GEOCHEMISTRY AND ECONOMIC POTENTIAL OF PEGMATITES IN THE THOMASTON-BARNESVILLE DISTRICT, GEORGIA

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GEOLOGIC REPORT 7

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ABSTRACT

The Thomaston-Barnesville district is one of twelve presently recognized pegmatite districts in Georgia which form part of the Appalachian pegmatite province. The pegmatites of the Thomaston-Barnesville district are predominantly mica (muscovite) - rich. During World War II, this district was the largest producer of sheet and punch mica in the southeastern Piedmont of the United States. No mica has been mined in the Thomaston-Barnesville district for approximately 30 years. The current investigation evaluates this district's potential for rare metals and to a lesser extent its potential for mica and feldspar.

The present evaluation is based on minor and trace element geochemistry of muscovite collected from the Thomaston-Barnesville district's pegmatites. Over a period of nearly 50 years since the latest investigations in this district, cultural activities, natural reforestation, and rapid degradation of mine exposures left a poor physical record of the formerly known pegmatites. The resistance of muscovite to weathering combined with the presence of indicator elements in the muscovite for rare metals make muscovite an ideal sampling medium in this district.

Geochemical results show that anomalous indicator elements (Be, F, Ga, Li, Nb, Sn, Rb, Ta, and Zn) in muscovite coincide with the recorded occurrences of rare-metal bearing pegmatites. Anomalous indicator elements in muscovite helped identify other pegmatites which may contain rare-metal bearing minerals. Most of the pegmatites with anomalous indicator elements are concentrated in the central part of the Thomaston-Barnesville district although some pegmatites in other parts of this district also appear to have potential for containing rare-metal bearing minerals.

The potential for additional undeveloped sheet and punch muscovite deposits is good in parts of the district along the continuation of apparent structural trends; however, the difficulty of finding these relatively small targets may preclude additional work. Further development of some of the larger, partially mined pegmatites at depth or along strike and processing of mine dump material for scrap mica may be economically feasible for small operations. A few pegmatites in the Thomaston-Barnesville district contain unweathered feldspar, but most near-surface, pegmatitic feldspar is weathered to clay. The potential of this district for sodic and potassic feldspar is low.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the permission and interest of the numerous property owners to inspect and sample the old pegmatite workings. The author wishes to thank the reviewers of this manuscript for their thoughtful insights and efforts.

INTRODUCTION

PURPOSE OF INVESTIGATION

The current investigation evaluates the pegmatites in the Thomaston-Barnesville district for their rare- metal potential. Because the Thomaston-Barnesville district is the largest pegmatite district in Georgia, it was regarded as having a better than average potential for containing rare-metal bearing pegmatites. Rare metals which are commonly concentrated in pegmatites include beryllium, cesium, gallium, germanium, lithium, niobium, rubidium, tantalum, thorium, uranium, and zirconium. Uses for many of these metals has increased significantly since the last major pegmatite mining in Georgia.

Strategic demand and high prices encouraged the mining of pegmatites in Georgia for feldspar, sheet mica and punch mica, particularly during World War I and World War II. During World War II, mica production in the Georgia Piedmont accounted for 41 percent (over 146,000 lbs.) of the mica produced in the southeastern Piedmont (Jahns and others, 1952). The largest portion of this mica production was from the Thomaston-Barnesville district. Investigations prior to 1950 concentrated on the mica content and not the potential for rare metals in these pegmatites.

GRANITIC PEGMATITES

COMPOSITION AND CLASSIFICATION

Pegmatites of the Thomaston-Barnesville district are generally granitic in composition. Granitic pegmatites are coarse-grained, lensoidal, dike-like intrusions generally composed of various proportions of quartz, mica (generally muscovite), and potassic or sodic feldspar. Accessory minerals such as tourmaline, garnet, and beryl may also be present. Granitic pegmatites are classified on the basis of geological-petrogenetic criteria developed by Ginsburg and others (1979) and recently introduced into North America by Cerny (1982a). The four basic types of granitic pegmatites are: 1) miarolitic pegmatites, 2) rare-element pegmatites, 3) mica-bearing pegmatites, and 4) maximal depth pegmatites (Cerny, 1982a). Brief descriptions of each type given below are based on Cerny (1982a).

Miarolitic pegmatites occur as pods in the upper parts of epizonal granite intrusions that are emplaced into low-grade metamorphic country rocks. These pegmatites are characterized by crystal-lined cavities containing such minerals as quartz, feldspar, fluorite, beryl, tourmaline and topaz. These cavities are the sources of many museum quality specimens and gemstones such as aquamarine (beryl), tourmaline and topaz.

Rare-element pegmatites generally occur in cordierite-amphibolite facies metamorphic rocks peripheral to differentiated allochthonous granites. These pegmatites are formed at pressures equivalent to intermediate depths (3.5-7 km). These pegmatites are enriched in one or more of the following elements: lithium, cesium, rubidium, tantalum, tin, and niobium. In addition to quartz, sodic and potassic feldspar, lepidolite, beryl, cassiterite and tantalite may be present.

Mica-bearing pegmatites occur in almandine-amphibolite facies metamorphic rocks and are formed at pressures equivalent to depths of 7 to 11 kilometers. Typical mineralogy includes quartz, muscovite, and sodic and potassic feldspar. Additional minerals which may be present include biotite, tourmaline, beryl and garnet. Although pegmatites of this class are primarily important for their mica content, some like the Cochran mine in north Georgia and the giant rare-element bearing Greenbushes pegmatite in Australia (Partington, 1990) may be important sources of rare-element bearing minerals. The source intrusions for mica-bearing pegmatites are commonly not apparent. The genesis of mica-bearing pegmatites may be due to anatexis or by separation from an anatectic, more or less autochthonous granite (Cerny, 1982a).

Maximal depth pegmatites occur in upper amphibolite- to granulite-facies terranes, and commonly grade into migmatites. Maximal depth pegmatites are believed to form at pressures equivalent to depths greater than 11 kilometers (Cerny, 1982a). These pegmatites consist mainly of sodic and potassic feldspar with lesser amounts of quartz and minor amounts of muscovite and biotite. The pegmatites of this class may be barren, allanite plus monazite-bearing or ceramic (feldspar-rich).

