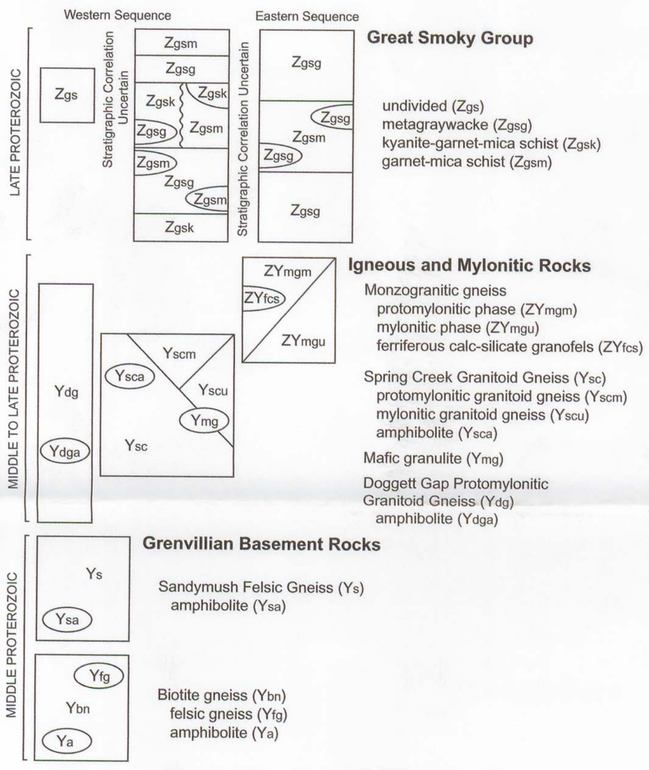
DIVISION OF LAND RESOURCES
DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

NORTH CAROLINA GEOLOGICAL SURVEY
GEOLOGIC MAP SERIES - 8

# BEDROCK GEOLOGIC MAP OF THE FINES CREEK 7.5-MINUTE QUADRANGLE, NORTH CAROLINA

Mark W. Carter and Leonard S. Wiener
1999

## Map Units




**Great Smoky Group**

undivided (Zgs)
metagraywacke (Zgsg)
kyanite-garnet-mica schist (Zgsk)
garnet-mica schist (Zgsm)

**Igneous and Mylonitic Rocks**

Monzogranitic gneiss
protomylonitic phase (ZYmgm)
mylonitic phase (ZYmgu)
ferriferous calc-silicate granofels (ZYfcs)

Spring Creek Granitoid Gneiss (Ysc)
protomylonitic granitoid gneiss (Yscm)
mylonitic granitoid gneiss (Yscu)
amphibolite (Ysca)

Mafic granulite (Ymg)

Doggett Gap Protomylonitic Granitoid Gneiss (Ydg)
amphibolite (Ydga)

**Grenvillian Basement Rocks**

Sandymush Felsic Gneiss (Ys)
amphibolite (Ysa)

Biotite gneiss (Ybn)
felsic gneiss (Yfg)
amphibolite (Ya)

## Description of Map Units

**Great Smoky Group:** An interbedded, intergradational, and intragradational sequence of sedimentary rocks metamorphosed to kyanite grade, but bedding and other primary sedimentary structures are widely preserved. Undivided ($Z_{gs}$) southwest of Hurricane Mountain, but subdivided and mapped elsewhere based on dominant rock type into three general lithologic units:

**metagraywacke ($Z_{gsg}$):** Metagraywacke is the dominant rock type, but kyanite-garnet-mica schist, garnet-mica schist, and calc-silicate granofels are locally interbedded throughout the unit. Metagraywacke is light gray to medium gray; coarse- to very coarse-grained (locally); granoblastic to lepidoblastic (locally); thin- to thick-bedded; generally poorly sorted; locally pebbly to conglomeratic and graded; feldspathic to arkosic; commonly sulfidic. Coarse grains range in size from granules to pebbles, and in shape from angular feldspar particles to rounded and subrounded quartz particles. Rare lithic fragments are angular to subrounded. Coarse grains are matrix supported and typically flattened and elongated. Metagraywacke is composed of quartz (23-44%), biotite (17-31%), plagioclase (14-15%), K-feldspar (~15%), muscovite (8-13%), garnet (~9%), opaque minerals (trace-8%), zircon (~1%), and accessory epidote-group minerals, sphene, and apatite. Interbedded calc-silicate granofels is medium to light gray; granoblastic; poorly foliated; thin- to thick-bedded; composed of[b]: quartz (36-57%), plagioclase (28-37%), hornblende (8-18%), garnet (5-6%), and accessory opaque minerals, epidote-group minerals, sphene, and chlorite.

**garnet-mica schist ($Z_{gsm}$):** Rock is dark gray to light gray, and lustrous; lepidoblastic to inequigranular with abundant garnet porphyroblasts. Locally coarsely crystalline; locally graphitic and sulfidic. Locally interbedded with metagraywacke and calc-silicate granofels.

