THE GEOLOGY OF GOLD OCCURRENCES IN THE WEST-CENTRAL GEORGIA PIEDMONT

The Carroll County gold belt and the southwestern portion of the Dahlonega gold belt

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Cover Photo: Miners and workings at the Yorkville Mine, Paulding County (Circa 1930). Photo courtesy of Georgia Department of Archives and History.

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ABSTRACT

Gold deposits of the western part of the northern Piedmont occur within the Carroll County gold belt and the southwestern extension of the Dahlonega gold belt. These belts extend from Canton in Cherokee County southwestward to the Georgia-Alabama state line and include parts of Cherokee, Bartow, Cobb, Paulding, Douglas, Haralson and Carroll Counties. Most abandoned mines and prospects occur in the northeastern portion of this area.

The study area is underlain by rocks of the New Georgia Group and the western belt of the Sandy Springs Group. Rocks of the New Georgia Group are interpreted as the oldest in the study area and consist predominantly of metavolcanic rocks with lesser amounts of interlayered metasediments. Rocks of the western belt of the Sandy Springs Group are interpreted to overlie gradationally those of the New Georgia Group and to consist predominantly of metasediments with lesser amounts of metavolcanic rocks. These two groups probably represent the filling of a backarc basin initially dominated by volcanic rocks and subsequently with sediments as volcanic activity in the basin waned and clastic sedimentation increased. Whole rock and trace element chemistry as well as relict textural features of mafic and felsic metavolcanic rocks from these two groups indicate protoliths of subaqueous basaltic and dacitic flows, tuffs and hypabyssal rocks.

Rocks in the study area have been deformed by at least four fold events of progressively weaker intensity and have undergone one episode of prograde metamorphism that occurred approximately 365 million years ago. Metamorphic grade within the study area varies from greenschist facies (biotite subfacies) to amphibolite facies (kyanite subfacies). Locally, rocks in the study area exhibit slight effects of retrograde metamorphism.

Gold was mined intermittently from 77 mines and prospects from about 1830 to about 1935. Lode gold occurs within sulfide-bearing, concordant quartz bodies that have undergone the same deformation as the host rocks. Gold was mined by open-cut and/or hydraulic methods in saprolite, by placer operations in alluvium, and by underground lode mining in fresh rock.

In the study area most gold mines and prospects are located in the South Canton area, the Burnt Hickory Ridge area, the Villa Rica area and, to a lesser degree, the Acworth area. In these areas gold occurs within sequences of metavolcanic rocks (amphibolites, quartzofeldspathic gneisses and iron formation) of the New Georgia Group and mixed sequences of metavolcanic and metasedimentary rocks (mica schists, metagraywacke and biotite gneiss) of the New Georgia Group and Sandy Springs Group (western belt). Gold deposits are especially common at the transitions between metavolcanic and metasedimentary sequences. Gold is interpreted as syngenetic in origin and predominantly occurs in concordant quartz bodies. The auriferous quartz bodies are interpreted to have been deposited on the sea floor with volcanic and sedimentary rocks in the vicinity of a volcanic vent. During regional metamorphism and deformation, gold and some base metals were remobilized on a local scale and concentrated as ore shoots in structurally favorable sites within the quartz bodies. The degree of remobilization appears to be proportional to the intensity of metamorphism and deformation. Weathering and erosion of the gold deposits has produced a supergene enrichment of gold in saprolite and a mechanical concentration in alluvium.

INTRODUCTION

This report is the result of a study of gold deposits of the Carroll County gold belt and the southwestern portion of the Dahlonega gold belt in the northern Piedmont of west-central Georgia. The study area extends from Canton southwestward to the Georgia-Alabama state line and includes parts of Cherokee, Bartow, Cobb, Paulding, Douglas, Haralson and Carroll Counties (Figure 1).

This study is a continuation of the work done by German (1985) on the northeastern part of the Dahlonega gold belt and examines in detail the gold deposits which occur in the area studied by McConnell and Abrams (1984). Gold deposits of the northern Piedmont of Georgia occur in a belt that extends from North Carolina southwestward across Georgia into Alabama and are generally confined to the New Georgia Group (McConnell and Abrams, 1984; German, 1985). In the study area, however, this belt of gold occurrences becomes less defined and was divided by Jones (1909) into the Dahlonega belt and the Carroll County belt (Figure 2).

Work on this study consisted of detailed and reconnaissance geologic mapping conducted between November 1984 and February 1986 and petrographic and geochemical analysis of selected rock samples. Detailed geologic mapping at a scale of 1:24,000 was conducted in areas where there is a high density of abandoned mines and/or prospects or where detailed mapping was lacking. Detailed

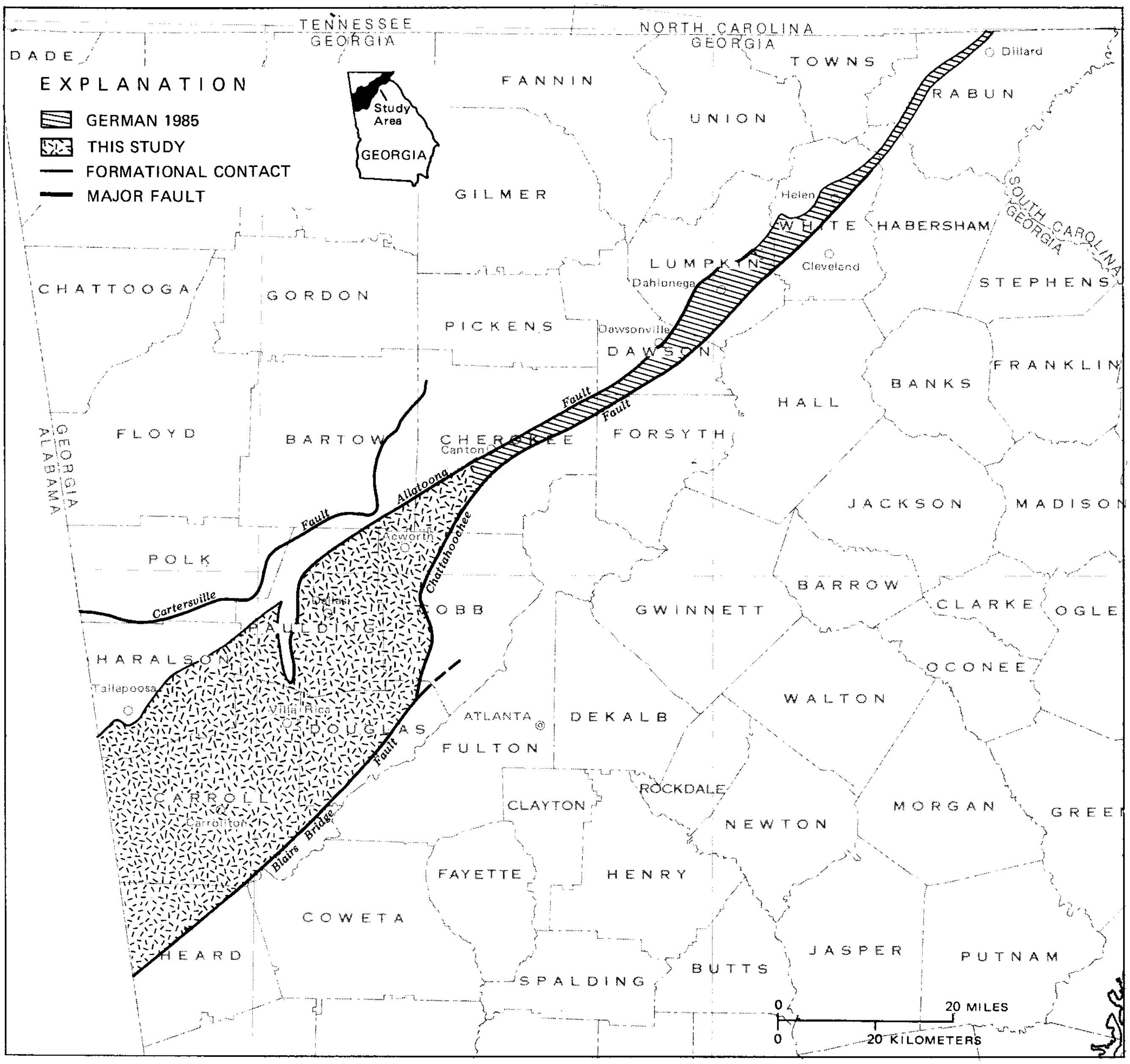

Figure 1. Geographic extent of the study area (ruled). Unruled area studied by German (1985).

mapping also was conducted in areas where it was necessary to reconcile mapping of previous investigators (Plate 1). Reconnaissance mapping was conducted in areas where abandoned mines and prospects are sparse, and areas not mapped as part of this study were field checked to determine the accuracy of previous mapping and to maintain continuity within this report.

An attempt was made to locate all gold mines and prospects. These are described in Appendix 1. Plate 1 depicts the geology and distribution of gold mines and prospects over the entire study area, whereas Plates 2, 3 and 4 show the relationships between mine workings and the geology of three districts within the study area. Sample localities and brief lithologic descriptions of samples from Tables 2, 3, 4 and 5 are given in Appendix 2.

PREVIOUS INVESTIGATIONS

Most previous work in the study area can be placed into two chronologically and topically distinct categories, consisting of mineral commodity studies prior to 1950 and geologic investigations from 1950 to the present. Mineral commodity studies included investigations of mineral deposits in general (Peck, 1833); corundum (King, 1894); gold (Yeates and others, 1896; Jones, 1909; Pardee and Park,

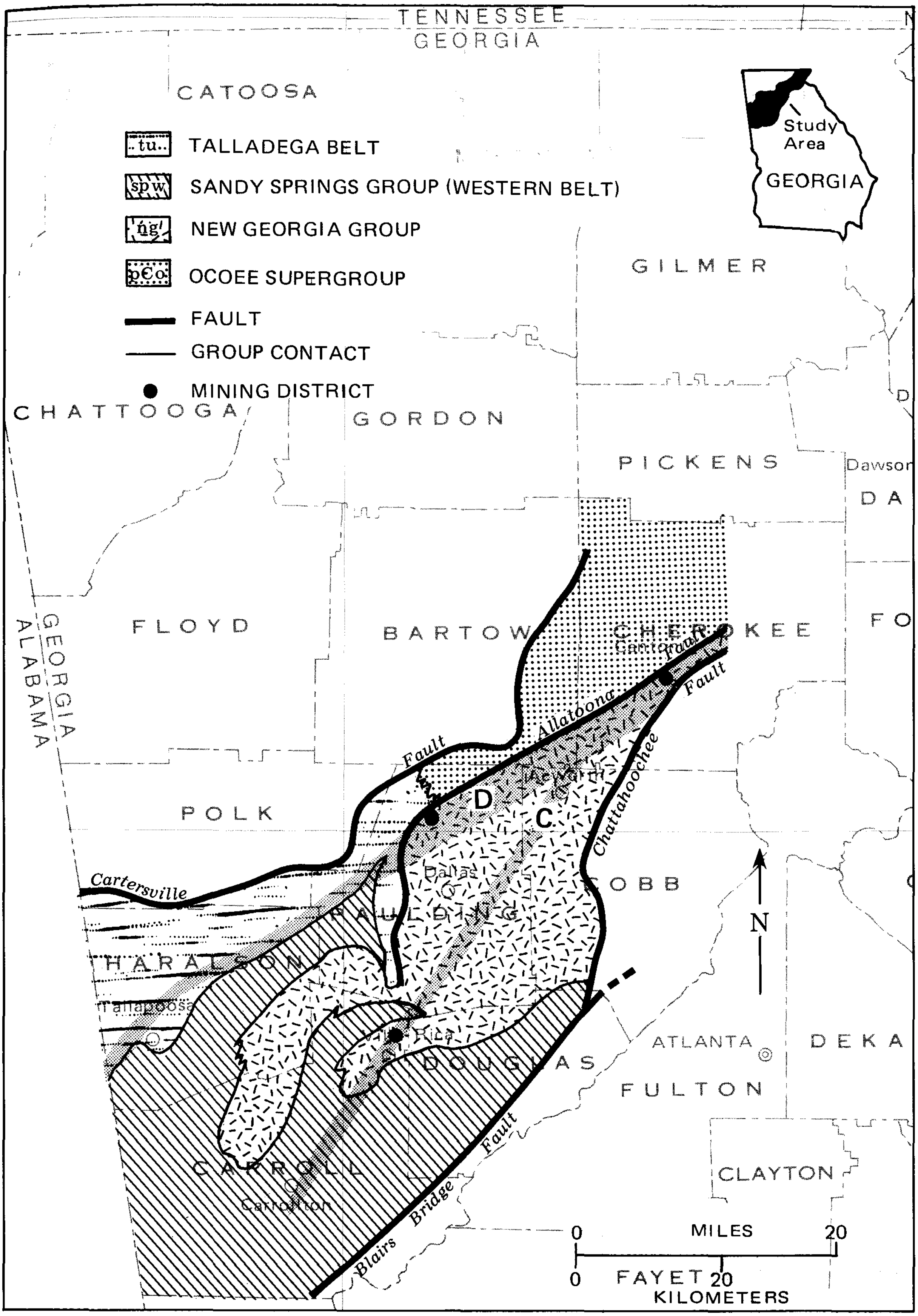

Figure 2. Generalized geologic map of the study area. Dahlonega (D) and Carroll County (C) gold belts (after Jones, 1909) are superimposed. Mining districts discussed in the text are indicated by darkened circles.

1948); granites and gneisses (Watson, 1902); manganese (Watson, 1908; Pierce, 1944; Hull and others, 1919); asbestos, talc and soapstone (Hopkins, 1914); feldspar and mica (Galpin, 1915); pyrite (Shearer and Hull, 1918); iron ore (Haseltine, 1924); mica-bearing pegmatites (Furcron and Teague, 1943); and pegmatites in general (Heinrich and others, 1953). Although these studies provided very valuable site-by-site descriptions of mines, prospects and mineral localities, only limited detail was given on local and regional geology.

Prior to 1950 very little information was published on the stratigraphy, structure or metamorphic history of the study area. Rocks were simply referred to as crystalline terrains, or, at best, most mafic units were called Roan Gneiss and nearly all other rock units Carolina Gneiss after the usage employed by early workers such as Keith (1909) or LaForge and Phalen (1913). Notable exceptions, however, were published (1895) and unpublished work by Hayes in the Cartersville area and the 1939 state geologic map by Stose and others. Although detailed geologic relationships were being revealed in other parts of the state, this generally was not the case in the study area.

In 1950 the nature of geologic investigations began to change as detailed and reconnaissance mapping began to reveal stratigraphic sequences and deformational and metamorphic histories. The first of these was Kesler's (1950) report on the Cartersville mining district. A report that was to serve as a foundation for subsequent investigations was Crickmay's (1952) report on the crystalline rocks of Georgia. That same year Hurst (1952) reported on the geology of the Kennesaw Mountain-Sweat Mountain area and Schepis (1952) reported on the geology of a portion of Douglas County. Only two studies (Hurst, 1959 and Croft, 1963) were conducted in the study area during the remainder of the 1950's and the entire decade of the 1960's.

Beginning with the 1970's, geological investigations in the study area increased significantly. In 1970 Cook reported on the massive sulfide bodies of west-central Georgia, and Kesler and Kesler (1970) reported on the amphibolites of the Cartersville district. Also that year, four reports on the regional geology of the study area were published (Crawford, 1970; Crawford and Medlin, 1970; Hurst, 1970; and Hurst and Crawford, 1970). The following year Hurst and Long (1971) and Long (1971) published complementary reports on the Chattahoochee-Flint Rivers area, and Crawford and Medlin (1971) reported on stratigraphic and structural features of the Piedmont. Two years later investigators reported on the petrology and geochemistry of the Austell Gneiss (Coleman and others, 1973); the regional geology of part of the Piedmont and/or Blue Ridge of Georgia (Crawford and Medlin, 1973; Medlin and Crawford, 1973; Hurst, 1973; Fairley, 1973); and the amphibolites of the Cartersville-Villa Rica area (Hurst and Jones, 1973; Jones and others, 1973). From 1976 through 1979 publications on parts of the study area included petrologic studies by Bearden (1976) and Sanders and others (1979); geologic maps by Crawford (1976, 1977a, 1977b); a geochemical study by Sanders (1977); and two mineralogical studies by Cook (1978a, 1978b).

During the early and mid-1980's, many reports were produced on part or all of the study area. Those reports primarily concerned with economic geology included McConnell and Costello (1980a); Pate (1980); Abrams and others (1981); Abrams and McConnell (1982a, 1982b, 1982c, 1984); McConnell and Abrams (1982b, 1983); Paris (1986); and McConnell and others (1986). Reports primarily concerned with local or regional geology included McConnell (1980); Abrams and McConnell (1981a, 1981b); Costello and others (1982); McConnell and Abrams (1982a); and Abrams (1983). McConnell and Abrams (1984) published a comprehensive, regional synthesis and revision of the geology and mineral deposit genesis of the study area. Higgins and others (1984, 1986) proposed an alternate interpretation of the geology of the Piedmont and Blue Ridge based on the hypothesis that the Piedmont and Blue Ridge consist of numerous stacked thrust sheets.

STRATIGRAPHY

Introduction

Most rocks in the study area are assigned to the New Georgia Group or the western belt of the Sandy Springs Group (Figure 3). McConnell and Abrams (1984) defined the New Georgia Group as a predominantly metavolcanic sequence of bimodal composition with minor pelitic metasedimentary units and the Sandy Springs Group (western belt) as a predominantly clastic metasedimentary sequence with proportionally smaller amounts of metavolcanic rocks. Based on whole rock chemistry, trace element chemistry and the relative proportions of metavolcanic and metasedimentary rocks in these two groups, McConnell and Abrams (1984) proposed that these two groups represented the formation and filling of a back-arc basin. Also, the abundance of metavolcanic rocks in the New Georgia Group was interpreted by McConnell and Abrams (1984) to indicate that the New Georgia Group is the older of the two groups and grades upward into the overlying Sandy Springs Group, representing a sequence of extensive, initial volcanism followed by a sequence of extensive clastic sedimentation. Rocks not assigned to these two groups were designated as either unassigned rocks or Paleozoic meta-igneous rocks. It is conceivable that the stratigraphic order proposed by McConnell and Abrams (1984) is reversed, but definitive evidence to prove either stratigraphic interpretation has been obscured by regional metamorphism and multiple deformation.

A complete reexamination of the stratigraphy of the study area is beyond the scope of this report. Although detailed mapping for this study was conducted only in specific areas, in general, the mapping tended to agree with the work of McConnell and Abrams (1984). For this reason, most of their stratigraphy is adopted for use in this report.

Recently, traditional thinking on the geology of the southernmost Appalachians, and of Georgia in particular, has been questioned by Higgins and others (1986). They have proposed that most contacts between the various rock units in the study area are fault contacts even though many

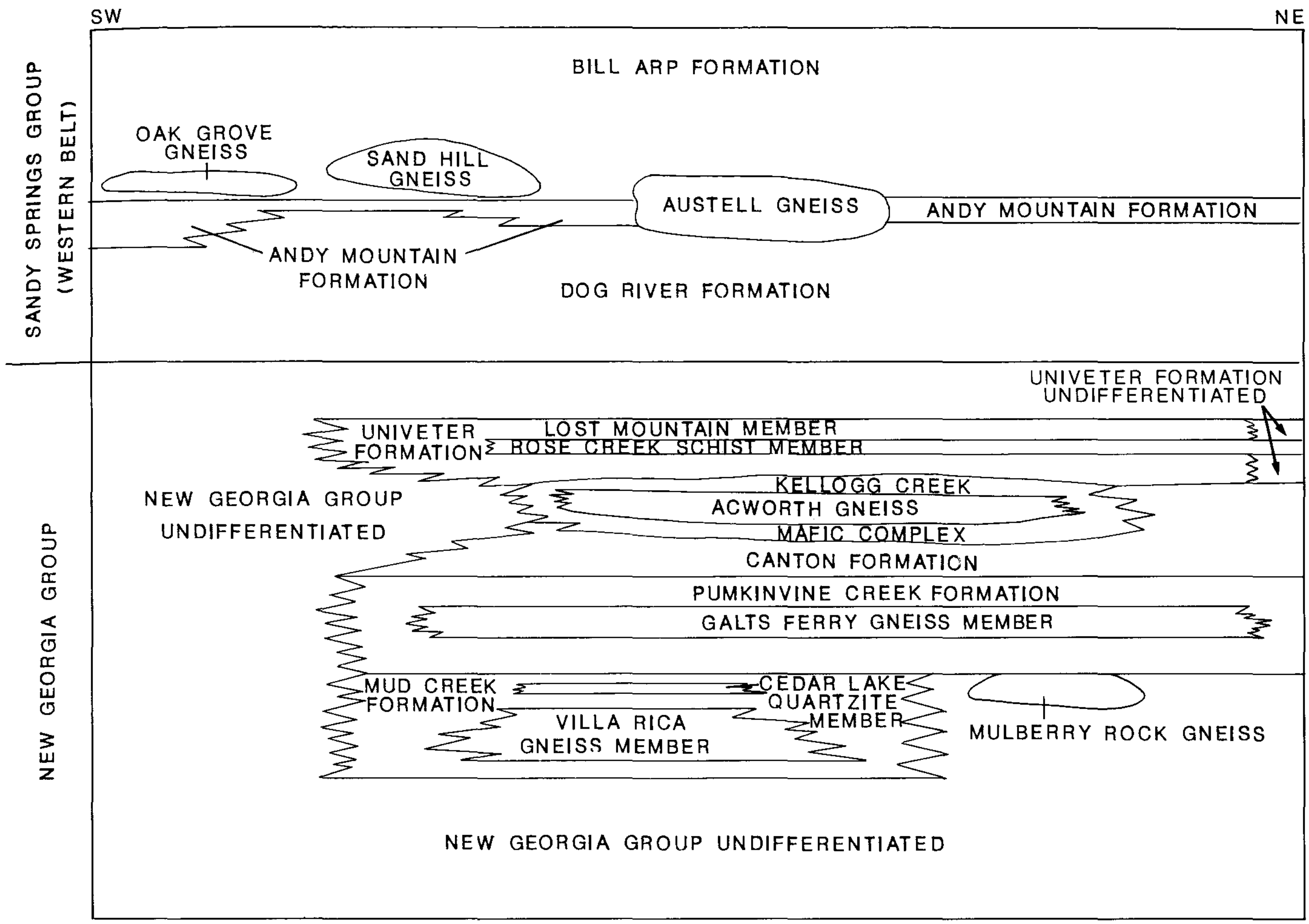

Figure 3. Diagrammatic stratigraphic section of rock units in the study area.

of these contacts are gradational. Sequences considered conformable (Crawford and Medlin, 1973; McConnell and Abrams, 1984; German, 1985) are interpreted to be composed of several stacked thrust sheets (Higgins and others, 1986) whose contacts often crosscut mappable units within the sequences. The thrust sheets often are defined at localities in the Southern Piedmont and then correlated with units believed to be similar in the northern Piedmont and Blue Ridge even though the units may have significantly different characteristics (McConnell and Abrams, 1986, p. 27). Also, most of the known gold and massive sulfide deposits are interpreted to occur in a predominantly mafic metavolcanic sequence (Ropes Creek Metabasalt) which is defined largely by the presence of oxide facies iron formation (Higgins and others, 1986, p. 131). Using these criteria, occurrences of oxide facies iron formation within other rock units are interpreted as klippen of Ropes Creek Metabasalt. Defining a rock unit in this manner and placing faults around such iron formations is not justified since oxide facies iron formation is an integral part of many metallogenic provinces and occurs in various stratigraphic positions within volcanic and mixed volcanic-sedimentary sequences (Gross, 1980; Franklin and others, 1981).

Although it is agreed that thrusting has played a major role in the development of the study area, detailed work by German (1985) and this study do not support the model proposed by Higgins and others (1986). For the above reasons, Higgins and others' (1986) thrust sheet stratigraphy will not be used in this report.

New Georgia Group

Introduction

The New Georgia Group is the key unit in the study area since it is host for the majority of the known gold deposits. Occurring in the central and northeastern part of the study area, this unit is exposed over a seven county area (Plate 1). German (1985) found that the New Georgia Group extends northeastward to the vicinity of Helen, Georgia, and is the principal stratigraphic unit of the northeastern portion of the Dahlonega gold belt.

The thickness of the New Georgia Group is impossible to determine reliably due to faulting and multiple folding but probably is on the order of one to five kilometers. Units comprising the New Georgia Group are described below in a probable ascending order modified from the stratigraphic order proposed by McConnell and Abrams (1984).

New Georgia Group Undifferentiated

(modified after McConnell and Abrams, 1984)

Rocks mapped as New Georgia Group undifferentiated crop out over southwestern Cobb County and southeastern Paulding County (Plate 1). Major lithologies include amphibolite, hornblende-plagioclase gneiss and quartzofeldspathic gneiss. Minor amounts of chlorite schist, epidote quartzite, iron formation, kyanite-muscovite-quartz schist and sericite quartzite are also present locally.

Mud Creek Formation

(Abrams and McConnell, 1981a; McConnell and Abrams, 1984)

The Mud Creek Formation crops out near the center of the study area in the vicinity of Villa Rica and in the nose and northwestern limb of the Austell-Frolona antiform. Abrams and McConnell (1981a) and McConnell and Abrams (1984) divided the Mud Creek Formation into a biotite-quartz-plagioclase orthogneiss which they formally called the Villa Rica Gneiss; garnet-biotite gneiss; magnetite quartzite (banded iron formation) which they formally termed the Cedar Lake Quartzite; and interlayered hornblende-plagioclase amphibolite ± garnet, hornblende gneiss, garnet-biotite-quartz plagioclase gneiss, and biotite schist which they called Mud Creek formation undifferentiated. The importance of the Villa Rica Gneiss as a host for gold deposits will be discussed later in the section on the Villa Rica district.

Pumpkinvine Creek Formation

(modified after McConnell and Abrams, 1984)

The Pumpkinvine Creek Formation (undifferentiated) as described by McConnell (1980) and McConnell and Abrams (1984) consists of amphibolite with interlayered garnet-hornblende-plagioclase gneiss, sericite phyllite, and magnetite quartzite (iron formation). Hornblende-quartz-plagioclase gneiss with interlayered hornblende gneiss and actinolite-chlorite schist was termed the Galts Ferry Gneiss Member (McConnell, 1980; McConnell and Abrams, 1984). Plagioclase and quartz megacrysts in the hornblende-quartz-plagioclase gneiss are interpreted as recrystallized phenocrysts or crystal fragments. German (1985, this study) also includes a coarsely porphyroblastic garnet-hornblende-quartz-plagioclase gneiss ± calcite and/or staurolite in the unit mapped as Pumpkinvine Creek Formation undifferentiated. Detailed mapping in the Burnt Hickory Ridge and South Canton areas indicates that rocks of the Pumpkinvine Creek Formation form a conformable sequence of mafic and felsic to intermediate metavolcanic rocks similar to gold and sulfide-bearing sequences in greenstone belts in the Canadian Shield (Franklin and others, 1981) and southern Africa (Anhaeusser, 1976).

The Pumpkinvine Creek Formation is an important host for gold deposits both in the study area and in Dawson and Lumpkin Counties northeast of the study area (German, 1985). Whole rock and trace element chemistry of amphibolites and quartzofeldspathic gneisses (McConnell, 1980; McConnell and Abrams, 1984; German, 1985) and relict volcanic features (pillows and amygdules) in amphibolites (Hurst and Jones, 1973; McConnell and Abrams, 1982b, 1983b, 1984) in this formation strongly indicate an oceanic volcanism origin. Additional geochemical data on the Pumpkinvine Creek Formation will be presented and discussed in a later section (Tectonic Setting).

