North Carolina Department of Environmental Quality
Division of Energy, Mineral and Land Resources
Toby Vinson, Director
Kenneth B. Taylor, State Geologist

North Carolina Geological Survey
Open File Report 2024-05

CORRELATION OF MAP UNITS

DEVONIAN

Spruce Pine Plutonic Suite

- Dspg — granodiorite
- Dspp — pegmatite

CAMBRIAN / NEOPROTEROZOIC

Ashe Metamorphic Suite

- Za — undivided
- Zapm — pegmatite and metasomatic schist
- Zakg — kyanite gneiss
- Zas — schist
- Zaa — amphibolite
- Zacs — chloritic schist
- Zad — dunite

stratigraphic relations uncertain

INTRODUCTION

The Spruce Pine 7.5-minute quadrangle lies in Mitchell, Avery, and McDowell counties, western North Carolina. Within the quadrangle are the towns of Spruce Pine and Grassy Creek and portions of the Pisgah National Forest and the Blue Ridge Parkway. U.S. Highway 19 and N.C. Highway 226 are the major transportation corridors on the quadrangle. The major water features are the North Toe River, Gusher Knob Lake, Deer Park Lake, Swiss Pine Lake, and Emerald Lake. Total elevation relief is 3,200 feet (975 m) with a low of 2,090 feet (637 m) along Pepper Creek and a high of 5,290 feet (1612 m) at Big Bald. Pisgah National Forest holdings are in the north and southeast corner of the quadrangle. The Blue Ridge Parkway is also located in the southeast corner of the quadrangle.

GEOLOGIC OVERVIEW

Bedrock of the Spruce Pine quadrangle is entirely within the Fries/Spruce Pine thrust sheet of the eastern Blue Ridge portion of the Tugaloo terrane (Trupe, 1997; Hatcher and others, 2007).

The Fries/Spruce Pine thrust sheet contains Neoproterozoic metasedimentary and mafic rocks of the Ashe Metamorphic Suite. 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. Amphibolite facies metamorphism associated with Acadian/Neoacadian orogenesis overprints older fabrics (Johnson and others, 2001).

Numerous Devonian-aged granodioritic bodies and pegmatites of the Spruce Pine Plutonic Suite intrude the Ashe Metamorphic Suite (Brobst, 1962; Kish, 1983, 1989). These bodies are typically concordant with, but locally cross-cut metamorphic foliation on the quadrangle. Xenoliths of foliated metasedimentary rocks are locally present within the bodies. Metasedimentary lithologies near pegmatites are commonly more micaceous and coarse-grained than those where pegmatites are absent.

Brittle fractures of likely Mesozoic or younger age strike in all directions but display a prominent ENE-WSW orientation. This orientation is parallel to the Laurel Creek lineament on the Spruce Pine quadrangle (Langille and others, 2023).

DESCRIPTION OF MAP UNITS[1]

WESTERN TUGALOO TERRANE

Spruce Pine Plutonic Suite

Dspg

Granodiorite— White to very light-gray, mottled; non-foliated to weakly foliated; coarse-grained; equigranular to inequigranular; granoblastic. Bodies are lenticular to tabular. Thickness of bodies ranges from decimeters to kilometers. Consists of plagioclase feldspar, quartz, potassium feldspar, and muscovite. Accessory minerals include biotite, garnet, apatite, epidote group minerals, thulite, pyrite, chalcopyrite, and pyrrhotite.

Dspp

Pegmatite — White to very light-gray, mottled; non-foliated to weakly foliated; very coarse-grained; equigranular to inequigranular; granoblastic. Bodies are lenticular to tabular. Thickness of bodies ranges from decimeters to tens of meters. Pegmatite occurs as sill-like or cross-cutting bodies within the Ashe Metamorphic Suite. Mineralogically similar to Spruce Pine granodiorite (Swanson and Veal, 2010). Consists of plagioclase feldspar, quartz, potassium feldspar, and muscovite. Accessory minerals vary greatly upon locality and include biotite, garnet, apatite, epidote group minerals, pyrite, chalcopyrite, pyrrhotite, beryl, samarskite, columbite, autunite, and torbernite.

Ashe Metamorphic Suite

Undivided — Heterogeneous unit consisting of interlayered layers and lenses of laterally and vertically grading sedimentary and mafic volcanic rocks metamorphosed to kyanite and sillimanite grade. Rock types include schist, schistose metawacke, sandy metawacke, conglomeratic metawacke, metaconglomerate, metasandstone, amphibolite, and minor calc-silicate. Thickness of layering ranges from centimeters to meters. Where possible Za was mapped and subdivided based on dominant rock type.