**kyanite-garnet-mica schist ($Z_{gsk}$):** Rock is light gray and lustrous; typically inequigranular, with kyanite and garnet porphyroblasts, to lepidoblastic; commonly coarsely crystalline; thin-bedded; finely foliated; locally sulfidic; composed of: muscovite (22-44%), biotite (17-22%), plagioclase (14-19%), quartz (9-17%), garnet (3-9%), kyanite (1-9%), and accessory opaque minerals, staurolite, tourmaline, zircon, epidote-group minerals, and apatite. Locally interbedded with calc-silicate granofels and metagraywacke.

**Monzogranitic gneiss:** An igneous unit, later mylonitized, the rock is characterized by pink to pale purple feldspar and grayish blue quartz grains. Monzogranitic in composition: quartz (32-37%), plagioclase (19-23%), K-feldspar (10-26%), and biotite (trace-2%), with accessory and/or alteration epidote-group minerals (trace-14%), sericite (14-17%), opaque minerals, muscovite, apatite, sphene, zircon, and garnet. May in part coincide with the Max Patch Granite of Keith (1904). Subdivided and mapped into two units based on degree of mylonitization:

**protomylonitic phase ($ZY_{mgm}$):** Rock is medium- to very coarse-grained; inequigranular porphyroblastic (typically asymmetric megacrysts range in size from 0.5 cm to 2.5 cm in long dimension); protomylonitic to mylonitic. Includes localized areas of unmylonitized, medium- to coarse-grained, granoblastic to inequigranular granitoid rock.

**mylonitic phase ($ZY_{mgu}$):** A pervasively mylonitized phase of the Monzogranitic gneiss unit, the rock is fine- to medium-grained; inequigranular to lepidoblastic; mylonitic to ultramylonitic. Includes localized areas of less pervasively mylonitized rock.

**Ferriferous calc-silicate granofels ($ZY_{fcs}$):** Age unknown (probably Middle to Late Proterozoic). Magnetite-garnet-epidote-hornblende-quartz rock is very dusky red, weathers to moderate reddish brown to dark reddish brown; granoblastic (fine- to medium-grained) to porphyroclastic; massive to thinly foliated, locally mylonitized. One sample composed of quartz (38%), hornblende (30%), epidote-group minerals (16%), garnet (14%), and accessory and/or alteration opaque minerals, biotite, apatite, and zircon. Rock characterized by its ferriferous nature; dense; weakly to strongly magnetic; hematitic staining on weathered surfaces diagnostic.

**Spring Creek Granitoid Gneiss ($Y_{sc}$):** A heterogeneous metamorphosed igneous unit dominated by biotite granitic gneiss interlayered with biotite granodioritic gneiss, tonalitic gneiss, quartz monzodioritic gneiss, amphibolite, biotite gneiss, and biotite schist. Granitoid rock types are light gray, mottled with pinkish gray to pale reddish brown; medium- to coarse-grained; granoblastic to lepidoblastic to inequigranular; locally protomylonitized and mylonitized (particularly to the north and west); poorly foliated to foliated; massive to medium-layered. Biotite granitic gneiss composed of quartz (25-41%), K-feldspar (27-36%), plagioclase (16-32%), biotite (4-24%), muscovite (trace-2%), and accessory sericite, epidote-group minerals, opaque minerals, apatite, sphene, and zircon. Granodioritic to tonalitic gneiss interlayers are more abundant to the north and west, and are composed of plagioclase (36-42%), quartz (24-39%), biotite (10-18%), K-feldspar (5-18%), and accessory epidote-group minerals, muscovite, sphene, opaque minerals, zircon, and apatite. Quartz monzodioritic gneiss occurs locally throughout the unit and is characterized by irregularly shaped lensoid to orbicular aggregates of biotite up to 3.0 cm in diameter in a granoblastic matrix of fine- to medium-grained feldspar and quartz.

**$Y_{sc}$?:** Stratigraphic assignment uncertain.

**protomylonitic granitoid gneiss ($Y_{scm}$):** Rock is characterized by pervasive protomylonitization to mylonitization, and is medium- to coarse-grained; lepidoblastic to inequigranular porphyroclastic (typically asymmetric megacrysts range in size from 0.5 cm to 2.0 cm in long dimension); well-foliated. Composition similar to granodioritic to tonalitic phases of the Spring Creek Granitoid Gneiss. Includes local areas of unmylonitized gneiss.

**$Y_{scm}$?:** Stratigraphic assignment uncertain.

**mylonitic granitoid gneiss ($Y_{scu}$):** Rock is characterized by pervasive mylonitization to ultramylonitization, and is fine- to medium-grained; lepidoblastic to inequigranular (asymmetric megacrysts range in size from 0.1 cm to 0.5 cm in long dimension); well-foliated to strongly foliated. Includes areas of less pervasively mylonitized rock.