Canton Formation

(modified after McConnell and Abrams, 1984)

Bayley (1928) described a stratigraphic unit of graphitic, garnetiferous schist he called the Canton Schist for exposures in the vicinity of Canton, Georgia. The unit was subsequently redefined as the Canton Formation by McConnell and Abrams (1984) and was reported to consist of garnet-sericite schist interlayered with garnet-graphite schist ± kyanite, micaceous quartzite and metagraywacke. Field mapping for the current study in the South Carolina quadrangle revealed a sequence of interlayered phyllitic graphite-garnet-sericite-quartz schist ± biotite, silvery garnet-muscovite-biotite-quartz schist and muscovite-biotite-plagioclase-quartz gneiss (metagraywacke). Graphite is abundant in this formation at the type locality at Canton and to the southwest of Canton; however, northeast of the type locality graphite becomes much less abundant (German, 1985). Northeast of the type locality, German (1985) subdivided the Canton Formation into four members and noted the occurrence within this formation of numerous metavolcanic rocks. The Canton Formation also is host for at least 41 gold deposits from White County to Paulding County (German, 1985, this study) and one massive sulfide deposit in Cherokee County.

Higgins and others (1986) disagreed with McConnell and Abrams' (1984) claim that the original name, Canton Schist (Bayley, 1928), was too restrictive and proposed the use of the older term for this unit. Detailed mapping by the author in the northeastern part of the study area and in the northeastern part of the Dahlonega gold belt (German, 1985) indicates that the term Canton Schist is, in fact, too restrictive and should be replaced by the more appropriate term Canton Formation, as McConnell and Abrams (1984) proposed. Although the Canton Formation is composed primarily of schists of various compositions, the presence of varying amounts of metagraywacke; quartzite; amphibolite; quartzofeldspathic gneiss; aluminous, manganiferous and oxide facies iron formations; and tourmalinite demonstrate the lithologic diversity of this unit.

Kellogg Creek Mafic Complex/Acworth Gneiss

(modified after McConnell and Abrams, 1984)

The Kellogg Creek Mafic Complex crops out in the northeastern part of the study area along the flanks of an F_2 antiformal feature (Plate 1). Several mafic rock types make up this unit. These include interlayered garnet-hornblende-plagioclase amphibolite; medium- to coarse-grained, weakly foliated amphibolite (metagabbro); and lesser amounts of chlorite-anthophyllite rocks (meta-ultramafic rocks or hydrothermal alteration zones). McConnell and Abrams (1984) suggest that protoliths of the garnet-hornblende-plagioclase amphibolites may be extrusive phases of the protoliths of the metagabbros.

Enclosed by rocks of the Kellogg Creek Mafic Complex are two separate units of a foliated, medium-grained muscovite-epidote-biotite-quartz-plagioclase orthogneiss called the Acworth Gneiss (McConnell and Abrams, 1984) (Plate 1). The presence of mafic xenoliths within the Acworth Gneiss suggests that the protolith of the gneiss intruded the Kellogg Creek Mafic Complex.

McConnell and Abrams (1984) interpreted the Kellogg

Creek Mafic Complex and the Acworth Gneiss as the two oldest units of the New Georgia Group and showed the Kellogg Creek Mafic Complex in fault contact with the Univeter Formation. Data from the current investigation strongly suggest that this contact is conformable, making the Kellogg Creek Mafic Complex and Acworth Gneiss much younger (Figure 3, Plate 1). The Kellogg Creek Mafic Complex and the Acworth Gneiss are interpreted to represent a sequence of plutonic/volcanic rocks that conformably lies between the Canton and Univeter Formations.

Univeter Formation
(modified after McConnell and Abrams, 1984)

McConnell and Abrams (1984) assigned the name Univeter Formation to a predominantly metavolcanic sequence in the northeastern part of the study area. They subdivided this formation into the Lost Mountain Amphibolite, consisting of amphibolite, hornblende gneiss and minor iron formation, and the Rose Creek Schist, consisting of garnet-biotite-muscovite-quartz schist and minor garnet-hornblende-muscovite-quartz schist.

In addition to those lithologies, detailed field mapping for this study in the South Canton quadrangle also revealed the presence of sericite-quartz schist, feldspathic sericite-quartz schist and muscovite-biotite-plagioclase-quartz gneiss (quartzofeldspathic gneiss) within areas previously mapped as Lost Mountain Amphibolite. Feldspar and quartz megacrysts in the quartzofeldspathic gneiss are interpreted as recrystallized phenocrysts or crystal fragments, suggesting a volcanic protolith. Predominantly mafic sequences in the Univeter Formation also contain a felsic to intermediate facies northeast of the study area (German, 1985). Since the Lost Mountain Amphibolite contains lithologies other than amphibolite, it is herein designated the Lost Mountain Member. The name Rose Creek Schist is retained unchanged.

The Univeter Formation can be mapped within the study area from eastern Paulding County northeastward to central Cherokee County. Gillon (1982) and German (1985) mapped this unit northeast of the study area to the Lake Burton area in Habersham County. The Univeter Formation is host for at least 31 gold mines and prospects and at least five massive sulfide mines and prospects.

McConnell and Abrams (1984) proposed that the Univeter Formation is in fault contact with the Canton Formation. However, mapping by German (1985) northeast of the study area and for this report in the South Canton quadrangle indicates that the Univeter and Canton Formations are locally interlayered at their contact and therefore form a conformable sequence. Southwest of the South Canton area, the Univeter Formation is in conformable contact with rocks of the Kellogg Creek Mafic Complex (See discussion in the preceeding section). Higgins and others (1986) propose the abandonment of the term, Univeter Formation, since they consider the unit to be part of their Ropes Creek Metabasalt. Since the author, for reasons previously cited, does not agree with the premises on which Higgins and others (1986) define their Ropes Creek Metabasalt, the Univeter Formation is retained for use in this report.

Since the designated type locality for the Univeter Formation (McConnell and Abrams, 1984) does not thoroughly show the lithologic diversity of this formation, two reference localities are herein designated. These are located along Holly Road and the Little River on the South Canton 7.5-minute topographic quadrangle (Figure 4).

Sandy Springs Group (western belt)

Introduction

McConnell and Abrams (1984) introduced the term Sandy Springs Group (western belt) for a sequence of rocks very similar to the Sandy Springs Group as described by Higgins (1966) and defined by Higgins and McConnell (1978a; 1978b). Both sequences generally consist of a basal gneiss-schist-amphibolite unit with significant amounts of amphibolite and iron formation in the lowermost part of the unit. The gneiss-schist-amphibolite unit is overlain by a unit of quartzite which is in turn overlain by a unit consisting of metagraywacke (biotite-plagioclase-quartz gneiss) and graphitic phyllite with little or no amphibolite. Since these two sequences are separated by the Blairs Bridge and Chattahoochee faults, McConnell and Abrams (1984) called the sequences an eastern and a western belt of the same group. The Sandy Springs Group (western belt) was interpreted by McConnell and Abrams (1984) to overlie conformably the New Georgia Group and to record the final infilling of a back-arc basin as volcanism waned and sedimentation became dominant. The thickness of the western belt of the Sandy Springs Group is unknown but is estimated to range from one to five kilometers. Formations in this group are described below in a probable ascending order.

Dog River Formation
(modified after McConnell and Abrams, 1984)

The Dog River Formation (McConnell and Abrams, 1984) consists of muscovite-biotite-quartz-feldspar gneiss (metagraywacke), garnet-muscovite schist, amphibolite and iron formation. Amphibolites and garnet-muscovite-quartz schists locally are separately mappable units. In addition to those units mapped by McConnell and Abram (1984), mappable units of medium-grained hornblende-biotite-quartz-plagioclase gneiss ± garnet (biotite gneiss) occur in southern Carroll County. This gneiss locally contains magnetite porpyroblasts up to 1 cm in diameter. The Dog River Formation is restricted to the southwestern portion of the study area.

Citing its abundance of amphibolite and iron formation (metavolcanic rocks), McConnell and Abrams (1984) interpreted the Dog River Formation as gradationally overlying the New Georgia Group. The Dog River Formation is correlative with the Powers Ferry Formation of the eastern belt of the Sandy Springs Group.

Andy Mountain Formation
(McConnell and Abrams, 1984)

The Andy Mountain Formation crops out in the study area just east and south of Villa Rica and south and west of Carrollton. Rocks that make up this formation were named

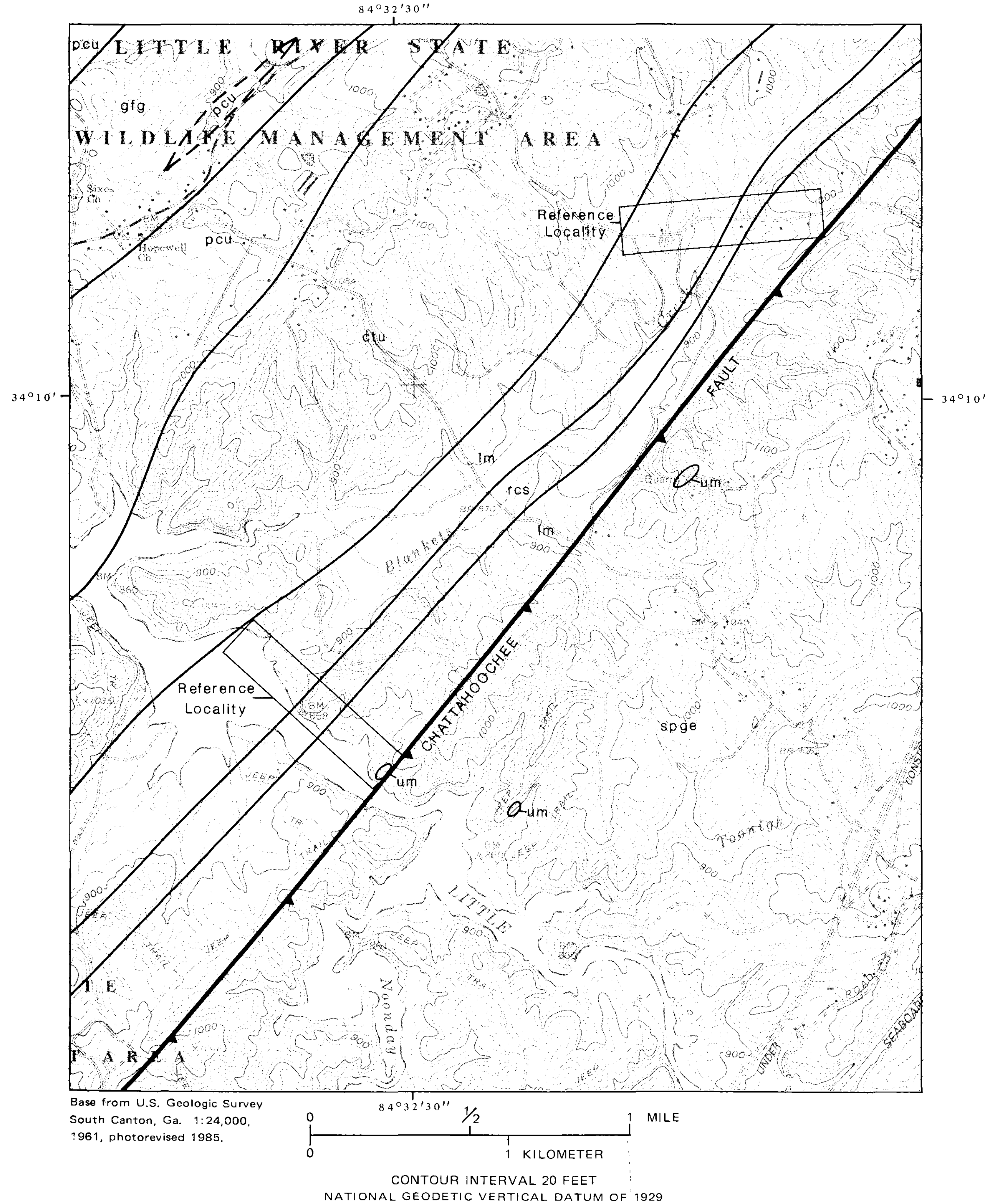

Figure 4. Reference localities for the Univeter Formation (South Canton 7.5-minute topographic quadrangle). spge- Sandy Springs Group (eastern belt), pcu- Pumpkinvine Creek Formation, gfg- Galts Ferry Gneiss Member, ctu- Canton Formation, lm- Lost Mountain Member, rcs- Rose Creek Schist Member, um- meta-ultramafic rocks.

the Andy Mountain Formation by Abrams and McConnell (1981a) and McConnell and Abrams (1984). The Andy Mountain Formation consists of biotite-garnet-plagioclase-muscovite-quartz schist ± graphite, staurolite and kyanite; feldspathic, micaceous garnet quartzite; and clean, sugary quartzite ± garnet.

Bill Arp Formation
(Crawford and Medlin, 1973 and Abrams and McConnell, 1981a)

The Bill Arp Formation crops out in the core and limbs of the Austell/Frolona antiform in the southeastern part of the study area. Rocks that make up the Bill Arp Formation were described originally by Crawford and Medlin (1973) and later formalized by Abrams and McConnell (1981a). This formation consists of a sequence of interlayered garnet-biotite-muscovite-plagioclase-quartz schist, muscovite schist, quartz-muscovite-biotite schist, muscovite-biotite-quartz-plagioclase schist and muscovite-biotite-plagioclase-quartz gneiss (metagraywacke). Small, concordant bodies rich in calcium-bearing minerals occur locally within the Bill Arp Formation. These light-colored, elliptical pods consist predominantly of quartz and calcite with minor amounts of hornblende and garnet. Most pods are less than one foot (30 cm) thick, and many are concentrically zoned. Sanders and others (1979) interpret the pods to be metamorphosed calcareous concretions.

Paleozoic Plutonic Rocks

Introduction

McConnell and Abrams (1984) discussed three categories of Paleozoic plutonic rocks that are present in the Piedmont of central and western Georgia. These rocks are grouped as premetamorphic intrusives (show penetrative deformation fabrics and are associated with extrusive phases), pre- to synmetamorphic intrusives (also show penetrative deformational fabrics but have no associated extrusive phases), and postmetamorphic intrusives (have no penetrative deformational fabric or associated extrusive phases). Only premetamorphic and pre- to synmetamorphic intrusives are present in the study area. The premetamorphic intrusives include the Villa Rica Gneiss, the Acworth Gneiss and the Galts Ferry Gneiss (discussed above). The pre- to synmetamorphic intrusives include the Austell Gneiss, the Sand Hill Gneiss, the Mulberry Rock Gneiss and the Oak Grove Gneiss.

Austell Gneiss
(Medlin and Crawford, 1973 and Abrams and McConnell, 1981a)

The Austell Gneiss is exposed in the core and limbs of the Austell/Frolona antiform in the southeastern part of the study area. The gneiss is a fine- to coarse-grained blastoporphyritic to nonporphyritic gneiss composed of muscovite, biotite, oligoclase, quartz, and microcline. The term Austell Gneiss was introduced informally by Medlin and Crawford (1973) and was formalized by Abrams and McConnell (1981a).

The Austell Gneiss has been described as a granite (Hayes, 1895; Crickmay, 1952), granite augen gneiss (Shepis, 1952), augen gneiss (Higgins, 1966) and gneiss (Medlin and Crawford, 1973; Abrams and McConnell, 1981a; Abrams, 1983; McConnell and Abrams, 1984). A sediment (Medlin and Crawford, 1973; Crawford and Medlin, 1973; Coleman and others, 1973) and an igneous intrusive rock (Abrams and McConnell, 1981a; Abrams, 1983; McConnell and Abrams, 1984) have been proposed as protoliths for this gneiss, but the presence of xenoliths of the Bill Arp Formation in the Austell Gneiss (Abrams, 1983) tends to confirm an igneous intrusive origin.

Sand Hill Gneiss
(McConnell and Abrams, 1984)

The Sand Hill Gneiss is a fine- to coarse-grained blastoporphyritic to non-porphyritic gneiss consisting of muscovite, biotite, oligoclase, quartz and microcline. Large, euhedral microcline megacrysts exhibit at least two preferred orientations probably coinciding with intersecting foliations.

Crickmay (1952) first described this gneiss and considered it part of the Austell Gneiss. The name Sand Hill Gneiss was formally introduced by McConnell and Abrams (1984). This gneiss is probably of igneous origin (McConnell and Abrams, 1984) although a sedimentary protolith has been proposed (Medlin and Crawford, 1973; Crawford and Medlin, 1973).

Mulberry Rock Gneiss
(McConnell and Abrams, 1984)

The Mulberry Rock Gneiss is exposed in the northwestern part of the study area along the boundary between the northern Piedmont and the Talladega belt. McConnell and Abrams (1984) described this unit as a medium-grained, equigranular muscovite-quartz-microcline-plagioclase orthogneiss. They also speculate that this gneiss could be Precambrian basement.

Oak Grove Gneiss

A rock unit in Carroll County (Crawford, 1970; German this report) is herein named the Oak Grove Gneiss for exposures along the east side of U.S. Highway 27 in the community of Oak Grove, Georgia (Carrollton 7.5-minute quadrangle, Figure 5). This rock unit is a leucocratic, medium- to coarse-grained, blastoporphyritic biotite-muscovite-plagioclase-quartz-microcline orthogneiss (Figure 6). Microcline megacrysts up to 2 cm in diameter are common. Zoned, undeformed microcline megacrysts up to 3 cm in longest dimension are present locally. The Oak Grove gneiss is coarse-grained throughout except near its periphery, where individual mineral crystals are somewhat comminuted and the gneiss exhibits an augen texture (Figure 7).

In sharp contact with the orthogneiss are mica schists and metagraywacke of the Bill Arp Formation. Two small outliers of the orthogneiss are exposed just north of the main body and are bounded by metagraywacke, garnet-muscovite schist and amphibolite of the Dog River Formation; mica schist and metagraywacke of the Bill Arp Formation; and graphite schist of the Andy Mountain Formation (Plate 1). The Oak Grove Gneiss is probably a pre- to synmetamorphic pluton and is very similar mineralogically and texturally to the Austell and Sand Hill Gneisses. The similarities between these three bodies strongly suggest that they derived from a common parent magma and could be connected at depth.

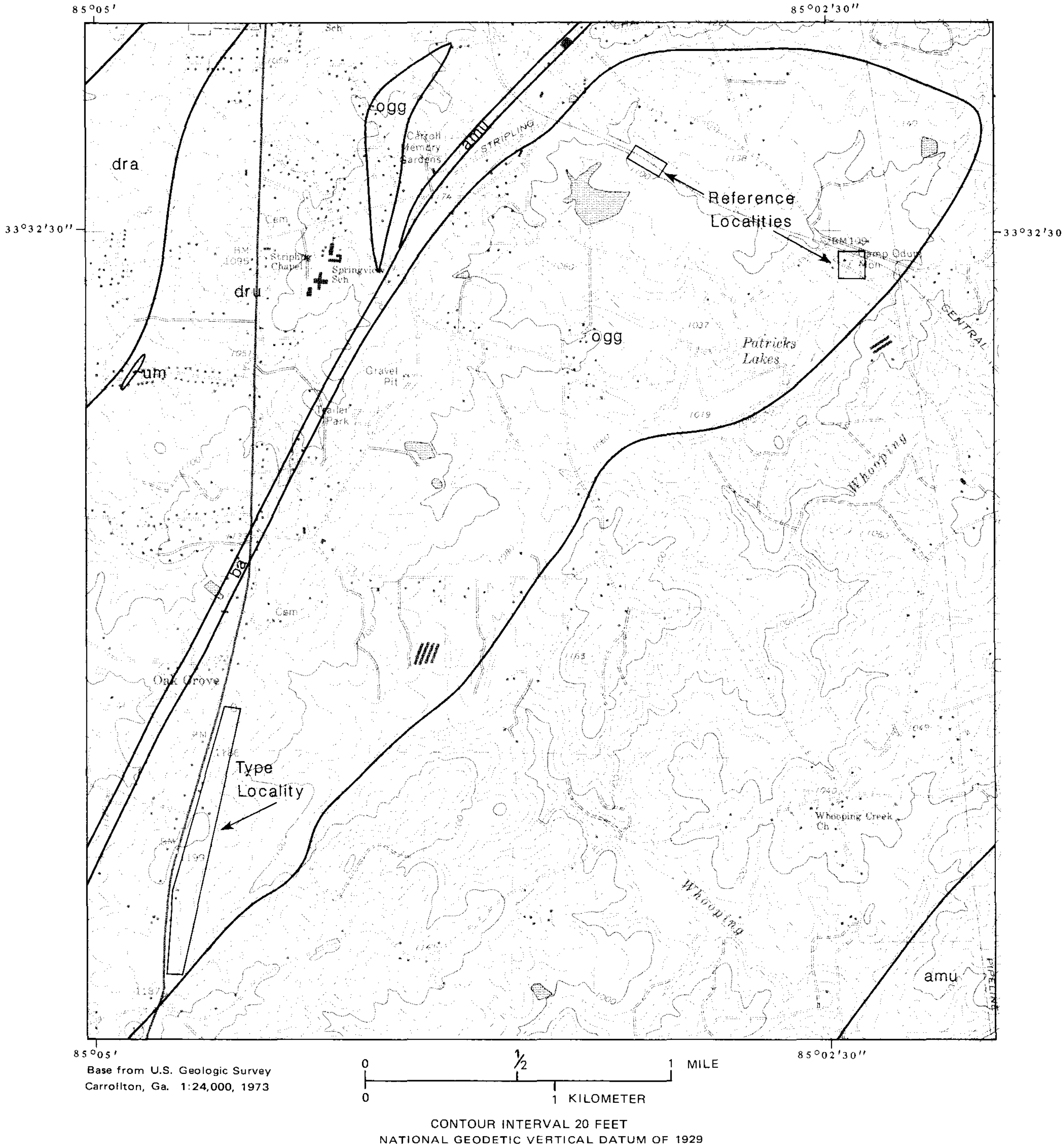

Figure 5. Type locality and reference localities of the Oak Grove Gneiss (Carrollton 7.5-minute topographic quadrangle). ogg- Oak Grove Gneiss, ba- Bill Arp Formation, amu- Andy Mountain Formation, dru - Dog River Formation.

Figure 6. Photograph of an exposure of Oak Grove Gneiss at the type locality. Length of pocket knife is 8 cm.

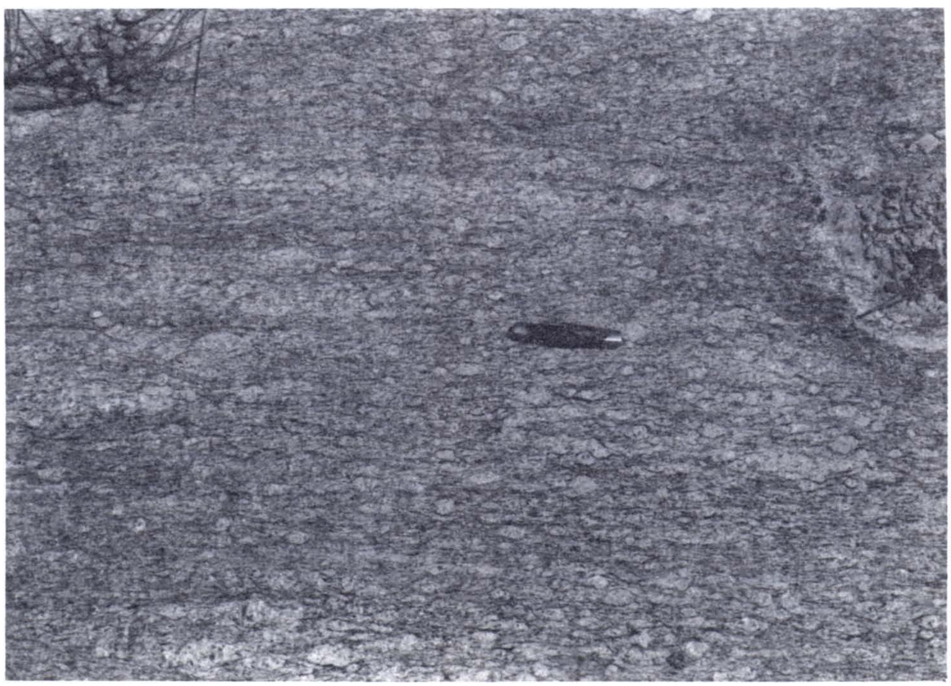

Figure 7. Photograph of augen-textured Oak Grove Gneiss near the periphery of the body. Length of pocket knife is 8 cm.

Unassigned Rocks

Unassigned (or unnamed) rocks given only a lithologic designation by McConnell and Abrams (1984, Plate 1) are common in the study area, particularly in the west and northwest. McConnell and Abrams (1984) suggest that certain unassigned rock units such as felsic gneisses and interlayered amphibolite, hornblende gneiss and felsic gneiss are probably part of the New Georgia Group, whereas some units of amphibolite and banded iron formation could be assigned to either the New Georgia Group or the Sandy Springs Group (western belt). On the basis of limited reconnaissance mapping in areas of unassigned rocks, most of McConnell and Abrams' (1984) unassigned rocks are assigned to the New Georgia Group (Plate 1). Other rocks previously unassigned inlcude chlorite schist ± garnet, biotite or anthophyllite; kyanite-muscovite-quartz schist and sericite quartzite ± kyanite and pyrite; muscovite-kyanite-quartz granofels ± pyrite; carbonaceous schist; sericite schist with interlayered quartzite and hornblende gneiss; garnet-muscovite schist; biotite-garnet-muscovite schist; epidote quartzite; coarse-grained, weakly foliated amphibolite (metagabbro); and anthophyllite-chlorite-talc rocks (meta-ultramafic rocks or metamorphosed hydrothermal alteration zones associated with ore bodies) (McConnell and Abrams, 1984).

Rocks Northwest and Southwest of the Study Area

Rocks bordering the study area on the northwest are part of the Ocoee Supergroup and Talladega belt. These include biotite-sericite-plagioclase-quartz metasandstone and sericite phyllite of the Etowah Formation of the Great Smoky Group; metasandstone, sandy marble and metasiltstone ± calcite and/or graphite of the Wilhite Formation of the Walden Creek Group (McConnell and Costello, 1980b; McConnell and Abrams, 1984); and plagioclase-biotite-quartz metasiltstone and chlorite-sericite phyllite of the Talladega belt. Rocks along the southeastern border include clean quartzite, metagraywacke, kyanite-quartz schist, staurolite-muscovite-quartz schist, amphibolite and biotite gneiss of the Sandy Springs Group (eastern belt) and migmatitic garnet amphibolite and meta-quartz diorite of the Laura Lake Mafic Complex (McConnell and Abrams, 1984). A klippe of interlayered metagraywacke, mica schist and amphibolite (Powers Ferry Formation) of the Sandy Springs Group (eastern belt) is also found in the northeastern part of the study area (McConnell and Adams, 1984) (Plate 1).

STRUCTURE

The study area is a distinct lithotectonic terrain that is almost entirely bounded by major faults (Plate 1). On the northwest, the study area is bounded by the Allatoona fault. Along this fault, terrain of the northern Piedmont province was thrust over that of the Blue Ridge province. Along the northern edge of the study area, in Cherokee, Bartow and eastern Paulding counties, the Allatoona fault forms a distinct boundary between rocks of the New Georgia Group, that contain a substantial volcanic component, and the metasedimentary rocks of the Ocoee Supergroup. A distinct metamorphic discontinuity also exists along this boundary since rocks north of this boundary (Ocoee Supergroup) are of biotite to kyanite grade while those immediately south of this boundary (Dahlonega gold belt) are of staurolite grade. This aspect is discussed more fully in the section on metamorphism.

The presence of the Allatoona fault is uncertain from western Paulding County through Haralson County. At this point, rocks considered part of the northern Piedmont are in contact with those of the Talladega belt, and on either side of this contact rocks are of biotite to garnet grade. Although rocks of the northern Piedmont in the Paulding-Haralson County area are a mixture of metasedimentary and metavolcanic rocks, whereas rocks of the Talladega belt are overwhelmingly metasedimentary, a distinct lithologic or tectonic break is not clearly defined.