In the southeastern United States, the most abundant pegmatites are the mica-bearing and the maximal depth types. These pegmatites have been principally mined for mica or feldspar. Several groups or districts of rare-element bearing pegmatites occur in the southeastern United States. These have been important producers of lithium (King's Mountain district, North Carolina), beryllium (Troup County district, Georgia) (Furcron and Chancey, 1954; Furcron, 1959), and tin and tantalum (Rockford district, Alabama) (Foord and Cook, 1989). Miarolitic pegmatites are currently unknown in the southeastern United States.

PEGMATITE PROVINCES, BELTS, DISTRICTS, FIELDS AND GROUPS

Granitic pegmatites occur in spatially and/or genetically definable groups. Such distributions have been defined by Ginsburg and others (1979) and Cerny (1982a). The largest defined entity is a pegmatite province which includes the entire group of pegmatite fields or belts within a single metallogenic province. A pegmatite belt consists of pegmatite fields or districts which are related to each other by a large scale linear geologic structure and occur in a common structural position and geological environment. A pegmatite district contains several associated pegmatite fields, which are separated from other pegmatite fields either territorially or geologically. A pegmatite field is an area containing pegmatites which include a single formation type with a common geological-structural environment, age and igneous source. The smallest definable occurrence of pegmatites is a pegmatite group defined in a similar manner to a pegmatite field except that it is a spatially distinct part of a pegmatite field (Ginsburg and others, 1979; Cerny, 1982a). Isolated pegmatites may only appear to be isolated because of the lack of known additional occurrences in the area.

THE THOMASTON-BARNESVILLE DISTRICT

The Thomaston-Barnesville district is one of twelve pegmatite districts presently recognized in Georgia (Cocker, 1990). These pegmatite districts are concentrated in two distinct belts (Figure 1): the Blue Ridge belt and the Piedmont belt, which form part of the southernmost segment of the Appalachian pegmatite province (Jahns and others, 1952).

The Thomaston-Barnesville district, as referred to in this report, is principally that district of the same name as described by Furcron and Teague (1943) and by Heinrich and others (1953). This district was defined by those authors principally on the basis of mining or prospecting of the

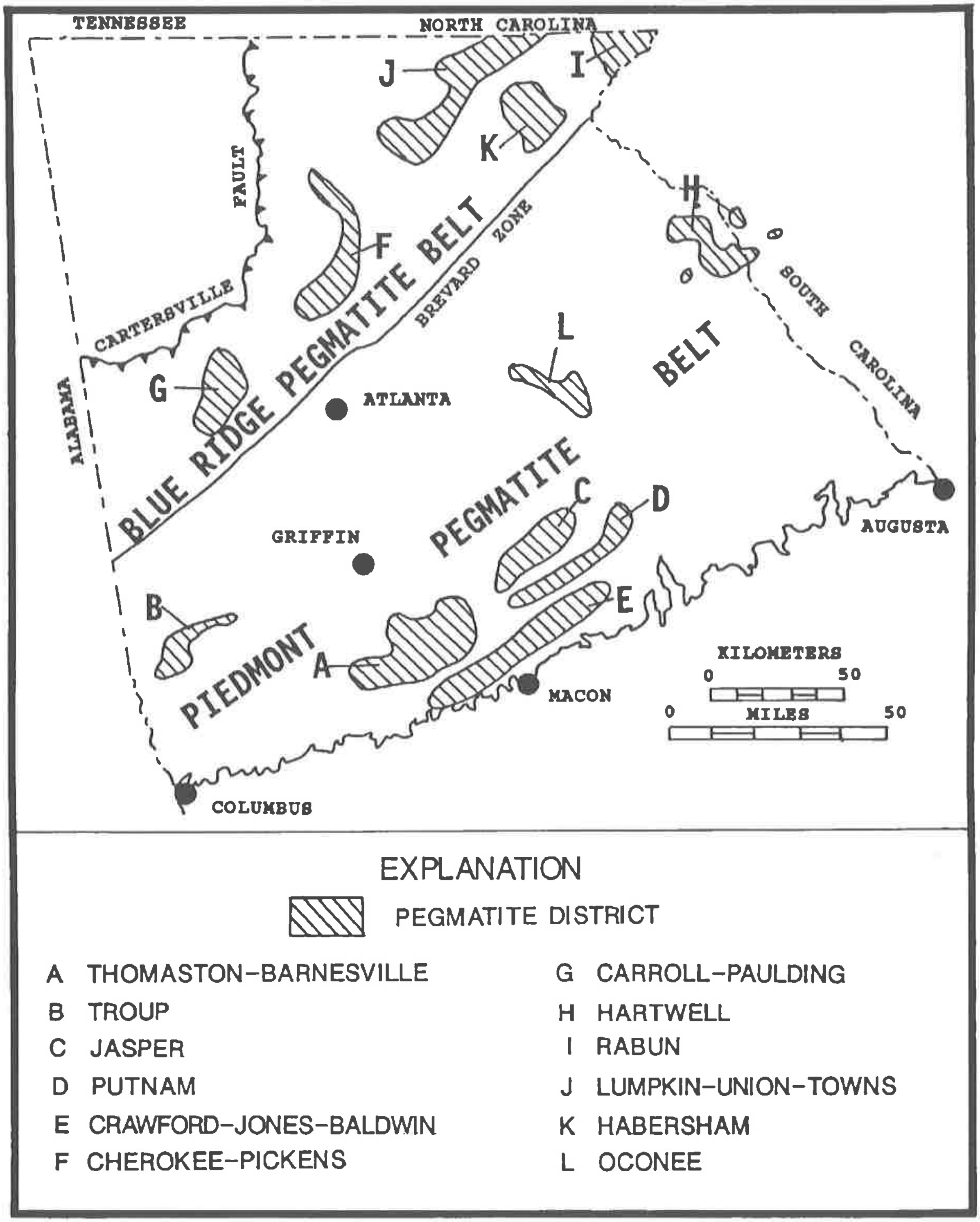

Figure 1. Pegmatite belts and districts in Georgia. The Thomaston-Barnesville district lies within the Piedmont pegmatite belt. (Modified from Cocker, 1992).

