A PETROLOGIC AND ECONOMIC STUDY OF A HYDROTHERMAL ALTERATION ZONE IN LUMPKIN COUNTY, GEORGIA

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INFORMATION CIRCULAR 89

Cover photo: The lower contact of the alteration zone at Castleberry Bridge.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

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ABSTRACT

Three core holes were drilled in Lumpkin County between Auraria and Dahlonega to study the petrology and economic potential of a zone of hydrothermal alteration containing abundant disseminated sulfides. This zone is the largest of several similar zones within the Dahlonega gold belt and was chosen for further study because of its potential as a host for base or precious metal deposits.

The alteration zone consists of sericitized and chloritized biotite-muscovite-plagioclase-quartz schist containing variable amounts of sulfides (pyrite, chalcocite, chalcopyrite, sphalerite, covellite and galena), hornblende, garnet, staurolite and kyanite. Sulfide concentrations range from as high as 50% in 1-5 cm thick zones to disseminated trace amounts elsewhere, averaging from approximately 1 to 7% disseminated modal sulfides. Local intervals near the southwestern end of the alteration zone contain abundant modal staurolite and kyanite. Abundant kyanite also occurs in local quartz veins.

Trace amounts of precious metals (gold and/or silver) were detected in five of the two-hundred and twenty-three core, outcrop and soil samples. Base metal (copper, lead and zinc) concentrations were locally anamolous, particularly in core #3. Although economic concentrations of base or precious metals were not encountered, the economic potential of the hydrothermal alteration zone is not necessarily lessened since mineralization in similar lithologies worldwide is not uniform and three core holes are not sufficient to evaluate adequately the economic potential of a unit of this size.

Trace element and major oxide chemistry of the sericitized and chloritized felsic schists indicate that they are chemically similar to adjacent, unaltered, quartzofeldspathic gneisses and to the Barlow Gneiss and Galts Ferry Gneiss, all of the Pumpkinvine Creek Formation. Sericitization and chloritization are largely confined to a felsic portion of the Pumpkinvine Creek Formation.

Geochemical data indicate that the hydrothermal alteration zone has been enriched markedly in aluminum, iron, magnesium, sulfur, copper, zinc and lead and much less so in titanium, calcium, fluorine, strontium and arsenic. There is a distinct depletion in silica and sodium. Petrographic data strongly suggest that hydrothermal alteration occurred after the peak of regional dynamic metamorphism roughly coinciding with the intrusion of metatrondhjemite (metadacite?) bodies immediately northeast of the study area.

INTRODUCTION

Three core holes were drilled in Lumpkin County in a unit containing a large zone of sericitic and chloritic felsic schist interpreted herein to be an alteration zone. Published information (Cook and Burnell, 1985; German, 1985) on the sulfide mineralization in this zone indicated its potential as a host for precious and/or base metal deposits. Core drilling was necessary to obtain subsurface lithologic and stratigraphic data and unweathered samples for geochemical analysis to aid in the understanding of the zone's origin and economic potential.

The alteration zone is located in Lumpkin County between Auraria and Dahlonega on the Dawsonville and Campbell Mountain 7.5-minute topographic quadrangles (Figure 1). The study area is accessible via Georgia Highways 9E and 53 and numerous secondary paved roads. The zone is part of a rock unit that extends approximately 5 miles (8 km) from near Auraria to Dahlonega (Plate 1) (Cook and others, 1984; German, 1985). The unit pinches out to the southwest and to the northeast, and at its widest point is approximately 3000 feet (900 meters) thick.

Naturally occurring exposures of the alteration zone are rare. The best exposures are roadcuts along Highway 9E at Crooked Creek near the northeastern end of the zone and at Castleberry Bridge near the southwestern end. Several sec-

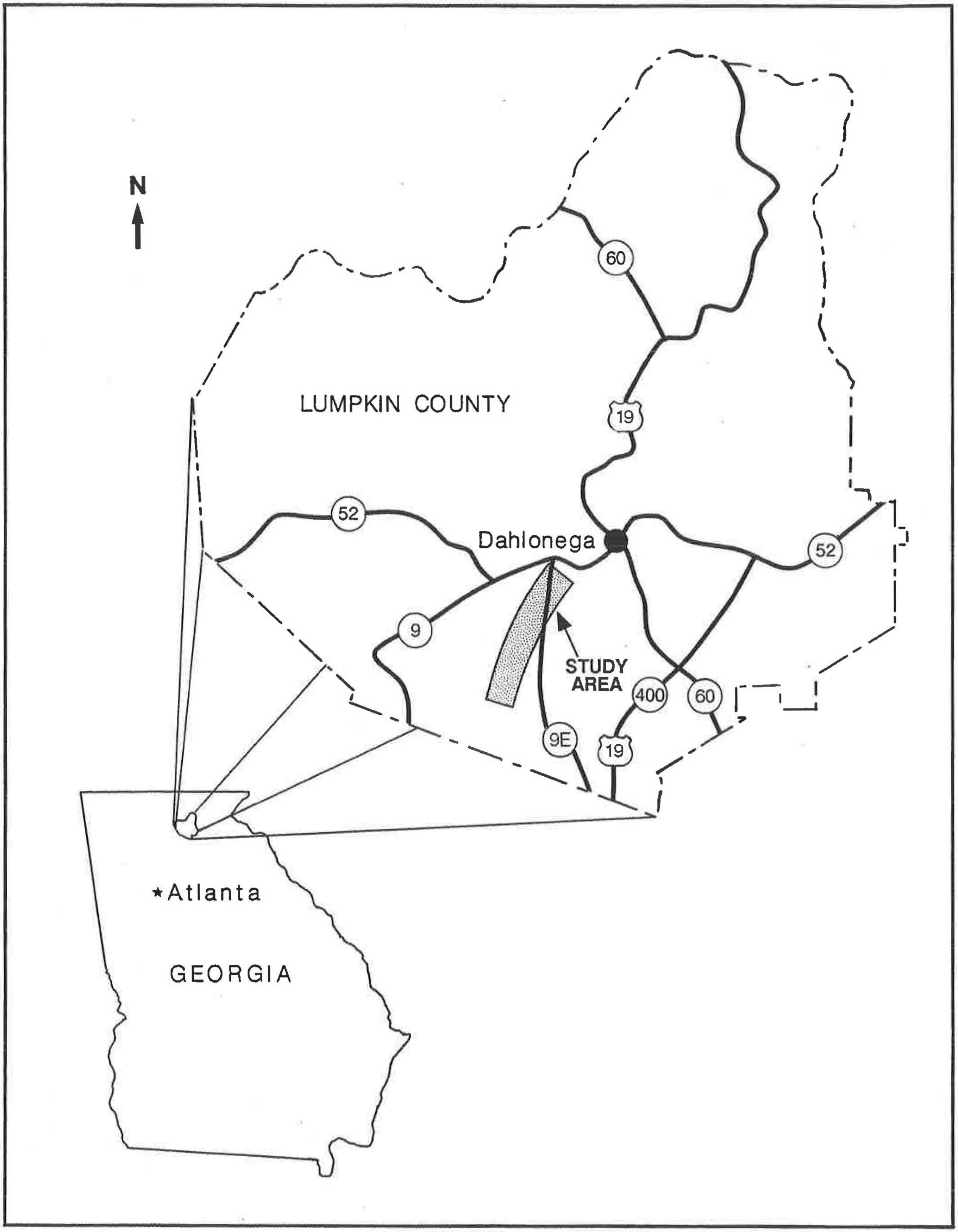


Figure 1. Location of the study area.

ondary drainage valleys also contain good exposures.

METHODS

The selection of drilling locations was determined by physical access for the drill rig and the granting of property access by landowners. Where possible, drill sites were located as near as possible to major outcrops so that surface-subsurface correlations could be made. Hole #1 was drilled to 249 feet (74.7 meters) on the Charlie Woody property, and hole #2 was drilled to 501 feet (150 meters) on the Clarence Woody property, both in the northeastern third of the unit. Hole #3 was drilled to 240 feet (72 meters) on the George David property near Castleberry Bridge (Plate 1) (Appendix A). Actual thicknesses of penetrated section for the three holes were approximately 176 ft. (52.8 m), 354 ft. (106.2 m), and 120 ft. (36 m), respectively. All drilling was done by the Geologic Survey using conventional wireline coring techniques. Drilling was conducted between December 1986 and May 1987.

After drilling was completed, the core was logged and individual lithologies were sampled for thin sections and geochemical analyses. Geologic mapping, also, was conducted and supplemental outcrop and soil samples were collected. Twenty-four polished and twenty-two conventional thin sections were made and were examined by conventional petrographic techniques. Sulfide minerals were identified and examined by reflected light techniques.

Geochemical analyses were performed on two-hundred and twenty-three samples from the core and surface exposures. Analyses were performed for base and precious metals (Au, Ag, Cu, Pb, Zn and Mo), major element constituents, and certain trace elements (Y, Zr, Nb, Ti, Cr, V, Ni, F, Rb, Sr, As, Sb, Hg and Bi). All samples were analyzed for gold and silver; whereas, only selected samples were analyzed for the remaining elements. Samples for whole rock and trace element analyses were selected to obtain a representative sampling of the various rock types. Also, lithologies with visible sulfide mineralization were sampled for analysis. Analyses were performed by Skyline Labs, Wheat Ridge, Colorado. Au and Ag concentrations were determined by fire assay; Cu, Pb, Zn, Hg, Bi, Rb, Sr and Ni by AA; Mo, Y, Zr, Nb, Ti, Cr, V, As and Sb by ICP; and F by specific ion electrode. FeO concentrations were determined by titration, and all other major oxides by ICP.

LITHOLOGY

The alteration zone is part of a rock unit that consists of largely unaltered amphibole felsic gneiss, epidote-chlorite amphibole gneiss, amphibolite, quartzofeldspathic gneiss, magnetite quartz granofels (iron formation) and a zone of altered rocks. The unaltered amphibole felsic gneiss composes the major portion of the rock unit. This felsic gneiss is poorly exposed, and only saprolite outcrops were observed. The deeply weathered nature of this gneiss accounts for the lowlands along Camp Creek and its tributaries. The alteration zone consists of sericitized and chloritized biotite-muscovite-plagioclase-quartz schist (pyrite, hornblende, garnet, staurolite and kyanite) (Plate 1) (Figure 2). Sericitization is pervasive in the southwestern half of the zone with chloritization dominant in the northeastern half (Figure 3). The altered and unaltered rocks are bordered on the west and northwest by biotite-muscovite-garnet-quartz-plagioclase schist, garnet-plagioclase-biotite-quartz schist, and slightly graphitic plagioclase-biotite-muscovite-quartz schist of the Proctor Creek and Palmer Creek Members of the Canton Formation (Figure 4); and on the east and southeast by amphibolite of the Pumpkinvine Creek Formation. At Castleberry Bridge, the northwestern contact of the alteration zone is exposed. There sericitized biotite-muscovite-plagioclase-quartz schist grades into unaltered garnet-plagioclase-biotite-quartz schist and slightly graphitic, plagioclase-biotite-muscovite-quartz schist over an interval of approximately 1 meter (Figure 5). In the gradational zone, the decrease in biotite, the appearance of sericite and sulfides and the distinct color change are outstanding features. The contact with amphibolite of the Pumpkinvine Creek Formation is not exposed, but, as observed in hole #2, also is gradational over approximately 1 meter.

Disseminated throughout the alteration zone are various amounts of sulfide minerals. Sulfides make up from 1.1 to 7.1% of the felsic schist (Table 1) in the southwestern portion of the zone. Throughout the remainder of the alteration zone sulfide concentrations up to 50% are present in local thin layers (1-5 cm) (German, 1985). Reflected light petrography indicates that the sulfides are predominantly pyrite with variable minor amounts of chalcocite, chalcopyrite, sphalerite and covellite. No sulfides of lead were observed during this study, although chemical analyses show the presence of lead, and galena has been found at the Castleberry Bridge exposure (Robert B. Cook, Jr., personal communication, 1989).

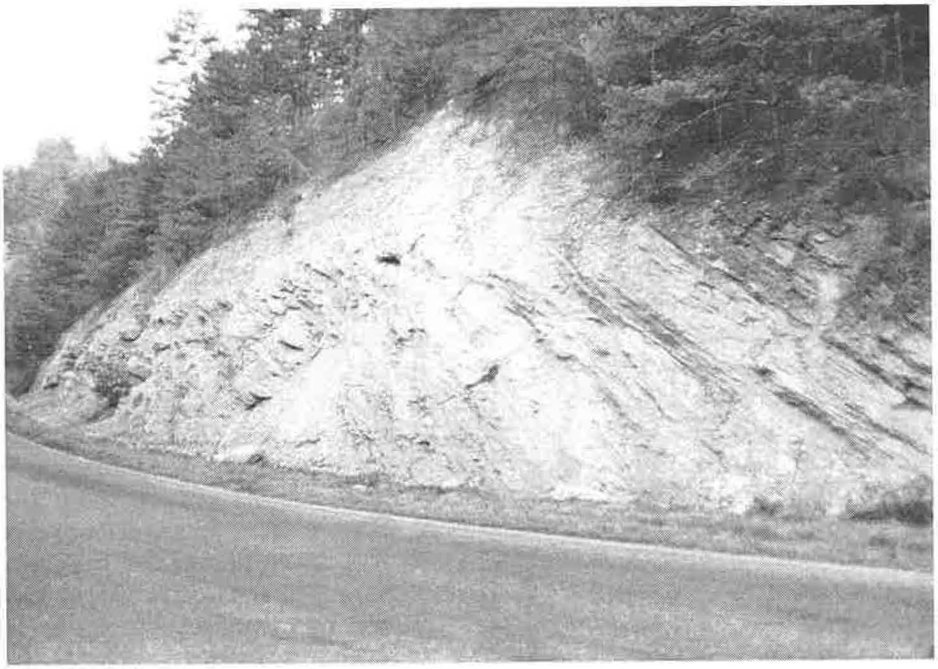


Figure 2. The Castleberry Bridge outcrop. The light-colored rock is sericitic felsic schist. Small tree at left, at the base of the outcrop, is approximately 6 feet in height.

Most outcrops of the felsic schist are conspicuously light in color compared to adjacent rocks. Weathering of these outcrops enhances the light color as abundant plagioclase is weathered to clay. Weathering also produces local encrustations of the mineral pickeringite ($MgAl_2(SO_4)_4 \cdot 22H_2O$) (Figure 6) with possible minor amounts of epsomite ($MgSO_4 \cdot 7H_2O$), alunogen ($Al_2(SO_4)_3 \cdot 17H_2O$) and magnesite ($MgCO_3$). Because these minerals are soluble in water, they occur mainly in the more protected recesses of the outcrops. The occurrence of pickeringite in Georgia has not been previously reported.