On the southeast, the study area is bounded by the Chattahoochee and Blairs Bridge faults. McConnell and Abrams (1984) defined the Chattahoochee fault as a major structure separating higher grade, migmatitic rocks of the eastern belt of the Sandy Springs Group on the southeast from lower grade, unmigmatized rocks of the New Georgia Group on the northwest. This fault is a distinct tectonic and lithologic boundary and was traced northeastward to the Lake Burton area in Rabun County by German (1985). Although he used the term, Dahlonega fault, Nelson (1985) traced the same fault into North Carolina. To the southwest, the Chattahoochee fault is overridden by the Blairs Bridge fault which is then traceable southwestward to the Georgia-Alabama state line (McConnell and Abrams, 1984). The Blairs Bridge fault juxtaposes rocks of the eastern and western belts of the Sandy Springs Group (McConnell and Abrams, 1984).

McConnell and Abrams (1984) interpreted the Allatoona fault as a premetamorphic fault, whereas German (1985) considered movement along this fault to have been later than the peak of metamorphism because the fault truncates part of a major fold. If both interpretations are correct, the Allatoona fault probably has had a complex history of movement. The Chattahoochee fault was interpreted as a post-peak metamorphic fault by McConnell and Abrams (1984) and as a peak- to post-peak metamorphic fault by German (1985). The Blairs Bridge fault postdates the Chattahoochee fault.

Rocks in the study area reveal a complex structural history. All rocks within the study area possess a regional foliation that generally strikes northeast. This foliation wraps around the noses of most regional folds but is partially or totally transposed by the development of a subsequent axial planar foliation in many tightly appressed F_2 folds. Outcrop patterns in the study area are very similar to the outcrop patterns of refolded folds where the axial traces of both sets of folds are parallel (Ramsey, 1962). This similarity and the observation that foliations bend around the noses of some folds strongly indicate that outcrop patterns in the study area define refolded folds.

Abrams and McConnell (1981a) were the first to note that rocks in the study area have undergone multiple deformation. Prior to their work, structural interpretations of rocks in the study area were based on the assumption of only one fold event. Abrams and McConnell (1981a) and McConnell and Abrams (1984, Figure 27) proposed that rocks within the study area were folded into a regional, northwest vergent, recumbent anticline and subsequently refolded into a series of antiformal and synformal anticlines (F_2 folds) that trend northeast. In all, McConnell and Abrams (1984) were able to recognize four fold events characterized by initially intense deformation followed by progressively weaker deformation. Their four fold events correlate favorably with those recognized in this study and those recognized in adjacent areas by Gillon (1982), Nelson (1985) and German (1985) (Table 1). Folds recognized in this study are summarized below.

The first fold event that can be recognized in rocks within the study area is expressed by recumbent isoclines that are locally observed as rootless, intrafolial folds. These folds trend northeast and are northwest vergent. F_1 folding was accompanied by the development of a regional S_1 foliation.

Folding associated with the second fold event (F_2) refolded the F_1 folds and, in many areas, completely masked evidence of the earlier event. F_2 folds trend northeast and appear co-axial to F_1 folds. These folds are upright to northwest vergent and are responsible for most outcrop patterns within the study area. An axial planar foliation (S_2) is pervasive in very tightly appressed F_2 folds near the northwestern and southeastern boundaries of the study area but is rarely observed near the center of the study area where these folds are more open (Figure 8).

Upright, open folds that trend north-northeast record a third fold event (F_3). These folds are observable in Carroll, Douglas and Paulding Counties and are very similar to F_2 folds except for their more northerly trend (Figure 8, Plate 1). McConnell and Abrams (1984) interpreted these folds as F_2 folds (F_{2a}), proposing that they resulted from a change in the stress field during the deformation that produced other F_2 folds.

The youngest folds recognized in the study area are broad, upright warps. These folds trend north-northwest and have had negligible effect on the rocks in the study area.

METAMORPHISM

Rocks in the study area have undergone one strong episode of regional metamorphism that is interpreted to have occurred in the late Devonian, approximately 365 million years ago, based on an extrapolation of metamorphism dates from the Southern Piedmont (Dallmeyer, 1978). Metamorphic grade generally increases from north to south and varies from greenschist facies (biotite subfacies) to lower amphibolite facies (kyanite subfacies) (Figure 9). The arcuate shape of some metamorphic isograds and the coincidence of isograds with some faults and stratigraphic contacts (Figure 10) suggest that isograds were deformed by late deformation or, in some instances, are merely a reflection of the bulk composition of the original rock.

Typical mineralogical assemblages of greenschist facies rocks within the study area include quartz, albite, chlorite, epidote, muscovite and biotite for derivatives of pelitic rocks and chlorite, epidote, actinolite and albite for derivatives of mafic rocks. Mineral assemblages of lower amphibolite facies rocks include quartz, oligoclase, biotite, almandite, muscovite, staurolite and kyanite for derivatives of pelitic rocks and hornblende, oligoclase and garnet for derivatives of mafic rocks. Rocks of lower amphibolite facies that are rich in Mg0, such as the metamorphosed hydrothermal alteration assemblages, may contain cummingtonite, anthophyllite and olivine.

Most rocks in the study area also have experienced slight retrograde metamorphism. This retrograde effect is observable as the local alteration of biotite and/or garnet to chlorite (Figure 11). Where present as an alteration of biotite, chlorite crystals have grown across the dominant foliation. Slight metamorphic retrogression of the rocks of the study area also was observed by McConnell (1980) and McConnell and Abrams (1984). They suggest that late deformation may have caused retrograde effects since metamorphic retrogression is most discernible along the northern boundary of the study area where the boundary corresponds with the Allatoona fault; however, the occurrence of these retrograde effects throughout the study area suggests that they also could have resulted from an adjustment to lower temperature-pressure conditions during uplift and denudation.

ECONOMIC GEOLOGY

Introduction

The study area encompasses a region that includes the Carroll County gold belt and the southwestern portion of the Dahlonega gold belt. Gold was mined from these areas intermittently from the early 1830's to about 1930. Total production for this time period is unknown due to the scarcity of production records, but judging from the number of mines present, production was probably a significant percentage of the total state-wide recorded production of just over one-half million ounces. Recorded production and other pertinent information on each mine or prospect is given in Appendix 1.

Gold mining in this part of the state, as in the northeastern portion of the Dahlonega gold belt, consisted of placer mining of alluvium, open-cut mining of saprolite and underground lode mining. Mining techniques employed at many mines evolved over time from the initial placer mining of alluvium to open-cut mining and underground lode mining once it was realized that the source of the placer gold was the underlying bedrock.

Most mining operations in the study area only made use of the weathered portion of the deposits and the placer deposits derived from them. Once unweathered rock was reached ore grades usually dropped to the extent that mining was no longer profitable. At those mines where ore grade remained suitably high, an additional problem of extracting the gold from pyritic ore was encountered. This problem was overcome, at least temporarily, at some mines such as the Royal/Vindicator and Mason, by the use of a chlorination or cyanidation process. The supergene enrichment of the gold deposits in the study area is also typical of deposits in the adjacent part of the Dahlonega gold belt to the northeast (Lesure, 1971; German, 1985).

Table 1
Correlation chart of fold events in the northern Piedmont of Georgia

This Study	Greater Atlanta Area (after McConnell and Abrams, 1984)	Northeastern part of Dahlonega gold belt (after German, 1985)	Cowrock and Helen 7.5-minute quadrangles (after Gillon, 1982)		Northwestern part of Greenville 2° quadrangle (after Nelson, 1985)
F_1 Rootless, recumbent isoclines; S_1 foliation; NE trend.	F_1 Isoclinal recumbent ENE trend; dominant S-surface	Not recognized	F_1 Isoclinal recumbent flow folding	NE-WNW axes; NW-N vergence in Union Grove Fm; SW vergence in Richard Russell Fm.	F_1—Rootless recumbent to reclined isoclinal folds that trend northeast. F_1 folds lie in the regional foliation and may be coplanar with F_2 folds.
F_2 Isoclinal to open; upright to NW vergent; NE trend; S_2 axial planar foliation totally transposes S_1 foliation locally; responsible for most outcrop patterns.	F_2 Upright to overturned; isoclinal to open; NE trend; responsible for outcrop patterns.	F_1 Extremely tight isoclines; NE trend; NW & SE vergence; dominant S-surface; responsible for outcrop patterns.	F_2 Upright, isoclinal, flexural slip to flexural flow folding	NE-SW axes; NW & SE vergence of folds in Union Grove Fm; SE vergence in Helen Group.	F_2—Steep to recumbent isoclinal folds that form major folds. F_2 folds deformed S_1 regional foliation, probably occurred after peak metamorphism, and rarely have well-developed axial plane foliations (S_2).
F_3 Upright; open; NNE trend; responsible for some outcrop patterns.	F_{2a} Upright; open; NE trend.	F_2 Isoclinal to open; co-axial to F_1; crenulation cleavage.	F_3 nonpenetrative SE dipping cleavage; flexural slip folding	NE-SW axes; NW vergence	F_3—Upright to slightly inclined conjugate fold sets that trend northeast and northwest. F_3 fold sets have planar crenulation cleavage in pelitic units and probably are late metamorphic.
Not recognized	F_3 Open to isoclinal; SW vergence; SE trend; mainly restricted to Blue Ridge.	Not recognized	Not recognized		Not recognized
F_4 Broad; upright; NNW trend.	F_4 Upright; open; NW trend.	F_3 Broad; upright; SE or NW trend.	F_4 upright flexural slip folding	NE-WNW-S axes; slightly overturned to reclined folds	F_4—Post-F_3, folding about east-west and north-north-east axes, as suggested by statistical fold analyses. Field studies, however, have not identified axial planar cleavages associated with these later folds.

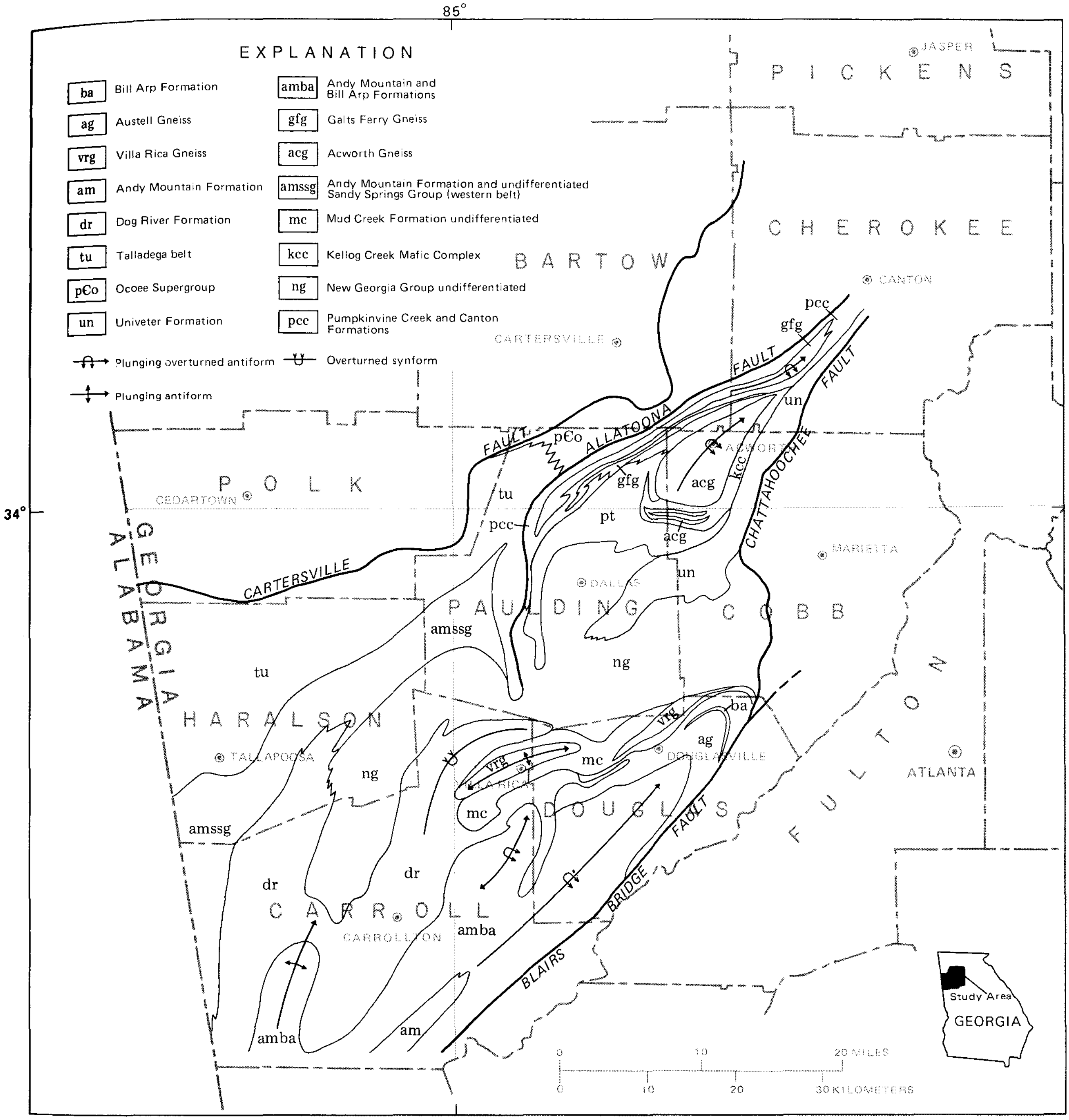

Figure 8. Generalized geologic map showing major F_2 outcrop patterns in the study area (Modified after McConnell and Abrams, 1984).

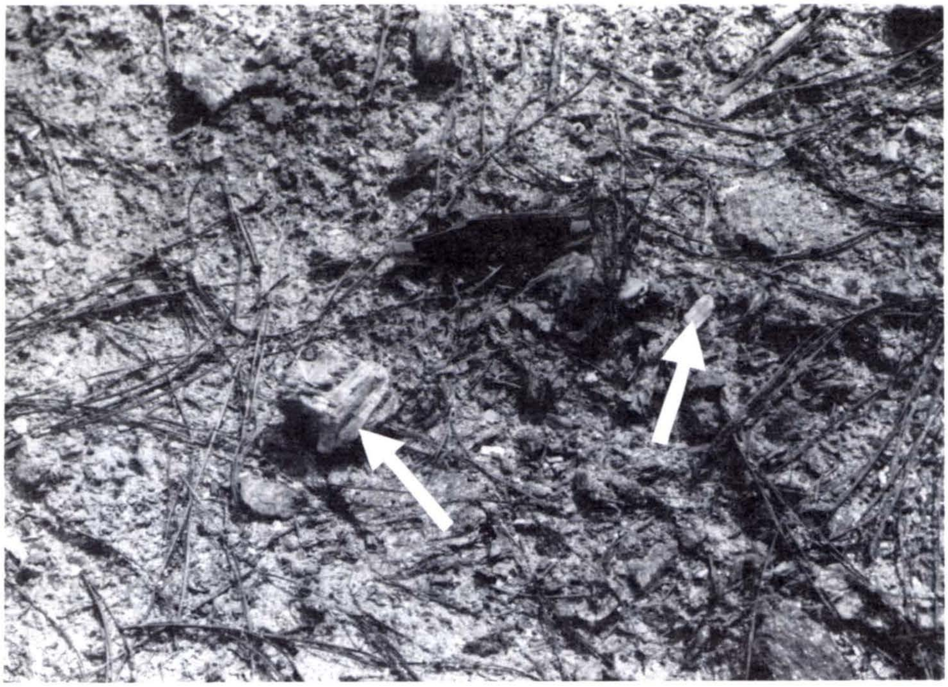

Figure 9. Kyanite crystals in saprolite of the Dog River Formation (Carrollton 7.5-minute topographic quadrangle). Length of pocket knife is 8 cm.

Gold Mineralization

Gold occurs in the study area under very similar circumstances to those in the adjacent part of the Dahlonega belt to the northeast. However, the structural and stratigraphic complexity and the variability of metamorphic grade produced conditions that are in many ways unique to the study area. In both regions, gold is predominantly found in sulfide-bearing quartz bodies that generally are parallel to the regional foliation (Figure 12) and exhibit the same deformation as the host rocks.

The term "vein" was previously used to describe the auriferous quartz bodies in rocks of the Dahlonega and Carroll County gold belts (Yeates and others, 1895; Jones, 1909; German, 1985). The use of the term "vein" normally implies a crosscutting orientation and a secondary, rather than a primary, origin. To avoid any confusion over the orientation and origin of the auriferous quartz bodies the term "vein" should not be used in describing these ore bodies. Although many of the auriferous quartz bodies are vein-like in some ways, they are not veins in the strict sense of the term.

The auriferous quartz bodies are generally lenticular or tabular in shape and somewhat discontinuous along strike. The bodies vary in thickness from less than five centimeters up to three meters and occur singly or as a parallel to subparallel series (stringers). Barren quartz bodies with the same geometry and orientation also occur locally. The auriferous quartz bodies are composed predominantly of quartz and may contain variable amounts of pyrite, pyrrhotite, calcite, ankerite, muscovite, biotite, chlorite, hornblende, silver, garnet, galena, sphalerite, arsenopyrite, chalcopyrite, magnetite or feldspar. Within the auriferous bodies, most gold occurs in rich shoots or pods. For example, at the Battle Branch Mine in Lumpkin County in the northeastern portion of the Dahlonega gold belt (German, 1985), most gold is confined to thin layers within the quartz body (Park and Wilson, 1936). Gold mineralization at the Pine Mountain (Stockmar) Mine at Villa Rica appears to be somewhat similar to that of the Battle Branch Mine.

Closely associated with many of the auriferous quartz bodies are oxide, sulfide and aluminous facies iron formations. At several abandoned mines in the study area thin units of oxide facies iron formation were mined as gold ore, and, indeed, oxide facies iron formations in the gold belts are generally auriferous (McConnell and Abrams, 1984, p. 67; German, unpublished data). However, as Yeates and others (1896) often observed, the highest grade auriferous bodies tend to be distinct quartz bodies separate from, but spatially associated with, oxide facies iron formation.

The overall geologic setting of the gold deposits of the study area is very similar to those in the northeastern portion of the Dahlonega belt. Most of the gold occurs in quartz bodies within sequences of metavolcanic rocks or sequences of mixed metavolcanic and metasedimentary rocks, and most deposits are spatially associated with iron formation. Gold deposits in both the study area and the northeastern part of the Dahlonega belt show evidence of recrystallization and remobilization during regional metamorphism.

Notable differences between gold depoits in the study area and those in the northeastern part of the Dahlonega belt (German, 1985) also are apparent. One important

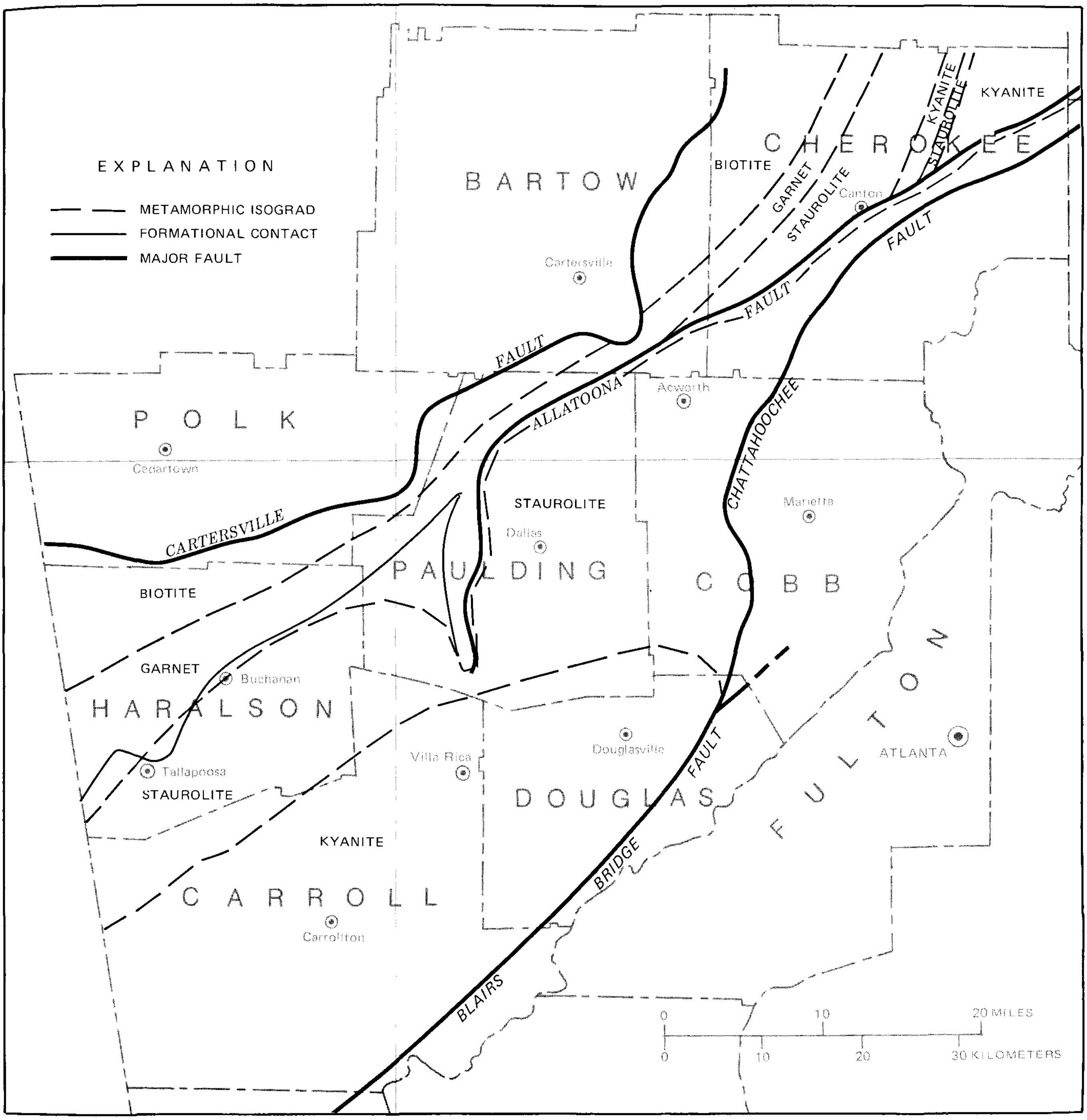

Figure 10. Metamorphic isograds in the study area (After McConnell and Abrams, 1984). Isograd boundaries are dotted where inferred.

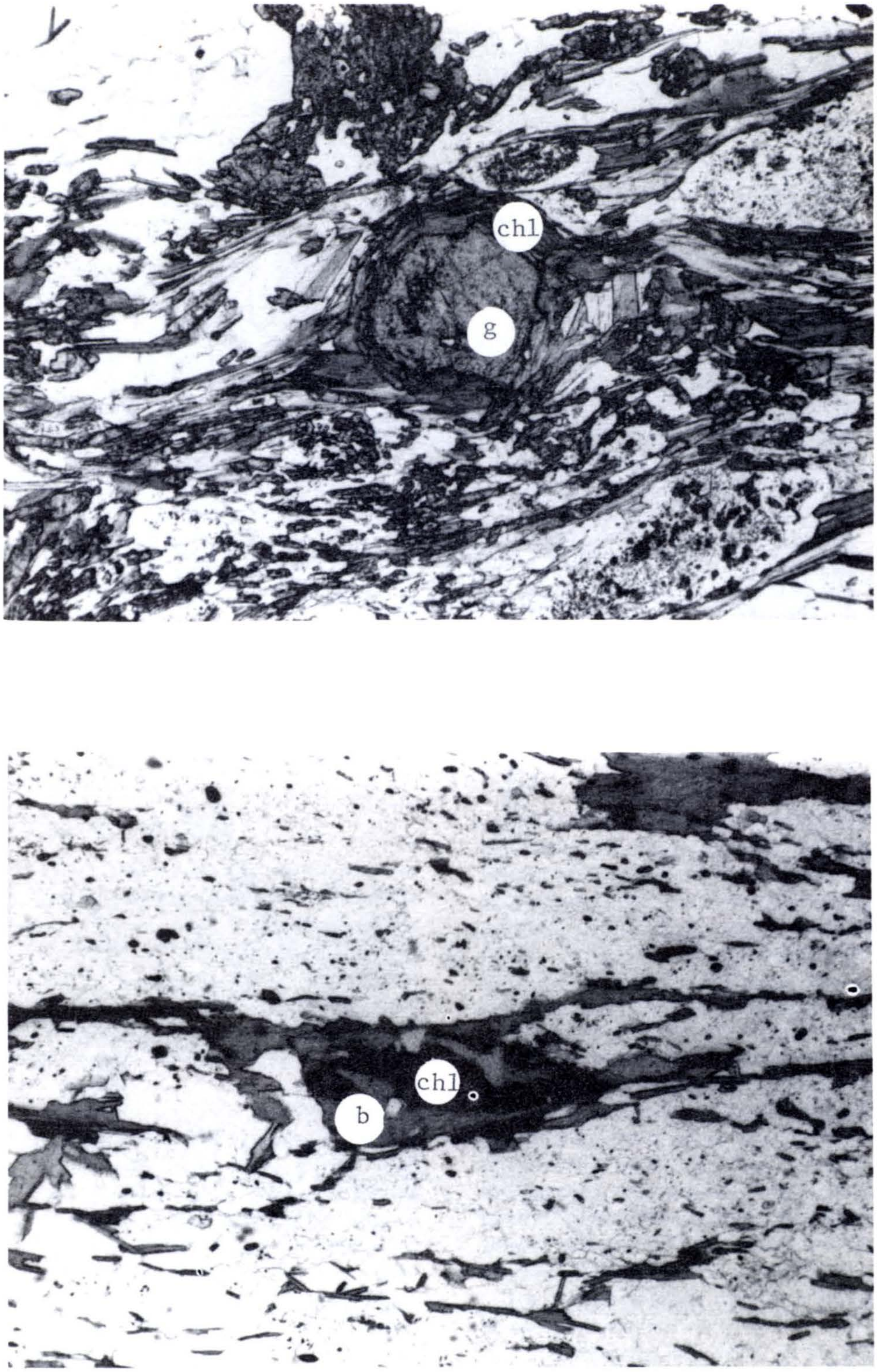

Figure 11. Local retrogression of garnet (g at top) and biotite (b at bottom) to chlorite (chl). Top photomicrograph is garnet-biotite-muscovite-chlorite-plagioclase-quartz gneiss of the Galts Ferry Gneiss (Burnt Hickory Ridge 7.5-minute quadrangle). Lower photomicrograph is chlorite-biotite-quartz-muscovite schist of the Bill Arp Formation (Bowden East 7.5-minute quadrangle).

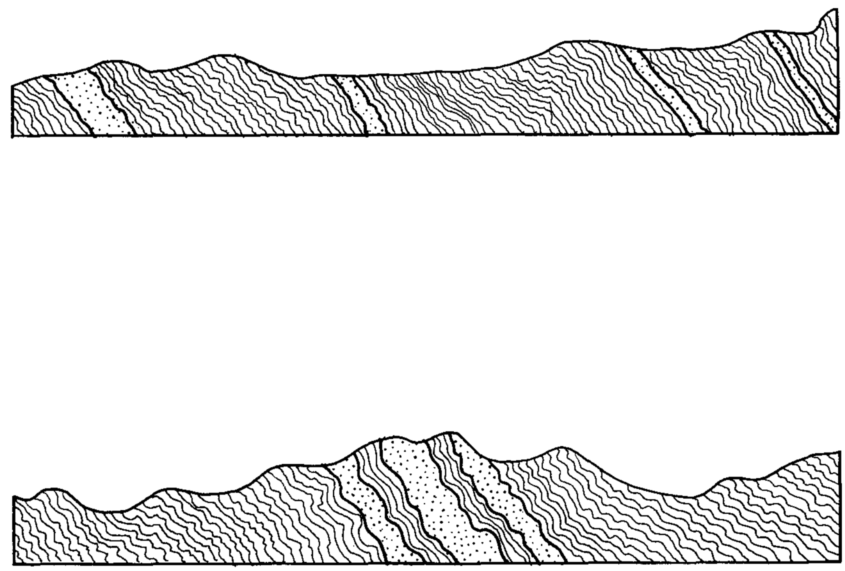

Figure 12. Diagrammatic cross-sections through the Evans gold property (top) and the Macou Mine (from Yeates and others, 1896) showing the concordant relationship between the auriferous quartz bodies (dot and dash pattern) and the host rocks.

difference is the nature of the host rocks. Over 50 percent of the gold deposits of the Carroll County belt are hosted by the Villa Rica Gneiss, a medium- to coarse-grained hypabyssal pluton of dacitic composition. The only deposit in the northeastern part of the Dahlonega belt that has a similar setting is the deposit at the Crisson Mine in Lumpkin County (German, 1985). All others occur within fine-grained metavolcanic rocks or metasedimentary rocks. Another feature unique to gold deposits in the study area is the spatial association of talc-chlorite-anthophyllite rocks and kyanite-sericite quartzite (metamorphosed hydrothermal alteration assemblages) with some mines within the Villa Rica Gneiss.