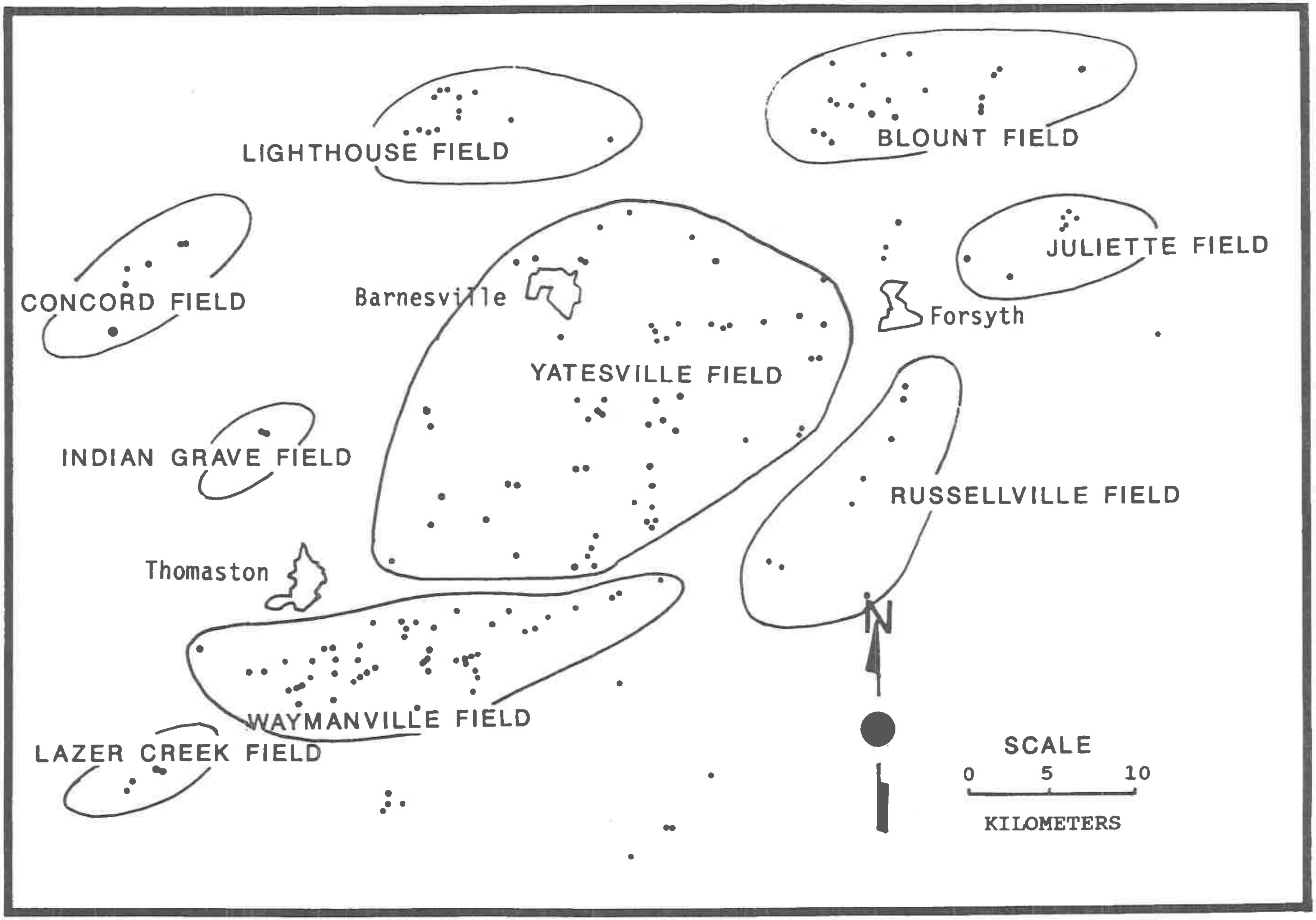

Figure 2. Pegmatite fields within the Thomaston-Barnesville district. Pegmatites in the two largest fields - Waymanville and Yatesville yielded most of the known mica production. The cities - Forsyth, Thomaston and Barnesville are included as geographical references. Figures 3 and 4 provide more geographical references.

muscovite-bearing pegmatites within Monroe, Lamar and Upson counties. The present study extends the district to include nearby muscovite-bearing pegmatites which have similar physical and compositional characteristics, and are in close spatial proximity to those pegmatites which have previously been included in the district.

The Thomaston-Barnesville district can be divided into a number of pegmatite fields based on the spatial distributions of the currently known pegmatites. These fields are outlined on Figure 2. The majority of known pegmatites occur in a broad band that extends from a point south of Thomaston northeast through Yatesville (Waymanville and Yatesville fields). The Indian Grave, Concord, Lighthouse, Blount, Juliette, Russellville, and Lazer Creek pegmatite fields appear to be geographically isolated from each other. The Lazer Creek field may be an extension of the Waymanville field.

PAST MINING ACTIVITY

Past mining activity within the Thomaston-Barnesville district focussed on high-quality mica. All of the mica that was mined in the Thomaston-Barnesville district apparently was muscovite. The term mica includes a number of distinctly different mineral species; however, muscovite is the most important species for its physical properties. The term "mica" is retained in this publication in the circumstances in which muscovite is referenced as mica in the publications cited.

Mica is important for its physical properties. Mica is graded by: size, color, clearness, uniform perfect cleavage, flexibility, electric power factor, and freedom from intergrowths with other minerals and from clays, spots and stains (Whitlatch and others, 1962). Sheet and punch mica are large, principally defect-free muscovite crystals or parts of large muscovite crystals found only in pegmatites. Sheet and punch mica are used for a variety of purposes, including: electrical insulation and specialty window panes. Good quality sheet and punch mica command high prices because of their rarity. Scrap, flake and ground mica are derived from the smaller and commonly defect-ridden micas and are more abundant than the sheet and punch mica. Dry ground mica is used in concrete, stucco, backing for asphalt, roofing, dusting powder for rubber tires, fireproofing material, lubricants, and in molded insulation (Whitlatch and others, 1962). Jahns and Lancaster (1950) provide a detailed study of commercial sheet muscovite properties.

During World Wars I and II, the restriction of strategic sheet and punch mica supplies caused an increase in demand and price. Higher, subsidized prices encouraged prospecting and mining of mica-bearing pegmatites within Georgia. Mica production in Georgia was initially centered in the northern part of the Blue Ridge pegmatite belt. Until about 1918, most of the mica production in Georgia was from hard-rock mines in the Lumpkin-Union-Towns and the Cherokee-Pickens districts. Because of dwindling reserves in the Blue Ridge, the discovery of rich, mica-bearing pegmatites in the Piedmont, combined with the ease and low-cost of saprolite versus hard-rock mining, the bulk of mica production shifted to the Thomaston-Barnesville and Hartwell districts in the Piedmont pegmatite belt.

