DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

Whole-rock and trace-element analyses of some alumina-rich gneiss and schist from the Blue Ridge, North Carolina and Georgia

by

Frank G. Lesure

U.S. Geological Survey

Reston, Virginia

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Samples of alumina-rich gneiss and schist collected as part of wilderness and other studies of the U.S. Geological Survey (USGS) in the Blue Ridge of North Carolina and Georgia were analyzed for major and trace elements. Trace elements were also determined for two previously analyzed alumina-rich argillite and slate samples of the Ocoee Supergroup for comparison (Hadley and Goldsmith, 1963, table 7, sample CT298 and table 11, sample CT328). Because no further studies on these rocks are planned, the data are released in Open-File so that the information will not be lost.

Sample descriptions and locations

F13-25LC	Fine-grained, light gray to pale purple quartz-biotite-garnet schist interlayered with mafic schist, which was not sampled; Franklin Construction Company quarry, 3 mi southwest of Franklin, Macon County, N.C.
F20-23	Coarse-grained, pale red-purple to light gray sillimanite-mica-garnet schist, 3.8 mi south of Franklin, N.C.
F20-32	Fine-grained, olive-gray calc-silicate granolfels, mostly clinozoisite, quartz, and hornblende, 3.7 mi south of Franklin, N.C.
F20-68	Coarse-grained, pale red-purple to light gray biotite-sillimanite-garnet schist, 2 mi south of Franklin, N.C.
CT-298	Green, slaty metasiltstone, cut on Tennessee Highway 73, 2 mi east of Gatlinburg, Tennessee (Hadley and Goldsmith, 1963, table 7, p. B42).
CT-328	Medium-dark-gray, moderately foliated argillite, Styx Branch, 500 ft northwest of junction with Alum Creek south of Mount Le Conte, Sevier County, Tennessee.
TA197R1	1-ft chip sample, medium- to coarse-grained biotite-kyanite-quartz schist, road cut 0.9 mi southwest of Yellow Mountain, Clarkesville NE quadrangle, Habersham County, Ga.
NCC015	3-ft chip sample, garnet-kyanite-mica schist from road cut on Mineral Creek Road, 0.2 mi west of Beetree Gap, Craggy Mountain Wilderness Study Area, Buncombe County, N.C. (Lesure and others, 1982, table 2 and pl. 1C).
NCC041	9-ft chip sample, biotite-garnet schist, road cut along the Blue Ridge Parkway, 0.2 mi northwest of Craggy Dome, Craggy Mountain Wilderness Study Area, Buncombe County, N.C. (Lesure and others, 1982, table 2 and pl. 1C).
NCC055	6-ft chip sample, biotite-quartz gneiss, same location as NCC041
NCC056	3-ft chip sample, mica-kyanite gneiss, Celo kyanite mine, Yancey County, N.C.; sample from area of channel sample E24 of Chute (1944)
NCC057	6-ft chip sample, mica-kyanite gneiss, Celo kyanite mine, Yancey County, N.C.; sample from area of channel sample D23 of Chute (1944)
NCC058	3-ft chip sample, mica-kyanite gneiss, Celo kyanite mine, Yancey County, N.C.
NCC059	3-ft chip sample, feldspathic quartzite, Celo kyanite mine, Yancey County, N.C.
NCC0560	6-ft chip sample, mica-kyanite gneiss, Celo kyanite mine, Yancey County, N.C.; sample from area of channel sample A2 of Chute (1944)