**$Y_{scu}$?:** Stratigraphic assignment uncertain.

**amphibolite ($Y_{sca}$):** Amphibolite, and where retrogressed, biotite schist. Rock is dark greenish gray to greenish black to brownish black; fine- to coarse-grained; nematoblastic to lepidoblastic; well foliated; thin- to medium-layered; composed of[b] hornblende (24-70%), plagioclase (21-56%), epidote-group minerals (7-16%), and accessory opaque minerals, quartz, sphene, sericite, apatite, and talc. Where retrogressed, biotite replaces hornblende as the dominant mafic phase. Thin interlayers of biotite-rich gneiss and schist within the Spring Creek represent retrogressive equivalents of amphibolite.

**Mafic granulite ($Y_{mg}$):** Rock is typically medium gray to medium bluish gray; medium- to coarse-grained; granoblastic; massive to weakly layered (layering, where present, ranges from 0.2 cm to 3.0 cm thick); dioritic to quartz dioritic to tonalitic in composition: plagioclase (38-64%), hornblende (7-36%), quartz (3-18%), hypersthene (0-10%), K-feldspar (0-7%), biotite (trace-25%), and accessory opaque minerals, apatite, epidote-group minerals, sphene, garnet, muscovite, and zircon. Rock is commonly retrogressed to medium dark gray to grayish olive-green amphibolite; medium- to coarse-grained; nematoblastic; foliated; thin-layered. Composed principally of plagioclase, hornblende, and variable amounts of biotite. Very locally completely altered to grayish black to brownish black, fine- to medium-grained, lepidoblastic, biotite gneiss and biotite schist.

**Doggett Gap Protomylonitic Granitoid Gneiss ($Y_{dg}$):** Granitic to granodioritic rock is light gray to medium light gray to very pale orange; inequigranular (asymmetric megacrysts range from 0.5 cm to 4.0 cm in long dimension); protomylonitic to mylonitic; medium- to well-foliated foliated; composed of[c] K-feldspar (33-40%), plagioclase (26-38%), quartz (22-36%), biotite (7-13%), and accessory muscovite, epidote-group minerals, opaque minerals, sphene, apatite, zircon, and sericite. Subordinate interlayered rock types include biotite granitic gneiss, amphibolite, and biotite schist.

**amphibolite ($Y_{dga}$):** Amphibolite, and where retrogressed, biotite schist. Rock is dark greenish gray to grayish olive-green to brownish black; fine- to coarse-grained; nematoblastic to lepidoblastic; weakly to strongly foliated; massive to thin-layered; composed of[b] hornblende (~55%), plagioclase (~36%), quartz (~4%), and accessory epidote-group minerals, opaque minerals, sphene, and K-feldspar. Where retrogressed, biotite replaces hornblende as the dominant mafic phase.

**Sandymush Felsic Gneiss ($Y_s$):** The unit is an interlayered sequence of granitic gneiss to biotite granitic gneiss to quartz dioritic gneiss and biotite gneiss. Locally interlayered with amphibolite and very rare calc-silicate granofels. Layers ranging from several centimeters to several decimeters in thickness exhibit protomylonitic to mylonitic fabric and are scattered throughout the map unit. Felsic interlayers dominate and are very light gray to medium light gray to grayish orange pink to very pale orange; medium-grained; granoblastic to lepidoblastic. Thickness of layers range from millimeters to decimeters. Composed of[d] quartz (10-70%), plagioclase (10-62%), K-feldspar (1-33%), biotite (1-3%), and accessory epidote-group minerals, muscovite, magnetite, other opaque minerals, garnet, sphene, apatite, and zircon. Mafic interlayers are more biotite rich and are medium dark gray to dark gray to greenish black to olive-black; generally fine-grained; granoblastic to lepidoblastic. Thickness of mafic layers range from millimeters to centimeters. Calc-silicate granofels is very light gray to yellowish gray to very pale orange; typically medium-grained; granoblastic to nematoblastic; massive to foliated; thin- to medium-layered to podiform; composed of plagioclase, K-feldspar, quartz, epidote-group minerals, hornblende, diopside, and accessory biotite, sphene, and garnet.

**amphibolite ($Y_{sa}$):** Amphibolite, and where retrogressed, biotite schist. Rock is dark greenish gray to greenish black to brownish black; medium-grained; nematoblastic to lepidoblastic; poorly foliated to foliated; layered; composed of[b] hornblende (44-72%), plagioclase (21-42%), biotite (0-11%), quartz (1-7%), and accessory epidote-group minerals, K-feldspar, opaque minerals, garnet, sphene, and apatite. Where retrogressed, biotite replaces hornblende as the dominant mafic phase.