Gold Mining Districts

Introduction

Although abandonded mines and prospects occur throughout the study area, they are particularly abundant in the South Canton area in Cherokee County, the Burnt Hickory Ridge area in Paulding County and the Villa Rica area in Carroll and Douglas Counties. These areas were studied in detail for this report to determine the various controls on the occurrence of gold. The mines and prospects and their geologic setting in each area are discussed below. In this report each area is considered as a separate mining district.

South Canton District

The South Canton district (Figure 13), part of the Dahlonega gold belt, is located in the South Canton 7.5-minute topographic quadrangle in Cherokee County, northeast of the Little River and southeast of Lake Allatoona and the Etowah River. Geologically, this district is bounded by the Chattahoochee fault on the southeast and by the Allatoona fault on the northwest (Plate 2). Rocks in the district are a mixed metavolcanic and metasedimentary sequence of the Pumpkinvine Creek, Canton and Univeter Formations. Gold was mined from this district from at least fourteen mines and prospects beginning in about 1830 and continuing intermittently until about 1930 (Yeates and others, 1896; Jones, 1909; Pardee and Park, 1948).

Within the district, rocks of the Pumpkinvine Creek Formation consist of amphibolite, biotite-muscovite-quartz-plagioclase gneiss ± hornblende (Galts Ferry Gneiss Member), coarsely porphyroblastic garnet-biotite-hornblende-quartz plagioclase gneiss ± calcite and/or staurolite, chlorite schist, pyrite-sericite-quartz schist and iron formation. Rocks of the Canton Formation consist of interlayered phyllitic graphite-garnet-sericite-quartz schist ± biotite, silvery garnet-muscovite-biotite-quartz schist and minor amounts of biotite-plagioclase-quartz gneiss (metagraywacke); and those of the Univeter Formation consist of amphibolite, pyrolusite-stained sericite-quartz schist, light-colored, feldspathic sericite-quartz schist, muscovite-biotite-plagioclase-quartz gneiss, iron formation (Lost Mountain Member) and garnet-biotite-muscovite-quartz schist (Rose Creek Schist Member) (Table 2). The South Canton district is bounded on the northwest by biotite-muscovite-plagioclase-quartz metasandstone and quartz-biotite-muscovite schist of the Etowah Formation of the Great Smoky Group, and on the southeast by migmatized, plagioclase-biotite-muscovite-quartz schist and amphibolite of the Powers Ferry Formation of the Sandy Springs Group (eastern belt).

Outcrop patterns within the district define a regional,

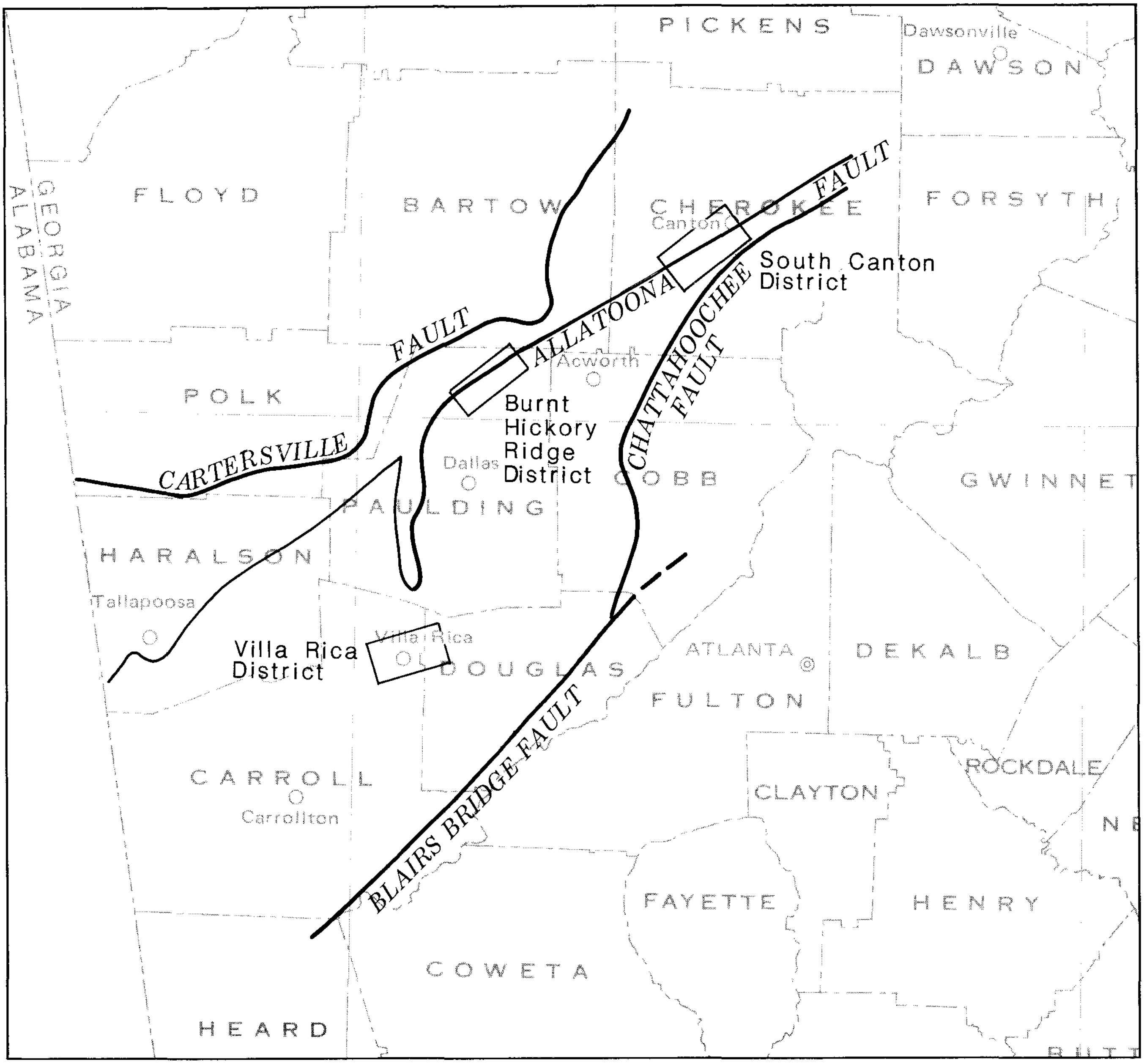

Figure 13. Outline of the study area showing important former gold-mining districts discussed in the text.

northwest-vergent antiform that is truncated on its northwestern limb by the Allatoona fault (Plate 2). This fold, which plunges gently to the northeast, is interpreted as an F_2 fold on a regional nappe (F_1). An alternate interpretation is that the fold is the axis of the regional nappe (F_1). The regional foliation strikes northeast, dips southeast and is axial planar except where deformed locally by small scale folds.

Abandoned gold mines and prospects are evenly distributed over the area. Those occurring within the Pumpkinvine Creek Formation include the Case, McCandless, Downing Creek, Sixes, Coggins, Cherokee and Lovingood Mines. Those located in the Canton Formation include the LaBelle, Macou and Casteel Mines. Mines in the Univeter Formation include the Putnam, 301 and Haynes. Workings of the Clarkston Mine are astride the contact between the Pumpkinvine Creek and Canton Formations. Mining methods employed in this district included placer, open-cut and underground lode mining.

Most mines and prospects in the South Canton district occur within metavolcanic rocks in the Pumpkinvine Creek and Univeter Formations. Mine workings are particularly abundant in the vicinity of or along the strike of thin (<1 ft.) units of iron formation. Those mines or prospects directly associated with iron formation include the Clarkston, Cherokee and Putnam. Those spatially associated with iron

TABLE 2
Modal Analysis of Selected Rocks of the South Canton District*

	Pumpkinvine Creek Formation				Canton Formation			Univeter Formation				Etowah Formation			Powers Ferry Formation	
Sample #	SC-6	SC-14	SC-23	SC-26	SC-5	SC-20	SC-21	SC-9	SC-11	SC-17	SC-30	SC-1	SC-2	SC-25	SC-12	SC-28
Quartz	68		10		70	37	35	65	46	39	44	85	5	76	72	39
Plagioclase (albite/oligoclase)		35		44				10	2			5		10	5	25
Hornblende		56	5	55								2				
Biotite	2				15		4	10	15	15	10	2	10	5	7	30
Muscovite	15				9	36	40	10	25	35	40		85	5	15	2
Garnet	2		1		5	15	10		2	10	5					1
Chlorite	3		80	tr	tr			tr	3	tr	1	1		3	tr	
Epidote/Clinozoisite		7	1	tr				5	1			5	tr			3
Sphene		2														tr
Magnetite/Ilmenite	3	tr	3	1	1	2	1		2	1		tr	tr	1	1	
Calcite/Ankerite	5								1							
Staurolite					tr	tr	tr									
Kyanite									tr							
Tourmaline	2				tr	tr	tr		tr	tr	tr			tr		
Pyrite/Pyrrhotite								tr	2							
Graphite						10	10									
Zircon									1	tr						

*Visual estimates

formation include the Case and the 301. The Cherokee Mine is especially interesting. This mine consists of numerous surface and underground workings that are confined to a sequence of interlayered amphibolite, pyrolusite-stained sericite-quartz schist, magnetitie-garnet-muscovite-quartz gneiss, feldspathic sericite-quartz schist and iron formation. The gold reportedly occurred in concordant, sulfidic quartz bodies (Yeates and others, 1896; Jones, 1909). This sequence of lithologies is located at the contact between the Pumpkinvine Creek and Canton Formations and is very similar to the sequence found on Findley Ridge at Dahlonega (Cook and Burnell, 1983; German, 1985, 1986).

Not all mines and prospects in this district occur within rocks clearly of volcanic origin. The LaBelle Mine and Macou and Casteel prospects are located within rocks of the Canton Formation that, at least in this district, seem to be largely sedimentary in origin although some of the graphitic schists may have volcanic affinities. Gossan-like float found in and near workings of the LaBelle Mine suggests that the ore was an auriferous pyritic zone within the graphitic schists. Workings of the Macou and Casteel prospects that have not been destroyed by residential development are on strike with those of the LaBelle and probably followed the same pyritic zone.

Burnt Hickory Ridge District

The Burnt Hickory Ridge district (Figure 13), like the South Canton district, is part of the Dahlonega gold belt. Located in Paulding County, this district covers an area that includes the southwestern quarter of the Burnt Hickory Ridge 7.5-minute topographic quadrangle and a small portion of the northwestern corner of the Dallas, northeastern corner of the Yorkville and southeastern corner of the Taylorsville 7.5-minute topographic quadrangles. This district is bounded on the northwest by the Allatoona fault and on the southeast by an unnamed fault (Plate 3). This district is on strike with South Canton district and contains some of the same rock units. Gold was mined from at least ten mines and prospects during the period between 1845 and 1900 (Yeates and others, 1896; Jones 1909). Manganese and massive sulfide deposits were also mined from this area during the same time period (Shearer and Hull, 1918; McConnell and Abrams, 1984). Although previously mapped (Crawford, 1976; McConnell, 1980; McConnell and Abrams, 1984), this area was remapped in detail for this study.

Rocks in the Burnt Hickory Ridge district (Plate 3) include those of the Pumpkinvine Creek Formation and the Canton Formation (Table 3). Within the district, rocks of the Pumpkinvine Creek Formation consist of fine- to medium-grained amphibolite with minor biotite-plagioclase-quartz gneiss (quartzfeldspathic gneiss) and iron formation. Light-colored, fine- to medium-grained biotite-muscovite-quartz-plagioclase gneiss and muscovite-plagioclase-quartz gneiss was mapped as the Galts Ferry Gneiss Member.

Rocks of the Canton Formation consist of a sequence of interlayered biotite-quartz schist, biotite-chlorite-muscovite-quartz schist, biotite-muscovite-quartz schist, graphite-garnet-muscovite-quartz schist, biotite-chlorite-plagioclase-quartz schist, amphibolite, biotite-amphibole gneiss, sericite-quartz schist and iron formation. This sequence of rocks crops out in the center of the district and along the northwestern border. Chlorite is abundant locally in this sequence, and all except three of the gold mines in this district are confined to this unit (Plate 3).

Bordering the Burnt Hickory Ridge district on the northwest are chlorite-biotite-sericite-quartz phyllite ± graphite and biotite-sericite-plagioclase-quartz metasiltstone of the Etowah Formation of the Great Smoky Group. Rocks on the southeast boundary of the district consist of hornblende-biotite-quartz-plagioclase gneiss and amphibolite. Based on lithologic similarities and metamorphic grade, McConnell and Abrams (1984) interpreted these rocks on the southeast as a klippe of rocks of the Powers Ferry Formation of the Sandy Springs Group (eastern belt).

The Burnt Hickory Ridge district is located along the same regional fold as the South Canton district. Outcrop pattern of rocks in the Burnt Hickory Ridge district suggest that the structure here is somewhat more complicated than in the South Canton district (Plate 3). The manner in which units are repeated or are absent suggests that faults and/or parasitic folds complicate the local structure.

Mine workings in this district consist of placer workings in stream valleys; open-cuts, pits and trenches in saprolite; and underground lode mining in relatively fresh rock. Nearly all mines and prospects are located in the sequence of schists with minor amphibolite and iron formation that is the southwesternmost extent of the Canton Formation. At least one thin (< 2 ft.) unit of iron formation can be mapped through most of the mines and prospects. The presence of iron formation, amphibolite and rock that may be metamorphosed felsic volcanics (sericite-quartz-schist) here in the Canton Formation indicate a mixed metasedimentary/ metavolcanic environment. This obvious lithologic control for most gold deposits in this district strongly suggests a syngenetic origin for the gold.

Villa Rica District

The Villa Rica district is located in Douglas, Carroll and Paulding Counties around the town of Villa Rica, Georgia (Figure 13). This district covers part of the New Georgia, Villa Rica, Nebo and Winston 7.5 minute topographic quadrangles (Plate 4). Gold and some massive sulfide deposits were mined from this district mainly prior to 1900. Previous reports on this area include those by Yeates and others (1896), Brewer, (1897), Jones (1908), Cook (1970), Crawford and Medlin (1973), Pate (1980), Abrams and others (1981), Abrams and McConnell (1981a) and McConnell and Abrams (1984). The Villa Rica district is part of the Carroll County gold belt as defined by Jones (1909).

Rocks in the Villa Rica district (after McConnell and Abrams, 1984) are a sequence of mixed metavolcanic and metasedimentary rocks that make up part of the New Georgia Group and Sandy Springs Group (western belt) (Table 4). Rocks of the Mud Creek Formation of the New Georgia Group underlie part of this district and consist of amphibolite, garnet-biotite-quartz-plagioclase gneiss and biotite schist (Mud Creek Formation undifferentiated); biotite-quartz-plagioclase orthogneiss (Villa Rica Gneiss Member); and magnetite quartzite (Cedar Lake Quartzite Member). Formations of the Sandy Springs Group (western belt) exposed in this district include the Bill Arp Formation, Andy Mountain Formation and the Dog River Formation. The Bill

TABLE 3
Modal Analysis of Selected Rocks of the Burnt Hickory Ridge District*

	Pumpkinvine Creek Formation					Galts Ferry Gneiss			Canton Formation		
	BH-1	BH-4	BH-12	BH-14	BH-21	BH-2	BH-9	BH-19	BH-8	BH-125	BH-18
Quartz						45	40	45	78	50	66
Plagioclase (albite/oligoclase)	30	20	42	48	20	35	44	44	10		3
Hornblende	35	65	52	49	65						
Biotite							5	2	1	5	20
Muscovite						20	10	2	tr	40	
Garnet							tr	1		1	
Chlorite								3	10	3	5
Epidote/Clinozoisite	35	15	3	tr	14	tr	1	3			2
Sphene					1						
Magnetite/Ilmenite	tr		3	3		tr			1	1	
Calcite/Ankerite										tr	3
Tourmaline										tr	1

*Visual estimates

TABLE 4
Modal Analysis of Selected Rocks of the Villa Rica District*

	Amphibolite within Villa Rica Gneiss		Villa Rica Gneiss				Austell Gneiss
	VR-1	VR-2	TJ**	N-34**	232-2**	VR-17**	233A**
Quartz			25	24	22	15	20
Plagioclase (albite/oligoclase)	15	15	65	60	65	50	27
Microcline				3		2	35
Hornblende	73	70	1	1			
Biotite			4	4	5	15	6
Muscovite			3	3	5		3
Epidote/Clinozoisite	10	13	2	5	4	15	2
Sphene	2	1					
Magnetite/Ilmenite		1					

*Visual estimates
**From Abrams (1983)

Arp Formation consists of interlayered garnet-biotite-muscovite-plagioclase-quartz schist, muscovite schist, quartz-muscovite-biotite schist, muscovite-biotite-quartz-plagioclase schist and muscovite-biotite-quartz-feldspar gneiss (metagraywacke) (McConnell and Abrams, 1984). The Andy Mountain Formation consists of biotite-garnet-plagioclase-muscovite quartz schist and micaceous quartzite ± garnet and/or feldspar (McConnell and Abrams, 1984). The Dog River Formation consists of muscovite-biotite-quartz-feldspar gneiss (metagraywacke), garnet-muscovite schists, amphibolite and iron formation (McConnell and Abrams, 1984). Also present in this district are magnetite quartzite (iron formation); an undifferentiated sequence of interlayered amphibolite, hornblende gneiss and quartzofeldspathic gneiss; and metamorphosed hydrothermal alteration assemblages consisting of olivine, actinolite, talc, anthophyllite and chlorite.

The Villa Rica district is centered about an elongate dome that plunges gently northeast and southwest. This dome was interpreted as an F_2 fold by McConnell and Abrams (1984). The core of the dome is the Villa Rica Gneiss Member of the Mud Creek Formation and its flanks are undifferentiated Mud Creek Formation.

Of the 18 gold mines and prospects located in the Villa Rica district, 17 are located within the Villa Rica Gneiss. This gneiss is dacitic in composition and is locally interlayered with amphibolite and metasedimentary rocks. These factors led McConnell and Abrams (1984) to interpret this unit as a dacitic, subvolcanic intrusive. Mining techniques employed in the district consisted of placer mining of stream gravels, open-cut mining of saprolite and a small amount of underground lode mining. Open-cut mining of saprolite appears to have been the most commonly used mining method in this district. Extensive overlapping open-cuts and pits can be observed at the Clopton (Clompton) and Pine Mountain (Stockmar) Mines. Mining of the saprolite mantle of the Villa Rica Geniss probably was made easy since the gneiss is deeply weathered throughout the district. The absence of extensive underground workings in fresh rock suggests a supergene enrichment of gold in saprolite of the Villa Rica

Gneiss. The Pine Mountain (Stockmar) Mine and possibly the McManus property are associated with a unique siliceous zone in the Villa Rica Gneiss (Plate 4). The zone is a pyrite-paragonite-muscovite quartzite ± kyanite and is interpreted as a metamorphosed hydrothermal alteration assemblage (Abrams and McConnell, 1984).

Other Areas

In addition to those districts previously described, other areas contain significant numbers of abandoned mines and prospects. One such area is around the town of Acworth (Plate 1). Although the density or historical importance of abandoned mines and prospects here is not as great as in the Burnt Hickory Ridge district to the southwest or the South Canton district to the northeast, several abandoned mines occur scattered over parts of Bartow, Cherokee and Cobb Counties. Most of these were small-scale operations although notable exceptions were the Georgianna and the Bell Star Mines. In the Acworth area, mines and prospects occur within the Pumpkinvine Creek Formation, Univeter Formation and the Kellogg Creek Mafic Complex of the New Georgia Group (McConnell and Abrams, 1984) along the flanks of an F_2, faulted fold.

Significant gold deposits that do not occur in the New Georgia Group include the Bonner Mine in Carroll County and mines and prospects north and south of Tallapoosa, in Haralson County. The Bonner Mine is located within garnet-muscovite-biotite-quartz schist with minor amphibolite and iron formation of the Dog River Formation of the Sandy Springs Group (western belt). Although located in a unit that contains few, if any, other gold deposits, the Bonner Mine was a major producer in the state between 1840 and 1860 (Appendix 1).

Of the mines and prospects south of Tallapoosa, the Royal-Vindicator Mine was by far the most important. This mine was operated from about 1840 intermittently until 1920. The mine workings are located in quartz bodies within a quartzofeldspathic gneiss which is part of a sequence of interlayered greenstone and quartzofeldspathic gneiss (Paris, 1986). The correlation of the greenstone/quartzofeldspathic gneiss sequence with other units in the study area is uncertain; however, the sequence is most likely correlative with the Hillabee Greenstone to the southwest in Alabama since the two units are lithologically similar and occupy similar stratigraphic positions between rocks of the northern Piedmont and Talladega belt provinces. An alternate correlation is with the Pumpkinvine Creek Formation to the northeast. Gold at the Royal-Vindicator Mine is disseminated throughout the ore body within the quartzofeldspathic gneiss. The ore body does not exhibit the same degree of recrystallization as other ore bodies in the study area, possibly as a result of the slightly lower metamorphic grade (garnet) in the mine area compared to most other localities (staurolite to kyanite) in the study area. The lack of significant recrystallization also could be attributed to less intense deformation in the mine area.

The prospects north of Tallapoosa include the Layton, Edwards, Brock and an unnamed prospect. The lack of extensive abandoned workings at these prospects appears to indicate minor amounts of gold, but the prospects are significant in that they occur within rocks of the Talladega belt, indicating that the Talladega belt may have an unrealized potential for the occurrence of gold in economic quantities.

Sulfide Deposits

Closely associated with the gold deposits in the study area are massive and disseminated sulfide deposits. Though sulfide mines are not as common as gold mines within the study area, sulfide deposits were mined and prospected intermittently from the 1840's to the 1920's (Shearer and Hull, 1918; Cook, 1970; Abrams and McConnell, 1984). Gold and sulfide deposits in the study area occur within the same geologic units. Deposits occur within the Univeter and Mud Creek Formations of the New Georgia Group, undifferentiated rocks of the New Georgia Group and in the Dog River Formation of the Sandy Springs Group (western belt).

Most sulfide mines and prospects occur within the northwestern and central portions of the study area. Important mines include the Reeds Mountain, Smith-McCandless and Tallapoosa (Waldron) Mines in Haralson County; the Little Bob, Rush-Banks and Swift (McClarity) Mines in Paulding County; the Villa Rica (Durgy) Mine in Douglas County; and the Bell Star (Southern Star) Mine in Cherokee County. More detailed information than will be presented here can be found in reports by Shearer and Hull (1918), Cook (1970), Abrams and McConnell (1984, 1986).

Within the study area sulfide mines occur within diverse host rock assemblages. Host rocks include amphibolite, hornblende gneiss, quartzofeldspathic gneiss, chlorite schist ± garnet, mica-quartz schist, sericite quartzite, sericite schist and garnet biotite gneiss (Abrams and McConnell, 1986). Most of the sulfide deposits occur within lithologic units dominated by mafic metavolcanic rocks although the ore body itself may occur in any of the other lithologies mentioned above. Most deposits are also closely associated with oxide and sulfide facies iron formation and various lithologies interpreted as alteration zones by Abrams and McConnell (1984, 1986). The alteration zones consist of chlorite schists ± garnet, sericite schists and quartzites, chlorite-anthophyllite schists ± talc and cummingtonite, and kyanite-quartz granofels. Abrams and McConnell (1984, 1986) interpreted the alteration zones as metamorphosed, hydrothermally altered rocks that served as conduits for hydrothermal fluids. Ore minerals are predominantly pyrite, pyrrhotite and chalcopyrite with small amounts of sphalerite, galena, magnetite, chalcocite, gahnite, silver and gold (Shearer and Hull, 1918; Cook, 1970; Abrams and McConnell, 1984, 1986). Calcite, quartz, biotite, chlorite, amphibole, sericite and garnet are typical gangue minerals (Shearer and Hull, 1918; Cook, 1970).

Shearer and Hull (1918) and Cook (1970) interpreted the sulfide deposits within the study area as epigenetic deposits that resulted from hydrothermal replacement of country rock along shear zones. The volcanic affinity of the host rock assemblages, the stratabound nature of most ore bodies, ore mineralogy, and an overall similarity to many volcanogenic sulfide deposits strongly suggests that these deposits are volcanogenic in origin. This interpretation is also favored by McConnell and Abrams (1984) and Abrams and McConnell (1984, 1986).

The occurrence of gold in many of the sulfide deposits makes them potential sources for this metal. Gold was reported in ore-grade quantities (at current prices) at two of the sulfide deposits. The Villa Rica (Durgy) Mine, which began as a gold mine, contained ore that averaged 0.3 oz.Au/ton (Yeates and others, 1896). Ore at the Tallapoosa Mine averaged 0.1 oz.Au/ton (Shearer and Hull, 1918).

Tectonic Setting

This investigation has revealed that most gold deposits within the study area are hosted by rocks interpreted as metamorphosed volcanic rocks and include quartzofeldspathic gneisses, amphibolite and iron formation. The association between metavolcanic rocks and gold deposits is evident in the South Canton, Burnt Hickory Ridge and Villa Rica districts, as well as in other regions of the study area. In these areas gold is confined almost exclusively to sequences of metavolcanic rocks or sequences of mixed metavolcanic and metasedimentary rocks and to placers derived from them (Plates 2, 3, 4). Mafic and felsic metavolcanic sequences that host numerous gold deposits are the Pumpkinvine Creek Formation, the Lost Mountain Member of the Univeter Formation and the Villa Rica Gneiss Member of the Mud Creek Formation. Predominantly metasedimentary units that host gold deposits are the Canton Formation and the Dog River Formation. All of the above units are part of the New Georgia Group with the exception of the Dog River Formation which is part of the Sandy Springs Group (western belt).

The volcanic affinity for many of the rocks in the study area has been well-documented. Local relict features such as pillows (Hurst and Jones, 1973; McConnell and Abrams, 1984) and amygdules (McConnell and Abrams, 1984; German, 1985) have been recognized in amphibolites of the Pumpkinvine Creek Formation and Univeter Formation. Felsic gneisses within the Pumpkinvine Creek Formation, within undifferentiated rocks of the New Georgia Group and within the Lost Mountain Member of the Univeter Formation exhibit megacrystic textures that are interpreted as recrystallized volcanic textures (German, 1985; this study). Published whole rock and trace element analyses of amphibolites in the study area and adjoining areas show a strong abyssal tholeiite affinity (McConnell, 1980; McConnell and Abrams, 1984; German, 1985). Associated felsic gneisses are dacitic (quartz diorite) in composition and are interpreted as metamorphosed tuffs, lava flows and/or hypabyssal intrusions (McConnell, 1980; McConnell and Abrams, 1984; German, 1985). Banded magnetite quartzite (iron formation) $\pm$ sulfides and/or garnet, kyanite-quartz granofels, chlorite-anthophyllite rock and tourmalinite interlayered with or closely associated with the quartzofeldspathic gneisses and amphibolites are interpreted as either metamorphosed, chemically precipitated exhalative rocks or metamorphosed hydrothermally altered rocks often associated with base or precious metal deposits.

