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

North Carolina Geological Survey
Open File Report 2021-03

Little Switzerland 7.5-minute Quadrangle, Open File Report 2021-03

CORRELATION OF MAP UNITS

CAMBRIAN

- Ꞓs — Shady Dolomite
- Chilhowee Group
  - Ꞓce — Erwin Formation

NEOPROTEROZOIC

Ashe Metamorphic Suite

- Zass — Metasandstone
- Za — undivided
  - Zapm — pegmatite and metasomatic schist
  - Zaa — amphibolite
  - Zau — ultramafic bodies

stratigraphic relations uncertain

MESOPROTEROZOIC

- Ybm — Brown Mountain granite
- Ybmb — Brown Mountain granite-biotite phase
- Ywc — Wilson Creek Gneiss
- Ycu — Cranberry Gneiss undivided

INTRODUCTION

The Little Switzerland 7.5-minute quadrangle lies in McDowell and Mitchell counties, western North Carolina. Within the quadrangle is the town of Little Switzerland and the smaller communities of Woodlawn and Sevier. The Blue Ridge Parkway, U.S. Route 221, and N.C. Highway 226 are the major transportation corridors on the quadrangle. The major water feature is the North Fork of the Catawba River and minor water features are Armstrong Creek, Pepper Creek, Cox Creek, and Grassy Creek. Total elevation relief is 2,670 feet with a low of 1,260 feet along the North Fork of the Catawba River and a high of 3,930 feet at Rich Knob. The Blue Ridge escarpment, the rugged transition zone between the Blue Ridge and Piedmont physiographic provinces, transects the quadrangle. The Eastern Continental Divide represents the top of the escarpment in this region.

GEOLOGIC OVERVIEW

Bedrock of the Little Switzerland quadrangle is composed of units within four thrust sheets (from structurally highest to lowest): Fries/Spruce Pine, Fork Ridge, Table Rock, and Wilson Creek. The Table Rock and Wilson Creek thrust sheets comprise the Grandfather Mountain window, a tectonic window overlain by the Blue Ridge-Piedmont Megathrust that contains the two upper thrust sheets exposed on the quadrangle (Fries/Spruce Pine, and Fork Ridge). Brief descriptions of the units within these thrust sheets are given below, beginning in the northwest corner of the map and proceeding to the southeast.

FRIES/SPRUCE PINE THRUST SHEET

The Fries/Spruce Pine thrust sheet is part of the western Tugaloo terrane. This 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.

Numerous pegmatites occur within the AMS and are thought to be related to the 392-361 Ma pegmatites within the Spruce Pine Plutonic Suite (Kish, 1983, 1989; Johnson and others, 2001). Pegmatite bodies are typically concordant with metamorphic foliation on the quadrangle. Xenoliths of foliated metasedimentary rocks are locally present within the pegmatites. Metasedimentary lithologies in close proximity to pegmatites are more micaceous and coarse-grained than those where pegmatites are absent.
Rocks of the Spruce Pine thrust sheet are structurally above the Fork Ridge thrust sheet.

FORK RIDGE THRUST SHEET

On the Little Switzerland quadrangle, the Fork Ridge thrust sheet is comprised of the Cranberry Gneiss, a heterogeneous unit consisting of several undifferentiated lithologies. The unit is interpreted to be Mesoproterozoic in age (Bryant and Reed, 1970) although there may be Neoproterozoic rocks included within the strongly mylonitic Linville Falls shear zone at the base of the unit (Trupe, 1997). The primary lithology of the unit is a granitic to granodioritic orthogneiss with lesser amounts of biotite granitic gneiss and amphibolite. Lesser amounts of chlorite and muscovite within the unit differentiate it from the Brown Mountain Granite on the quadrangle.

The Fork Ridge thrust sheet and the underlying Grandfather Mountain Window are separated by the Linville Falls fault, an Alleghanian greenschist-facies ductile thrust fault (Van Camp and Fullagar, 1982).

GRANDFATHER MOUNTAIN WINDOW

The Grandfather Mountain Window consists of Mesoproterozoic basement gneisses overlain by rocks of the Table Rock thrust sheet.

Tablerock thrust sheet

The Tablerock thrust sheet consists of Cambrian meta-arenites of the Chilhowee Group that are conformably overlain by the Shady Dolomite. These units represent the rift-to-drift transition during the opening of the Iapetus Ocean basin (Hatcher et al., 2007). Rocks of the Table Rock thrust sheet are overturned in the southeastern portion of the quadrangle, possibly the result of sheath folding during Alleghanian orogenesis (see Walker, 2012). These rocks are structurally above the Wilson Creek Gneiss along the Tablerock thrust fault (Bryant and Reed, 1970).

Proterozoic basement within the Grandfather Mountain Window

Wilson Creek gneiss is primarily a proto- to mylonitic biotite granitic orthogneiss. It outcrops SE of the Linville Falls fault and is interpreted to be Mesoproterozoic in age (Bryant and Reed, 1970).

The Brown Mountain Granite is locally strongly mylonitic, only recognizable by pink potassium-feldspar layers and plentiful chlorite and muscovite. It is structurally above rocks of the Table Rock thrust sheet along the Bald Mountain fault. Age of the Brown Mountain Granite is interpreted to be Neoproterozoic (Bryant and Reed, 1970).

DESCRIPTION OF MAP UNITS[1]

Ꞓs **Shady Dolomite —** Light gray to dark gray to bluish gray; fine- to medium-grained; thick-bedded; non- to weakly-foliated; locally mylonitic; locally brecciated; equigranular, granoblastic, consists of primarily of dolomite with minor quartz, pyrite siderite, feldspar, and muscovite; locally contains chert nodules.