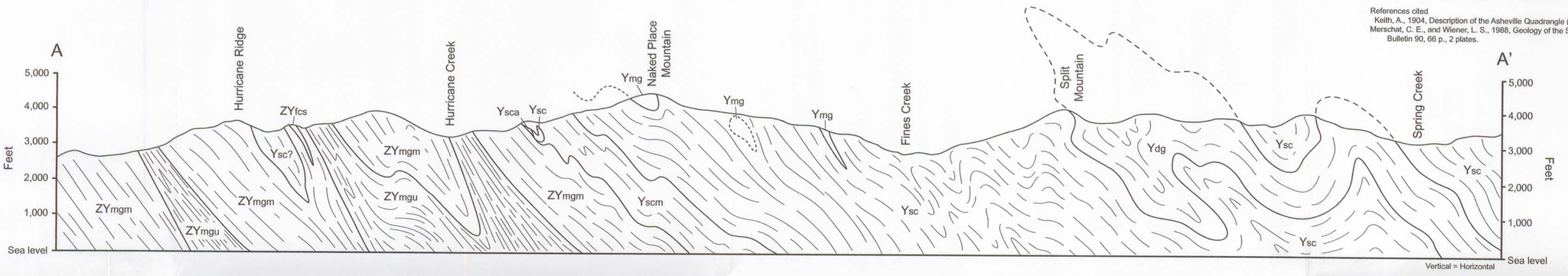
**Biotite gneiss ($Y_{bn}$):** The unit is an interlayered sequence of biotite granitic gneiss and biotite gneiss, locally interlayered with amphibolite and felsic gneiss. Locally migmatitic and mylonitic. Layering ranges from about 1.0 cm to about 1.0 dm in thickness. Biotite granitic gneiss interlayers are light gray to pinkish gray to pale reddish brown; medium- to coarse-grained; granoblastic to lepidoblastic; poorly foliated to foliated. Biotite gneiss interlayers are light to medium gray; fine- to medium-grained; lepidoblastic to granoblastic; well foliated; composition ranges from granodiorite to quartz diorite[a]: plagioclase (23-52%), quartz (14-33%), biotite (16-24%), hornblende (0-19%), K-feldspar (0-10%), and accessory muscovite, garnet, epidote-group minerals, opaque minerals, sphene, zircon, and apatite.

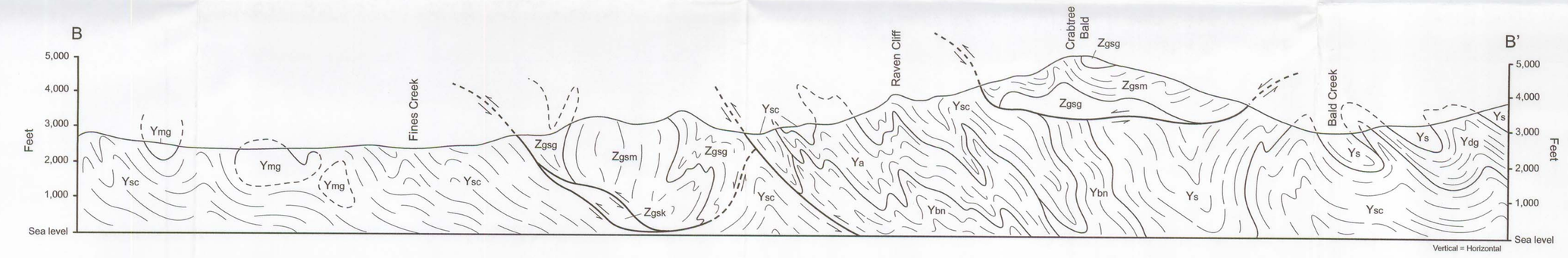
**amphibolite ($Y_a$):** Amphibolite, and where retrogressed, biotite schist. Rock is dark greenish gray to black to brownish black; fine- to coarse-grained; nematoblastic to lepidoblastic; locally mylonitic; poorly foliated to well foliated; layered; composed of[b] plagioclase (~54%), hornblende (~27%), biotite (~8%), quartz (~3%), and accessory epidote-group minerals, sericite, apatite, sphene, opaque minerals, and garnet (locally abundant). Where retrogressed, biotite replaces hornblende as the dominant mafic phase.

**felsic gneiss ($Y_{fg}$)[e]:** The unit consists of well foliated to massive layers of felsic gneiss ranging in thickness from centimeters to meters, repetitively interlayered with biotite gneiss and amphibolite. Felsic gneiss is very light gray to pale orange to medium light gray; medium- to coarse-grained; granoblastic to lepidoblastic; locally megacrystic; quartz dioritic in composition: quartz (~39%), plagioclase (~28%), K-feldspar (~24%), biotite (~9%), and accessory muscovite, epidote-group minerals, zircon, sphene, and opaque minerals.

[a]Modal analyses from sampled rocks in the adjacent Clyde 7.5' Quadrangle (NCGS unpublished data).
[b]Modal analyses from sampled rocks in the adjacent Sandymush 7.5' Quadrangle (Merschat and Wiener, 1988).
[c]Modal analyses supplemented with analyses from sampled rocks in the adjacent Sandymush 7.5' Quadrangle.
[d]Modal analyses supplemented with analyses from sampled rocks in the adjacent Sandymush and Clyde 7.5' Quadrangles.
[e]Description of rock unit from exposures in the adjacent Clyde 7.5' Quadrangle.