Major oxide and selected trace element chemistry of most amphibolites and greenstones collected for this study (Table 5, Figures 14, 15, 16, 17, 18) suggest an abyssal tholeiite affinity. Some deviations are notable, however, and are discussed below. Analyses from McConnell and Abrams (1984) and German (1985) are plotted for comparison (Figures 14, 15, 16) and tend to substantiate the abyssal tholeiite affinity.

Plots of TiO_2 and nickel versus FeO*/MgO (Figures 15 and 16) show the strongest tendency to fall in the abyssal tholeiite field. Chromium versus FeO*/MgO also shows this tendency (Figure 14), but to a lesser degree. Winchester and Floyd (1977) and Floyd and Winchester (1978) suggest that chromium and nickel may not always be immobile during metamorphism. However, the consistent trend illustrated in Figures 14, 15 and 16 of rocks collected over a wide area, and of greenschist to amphibolite facies metamorphism, strongly suggests that those elements were largely immobile in rocks of the northern Piedmont of Georgia. Amphibolites and greenstones in the study area were also analyzed for vanadium (Figure 17). Again, an abyssal tholeiite affinity is strongly suggested.

Figures 14, 15, and 18 show that the nickel/chromium content of greenstones at the Royal-Vindicator Mine and amphibolites interlayered with the Villa Rica Gneiss are relatively low, whereas the nickel/chromium content of amphibolites of the Pumpkinvine Creek and Dog River Formations are relatively high. This illustrated trend probably indicates that the protoliths of the greenstones at the Royal-Vindicator mine and the amphibolites interlayered with the Villa Rica Gneiss were more andesitic in composition than those of the Pumpkinvine Creek and Dog River Formations (Krauskopf, 1979, p. 478) or represented island arc basalts (Pearce and Cann, 1973). More data are needed on the Royal-Vindicator and Villa Rica Gneiss rocks before a definite affinity can be adequately postulated.

The apparent chemical affinity between most amphibolites and greenstones in the study area and abyssal tholeiites suggests that mafic metavolcanic rocks in the Dahlonega and Carroll County gold belts were formed at an oceanic ridge or in a back-arc basin. Although mafic rocks formed in these two environments tend to be chemically indistinct (Rogers, 1982), the presence of a large volume of metamorphosed, continentally derived sediments and possible volcaniclastic rocks strongly favors a back-arc basin environment (Figure 19). The suggested island arc affinity of some rocks also is supportive of this tectonic setting since both abyssal tholeiites and island arc basalts could be deposited there. Abrams and McConnell (1984) suggest that continental crust underlying part of the back-arc basin could have provided a source for the relatively large quantity of felsic metavolcanic rocks also found in the study area.

Genesis of Gold Deposits

The close association between gold deposits in the study area and certain lithologies was recognized by early investigators (Yeates and others, 1896; Jones, 1909; Pardee and Park, 1948). They reported that the gold miners in Georgia had recognized and actively exploited this association in the discovery of new deposits. Yeates and others (1896), Lindgren (1906), Jones (1909) and Pardee and Park (1948) believed the gold deposits are epigenetic in origin and were

TABLE 5
Whole Rock and Selected Trace Element Analyses of Mafic Metavolcanic Rocks From the Study Area*

Major Oxide	Pumpkinvine Creek Formation				Amphibolites in Villa Rica Gneiss		Greenstones at Royal-Vindicator mine			Dog River Formation						
	BH-12	BH-14	BH-20	BH-21	VR-1	VR-2	92-1	156-1	132-2	CAR-1	CAR-5	CAR-31	CAR-33	CAR-34	CAR-35	CAR-36
%SiO_2	48.6	45.7	47.7	48.0	47.6	48.8	48.9	50.0	47.0	53.3	52.8	50.6	50.5	46.3	44.2	51.3
%$A1_2O_3$	13.3	14.0	15.3	13.9	14.7	14.8	14.8	16.1	15.2	14.2	13.8	14.1	13.9	15.9	14.6	16.1
%Fe_2O_3	3.60	5.20	3.2	3.2	4.4	4.2	3.5	4.2	4.0	4.5	3.1	3.9	5.1	5.0	6.6	4.5
%FeO	12.2	11.4	7.6	8.3	7.4	6.9	7.5	5.3	7.1	8.8	8.0	7.8	10.2	10.1	4.2	4.6
%MgO	4.60	6.1	7.7	7.0	7.8	7.3	8.0	6.6	7.7	4.5	6.6	6.9	4.6	6.3	7.8	6.7
%CaO	8.40	7.5	12.0	12.2	12.6	12.6	11.9	9.5	12.8	6.6	7.7	8.7	9.2	9.9	17.9	9.2
%Na_2O	3.5	3.9	2.5	2.2	2.1	1.8	2.5	4.2	2.3	5.0	4.0	4.3	2.8	2.8	0.36	4.0
%K_2O	0.24	0.18	0.2	0.14	0.31	0.4	0.2	0.08	0.12	0.07	0.12	0.11	0.19	0.18	0.06	0.4
%TiO_2	2.4	2.3	0.93	1.40	1.3	1.2	1.1	1.0	1.3	1.8	1.0	1.3	2.1	1.7	0.69	0.6
%MnO	0.27	0.24	0.21	0.21	0.19	0.2	0.19	0.27	0.22	0.26	0.25	0.21	0.22	0.28	0.58	0.11
%P_2O_5	0.26	0.29	0.06	0.11	0.08	0.1	0.13	0.12	0.11	0.12	0.03	0.11	0.13	0.14	0.07	0.09
%LOI	0.37	1.2	0.85	0.78	0.8	0.8	1.8	3.0	1.9	0.16	0.27	0.91	0.34	0.3	1.5	1.7
Total	97.7	98.0	98.2	97.4	99.2	99.1	100.5	100.3	99.7	99.3	97.6	98.9	99.2	98.9	98.5	99.3
Trace Element																
ppm V	465	560	265	315	330	310	290	280	310	435	310	315	560	470	255	300
ppm Cr	100	200	500	445	85	75	45	30	45	145	200	220	50	50	520	440
ppm Ni	100	100	175	100	35	35	30	30	45	50	100	100	50	50	200	125

*Analyses performed by Skyline Labs, Inc.
Ferrous iron analyses by wet chemical methods.
All others by ICP.

TABLE 5 (Cont'd)
CIPW NORMS

Major Oxide	Pumpkinvine Creek Formation				Amphibolites in Villa Rica Gneiss		Greenstones at Royal-Vindicator mine			Dog River Formation						
	BH-12	BH-14	BH-20	BH-21	VR-1	VR-2	92-1	156-1	132-2	CAR-1	CAR-5	CAR-31	CAR-33	CAR-34	CAR-35	CAR-36
q	0.26			0.48		2.37				2.32	1.86		6.38		1.95	
c																
or	1.42	1.06	1.18	0.83	1.83	2.36	1.18	0.47	0.71	0.41	0.71	0.65	1.12	1.06	0.35	2.36
ab	29.62	33.00	21.16	18.62	17.77	15.23	21.16	35.54	19.46	42.31	33.85	36.39	23.69	23.69	3.05	33.85
an	19.87	20.16	29.94	27.64	29.77	31.12	28.57	24.84	30.80	16.10	19.35	18.85	24.80	30.29	38.05	24.80

TABLE 5 (Cont'd)
CIPW NORMS

Major Oxide	Pumpkinvine Creek Formation				Amphibolites in Villa Rica Gneiss		Greenstones at Royal-Vindicator mine			Dog River Formation						
	BH-12	BH-14	BH-20	BH-21	VR-1	VR-2	92-1	156-1	132-2	CAR-1	CAR-5	CAR-31	CAR-33	CAR-34	CAR-35	CAR-36
lc																
ne																
kp																
ac																
ns																
ks																
wo																
di-di	7.60	7.08	16.20	17.08	19.00	18.16	16.96	13.54	18.90	7.37	9.64	12.99	8.84	8.78	36.05	13.37
di-hd	9.23	5.40	7.49	9.12	6.96	6.61	6.99	3.67	6.87	5.70	5.59	6.16	7.70	5.92	3.56	2.75
di	16.82	12.48	23.68	26.20	25.96	24.76	23.94	17.21	25.77	13.07	15.23	19.15	16.54	14.70	39.61	16.12
hy-en	7.94	2.27	4.63	9.52	8.17	9.77	8.72	4.00	4.91	7.79	11.97	4.98	7.36	6.27	2.72	9.44
hy-fs	11.06	1.99	2.45	5.83	3.43	4.08	4.12	1.24	2.05	6.92	7.97	2.71	7.36	4.84	0.31	2.23
hy	19.00	4.26	7.08	15.35	11.60	13.85	12.83	5.24	6.95	14.71	19.94	7.69	14.72	11.11	3.03	11.67
ol-fo		6.75	4.94		1.72		2.35	4.32	3.86			4.33		3.75		0.74
ol-fa		6.51	2.88		0.79		1.22	1.48	1.77			2.60		3.20		0.19
ol		13.26	7.82		2.51		3.57	5.80	5.64			6.93		6.95		0.93
cs																
mt	5.22	7.54	4.64	4.64	6.38	6.09	5.07	6.09	5.80	6.52	4.49	5.65	7.39	7.25	9.57	6.52
il	4.56	4.37	1.77	2.66	2.47	2.28	2.09	1.90	2.47	3.42	1.90	2.47	3.99	2.32	1.31	1.14
hm																
nc																
tn																
pf																
ru																
ap	0.62	0.69	0.14	0.26	0.19	0.24	0.31	0.28	0.26	0.28	0.07	0.26	0.31	0.33	0.17	0.21
cc																
pr																
th																
fr																
zr																
hl																
cm																
Total	97.39	96.83	97.41	96.67	98.49	98.31	98.73	97.38	97.86	99.16	97.40	98.04	98.95	98.61	9707	97.61

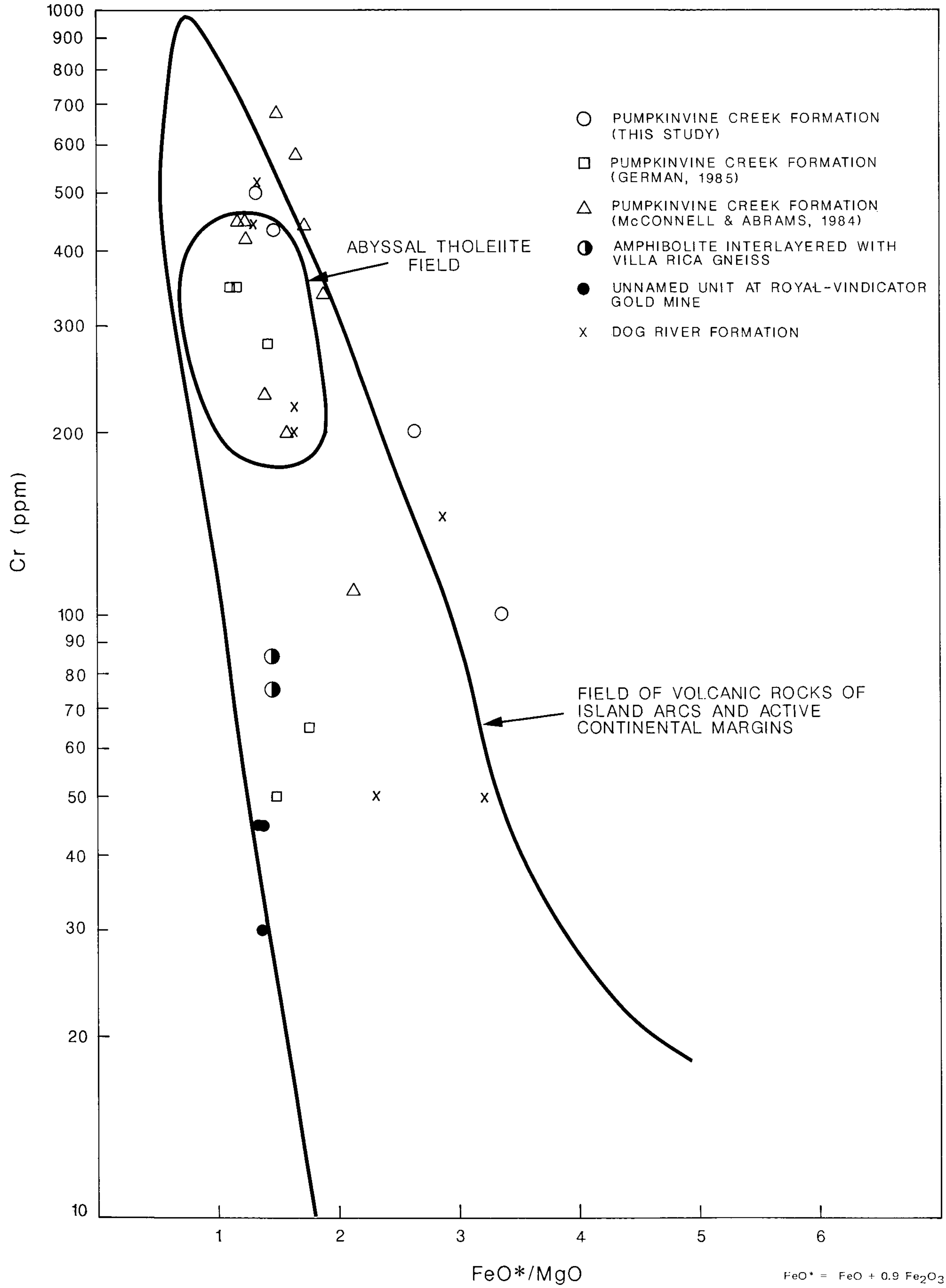

Figure 14. Discrimination of mafic metavolcanic rocks based on ppm Cr versus FeO*/MgO after Miyashiro and Shido (1975). Data from McConnell and Abrams (1984) and German (1985) are plotted for comparison.

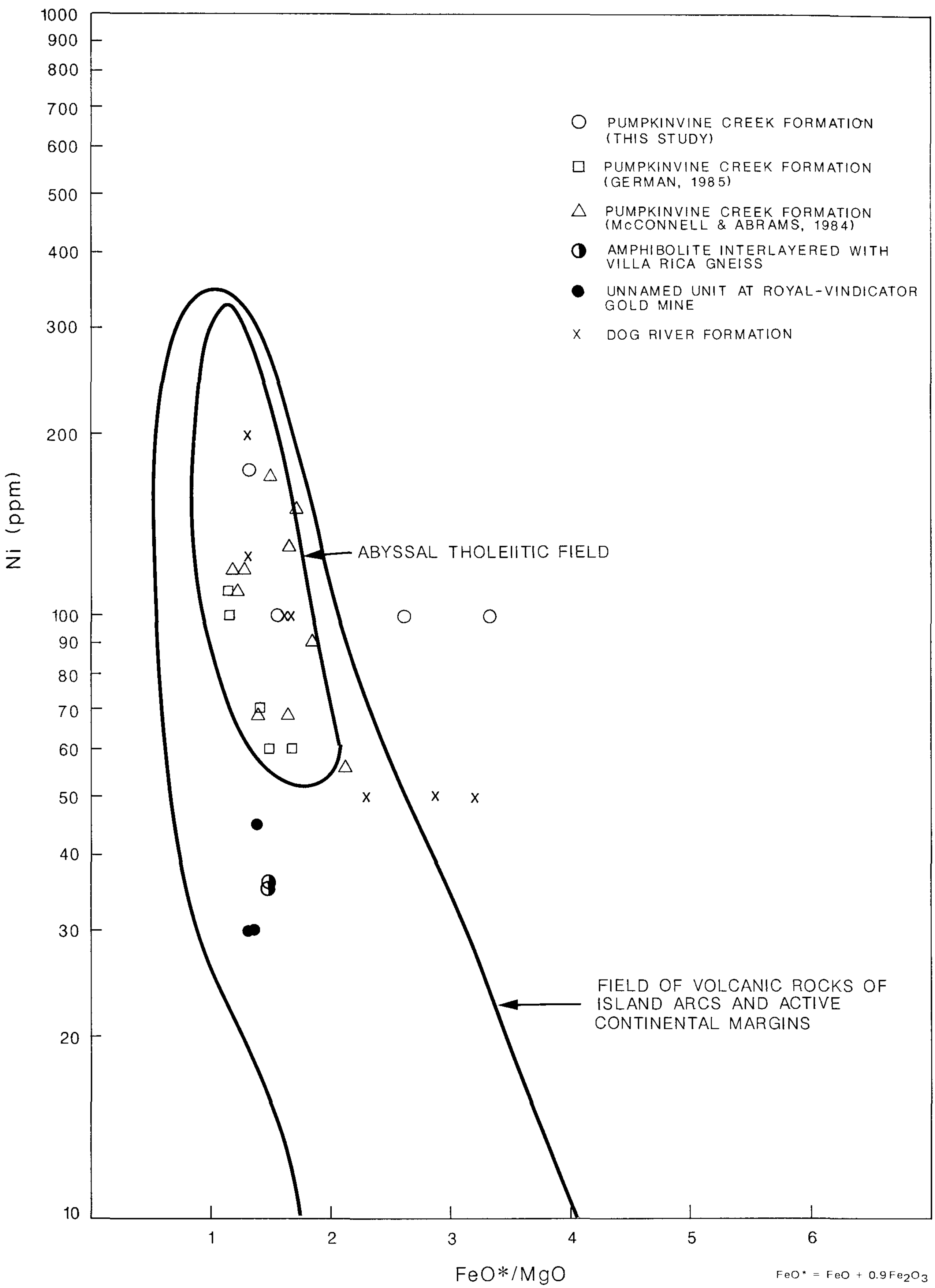

Figure 15. Discrimination of mafic metavolcanic rocks based on ppm Ni versus FeO*/MgO after Miyashiro and Shido (1975). Data from McConnell and Abrams (1984) and German (1985) are plotted for comparison.

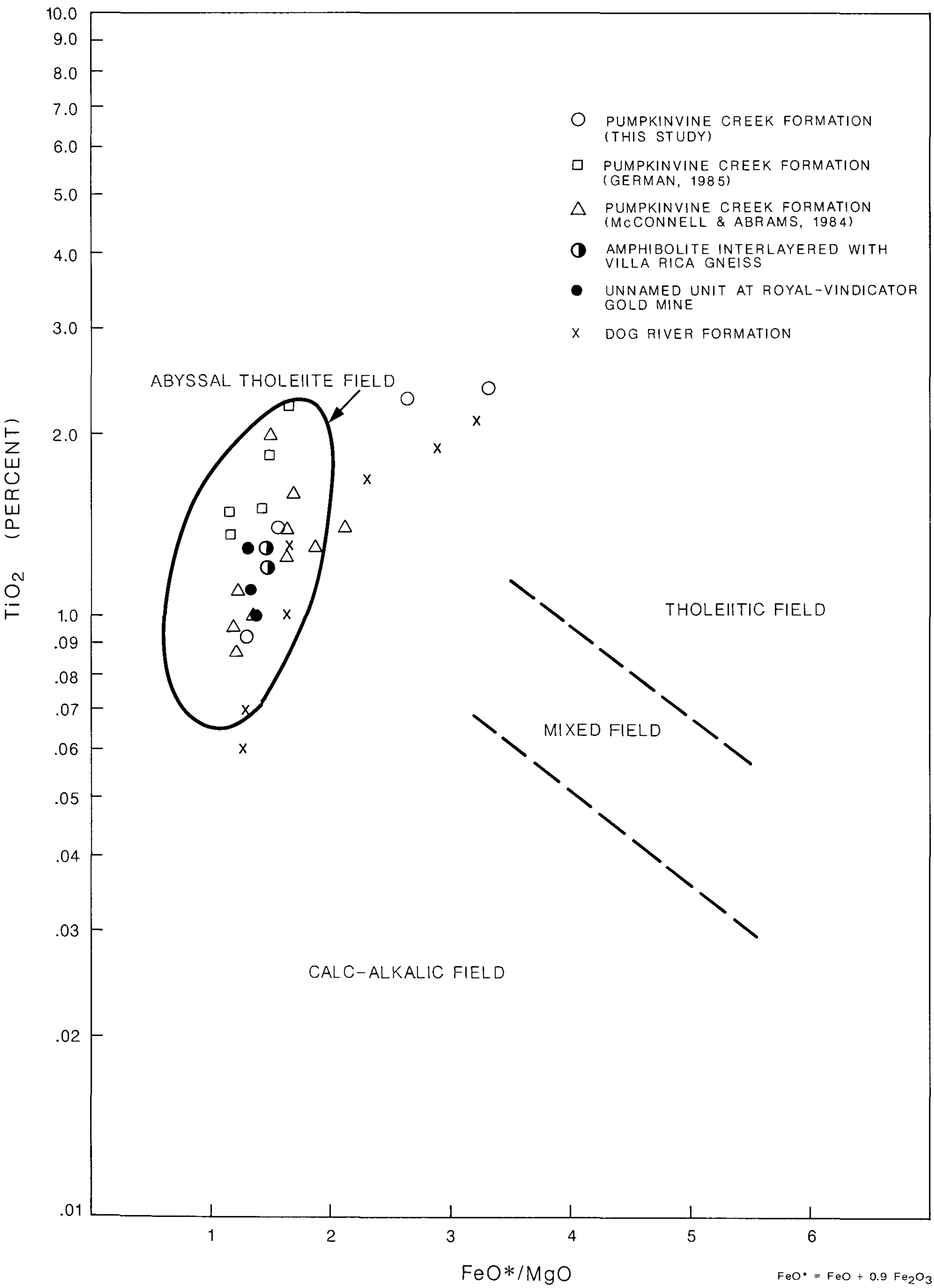

Figure 16. Discrimination of mafic metavolcanic rocks based on $\%TiO_2$ versus FeO*/MgO after Miyashiro and Shido (1975). Data from McConnell and Abrams (1984) and German (1985) are plotted for comparison.

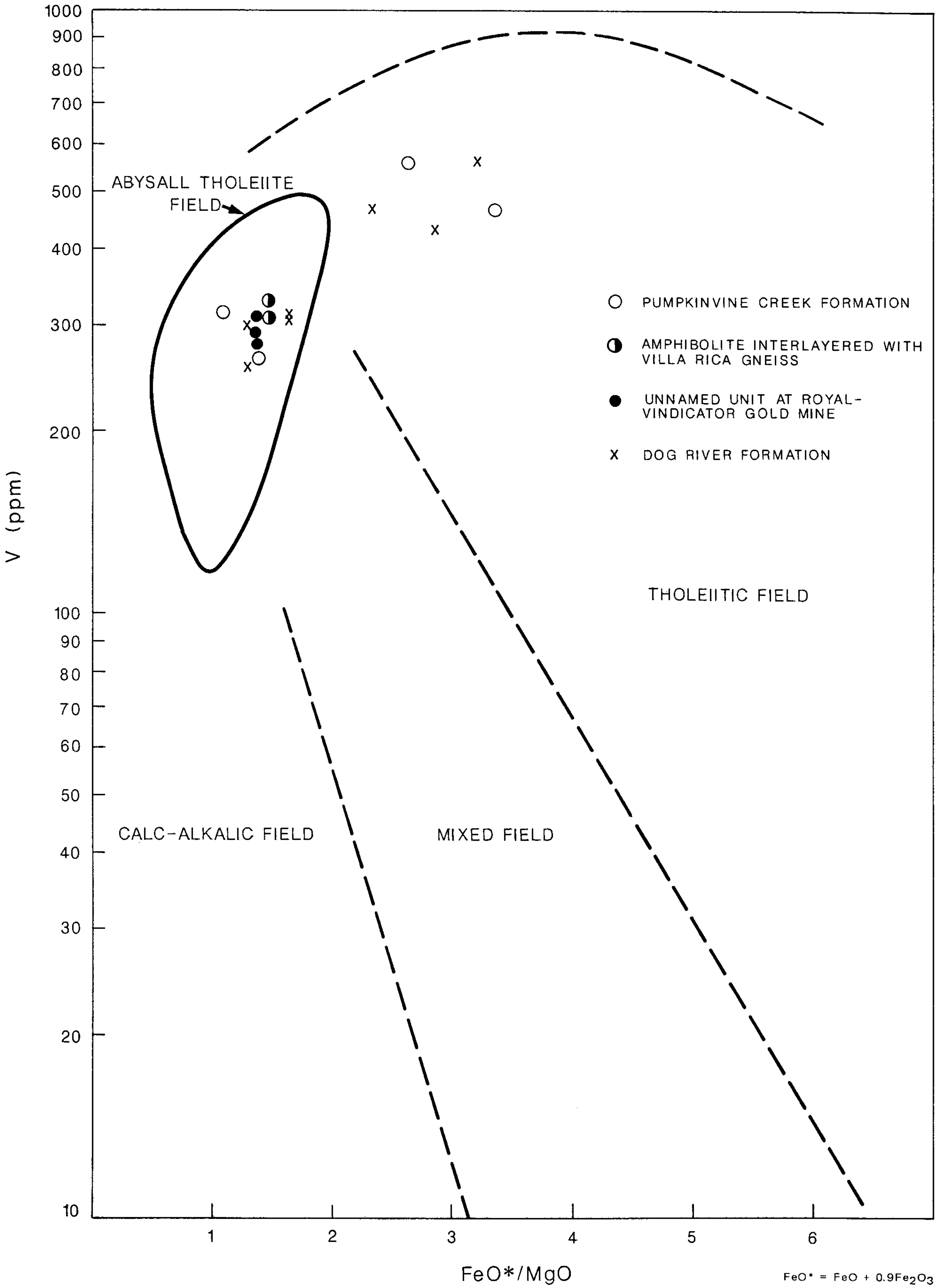

Figure 17. Discrimination of mafic metavolcanic rocks based on ppm V versus FeO*MgO after Miyashiro and Shido (1975).

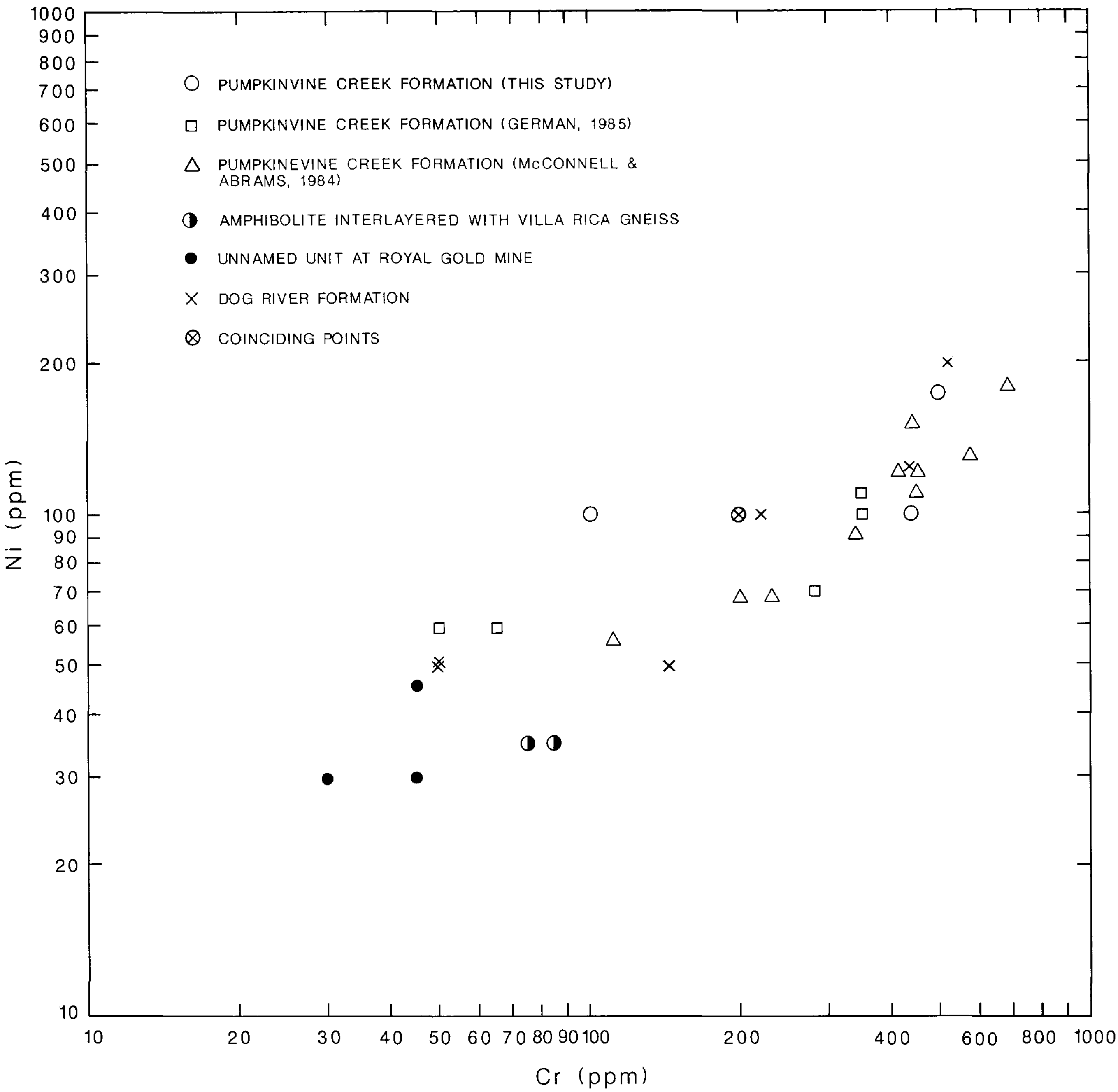

Figure 18. Nickel and chromium signatures of mafic metavolcanic rocks. Data from McConnell and Abrams (1984) and German (1985) are plotted for comparison.

deposited by hydrothermal fluids emanating into the country rock from some nearby igneous intrusion, replacing and recrystallizing the country rock at structurally controlled sites.