Za

Metawacke — medium-light-gray to medium-dark-gray; medium- to coarse-grained; weakly foliated to foliated; equigranular to inequigranular; granoblastic to lepidoblastic; locally migmatitic; consists of quartz, plagioclase feldspar, biotite, muscovite, garnet, epidote, staurolite, chlorite, opaques with trace potassium feldspar and zircon; thickness of layering ranges from decimeters to meters; interlayered with other Za lithologies.

Schistose Metawacke — medium-gray to dark-gray; fine- to medium-grained; well foliated; equigranular to inequigranular; granoblastic to lepidoblastic to porphyroblastic; locally migmatitic; consists of quartz, plagioclase feldspar, muscovite, biotite, garnet, minor sillimanite or kyanite, and accessory minerals; interlayered with other Za lithologies.

Zapm

Pegmatite and metasomatic schist— Heterogeneous mix of pegmatite, granodiorite, metasomatic schist, and other Ashe Metamorphic Suite lithologies. Pegmatite bodies range in size from sub-meter to decameter and are typically concordant with surrounding metasediments. Pegmatite is white to light gray to light pink; coarse-grained; granoblastic; consists of plagioclase feldspar, quartz, potassium feldspar, muscovite, biotite, and minor amounts of opaque minerals, and garnet. Metasomatic schist is dark gray; medium- to coarse-grained; well foliated; inequigranular; lepidoblastic; consists of muscovite, biotite, quartz, plagioclase feldspar, potassium feldspar, garnet, and minor accessory minerals.

Zakg

Kyanite gneiss — Highly altered and heterogeneous unit characterized by an abundance of kyanite and/or muscovite porphyroblasts. Typical rock is mottled light-gray to brown; coarse-grained; foliated; equigranular to inequigranular; porphyroblastic; locally migmatitic; consists of biotite, plagioclase, quartz, muscovite, kyanite and/or sillimanite, garnet, and minor accessory and trace minerals; kyanite porphyroblasts up to 15 cm; felsic interlayers may be due to metasomatism or migmatization; interlayered with other Za lithologies.

Zas

Schist — Very light-gray to greenish-gray to medium-gray; fine- to coarse-grained; strongly foliated; inequigranular; lepidoblastic to porphyroblastic; locally migmatitic; consists of muscovite, sericite, quartz, biotite, garnet, plagioclase feldspar, sillimanite or kyanite, chlorite, and trace opaques; interlayered with other Za lithologies.

Zaa

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. Interlayered with other Ashe Metamorphic Suite lithologies and locally intruded by pegmatite. Can occur as a minor rock type throughout the other map units, where it may represent a metamorphosed volcanic rock.

Zacs

Chloritic Schist — Heterolithic unit characterized by chlorite and/or actinolite. Chlorite and actinolite are found filling anastomosing shear zones and dilatant fractures. Chlorite is also retrogressed from biotite and garnet. Massive garnet-chlorite schist and garnet-chlorite-actinolite schist is dark-green; medium- to coarse-grained; foliated chlorite-bearing biotite schist and gneiss is Dark-gray, Dark-green, medium- to coarse grained, foliated actinolite schist. Felsic, medium- to coarse-grained, massive chlorite quartzofeldspathic, commonly sheared; interlayered with other Za lithologies. Description adapted from Borella (2000).

Zad

Dunite — Grayish-yellow-green; fine- to medium-grained; consists of forsterite, with minor enstatite and bronzite, and disseminated chromite; when altered, serpentine minerals, anthophyllite, talc, and vermiculite replace olivine as disseminated grains, and in interior veins and peripheral areas.

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

WHOLE ROCK ICP ANALYSIS OF SELECTED SAMPLES

Sample	Rock Type	Map Unit	SiO2	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	Cr2O3	LOI	Sum
BC-593	Alaskite	Dspg	74.03	14.93	0.96	0.08	1.38	5.39	2.47	0.01	0.03	0.03	<0.002	0.6	99.96
JRB607A	Sandy Metawacke	Zapm	70.65	14.02	4.49	1.17	0.91	0.84	4.06	0.7	0.19	0.06	0.006	2.7	99.9
JRB613	Metawacke Sequence	Zapm	66.47	15.47	7.35	1.66	0.74	1.04	3.62	0.73	0.12	0.09	0.011	2.5	99.86