References cited
Keith, A., 1904, Description of the Asheville Quadrangle (Tennessee and North Carolina): U.S. Geological Survey Geologic Atlas, Folio 116, 10 p.
Merschat, C. E., and Wiener, L. S., 1988, Geology of the Sandymush and Canton Quadrangles, North Carolina: North Carolina Geological Survey Bulletin 90, 66 p., 2 plates.




## Structural Features

(Observation sites are centered on the strike bar. The intersection point of multiple symbols marks the site of observation.)

### Stike and Dip of Planar Features

- bedding (15)
- bedding - top observed (41)
- vertical bedding
- later mylonitic foliation (53)
- early foliation(s) (32)
- coplanar early foliation(s) and bedding (66)
- overturned bedding (79)
- overturned bedding - top observed (87)
- vertical later mylonitic foliation
- vertical early foliation(s)
- joint (56)
- vertical joint

### Bearing and Plunge of Linear Features

- (64) mesoscale antiform
- (10) mesoscale synform
- (6) crenulation hinge
- (21) mineral lineation

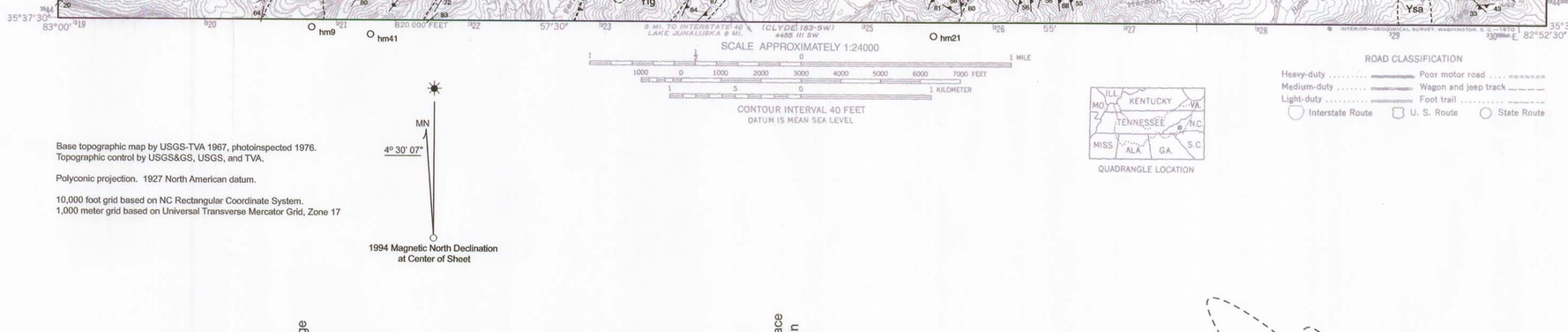
### Contacts

- stratigraphic contact: long dashed - approximately located; short dashed - inferred
- thrust fault: long dashed - approximately located; short dashed - inferred (teeth on upper plate)

## Mineral Resources

- Occurrence
- Prospect
- Quarry
- hm34 Heavy mineral and scintillation sample site. Sample numbers correspond to heavy mineral analyses listed in table below.

Commodity Symbols
mg magnetite
bs building stone

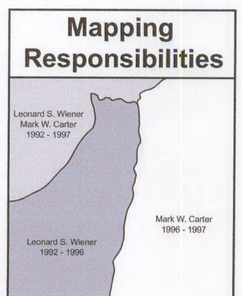



Base topographic map by USGS-TVA 1967, photoinspected 1976.
Topographic control by USGS&GS, USGS, and TVA.

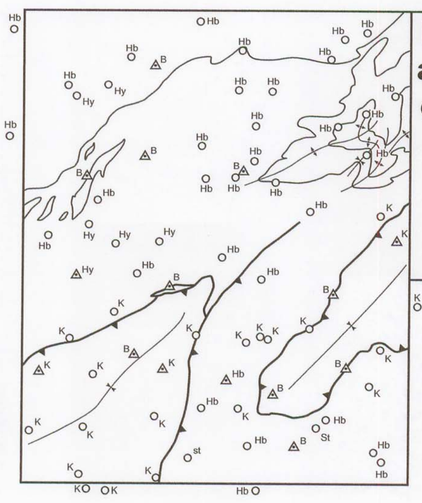
Polyconic projection. 1927 North American datum.

10,000 foot grid based on NC Rectangular Coordinate System.
1,000 meter grid based on Universal Transverse Mercator Grid, Zone 17

## Mapping Responsibilities




Acknowledgements
Support for geologic mapping through USGS STATEMAP National Mapping Program. Heavy mineral sampling and processing by Ginger Vaughn, Elizabeth Avera, and Scott Williams. Heavy mineral data preparation by Scott Williams and Sigrid Ballew. Reviews by Carl Merschat, Robert D. Hatcher, Jr., and Albert Carpenter are appreciated.