MM1	1-ft chip sample, fine-grained, pinkish-gray, speckled pale red-purple quartz-biotite-garnet gneiss, south edge of garnet mine on Mason Mountian, Macon County, N.C. (fig. 1A and B).
MM4	1-ft chip sample, similar to MM1, about 40 ft to the north (fig. 1B).
MM8	1-ft chip sample, medium-grained quartz-biotite-garnet-sillimanite gneiss, south wall of open cut of garnet mine (fig. 1B).
MM11	1-ft chip sample, quartz-garnet-pyroxene gneiss, eastern edge of open cut of garnet mine (fig. 1B).
MM12	1-ft chip sample, fine- to medium-grained, grayish-orange to light brown quartz-garnet-amphibole gneiss east of MM11 (fig. 1B).
MM14	1-ft chip sample, medium-grained, pale yellowish-brown amphibole-quartz gneiss, west edge of open cut of garnet mine (fig. 1B).
MM17	1-ft chip sample, coarse-grained, speckled dark yellowish-brown and grayish-red-purple garnet-biotite-quartz schist, loose block on floor of open cut, material being mined from near localities MM6 and MM7 (fig. 1B).
MM18	1-ft chip sample, coarse-grained biotite-sillimanite-garnet schist, Lower Pickens prospect, 0.5 mi northeast of garnet mine on the southeast slope of Mason Mountain. Macon County N.C. (fig. 1A).

Whole-rock analyses of the 23 samples of relatively fresh rock were made in USGS laboratories in Denver, Colo., Reston, Va., or Washington, D.C. Analyses for major elements Fe, Mg, Al, Si, P, K, Ca, Ti, and Mn were done for most samples by Leonard Shapiro (Samples MM1-MM18), F.W. Brown, Z.A. Hamlin, and Hezekiah Smith (samples NCC015-NCC060), and P.L.D. Elmore, Lowell Artis, S. Betts, G. Chloe, J.L. Glenn, James Kelsey, Hezekiah Smith, and D.E. Taylor (samples F13-25LC and F20-23, 32, and 68) using a single-solution method described by Shapiro (1967). Major elements for samples CT-298 and CT-328 were by L.D. Trumbull (Hadley and Goldsmith, 1963, tables 7 and 11). Major elements for sample TA 197R1 were analyzed in USGS laboratories, Denver, Colo., by J.E. Taggart, A.J. Bartel, and D.F. Siems using wavelength-dispersive X-ray fluorescence spectrometry (WDXRF, Taggart and others, 1987). All data , except for sulfur, are reported as oxides. Analyses of Na, Sc, total Fe, Co, Cr, Zn, As, Sb, Cs, La, Ce, Nd, Sm, Eu, Tb, Yb, Lu, Hf, Ta, Au, Th, and U were done by J.N. Grossman using instrumental neutron activation analysis (INAA) by the method described in Baedecker and McKown (1987). Titration methods of Peck (1964) and Engleman and others (1985) were used to determine CO_2 and FeO by Hezekiah Smith. Ferric oxide (Fe_2O_3) was calculated as the difference of total iron and iron measured as FeO. The gravimetric and fusion methods of Shapiro (1975) were used by Hezekiah Smith to measure H_2O^- and H_2O^+. Rubidium, Sr, Y, Ba, and Zr were determined by energy- dispersive X-ray fluorescence spectrometry (EDXRF) by J.R. Evans.

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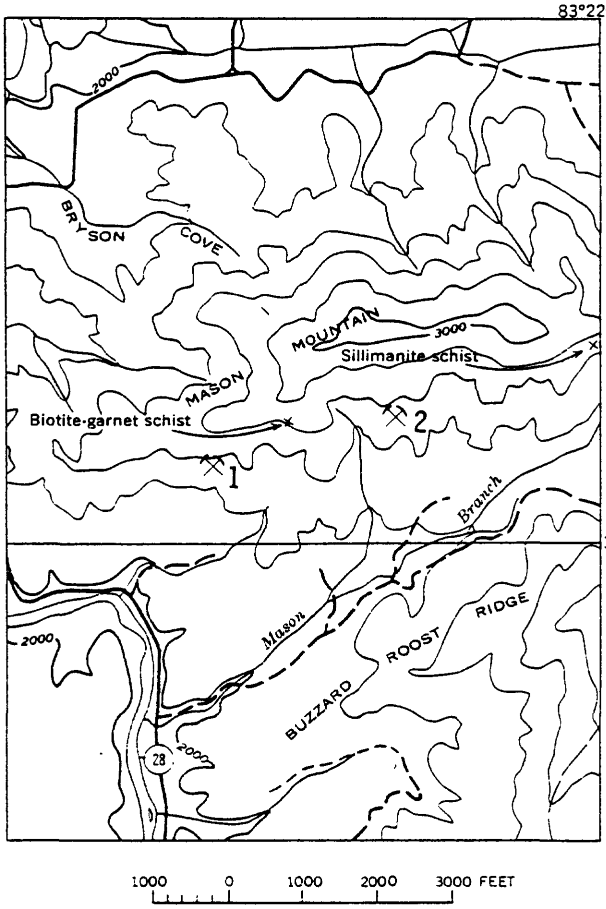