Chilhowee Group

Ꞓce **Erwin Formation—** Meta-arenite interlayered with minor amounts of dark-grey, thinly bedded phyllite. Meta-arenite is white to tan, fine- to medium-grained; thin- to thick-bedded; protomylonitic to mylonitic; locally brecciated with manganese matrix; consists of 80-98% quartz, 1-25% potassium feldspar, 0-10% muscovite/sericite, 1-3% plagioclase, and traces of magnetite, apatite, zircon, epidote group minerals, tourmaline, and sphene.

Ashe Metamorphic Suite

Zass **Metasandstone —** Interlayered metamorphosed sandstones including arkosic arenite, biotite metawacke, and quartzite. Tan to medium-gray to light-green; fine- to medium-grained; foliated to locally mylonitic; equigranular to inequigranular; consists of quartz, feldspar, muscovite, biotite, and minor accessory minerals; notably does not contain schist, amphibolite, or garnet.

Za **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 metawacke, arkosic meta-arenite, schist, biotite gneiss, amphibolite, and ultramafic rocks. Thickness of layering ranges from centimeters to meters.

Metawacke —Medium-light-gray to medium-dark-gray; medium- to coarse-grained; foliated; protomylonitic to mylonitic; equigranular to inequigranular; granoblastic to lepidoblastic; consists of quartz, plagioclase feldspar, biotite, muscovite, garnet, epidote, chlorite, opaque minerals, trace potassium feldspar, kyanite, sillimanite, and zircon; thickness of layering ranges from decimeters to meters. Muscovite-dominated varieties have millimeter scale “pin-striped” fabric.

Arkosic meta-arenite — Tan to medium-light-gray to gray; medium-grained, equigranular to inequigranular, foliated; consists of quartz, feldspar, with minor amounts of muscovite, biotite, and other accessory minerals.

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 of plagioclase feldspar, quartz, muscovite, biotite, garnet, kyanite, sillimanite, and minor accessory minerals.

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.

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.

Zau **Ultramafic bodies —** Dark-green to silvery-grayish-green; fine- to medium-grained; non-foliated to strongly foliated; equigranular; granoblastic to nematoblastic to lepidoblastic; consists of amphibole, relict pyroxene, actinolite, chlorite, talc, serpentine, opaque minerals, plagioclase feldspar, magnetite, spinel, and other accessory minerals. These mineralogical variations could not be mapped at a 1:24,000 scale.

Ybm **Brown Mountain granite —** Semi-massive variety is coarse grained and equigranular with little chlorite and muscovite; mylonitic variety is fine- to medium-grained and equigranular with alternating pink potassium feldspar layers with silver-green chlorite-muscovite layers; both varieties consist of potassium feldspar, quartz, plagioclase feldspar, muscovite, chlorite, and sericite; may contain small mafic/chloritic pods.

Ybmb **Brown Mountain granite-biotite phase —** fine- to medium-grained; mylonitic to protomylonitic; locally porphyroclastic; similar to Brown Mountain granitic orthogneiss but with more biotite.

Ywc **Wilson Creek Gneiss —** Heterogeneous unit with dioritic to granitic lithologies that have been variously sheared. Granitoid - Light-to medium-gray to light pink, fine- to coarse-grained; weakly- to well-foliated; mylonitic to protomylonitic; granoblastic to lepidoblastic; locally strongly layered; locally porphyroclastic; consists of potassium feldspar, plagioclase feldspar, quartz, biotite and minor amounts of sericite, chlorite, epidote group minerals, amphibole, and opaque minerals.

Ycu **Cranberry Gneiss undivided —** Heerogeneous unit consisting of granitic orthogneiss with minor amounts of biotite gneiss and amphibolite; white to light pink; medium- to coarse-grained; equigranular to inequigranular; mylonitic to protomylonitic; consists of potassium feldspar, quartz, plagioclase feldspar, biotite, and minor amounts of sericite/muscovite, opaque minerals, epidote, chlorite, garnet, and zircon.