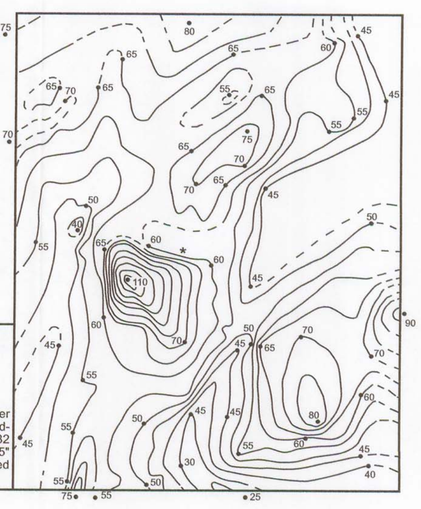

## Major Fold Axes and Distribution of Metamorphic Index Minerals

- O - Heavy Mineral Sample Site
- △ - Thin Section Sample Site

B - Biotite
St - Staurolite
K - Kyanite
Hb - Hornblende
Hy - Hypersthene

## Scintillation Readings

Isometric interval = 5 counts per second. Readings recorded at ground-level using a Mount Sopris SC-132 Scintillation Counter with a 1.5" x 1.5" sodium iodide crystal. * - isolated reading of ~3,000 c.p.s.



| Sampling Site | NC Coordinates |
|---|---|
| 1 | 742,500 N, 848,700 E |
| 2 | 739,400 N, 843,400 E |
| 3 | 740,700 N, 845,600 E |
| 4 | 730,100 N, 846,000 E |
| 5 | 734,400 N, 836,800 E |
| 6 | 720,300 N, 816,800 E |
| 7 | 716,700 N, 818,900 E |
| 8 | 707,000 N, 817,100 E |
| 9 | 705,400 N, 817,400 E |
| 10 | 720,200 N, 829,300 E |
| 11 | 719,300 N, 835,300 E |
| 12 | 718,200 N, 835,700 E |
| 13 | 720,100 N, 839,800 E |
| 14 | 718,000 N, 833,700 E |
| 15 | 729,200 N, 821,300 E |
| 16 | 717,600 N, 846,400 E |
| 17 | 713,900 N, 845,300 E |
| 18 | 709,500 N, 845,500 E |
| 19 | 707,900 N, 845,900 E |
| 20 | 711,100 N, 840,900 E |
| 21 | 703,100 N, 831,700 E |
| 22 | 709,600 N, 833,400 E |
| 23 | 705,700 N, 834,800 E |
| 24 | 713,000 N, 829,000 E |
| 25 | 743,400 N, 833,600 E |
| 26 | 747,300 N, 834,100 E |
| 27 | 730,300 N, 814,900 E |
| 28 | 729,000 N, 825,500 E |
| 29 | 711,500 N, 812,700 E |
| 30 | 740,100 N, 812,600 E |
| 31 | 744,300 N, 817,300 E |
| 32 | 743,700 N, 816,100 E |
| 33 | 744,800 N, 821,400 E |
| 34 | 746,800 N, 823,900 E |
| 35 | 749,900 N, 830,300 E |
| 36 | 740,000 N, 835,700 E |
| 37 | 736,800 N, 835,300 E |
| 38 | 735,000 N, 833,200 E |
| 39 | 738,100 N, 829,700 E |
| 40 | 735,100 N, 830,100 E |
| 41 | 705,100 N, 814,900 E |
| 42 | 748,700 N, 846,100 E |
| 43 | 722,400 N, 852,300 E |
| 44 | 722,000 N, 821,300 E |
| 45 | 727,200 N, 821,500 E |
| 46 | 727,200 N, 835,300 E |
| 47 | 725,900 N, 823,300 E |
| 48 | 712,800 N, 824,000 E |
| 49 | 734,300 N, 818,700 E |
| 50 | 730,700 N, 818,100 E |
| 51 | 711,300 N, 818,100 E |
| 52 | 747,700 N, 844,300 E |
| 53 | 709,100 N, 826,200 E |
| 54 | 715,400 N, 840,150 E |
| 55 | 713,000 N, 833,050 E |
| 56 | 743,250 N, 837,050 E |
| 57 | 754,000 N, 813,050 E |
| 58 | 746,300 N, 842,750 E |
| 59 | 736,800 N, 846,100 E |
| 60 | 731,450 N, 840,300 E |