Sample	Ba	Ni	Sc	Be	Co	Cs	Ga	Hf	Nb	Rb	Sn	Sr	Ta	Th	U	V	W	Zr	Y	La
BC-593	516	<20	<1	1	0.2	1.1	15.6	1.2	4.4	61.2	<1	318	0.5	2.2	0.8	<8	<0.5	21.9	6.5	2.4
JRB607A	1038	<20	11	<1	3.1	1.3	21.6	6.2	17.7	115.6	3	56.7	0.9	6.9	1.4	82	0.9	245.3	18.5	27.8
JRB613	644	39	13	<1	14.9	12	21.4	7.1	18.6	149.8	3	154.4	1.1	11.1	2.8	100	0.9	267.5	33.7	41.2

Sample	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Mo	Cu	Pb	Zn	Ni	As	Cd	Sb	Bi	Ag	Au	Hg	Tl	Se
BC-593	1.8	0.42	1.9	0.82	0.39	1.09	0.16	1.12	0.22	0.59	0.08	0.55	0.08	0.3	1	3.6	11	0.9	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5
JRB607A	49.2	6.71	24.6	4.7	0.99	3.63	0.56	3.25	0.65	2.12	0.33	2.55	0.39	0.6	4.3	3	37	5.4	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	0.4	<0.5
JRB613	88.6	10.03	36.7	7.23	1.33	6.42	0.97	6	1.22	3.58	0.53	3.64	0.5	1.1	12.5	6.5	79	34	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	0.4	<0.5

Whole Rock Inductively Coupled Plasma - Atomic Emission/Mass Spectrometer analysis conducted by Bureau Veritas, 9050 Shaughnessy St, Vancouver, BC Canada V6P 6E5.
Sample numbers correspond to thin section and whole rock sample localities shown on geologic map.
State Plane Coordinate System
LOI = Loss on ignition in percent
SUM = Sum total in percent
PPM = Parts per million. Ni analyzed by Bureau Veritas LF200 and AQ200 procedures.
Oxide values are in weight percent and trace elements values are in PPM.

REFERENCES

Allmendinger, R. W., Cardozo, N., and Fisher, D., 2012, Structural geology algorithms: Vectors and tensors in structural geology: Cambridge University Press.

Borella, J. W., 2000. The Crabtree-Penland Fault zone: Investigating a new control on the macroscopic brittle-ductile transformation through mapping and related structural studies. [M.S. Thesis]: University of North Carolina at Chapel Hill, 79p., scale 1:24,000. Georeferenced and digitized by NCGS.

Brobst, D.A., 1962, Geology of Spruce Pine district, Avery, Mitchell, and Yancey counties, North Carolina: U.S. Geological Survey, Bulletin B-1122-A, scale 1:24.000.

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).

Johnson, B.S., Miller, B., and Stewart, K., 2001, The nature and timing of Acadian deformation in the southern Appalachian Blue Ridge constrained by the Spruce Pine Plutonic Suite, western North Carolina: Geological Society of America Abstracts with Program, v. 33, p. 30.

Kish, S.A., 1983, A geochronological study of deformation and metamorphism in the Blue Ridge and Piedmont of the Carolinas. [Ph.D. Dissertation]: University of North Carolina at Chapel Hill, 220p.

Kish, S.A., 1989, Paleozoic thermal history of the Blue Ridge in southwestern North Carolina - constraints based on mineral cooling ages and the ages of intrusive rocks: Geological Society of America Abstracts with Program, v. 21, p. 45.

Langille, J.M., Palmer, M., and Green, C., 2023, Evidence for Cenozoic topographic rejuvenation associated with the Laurel Creek Lineament in the Spruce Pine 7.5-minute quadrangle, western North Carolina, USA, Journal of Maps, v. 19, no. 1, scale 1:24,000. Georeferenced and digitized by NCGS.

Misra, K.C. and Conte, J.A., 1991, Amphibolites of the Ashe and Alligator Back Formations, North Carolina: Geological Society of America Bulletin, v. 103, p. 737-750.