---

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

WHOLE ROCK ICP ANALYSIS[1] OF SELECTED SAMPLES

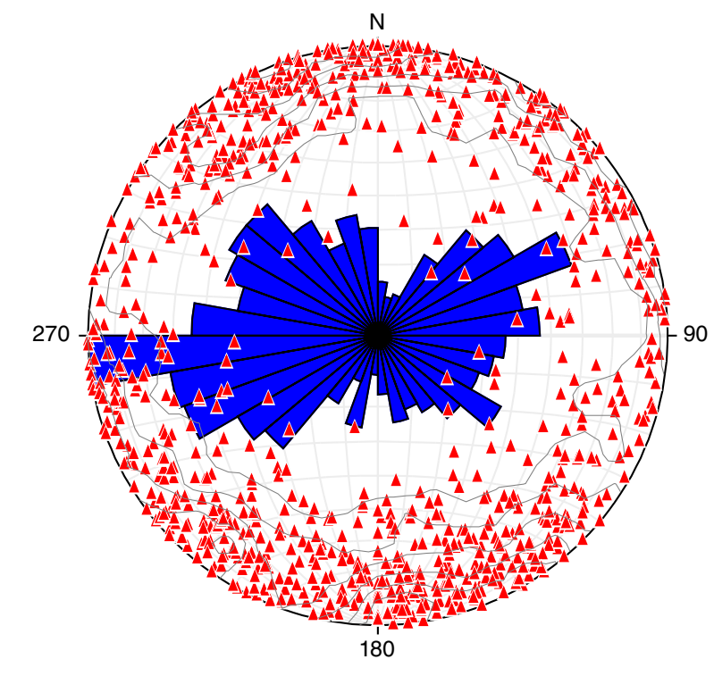
Sample	Rock Type	Map Unit	SiO2	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	Cr2O3	LOI	Sum	Ba	Ni	Sc	Be	Co	Cs	Ga	Hf	Nb	Rb	Sn	Sr	Ta	Th	U	V	W	Zr
19NB475	quartz arenite	Cce	97.78	0.38	1.55	0.03	0.03	0.02	0.14	0.19	0.01	0.02	0.003	-0.2	99.93	23	<20	<1	<1	1.3	<0.1	0.5	12.4	2.9	2.4	<1	2.1	0.2	3.5	1	10	<0.5	491.1
20BC90	breccia	Cce	4.97	1.15	80.9	0.05	0.06	0.03	0.06	0.12	1.14	0.06	<0.002	11.4	99.93	40	84	1	9	38.2	2.5	2.7	0.8	0.4	10.4	<1	16.2	<0.1	0.3	10.5	<8	2.7	32.6
20NB105	metaconglomerate	Cce	86.72	2.64	7.23	0.35	0.06	0.02	0.95	0.2	0.15	0.29	0.004	1.3	99.93	501	26	4	4	19.7	0.2	4.8	2.7	5.8	23.4	<1	19.3	0.3	4.6	3.5	18	7.6	103.9
20BC355	marble	Cs	37.3	9.09	2.27	10.28	14.08	0.74	3.17	0.45	0.1	0.04	0.005	22.1	99.76	844	<20	8	1	6.6	1.3	10.9	3.5	9.5	83.1	2	137.1	0.7	7.8	1.9	56	1.2	134.6
20SI135A	marble	Cs	7.01	0.37	0.73	19.46	28.16	<0.01	0.14	0.02	0.02	0.04	<0.002	43.7	99.64	11	<20	<1	<1	0.8	0.2	<0.5	<0.1	0.2	6.9	<1	260.2	<0.1	0.3	0.8	10	<0.5	3.9
20SI135B	marble	Cs	59.91	13.38	4.23	2.91	5.82	2.39	3.28	0.57	0.17	0.07	0.009	6.9	99.81	1030	27	11	4	5.6	1.2	18.8	9.5	33.7	79.6	3	217.3	2.3	9.3	2	72	1.3	368.9
20SI120	biotite gneiss	CZapm	66.58	16.22	5.12	1.69	0.72	2.27	4.37	0.58	0.15	0.07	0.007	2.1	99.89	402	25	17	<1	12.2	8.9	21.8	3.9	20.7	175.9	4	87.9	1.8	9.4	4.4	69	1.7	146
20BC263	schistose metawacke	CZapm	74.96	11.2	4.44	1.22	1	2.21	2.51	0.59	0.15	0.06	0.007	1.5	99.89	480	<20	8	4	8.2	4.3	13.4	8.1	14.5	93	2	128.6	0.9	10.3	1.7	60	1.4	307.6
20BC264	schistose metawacke	CZapm	75.34	14.45	0.87	0.09	0.96	6.1	1.04	0.02	<0.01	0.01	<0.002	1.1	99.98	131	<20	<1	2	0.8	0.6	11.5	0.2	3.6	33.4	<1	127.7	0.2	0.9	0.6	<8	1.6	4.2
20NB369	granitic orthogneiss	Ybm	83.98	7.27	2.04	0.31	0.11	0.08	4.47	0.48	0.03	0.01	<0.002	1.1	99.95	762	<20	4	<1	2.1	0.5	7.6	5.3	7.7	72.5	<1	54.5	0.6	9.3	1.3	22	1.5	213.3
20BC86	biotite granitic gneiss	Ycu	47.28	15.32	13.92	3.75	6.58	2.05	3.45	2.71	1.43	0.18	0.004	2.8	99.63	1505	21	20	3	29.3	1.4	22.6	12.6	32.6	114.9	2	786.5	1.4	5	1.7	148	0.6	553.8
20NB5	granitic orthogneiss	Ycu	71.64	14.14	2.68	0.49	1.07	3.2	4.76	0.26	0.06	0.03	<0.002	1.4	99.88	1409	<20	1	2	3.6	<0.1	16.3	4.9	6.9	109	1	299.4	0.3	10.7	1	19	<0.5	166.5
20SI33	diorite	Ycu	58.52	17.14	7.43	2.03	4.39	3.67	3.36	0.94	0.31	0.11	<0.002	1.8	99.81	903	<20	8	2	13.6	0.9	21.7	6.1	10.7	144	3	555.7	0.4	2.9	0.9	92	<0.5	239.1
LZ1	bgg	Ycu	69.84	13.44	4.89	0.09	0.8	4.63	4.91	0.39	0.05	0.09	<0.002	0.5	99.65	261	<20	2	3	0.7	1.1	38.2	23.5	77.4	69.6	4	33.5	4.8	15.1	2	<8	0.5	1058
20BC9	biotite gneiss	Ywc	81.69	8.17	2.64	0.47	0.2	0.06	3.95	0.72	0.02	0.02	0.003	1.9	99.92	749	<20	5	<1	3.3	0.5	9.2	7.8	10.7	65.7	1	35	0.6	10.1	1.5	54	0.6	309.5
20SI26	gneiss	Ywc	67.32	14.94	3.27	0.79	2.15	4.61	4.33	0.51	0.16	0.05	<0.002	1.6	99.87	1050	<20	2	3	5.5	0.5	17.1	5.6	14.3	125.9	1	248.3	0.8	15.2	1.4	34	<0.5	224.6
20SI206	mylonite	Ywc	79.1	9.91	2.57	0.64	0.06	0.53	3.31	0.63	0.04	0.02	<0.002	3	99.93	881	<20	6	2	5.3	0.5	10.5	6.9	9.1	73.7	1	27.6	0.5	6.6	1.4	43	<0.5	275.1
20SI28	arenite	Ywc	69.2	13.72	2.6	1.01	2.39	3.39	2.76	0.35	0.1	0.06	<0.002	4.2	99.9	679	<20	5	<1	3.2	2.4	16.3	4.8	9.2	108.2	2	204.4	0.6	8.7	2.4	25	0.9	174.9
20NB134	sandy metawacke	Za	80.14	8.53	3.5	0.94	0.69	2	1.72	0.62	0.1	0.04	0.004	1.6	99.88	418	<20	4	<1	6.1	<0.1	9.6	11.7	12.9	42	1	75.8	0.7	11.3	2.1	32	0.5	481.3
20NB310	amphibolite	Zaa	49.77	12.17	20.53	4.88	6.8	2.44	0.27	1.59	0.12	0.35	0.004	0.8	99.76	50	31	47	2	56.7	0.2	18	2.9	3.3	4.9	<1	97.5	0.1	0.5	0.1	531	<0.5	93.6
NB318	ultramafic	Zaa	63.18	13.51	8.75	0.03	11.36	0.01	0.03	0.55	0.03	0.1	0.008	2.3	99.82	13	<20	12	<1	3.3	<0.1	23.7	3.3	14.1	1	2	968.3	0.7	11.3	1.5	90	<0.5	126.2
LS19	metagraywacke	Zabg	69.77	13.10	4.35	1.35	2.51	3.19	2.64	0.86	0.22	0.07	0.004	1.4	99.67	0731	0005	08		027				013			0210	16					0465
LS11	garnet mica schist	Zabsi	60.91	18.58	6.23	2.57	0.26	0.30	5.44	1.04	0.12	0.03	0.009	4.0	99.71	1225	0005	16		012				019			0035	05					0305
BC356	ultramafic	Zass	66.36	15.73	5.03	1.28	2.04	4.09	2.69	0.99	0.19	0.11	0.007	1.3	99.84	578	<20	10	4	8.9	1.5	13.7	11	16.8	77.7	2	309.5	1.1	8.9	1.5	57	0.5	441.4