Heavy Mineral Distribution (in Percent)

| Sample | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Proportion of Heavy Minerals in Sample | 0.13 | 0.29 | 0.16 | 0.08 | 0.23 | 0.12 | 0.13 | 0.03 | 0.08 | 0.04 | 0.05 | 0.14 | 0.14 | 0.13 | 0.17 | 0.02 | 0.17 | 0.16 | 0.07 | 0.27 | 0.27 | 0.11 | 0.03 | 0.14 | 0.10 | 0.06 | 0.05 | 0.15 | 0.03 | 0.02 | 0.04 | 0.03 | 0.12 | 0.09 | 0.00 | 0.14 | 0.29 | 0.04 | 0.09 | 0.18 | 0.05 | 0.19 | 0.23 | 0.01 | 0.03 | 0.20 | 0.04 | 0.09 | 0.13 | 0.21 | 0.10 | 0.07 | 0.17 | 0.50 | 0.22 | 0.16 | 0.01 | 0.12 | 0.09 | 0.05 |
| Magnetite | 3.6 | 7.7 | 27.1 | 2.7 | 5.4 | 2.3 | 1.6 | 6.6 | 5.8 | 4.4 | 0.9 | 1.3 | 1.1 | 3.7 | 1.3 | 2.8 | 0.8 | 4.4 | 1.0 | 1.3 | 1.3 | 1.5 | 0.4 | 1.4 | 13.0 | 8.3 | 4.1 | 8.7 | 7.5 | 4.2 | 5.5 | 6.9 | 21.8 | 15.6 | 8.1 | 41.8 | 13.4 | 15.4 | 7.3 | 4.3 | 3.7 | 4.8 | 1.0 | 19.7 | 7.5 | 3.6 | 13.9 | 0.9 | 9.8 | 20.8 | 0.9 | 7.6 | 1.9 | 2.2 | 1.5 | 27.4 | 4.0 | 6.5 | 5.9 | 3.8 |
| Ilmenite | 13.0 | 4.6 | 9.8 | 28.7 | 5.2 | 23.5 | 39.4 | 59.8 | 66.0 | 37.3 | 6.4 | 11.9 | 10.4 | 4.8 | 74.5 | 14.1 | 10.4 | 29.6 | 18.8 | 34.1 | 28.1 | 0.5 | 56.3 | 17.3 | 23.9 | 38.1 | 51.3 | 43.8 | 50.9 | 27.3 | 38.3 | 15.4 | 30.5 | 46.9 | 43.7 | 21.5 | 14.7 | 5.5 | 32.4 | 24.4 | 49.6 | 31.4 | 13.4 | 10.8 | 1.4 | 16.9 | 11.6 | 32.2 | 12.6 | 34.5 | 35.7 | 20.8 | 12.8 | 6.4 | 3.5 | 42.3 | 56.9 | 35.1 | 10.4 | 1.0 |
| Hornblende | 15.9 | 48.4 | 23.7 | 2.0 | 59.6 | 2.9 | – | 0.5 | – | 1.0 | 2.0 | 4.0 | – | 23.6 | 3.0 | 9.2 | 0.1 | 30.1 | 9.4 | 0.5 | 17.3 | 45.8 | 4.5 | 54.7 | 9.6 | 11.9 | 14.9 | 19.6 | – | 15.8 | 19.9 | 43.8 | 20.7 | 6.7 | 5.1 | 7.3 | 58.9 | 21.6 | 11.1 | 43.6 | 0.5 | 30.9 | – | 9.2 | 39.3 | 29.4 | 43.0 | – | 38.3 | 25.6 | 0.5 | 12.0 | 39.2 | 4.4 | 11.8 | 18.8 | 0.5 | 26.2 | 16.5 | 47.6 |
| Epidote-Group Minerals | 41.9 | 24.0 | 24.1 | 10.2 | 16.6 | 2.4 | – | – | – | 1.0 | 6.0 | 17.8 | – | 41.4 | 1.5 | 19.9 | 3.0 | 24.9 | 43.1 | 1.0 | 40.0 | 21.2 | 3.5 | 13.8 | 30.5 | 25.7 | 9.6 | 13.7 | – | 14.4 | 6.1 | 15.4 | 13.7 | 3.0 | 8.7 | 14.3 | 8.7 | 36.0 | 22.2 | 16.3 | – | 20.0 | 0.5 | 38.1 | 35.1 | 37.1 | 15.9 | – | 25.3 | 11.1 | – | 38.8 | 29.4 | 29.3 | 24.6 | 6.1 | 3.8 | 25.7 | 56.4 | 37.0 |
| Zircon | 4.8 | 4.6 | 4.3 | – | 1.9 | 1.0 | – | 0.9 | 0.5 | 2.4 | – | 0.5 | – | 1.9 | 2.0 | 16.0 | – | 2.9 | 10.4 | 3.4 | 2.0 | 1.5 | 4.0 | 2.0 | 3.9 | 1.4 | 3.8 | 0.9 | 19.0 | 1.0 | – | 0.9 | 0.8 | 0.4 | – | 2.9 | 0.4 | 2.5 | 9.3 | – | 1.0 | 2.4 | – | 6.4 | 0.5 | 3.4 | 3.4 | 3.5 | 2.7 | 1.2 | 2.0 | 1.9 | 0.5 | 0.5 | 1.5 | 1.8 | 1.0 | 0.5 | 0.9 | 1.9 |
| Hematite | 0.5 | – | 0.7 | 4.4 | – | 6.4 | 4.4 | 7.9 | 4.2 | 3.8 | 2.5 | 1.5 | 2.5 | 1.4 | 1.0 | 8.8 | 3.0 | – | – | 0.5 | – | – | 1.5 | – | 2.6 | 2.8 | 1.0 | 0.5 | 0.9 | 8.6 | 6.1 | 2.8 | 1.6 | 3.4 | 5.5 | 2.3 | – | 1.3 | 0.9 | 1.0 | 12.0 | 1.0 | 2.0 | 0.8 | 1.4 | 1.0 | 3.0 | 6.0 | – | 0.8 | 0.5 | 0.9 | 0.5 | – | – | 0.4 | 1.0 | – | – | – |