The obvious lithologic association between gold (and base metal) deposits and metavolcanic rocks, particularly felsic gneisses and iron formation, is best explained if these deposits are considered to be syngenetic in origin. McConnell and Abrams (1984), Abrams and McConnell (1984) and German (1985) used a similar syngenetic model for gold and sulfide deposits in the study area and in the northeastern portion of the Dahlonega gold belt. In this model, gold and some base metals present in the system were incorporated into certain volcanic rocks and chemical sediments when they were deposited. Previously discussed geochemical and field data indicate that deposition occurred on the sea floor near a submarine vent (Figure 20), probably in a back-arc basin.

The source of the gold probably was the underlying volcanic pile (Figure 20), since these volcanic rocks, predominantly mafic in composition, generally contain elevated amounts of gold (Boyle, 1979, p. 38). Convection of thermal

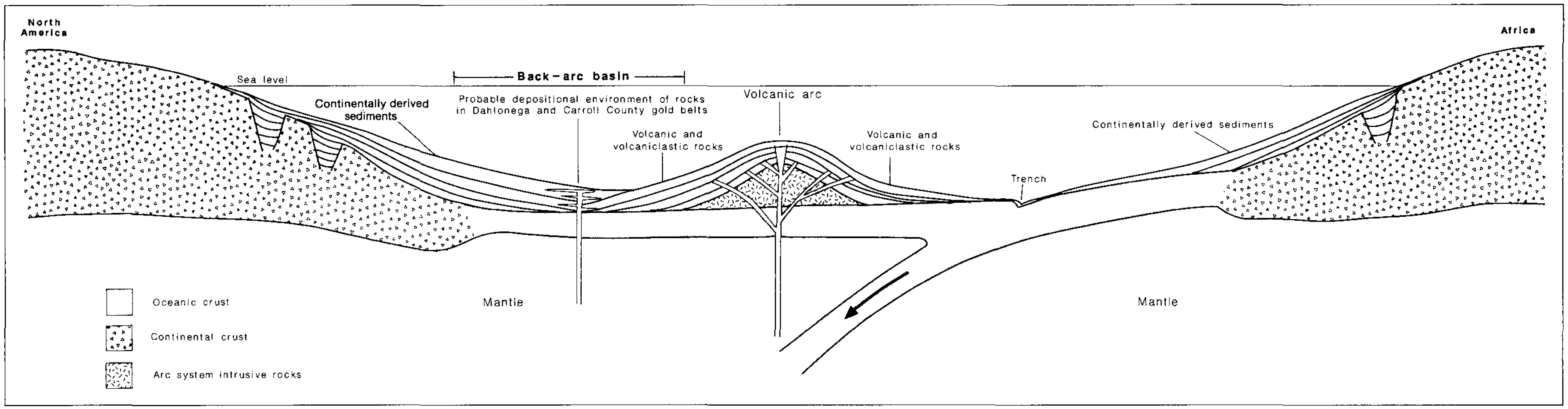

Figure 19. Diagrammatic representation of a developing volcanic arc and back-arc basin. The probable depositional environment (back-arc basin) of rocks in the Dahlonega and Carroll County gold belts is indicated. Although an island arc system is not present in the study area, the proximity of the proposed depositional environment to an arc system could account for the arch affinity of some of the metavolcanic rocks.

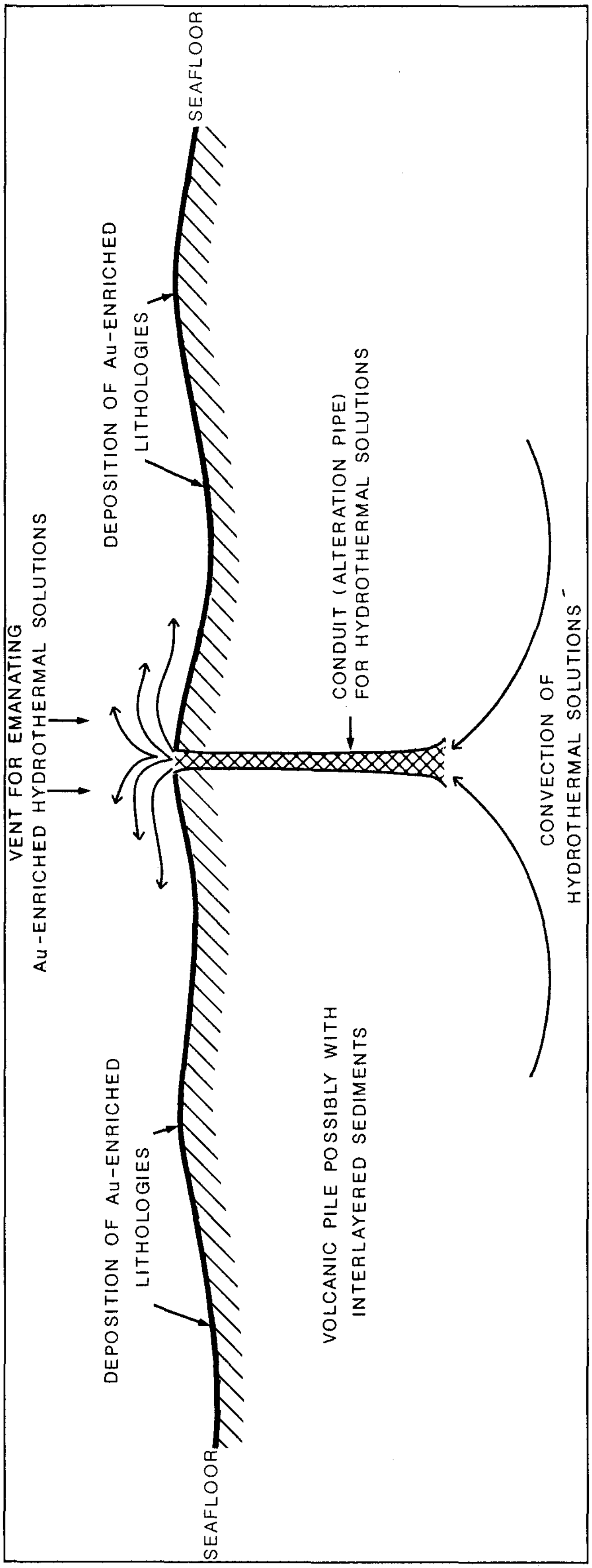

Figure 20. Proposed model for the syngenetic deposition of gold.

waters driven by the underlying magma heat source leached gold and other constituents from the volcanic pile. Upon reaching the sea floor, these elements were precipitated with silica to form quartz bodies and iron formations or were incorporated into contemporaneous flows and tuffs. This process is similar to the precipitation of gold and other metals from thermal waters in modern geothermal systems (Weissberg, 1969).

The occurrence of most gold in ore shoots, pods and fold hinges within the quartz bodies suggests that gold and some chalcophile elements were mobilized and concentrated at favorable sites within the quartz bodies during metamorphism and deformation. There is evidence that gold may have migrated to structurally controlled sites in the quartz bodies in sulfide solutions as the ion, AuS^- (Krauskopf, 1951; Weissberg, 1970) or may have diffused in a gaseous, ionic or molecular state along grain boundaries, fractures and pores in the host rock (Boyle, 1979, p. 399). Hale's (1974) work on the Coker Creek District of Tennessee indicates that gold was mobilized during metamorphism and deformation and diffused laterally into quartz "veins" forming in dilatant zones and, as a consequence, became somewhat depleted in host rock surrounding the "veins." In his work on the northeastern portion of the Dahlonega gold belt, German (1985) emphasized a similar mechanism for the formation of the concordant, auriferous quartz bodies. The auriferous quartz bodies are now believed to be partially to totally recrystallized primary features and the mobilization to be important only on a local scale.

CONCLUSIONS

Former gold mines and prospects in west-central Georgia are located in the southwestern part of the Dahlonega gold belt and in the Carroll County gold belt. Mines and prospects are clustered in the South Canton area, the Burnt Hickory Ridge area, the Villa Rica area and, to a lesser degree, the Acworth area. Most gold occurrences are associated with metavolcanic rocks (amphibolites, quartzofeldspathic gneisses and iron formation) of the New Georgia Group with a small number of occurrences associated with rocks of the Dog River Formation of the Sandy Springs Group (western belt). A still smaller number (mainly in Haralson County) are associated with rocks of the Talladega belt and rocks that may be correlative with the Hillabee Greenstone in Alabama. Important host rocks for gold deposits in the New Georgia Group include amphibolite, quartzofeldspathic gneiss (Galts Ferry Gneiss Member) and iron formation of the Pumpkinvine Creek Formation; mica schists, amphibolite and iron formation of the Canton Formation; a hyabyssal felsic gneiss (Villa Rica Gneiss Member) of the Mud Creek Formation; and, to a lesser extent, mafic rocks of the Kellogg Creek Mafic Complex and amphibolite, quartzofeldspathic gneiss, mica schist and iron formation of the Univeter Formation. Rocks of the Pumpkinvine Creek, Canton and Univeter Formations are traceable northeastward from the study area and make up the northeastern part of the Dahlonega gold belt (German, 1985).

An extrapolation of metamorphism dates from the southern Piedmont (Dallmeyer, 1978) suggests that rocks in the study area were metamorphosed to at least greenschist facies (biotite subfacies) and as high as amphibolite facies (kyanite subfacies) during the Acadian orogenic event in the late Devonian approximately 365 million years ago. Rocks in the study area have been deformed by at least four folding events. Rocks of the New Georgia Group are interpreted as the oldest rocks in the study area. The New Georgia Group is composed predominantly of metavolcanic rocks and grades upward into the overlying Sandy Springs Group (western belt), a predominantly metasedimentary sequence (McConnell and Abrams, 1984). McConnell and Abrams (1984) proposed that outcrop patterns of rocks in the study area are controlled by F_2 folds that refold an earlier F_1 axial planar foliation. Data from the present study also support the contention that F_2 folds refold an earlier foliation.

Whole rock and trace element chemistry of mafic metavolcanic rocks of the New Georgia and Sandy Springs (western belt) Groups plus the presence of abundant interlayered metasedimentary rocks strongly suggest that these rocks were deposited in a back-arc basin environment. Gold and other elements were leached from the underlying volcanic pile by convecting thermal waters and were deposited with silica to form quartz bodies and iron formations or were incorporated into contemporaneous flows and tuffs.

During regional metamorphism and deformation, gold and other constituents were remobilized and concentrated in ore shoots, pods and fold hinges within the concordant quartz bodies, however, remobilization and concentration seems to be only local in extent. Gold probably migrated to structurally favorable sites in the host rocks in sulfide solutions or diffused to these sites through pores and fractures as ions or molecules. Subsequent exposure and weathering of the gold deposits has resulted in a supergene enrichment of gold in saprolite and a mechanical concentration of gold in placers.

Investigations of the geology of the Dahlonega and Carroll County gold belts have revealed the geology of the belts and the various controls on the occurrence of gold. These investigations also have underscored the fact that at the current price for gold, the Dahlonega and Carroll County gold belts offer the potential for the discovery of new economic deposits and/or the reopening of older ones.

REFERENCES CITED

Abrams, C.E., 1983, Geology of the Austell-Frolona antiform, northwestern Georgia Piedmont (M.S. thesis): Athens, University of Georgia, 119 p.

Abrams, C.E., and McConnell, K.I., 1981a, Stratigraphy of the area around the Austell-Frolona antiform, west-central Georgia, *in* Wigley, P.B., ed., Latest thinking on the stratigraphy of selected areas in Georgia: Georgia Geologic Survey Information Circular 54-A, p. 55-67.

__________, 1981b, Emplacement of the Austell Gneiss: implications regarding the timing of metamorphism and deformation in the Piedmont of Georgia: Geological Society of America Abstracts with Programs, v. 13, no. 5, p. 1.

__________, 1982a, Relationship of banded iron formation to mines and prospects of western Georgia: Georgia Geologic Survey Open-File Map 82-5c, 1:100,000.

__________, 1982b, Banded iron formation: a key marker unit for massive sulfide exploration in the high grade metamorphic terrain of western Georgia: Geological Society of America Abstracts with Programs, v. 14, nos. 1 and 2, p. 1.

__________, 1982c, Lithologic and stratigraphic indicators for exploration in a high grade multiple deformed terrain, western Georgia Piedmont (abs.): Exploration for metallic resources in the southeast symposium, University of Georgia Center for Continuing Education, p. 1-3.

__________, 1984, Geologic setting of volcanogenic base and precious metal deposits of the West Georgia Piedmont: A multiple deformed terrain: Economic Geology, v. 79, no. 7, p. 1521-1539.

__________, 1986, Sulfide deposits of the northern Piedmont of Georgia, *in* McConnell, K.I., German, J.M. and Abrams, C.E., Gold and base metal mineralization host rocks in the Dahlonega and Carroll County gold belts, Georgia: Georgia Geological Society Guidebook, 21st annual field trip, 119 p.

Abrams, C.E., McConnell, K.I., Sanders, R.P., and Pate, M.L., 1981, Economic potential of a metavolcanic sequence in the Piedmont of northwestern Georgia: Geological Society of America Abstracts with Programs, v. 13, no. 5, p. 1.

Anhaeusser, C.R., 1976, Archean metallogeny in southern Africa: Economic Geology, v. 71, p. 16-43.

Bayley, W.S., 1928, Geology of the Tate quadrangle, Georgia: Georgia Geologic Survey Bulletin 43, 170 p.

Bearden, S., 1976, A petrographic and geochemical study of the Austell, Palmetto, and Sand Hill granite gneisses (abs.): Georgia Journal of Science, v. 34, no. 2, p. 84.

Boyle, R.W., 1979, The geochemistry of gold and its deposits: Geological Survey of Canada Bulletin 280, 584 p.

Brewer, W.M., 1897, The Villa Rica mining district, Georgia: Engineering and Mining Journal, v. 63, p. 483-487.

Coleman, S.L., Medlin, J.H., and Crawford, T.J., 1973, Petrology and geochemistry of the Austell gneiss in the western Georgia Piedmont: Geological Society of America Abstracts with Programs, v. 5, no. 5, p. 388.

Cook, R.B., Jr., 1970, Geologic history of massive sulfide bodies in west-central Georgia (Ph.D thesis): Athens, University of Georgia, 163 p.

__________, 1978a, Minerals of Georgia: their properties and occurrences: Georgia Geologic Survey Bulletin 92, 189 p.

__________, 1978b, Ore mineralogy of west-central Georgia massive sulfide deposits, *in* Short contributions to the geology of Georgia: Georgia Geologic Survey Bulletin 93, p. 22-31.

Cook, R.B., Jr., and Burnell, J.R., Jr., 1983, Geology of the Dahlonega district, Georgia: Geological Society of America Abstracts with Programs, v. 15, no. 2, p. 109.

Costello, J.R., McConnell, K.I., and Power, W.R., 1982, Geology of late Precambrian and early Paleozoic rocks in and near the Cartersville District, Georgia: 17th Annual Field Trip, Georgia Geological Society, 40 p.

Crawford, T.J., 1970, Geologic map Carroll-Heard Counties, Georgia, *in* Hurst, V.J., and Long, S.W., 1971, Geochemical study of alluvium in the Chattahoochee-Flint area, Georgia: University of Georgia Institute of Community and Area Development, 52 p.

__________, 1976, Geologic map of the Burnt Hickory Ridge quadrangle, Georgia: Georgia Geologic Survey Open-File Map, 1:24,000.

__________, 1977a, Geologic map of the Taylorsville quadrangle, Georgia: Georgia Geologic Survey Open-File Map, 1:24,000.

__________, 1977b, Geologic map of the Yorkville quadrangle, Georgia: Georgia Gelogic Survey Open-File Map, 1:24,000.

Crawford, T.J., and Medlin, J.H., 1970, Stratigraphic and structural features between the Cartersville and Brevard fault zones: Georgia Geological Society Guidebook 9, 35 p.

__________, 1971, The Georgia Piedmont west of Atlanta: stratigraphic and structural features: Geological Society of America Abstracts with Program, v. 3, no. 5, p. 306.

__________, 1973, The western Georgia Piedmont between the Cartersville and Brevard fault zones: American Journal of Science, v. 273, p. 712-722.

Crickmay, G.W., 1952, Geology of the crystalline rocks of Georgia: Georgia Geologic Survey Bulletin 58, 56 p.

Croft, M.G., 1963, Geology and ground-water resources of Bartow County, Georgia: U.S. Geological Survey Water-Supply Paper 1619-FF, 32 p.

Dallmeyer, R.D., 1978, $^{40}Ar/^{39}Ar$ incremental-release ages of hornblende and biotite across the Georgia Inner Piedmont: their bearing on late Paleozoic-early Mesozoic tectonothermal history: American Journal of Science, v. 278, p. 124-149.

Fairley, W.M., 1973, Correlations of stratigraphic belts of the northwest Georgia Piedmont and Blue Ridge: American Journal of Science, v. 273, p. 686-697.

Floyd, P.A., and Winchester, J.A., 1978, Identification and discrimination of altered and metamorphosed volcanic rocks using immobile elements: Chemical Geology, v. 21, p. 291-306.

Franklin, J.M., Lydon, J.W., and Sangster, D.F., 1981, Volcanic-associated massive sulfide deposits, *in* Skinner, B.J., ed., Economic Geology 75th Anniversary Volume, p. 485-627.

Furcron, A.S., and Teague, K.H., 1943, Mica-bearing pegmatites of Georgia: Georgia Geologic Survey Bulletin 48, 192 p.

Galpin, S.L., 1915, A preliminary report on the feldspar and mica deposits of Georgia: Georgia Geologic Survey Bulletin 30, 190 p.

German, J.M., 1985, The geology of the northeastern portion of the Dahlonega gold belt: Georgia Geologic Survey Bulletin 100, 41 p.

__________, 1986, The geology of the northeastern portion of the Dahlonega gold belt, *in* McConnell, K.I., German, J.M., and Abrams, C.E., Gold and base metal mineralization host rocks in the Dahlonega and Carroll County gold belts, Georgia: Georgia Geological Society Guidebook, 21st annual field trip, 119 p.

Gillon, K.A., 1982, Stratigraphic, structural, and metamorphic geology of portions of the Cowrock and Helen, Georgia 7½′ quadrangles (M.S. thesis): Athens, University of Georgia, 236 p.

Gross, G.A., 1980, A classification of iron formations based on depositional environments: Canadian Mineralogist, v. 18, p. 215-222.

Hale, R.C., 1974, Gold deposits of the Coker Creek District, Monroe County, Tennessee: Tennessee Division of Geology Bulletin 72, 93 p.

Haseltine, R.H., 1924, Iron ore deposits of Georgia: Georgia Geologic Survey Bulletin 41, 222 p.

Hayes, C.W., 1895, Unpublished geology of the Cartersville topographic quadrangle: scale 1:125,000.

Heinrich, E.W., Klepper, N.R. and John, R.H., 1953, Mica deposits of the southeastern Piedmont: U.S. Geological Survey Professional Paper 248-F, p. 327-400.

Higgins, M.W., 1966, Geology of the Brevard lineament near Atlanta, Georgia: Georgia Geologic Survey Bulletin 77, 49 p.

Higgins, M.W., Atkins, R.L., Crawford, T.J., Crawford, R.F., III, Cook, R.B., 1984, A brief excursion through two thrust stacks that comprise most of the crystalline terrane of Georgia and Alabama: Georgia Geological Society Guidebook, 19th annual field trip, 67 p.

Higgins, M.W., Atkins, R.L., Crawford, T.J., Crawford, R.F., Brooks, R., Cook, R.B., 1986, The structure, stratigraphy, tectonostratigraphy, and evolution of the southernmost part of the Appalachian orogen, Georgia and Alabama: U.S. Geological Survey Open-File Report 86-372, 162 p.

Higgins, M.W., and McConnell, K.I., 1978a, The Sandy Springs Group and related rocks in the Georgia Piedmont — nomenclature and stratigraphy, *in* Sohl, N.F., and Wright, W.B., eds., Changes in stratigraphic nomenclature by the U.S. Geological Survey, 1977: U.S. Geological Survey Bulletin 1457-A, p. A98-A105.

__________, 1978b, The Sandy Springs Group and related rocks of the Georgia Piedmont: nomenclature and stratigraphy *in* Short contributions to the geology of Georgia: Georgia Geology Survey Bulletin 93, p. 50-55.

Hopkins, O.B., 1914, A report on the asbestos, talc and soapstone deposits of Georgia: Georgia Geologic Survey Bulletin 29, 319 p.

Hull, J.P.D., LaForge, L., and Crane, W.R., 1919, Report on the manganese deposits of Georgia: Georgia Geologic Survey Bulletin 35, 295 p.

Hurst, V.J., 1952, Geology of the Kennesaw Mountain-Sweat Mountain area, Cobb County, Georgia (M.S. thesis): Atlanta, Emory University, 165 p.

__________, 1959, Geologic map of Kennesaw Mountain-Sweat Mountain area, Cobb County, Georgia: Georgia Geologic Survey Map RM-2, 1:24,000.

__________, 1970, The Piedmont in Georgia, *in* Fisher, G.W., Pettijohn, G.J., Reed, J.C., and Weaver, K.N., eds., Studies of Appalachian geology: central and southern: New York, Wiley Interscience, p. 383-396.

__________, 1973, Geology of the southern Blue Ridge belt: American Journal of Science, v. 273, p. 643-670.

Hurst, V.J., and Crawford, T.J., 1970, Sulfide deposits in the Coosa Valley area, Georgia: Coosa Valley Area Planning and Development Commission, 190 p.

Hurst, V.J., and Jones, L.M., 1973, Origin of amphibolites in the Cartersville-Villa Rica area, Georgia: Geological Society of America Bulletin, v. 84, p. 905-911.

Hurst, V.J., and Long, S.W., 1971, Geochemical study of alluvium in the Chattahoochee-Flint area, Georgia: University of Georgia Institute of Community and Area Development, 52 p.

Jones, L.M., Hurst, V.J., and Walker, R.L., 1973, Strontium isotope composition of amphibolite of the Cartersville-Villa Rica District, Georgia: Geological Society of America Bulletin, v. 84, p. 913-918.

Jones, S.P., 1909, Second report on the gold deposits of Georgia: Georgia Geologic Survey Bulletin 19, 283 p.

Keith, Arthur, 1909, Preliminary map of the Dahlonega district: U.S. Geological Survey Map, scale 1:72,000.

Kesler, T.L., 1950, Geology and mineral deposits of the Cartersville District, Georgia: U.S. Geological Survey Professional Paper 224, 97 p.

Kesler, T.L. and Kesler, S.E., 1971, Amphibolites of the Cartersville District, Georgia: Geological Society of America Bulletin, v. 82, p. 3163-3168.

King, F.P., 1894, A preliminary report on the corundum deposits of Georgia: Georgia Geologic Survey Bulletin 2, 133 p.

Krauskopf, K.B., 1951, The solubility of gold: Economic Geology, v. 46, p. 858-870.

Krauskopf, K.B., 1979, Introduction to geochemistry: New York, New York, McGraw-Hill Book Company, 616 p.

LaForge, L., and Phalen, W.C., 1913, Ellijay folio: U.S. Geological Survey Geologic Atlas of the United States, Folio 187, 22 p.

Lesure, F.G., 1971, Residual enrichment and supergene transport of gold, Calhoun Mine, Lumpkin County, Georgia: Economic Geology, v. 66, p. 178-186.

Lindgren, W., 1906, The gold deposits of Dahlonega, Georgia: U.S. Geological Survey Bulletin 293, p. 119-128.

Long, S.W., 1971, Mines and prospects of the Chattahoochee-Flint area, Georgia: University of Georgia Institute of Community and Area Development, 143 p.

McConnell, K.I., 1980, Origin and correlation of the Pumpkinvine Creek Formation: a new unit in the Piedmont of northern Georgia: Georgia Geologic Survey Information Circular 52, 19 p.

McConnell, K.I., and Abrams, C.E., 1982a, Geology of the Atlanta Region: preliminary maps: Georgia Geologic Survey Open-File Report 82-5.

__________, 1982b, Geology of the New Georgia Group and associated massive sulfide and gold deposits: West-central Georgia: Guidebook, Exploration for metallic resources in the southeast symposium, University of Georgia Center for Continuing Education, p. 143-170.

__________, 1983, Geochemistry of metamorphosed banded iron formation and alumino-silicate assemblages of western Georgia: Geological Society of America Abstracts with Programs, v. 15, no. 2, p. 90.