Systematic mining in the Thomaston-Barnesville district began about 1916 with the most extensive mining confined to the periods, 1917-24 and 1941-45 (Heinrich and others, 1953). During the period 1917-24, output from the Thomaston-Barnesville district is estimated at several hundred thousand pounds of trimmed mica (Heinrich and others, 1953). During World War II, the Thomaston-Barnesville district was the leading producer of sheet and punch mica in the southeastern Piedmont of the United States with 114,165 pounds or 32 percent of the total production (Jahns and others, 1952). Sixty-two percent of this production came from 4 mines: Adams, Battles, Earley Vaughn and Mitchell Creek (Heinrich and others, 1953). Although published, comprehensive data is incomplete following World War II, production of sheet mica apparently continued in a few of the larger mines at a decreased level into the early 1960's when price subsidies were discontinued (Whitlatch and others, 1962). Yearly production of sheet mica in Georgia ranged from 9,000 to 17,000 lbs./year during this period (Cocker, 1992). Several of the mines described by Heinrich and others (1953) have been significantly enlarged in the time between World War II and the present investigation.

Early, underground mining in this district involved selective removal of mica. After World War II, mining concentrated on the larger pegmatite bodies. Open-pit mining of the larger pegmatites probably involved the used of steam shovels, bulldozers and backhoes. Most mining activity was confined to the upper, weathered portion of a deposit (the upper 13 to 20 meters - 40 to 60 feet). The mica was trimmed by hand at the mine site or in the nearby towns of Thomaston, Barnesville, Yatesville, Culloden, and Forsyth.

High quality sheet mica of the type mined here in the past still commands premium prices. Within the United States, which imports nearly all of its sheet mica, no major source of sheet mica is being mined. In 1988, the United States imported approximately $2 million worth of sheet mica (Davis, 1988). The United States also produces and consumes considerable amounts of scrap, flake and ground mica. In 1988, the United States produced about $23 million worth of scrap, flake and ground mica and imported about $5.5 million dollars worth of scrap, flake and ground mica (Davis, 1988).

LOCATION AND SIZE

The Thomaston-Barnesville district is located approximately halfway between Macon and Griffin (Figure 1). Most of the pegmatites considered to be part of this district are located within the counties of Monroe, Upson and Lamar, but mica-rich pegmatites also occur in Pike, Talbot, Jasper and Butts Counties. The total area of this district is approximately 2000 square kilometers.

TERRAIN AND EXPOSURE

The terrain is generally gently rolling to flat with some of the major drainages cutting deeply into the more gentler terrain. Elevations range from 100 to 250 meters above sea level. The western side of the district is bounded by the elongate ridges of Pine Mountain. The gentle terrain is controlled mainly by deep saprolitization. Natural exposures are most common along deep drainages or hill tops. Road cuts locally expose bedrock. Exposures of pegmatites are rare. Most pegmatites were apparently discovered by farmers when they plowed up chunks of weathering-resistant mica.

VEGETATION

The vegetation of the region is governed principally by land-use. Much of the flat terrain is in pasture. The gently rolling terrain may also be in pasture, but is more commonly forested. Vast tracts of land have been clear-cut and replanted with pines one or more times. Recently reforested (5 to 15 years) land contains thick underbrush and is extremely difficult to traverse. Many previously farmed tracts have been abandoned and are now overgrown with climax forest flora (oaks, hickory, sweetgum).

Land-use requirements in this district commonly resulted in the filling-in or bulldozing of open-pits, shafts and mine dumps. Combined with rapid revegetation, many old mines and prospect pits have literally disappeared. Some of these former mines may be detectable by the presence of muscovite concentrated on the land surface.

PREVIOUS WORK

Galpin's (1915) study appears to be the first to locate and describe numerous feldspar and mica pegmatites as well as aplite dikes. Most of these descriptions and locations are generalized, and some of the described locations were difficult to verify. Because of the lack of prospecting activity prior to Galpin's investigations, many pegmatites had not been discovered. Smith (1931-1933) located and briefly described a significantly larger number of mica-bearing pegmatites that were discovered and developed during World War I. Smith's field notes are keyed numerically to pre-1920's soil maps. Furcron and Teague (1943) published many of Smith's descriptions along with their descriptions of mica-bearing pegmatites that were discovered and developed during the initial stages of World War II. Furcron and Teague (1943) published the first maps which show locations of individual pegmatite mines in Georgia.

Subsequent investigations by the United States Geological Survey (Jahns and others, 1952; Heinrich and others, 1953) and the United States Bureau of Mines (Beck, 1948) during World War II coincided with the extensive prospecting and mining of mica-bearing pegmatites throughout the southeastern Piedmont. Many of the locations and descriptions in Heinrich and others (1953) are based on Furcron and Teague (1943) and ultimately Smith (1931-1933). The studies by Jahns and others (1952) and Heinrich and others (1953) brought a wealth of data from other pegmatite districts in the United States and an expanded understanding of pegmatites. These earlier investigations provide critical information on the mineralogy, internal zoning and structure of the pegmatites in the southeastern Piedmont. Much of this information was nearly impossible to verify or elaborate on because of the poor physical condition of the older pegmatite mines and outcrops. Physical information on the pegmatites in this district which are contained in this report are principally based on descriptions obtained during the earlier studies.

The geologic setting of the district was poorly known at the time of the earlier studies. Subsequent investigations by Clarke (1952), Grant (1967) and Smith and others (1969), and more recently, by Schamel and others (1980), Higgins and others (1988), Hooper (1986) and Stieve (1984) contributed to an increased understanding of the lithologies and major structures in and adjacent to the district. Despite these efforts, the basic geologic framework within the Thomaston-Barnesville district remains poorly known. These later geologic contributions reflect the lack of recent interest in pegmatites and a lack of knowledge of the potential that the pegmatites' geology and geochemistry can contribute to the understanding of the regional geology.

SAMPLING AND ANALYTICAL PROCEDURES

LOCATIONS OF MINES, PROSPECTS AND SAMPLES

As previously described, the Thomaston-Barnesville district covers a large area and includes numerous mines and prospects which have been documented by Smith (1931-1933), Furcron and Teague (1943), Beck (1948), Heinrich and others (1953), Koch and others (1984 and 1987). It was difficult to find the mines and prospects located by the above authors due in part to the lack of map coverage or the relatively poor quality of the maps available at that time. Also, the occasional erroneous transcription of mine locations (Furcron and Teague, 1943; Beck, 1948; Heinrich and others, 1953; Koch and others, 1984 and 1987) initially described by Smith (1931-1933) was perpetuated by later authors. Text descriptions of the locations occasionally did not match the map locations. In addition, subsequent human activity or natural reforestation obliterated or obscured the former mining activity.

