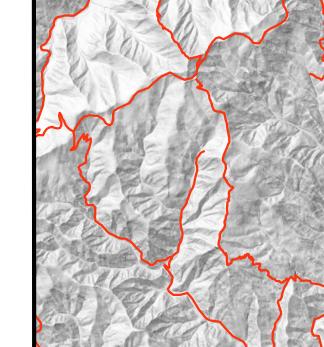


approximate extent of Brevard zone mylonitizatio

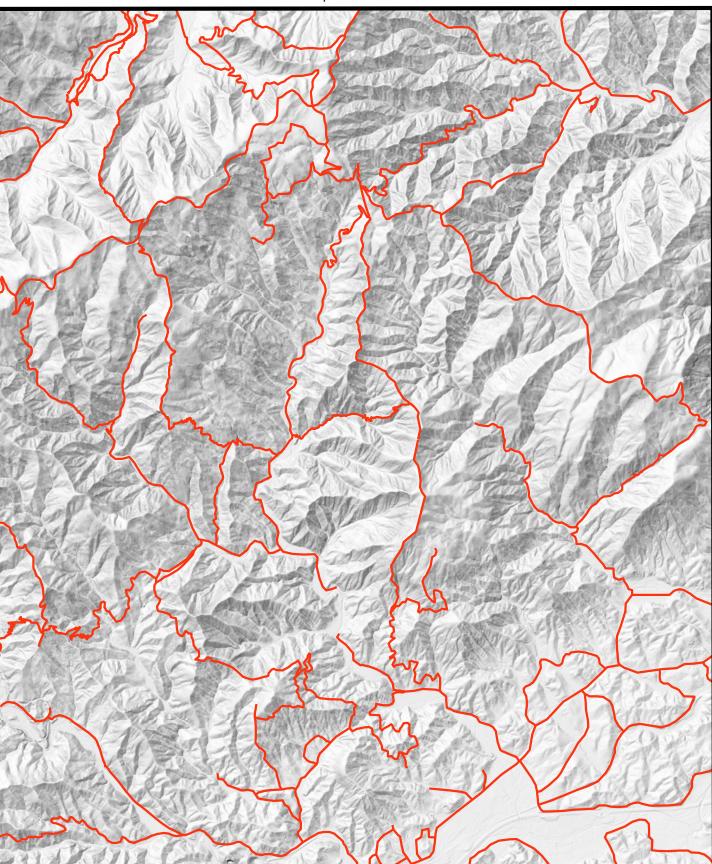


complete observation and thin-section data.





TRAVERSE MAP Hillshade derived from a six meter pixel resolution LiDAR (Light Detecting And Ranging) digital elevation model. Red lines show paths of field traverses.



Bedrock Geologic Map of the Old Fort 7.5-minute Quadrangle, McDowell and Yancey Counties, North Carolina

Bart L. Cattanach, G. Nicholas Bozdog, Sierra J. Isard, and Richard M. Wooten

Geology mapped from July 2018 to June 2019. Map preparation, digital cartography and editing by G. Nicholas Bozdog, Bart L. Cattanach, and Sierra J. Isard

temperature protomylonitic overprint. Radiometric age date of approximately 447 Ma (Moecher et al., 2011).

notably does not contain schist, amphibolite, or garnet.

sedimentary and mafic volcanic rocks metamorphosed to kyanite- and sillimanite-grade. Rock types include metawacke, arkosic meta-arenite, schist, graphitic schist, mylonite, phyllonite, biotite gneiss, and amphibolite. Zun Thickness of layering ranges from centimeters to meters.

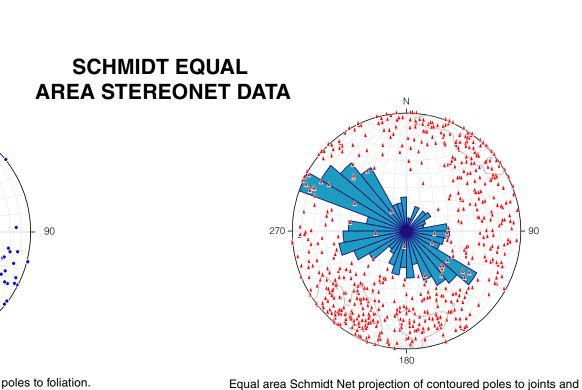
minerals, trace potassium feldspar and zircon; thickness of layering ranges from decimeters to meters.