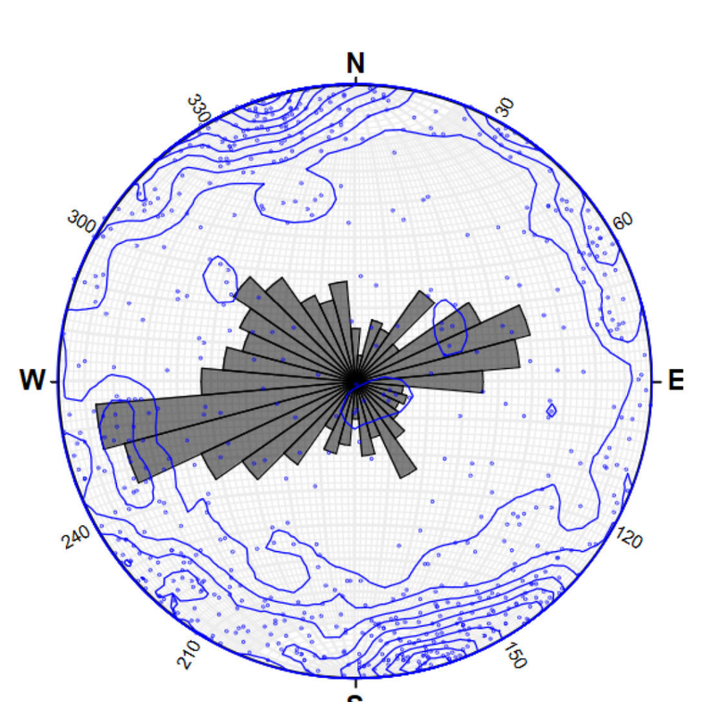
Raymond, L.A. and Abbott, R.N., 1997, Petrology and tectonic significance of ultramafic rocks near the Grandfather Mountain Window in the Blue Ridge belt, Toe terrane, western Piedmont, North Carolina, In: Paleozoic Structure, Metamorphism, and Tectonics of the Blue Ridge of Western North Carolina, Carolina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

Swanson, S.E. and Veal, W., 2010, Mineralogy and petrogenesis of pegmatites in the Spruce Pine District, North Carolina, USA. Journal of Geosciences. 55. 10.3190/jgeosci.062.

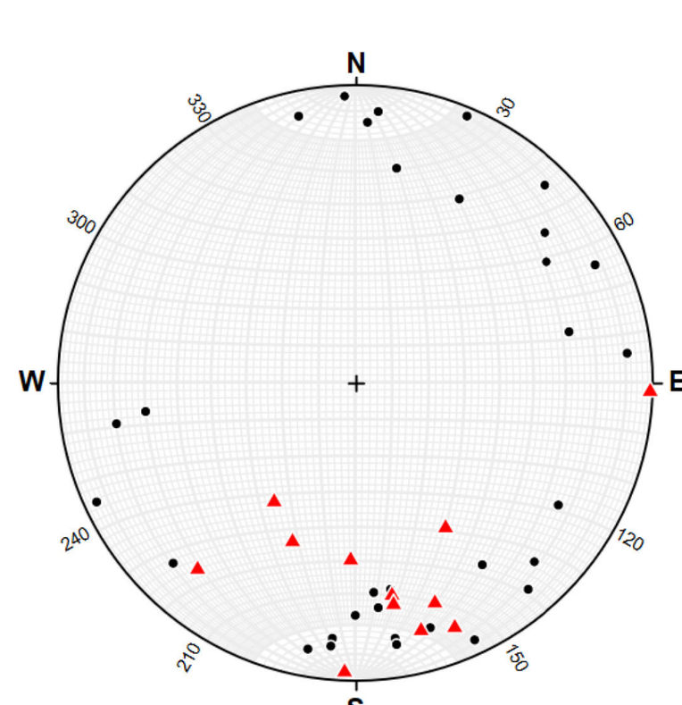
Trupe, C.H., 1997, Deformation and metamorphism in part of the Blue Ridge thrust complex, northwestern North Carolina. [Ph.D. Dissertation]: University of North Carolina at Chapel Hill, 176p.

SCHMIDT EQUAL AREA STEREONET DATA

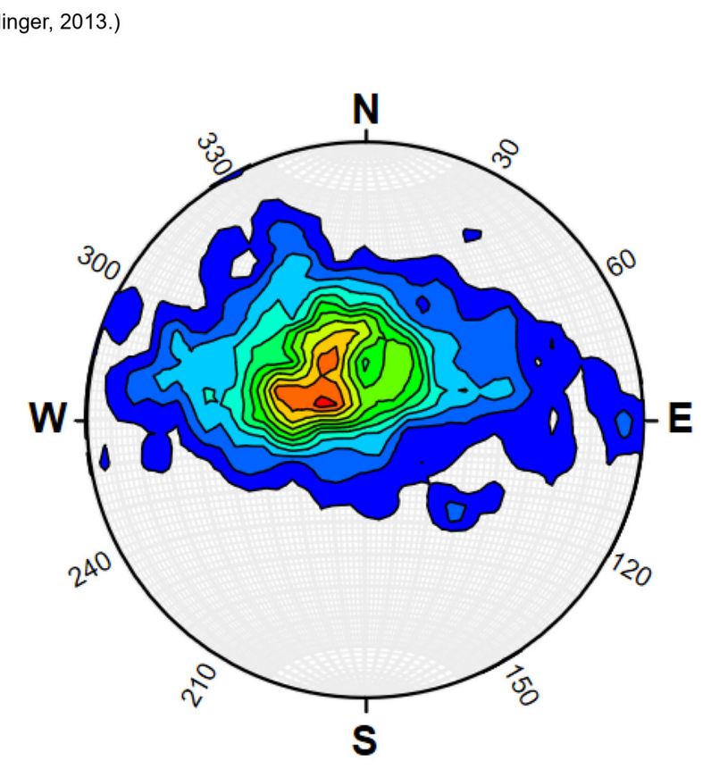
Stereonets created using Stereonet 10 (Allmendinger, et. al., 2012; Cardozo and Allmendinger, 2013.)