Pickeringite was positively identified from excellent crystalline specimens from the Highway 9E outcrop. Specimens from that locality occur as white to pale-yellow encrustations along joints, fractures and foliations. Inside the encrusted masses are delicate acicular crystals. Identification of this mineral was confirmed by x-ray diffraction analyses. No crystalline specimens of epsomite, alunogen or magnesite were found, but x-ray analyses indicated their presence in minor quantities.

Thin sections of the sericitized felsic schist reveal abundant plagioclase that is moderately to highly sericitized. The plagioclase occurs as part of a fine-grained groundmass and as lenticular masses (porphyroblasts or megacrysts). Some of the lenticular masses resemble flattened, stretched lapilli; however, recrystallization and shearing have greatly obscured any surviving primary features making recognition of such features difficult. Most biotite has been altered to chlorite. Remaining biotite crystals are very pale brown, suggesting that they have been leached of some of their iron. Light brown staurolite crystals, up to 2 mm long, are scattered throughout the sericitized felsic schist and are locally concentrated in zones where they comprise up to 15% of the rock. Kyanite occurs in the lower third of hole #3 and at the Castleberry Bridge outcrop as small clusters, up to 2 mm in diameter, that resemble sillimanite in hand sample. Lithologically similar rocks in Georgia have been described from other parts of the Dahlonega gold belt (German, 1985), the west-central Georgia Piedmont (Abrams and McConnell, 1984) and the Slate Belt (Carpenter and Allard, 1980; Carpenter, 1982). These have been mined locally for kyanite and pyrite.

The chloritized portion of the felsic schist is, generally, mineralogically similar to the sericitized portion. The mineral proportions of quartz and plagioclase are the same but kyanite, sericite and

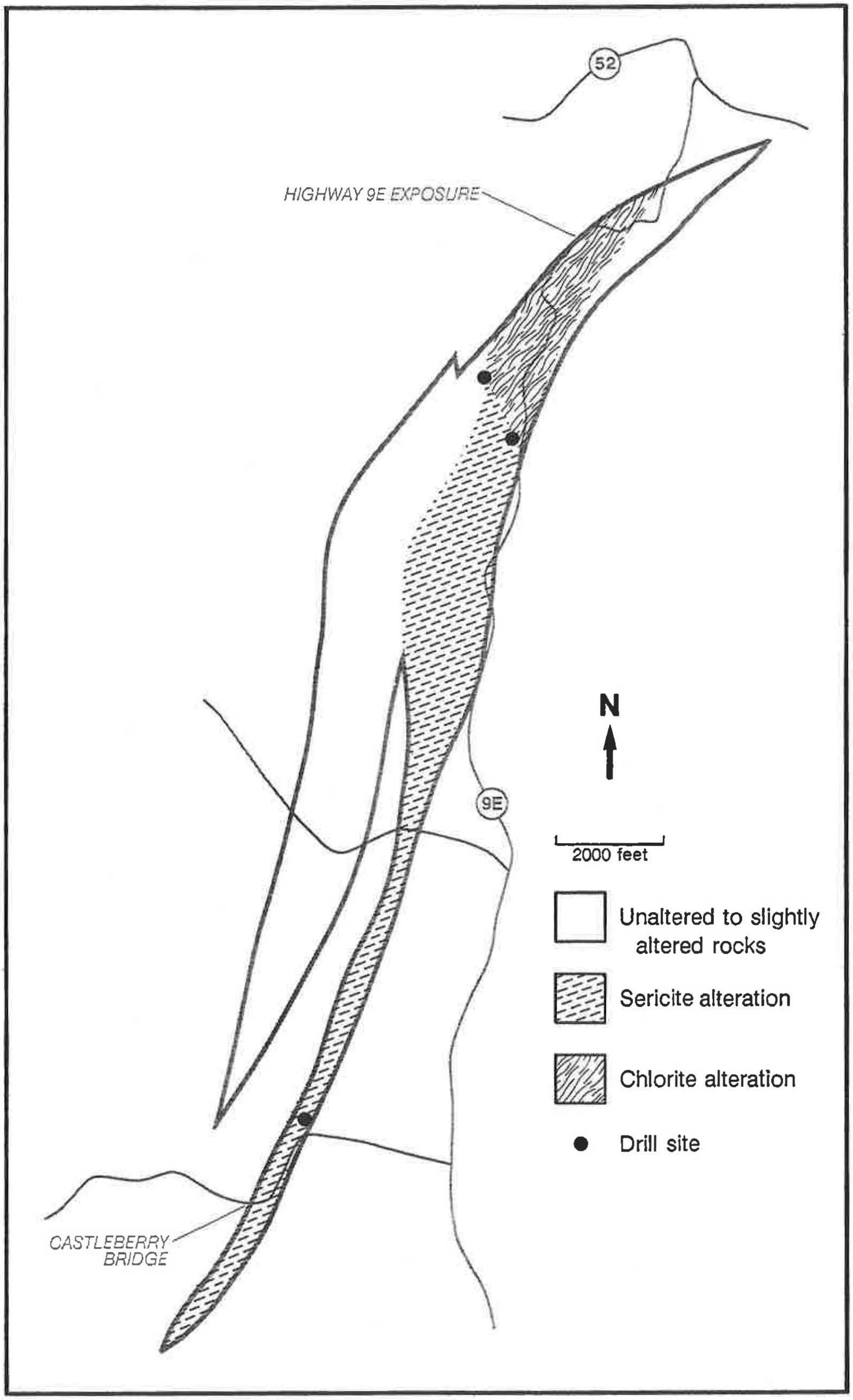


Figure 3. Areas of sericite versus chlorite alteration.

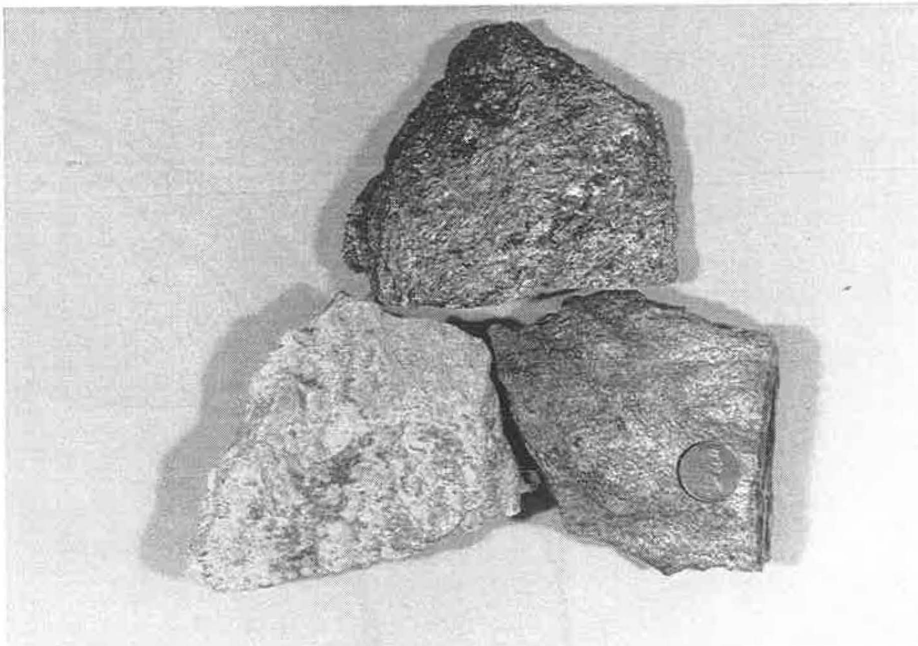


Figure 4. Lithologies from the Castleberry Bridge outcrop. Clockwise from lower left: sericitic felsic schist, garnet-plagioclase-biotite-quartz schist and slightly graphitic plagioclase-biotite-muscovite-quartz schist.

Figure 5. The lower contact of the alteration zone at Castleberry Bridge (at hammer). Contact dips approximately 30 degrees to the right (SE). Sericitic felsic schist (alteration zone) upper right and graphitic plagioclase -biotite-muscovite-quartz schist lower left.

TABLE 1

Modal Analyses of Representative Lithologies From Core Holes 1, 2 and 3*

	75-1	95-1	132-1	235-1	83-2	130-2	160-2	177-2	267-2	444-2	79-3	114-3	128-3	172-3	229-3
Quartz	39.6	19.7	39.5	35.0	51.7	53.1	48.3	36.0	12.5	6.6	46.1	38.1	39.7	35.0	29.7
Plagioclase	52.4	34.4	39.1	38.6	25.5	14.6	31.3	23.8	45.0	14.9	32.5	23.2	29.6	37.5	36.5
Muscovite**	5.0	0.3	17.4	2.8	6.8	9.6	0.9	1.7			2.0	18.4	7.1	10.1	2.3
Biotite	0.2	16.4	0.9	14.7		1.2		22.7	6.1		1.5		0.4	1.6	21.8
Hornblende		9.9					2.6	4.1	8.8	61.0	0.3				
Chlorite		7.5	2.4	2.2	7.1	14.4	12.0	1.2	21.9	15.6	5.9	1.8	5.6	8.6	1.2
Staurolite					1.8	6.1	1.0	0.3			1.2	14.2	15.3		
Kyanite		0.1				0.1							0.1	2.5	tr
Opaques***	tr	5.0	0.3	0.5	1.5	0.1		0.2	3.6	1.3	3.8	4.2	1.1	4.1	7.1
Epidote	0.2	0.4	0.2		2.8	0.1	1.4	6.9	0.5	0.3	6.3		0.6	0.3	1.1
Calcite	1.1	0.1		0.3			0.1								
Garnet		5.7		5.5	2.6		2.1	2.6	1.3						
Zircon								tr							
Tourmaline						0.1							0.3		

75-1 - quartzofeldspathic gneiss, 95-1 - sericitic felsic schist, 132-1 - quartzofeldspathic gneiss, 235-1 - sericitic felsic schist, 83-2 - sericitic felsic schist, 130-2 - sericitic felsic schist, 160-2 - sericitic felsic schist, 177-2 - sericitic felsic schist, 267-2 - chlorite felsic schist, 444-2 - amphibolite, 79-3 - sericitic felsic schist, 114-3 - sericitic felsic schist, 128-3 - sericitic felsic schist, 172-3 - sericitic felsic schist, 229-3 - sericitic felsic schist

* Based on point counts; >500 counts per sample

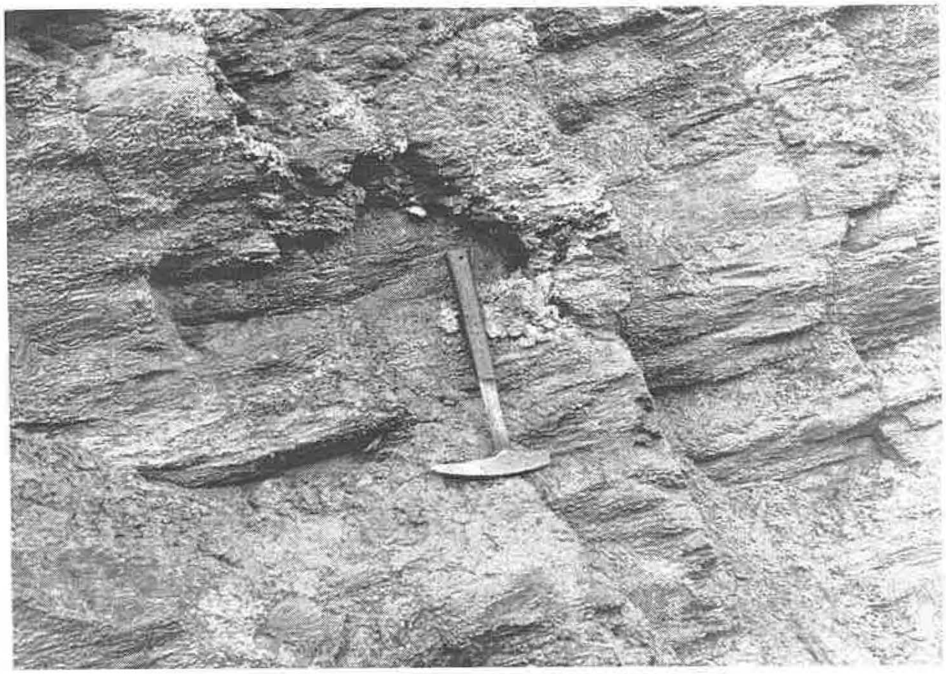
** Also includes sericite

*** Predominantly pyrite with minor amounts of chalcopyrite, chalcocite, covellite and magnetite

staurolite are absent. Nearly all mafic minerals (biotite and hornblende) have been altered to chlorite.

Parallel to subparallel to the foliation of the sericitized felsic schist are rare kyanite-quartz veins, 1-5 cm thick (Figure 7). The kyanite occurs as euhedral crystals up to 3 cm in length, aligned perpendicular to the sides of the vein (comb texture), indicating growth toward the center of the vein. Where the kyanite crystals meet in the center, they are deflected to either side along the center of the vein. The quartz in the veins is milky to vitreous in appearance and highly fractured. The veins are surrounded by alteration haloes, 1-2 cm thick, consisting of fine-grained kyanite, staurolite, biotite, sericite, quartz and sulfides. The mineralogy of the haloes is the same as the enclosing schist, plus additional kyanite and staurolite. The kyanite-quartz veins occur near the structural base of the sericitized schist in the interval that contains modal kyanite. These veins are mineralogically similar to those that traverse aluminum silicate-bearing rocks adjacent to the Bousquet gold deposit, Quebec, Canada (Valliant and others, 1983). Kyanite also was reported in the ore body at the Battle Branch gold mine just west of the Castleberry Bridge exposure (Plate 1) (Park and Wilson, 1934; Pardee and Park, 1948).