EXPLANATION

- MM4 Sample locality
  Analyzed sample
- MM10 Unanalyzed sample
- Strike and dip of layering
  - 80 Inclined
  - Vertical
- 20 Strike and dip of foliation
- 40 Strike and dip of joint
- Edge of open cut
- Contour-Interval 15 ft; datum assummed

Figure 1A.- Parts of the Alarka and Franklin 7.5 min. quadrangles, Macon County, N.C., showing location of garnet mine (1) and Lower Pickens prospect (2).

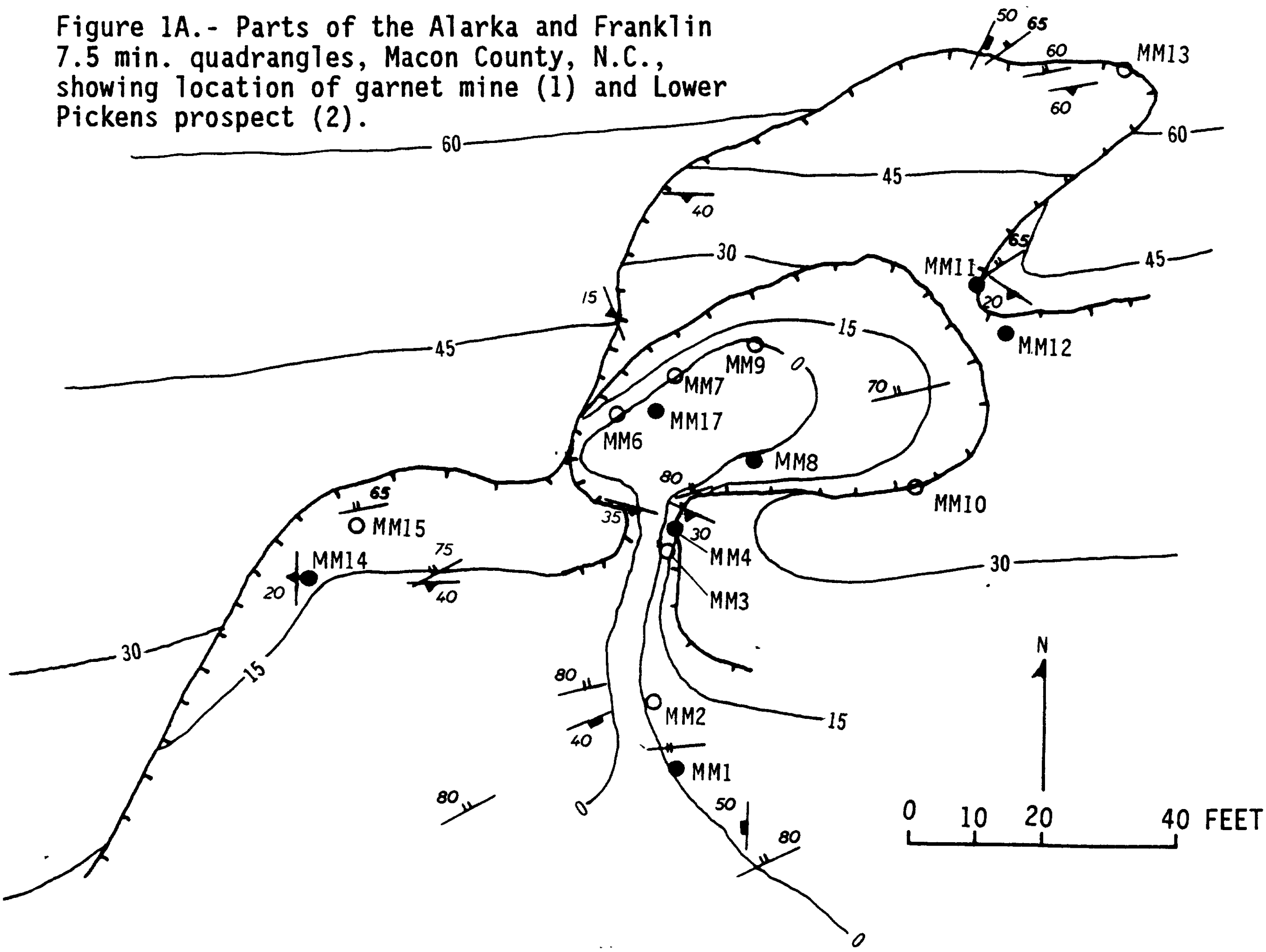

Figure 1B.- Sketch map of garnet mine, Mason Mountain, Macon County, N.C. showing workings as of 1963 and sample localities.

Table 1. Major and trace element analyses of some aluminous schist and gneiss from the Blue Ridge in North Carolina and Georgia.

	W-233297 F13-25LC	W-165661 F20-23	W-176091 F20-32	W-176092 F20-68	W-233319 CT-298	W-233318 CT-328	W-244835 TA197R1
SiO_2	55.1	48.7	47.00	43.90	55.85	52.75	56.70
TiO_2	1.3	1.4	1.30	2.50	.86	.68	1.12
Al_2O_3	19.5	29.4	16.60	27.80	20.78	25.39	20.50
Fe_2O_3*	9.87	9.37	12.90	15.44	8.90	7.72	8.64
Fe_2O_3	1.2	2.0	6.70	2.10	1.44	1.99	1.0
FeO	6.9	6.5	4.90	11.60	6.20	5.23	6.80
MnO	.19	.13	.12	.20	.14	1.07	.10
MgO	4.8	2.8	3.20	3.60	2.35	2.61	2.95
CaO	3.1	1.1	16.40	1.80	1.30	.20	2.10