Because one of the major goals of the present investigation is the evaluation of this district's pegmatites, the inspection and sampling of the known pegmatites required their location in the field. This investigation succeeded in finding most of these mines and prospects. Pegmatites, which belong to this district, are located on nineteen United States Geological Survey 7.5 minute quadrangle sheets. These 7.5 minute quadrangle maps (1:24000 scale) show the most accurate locations of these mines, prospects and sample points and are on file at the Georgia Geologic Survey. The locations of these mines, prospects and sample points are also given in Appendix I as UTM coordinates (in meters). The accuracy of most of the points actually located in this investigation in UTM coordinates is plus or minus 10 to 50 meters (about 30 to 150 feet). The locations of those mines and prospects which could not be found in the field during the present study are based on the descriptions by the previous authors, but the accuracy of these locations is uncertain. The mine and sample point locations were compiled from the 7.5 minute quadrangle maps onto four 1:100000 scale map sheets (Thomaston, Griffin, Milledgeville, and Macon) which are also on file at the Georgia Geologic Survey. A single sample location map was compiled from these four maps and reduced for this publication (Figure 3).

SAMPLING TECHNIQUES

The southeastern Piedmont in Georgia presents a difficult sampling situation. Prolonged and intensive subtropical to tropical weathering since the Late Cretaceous, has altered much of the near surface rock to saprolite. Hard bedrock exposures are locally abundant, but are generally rare. Most of the pegmatites within this district contain quartz, muscovite and a potassic and/or sodic feldspar. Quartz and muscovite are commonly the only minerals at or near the surface which have resisted the chemical weathering. The trace element geochemistry of muscovite and feldspar is useful in identifying pegmatites which may contain rare-metal bearing minerals. Muscovite concentrates and feldspar concentrates (where present) were collected.

Mineral concentrates were collected randomly at a dump, exposure or outcrop in an attempt to achieve an average or representative sample of the entire pegmatite. This sampling procedure attempted to minimize the effects of mineralogical and chemical zoning within each pegmatite. The lack of exposed workings in nearly all of the pegmatites and the apparent mixing of dump material during and after mining necessitated this type of sampling procedure. Any regional comparisons of pegmatite geochemistry should be based on a representative sample from each pegmatite. In a few instances, the scarcity of pegmatitic material restricted the diversity of samples which were collected.

SAMPLE ANALYSIS

Samples were analyzed by two different geochemical labs over the duration of this project. Twelve samples, which were collected during the initial stages of this investigation were analyzed by Skyline Labs in Wheatridge, Colorado. The remainder of the samples were analyzed by Bondar-Clegg, Inc. in North Vancouver, B.C. and Ottawa, Ontario. Two duplicates of the samples analyzed by Skyline Labs were also analyzed by Bondar-Clegg. The results were comparable. Skyline Labs used inductively coupled plasma spectroscopy to analyze the submitted samples. Bondar-Clegg used inductively coupled plasma spectroscopy, direct coupled plasma spectroscopy, atomic absorption spectrometry, gravimetric analysis, x-ray fluorescence, and specific ion analysis to analyze the submitted samples. The muscovite and feldspar analyses are presented in Appendix II and III respectively. Specific methods, extraction techniques, and lower detection limits for each element are given in Appendix IV. Minor changes in the lower detection limits for some elements by Bondar-Clegg during the course of this investigation did not affect the interpretation of the results because of the emphasis on high geochemical concentrations.

GENERAL GEOLOGIC SETTING

THE PINE MOUNTAIN BELT

The Thomaston-Barnesville district lies principally within the eastern end of the Pine Mountain belt (Figure 4). Muscovite-bearing pegmatites of this district also occur outside of the Pine Mountain belt to the north and east of the Towaliga and Box Ankle faults (Figure 4).

Rocks in the eastern end of the Pine Mountain belt are mainly Middle Proterozoic orthogneisses of the Wacoochee Complex and younger, metasedimentary rocks (Schamel and others, 1980). The most widespread lithology of the Wacoochee Complex is a strongly foliated granitic gneiss called the Woodland Gneiss (Hewett and Crickmay, 1937; Rankin and others, 1989). Orthogneiss which contain biotite, garnet and prominent hypersthene in the central part of the Thomaston-Barnesville district is known as the Jeff Davis Granite. A 1,051 Ma Rb-Sr isochron for the Woodland Gneiss (Rankin and others, 1989) indicates a Grenville age for the metamorphism of the orthogneiss. Charnockitic rocks indicate that the metamorphic grade was granulite facies.

Late Proterozoic or early Paleozoic age metasedimentary clastic rocks of the Pine Mountain Series overlie the