Trace element and whole rock geochemical analyses (Table 2, Figures 8 and 9) suggest that the sericitized felsic schist is a hydrothermally altered quartzofeldspathic gneiss. Titanium and zirconium content of this rock (Figure 8) indicate a chemical similarity to nearby unaltered felsic gneisses and to the Barlow Gneiss and Galts Ferry Gneiss Members of the Pumpkinvine Creek Formation (McConnell and Abrams, 1984; McConnell, 1980; German, 1985, 1988, 1989). Amphibolites (metabasalts) of the Pumpkinvine Creek Formation and amphibole gneisses from hole #2 plot in a distinctly different field. Two samples of chloritic felsic schist samples from the Highway 9E exposure plot in both fields, giving inconclusive results as to protolith. Analyses of two samples of mica schist in contact with the sericitic felsic schist from the Castleberry Bridge outcrop also give inconclusive results as to protolith, but mostly likely are



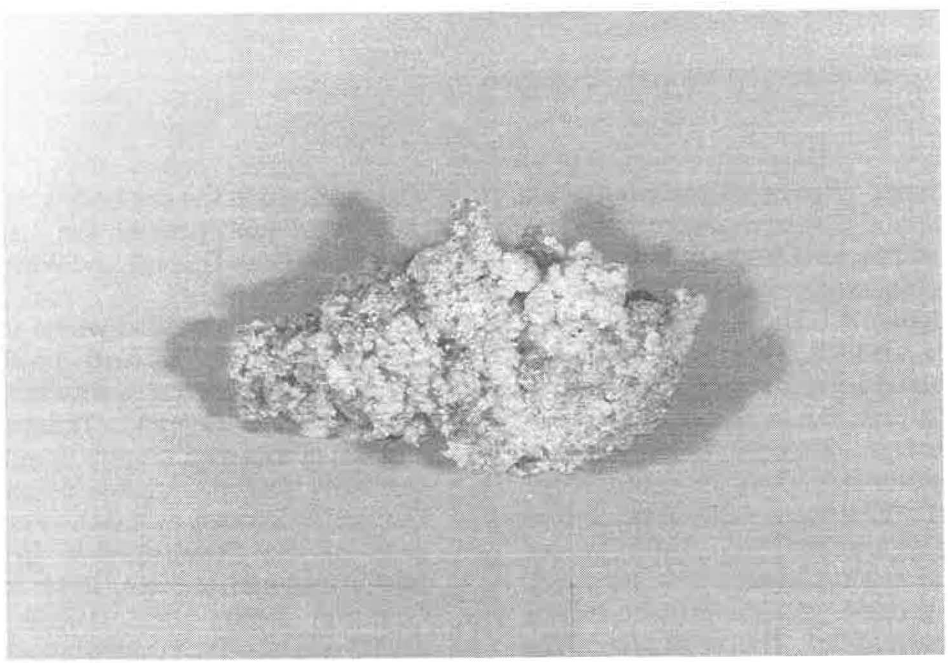


Figure 6. Above: Pickeringite from the Highway 9E outcrop. Below: Detail of a sample of pickeringite from the same outcrop. Length of sample is approximately 4 inches (10 cm).

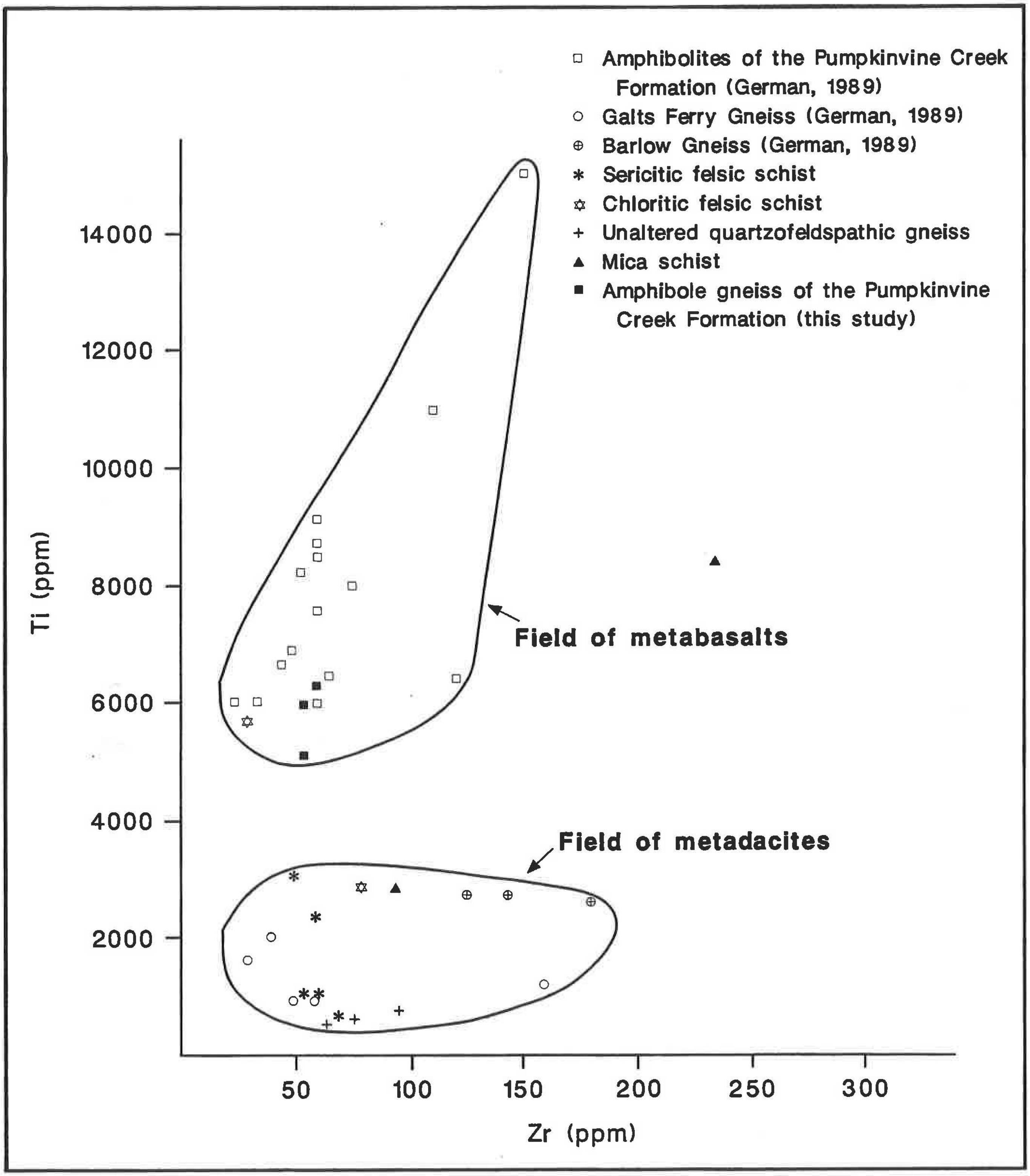


Figure 7. Plot of titanium versus zirconium for core and outcrop samples. Analyses of the Barlow Gneiss, Galts Ferry Gneiss and amphibolites of the Pumpkinvine Creek Formation (German, 1989) are plotted for comparison. The mica schist samples are from the Canton Formation near the north-western border of the alteration zone.

Table 2

Major Oxide, Trace Element and Normative Analyses of Selected Core and Outcrop Samples

Major oxide	64-1	76-1	87-1	106-2	267-2	417-2	104-3	158-3	195-3	CM-1D*	CM-1A*	CB-4*	CB-7*	CB-8*	275-2
SiO_2	77.5	75.5	78.9	75.9	51.0	50.1	58.1	61.1	60.6	51.5	66.0	60.7	72.7	61.5	nd
Al_2O_3	11.6	12.7	11.3	10.5	17.8	16.9	19.5	15.2	17.9	13.6	11.3	15.0	12.2	15.9	nd
Fe_2O_3	1.6	1.2	1.0	1.4	4.0	5.8	4.7	5.0	6.9	5.1	1.6	5.2	2.0	2.1	nd
FeO	0.9	1.6	0.9	2.4	9.1	8.0	3.4	1.9	2.4	10.9	6.0	1.7	2.5	6.8	nd
MgO	0.4	0.5	0.3	1.6	5.1	4.6	2.4	3.4	1.6	7.2	5.1	3.3	2.1	3.2	nd
CaO	0.4	0.9	0.9	1.6	4.7	7.3	3.4	4.9	1.7	0.8	1.3	0.4	1.1	1.6	nd
Na_2O	5.0	4.5	5.4	1.2	3.7	3.4	1.9	2.2	1.7	1.3	1.5	1.1	0.3	2.5	nd
K_2O	1.1	2.0	0.6	1.0	0.6	0.8	1.1	0.8	1.1	0.4	1.0	2.8	2.8	2.7	nd
TiO_2	0.1	0.1	0.1	0.1	0.8	1.0	0.5	0.1	0.4	1.0	0.5	0.1	0.5	1.4	nd
MnO	0.04	0.05	0.05	0.09	0.2	0.2	0.1	0.1	0.02	0.2	0.07	0.1	0.03	0.1	nd
P_2O_5	0.02	0.02	0.02	0.02	0.06	0.08	0.06	0.07	0.07	0.04	0.04	0.02	0.03	0.1	nd
LOI	0.8	1.4	0.9	2.0	1.9	0.8	1.7	3.6	3.5	2.1	2.7	5.3	3.3	1.5	nd
TOTAL	99.46	100.47	100.37	97.81	98.96	98.98	96.86	98.37	97.89	94.14	97.11	95.72	99.56	99.40	
Trace Element (ppm)															
Ti	600	700	500	600	5100	6000	3100	900	2300	5700	2800	900	2800	8400	6300
Zr	75	95	65	70	55	55	50	55	60	30	80	60	95	235	60
Cr	nd	nd	nd	10	<5	<5	<5	<5	5	10	10	10	35	45	<5
Y	30	40	20	30	25	20	<10	<10	<10	<10	14	<10	<10	30	12
V	nd	nd	nd	<10	195	285	165	105	135	320	130	155	185	195	410
Ni	nd	nd	nd	<5	<5	<5	<5	<5	10	<5	<5	<5	15	10	<5
Nb	<20	<20	<20	<20	<20	<20	<20	<20	<20	nd	nd	nd	nd	nd	nd
F	180	120	120	300	nd	nd	220	420	390	nd	nd	360	nd	nd	nd
Sr	60	60	60	40	nd	nd	95	85	80	nd	nd	75	nd	nd	nd
Rb	30	20	<10	20	nd	nd	20	20	30	nd	nd	40	nd	nd	nd
As	10	10	10	10	nd	nd	15	10	20	nd	nd	35	nd	nd	nd
Sb	<2	<2	<2	<2	nd	nd	<2	<2	<2	nd	nd	<2	nd	nd	nd
Hg	.01	.01	.01	.01	nd	nd	<.01	<.01	<.01	nd	nd	.01	nd	nd	nd
Bi	<1	<1	<1	<1	nd	nd	5	<1	<1	nd	nd	<1	nd	nd	nd
CIPW Norms															
Q	43.18	38.37	42.55	60.43	4.09	2.56	32.98	31.42	43.09	25.29	41.37	41.96	55.86	25.35	
C	1.43	1.48	0.09	4.79	2.72		9.61	2.06	11.64	10.38	5.81	10.56	6.99	6.37	
OR	6.59	11.92	3.86	6.11	3.77	4.93	6.83	5.11	6.89	2.70	6.26	18.30	17.19	16.29	
AB	43.88	38.39	45.92	10.60	32.24	29.29	16.90	19.63	15.24	11.95	13.45	10.29	2.73	21.60	
AN	2.13	4.57	4.46	8.15	23.61	28.94	17.31	25.15	8.45	4.30	6.56	1.83	5.47	7.31	
DI						6.06									
HY	1.21	3.23	1.45	7.56	25.80	17.54	8.02	8.93	4.22	35.26	23.03	9.09	7.73	16.97	
MT	2.35	1.75	1.46	2.12	5.97	8.56	7.16	6.36	7.11	8.04	2.46	5.89	3.01	3.11	
IL	0.19	0.23	0.17	0.20	1.66	1.93	1.04	0.28	0.76	1.98	0.97	0.34	0.95	2.72	
HM								0.88	2.41			1.69			
AP	0.05	0.05	0.05	0.05	0.15	0.19	0.15	0.17	0.18	0.10	0.10	0.05	0.07	0.29	

Q-quartrz, C-corundum, OR-orthoclase, AB-albite, AN-anorthite, DI-diopside, HY-hypersthene, MT-magnetite,IL-ilmenite,HM-hematite, AP-apatite.

64-1, 76-1, 897-1 - unaltered quartzofeldspathic gneiss
106-2, 104-3, 158-3, 195-3, CB-4 - sericitic felsic schist
CM-1A, CM-1D - chloritic felsic schist
CB-7, CB-8 - mica schist

267-2, 275-2, 417-2 - amphibole gneiss
*Outcrop samples
nd - Analysis not done

Analyses by Skyline Labs, Inc., Wheat Ridge, Colorado

Ferrous iron analyses by titration; all other major oxides by ICP.
Ni, Hg, Bi, Rb and Sr analyses by AA; all other trace elements by ICP.

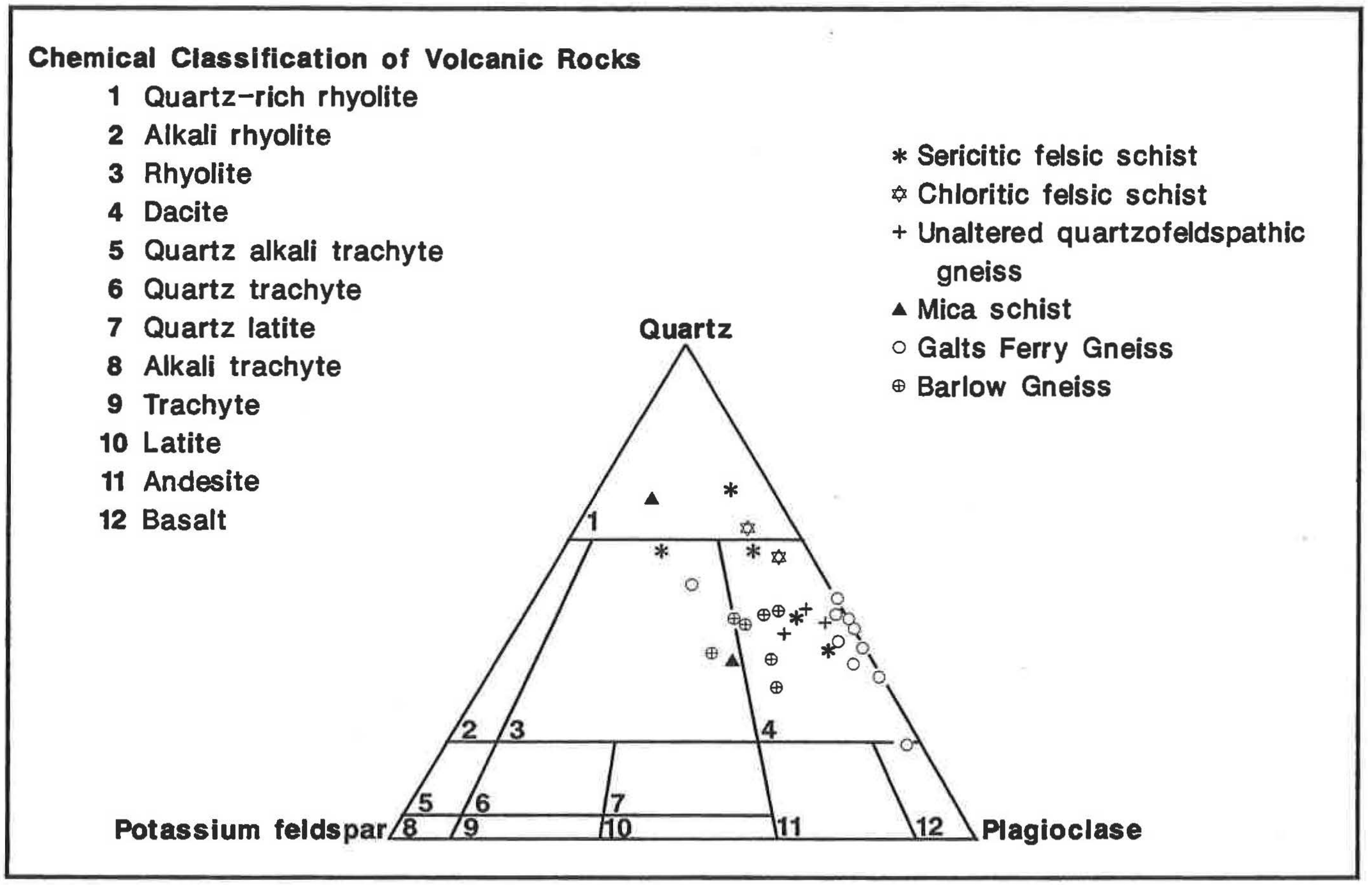


Figure 8. Chemical classification of altered and unaltered lithologies. Modified after Streckeisen (1970). Samples of the Galts Ferry Gneiss and the Barlow Gneiss (German, 1989) are plotted for comparison.