Sample	Y	La	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
19NB475	8	11.7	23.4	2.3	8.4	1.36	0.22	1.1	0.18	1.38	0.29	0.92	0.14	1.11	0.19	3.5	7.5	3.3	3	5.4	1	<0.1	0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5
20BC90	7.5	2.4	4.1	0.84	3.9	1.28	0.34	1.6	0.27	1.59	0.29	0.87	0.15	1.01	0.17	6.4	47.5	15.9	74	80.2	14.2	0.1	6.4	<0.1	<0.1	1	0.01	0.1	<0.5
20NB105	15.5	22	52.3	5.96	23.3	5.06	0.96	4.07	0.59	3.24	0.58	1.57	0.23	1.43	0.21	2.3	6	23.4	49	24.8	5.1	0.2	2.8	0.2	0.1	<0.5	0.05	0.7	<0.5
20BC355	20.2	28.2	53.7	6.3	23.1	4.26	0.55	3.81	0.61	3.63	0.74	2.2	0.33	2.12	0.32	0.5	3.6	3.1	11	12.3	0.7	<0.1	<0.1	0.1	<0.1	1	<0.01	<0.1	<0.5
20SI135A	2.7	4.3	8.2	0.95	3.6	0.53	0.19	0.58	0.08	0.5	0.1	0.26	0.04	0.23	0.03	4.1	1	32.9	17	1.9	1	0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5
20SI135B	42.4	44.5	89.6	11.4	44	9.01	1.18	8.18	1.31	7.69	1.57	4.45	0.64	4.13	0.66	0.2	29.2	1.4	38	26.9	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	0.1	<0.5
20SI120	16	14.6	27.8	3.54	13.4	2.58	0.51	2.66	0.45	2.82	0.55	1.53	0.23	1.46	0.23	0.3	39.9	6	61	21.2	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	0.5	<0.5
20BC263	17.3	7.8	32.5	2.28	8.4	1.78	0.46	1.79	0.34	2.48	0.61	2.03	0.32	2.19	0.35	0.7	6.5	2.9	50	18	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	0.4	<0.5
20BC264	6.2	3.6	4.1	0.68	2.7	0.65	0.33	0.77	0.14	1.02	0.21	0.62	0.08	0.44	0.06	0.4	0.9	11.8	5	1.2	3.8	<0.1	0.1	<0.1	<0.1	0.9	<0.01	<0.1	<0.5
20NB369	19.1	19.2	19.3	4.95	19.9	4.02	1.07	3.46	0.58	3.49	0.74	2.24	0.34	2.18	0.34	0.1	1.2	1.2	4	1.6	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5
20BC86	45.3	115.2	226.4	28.87	112.6	18.8	5.06	14.71	1.86	9.58	1.67	4.46	0.6	3.54	0.54	0.9	21.1	3.7	163	20.6	0.5	<0.1	<0.1	<0.1	<0.1	0.6	<0.01	0.6	<0.5
20NB5	9.1	40.8	66.5	6.9	21.9	2.85	0.89	2.37	0.3	1.65	0.31	0.86	0.12	0.8	0.12	0.4	1.7	5.5	35	2.2	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	0.2	<0.5
20SI33	24.7	37.2	76.7	10.02	40.1	7.71	1.67	6.52	0.89	4.69	0.88	2.35	0.31	1.98	0.28	0.2	1.6	1.5	82	5.7	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	0.7	<0.5
LZ1	89.2	306.6	498.9	68.38	251.7	43.27	2.83	33.41	4.23	20.93	3.6	9.7	1.36	8.75	1.33	4.5	3	9.1	201	0.8	<0.5	0.3	<0.1	<0.1	<0.1	<0.5	<0.01	0.2	<0.5
20BC9	13	16.1	46.4	3.78	13.5	2.4	0.55	2.14	0.36	2.34	0.51	1.63	0.24	1.63	0.27	0.5	2	3.6	6	3.6	4	<0.1	0.1	<0.1	<0.1	<0.5	0.02	0.1	<0.5
20SI26	18.2	59	112.4	12.5	41.3	5.9	1.21	4.48	0.59	3.08	0.6	1.72	0.25	1.59	0.23	0.3	5.3	2	46	2.9	0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	0.3	<0.5
20SI206	5.5	10.5	7.7	1.82	6.1	1	0.23	0.97	0.16	0.98	0.23	0.71	0.13	0.92	0.18	<0.1	4.8	2.7	15	4	1.6	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5
20SI28	18.8	34.7	68.2	8.01	29.6	5.26	1.03	4.37	0.61	3.44	0.65	1.93	0.28	1.79	0.27	0.3	1.2	15.6	22	1.5	3.6	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5
20NB134	24.4	27.7	57.2	6.83	25.4	4.92	1.19	4.5	0.72	4.32	0.9	2.65	0.38	2.55	0.38	0.8	3.9	2.4	26	9	9	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5
20NB310	46	5.6	11.6	2.28	12	4.05	1.51	5.81	1.07	7.31	1.66	5.23	0.75	4.79	0.78	0.5	54.7	1.9	48	17.4	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	<0.1	<0.5
NB318	27.8	47.7	97.3	10.67	39.3	7.31	1.34	6.39	0.96	5.52	1.11	3.04	0.43	2.86	0.43	0.2	10	5.5	10	6.2	<0.5	<0.1	<0.1	<0.1	<0.1	1	<0.01	<0.1	<0.5
LS19	041		096																										
LS11	031		016																										
BC356	29.3	22.3	65	6.07	22.9	4.44	1.06	4.17	0.74	4.71	1.08	3.69	0.57	3.82	0.66	0.3	3.9	3.7	60	15.8	1.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.01	0.4	<0.5