Na_2O	4.46	.78	.45	.72	2.38	.90	2.67
K_2O	2.0	4.7	.25	2.70	5.11	4.28	3.35
P_2O_5	.35	.30	.83	.55	.27	.13	.25
S	---	---	---	.42	---	1.30	---
H_2O^+	.73	1.7	1.6	1.70	4.08	2.73	1.40
H_2O^-	.06	.16	.11	.14	.08	.14	.05
CO_2	.15	.06	<.05	<.05	.01	.09	.02
Total	99.84	99.73	99.46	99.03	99.85	97.73[1/]	99.01
Element, in parts per million							
Sc	19.4	22.0	16.0	33	20.3	21.8	17.2
Cr	89	91	42	110	67	69	72
Co	31	34	41	57	18.8	17.0	18.9
Ni	76	73	27.0	140	33	25.0	35
Cu	92	100	340	150	39	37	---
Zn	168	170	150	251	190	173	139
As	4.0	---	---	---	6.4	24.0	<1.20
Rb	59	162	9.0	74	230	183	152
Sr	300	244	500	159	88	159	320
Y	57	87	57	102	76	46	---
Zr	275	380	174	640	165	144	---
Nb	32	45	27.0	100	26.0	18.0	---
Sb	.250	.43	<.50	<.70	<.50	.97	<.090
Cs	<.60	.84	<.40	.45	4.1	4.8	2.50
Ba	540	1,400	58	1,280	1,000	760	580
La	115	217	172	292	86	41	78
Ce	230	390	340	570	166	87	154
Nd	93	180	170	260	68	40	70
Sm	21.4	36	37	49	16.1	9.1	15.2
Eu	2.92	5.1	4.8	5.9	2.29	1.37	2.68
Tb	2.50	3.5	2.90	4.6	2.30	1.30	1.90
Yb	5.0	8.6	4.3	11.1	5.7	4.3	5.1
Lu	.72	1.20	.49	1.54	.87	.73	.70
Hf	7.6	11.0	4.8	17.6	4.3	3.6	8.6
Ta	2.21	3.2	2.10	8.0	1.70	1.22	1.65
Th	28.0	45	34	76	20.0	17.4	17.2
U	5.1	6.9	2.80	9.6	4.3	4.6	3.8