Contoured poles to joints and unidirectional rose diagram inset. Joint count = 699.

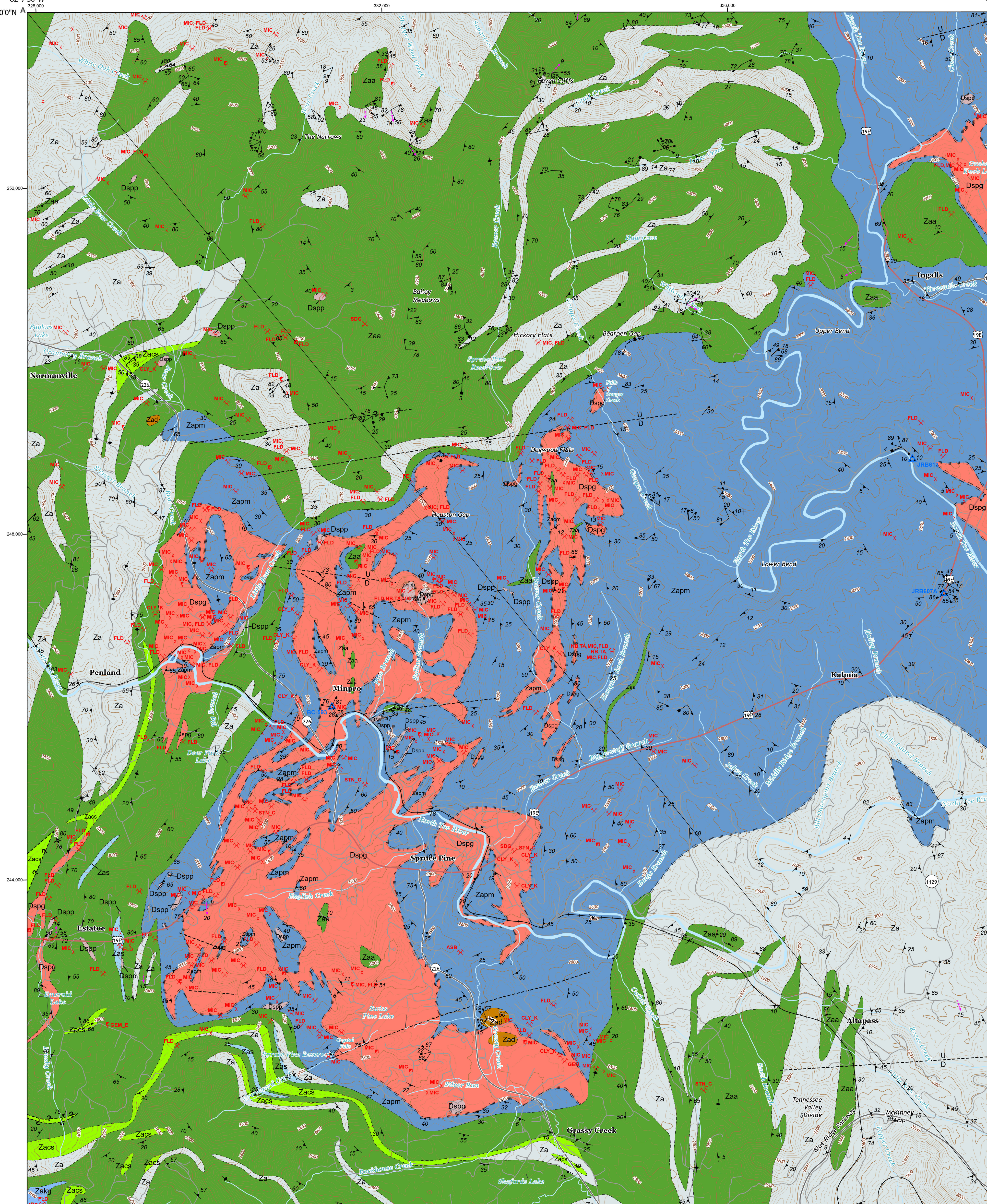


Bearing and plunge of fold hinges in blue and mineral lineations in red. Fold hinge count = 33. Mineral lineation count = 12.