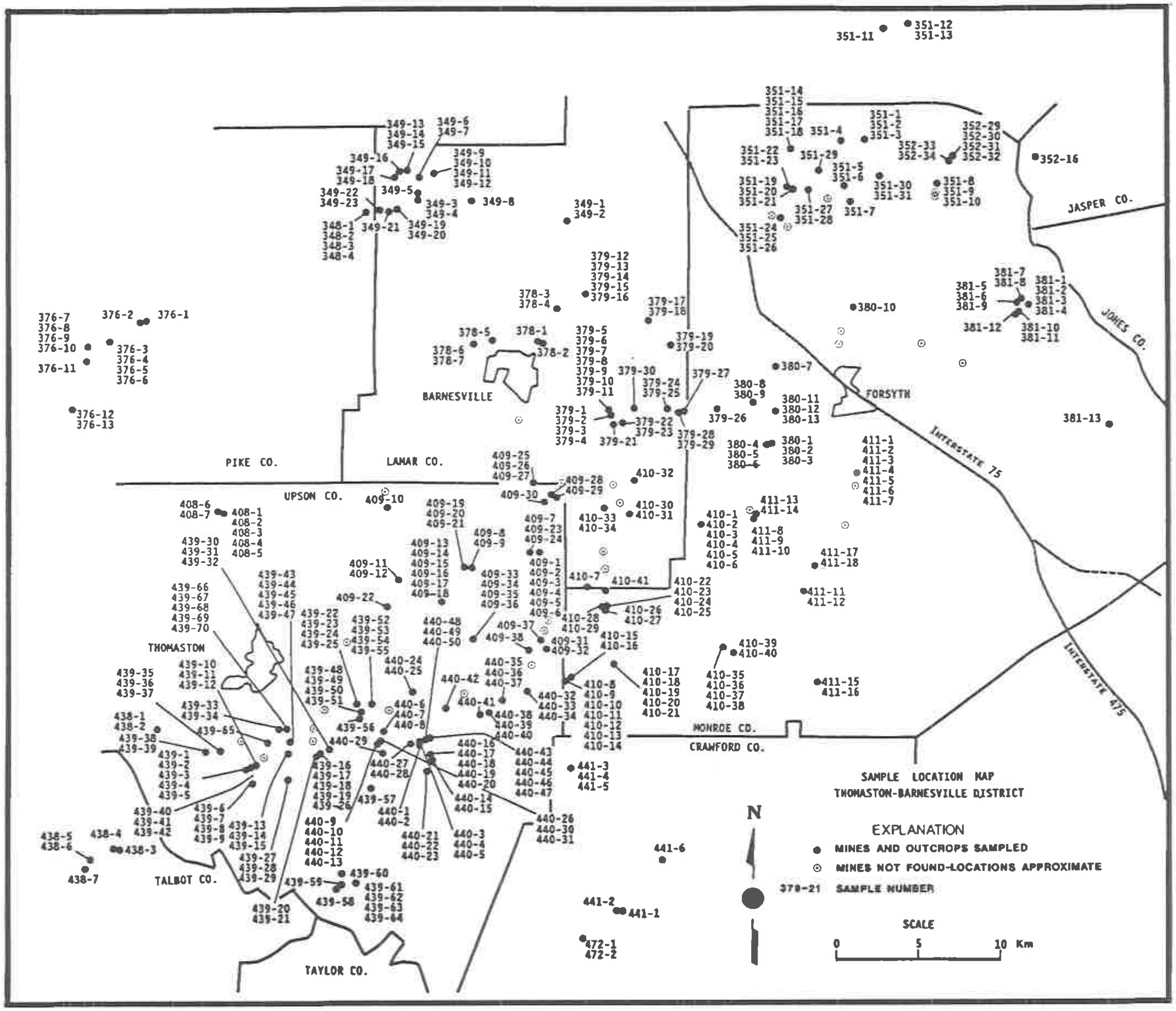

Figure 3. Sample location map. Map shows the location of all the pegmatite samples (solid circles) collected in this district and a number of feldspar pegmatites located to the south in Crawford County. Circles with a central dot are the approximate locations of mines or prospects which were not found during this investigation. Samples include muscovite, feldspar, biotite and tourmaline samples. Sample numbers are linked to mine and prospect names in Appendix I.