[1/]Sample CT-328 also reported to contain carbon (2.78 weight percent C) (Hadley and Goldsmith, 1963, table 11).

Table 1. Continued

	W-178856 MM1	W-178857 MM4	W-178858 MM8	W-178859 MM11	W-178860 MM12	W-178861 MM14	W-178862 MM17	W-178863 MM18
SiO_2	74.40	62.40	77.30	73.20	58.40	65.40	55.90	38.30
TiO_2	.84	1.60	.96	1.00	1.10	.78	.73	1.70
Al_2O_3	12.20	17.20	9.70	11.50	14.70	10.70	15.80	35.20
Fe_2O_3*	5.49	7.84	5.89	6.56	10.45	8.84	12.78	12.24
Fe_2O_3	1.70	2.60	1.10	1.60	3.50	.90	3.80	2.80
FeO	3.20	4.30	3.80	4.20	5.70	6.60	7.10	8.00
MnO	.21	.18	.17	.21	.27	.15	.28	.41
MgO	2.00	3.90	5.60	7.30	13.40	13.40	13.40	7.30
CaO	.89	1.60	.23	.22	.43	.65	.65	1.20
Na_2O	3.29	3.64	.23	.35	1.12	.81	.49	.47
K_2O	.71	.85	.46	.08	.06	.10	1.10	2.40
P_2O_5	.08	.18	.02	.13	.29	.19	.17	.55
S	---	---	---	---	---	---	---	---
H_2O^+	.55	.82	.78	.50	1.00	.59	.67	.83
H_2O^-	.02	.08	.08	.07	.16	.13	.11	.11
CO_2	.01	.01	.01	.01	.01	.01	.01	.01
Total	100.1	99.36	100.44	100.37	100.14	100.41	100.21	99.28
Element, in parts per million								
Sc	8.7	16.4	9.9	11.0	19.5	10.1	22.4	36
Cr	35	71	43	53	57	41	60	136
Co	8.5	16.2	11.8	13.0	20.2	14.5	23.0	19.6
Ni	11.0	28.0	20.0	20.0	25.0	18.0	23.0	38
Cu	170	35	33	32	68	29.0	2.70	23.0
Zn	43	146	150	133	250	150	440	2,750
As	<2.70	<5.0	<1.80	<3.1	<2.70	<3.0	<2.80	<6.0
Rb	4.0	32	5.0	<2.00	<2.00	<2.00	37	104
Sr	72	145	4.0	4.0	4.0	4.0	4.0	4.0
Y	34	62	28.0	39	58	39	43	139
Zr	380	460	500	600	690	470	440	610
Nb	13.0	36	<10.0	14.0	16.0	<10.0	14.0	57
Sb	<.220	<.40	<.290	<.30	<.40	.39	<.50	<.60
Cs	<.40	<.60	<.50	<.50	<.60	<.50	.46	.34
Ba	190	990	170	65	58	97	350	840
La	45	130	57	63	100	44	107	224
Ce	93	270	118	130	208	96	218	430
Nd	46	120	48	56	94	41	99	190
Sm	9.3	25.0	10.8	13.0	20.2	10.0	21.1	39
Eu	1.73	3.2	.68	.98	1.92	.77	1.60	3.9
Tb	1.30	3.0	1.40	1.80	2.70	1.40	2.40	4.0
Yb	3.5	5.7	3.9	4.7	6.4	4.6	3.7	14.0
Lu	.54	.82	.54	.71	1.00	.67	.56	1.96
Hf	14.0	14.0	16.2	18.7	19.0	16.6	16.1	18.0
Ta	1.37	3.2	1.27	1.57	1.50	1.08	1.10	4.0
Th	14.3	34	18.2	20.0	27.7	16.0	28.0	52
U	3.3	5.3	1.90	2.80	4.3	2.40	5.1	8.2