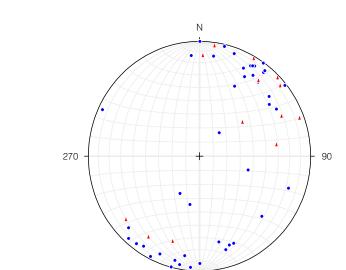
granoblastic to lepidoblastic; consists of quartz, plagioclase feldspar, muscovite > biotite, sericite, chlorite, with minor amounts of garnet, potassium feldspar, titanite, apatite, and other accessory minerals; locally has millimeter

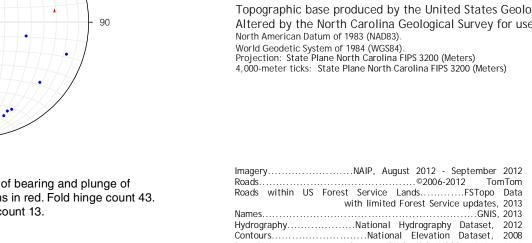
foliated; consists of quartz, feldspar, with minor amounts of muscovite, biotite, and other accessory minerals.

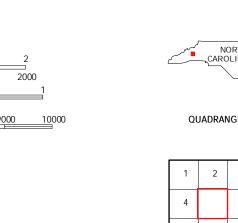
locally contains chlorite, staurolite, tourmaline, kyanite, graphite, and trace zircon.

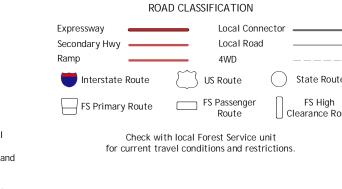
Amphibolite — Dark-green to black; fine- to coarse-grained; weakly to strongly foliated; equigranular; granoblastic to nematoblastic; consists of hornblende, plagioclase feldspar, epidote group minerals, quartz, garnet, chlorite, relict pyroxene, titanite, magnetite, and opaque minerals. Can occur as a very minor rock type throughout the other map units, where it may represent a metamorphosed volcanic rock.













4000 3000 2000

This is an Open-File Map. It has been reviewed internally for conformity with North Carolina Geological Survey mapping standards and with the North American Stratigraphic Code. Further revisions or corrections to this Open File map may occur. Some station data omitted from map to improve readability. Please contact the North Carolina Geological Survey for

This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program.

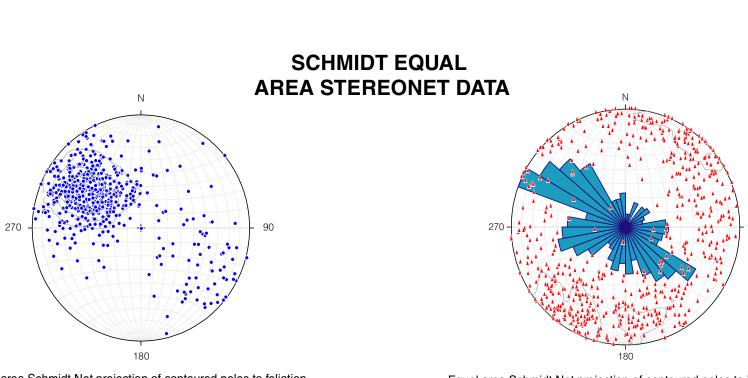
Metasandstone — Interlayered metamorphosed sandstones with compositions including arkosic arenite, biotite equigranular to inequigranular; consists of quartz, feldspar, muscovite, biotite, and minor accessory minerals;

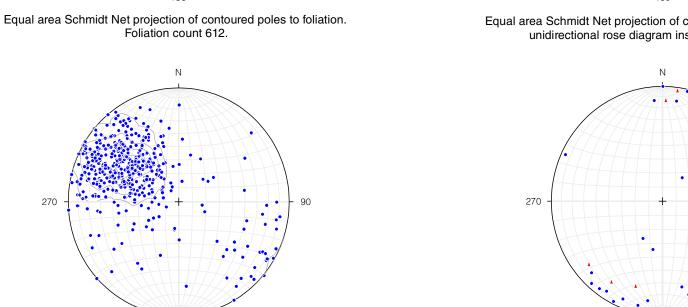
Biotite metawacke — Medium-light-gray to medium-dark-gray; medium- to coarse-grained; foliated; protomylonitic

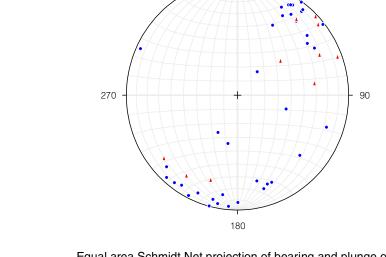
Muscovite metawacke — Light-tan to light-gray; fine- to medium-grained; foliated; protomylonitic to mylonitic;