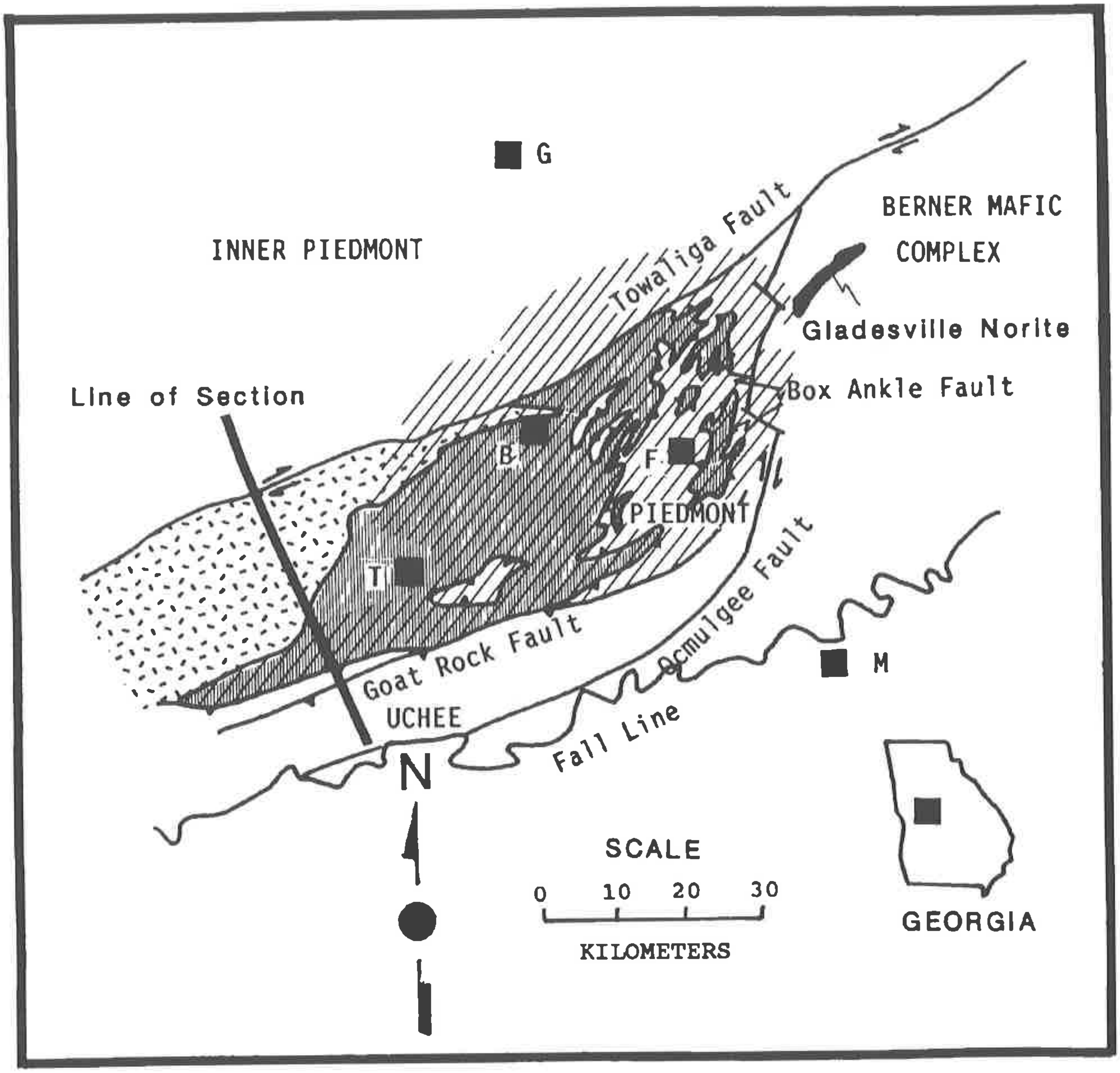

Figure 4. Generalized geologic map of the Thomaston-Barnesville district. The location of the Thomaston-Barnesville district is marked by diagonal lines; the Grenville age crystalline basement is shaded; the overlying Late Proterozoic to Early Paleozoic metasedimentary clastic rocks is speckled; and the adjoining metamorphic rocks (mainly gneisses) of the Uchee, Inner Piedmont, and Piedmont terranes; and the Berner mafic complex are labeled. The Gladesville norite is in black. The major faults - the Towaliga, the Box Ankle, the Goat Rock and the Ocmulgee - separate the major terranes. The principle cities (black boxes) are Macon (M), Forsyth (F), Barnesville (B), Thomaston (T), and Griffin (G). The cities - Forsyth, Thomaston and Barnesville, and the Towaliga and Goat Rock Faults are included as geographical references on the district maps which follow. The section line (Figure 5) is to the west of Thomaston. (Map is modified from Schamel and others (1980), Hooper and Hatcher (1989), and Hatcher and others (1989).

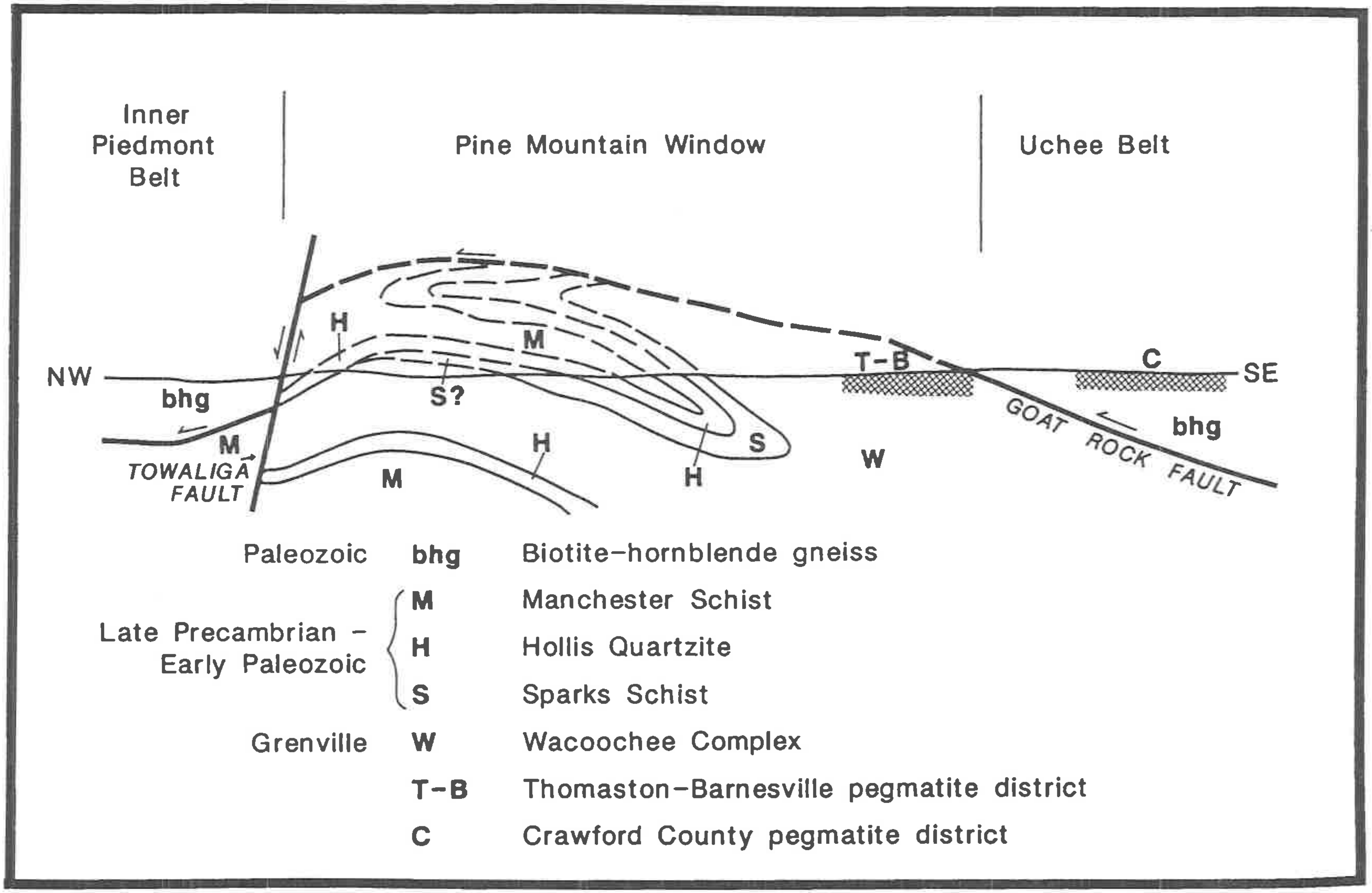

Figure 5. Cross-section through the Thomaston-Barnesville district. The line of this section is shown in Figure 4. Shaded areas indicate general position of the mica-rich pegmatites of the Thomaston-Barnesville district and the feldspar-rich pegmatites in Crawford County. This section is modified from Schamel and others (1980) and Cocker (1992).

Wacoochee Complex. Unconformably atop the Wacoochee Complex are feldspar augen schist, layered paragneiss, aluminous schist and quartzite of the Sparks Schist. Relatively pure quartzite of the Hollis Quartzite rests directly on either orthogneiss of the Wacoochee Complex or on the Sparks Schist. The uppermost unit in the study area is the Manchester Schist, which is a thick aluminous, garnet-(kyanite)-biotite-muscovite schist (Schamel and others, 1980).

Deformation of the Pine Mountain belt during a probable mid-Paleozoic event apparently remobilized and folded the Wacoochee Complex and the Pine Mountain Series into two (Schamel and others, 1980) or three (Sears and Cook, 1984) large nappes which are overturned to the northwest (Figure 5). The earlier, granulite facies metamorphism of the Wacoochee Complex was overprinted by a greenschist-amphibolite (Schamel and others, 1980) middle amphibolite (sillimanite) facies metamorphism which affected both the Wacoochee Complex and the overlying Pine Mountain Series rocks (Smith and others, 1969) during this probable mid-Paleozoic event (Schamel and others, 1980). Smith and others (1969) suggest that a kyanite-sillimanite isograd may be present within the eastern end of the Pine Mountain belt (Figure 4). Although the precise position of this isograd is uncertain, the isograd does indicate that rocks metamorphosed to the kyanite facies are presently located within an outer zone of sillimanite facies rocks. This present configuration represents an inverse zoning relationship between kyanite and sillimanite. Field studies by Hooper (1986) in the easternmost portion of the Pine Mountain belt indicate that no traces of the Grenville age granulite metamorphism are present and may have been destroyed by sillimanite facies metamorphism.