Table 1. Continued

	W-195712 NCC015	W-195713 NCC041	W-195714 NCC055	W-195715 NCC056	W-195716 NCC057	W-195717 NCC058	W-195718 NCC059	W-195719 NCC060
				Oxide, in weight percent				
SiO_2	43.50	50.60	70.40	52.50	54.50	54.30	78.40	57.90
TiO_2	1.30	1.30	1.20	1.00	.98	1.00	.66	.96
Al_2O_3	29.90	24.20	12.80	25.00	24.60	24.00	10.90	21.00
Fe_2O_3*	13.80	12.18	6.74	10.65	10.60	10.47	3.40	10.20
Fe_2O_3	6.60	3.10	1.20	1.70	1.80	1.70	1.00	1.40
FeO	5.80	7.40	4.90	7.70	7.60	7.60	2.20	7.20
MnO	.24	.17	.05	.11	.12	.13	.06	.12
MgO	3.90	3.60	2.20	3.00	2.90	2.90	.83	2.80
CaO	3.00	1.60	1.90	1.70	1.50	1.70	2.20	1.80
Na_2O	2.60	1.39	2.17	2.18	1.91	2.16	2.36	2.22
K_2O	1.10	3.80	2.50	3.70	3.50	3.30	.83	2.80
P_2O_5	.24	.22	.18	.32	.29	.32	.12	.33
S	1.00	.94	.02	.34	.22	.25	.02	.20
H_2O^+	1.30	1.80	.94	1.20	1.10	1.50	.31	1.20
H_2O^-	.50	.61	.36	.34	.34	.37	.27	.31
CO_2	.02	<.01	.01	.01	<.01	.01	<.01	.01
Total	101	100.73	100.83	100.8	101.36	101.24	100.16	100.25
				Element, in parts per million				
Sc	30	27.4	11.1	23.2	23.6	23.0	6.3	21.9
Cr	95	89	56	78	79	77	28.0	69
Co	49	38	13.4	24.0	23.1	22.0	5.0	22.0
Ni	68	43	23.0	33	38	38	13.0	38
Cu	110	140	7.1	56	56	54	5.0	47
Zn	82	187	110	165	172	160	44	150
As	<4.0	<5.0	<2.70	<5.0	<4.0	<5.0	<2.70	<4.0
Rb	48	172	91	161	156	148	28.0	146
Sr	500	115	267	190	195	170	114	167
Y	71	84	27.0	69	74	76	35	69
Zr	261	281	470	236	218	234	297	251
Nb	21.0	28.0	<10.0	22.0	22.0	24.0	12.0	19.0
Sb	<.50	<.50	<.260	.260	<.40	<.40	<.210	<.40
Cs	<.80	2.20	1.40	3.4	2.20	2.50	.64	2.50
Ba	490	680	720	780	700	680	240	430
La	154	108	40	102	106	100	25.8	75
Ce	300	208	108	194	198	188	52	144
Nd	130	89	37	85	97	89	27.0	62
Sm	25.3	19.8	8.1	19.1	18.9	18.6	5.7	14.7
Eu	2.45	2.38	1.27	2.78	2.75	2.64	1.15	2.28
Tb	2.90	2.80	1.20	2.40	2.50	2.41	1.10	2.20
Yb	11.0	7.4	3.5	7.0	6.6	7.2	3.3	7.5
Lu	1.54	1.14	.52	1.07	1.00	1.08	.46	1.10
Hf	6.6	7.6	15.6	6.3	5.5	6.7	9.8	6.8
Ta	1.29	1.53	.63	1.37	1.40	1.60	1.10	1.33
Th	32	26.6	16.7	21.9	22.7	22.1	11.3	17.1
U	2.10	5.0	2.10	4.7	4.6	5.1	2.60	3.7