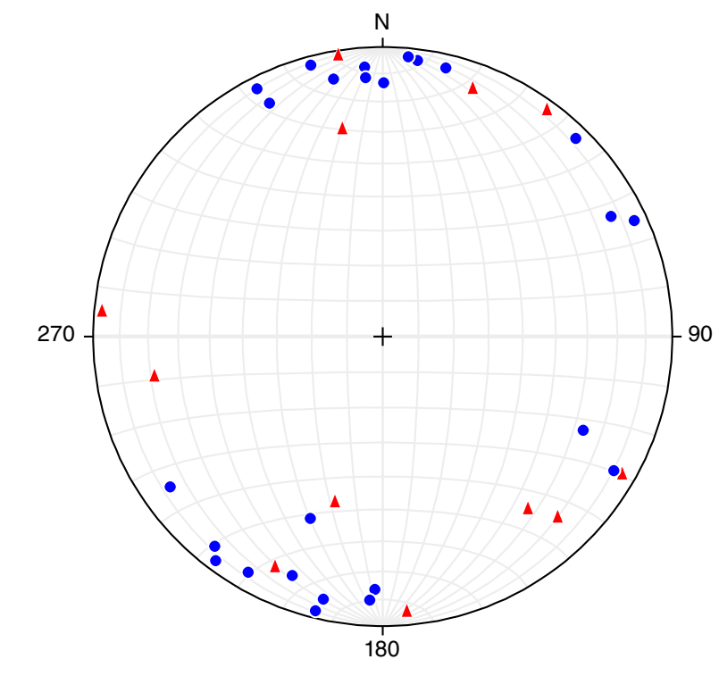
Whole Rock Inductively Coupled Plasma - Atomic Emission/Mass Spectrometer analysis conducted by Bureau Veritas, 9050 Shaughnessy St, Vancouver, BC Canada V6P 6E5.
Sample numbers correspond to thin section and whole rock sample localities shown on geologic map
State Plane Coordinate System
LOI = loss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

SCHMIDT EQUAL AREA STEREONET DATA

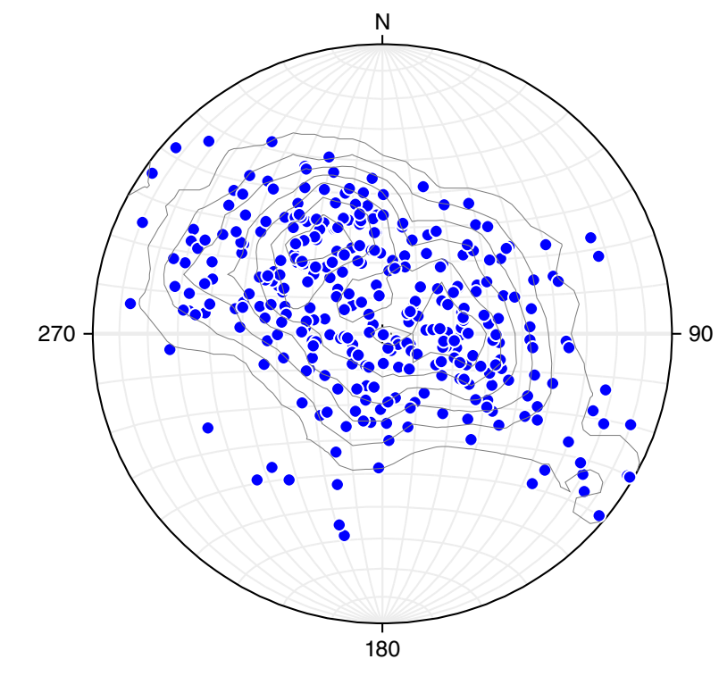
Stereonets created using Stereonet 10 (Allmendinger, et al., 2012; Cardozo and Allmendinger, 2013.)