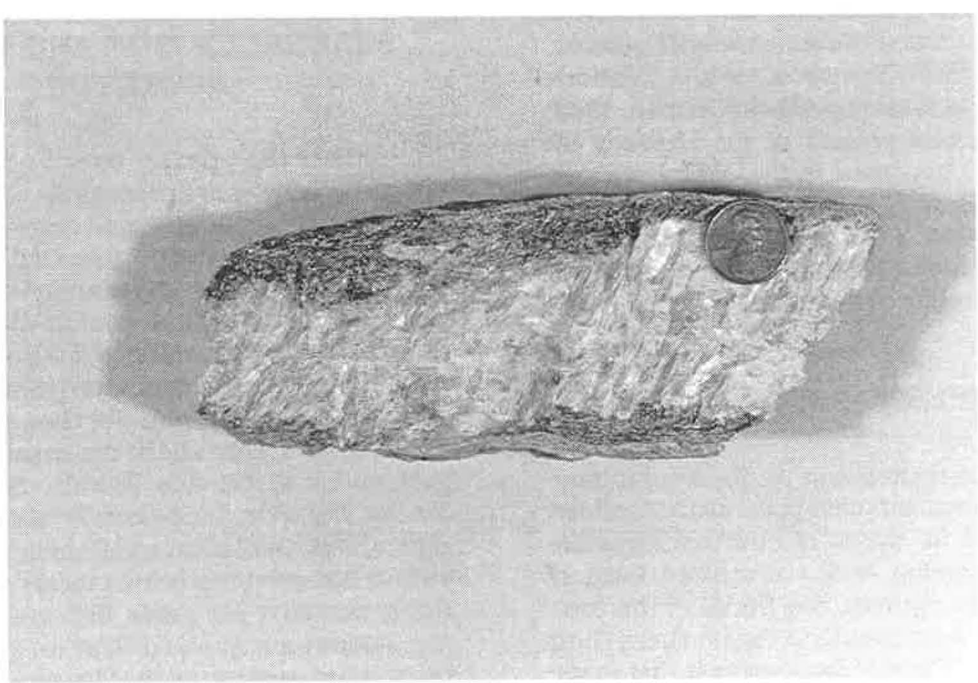


Figure 9. Part of a kyanite-quartz vein from the Castleberry Bridge outcrop.

metasediments.

A chemical classification of these samples based on normative analyses (Table 2) is illustrated in Figure 9. Unaltered felsic gneisses plot in the dacite field as do most of the sericitic felsic schists samples.

STRUCTURE

The rock unit containing the alteration zone is located on the northwestern flank of the Auraria antiform (German, 1985). From southwest to northeast, strike of the unit varies from about N 25° E, to nearly due north, to about N 45° E (Plate 1). The unit roughly coincides with a magnetic high (Brown and others, 1953).

The dip of the dominant foliation varies from 23 to 79 degrees and generally increases to the northeast. The dominant foliation within the unit and throughout the Auraria antiform and Dahlonega gold belt is axial planar and probably S_2 (German, 1985; 1988). S_1 foliations appear to be totally transposed; however, at the Highway 9E exposure, two foliations are observable. Both foliations appear to have the same strike and both dip to the southeast, one approximately 30 degrees more steeply than the other. Cleavage along these foliations causes the rock to weather out as rhombic-shaped blocks. The intersection of these foliations, along with attendant crenulations, produces well-defined lineations that plunge from 10 to 20 degrees to the northeast (Figure 10). Two foliations also were observed just northeast of the study area at Dahlonega (German, 1985), but only one foliation was observed southwest of the Highway 9E outcrop. Based on the pervasive transposition of S_1 foliations throughout the Dahlonega gold belt (German, 1985; 1988), the foliations present at the Highway 9E outcrop and just northeast in the Dahlonega area most likely are S_2 or S_3. Outcrop patterns and the plunge of rock fabric lineations (Figure 10) suggest that the alteration zone is part of a parasitic antiform on the Auraria antiform and plunges gently to the northeast.

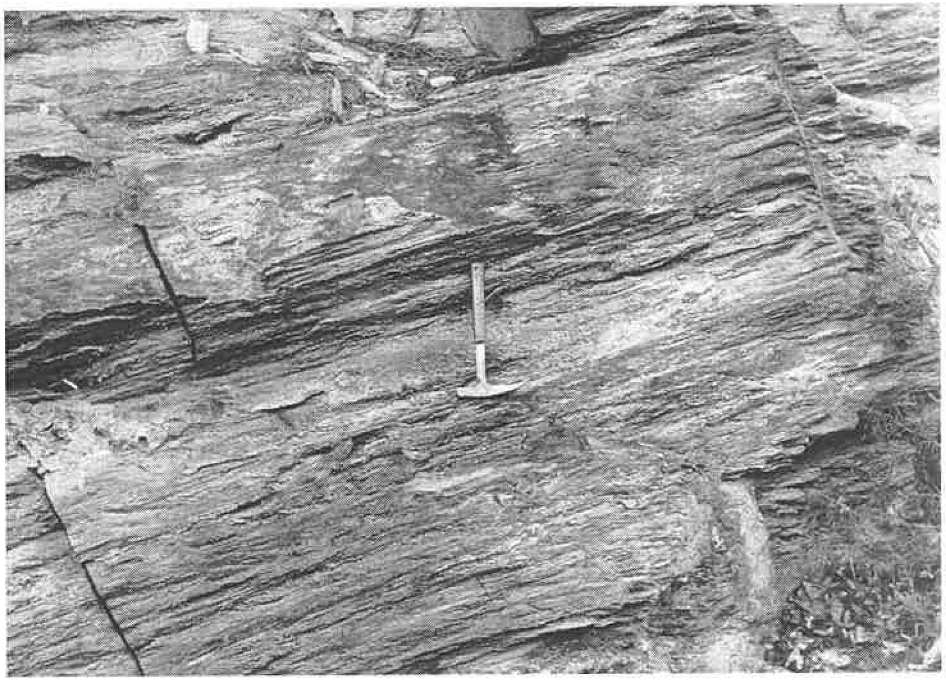
HYDROTHERMAL ALTERATION

Hydrothermal alteration as observed in surface and subsurface samples appears to be confined largely to a unit (or units) of quartzofeldspathic gneiss. Sericitization is the dominant form of alteration in the southern two-thirds of the zone with chloritization dominant in the northern third (Figure 3). Trace element data suggest that mafic rocks also may have been altered in the northern third of the study area. The intersection of unaltered quartzofeldspathic gneisses in holes 1 and 2 provided an opportunity to compare the chemistry of the unaltered and sericitized lithologies. Comparisons of their major element chemistry (Table 2, Figure 11) indicate that the hydrothermally altered lithologies (sericitic felsic schists) have been enriched in aluminum, iron and magnesium and depleted in sodium and silica. There is minor enrichment in titanium, calcium, fluorine, strontium and arsenic; potassium content has remained constant. The somewhat high silica content of the unaltered quartzofeldspathic gneisses, compared with other quartzofeldspathic gneisses in the Dahlonega gold belt, suggest that some silicification of these lithologies may have occurred; however, otherwise they are unaltered.

Mineralogical assemblages in the sericitic felsic schist also indicate the removal and introduction of other elements. The most notable additions are sulfur and trace amounts of copper, zinc and lead for the formation of abundant pyrite and minor amounts of other sulfides. Iron and potassium, liberated by the alteration of biotite to chlorite, were made available for the formation of sericite (after plagioclase) and iron-bearing sulfides. The sericitization of the plagioclase (albite/oligoclase) liberated sodium, calcium and silica and accounts for the depletion of these constituents in the sericitic felsic schist. Abundant iron and alumina in the hydrothermal system favored the formation locally of abundant staurolite and kyanite.

MINERALIZATION AND ECONOMIC POTENTIAL

One of the primary reasons for drilling this alteration zone was to assess its economic potential. However, no economic quantities of base or precious metals were detected. Of the two-hundred and twenty-three samples analyzed for gold and silver, only one sample contained gold above or equal to the detection limit of 0.005 oz/T (Appendix B). Although pyritic, sericitized felsic schist, which is a major lithology from the core, is the ore, or is closely associated with the ore, at several important gold mines in Canada (Hemlo, SOQUEM-Silver Stacks, Val d'Or, Teck-Corona, etc.) (Valliant and others, 1983; McMillan and Robinson, 1985), world wide it has erratic precious metal signatures and rarely contains ore-grade deposits. According to the landowners at the drill sites, placer gold has been found in streams that traverse this unit, but



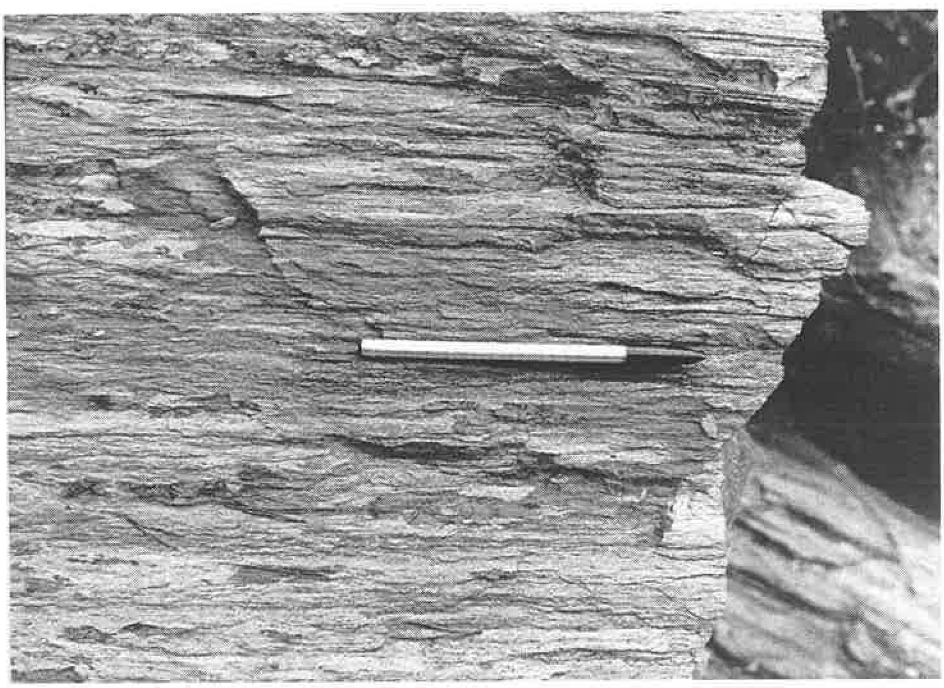


Figure 10. Above: Lineations at the Highway 9E outcrop. Outcrop - scale view. Below: Detail of lineations from the same outcrop.