Contoured poles to foliation. Foliation count = 1543.

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



Coordinate System: NAD 1983 StatePlane North Carolina FIPS 3200
Projection: Lambert Conformal Conic
Datum: North American 1983

This map is not a legal document. Boundaries may be generalized for this map scale. Private lands within government reservations may not be shown. Obtain permission before entering private lands.

Imagery....NAIP, September 2020 - September 2020
Roads....U.S. Census Bureau, 2016 - 2016
Roads within US Forest Service Lands....FSTopo Data with limited Forest Service updates, Not Available
Names....GNIS, 1980 - 2022
Hydrography....National Hydrography Dataset, 2004 - 2021
Contours....National Elevation Dataset, 2022
Boundaries....Multiple sources; see metadata file 2017 - 2021
Wetlands....FWS National Wetlands Inventory Not Available

MN GN 7°4' 126 MILS 0°37' 11 MILS

UTM GRID AND 2019 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

U.S. National Grid
100,000-m Square ID
'00
LV | MV
Grid Zone Designation
17S

SCALE 1:24,000

KILOMETERS 1 0.5 0 1 2
METERS 1000 500 0 1000 2000
MILES 1 0.5 0 1
FEET 1000 500 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000

CONTOUR INTERVAL 40 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

This product was produced to conform with the National Geospatial Program US Topo Product Standard.

NORTH CAROLINA
QUADRANGLE LOCATION

Bakersville	Carvers Gap	Newland
Micaville	Spruce Pine	Linville Falls
Celo	Little Switzerland	Ashford

ADJOINING QUADRANGLES

ROAD CLASSIFICATION
Secondary Hwy — Local Connector
4WD — Local Road
US Route — State Route

Spruce Pine, NC
2024

EXPLANATION OF MAP SYMBOLS

CONTACTS

Zone of Confidence: 300m

Contact—Identity and existence certain, location inferred.

Gradational contact—Identity and existence certain, location inferred

Fault (generic; subvertical, or high-angle; where possible: U, upthrown block; D, downthrown block.)—Identity or existence questionable, location inferred.

Fault (generic; subvertical, or high-angle; where possible: U, upthrown block; D, downthrown block.)—Identity or existence certain, location inferred.

PLANAR FEATURES

(For multiple observations at one locality, symbols are joined at the "tail" ends of the strike lines)

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

LINEAR FEATURES

- Inclined aligned-mineral lineation—Showing bearing and plunge
- Inclined fold hinge of generic (type or orientation unspecified) small, minor fold (1st option)— Showing bearing and plunge
- Inclined generic (origin or type not known or not specified) lineation or linear structure—Showing bearing and plunge