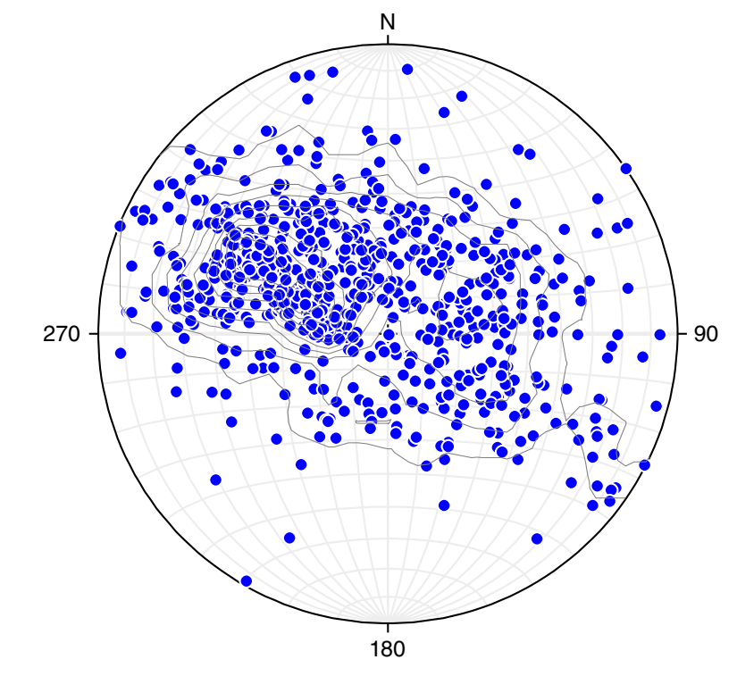
Contoured poles to joints and unidirectional rose diagram inset. Joint count 923.



Bearing and plunge of fold hinges in blue and mineral lineations in red. Fold hinge count 25. Mineral lineation count 12.



Contoured poles to mylonitic foliation. Mylonitic foliation count 335.



Contoured poles to foliation. Foliation count 683.

REFERENCES

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

Brobst, D.A., 1962, Geology of the Spruce Pine district, Avery, Mitchell and Yancey counties, North Carolina, U.S. Geological Survey Bulletin 1122-A, map scale 1:24,000.

Bryant, B. and Reed, J.C., Jr., 1970, Geology of the Grandfather Mountain window and vicinity, North Carolina and Tennessee: U.S. Geological Survey Professional Paper 615, 190 p. map scale 1:62,500.

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. A30.

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, 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.

Lewis, S.E. and Butler, J.R., 1982, Geologic map of the Little Switzerland Quadrangle, North Carolina, unpublished raw data

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.

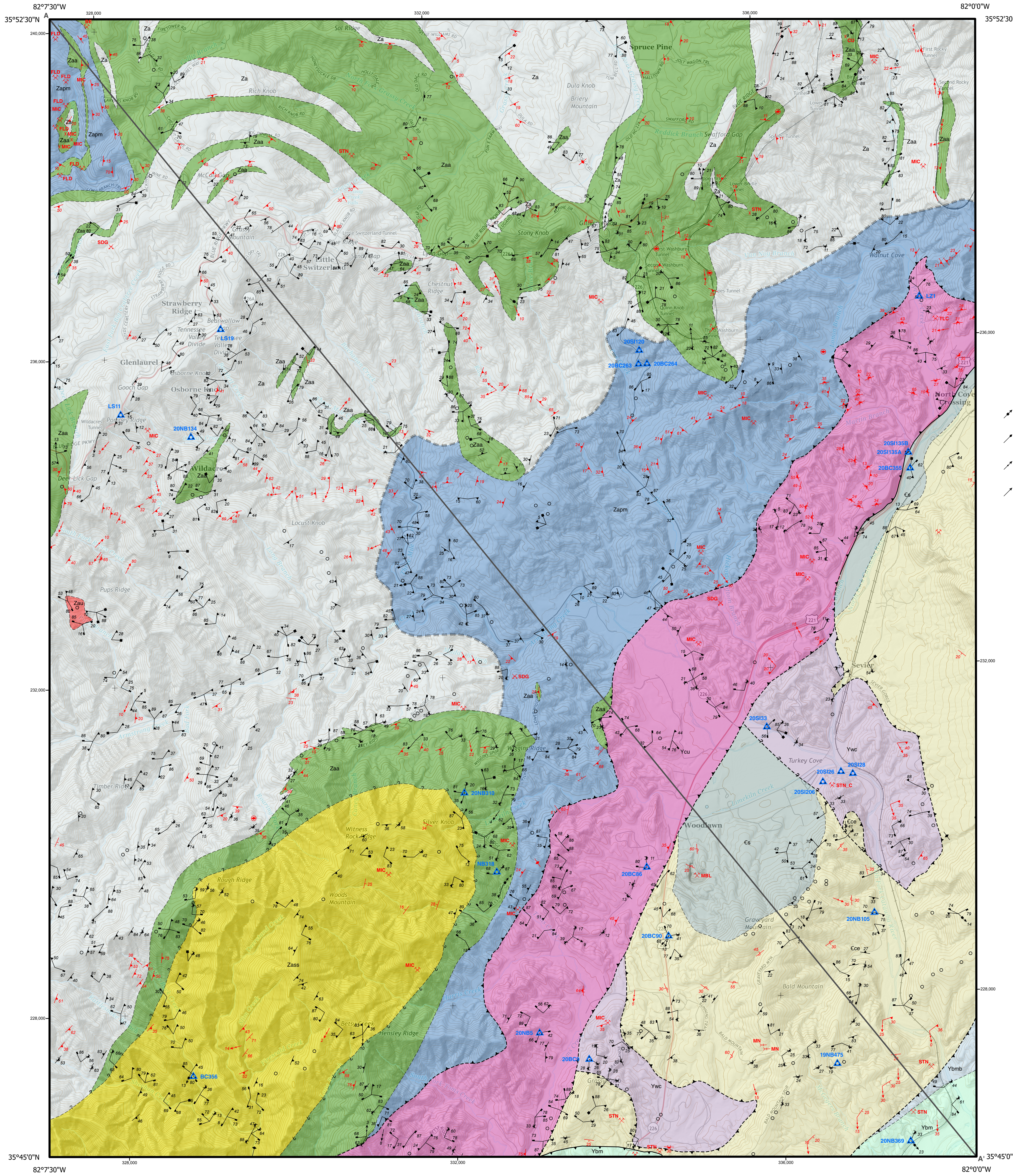
Trupe, C.H. (1997). Deformation and metamorphism in part of the Blue Ridge thrust complex,northwestern North Carolina. [Ph.D. thesis], Chapel Hill, NC: The University of North Carolina.