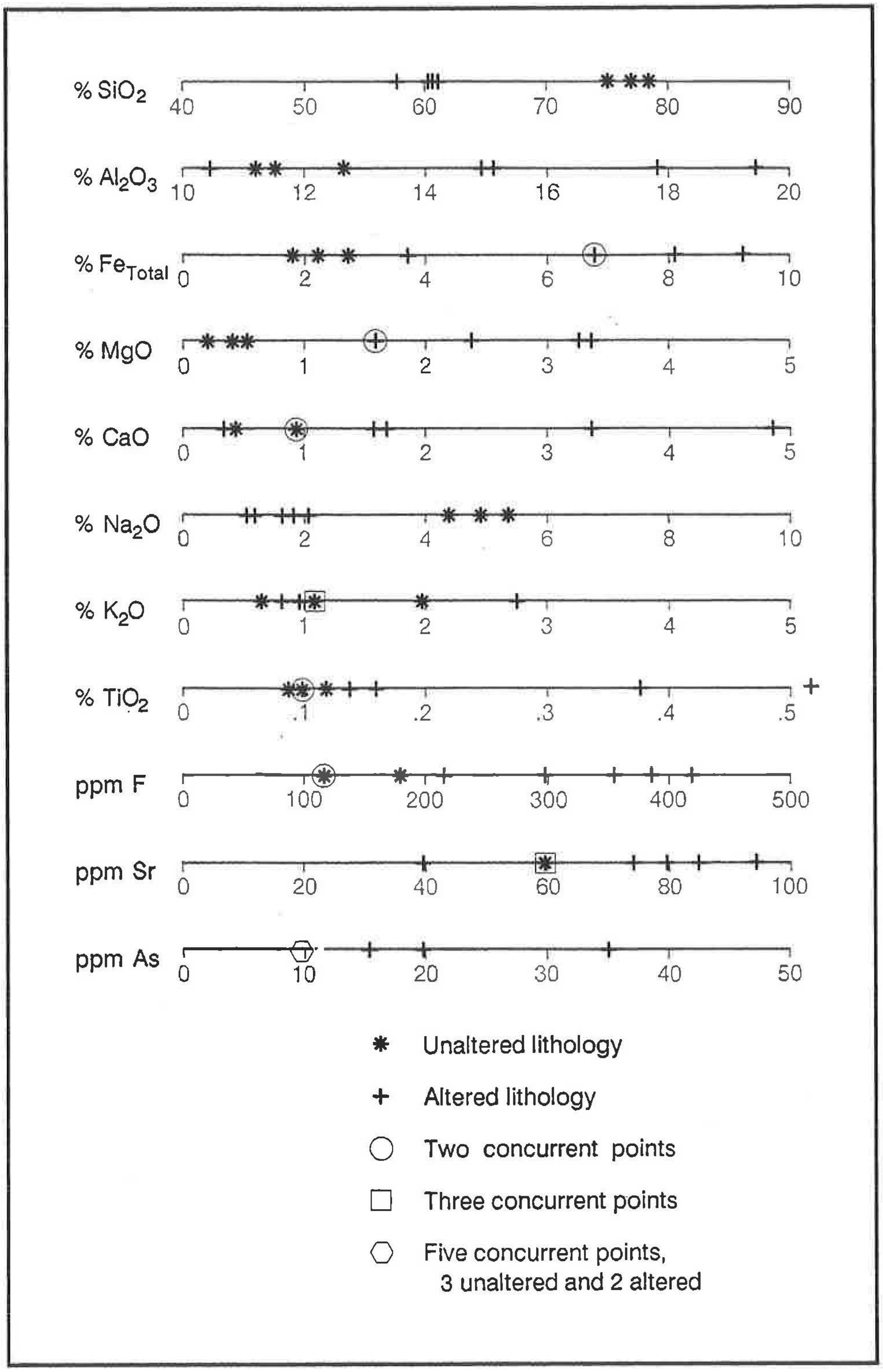


Figure 11. Major and trace element chemistry of unaltered and altered lithologies.

the source of the gold is unknown. Silver was detected in two samples from the Castleberry Bridge (CB-3) and Highway 9E (CM-1D) exposures (Appendix B), and in two soil samples (PSS-14 and 47) (Figure 12). One sample from the roadcut on Highway 9E contained 14 ppm (0.47 oz/T) silver. The presence of sulfides (predominantly pyrite) in quantities up to 50% in surface exposures (German, 1985) suggested that pyrite and, possibly, other sulfides might be present in appreciable quantities at depth. Although anomalous amounts of copper, lead and zinc were detected in some samples, none were ore-grade.

Core hole #3 from the George David property was analyzed the most thoroughly since the entire core consists of sericitic felsic schist with disseminated sulfide mineralization throughout. Figure 13 shows analyses in ppm for copper, lead and zinc with depth. One copper anomaly (180-305 ppm) occurs at 70-80 feet and another (165-650 ppm) at 165-220 feet. One significant zinc anomaly (120-1050 ppm) is present at approximately 207-224 feet. In this interval zinc concentrations reach 0.1%. Lead and molybdenum concentrations are generally at or below detection limits. A reconnaissance geochemical survey of soil and saprolite (Figures 14, 15, and 16) did not reveal any significant anomalies.

Core from holes 1 and 2 were analyzed less thoroughly than that from hole #3 because lithologies encountered in these holes exhibited little alteration and contained few disseminated sulfides. A possible minor zinc anomaly (210 ppm) occurs at 158 feet in hole #1 (Appendix B). Hole #2 contains a minor zinc anomaly (105 ppm) at 195 feet and copper anomalies (720 and 240 ppm) at 65 and 213 feet, respectively. As in hole #1, anomalous lead or molybdenum were not encountered.

Samples collected from the Castleberry Bridge outcrop (samples CB-1 through CB-8, Appendix B) were anomalous in copper (15-305 ppm), lead (15-570 ppm), zinc (25-185 ppm) and molybdenum (4-18 ppm). A separate bulk sample from the Castleberry Bridge outcrop was anomalous in Cu (150 ppm), Pb (240 ppm) and zinc (460 ppm) (Robert B. Cook, personal communication, 1989).

Slightly elevated concentrations of copper in hole #3 correlate with the presence of chalcocite and chalcopyrite in the samples. Minute sphalerite crystals were observed in thin sections from the interval 200 to 220 feet, which has the highest concentrations of zinc. Zinc is also known to substitute freely for iron in staurolite, and staurolite from Georgia has been reported to contain up to 5.5 weight percent zinc (Griffen and Ribbe, 1973). Acid dissolution of the samples before assaying would only liberate zinc present as a sulfide; therefore, any zinc in staurolite would not be detected. Zinc assays, then, do not include zinc that may reside in silicate minerals such as staurolite. This also is supported by the negative correlation between modal staurolite and assay zinc (Table 3).

DISCUSSION AND CONCLUSIONS

Although the unit studied for this report was designated as a separate mappable unit and assigned to the Canton Formation (German, 1985), data gathered during this study indicate that the unit is part of the Pumpkinvine Creek Formation which was locally hydrothermally altered. Core from three holes indicates that the unit consists of hydrothermally altered rocks and unaltered amphibole felsic gneiss, quartzofeldspathic gneiss, amphibolite and magnetite quartz granofels (iron formation).

Hydrothermal alteration appears to be largely confined to a unit of quartzofeldspathic gneiss. The action of hydrothermal fluids rich in potassium, sulfur, alumina and trace metals brought about the sericitization of plagioclase, alteration of mafic minerals to chlorite, the formation of pyrite and other sulfides, and the formation of aluminosilicate minerals. The alignment of sericite (after plagioclase) parallel to the regional foliation and the presence of partially sericitized plagioclase porphyroblasts indicates that alteration was synkinematic. Limited recrystallization of the sericite to muscovite suggests that the alteration took place after the peak of regional dynamic metamorphism. The cross-cutting nature of the kyanite-quartz veins suggests that they were emplaced subsequent to the main hydrothermal event, and may be related to the formation of kyanite-bearing ore bodies at the Battle Branch gold mine.

A possible source of the hydrothermal fluids may have been the two meta-trondhjemite intrusions (Cook and others, 1984; German, 1985) immediately northeast of the study area (Plate 1). These intrusions have associated dikes cross-cutting the country rock, and the dikes and parent intrusions have been overprinted with a late metamorphic fabric, indicating that the intrusions were syn- to late-kinematic, roughly coinciding with the episode of hydrothermal alteration described here.

Comparison of the trace element and whole rock chemistry of the alteration zone with that of adjacent unaltered rocks suggests that the altered rock was a quartzofeldspathic gneiss similar to the Barlow Gneiss or Galts Ferry Gneiss. Based on

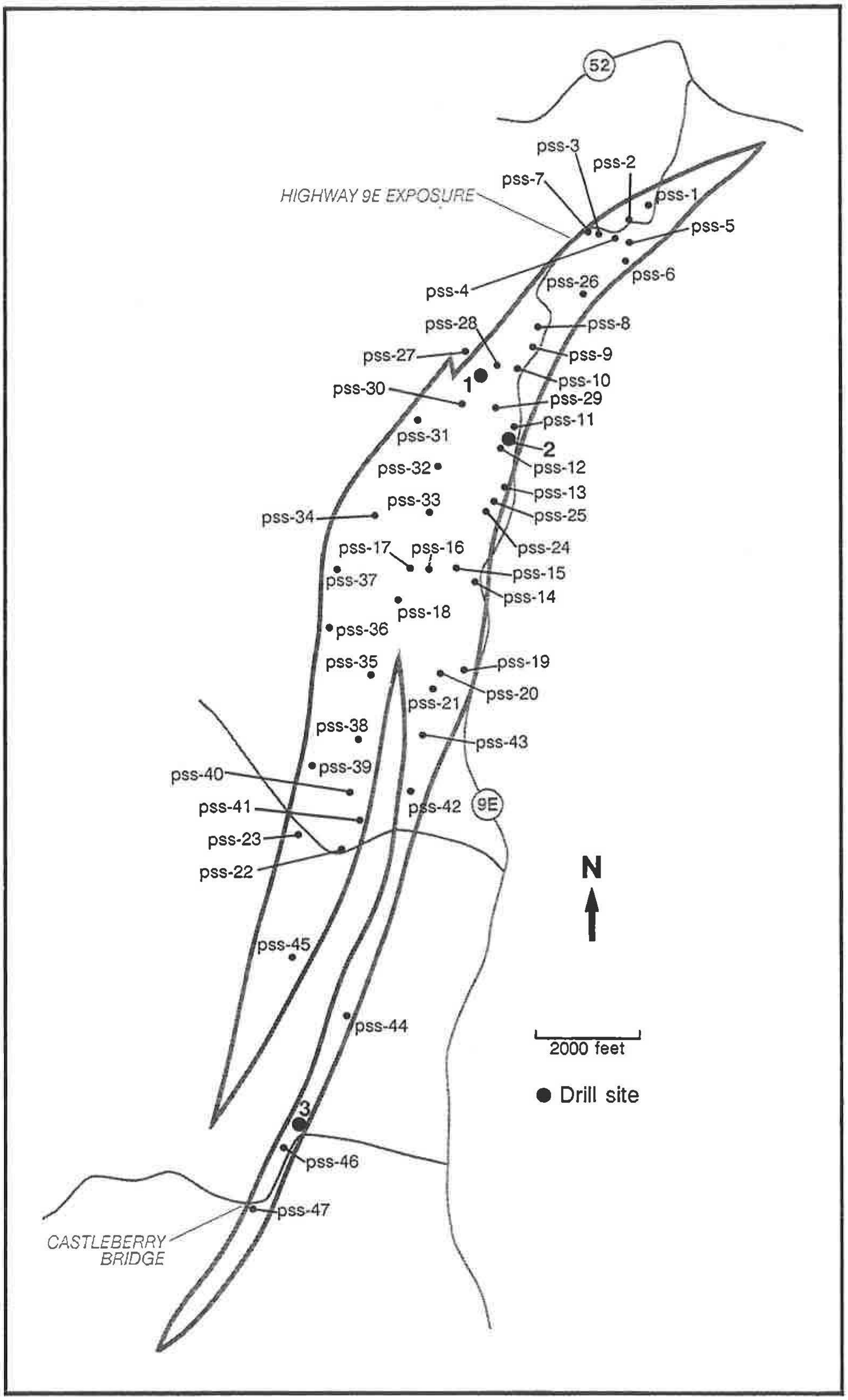


Figure 12. Location of soil samples.

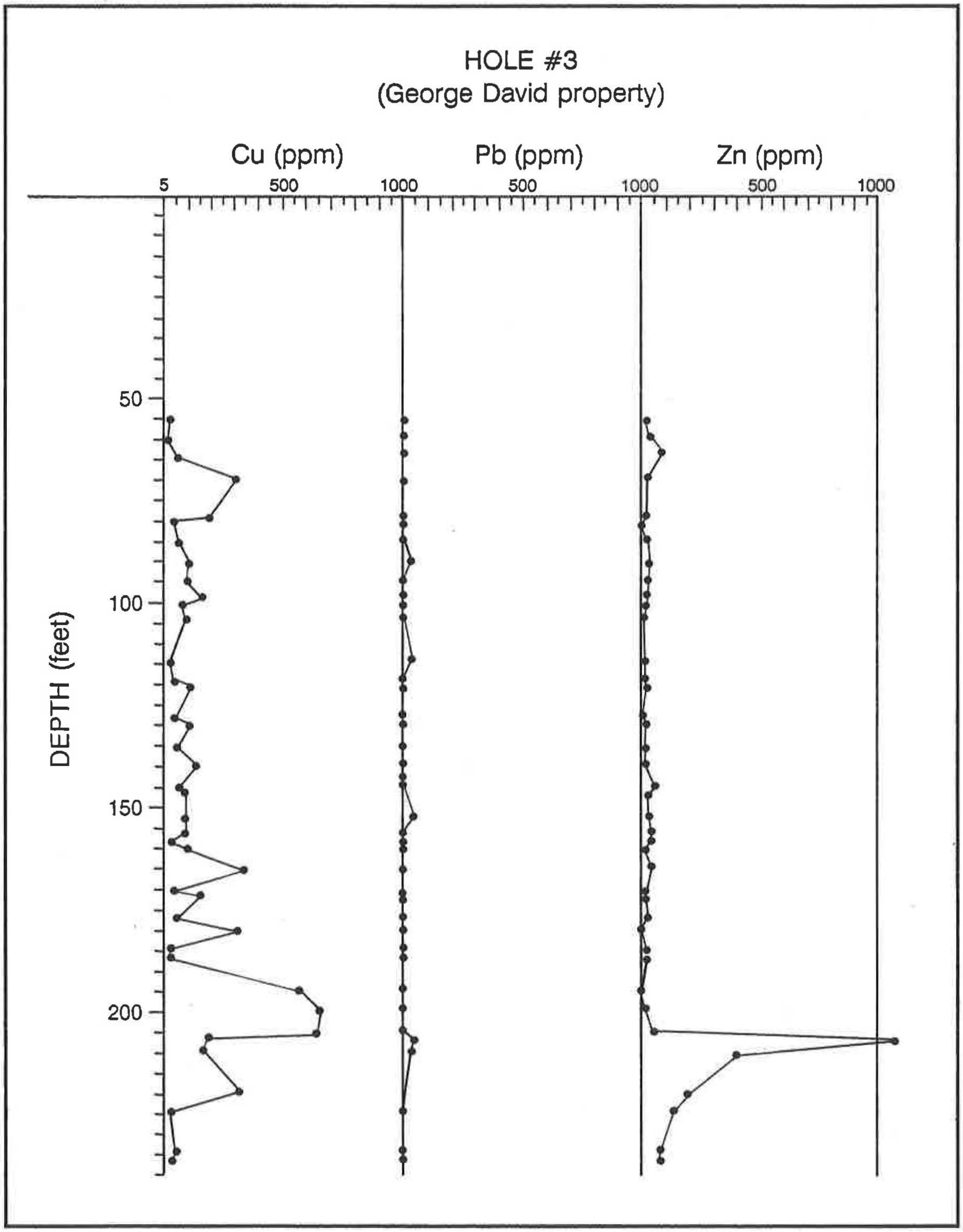


Figure 13. Copper, lead and zinc analyses with depth for core hole #3.