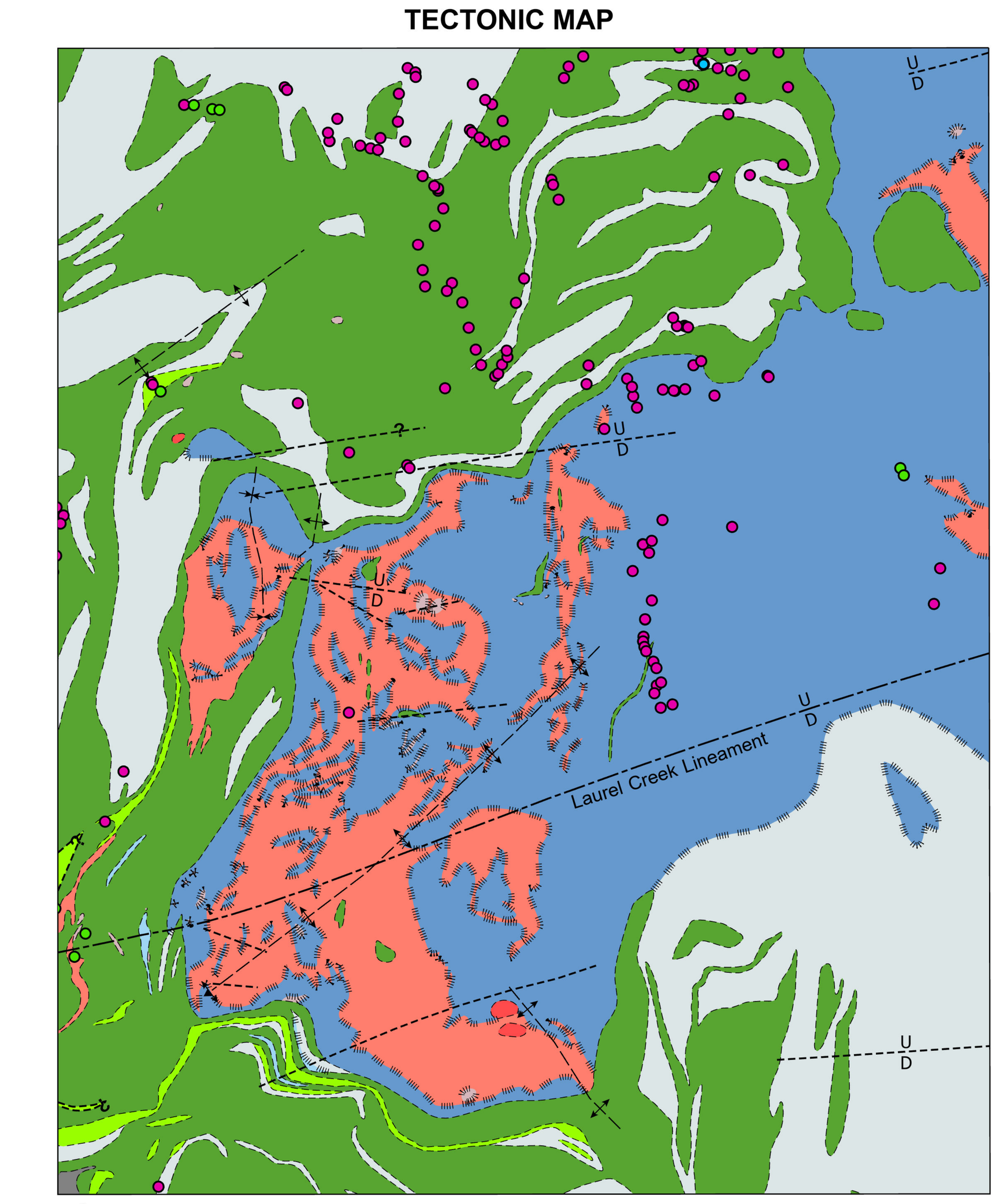
OTHER FEATURES

- Float station
- 20SI135B — Thin section and whole rock analysis sample location
- Prospect (pit or small open cut)
- Abandoned sand, gravel, clay, or placer pit
- Abandoned open pit, quarry, or glory hole
- Abandoned adit or tunnel entrance

NATURAL RESOURCES

MIC - Mica **SDG** - Sand and gravel **STN_C** - Crushed stone **STN** - Stone
TLC - Talc **CU** - Copper **FLD** - Feldspar **BE** - Beryl **MN** - Manganese **MBL** - Marble