Van Camp, S.G. and Fullagar, P.D., 1982, Rb-Sr whole-rock ages of mylonites from the Blue Ridge and Brevard zone of North Carolina, in: Geological Society of America Abstracts with Programs, v. 14, no. 1-2, p. 92-93.

Walker, Ann Elizabeth, 2014, Structural analysis of the Tablerock thrust sheet, Grandfather Mountain window, northwestern North Carolina: Emplacement kinematics of a large horse in a major thrust system. [MS Thesis], University of Tennessee. https://trace.tennessee.edu/utk_gradthes/2760

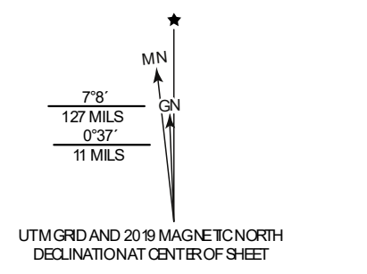
NORTH CAROLINA
Department of Environmental Quality

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



Produced by the United States Geological Survey
North American Datum of 1983 (NAD83)
World Geodetic System of 1984 (WGS84).
Projection: State Plane North Carolina FIPS 3200 (Meters)
4,000-meter ticks: State Plane North Carolina FIPS 3200 (Meters)

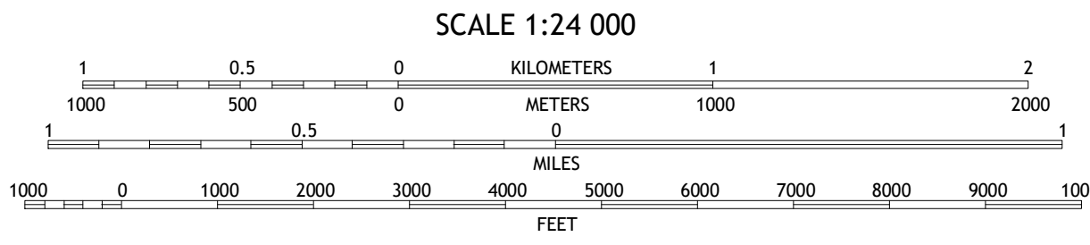
Imagery....................NAIP, May 2016 - November 2016
Roads....................U.S. Census Bureau, 2016
Roads within US Forest Service Lands....................FSTopo Data with limited Forest Service updates, 2012 - 2016
Names....................GNIS, 1980 - 2018
Hydrography....................National Hydrography Dataset, 2004 - 2018
Contours....................National Elevation Dataset, 2008
Boundaries..........Multiple sources; see metadata file 2017 - 2018
Wetlands..........FWS National Wetlands Inventory 1986



UTM GRID AND 2019 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

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

SCALE 1:24 000



CONTOUR INTERVAL 40 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

This map was produced to conform with the National Geospatial Program US Topo Product Standard, 2011.
A metadata file associated with this product is draft version 0.6.18

QUADRANGLE LOCATION

1	2	3
4		5
6	7	8

- 1 Micaville
- 2 Spruce Pine
- 3 Linville Falls
- 4 Celo
- 5 Ashford
- 6 Old Fort
- 7 Marion West
- 8 Marion East

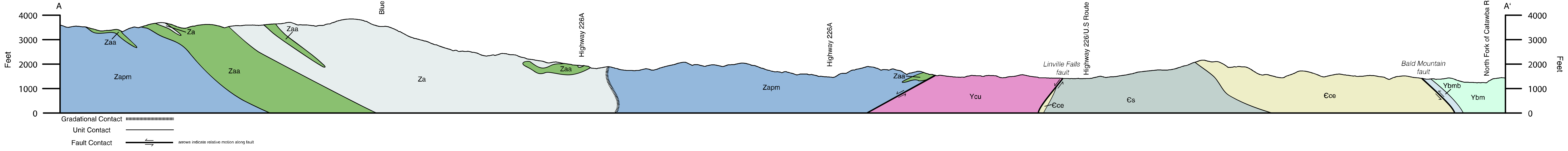
ADJOINING QUADRANGLES

ROAD CLASSIFICATION

Expressway	Local Connector
Secondary Hwy	Local Road
Ramp	4WD
Interstate Route	US Route
State Route	FS Primary Route
FS Passenger Route	FS High Clearance Route

Check with local Forest Service unit for current travel conditions and restrictions.

LITTLE SWITZERLAND, NC
2019



Research supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program under STATEMAP (award number G20AC00249, 2020) 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 Little Switzerland 7.5-minute Quadrangle, McDowell and Mitchell Counties, North Carolina

By

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

Geology mapped from August 2020 to May 2021. Additional structural measurements from Lewis and Butler (1982).
Portions of map modified from Brobst (1962), Bryant and Reed (1970), and Lewis and Butler (1982).
Map preparation, digital cartography and editing by G. Nicholas Bozdog, Bart L. Cattanach, and Sierra J. Isard
2021

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 complete observation and thin-section data.

EXPLANATION OF MAP SYMBOLS

CONTACTS

Zone of Confidence: 300m

- Contact—Identity and existence certain, location inferred
- Contact—Identity questionable, existence certain, location inferred
- Gradational contact—Identity and existence certain, location inferred
- Tear fault — Identity and existence questionable, location inferred.
- Thrust fault (1st option)—Identity and existence certain, location inferred. Saw teeth on upper (tectonically higher plate).
- Thrust fault (1st option)—Identity and existence certain, location accurate. Saw teeth on upper (tectonically higher plate).