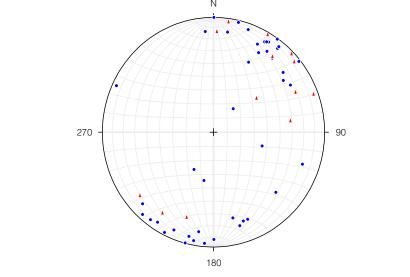
Schist - Garnet-mica schist, muscovite schist, muscovite-biotite schist; very light-gray to greenish-gray to medium-gray; medium- to coarse-grained; well foliated and locally mylonitic; inequigranular; lepidoblastic; consists

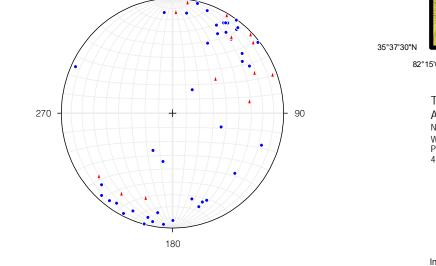
metawacke, garnet-mica schist, and phyllite.

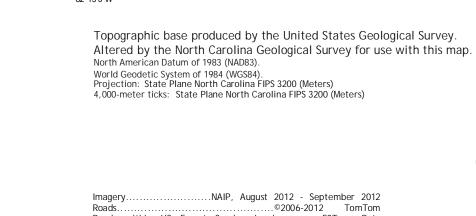




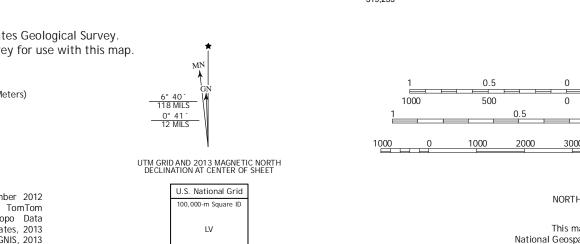


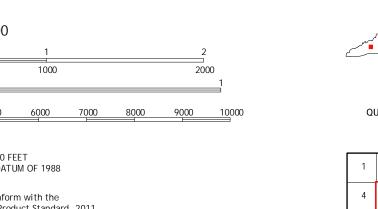


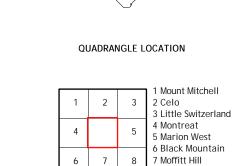




...Census, IBWC, IBC, USGS, 1972 - 2012









(For multiple observations at one locality, symbols are joined at the "tail" ends of the strike lines) (Symbols in red taken from Butler, 1970.) Inclined metamorphic or tectonic foliation—Showing Small, minor inclined joint—Showing strike and dip Inclined metamorphic or tectonic foliation, for multiple observations at one locality—Showing strike and dip Small, minor inclined joint, for multiple observations at one locality—Showing strike and dip ✓ Vertical metamorphic or tectonic foliation—Showing strike

Small, minor vertical or near-vertical joint, for multiple observations at one locality—Showing strike > Vertical metamorphic or tectonic foliation, for multiple observations at one locality—Showing strike Inclined mylonitic foliation, for multiple observations at one locality—Showing strike and dip

Inclined mylonitic foliation—Showing strike and dip Vertical metamorphic or tectonic mylonitic foliation, for ▼ Vertical mylonitic foliation—Showing strike multiple observations at one locality—Showing strike Inclined generic foliation (origin not specified)—Showing

EXPLANATION OF MAP SYMBOLS

CONTACTS

Zone of Confidence: 300m

PLANAR FEATURES

Contact—Identity and existence certain, location accurate

Contact—Identity questionable, existence certain,

 \Rightarrow \Rightarrow \Rightarrow \Rightarrow \Rightarrow \Rightarrow

Strike-slip fault, right-lateral offset--Identity questionable,

existence certain, and location accurate. Arrows show

LINEAR FEATURES

(Symbols in red taken from Butler, 1970.)

Inclined slickenline, groove, or striation on fault

or linear structure—Showing bearing and plunge

surface—Showing bearing and plunge

location accurate

OTHER FEATURES Inclined aligned-mineral lineation—Showing bearing and plunge Thin section and whole rock analysis sample location

X Prospect (pit or small open cut) Inclined fold hinge of generic (type or orientation unspecified) small, minor fold—Showing bearing and plunge Abandoned sand, gravel, clay, or placer pit Inclined generic (origin or type not known or not specified) lineation Abandoned open pit, quarry, or glory hole

Inclined crenulation lineation—Showing bearing and plunge

NATURAL RESOURCES SDG - Sand and gravel

METAMORPHIC AND TECTONIC CONDITIONS

Brevard Zone deformation Location where garnet was observed Location where kyanite was observed