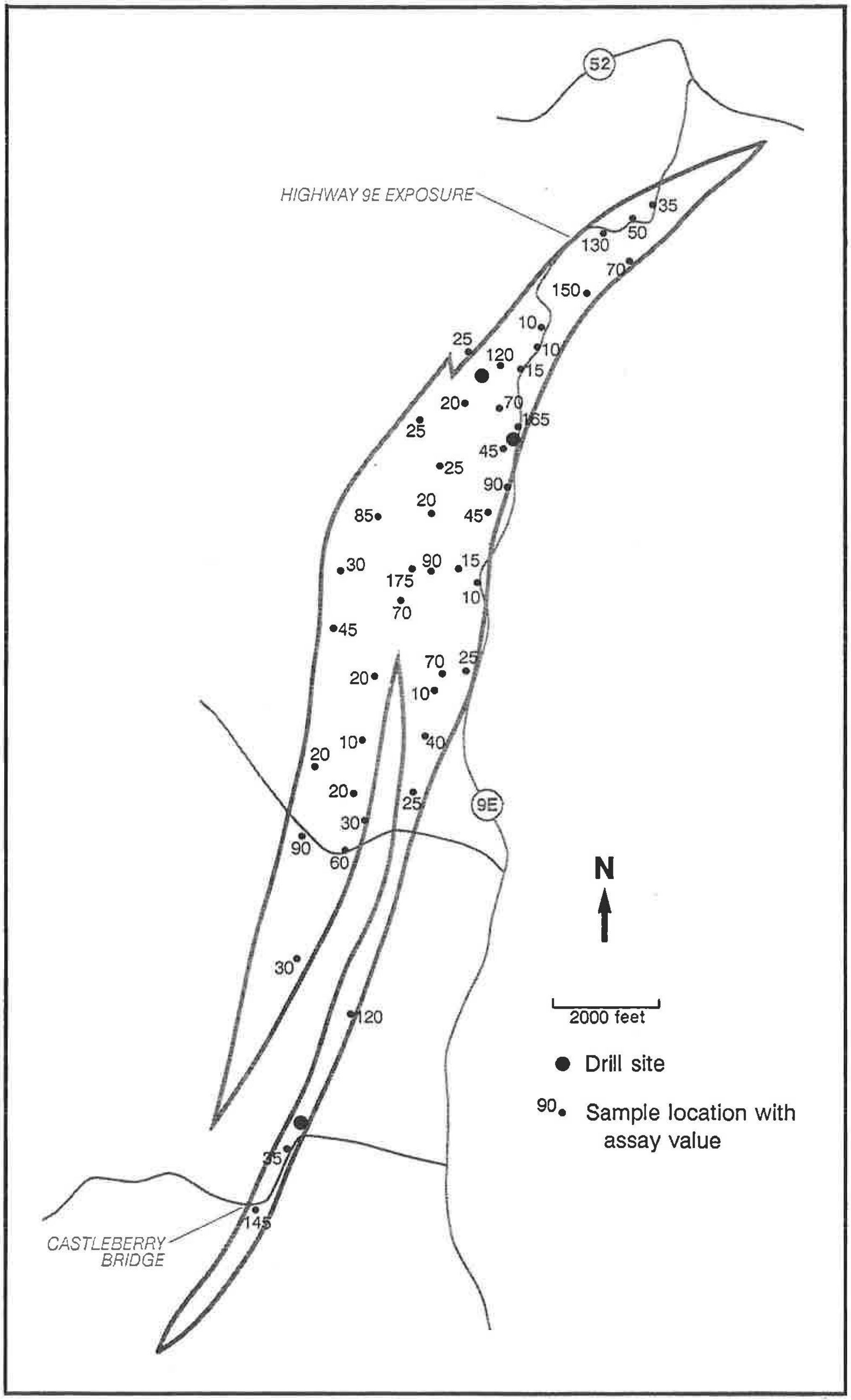


Figure 14. Reconnaissance geochemical survey for copper. Values are in ppm.

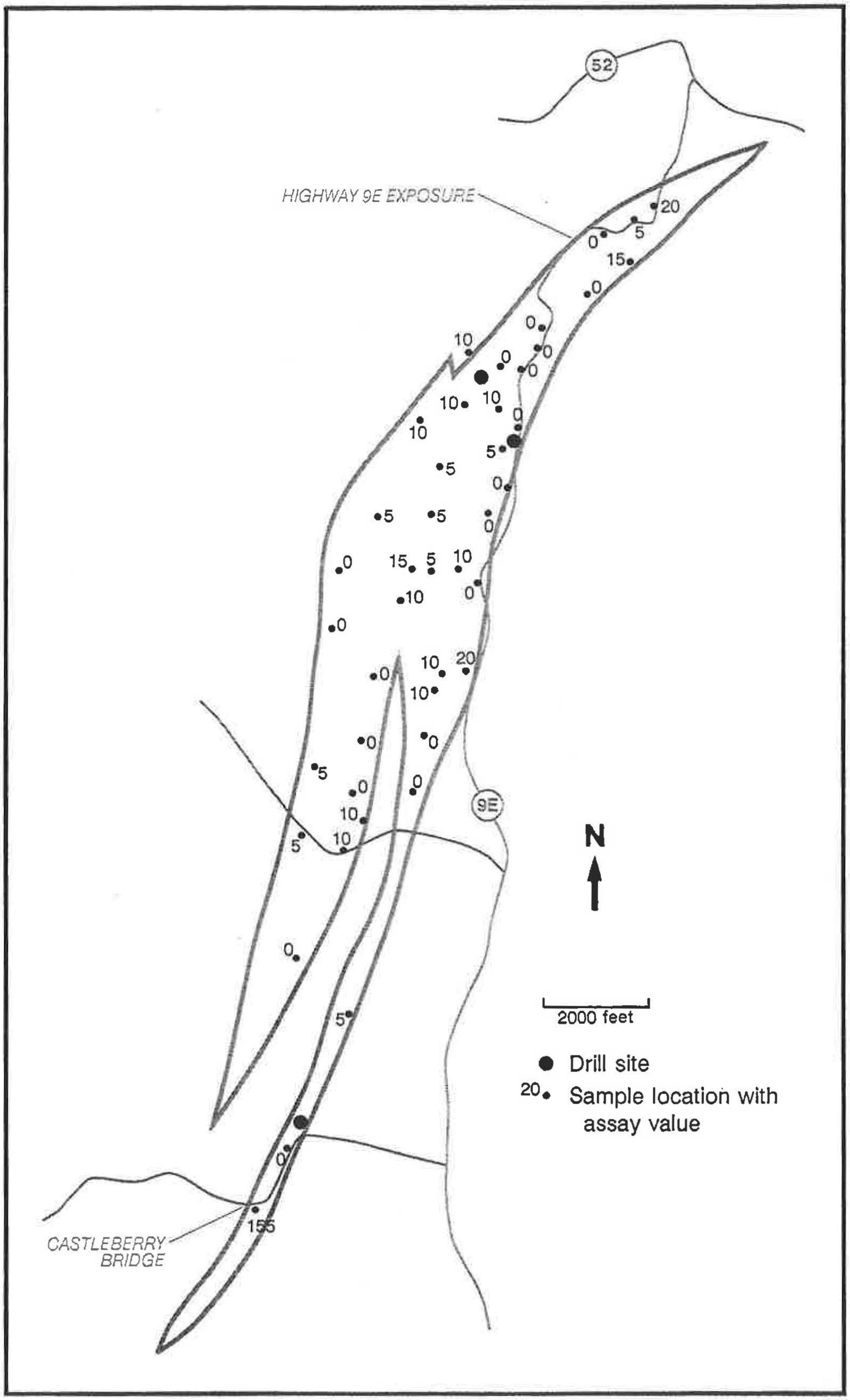


Figure 15. Reconnaissance geochemical soil survey for lead. Values are in ppm.

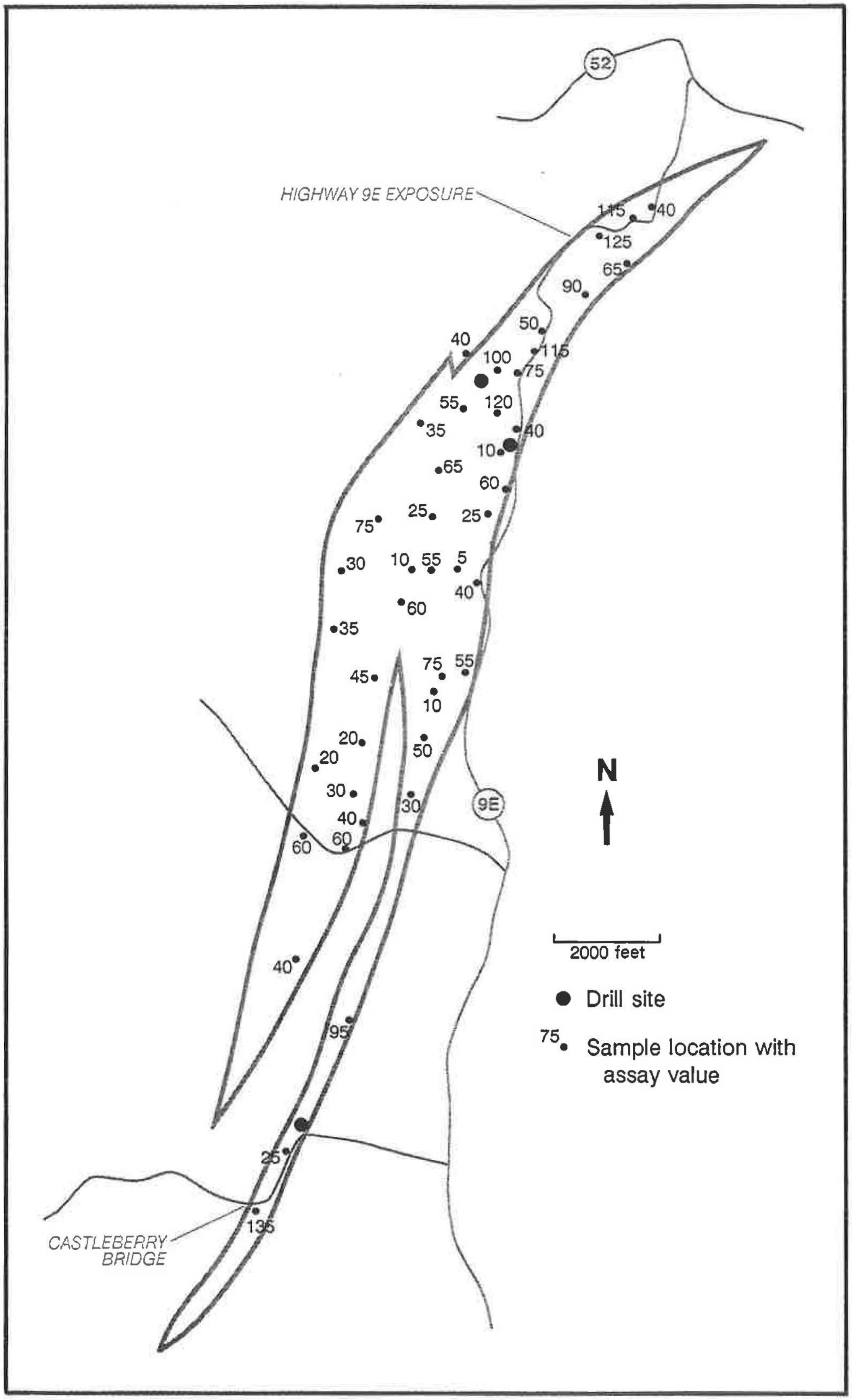


Figure 16. Reconnaissance geochemical soil survey for zinc. Values are in ppm.

Table 3

Comparison of Zinc Content Versus Percent Modal Staurolite

Sample	ppm Zn	% Modal Staurolite
83-2	20	1.8
110-2	5	1
64-3	85	1
71-3	10	10
79-3	5	10
91-3	20	7
98-3	15	10
114-3	5	14
128-3	20	15
146-3	20	10
153-3	25	5
180-3	<5	10
185-3	10	<1
195-3	<5	5
207-3	1050	<1
209-3	390	<1
219-3	165	<1
224-3	120	<1
CB-4	90	11

microscopic textures, the protolith of the quartzofeldspathic gneiss may have been a pyroclastic rock. Stratigraphic and geochemical data suggest that the sericitized felsic schist (altered quartzofeldspathic gneiss) and unaltered quartzofeldspathic gneiss are the same rock unit. Limited geochemical and petrologic data from the Highway 9E exposure near the northeastern end of the unit suggest that alteration also may have affected some of the mafic rocks of the Pumpkinvine Creek Formation.

The presence of several percent disseminated sulfides suggests that this zone may be host for economic quantities of precious and/or base metals. Similar rocks with disseminated sulfides (mostly pyrite) at the Haile Mine in Lancaster County, South Carolina and in the Abitibi Greenstone Belt of Canada are host for important gold deposits (Pardee and Park, 1948; Filion and others, 1977; Spence and others, 1980; Valliant and others, 1983). Also, the local presence of abundant aluminosilicate minerals (kyanite and staurolite) indicates possible economic precious and/or base metal mineralization (Allard and Carpenter, 1988).

Chemical analysis of core, outcrop and soil samples did not reveal economic concentrations of base or precious metals. Local concentrations of copper, lead and zinc above background, however, indicate enrichment similar to ore-forming processes elsewhere and the potential for economic concentrations of these metals. The distinct depletion of sodium and the presence of normative corundum, as found here, are, sometimes, used as guides to economic mineralization (Gilles O. Allard, personal communication, 1989).

Anomalous silver was detected in four samples, and a very small amount of gold was detected in one sample. The fact that very little gold or silver was detected in the core and outcrop samples is not altogether unexpected since lithologically similar rocks in the Teck-Corona Mine, Ontario, Canada were drilled (75 holes) and assayed extensively before economic amounts of gold were detected (McMillan and Robinson, 1985). The three core holes plus surface evaluation provide a data base that, hopefully, will encourage further evaluation of this area by the private sector.