__________, 1984, The geology of the Greater Atlanta Region: Georgia Geologic Survey Bulletin 96, 127 p.

__________, 1986, Geology of the Dahlonega and Carroll County gold districts in west-central Georgia, *in* McConnell, K.I., German, J.M., and Abrams, C.E., Gold and base metal mineralization host rocks in the Dahlonega and

Carroll County gold belts, Georgia: Georgia Geological Society Guidebook, 21st annual field trip, 119 p.
McConnell, K.I., and Costello, J.O., 1980a, Uranium evaluation of graphitic phyllites and other selected rocks in Georgia: Georgia Geologic Survey Open-File Report 80-5, 41 p.
__________, 1980b, Guide to geology along a traverse through the Blue Ridge and Piedmont Provinces of north Georgia, *in* Frey, R.W., ed., Excursions in southeastern geology: American Geological Institute, v. 1, p. 241-258.
McConnell, K.I., German, J.M., and Abrams, C.E., 1986, Gold and base metal mineralization host rocks in the Dahlonega and Carroll County gold belts, Georgia: Georgia Geological Society Guidebook, 21st annual field trip, 119 p.
Medlin, J.H., and Crawford, T.J., 1973, Stratigraphy and structure along the Brevard zone in western Georgia and eastern Alabama: American Journal of Science, v. 273-A, p. 89-104.
Miyashiro, Akiho, and Shido, Fumiko, 1975, Tholeiitic and calc-akalic series in relation to the behaviors of titanium, vanadium, chromium, and nickel: American Journal of Science, v. 275, p. 265-277.
Nelson, A.E., 1985, Major tectonic features and structural elements in the northwest part of the Greenville quadrangle, Georgia: U.S. Geological Survey Bulletin 1643, 22 p.
Pardee, J.T., and Park, C.F., Jr., 1948, Gold deposits of the southern Piedmont: U.S. Geological Survey Professional Paper 213, 156 p.
Paris, T.A., 1986, Geology of the Royal-Vindicator gold deposit, Haralson County Georgia: Geological Society of America Abstracts with Programs, v. 18, no. 1, p. 60.
Park, C.F., Jr., and Wilson, R.A., 1936, The Battle Branch gold mine, Auraria, Georgia: Economic Geology, v. 31, p. 73-92.
Pate, M.L., 1980, Gold, pyrite and asbestos deposits of the Villa Rica mining district. west-central Georgia: A preliminary report: Georgia Geologic Survey Open File Report 81-3, 24 p.
Pearce, J.A. and Cann, J.R., 1973, Tectonic setting of basic volcanic rocks determined using trace element analyses: Earth and Planetary Science Letters, v. 19, p. 290-300.
Peck, J., 1833, Geological and mineralogical account of the mining districts in the state of Georgia, western part of North Carolina and of east Tennessee: American Journal of Science, v. 23, p. 1-10.
Pierce, W.G., 1944, Cobalt-bearing manganese deposits, Alabama, Georgia, Tennessee: U.S. Geological Survey Bulletin 940-J, p. 271-283.
Ramsay, J.G., 1962, Interference patterns produced by the superposition of folds of similar type: Journal of Geology, v. 70, no. 4, p. 466-481.
Rogers, J.J.W., 1982, Criteria for recognizing environments of formation of volcanic suites; application of these criteria to volcanic suites in the Carolina slate belt, *in* Bearce, D.N., Black, W.W., Kish, S.A. and Tull, J.F., eds., Tectonic studies in the Talladega and Carolina Slate Belts, Southern Appalachian orogen: Geological Society of America Special Paper 191, p. 99-107.
Sanders, R.P., 1977, Major element chemical variation in several bodies of granite gneiss of the Piedmont of west Georgia (abs.): Georgia Journal of Science, v. 35, no. 2, p. 89.
Sanders, R.P., Jeffers, Larry, and Reid, B.J., 1979, Petrology of elliptical calcareous pods in metagraywackes (abs.): Georgia Journal of Science, v. 37, no. 2, p. 88.
Schepis, E.L., 1952, Geology of eastern Douglas County, Georgia (M.S. thesis): Atlanta, Emory University, 52 p.
Shearer, H.K., and Hull, J.P.D., 1918, A preliminary report on a part of the pyrites deposits of Georgia: Georgia Geologic Survey Bulletin 33, 229 p.
Stose, G.W., Smith, R.W., Cooke, C.W., Crickmay, G.W. and Butts, C., 1939, Geologic map of Georgia: Georgia Geologic Survey and U.S. Geological Survey, 1:500,000.
Watson, T.L., 1902, A preliminary report on a part of the granites and gneisses of Georgia: Georgia Geologic Survey Bulletin 9-A, 367 p.
__________, 1908, A preliminary report on the manganese deposits of Georgia: Georgia Geologic Survey Bulletin 14, 195 p.
Weissberg, B.G., 1969, Gold-silver ore-grade precipitates from New Zealand thermal waters: Economic Geology, v. 64, p. 95-108.
__________, 1970, Solubility of gold in hydrothermal alkaline sulfide solutions: Economic Geology, v. 65, p. 551-556.
Winchester, J.A. and Floyd, P.A., 1977, Geochemical discrimination of different magna series and their differentiation products using immobile elements: Chemical Geology, v. 20, p. 325-343.
Yeates, W.S., McCallie, S.W., and King, F.P., 1896, A preliminary report on a part of the gold deposits of Georgia: Georgia Geologic Survey Bulletin 4-A, 542 p.

Appendices

Appendix 1

Mine and prospect names used in this appendix are the same as those used by Yeates and others (1896) and Jones (1909). Where mines and prospects are known by two names, both are given. Production data only refer to gold although silver and some base metals do occur with the gold. The numbering system is a continuation of that used by German (1985).

Mine or Prospect	#	County	7.5-Minute Quadrangle	Type of Workings	Geologic setting	Pro-duction	Remarks
Case Property	140	Cherokee				nr*	Exact location unknown.
McCandless Property	141	Cherokee	South Canton			nr	Exact location unknown.
Downing Creek Placer	142	Cherokee	South Canton	Placer workings along Downing Creek and one of its tributaries.	Placers overlie undifferentiated amphibolite of the Pumpkinvine Creek Formation.	nr	
Sixes Mine	143	Cherokee	South Canton	Placer workings along a tributary of the Etowah River (Sixes Creek), three pits, two shafts, and one adit.	Host rocks are felsic gneiss (Galts Ferry Gneiss) and undifferentiated amphibolite of the Pumpkinvine Creek Formation.	nr	
Coggins Property	144	Cherokee	South Canton			nr	Exact location unknown. Probably immediately NW of Sixes Mine.
Haynes Property	145	Cherokee	South Canton	One pit.	Host rocks are undifferentiated felsic gneiss and amphibolite of the Univeter Formation.	nr	
LaBelle Mine	146	Cherokee	South Canton	Placer workings along a tributary of Blankets Creek, seven pits, one shaft and one adit.	Host rocks are banded garnet-muscovite-quartz schist and graphite garnet-biotite-muscovite quartz schist ± pyrite of undifferentiated Canton Formation.	nr	
Macou Prospect	147	Cherokee	South Canton	Three pits and one open cut.	Host rock is banded garnet-biotite-sericite-quartz schist of the Canton Formation.	nr	
Casteel Property	148	Cherokee	South Canton			nr	Exact location unknown. Probably immediately South of Macou Prospect.
Clarkston Mine	149	Cherokee	South Canton	Four pits, one shaft and one adit.	Host rocks are garnet-graphite schist, garnet-biotite-muscovite quartz schist and iron formation of undifferentiated Canton Formation near the contact with Pumpkinvine Creek Formation.	nr	
Putnam Mine	150	Cherokee	South Canton	Placer workings along Blankets Creek and two of its tributaries.	Placers overlie undifferentiated amphibolite, felsic gneiss and iron formation of the Univeter Formation.	nr	
Farrar (301) Mine	151	Cherokee	South Canton	Three pits and one shaft.	Host rock is plagioclase-biotite-muscovite-quartz gneiss of the Univeter Formation.	nr	
Lovingood Prospect	152	Cherokee	South Canton			nr	Exact location unknown.
Cherokee Mine	153	Cherokee	South Canton	Placer workings in two tributaries of Blankets Creek, at least seven adits, five vertical shafts, one large open cut and numerous pits.	Host rock is a sequence of interlayered amphibolite, manganiferous sericite-quartz schist, magnetite-garnet-muscovite-quartz gneiss, feldspathic sericite-quartz schist and iron formation at the contact between the Pumpkinvine Creek and Canton Formations.	nr	

Appendix 1 (CON'T)

Mine or Prospect	#	County	7.5-Minute Quadrangle	Type of Workings	Geologic setting	Production	Remarks
Kitchens Prospect	154	Cherokee	South Canton	Six pits, one adit and several trenches.	Host rocks are undifferentiated sericite-quartz schist and garnet biotite-muscovite-quartz schist of the Canton Formation.	nr	
William Poor Property	155	Cherokee	South Canton			nr	Exact location unknown.
Evans (Cobb) Prospect	156	Cherokee	South Canton			nr	Exact location unknown.
Williams Property	157	Cherokee	Kennesaw			nr	Exact location unknown.
Kellogg Mine	158	Cherokee	Kennesaw			5,000 oz.[1]	Exact location unknown.
Bell Star Mine	159	Cherokee	Kennesaw	Nine pits, one shaft, one small cut and numerous trenches.	Host rocks are garnet-biotite-muscovite-quartz schist interlayered with minor garnet-chlorite quartz schist, biotite felsic gneiss, pyrite-sericite-quartz schist and amphibolite of the Rose Creek Schist member of the Univeter Formation.	nr	
Tripp Property	160	Cherokee	Acworth			nr	Exact location unknown.
Georgianna Mine	161	Cherokee	Acworth	Four small pits.	Host rock is felsic gneiss of the Galts Ferry Gneiss member of the Pumpkinvine Creek Formation.	nr	Mine property is now a subdivision.
Stansill Property	162	Bartow	Acworth			nr	Exact location unknown.
Glade Mine	163	Bartow	Acworth	Placer workings in two tributaries of Allatoona Creek and several small pits	Host rocks are felsic gneiss (Galts Ferry Gneiss Member) and undifferentiated amphibolite of the Pumpkinvine Creek Formation.	nr	
Robertson Property	164	Bartow	Acworth			nr	Exact location unknown.
McDaniel Property	164A	Bartow	Acworth			nr	Exact location unknown.
Granville Mine	165	Bartow	Acworth	Three small pits and several trenches.	Host rock is amphibolite of the Kellogg Creek Mafic Complex	nr	
Avery (Gold Branch) Mine	166	Bartow	Acworth			nr	Exact location unknown.
Howard Property	167	Bartow	Acworth			nr	Exact location unknown.
Goings Mine	168	Bartow	Acworth/ Allatoona Dam	Placer workings along two tributaries of the Etowah Riber and one adit.	Host rocks are felsic gneiss (Galts Ferry Gneiss Member) and amphibolite of the Pumpkinvine Creek Formation.	nr	Part of workings are covered by Lake Allatoona
Hamilton Mine	169	Cobb	Acworth	Five pits and two small cuts.	Host rocks are felsic gneiss and amphibolite of the Acworth Gneiss.	nr	
Freeman Prospect	170	Cobb	Acworth			nr	Exact location unknown.
Payne, Kendrick, Randall and House Property	171	Cobb	Acworth	Two pits and one trench	Host rock is amphibolite of the Lost Mountain Member of the Univeter Formation.	nr	

Appendix 1 (CON'T)

Mine or Prospect	#	County	7.5-Minute Quadrangle	Type of Workings	Geologic setting	Pro-duction	Remarks
Hadaway Prospect	172	Cobb	Lost Mountain			nr	Exact location unknown.
Kemp Property	173	Cobb	Lost Mountain			nr	Exact location unknown.
Mason Mine	174	Cobb	Lost Mountain			nr	Exact location unknown.
Hathaway Property	174A	Cobb	Lost Mountain			nr	Exact location unknown.
Cox Property	175	Cobb	Kennesaw			nr	Exact location unknown.
Sheffield/Heidt Prospect	176	Paulding	Burnt Hickory Ridge	Placer workings along a tributary of Raccoon Creek and at least seven pits.	Host rock is a sequence of interlayered chlorite-biotite-schist ± calcite and plagioclase, plagioclase-biotite chlorite-muscovite-quartz schist, biotite-muscovite-quartz schist, graphite-garnet-muscovite-quartz schist, biotite-chlorite-plagioclase-quartz schist, amphibolite, biotite-amphibole gneiss, sericite-quartz schist and iron formation of undifferentiated Canton Formation.	nr	
Michigan Mine	177	Paulding	Burnt Hickory Ridge/Yorkville			nr	Exact location unknown. Probably placers along Raccoon Creek and its tributaries.
Twilley Mine	178	Paulding	Burnt Hickory Ridge	Placer workings along a tributary of Murry Creek, thirteen pits, three trenches, one adit, two shafts and one open cut.	Same as Sheffield/Heidt.	nr	
Russell Mine	179	Paulding	Burnt Hickory Ridge	Placer workings along a tributary of Murry Creek, one open cut three trenches, two vertical shafts, one adit and five pits.	Same as Sheffield/Heidt.	nr	
Merritt Mine	180	Paulding	Burnt Hickory Ridge	Placer workings along a tributary of Dunaway Branch, three pits, three trenches, one small open cut and one adit.	Same as Sheffield/Heidt.	nr	
Dunaway Mine	181	Paulding	Burnt Hickory Ridge	Placer workings along a tributary of Pumpkinvine Creek, two pits, one open cut, one adit and seven trenches.	Same as Sheffield/Heidt.	nr	
Hobbs Mine	182	Paulding	Burnt Hickory Ridge			nr	Exact location unknown.
Hodges Prospect	183	Paulding	Burnt Hickory Ridge	Several pits	Same as Sheffield/Heidt.	nr	

Appendix 1 (CON'T)

Mine or Prospect	#	County	7.5-Minute Quadrangle	Type of Workings	Geologic setting	Production	Remarks
Mathews Property	184	Paulding	Taylorsville			nr	Exact location unknown.
Yorkville Mine	185	Paulding	Yorkville	Placer workings along a tributary of Gold Mine Branch, a series of overlapping cuts and at least ten adits.	Host rocks are phyllitic plagioclase-epidote-chlorite-quartz metasiltstone ± muscovite with minor amphibolite and iron formation.	nr	
Barton Mine	186	Paulding	Yorkville	Placer workings along a tributary of Gold Mine Branch, twelve pits and one open cut.	Host rocks are chlorite-biotite-quartz schist and greenstone.	nr	
Parker Property	187	Paulding	Dallas			nr	Exact location unknown.
Austin Mine	188	Paulding	Nebo			nr	Exact location unknown.
Carnes Prospect	189	Douglas	Winston			nr	Exact location unknown.
Baggett Prospect	190	Douglas	Winston			nr	Exact location unknown.
Astinol Prospects	191	Douglas	Nebo			nr	Exact location unknown. Workings by same name also reported on the New Georgia Quad.
Triglone Mine	192	Douglas	Nebo				Exact location unknown
Roach Prospect	193	Douglas	Nebo	Placer workings along a tributary of Town Branch.	Placers overlie a biotite-quartz plagioclase orthogneiss (Villa Rica Gneiss Member) of the Mud Creek Formation.	nr	
212 Prospect	194	Douglas	New Georgia	Placer workings along a tributary of Mud Creek.	Placers overlie a biotite-quartz-plagioclase orthogneiss (Villa Rica Gneiss Member) of the Mud Creek Formation	nr	
Pine Mountain (Stockmar) Mine	195	Douglas	New Georgia	Three adits and three open cuts.	Host rock is a siliceous zone in a biotite-quartz-plagioclase orthogneiss (Villa Rica Gneiss Member) with local amphibolite and chlorite schist of the Mud Creek Formation.	nr	
McManus Property	196	Douglas	New Georgia/ Villa Rica	Placer workings and shallow overlapping cuts along two tributaries of Town Branch.	Host rock is a biotite-quartz-plagioclase orthogneiss (Villa Rica Gneiss Member) of the Mud Creek Formation.	nr	
Southern Klondyke Mine	197	Carroll	New Georgia	Placer workings along Mud Creek, one open cut and three pits.	Host rock is a biotite-quartz-plagioclase orthogneiss (Villa Rica Gneiss Member) of the Mud Creek Formation.	nr	
Clopton (Clompton) Mine	198	Carroll	New Georgia/ Villa Rica	Series of extensive overlapping open cuts.	Host rock is a biotite-quartz plagioclase orthogneiss (Villa Rica Gneiss Member) of the Mud Creek Formation.	65 oz. from 1 small cut.[2]	
Chambers Mine	199	Carroll	Villa Rica/ New Georgia	Placer workings along a tributary of the Tallapoosa River, two large branching cuts and one shaft.	Host rock is a biotite-quartz-plagioclase orthogneiss (Villa Rica Gneiss Member) of the Mud Creek Formation. Locally amphibolite is interlayered with the orthogneiss.	nr	

Appendix 1 (CON'T)

Mine or Prospect	#	County	7.5-Minute Quadrangle	Type of Workings	Geologic setting	Pro-duction	Remarks
Jones Mine	200	Carroll	Villa Rica	Placer workings along two tributaries of the Tallapoosa River.	Same as Chambers Mine.	nr	
Lassetter Prospect	201	Carroll	Villa Rica			nr	Exact location unknown.
Hixon Prospect	202	Carroll	Villa Rica			nr	Exact location unknown.
Hart Mine	203	Carroll	Villa Rica	Two small cuts and four pits.	Same as Chambers Mine.	nr	
Askew Prospect	204	Carroll	Villa Rica			nr	Exact location unknown.
Davis Prospect	205	Carroll	Villa Rica			nr	Exact location unknown.
Stacey Mine	206	Carroll	Carrollton	Four pits.	Host rocks are garnet-muscovite-biotite-quartz schist with minor iron formation and a chlorite-anthophyllite rock of the Bill Arp Formation.	nr	
Bonner Mine	207	Carroll	Roopville/ Bowdon East	Placer workings along tributaries of Buffalo Creek, at least eight adits and two large pits.	Host rocks are a manganiferous garnet-muscovite-biotite-quartz schist with minor amphibolite and iron formation of the Dog River Formation.	Pre-Civil War: 25,000 oz.[1]	Far from any other mines in the study area.
McBrayer Property	208	Haralson	Draketown			nr	Exact location unknown.
Dean Property	209	Haralson	Draketown			nr	Exact location unknown.
Crew Prospect	210	Haralson	Draketown			nr	Exact location unknown.
Layton Property	211	Haralson	Buchanan	Placer workings along a tributary of the Tallapoosa River.	Placers overlie a biotite-chlorite-feldspar-quartz metasiltstone of the Talladega belt.	nr	
Unnamed prospect	212	Haralson	Buchanan	Placer workings along a tributary of Wood Creek and one shaft.	Host rock is a biotite-chlorite-feldspar-quartz metasiltstone of the Talladega belt.	nr	
Edwards Mine	213	Haralson	Buchanan			nr	Exact location unknown.
Brock Prospect	214	Haralson	Tallapoosa North	Placer workings along a tributary of the Tallapoosa River, one shaft and several small pits.	Host rock is a biotite-feldspar-chlorite-quartz metasiltstone of the Talladega belt.	nr	
Royal-Vindicator Mine	215	Haralson	Tallapoosa South	One large open cut, several pits and extensive underground workings.	Host rock is in a silicified zone in a felsic gneiss within a sequence of interlayered felsic gneiss and greenstone with minor iron formation.	5,000 oz. from main open cut.[1,2]	
Chandler Prospect	216	Haralson	Tallapoosa South			nr	Exact location unknown.

*nr-not recorded
1-Yeates and others (1896)
2-Jones (1909)

APPENDIX 2
Lithologic Descriptions and Locations of Samples in Tables 2, 3, 4 and 5

Sample #	Lithology	Rock Unit	Sample Location
Table 2			
SC-6	Dark gray, fine-grained magnetite-calcite-sericite quartzite ± biotite, chlorite, tourmaline and garnet	Pumpkinvine Creek Formation	South Canton Quad Lat.-34° 09′ 48″ N Long.-84° 33′ 21″ W
SC-14	Dark green to black fine-grained epidote amphibolite	Pumpkinvine Creek Formation	South Canton Quad Lat.-34° 10′ 55″ N Long.-84° 32′ 34″ W
SC-23	Light green, fine- to medium-grained hornblende-quartz-chlorite schist ± magnetite, epidote and garnet	Pumpkinvine Creek Formation	South Canton Quad Lat.-34° 13′ 03″ N Long.-84° 30′ 27″ W
SC-26	Dark green, fine-grained amphibolite	Pumpkinvine Creek Formation	South Canton Quad Lat.-34° 12′ 34″ N Long.-84° 31′ 00″ W
SC-5	Light to dark gray garnet-muscovite-biotite-quartz schist	Canton Formation	South Canton Quad Lat.-34° 09′ 36″ N Long.-84° 33′ 18″ W
SC-20	Gray graphite-garnet-sericite-quartz phyllite/schist	Canton Formation	South Canton Quad Lat.-34° 11′ 37″ N Long.-84° 31′ 39″ W
SC-21	Gray biotite-garnet-graphite-quartz-sericite schist/phyllite	Canton Formation	South Canton Quad Lat.-34° 11′ 56″ N Long.-84° 31′ 04″ W
SC-9	Light gray to tan muscovite-biotite-plagioclase-quartz gneiss	Lost Mountain Member of Univeter Formation	South Canton Quad Lat.-34° 10′ 24″ N Long.-84° 31′ 19″ W
SC-11	Silvery-gray, fine-grained, schistose biotite-muscovite-quartz gneiss ± garnet, chlorite, plagioclase, magnetite and pyrite	Univeter Formation (Rose Creek Schist Member?)	South Canton Quad Lat.-34° 10′ 37″ N Long.-84° 31′ 12″ W
SC-17	Silvery to tan, fine-grained garnet-biotite-muscovite-quartz schist	Rose Creek Schist Member of the Univeter Formation	South Canton Quad Lat.-34° 10′ 47″ N Long.-84° 31′ 04″ W
SC-30	Silvery, fine-grained garnet-biotite-muscovite-quartz schist	Rose Creek Schist Member of the Univeter	South Canton Quad Lat.-34° 09′ 07″ N Long.-84° 32′ 52″ W
SC-1	Light gray to tan, fine-grained hornblende-biotite-epidote-plagioclase quartzite	Etowah Formation Formation	South Canton Quad Lat.-34° 11′ 23″ N Long.-84° 33′ 58″ W
SC-2	Silvery, fine-grained quartz-biotite-sericite schist	Etowah Formation	South Canton Quad Lat.-34° 11′ 23″ N Long.-84° 33′ 58″ W
SC-25	Light gray, fine-grained biotite-muscovite-plagioclase-quartz metasandstone	Etowah Formation	South Canton Quad Lat.-34° 13′ 38″ N Long.-84° 30′ 00″ W
SC-12	Dark gray, fine- to medium-grained plagioclase-biotite-muscovite-quartz schist	Powers Ferry Formation	South Canton Quad Lat.-34° 10′ 27″ N Long.-84° 30′ 56″ W
SC-28	Dark gray, medium-grained garnet-muscovite-plagioclase-biotite-quartz schist	Powers Ferry Formation	South Canton Quad Lat.-34° 08′ 53″ N Long.-84° 32′ 27″ W
Table 3			
BH-1	Dark green to black, fine-grained epidote amphibolite	Pumpkinvine Creek Formation	Burnt Hickory Ridge Quad Lat.-34° 01′ 27″ N Long.-84° 52′ 12″ W
BH-4	Dark green, fine-grained epidote amphibolite	Pumpkinvine Creek Formation	Burnt Hickory Ridge Quad Lat.-34° 02′ 06″ N Long.-84° 51′ 26″ W

APPENDIX 2 (CON'T)

Sample #	Lithology	Rock Unit	Sample Location
Table 3 Cont'd			
BH-12	Dark green, fine-grained epidote amphibolite	Pumpkinvine Creek Formation	Burnt Hickory Ridge Quad Lat.-34° 02′ 00″ N Long.-84° 51′ 15″ W
BH-14	Dark green, very fine-grained amphibolite	Pumpkinvine Creek Formation	Burnt Hickory Ridge Quad Lat.-34° 01′ 32″ N Long.-84° 51′ 46″ W
BH-21	Dark green to black, fine-grained epidote amphibolite	Pumpkinvine Creek Formation	Burnt Hickory Ridge Quad Lat.-34° 00′ 53″ N Long.-84° 50′ 31″ W
BH-2	Light gray to tan, fine- to medium-grained muscovite-plagioclase-quartz gneiss	Galts Ferry Gneiss	Burnt Hickory Ridge Quad Lat.-34° 02′ 03″ N Long.-84° 51′ 42″ W
BH-9	Light gray, medium-grained biotite-muscovite-quartz-plagioclase gneiss	Galts Ferry Gneiss	Burnt Hickory Ridge Quad Lat.-34° 01′ 53″ N Long.-84° 49′ 55″ W
BH-19	Light gray to tan, medium-grained biotite-muscovite-plagioclase-quartz gneiss ± chlorite, garnet and epidote	Galts Ferry Gneiss	Burnt Hickory Ridge Quad Lat.-34° 00′ 28″ N Long.-84° 52′ 22″ W
BH-8	Light gray, fine-grained biotite-chlorite-plagioclase-quartz schist	Canton Formation	Burnt Hickory Ridge Quad Lat.-34° 02′ 38″ N Long.-84° 50′ 00″ W
BH-15	Light gray, silvery, fine- to medium-grained biotite-muscovite-quartz schist ± chlorite and garnet	Canton Formation	Burnt Hickory Ridge Quad Lat.-34° 01′ 21″ N Long.-84° 51′ 47″ W
BH-18	Dark gray, fine- to medium-grained plagioclase-chlorite-biotite-quartz schist ± calcite and epidote	Canton Formation	Burnt Hickory Ridge Quad Lat.-34° 00′ 34″ N Long.-84° 52′ 10″ W
Table 4			
VR-1	Dark green to black, fine-grained epidote amphibolite	Amphibolite within Villa Rica Gneiss	Villa Rica Quad Lat.-33° 44′ 23″ N Long.-84° 56′ 17″ W
VR-2	Dark green to black, fine- to medium-grained epidote amphibolite	Amphibolite within Villa Rica Gneiss	Villa Rica Quad Lat.-33° 45′ 00″ N Long.-84° 55′ 58″ W
VR-17	Light-colored, medium- to coarse-grained microcline-epidote-biotite-quartz-plagioclase gneiss	Villa Rica Gneiss	Villa Rica Quad Lat.-33° 44′ 17″ N Long.-84° 54′ 17″ W
232-2	Light-colored, medium- to coarse-grained epidote-muscovite-biotite-quartz-plagioclase gneiss	Villa Rica Gneiss	Villa Rica Quad Lat.-33° 44′ 04″ N Long.-84° 58′ 10″ W
TJ	Light-colored, medium- to coarse-grained hornblende-epidote-muscovite-biotite-quartz-plagioclase gneiss	Villa Rica Gneiss	Villa Rica Quad Lat.-33° 43′ 53″ N Long.-84° 58′ 27″ W
N-34	Light colored, medium- to coarse-grained hornblende-epidote-muscovite-biotite-quartz-plagioclase gneiss	Villa Rica Gneiss	Nebo Quad Lat.-33° 45′ 27″ N Long.-84° 50′ 44″ W
233A	Light-colored, coarse-grained epidote-muscovite-biotite-quartz-plagioclase-microcline gneiss	Austell Gneiss	Winston Quad Lat.-33° 42′ 16″ N Long.-84° 52′ 22″ W

APPENDIX 2 (CON'T)

Sample #	Lithology	Rock Unit	Sample Location
Table 5			
BH-12	See Table 3 above		
BH-14	See Table 3 above		
BH-20	Dark green to black, fine-grained amphibolite	Pumpkinvine Creek Formation	Burnt Hickory Ridge Quad Lat.-34° 00′ 22″ N Long.-84° 51′ 26″ W
BH-21	See Table 3 above		
VR-1	See Table 4 above		
VR-2	See Table 4 above		
92-1	Greenstone from core at Royal-Vindicator Mine	Unnamed	Tallapoosa South Quad Lat.-33° 42′ 34″ N Long.-85° 16′ 57″ W
156-1	Greenstone from core at Royal-Vindicator Mine	Unnamed	Tallapoosa South Quad Lat.-33° 42′ 34″ N Long.-85° 16′ 57″ W
132-2	Greenstone from core at Royal-Vindicator Mine	Unnamed	Tallapoosa South Quad Lat.-33° 42′ 34″ N Long.-85° 16′ 57″ W
CAR-1	Dark gray to black, fine-grained amphibolite	Dog River Formation	Carrollton Quad Lat.-33° 37′ 12″ N Long.-84° 01′ 12″ W
CAR-5	Dark gray, fine-grained amphibolite	Dog River Formation	Carrollton Quad Lat.-33° 35′ 28″ N Long.-85° 01′ 48″ W
CAR-31	Dark gray to black, fine-grained amphibolite	Dog River Formation	Carrollton Quad Lat.-33° 32′ 24″ N Long.-85° 05′ 33″ W
CAR-33	Dark gray to black, fine- to medium-grained amphibolite	Dog River Formation	Carrollton Quad Lat.-33° 31′ 03″ N Long.-85° 07′ 18″ W
CAR-34	Dark green to black, fine-grained amphibolite	Dog River Formation	Carrollton Quad Lat.-33° 34′ 43″ N Long.-85° 06′ 03″ W
CAR-35	Light to dark green, fine-grained epidote amphibolite	Dog River Formation	Carrollton Quad Lat.-33° 36′ 55″ N Long.-85° 06′ 32″ W
CAR-36	Dark green to black, fine-grained epidote amphibolite	Dog River Formation	Carrollton Quad Lat.-33° 36′ 40″ N Long.-85° 06′ 18″ W

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EXPLANATION

PALEOZOIC

ag — AUSTELL GNEISS — Fine- to medium-grained, blastoporphyritic muscovite-oligoclase-quartz-microcline orthogneiss.

mrg — MULBERRY ROCK GNEISS — Medium-grained muscovite-quartz-microcline-plagioclase orthogneiss.

shg — SAND HILL GNEISS — Fine- to coarse-grained, blastoporphyritic to non-porphyritic muscovite-biotite-oligoclase-microline-quartz orthogneiss.

ogg — OAK GROVE GNEISS — Medium- to coarse-grained, blastoporphyritic biotite-muscovite-oligoclase-quartz-microcline orthogneiss.