PLANAR FEATURES

(For multiple observations at one locality, symbols are joined at the "tail" ends of the strike lines)
(Planar features in red taken from Lewis and Butler, 1982)

- 64 — Inclined metamorphic or tectonic foliation—Showing strike and dip
- 80 78 — Inclined metamorphic or tectonic foliation, for multiple observations at one locality—Showing strike and dip
- Vertical metamorphic or tectonic foliation—Showing strike
- Vertical metamorphic or tectonic foliation, for multiple observations at one locality—Showing strike
- Vertical mylonitic foliation—Showing strike
- 79 — Inclined mylonitic foliation—Showing strike and dip
- 36 — Inclined bedding—Showing strike and dip
- 27 — Overturned bedding—Showing strike and dip
- 71 — Small, minor inclined joint—Showing strike and dip
- 86 66 — 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
- Small minor vertical or near-vertical joint—Showing strike
- 23 46 — Inclined mylonitic foliation, for multiple observations at one locality—Showing strike and dip
- Vertical mylonitic foliation, for multiple observations at one locality—Showing strike
- Horizontal foliation
- 39 — Inclined bedding, for multiple observations at one locality—Showing strike and dip

LINEAR FEATURES

(Linear features in red taken from Lewis and Butler, 1982)

- 6 — Inclined aligned-mineral lineation—Showing bearing and plunge
- 18 — Inclined slickenline, groove, or striation on fault surface—Showing bearing and plunge
- 56 — Inclined fold hinge of generic (type or orientation unspecified) small, minor fold—Showing bearing and plunge
- 12 — Inclined generic (origin or type not known or not specified) lineation or linear structure—Showing bearing and plunge

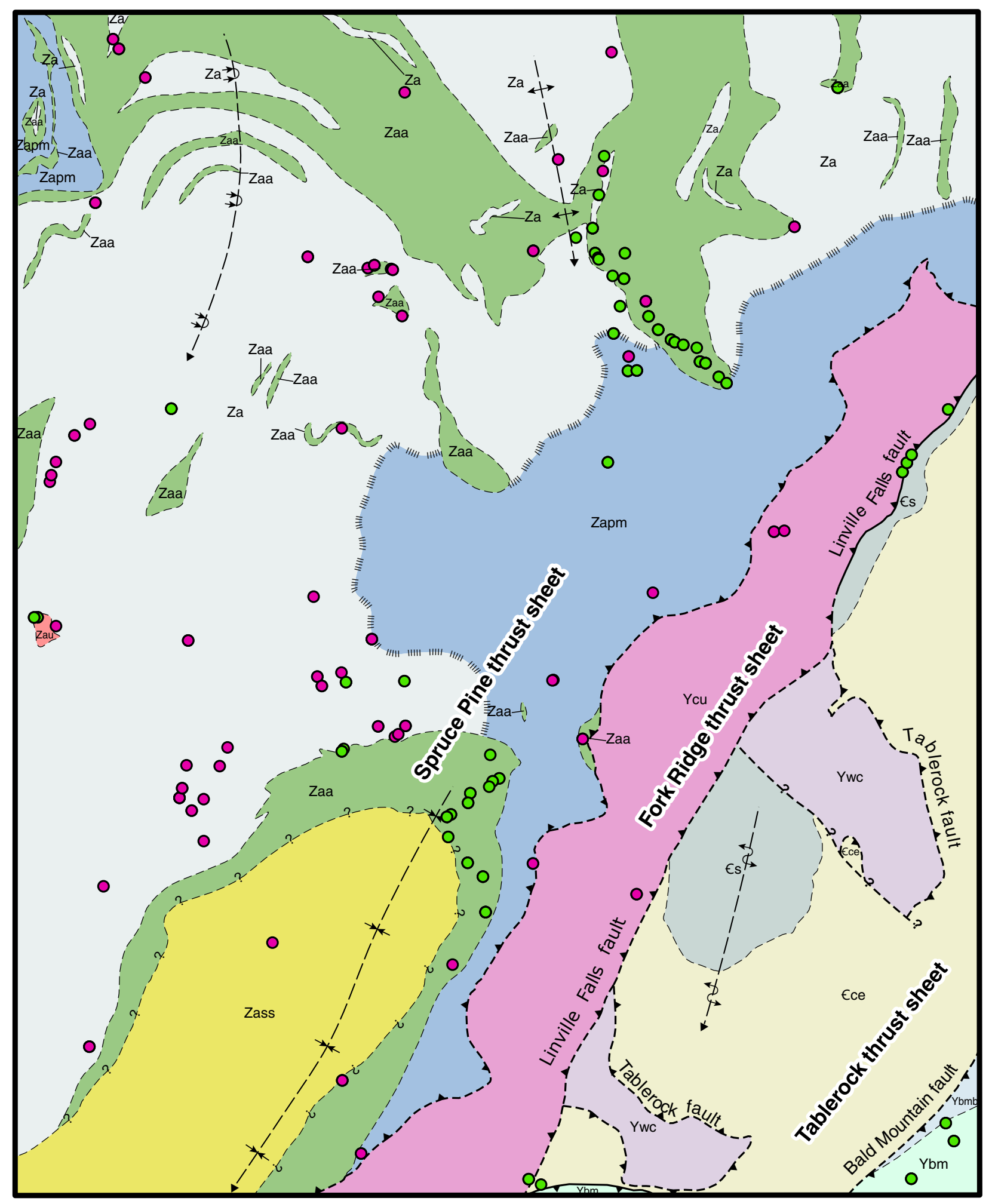
OTHER FEATURES

- ○ Float station
- 20SI135B △ Thin section and whole rock analysis sample location
- X 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 garnet was observed
- ◀ Arrow—Shows plunge direction of fold
- Anticline—Identity and existence certain, location approximate
- Syncline—Identity and existence certain, location approximate
- Overturned syncline—Identity and existence certain, location approximate. Beds on one limb are overturned; arrows show dip direction of limbs
- Inverted syncline—Identity and existence certain, location approximate. Beds on both limbs are overturned; arrows show dip direction of limbs

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.