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APPENDICES

APPENDIX A

CORE LOG DESCRIPTION

Location: Charlie Woody farm, Lumpkin County — Hole: #1 (GGS-3570)

Date drilled: December/January, 1986-87 — Depth: 249' — Angle: Vertical

Depth (ft)	Description
0-20.5	Saprolite and soil; no recovery
20.5-41	Light gray to tan quartzofeldspathic gneiss saprolite. Cut 20.5'; recovered 1.5.
41-71	Quartzofeldspathic gneiss - moderately to badly weathered, light tan to light gray, very fine to fine-grained, well foliated, biotite and muscovite accessory minerals, MnO_2 staining on fractures and foliation planes, foliation dip approx. 45 degrees. Cut 30'; recovered 16'.
71-89.5	Biotite-sericite quartzofeldspathic gneiss - tan to gray, very fine to fine-grained, phyllitic, well-foliated, local garnets 1-3 mm in diameter, local discontinuous quartz lenses 0.5-1 cm thick from 81 to 85'.
89.5-90	Sericite-biotite-quartz phyllite - light gray, fine-grained.
90-93	Biotite-sericite quartzofeldspathic gneiss - white to tan, very fine grained.
93-94.5	Garnet-biotite-sericite-quartz schist - dark gray, fine-grained, phyllitic.
94.5-105	Interlayered biotite-sericite quartzofeldspathic gneiss and garnet-biotite-sericite-quartz schist - as above, garnets up to 0.5 cm in diameter.
105-156.5	Biotite-sericite quartzofeldspathic gneiss - as above, local quartz lenses 1-2 cm thick, slightly calcareous.
156.5-160	Hornblende-chlorite-biotite-quartz schist (garnet and pyrite) - dark gray, medium-grained.
160-161	Biotite-sericite quartzofeldspathic gneiss - as above.
161-179.5	Garnet-muscovite-biotite-quartz schist - light to dark gray, fine-grained, numerous flexural flow folds, locally very quartzose, locally contains chlorite and garnet crystals up to 0.5 cm in diameter.
179.5-227	Muscovite-plagioclase quartzofeldspathic gneiss - as above, local 1-2 mm micaceous zones, locally interlayered with fine-grained biotite-muscovite-quartz schist, locally contains subhedral to anhedral garnets up to 1 cm in diameter.
227-249	Garnet-muscovite-biotite-quartz schist - as above, local hornblende.

CORE LOG DESCRIPTION

Location: Clarence Woody farm, Lumpkin County — Hole: #2 (GGS-3571)

Date drilled: February/March, 1987 — Depth: 501 — Angle: Vertical

Depth (ft)	Description
0-53	Soil and saprolite; no recovery.
53-66	Chlorite-sericite-felsic schist (±garnet) - light gray, very fine-grained, well-foliated, locally disseminated pyrite and magnetite crystals 0.5-1 mm in diameter, deformed lapilli(?) at 53-54', staurolite(?) present locally, amphibolite -rich zone at 59'.
66-75	Garnet-chlorite schist (±amphibole) - light to dark green, fine-grained, disseminated pyrite and magnetite, garnets elongated to round up to 0.5 cm in diameter, quartz lens 2-3 cm thick at 71'.
75-170	Garnet-chlorite-sericite-felsic schist - light greenish gray , very fine- to fine-grained, well-foliated, phyllitic, garnets up to 1.5 mm in diameter, disseminated pyrite and pyrrhotite, 2-3 cm thick quartz lens at 79', 8 cm thick quartz lens at 114', garnetiferous and amphibole-rich zone 155-158', 1 ft thick quartz lens 158-159', 1 ft thick quartz lens 165-166'.
170-200	Garnet-epidote-amphibolite gneiss - light to dark green, fine- to medium-grained, well-foliated, garnets up to 1 cm in diameter, radiating hornblende crystals on foliation planes (chicken track texture), locally chloritic, local light-colored felsic lenses.
200-232	Garnet-epidote-amphibole gneiss as above interlayered with exhalite zones - exhalite zones are gray, fine-grained, composed of quartz and disseminated magnetite, most zones are 1-10 cm thick.
232-295	Garnet-epidote-amphibolite gneiss - as above.
295-311.5	Hornblende-garnet-biotite-quartz schist - light gray to tan, well-foliated, fine-grained, garnets up to 1 cm in diameter with mafic-poor reaction haloes, disseminated magnetite, locally calcareous.
311.5-321	Hornblende-garnet-biotite-quartz schist as above interlayered with exhalite zones as above.
321-501	Epidote-chlorite-amphibole gneiss - light to dark green, fine- to medium-grained, well-foliated, radiating hornblende crystals on foliation planes (chicken track), 25 cm quartz lens at 378', 3 cm exhalite zone at 417', 5 cm exhalite zone at 445', garnetiferous zone at 460-471', 4 cm quartz lens at 471', 8 cm quartz lens at 480', 1-2 cm exhalite zone at 500.5'.

APPENDIX A (Continued)

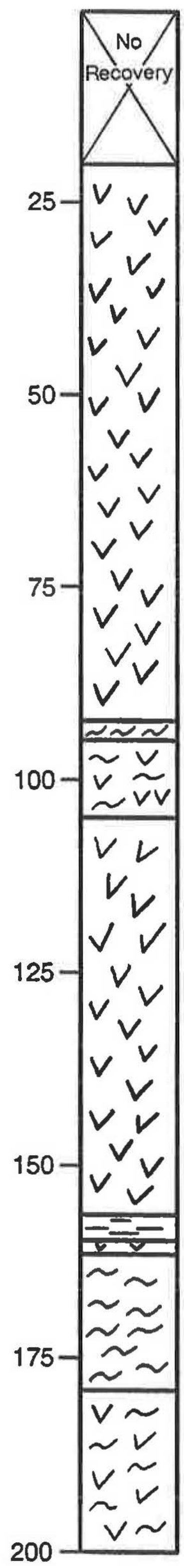
CORE LOG DESCRIPTION

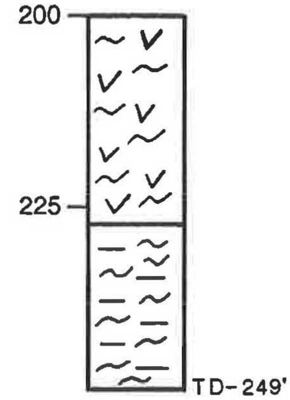
Location: George David property, Lumpkin County — Hole #3(GGS-3580)

Date drilled: April/May, 1987 — Depth: 240' — Angle: Vertical

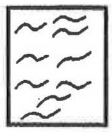
Depth (ft)	Description
0-53	Soil and saprolite; no recovery.
53-175	Hornblende-chlorite-staurolite-biotite-sericite-quartz plagioclase schist - gray to tan, fine-grained, well -foliated , banded, disseminated pyrite varies from a tract to 15%, light brown staurolite (?) is present locally, below 75' hornblende decreases in abundance, 5 cm quartz lens at 93', 15 cm quartz lens at 108', pyrite content increases to as high as 20% locally below 150'. Locally (114'-128'), staurolite content is up to 15%.
175-240	Staurolite-kyanite-chlorite-biotite-sericite-quartz-plagioclase schist - as above without hornblende, 30 cm quartz lens at 208', 5 cm kyanite-quartz lens at 216', kyanite quartz lens at 222'.

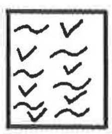
Lithologic Log - Core #1

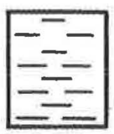


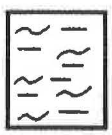


 Quartzofeldspathic gneiss.

 Garnet-biotite-muscovite-quartz schist. Relative biotite/muscovite percentages vary.

 Interlayered quartzofeldspathic gneiss and garnet-biotite-muscovite-quartz-schist.

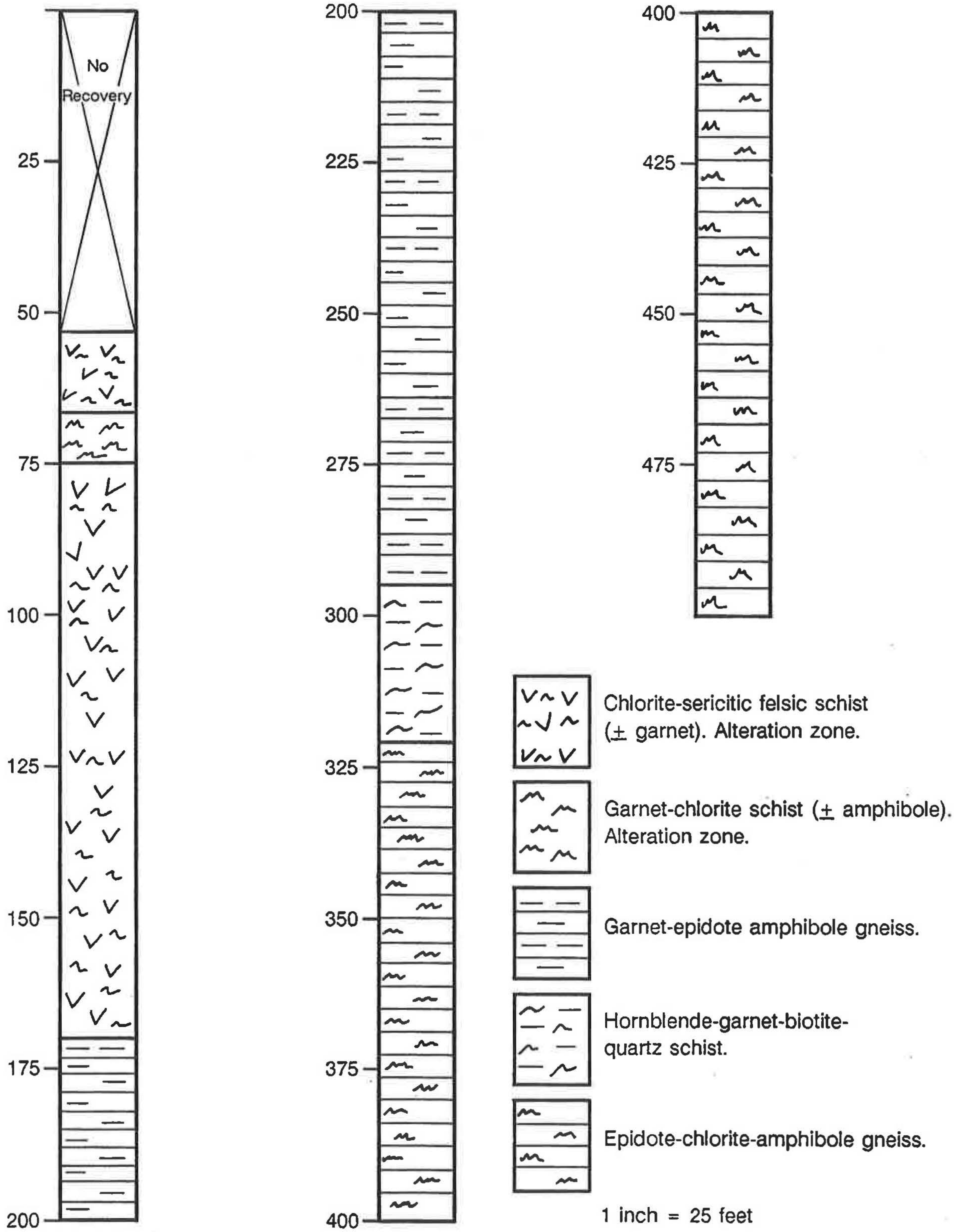
 Hornblende-chlorite-biotite-quartz schist ± garnet and pyrite. Alteration zone.

 Hornblende-garnet-muscovite-biotite-quartz schist.

1 inch = 25 feet

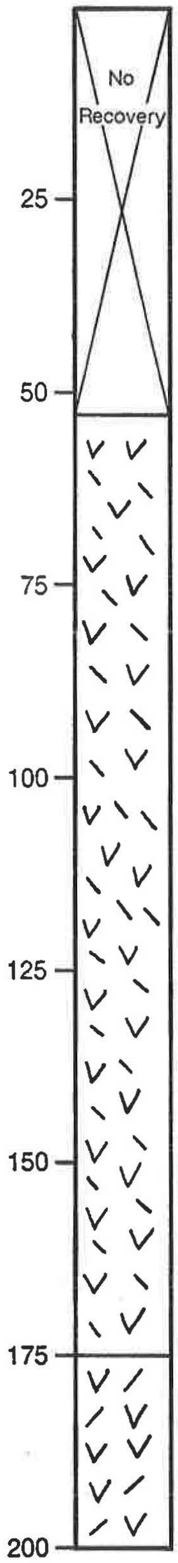
APPENDIX A (Continued)

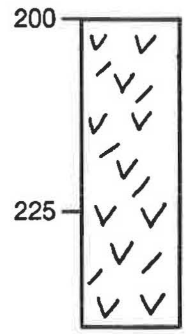
Lithologic Log - Core #2

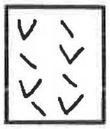


APPENDIX A (Continued)

Lithologic Log - Core #3







Hornblende-chlorite-staurolite-biotite-sericitic felsic schist. Alteration zone.

Staurolite-kyanite-chlorite-biotite-sericitic felsic schist. Alteration zone.

1 inch = 25 feet

APPENDIX B

Base and Precious Metal Analyses of Core, Outcrop and Soil Samples

Sample #	Au (oz/T)	Ag (oz/T)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)
Hole #1						
62-1	<.005	<.01	10	35	65	6
63-1	<.005	<.01	10	<5	70	2
64-1	<.005	<.01	5	<5	75	2
68-1	<.005	<.01	5	<5	55	<2
73-1	<.005	<.01	<5	<5	55	<2
75-1	<.005	<.01	<5	<5	40	<2
76-1	<.005	<.01	<5	<5	65	2
81-1	<.005	<.01	5	<5	60	<2
87-1	<.005	<.01	<5	<5	30	<2
92-1	<.005	<.01				
95-1	<.005	<.01				
98-1	<.005	<.01				
102-1	<.005	<.01	5	<5	20	<2
103-1	<.005	<.01	<5	<5	30	2
107-1	<.005	<.01	<5	<5	60	<2
116-1	<.005	<.01	<5	<5	55	<2
122-1	<.005	<.01	<5	<5	60	<2
132-1	<.005	<.01	<5	<5	65	<2
138-1	<.005	<.01				
156-1	<.005	<.01				
158-1	<.005	<.01	5	<5	210	<2
168-1	<.005	<.01				
173-1	<.005	<.01				
186-1	<.005	<.01				
189-1	<.005	<.01				
196-1	<.005	<.01				
222-1	<.005	<.01				
235-1	<.005	<.01				
243-1	<.005	<.01				
248-1	<.005	<.01				
Hole #2						
53-2	<.005	<.01				
53-2	<.005	<.01				
56-2	<.005	<.01				
60-2	<.005	<.01				
65-2	<.005	<.01	720	<5	10	12
67-2	<.005	<.01	50	<5	15	4
68-2	<.005	<.01	65	<5	20	30
70-2	<.005	<.01				
72-2	<.005	<.01				
74-2	<.005	<.01				
76-2	<.005	<.01				
83-2	<.005	<.01	15	<5	20	4
86-2	<.005	<.01				
90-2	<.005	<.01				
92-2	<.005	<.01				
95-2	<.005	<.01				

APPENDIX B (Continued)
Base and Precious Metal Analyses of Core, Outcrop and Soil Samples