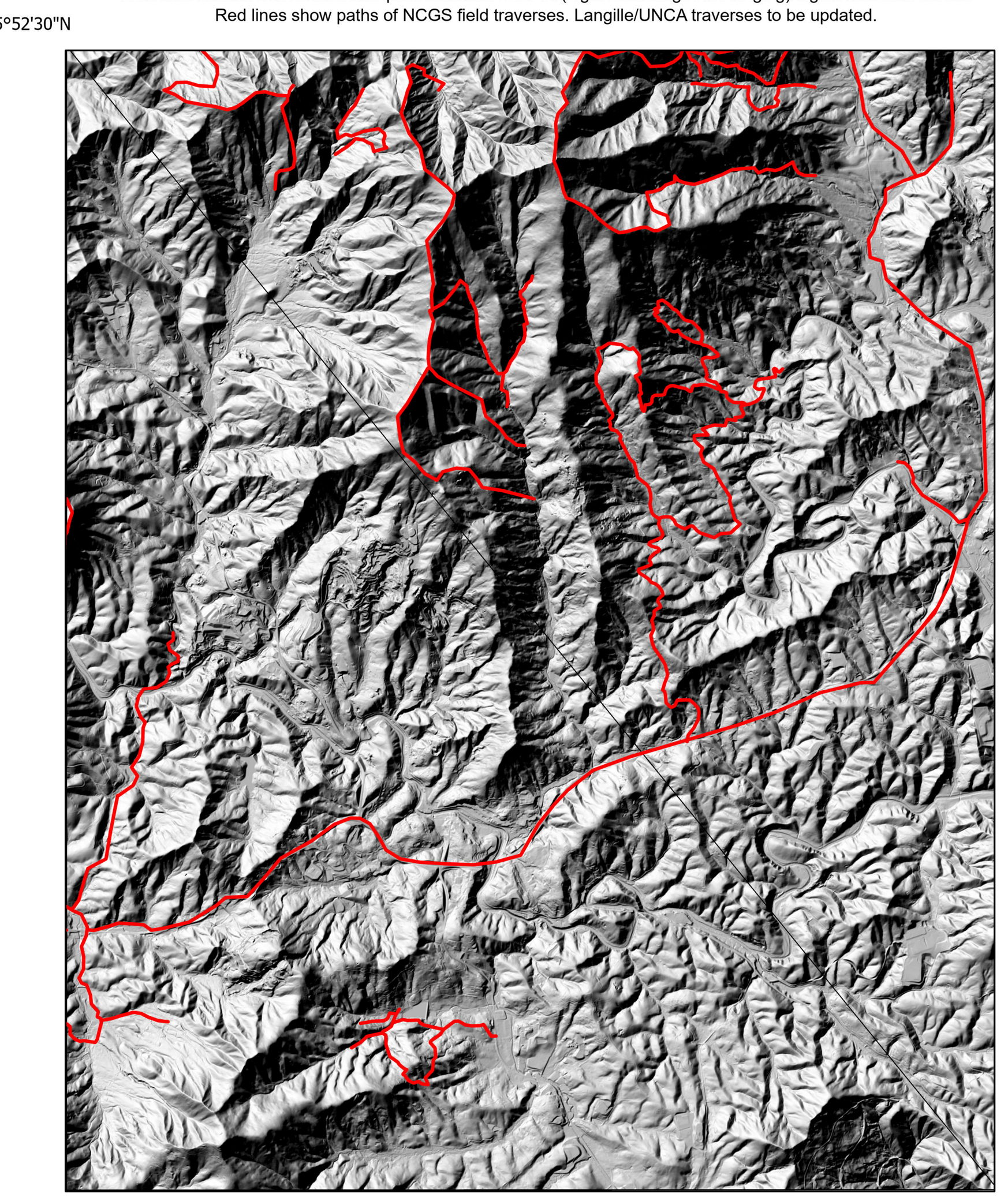
TECTONIC MAP

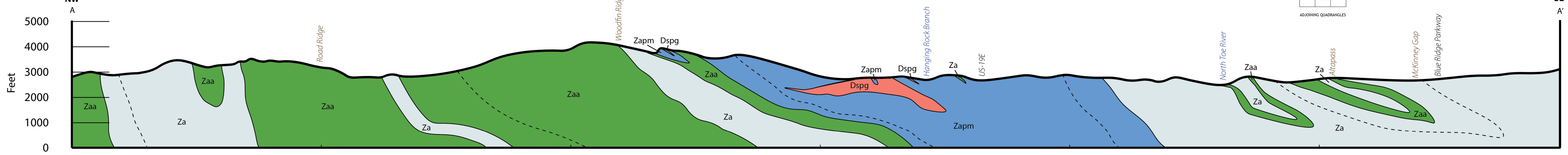


- Location where chlorite was observed
- Location where kyanite was observed
- Location where garnet was observed
- Arrow—Shows plunge direction of fold
- Antiform—Identity and existence certain, location approximate
- Synform—Identity and existence certain, location approximate
- Lineament — An extensive linear surface feature.

TRAVERSE MAP

Hillshade derived from a six meter pixel resolution LIDAR (Light Detecting And Ranging) digital elevation model. Red lines show paths of NCGS field traverses. Langille/UNCA traverses to be updated.





Unit contact
Form lines — interpretive patterns of subsurface foliation and orientations based upon surficial structural measurements

Research supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program under STATEMAP (award number G22AC00395) 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. Government.

Bedrock Geologic Map of the Spruce Pine 7.5-minute Quadrangle, Mitchell, Avery, and McDowell Counties, North Carolina

By
Jackie Langille, Megan Palmer, Bart Cattanach, Joshua Benton, Brennan Trantham, Ashley Lynn

Geology mapped from May 2022 to December 2023. Additional structural measurements and unit adaptation from Brobst (1962), Borella (2000).
Map preparation, digital cartography and editing by Brennan Trantham, Bart Cattanach, Ashley Lynn, Sierra J. Isard, and Jesse Hill, 2023, 2024.