| Sphene | 18.3 | 10.6 | 9.8 | 2.9 | 10.4 | 1.0 | – | – | – | – | 1.0 | 1.5 | – | 11.1 | – | 4.4 | 1.5 | 6.7 | 9.9 | – | 7.4 | 2.5 | 2.0 | 3.9 | 12.2 | 4.6 | 0.5 | 2.3 | – | 1.4 | – | 0.9 | 2.0 | 0.4 | 0.9 | 0.9 | 3.9 | 14.8 | 11.1 | 5.3 | – | 8.1 | – | 6.0 | 10.2 | 6.8 | 6.5 | – | 7.2 | 2.4 | – | 14.3 | 12.8 | 4.4 | 3.9 | – | – | 5.6 | 9.4 | 8.2 |
| Garnet | 1.4 | – | – | 38.4 | – | 26.4 | 15.7 | 10.3 | 9.4 | 36.8 | 71.4 | 55.8 | 78.2 | 7.7 | 7.4 | 5.3 | 56.1 | 1.4 | 6.9 | 50.8 | 3.9 | 24.6 | 11.0 | 6.9 | – | 3.7 | 6.2 | 5.0 | 6.9 | 1.4 | 2.8 | 0.5 | 0.4 | – | – | – | – | – | 2.3 | 2.9 | 14.0 | – | 47.5 | 0.8 | 2.8 | 0.5 | – | 39.2 | – | – | 49.0 | – | 2.9 | 50.4 | 47.3 | – | 0.5 | – | 0.5 | 0.5 |
| Leucoxene | 0.5 | – | 0.4 | 0.5 | 1.0 | 1.5 | 1.0 | 3.3 | 3.8 | 2.9 | – | 1.0 | – | – | 2.5 | – | – | – | – | – | – | 1.0 | – | 4.4 | 3.7 | 8.6 | 3.7 | 14.8 | 25.9 | 21.3 | 13.5 | 5.5 | 21.5 | 28.0 | 9.0 | – | 3.0 | 3.2 | 2.4 | 1.9 | 1.4 | 0.5 | 6.8 | 1.9 | 1.5 | 2.6 | 1.5 | 4.0 | 3.2 | 3.0 | 3.7 | – | – | – | 2.9 | 29.3 | 0.5 | – | – |
| Staurolite | – | – | – | 8.3 | – | 28.8 | 31.5 | 3.3 | 6.1 | 6.7 | 4.5 | 3.0 | 4.0 | 1.9 | – | 10.7 | 13.9 | – | – | 1.5 | – | 1.0 | 10.5 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 9.2 | – | 25.2 | 0.4 | – | – | – | 10.4 | – | – | 5.5 | – | 0.1 | 1.5 | 3.5 | – | – | – | – |
| Kyanite | – | – | – | 2.0 | – | 3.9 | 6.4 | 6.1 | 2.4 | 3.6 | 5.5 | 2.0 | 3.0 | 1.4 | – | 8.8 | 11.4 | – | – | 6.9 | – | 1.5 | 3.0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 7.7 | – | 9.9 | 0.4 | – | – | – | 6.4 | – | – | 3.0 | – | – | 2.5 | – | – | – | – |
| Tourmaline | – | – | – | 0.1 | – | – | – | 1.4 | 0.9 | 0.5 | 0.1 | – | 1.0 | – | – | – | – | – | – | – | – | – | 0.5 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 0.5 | – | – | – | – | – | – | – | – | – | – | 1.0 | – | – | – | – | – |
| Rutile | – | – | – | – | – | – | – | – | 0.9 | – | – | – | – | 1.0 | – | – | – | 0.5 | – | – | – | – | 1.0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 0.4 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Hypersthene | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 4.9 | – | – | – | – | – | – | – | – | – | – | – | 1.8 | – | – | – | 2.7 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 0.4 | – | – | – | – | – | – | – | – | – | – |
| Talc/ Anthophyllite | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 1.0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Diopside | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 0.4 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Actinolite/ Tremolite | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 2.0 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

## Mineral Resources