Sample #	Au (oz/T)	Ag (oz/T)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)
Hole #2 (Cont.)						
96-2	<.005	<.01	5	<5	5	<2
98-2	<.005	<.01				
104-2	<.005	<.01				
106-2	<.005	<.01				
110-2	<.005	<.01	10	<5	5	2
115-2	<.005	<.01				
116-2	<.005	<.01				
119-2	<.005	<.01	10	<5	<5	4
121-2	<.005	<.01				
130-2	<.005	<.01				
133-2	<.005	<.01				
139-2	<.005	<.01				
149-2	<.005	<.01				
155-2	<.005	<.01				
159-2	<.005	<.01	20	<5	20	<2
160-2	<.005	<.01				
172-2	<.005	<.01				
177-2	<.005	<.01				
180-2	<.005	<.01				
187-2	<.005	<.01				
195-2	<.005	<.01	20	<5	105	<2
201-2	<.005	<.01	30	<5	85	2
205-2	<.005	<.01	25	<5	75	<2
206-2	<.005	<.01	25	<5	70	<2
209-2	<.005	<.01	10	<5	45	2
213-2	<.005	<.01	240	<5	85	2
214-2	<.005	<.01				
227-2	<.005	<.01	15	<5	60	<2
228-2	<.005	<.01				
234-2	<.005	<.01				
242-2	<.005	<.01				
246-2	<.005	<.01				
267-2	<.005	<.01				
275-2	<.005	<.01				
277-2	<.005	<.01				
296-2	<.005	<.01				
298-2	<.005	<.01				
302-2	<.005	<.01				
311-2	<.005	<.01	<5	<5	40	2
314-2	<.005	<.01				
315-2	<.005	<.01	<5	<5	75	<2
316-2	<.005	<.01	<5	<5	70	<2
318-2	<.005	<.01	<5	<5	30	2
320-2	<.005	<.01	95	<5	25	<2
323-2	<.005	<.01				
332-2	<.005	<.01				
343-2	<.005	<.01				
362-2	<.005	<.01				

APPENDIX B (Continued)
Base and Precious Metal Analyses of Core, Outcrop and Soil Samples

Sample #	Au (oz/T)	Ag (oz/T)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)
Hole #2 (Cont.)						
384-2	<.005	<.01				
417-2	<.005	<.01				
440-2	<.005	<.01				
444-2	<.005	<.01				
446-2	<.005	<.01	5	<5	35	<2
449-2	<.005	<.01	35	<5	65	<2
451-2	<.005	<.01				
461-2	<.005	<.01				
487-2	<.005	<.01				
493-2	<.005	<.01				
Hole #3						
55-3	<.005	<.01	15	<5	15	2
59-3	<.005	<.01	10	<5	35	<2
64-3	<.005	<.01	65	<5	85	<2
71-3	<.005	<.01	305	<5	10	<2
79-3	<.005	<.01	180	<5	5	<2
81-3	<.005	<.01	45	<5	<5	4
85-3	<.005	<.01	65	<5	15	2
91-3	<.005	<.01	125	15	20	<2
95-3	<.005	<.01	100	<5	15	2
98-3	<.005	<.01	170	<5	15	<2
101-3	<.005	<.01	80	<5	15	2
104-3	.005	<.01	105	<5	15	<2
114-3	<.005	<.01	20	5	5	<2
119-3	<.005	<.01	50	<5	10	<2
122-3	<.005	<.01	130	<5	20	4
128-3	<.005	<.01	50	<5	5	<2
130-3	<.005	<.01	110	<5	15	2
136-3	<.005	<.01	50	<5	10	2
138-3	<.005	<.01	145	<5	15	<2
145-3	<.005	<.01	65	<5	60	<2
146-3	<.005	<.01	80	<5	20	<2
153-3	<.005	<.01	80	20	25	<2
157-3	<.005	<.01	80	<5	40	<2
158-3	<.005	<.01	25	<5	35	2
160-3	<.005	<.01	105	<5	10	<2
165-3	<.005	<.01	345	<5	40	2
171-3	<.005	<.01	45	<5	10	<2
172-3	<.005	<.01	165	<5	15	<2
177-3	<.005	<.01	50	<5	20	<2
180-3	<.005	<.01	320	<5	<5	2
185-3	<.005	<.01	25	<5	10	4
187-3	<.005	<.01	25	<5	15	<2
195-3	<.005	<.01	560	<5	<5	4
201-3	<.005	<.01	650	<5	10	<2
205-3	<.005	<.01	640	<5	45	4
207-3	<.005	<.01	190	15	1050	4

APPENDIX B (Continued)
Base and Precious Metal Analyses of Core, Outcrop and Soil Samples

Sample #	Au oz/T)	Ag (oz/T)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)
Hole #3 (Cont.)						
209 - 3	<.005	<.01	160	10	390	<2
219 - 3	<.005	<.01	315	<5	165	<2
224 - 3	<.005	<.01	25	<5	120	<2
229 - 3	<.005	<.01				
234 - 3	<.005	<.01	40	<5	80	<2
237 - 3	<.005	<.01	35	<5	80	<2
Outcrop Samples						
CB - 1	<.005	<.01	20	15	25	12
CB - 3	<.005	0.03	40	570	185	8
CB - 4	<.005	<.01	305	25	90	6
CB - 5	<.005	<.01	15	30	25	6
CB - 7	<.005	<.01	95	20	130	18
CB - 8	<.005	<.01	35	<5	35	4
CM-1A	<.005	<.01	5	<5	5	4
CM-1B	<.005	<.01	5	<5	5	6
CM-1C	<.005	<.01	5	<5	10	10
CM-1D	<.005	0.47	55	<5	45	4
PSS - 4	<.005	<.01	75	<5	120	<2
PSS - 5	<.005	<.01	100	<5	80	<2
PSS - 7	<.005	<.01	130	<5	85	<2
PSS-25	<.005	<.01	105	10	55	2
Soil Samples						
PSS - 1	<.005	<.01	35	20	40	<2
PSS - 2	<.005	<.01	50	5	115	<2
PSS - 3	<.005	<.01	130	<5	125	<2
PSS - 6	<.005	<.01	70	15	65	<2
PSS - 8	<.005	<.01	10	<5	50	<2
PSS - 9	<.005	<.01	10	<5	115	<2
PSS-10	<.005	<.01	15	<5	75	<2
PSS-11	<.005	<.01	165	<5	40	<2
PSS-12	<.005	<.01	45	5	10	<2
PSS-13	<.005	<.01	90	<5	60	<2
PSS-14	<.005	0.25	10	<5	40	2
PSS-15	<.005	<.01	15	10	5	<2
PSS-16	<.005	<.01	90	5	55	<2
PSS-17	<.005	<.01	125	15	10	<2
PSS-18	<.005	<.01	70	10	60	2
PSS-19	<.005	<.01	25	20	55	<2
PSS-20	<.005	<.01	70	10	75	2
PSS-21	<.005	<.01	10	10	10	<2
PSS-22	<.005	<.01	60	10	60	<2
PSS-23	<.005	<.01	90	5	60	<2
PSS-24	<.005	<.01	45	<5	25	<2
PSS-26	<.005	<.01	150	<5	90	nd*

*Analysis not done

APPENDIX B (Continued)

Base and Precious Metal Analyses of Core, Outcrop and Soil Samples

Sample #	Au (oz/T)	Ag (oz/T)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)
Soil Samples (Cont.)						
PSS-27	<.005	<.01	25	10	40	nd
PSS-28	<.005	<.01	120	<5	100	nd
PSS-29	<.005	<.01	70	10	120	nd
PSS-30	<.005	<.01	20	10	55	nd
PSS-31	<.005	<.01	25	10	35	nd
PSS-32	<.005	<.01	25	5	65	nd
PSS-33	<.005	<.01	20	5	25	nd
PSS-34	<.005	<.01	85	5	75	nd
PSS-35	<.005	<.01	20	<5	45	nd
PSS-36	<.005	<.01	45	<5	35	nd
PSS-37	<.005	<.01	30	<5	30	nd
PSS-38	<.005	<.01	10	<5	20	nd
PSS-39	<.005	<.01	20	5	20	nd
PSS-40	<.005	<.01	20	<5	30	nd
PSS-41	<.005	<.01	30	10	40	nd
PSS-42	<.005	<.01	25	<5	30	nd
PSS-43	<.005	<.01	40	<5	50	nd
PSS-44	<.005	<.01	120	5	95	nd
PSS-45	<.005	<.01	30	<5	40	nd
PSS-46	<.005	<.01	35	<5	35	nd
PSS-47	<.005	.02	145	155	135	nd

DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
GEORGIA GEOLOGIC SURVEY

GEOLOGIC MAP OF THE STUDY AREA AND VICINITY

EXPLANATION

Late Proterozoic and/or Early Paleozoic

New Georgia Group (stratigraphic order uncertain)

Canton Formation

h Helen Member - metagraywacke and biotite-garnet-muscovite-quartz schist (±staurolite) with minor amphibolite.

cs Chestatee Member - interlayered amygdaloidal amphibolite, hornblende-plagioclase gneiss, muscovite-biotite-quartz-plagioclase gneiss (metatuff?), and leucocratic muscovite-pyrite-plagioclase-quartz gneiss (metatuff?).

plc Palmer Creek Member - thinly layered biotite-quartz schist (±garnet and/or hornblende) with garnet-biotite-muscovite-quartz schist and minor amphibolite.

pc Proctor Creek Member - silvery muscovite-garnet-biotite-quartz schist.

cp Unnamed, coarsely porphyroblastic muscovite-garnet-biotite-plagioclase-quartz coronite.

Pumpkinvine Creek Formation

pcu Pumpkinvine Creek Formation undifferentiated - thinly layered to massive amphibolite, lesser amounts of very coarsely porphyroblastic garnet-biotite-hornblende-quartz-plagioclase gneiss (±calcite and/or staurolite) and iron formation.

blg Barlow Gneiss Member - muscovite-biotite-plagioclase-quartz gneiss containing flattened megacrysts of blue quartz and/or plagioclase. Locally interlayered with amphibolite.

pss Zone of local to pervasive hydrothermal alteration consisting of sericitized and chloritized felsic schists and unaltered quartzofeldspathic gneiss, amphibole gneiss and iron formation.

Unassigned rocks

bg Biotite metatrondjemite

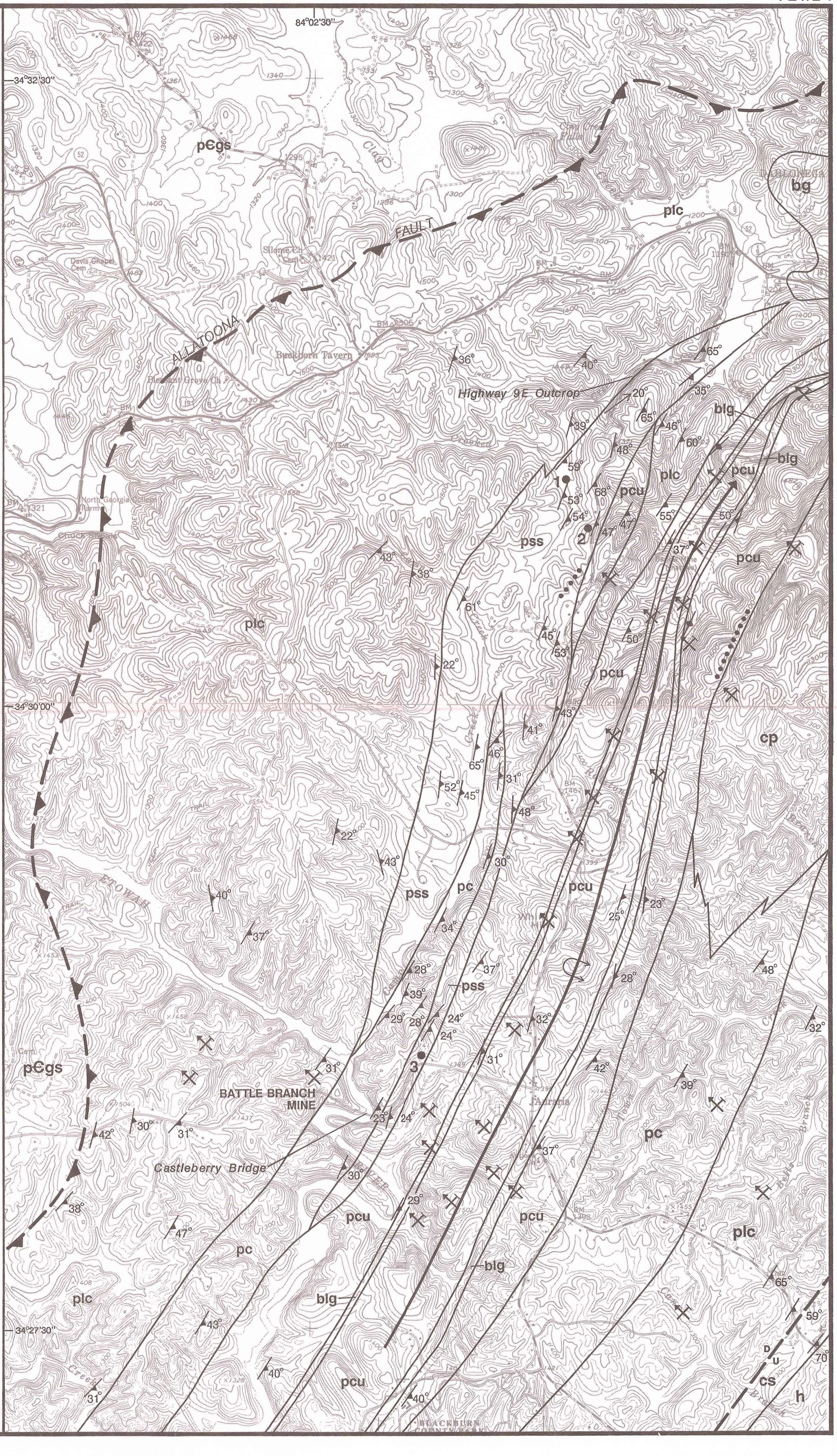
Rocks northwest of the Allatoona fault

p€gs Great Smoky Group - metagraywacke, locally conglomeratic metasandstone, muscovite-biotite-quartz schist, and minor amphibolite.

	Explanation
••••••••	iron formation
——	contact
▼— —▼	thrust fault
— D/U —	reverse fault
25°	strike and dip of foliation
—◆—	strike of vertical foliation
——→20°	plunge and trend of lineations
⟶	trend of overturned antiform
⚒	abandoned gold mine or prospect
•1	drill site

(modified after German, 1985)

Geology and Compilation by Jerry M. German
1991



Base map from U.S. Geological Survey 1:24,000 maps: Campbell Mountain, GA., 1950 and Dawsonville, GA., 1964, photorevised 1985.

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