LATE PROTEROZOIC AND/OR EARLY PALEOZOIC

Sandy Springs Group (western belt) (stratigraphic order uncertain)

ba — BILL ARP FORMATION — Interlayered garnet-biotite-muscovite-plagioclase-quartz schist, muscovite-quartz schist, quartz-muscovite-biotite schist, muscovite-biotite-quartz-plagioclase schist, and metagraywacke. Locally contains concordant hornblende-garnet-quartz-calcite lenses.

amu, amq — ANDY MOUNTAIN FORMATION — Undifferentiated biotite-garnet-plagioclase-muscovite-quartz schist ± graphite, staurolite and kyanite; and feldspathic, micaceous garnet quartzite (amu); and clean, sugary quartzite ± garnet (amq).

dru, drs, dra, drb — DOG RIVER FORMATION — Undifferentiated muscovite-biotite-quartz-feldspar gneiss (metagraywacke), garnet-muscovite-quartz schist and amphibolite (dru); garnet-muscovite-quartz schist (drs); amphibolite (dra); and biotite gneiss (drb).

New Georgia Group (stratigraphic order uncertain)

unu, lm, rcs — UNIVETER FORMATION — Undifferentiated amphibolite, biotite-plagioclase-quartz gneiss ± muscovite with minor iron formation (unu); amphibolite and hornblende gneiss with iron formation, quartzofeldspathic gneiss and sericite-quartz schist (Lost Mountain Member) (lm); and garnet-biotite-muscovite-quartz schist varying to garnet-hornblende-muscovite-quartz schist (Rose Creek Schist Member) (rcs).

kcc, acg — KELLOGG CREEK MAFIC COMPLEX/ACWORTH GNEISS — Garnet amphibolite, metagabbro and lesser amounts of meta-ultramafic rocks (Kellogg Creek Mafic Complex) (kcc) intruded by a medium-grained biotite-quartz-plagioclase orthogneiss ± muscovite and epidote (Acworth Gneiss) (acg).

ctu — CANTON FORMATION UNDIFFERENTIATED — Undifferentiated phyllitic graphite-garnet-sericite-quartz schist ± biotite, silvery garnet-muscovite-biotite-quartz schist, metagraywacke, biotite-muscovite-quartz schist, biotite-chlorite-plagioclase-quartz schist, amphibolite, sericite-quartz schist and iron formation.

pcu, msa, gfg — PUMPKINVINE CREEK FORMATION — Undifferentiated amphibolite with minor garnet-hornblende-plagioclase gneiss, calcite-garnet-biotite-hornblende-quartz-plagioclase gneiss ± staurolite, chlorite schist, pyrite-sericite-quartz schist and iron formation (pcu); iron formation, amphibolite, manganiferous sericite-quartz schist, magnetite-garnet-muscovite-quartz gneiss and feldspathic sericite-quartz schist (msa); biotite-muscovite-quartz-plagioclase gneiss and hornblende-quartz-plagioclase gneiss with minor hornblende gneiss and actinolite-chlorite schist (Galts Ferry Gneiss Member) (gfg).

mcu, vrg, clq, mcb — MUD CREEK FORMATION — Undifferentiated amphibolite ± garnet, hornblende gneiss, garnet-biotite-quartz-plagioclase gneiss and biotite-quartz schist (mcu); biotite-quartz-plagioclase orthogneiss (Villa Rica Gneiss Member) (vrg); magnetite quartzite (Cedar Lake Quartzite Member) (clq); and garnet-biotite gneiss (mcb).

ngc, ngk, nge, ngaf, ngf, nga — NEW GEORGIA GROUP UNDIFFERENTIATED — Mappable units of chlorite schist ± garnet, biotite or anthophyllite (ngc); kyanite-muscovite-quartz schist and sericite quartzite ± kyanite and pyrite (ngk); epidote quartzite (nge); interlayered amphibolite, hornblende gneiss and quartzofeldspathic gneiss (ngaf); felsic gneiss (ngf); and amphibolite and hornblende gneiss (nga).

Rocks Bounding The Study Area (stratigraphic order unknown)

tu — TALLADEGA BELT — Undifferentiated metasiltstone and phyllite.

p€o — OCOEE SUPERGROUP — Metapelites, metapsammites, metaconglomerates and marbles of various compositions.

spge, pfs, pfu — SANDY SPRINGS GROUP (eastern belt) — Undifferentiated biotite gneiss, muscovite-biotite-quartz schist, amphibolite, micaceous quartzite and kyanite-staurolite-quartz schist (spge); mica-quartz schist (pfs); and undifferentiated biotite gneiss, mica-quartz schist and amphibolite (pfu). Units (pfs) and (pfu) are present as a klippe within the study area.

Unassigned or Unnamed Rocks (stratigraphic order unknown)

cs — chlorite schist ± garnet, biotite or anthophyllite

bif — magnetite quartzite (banded iron formation) (thickness exaggerated)

kq — kyanite-quartz granofels

gs — carbonaceous schist

ss/hgn — sericite schist with interlayered quartzite and hornblende gneiss

gms — garnet-muscovite-quartz schist

q — pyrite-paragonite-muscovite quartzite ± kyanite

amp — amphibolite and hornblende gneiss

fgn — felsic gneiss

gab — metagabbro

um — meta-ultramafic rocks, includes actinolite-anthophyllite-chlorite-talc hydrothermal alteration assemblages

csa — chlorite schist and amphibolite

fgs — felsic gneiss and pyrite-sericite-quartz schist

grn — greenstone and quartzofeldspathic gneiss

U/D — thrust fault, dashed where inferred

reverse fault, dashed where inferred

contact, dashed where inferred

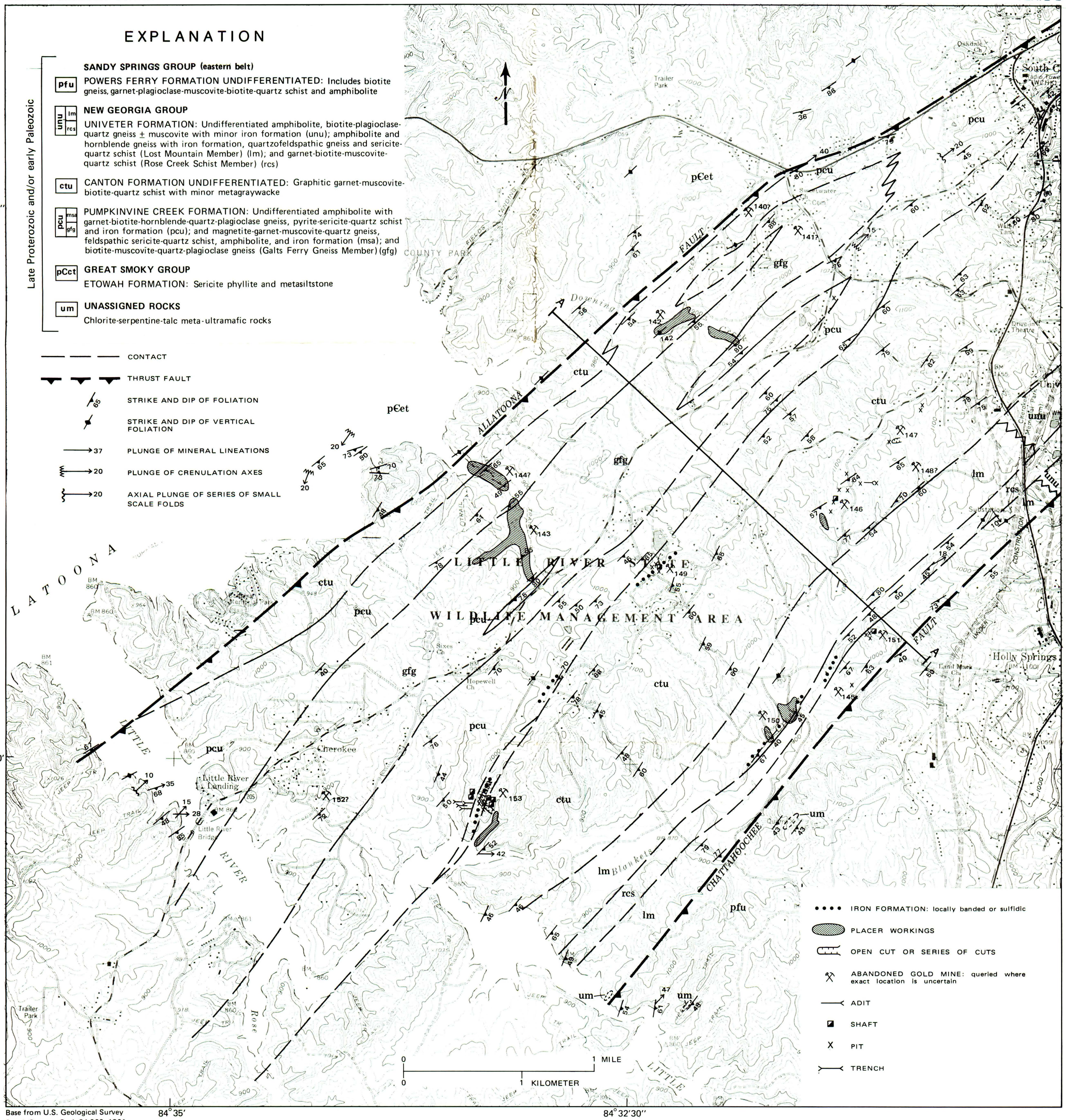
• 200 — abandoned gold mine, queried if exact location is uncertain

Geology and Compilation
by
Jerry M. German
1988

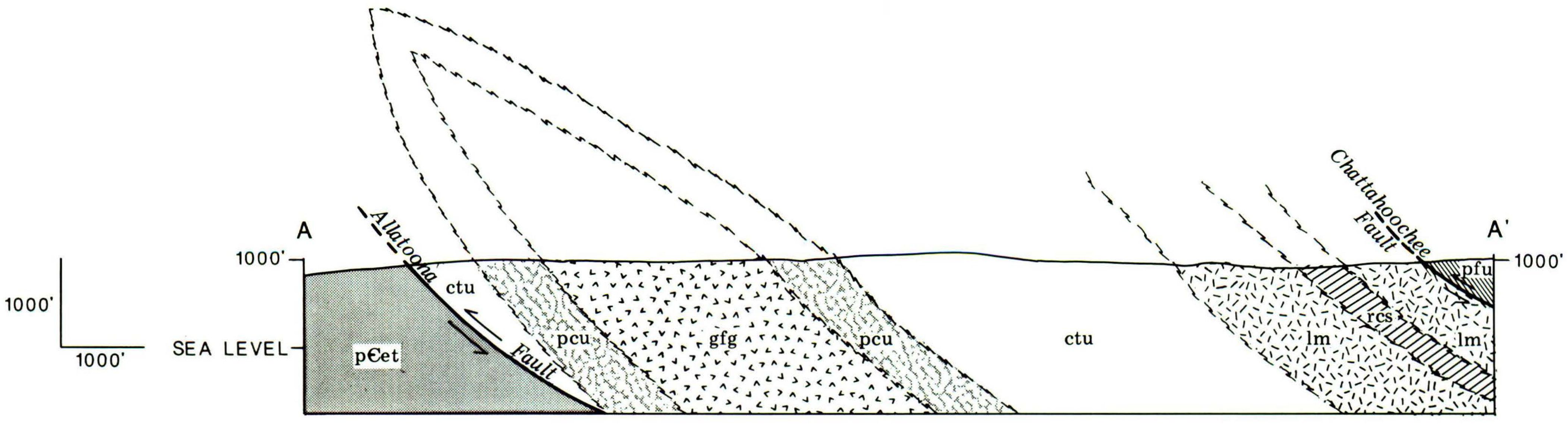
#	MINE	#	MINE	#	MINE
140	Case Property	165	Granville Mine	191	Astinol Prospects
141	McCandless Property	166	Avery (Gold Branch) Mine	192	Triglone Mine
142	Downing Creek Placer	167	Howard Property	193	Roach Prospect
143	Sixes Mine	168	Goings Mine	194	212 Prospect
144	Coggins Property	169	Hamilton Mine	195	Pine Mountain (Stockmar) Mine
145	Haynes Property	170	Freeman Prospect	196	McManus Property
146	LaBelle Mine	171	Payne, Kendrick, Randall and House Property	197	Southern Klondyke Mine
147	Macou Prospect	172	Hadaway Prospect	198	Clopton (Clompton) Mine
148	Casteel Property	173	Kemp Property	199	Chambers Mine
149	Clarkston Mine	174	Mason Mine	200	Jones Mine
150	Putnam Mine	174 A	Hathaway Property	201	Lassetter Prospect
151	Farrar (301) Mine	175	Cox Property	202	Hixon Prospect
152	Lovingood Prospect	176	Sheffield/Heidt Property	203	Hart Mine
153	Cherokee Mine	177	Michigan Mine	204	Askew Prospect
154	Kitchens Prospect	178	Twilley Mine	205	Davis Prospect
155	William Poor Property	179	Russell Mine	206	Stacey Mine
156	Evans Prospect	180	Merritt Mine	207	Bonner Mine
157	Williams Property	181	Dunaway Mine	208	McBrayer Property
158	Kellogg Mine	182	Hobbs Mine	209	Dean Property
159	Bell Star Mine	183	Hodges Prospect	210	Crew Prospect
160	Tripp Property	184	Mathews Property	211	Layton Property
161	Georgianna Mine	185	Yorkville Mine	212	Unnamed Prospect
162	Stansill Property	186	Barton Mine	213	Edwards Mine
163	Glade Mine	187	Parker Property	214	Brock Prospect
164	Robertson Property	188	Austin Mine	215	Royal/Vindicator Mine
164 A	McDaniel Property	189	Carnes Prospect	216	Chandler Prospect
		190	Baggett Prospect		

Based from U.S. Geologic Survey
Anniston, Alabama-Georgia, 1:100,000, 1981,
Atlanta, Georgia, 1:100,000, 1981,
Cartersville, Georgia, 1:100,000, 1981,
Griffin, Georgia, 1:100,000, 1979, and
La Grange, Alabama-Georgia, 1:100,000, 1978.

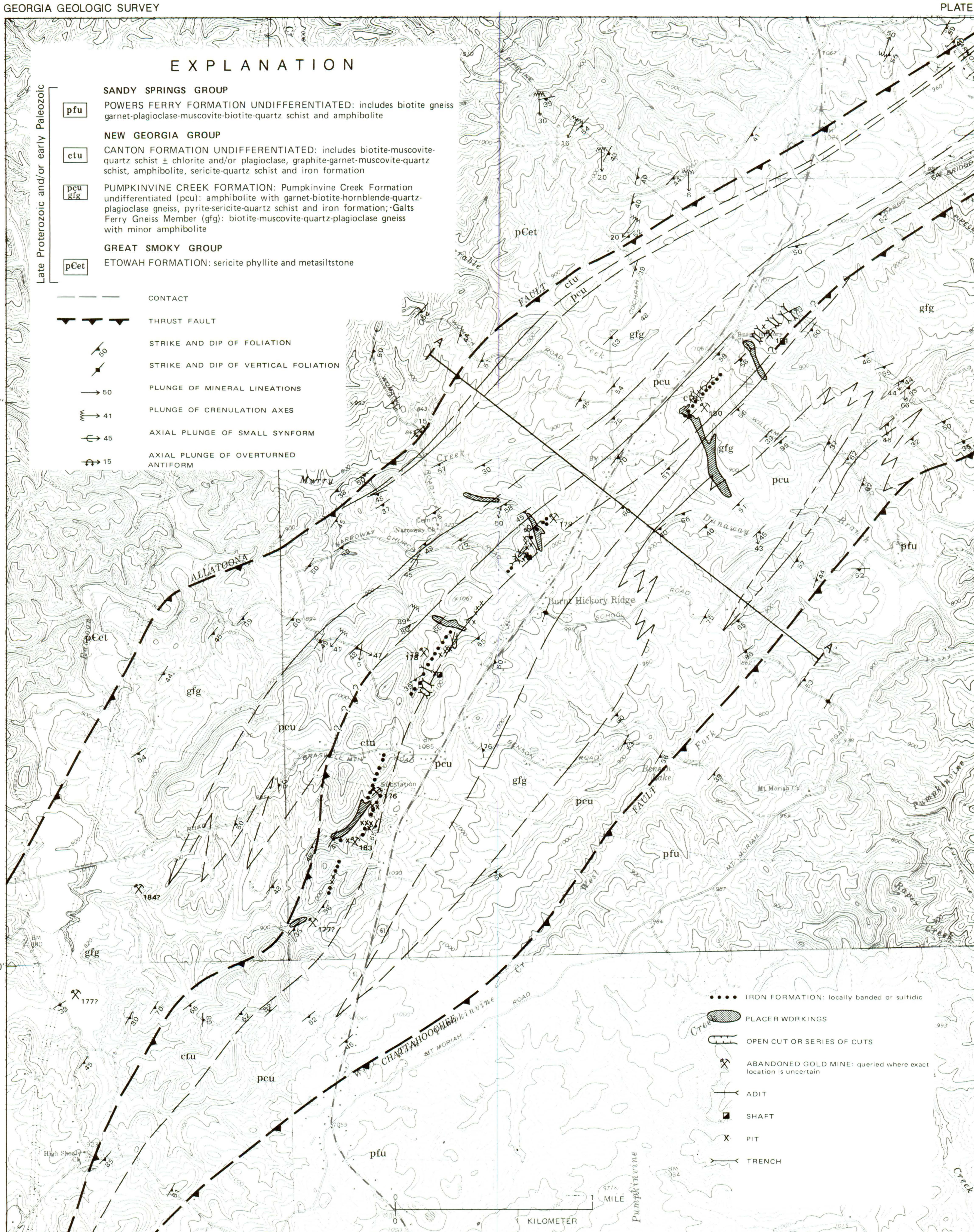
GEOLOGY OF THE CARROLL COUNTY GOLD BELT AND SOUTHWESTERN PORTION OF THE DAHLONEGA GOLD BELT



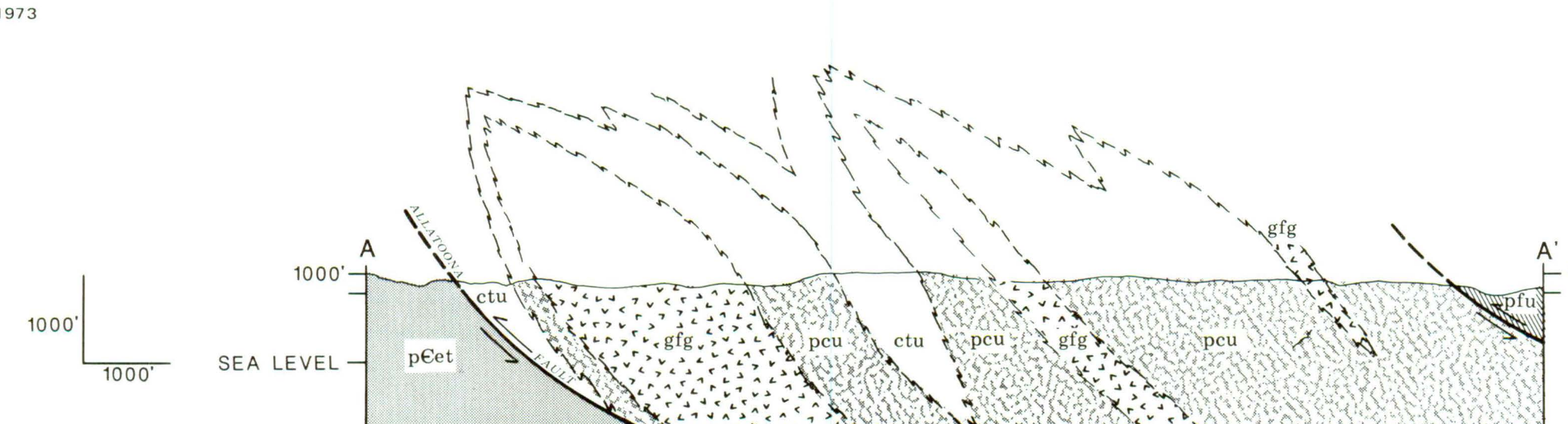
Base from U.S. Geological Survey
South Canton, Ga 1:24,000, 1961
Interim revisions as of 1985



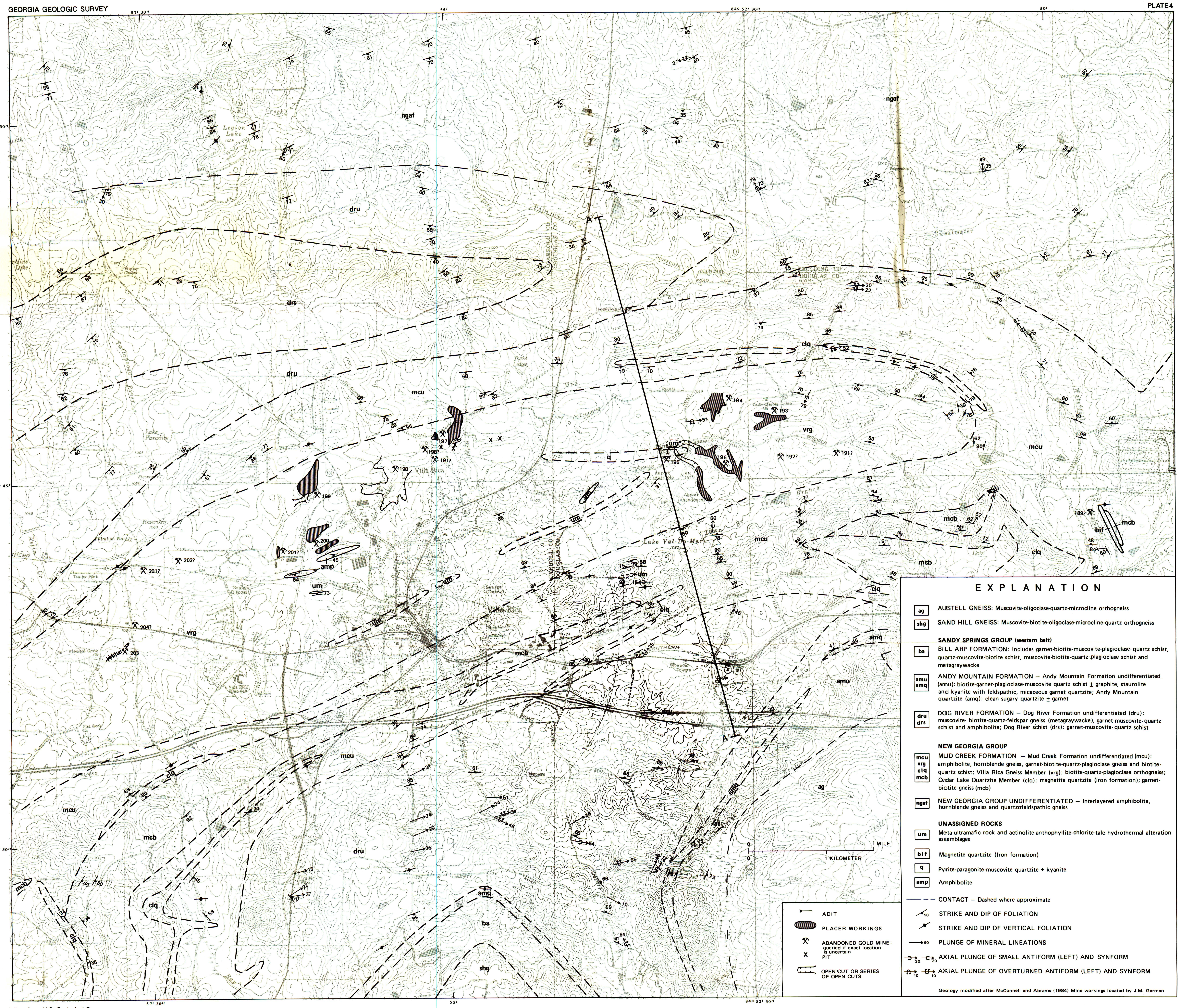
GEOLOGY OF THE SOUTH CANTON DISTRICT



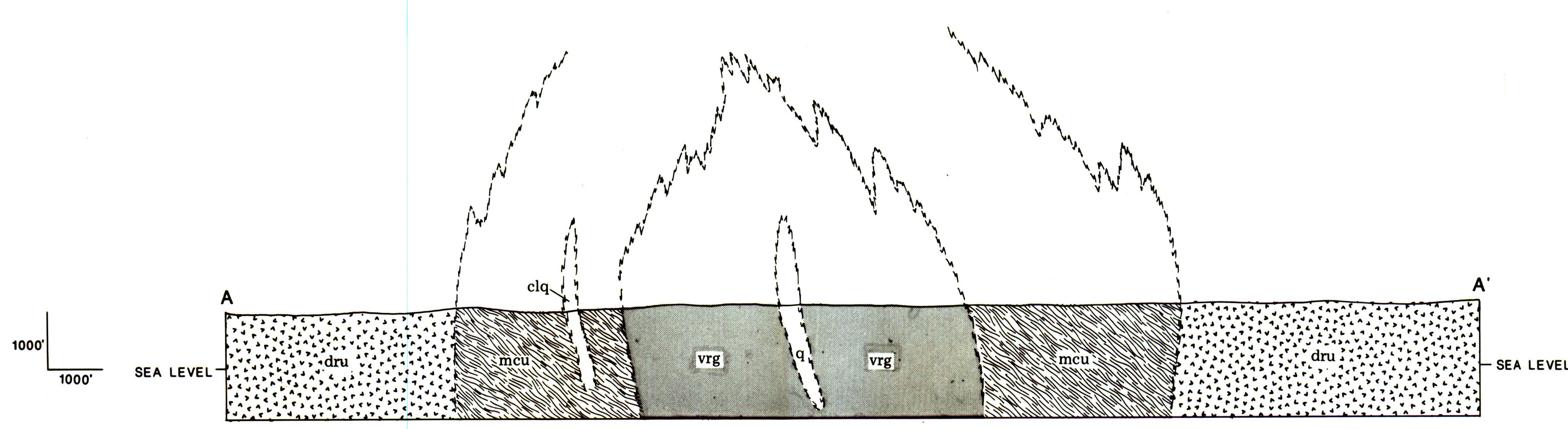
Base from U.S. Geological Survey
Dallas, Ga. 1:24,000, 1972,
Taylorsville, Ga. 1:24,000, 1972,
Burnt Hickory Ridge, Ga. 1:24,000,
1972 and Yorkville, Ga. 1:24,000, 1973



GEOLOGY OF THE BURNT HICKORY RIDGE DISTRICT



Base from U.S. Geological Survey
New Georgia, Ga 1:24,000, 1982,
Villa Rica, Ga 1:24,000, 1982,
Nebo, Ga 1:24,000, 1982 and
Winston, Ga 1:24,000, 1982



GEOLOGY OF THE VILLA RICA DISTRICT