Descriptions of the host rocks by Furcron and Teague (1943) and by Heinrich and others (1953) do not suggest any particular lithologic control on pegmatite emplacement. Late orogenic conjugate shears, kinks, and warps, possibly formed during the Late Paleozoic (Schamel and others, 1980) may have localized emplacement of the pegmatites in the Thomaston-Barnesville district. Pegmatites commonly occur within or near the contact of the Jeff Davis Granite where it was mapped in the central portion of the district (Clarke, 1952). This suggests that the Jeff Davis Granite may have been more susceptible to brittle fracturing during this late orogenic event and that these fractures may have been open to deep-seated magmatic fluids. (Radiometric ages and other age relations discussed later indicate that the pegmatites are more than 500 million years younger than the Jeff Davis Granite and have no magmatic affinity to this granite).

THE UCHEE BELT

The Uchee belt is a poorly known metamorphic sequence consisting of layered, migmatitic biotite-hornblende gneiss and amphibolite of intermediate to mafic composition (Schamel and others, 1980). These rocks are believed to be mainly metavolcanics metamorphosed to the sillimanite facies. In western Georgia, the Uchee belt consists of hornblende gneisses, amphibolites, gneissic metasediments, migmatites, and granitic to monzonitic gneisses (Hanley, 1986). The Uchee belt may be the westward continuation of the Carolina or Avalon terranes (Hatcher and others, 1989). The Uchee belt is separated from the Pine Mountain belt by the Goat Rock Fault (Figure 4), a major, regional, pre-metamorphic peak thrust fault.

Muscovite-bearing pegmatites are unknown in the Uchee belt immediately adjacent to the Thomaston-Barnesville district. Feldspar-rich pegmatites are locally common south of the Goat Rock fault in this part of the Uchee belt (Galpin, 1915; this study).

THE INNER PIEDMONT

Immediately north of the Pine Mountain belt (Figure 4), the Inner Piedmont contains interlayered biotite gneiss, biotite muscovite schist, and minor amphibolite. Schamel and others (1980) suggest that these rocks may have been derived from immature clastic sediments, which may have been volcanic in origin. The Inner Piedmont is separated from the Pine Mountain belt by the Towaliga fault. The Towaliga fault is a complex structure having undergone several periods of movement. The latest movement is thought to be normal and after peak metamorphism (Schamel and others, 1980).

THE PIEDMONT

Along its eastern side (Figure 4), the Pine Mountain belt is separated from sillimanite grade paragneisses and schists of the Piedmont terrane by the pre-metamorphic peak Box Ankle fault (Hooper, 1986). The Box Ankle fault is a thrust fault characterized by a prograde mylonite (Hooper, 1986).

The Piedmont terrane east of the Box Ankle fault is dominantly a heterogeneous biotite gneiss which locally grades into an amphibole gneiss. Felsic orthogneisses which range from layers up to plutons in size (Hooper, 1986) are also present.

THE BERNER MAFIC COMPLEX

The Berner mafic complex (Figure 4) occurs east of the Piedmont terrane and is separated from the Piedmont terrane by the post-metamorphic peak Ocmulgee fault (Hooper, 1986). This complex consists of a series of layered mafic to felsic meta-volcanic gneisses which have been intruded by a series of ultramafic to felsic meta-plutonic rocks (Hooper, 1986). Metamorphic grade is suggested to be upper greenschist to lowermost amphibolite facies (Hooper, 1986), although Matthews (1967) has reported the presence of sillimanite.

PEGMATITES OF THE THOMASTON-BARNESVILLE DISTRICT

PHYSICAL CHARACTERISTICS

The pegmatites of the Thomaston-Barnesville district are small to medium in size. They range from 2 inches (11 centimeters) to 25 feet (8 meters) in width. Most of the pegmatites are less than 200 feet (65 meters) long, although a few may be 200 to 1,000 feet (65 to 325 meters) in length. The most elongate workings in this district, the Brown mine in Upson County, extends over 1,000 feet (325 meters). The Brown mine pegmatite consists of a series of en echelon pods and lenses rather than a singular body. This type of occurrence is unusual in the Piedmont (Jahns and others, 1952). The vertical extent of these pegmatites is largely unknown, because mining or exploration rarely extended below 100 feet (32 meters) or the depth of weathering (Heinrich and others, 1953).

Approximately half of the pegmatites in the district are concordant to the gneissic foliation. The prevailing strike of both pegmatites and gneissic foliation is northeast and the general dip is southeast. The strike of most pegmatites is from N.0^{o}E to N.60^{o}E. More than two-thirds of the pegmatites are steeply dipping to the southeast or are vertical. Very few dips are less than 30 degrees. Attitudes of pegmatites in the Thomaston-Barnesville district have been tabulated in Appendix V. In those deposits where it has been determined, the plunge is generally steep to the southwest (Heinrich and others, 1953; Jahns and others, 1952).

On a district-scale map (Figure 6), the prevalent northeast strike of the individual pegmatites (Jahns and others, 1952; Heinrich and others, 1953) reflects the overall trend of the central part of the district. The pegmatites appear to have a more north-northeasterly trend in the northeastern section of the district. Pegmatites in the adjacent Jasper County district have a similar north-northeasterly trend. A number of northwesterly-trending pegmatites appear to define a conjugate set of fractures with the northeast-trending pegmatites. The development of the fractures into which the pegmatites were emplaced may reflect regional stress patterns developed prior to or during emplacement of the pegmatites.

The pegmatites in the Thomaston-Barnesville district occur in three primary forms (Figure 7):

1) tabular bodies, lenses and pods;

2) trough- or U-shaped bodies; and

3) T- or Y-shaped bodies (Heinrich and others, 1953).

Most pegmatites in this district belong to the first form; they may be concordant or discordant to the metamorphic foliation. Four trough-shaped pegmatites (the Joe Persons, the Corley, the Stevens-Rock and the Barron pegmatites) are known in this district. The Early Vaughn, the Battles and the Mitchell-Creek pegmatites are T- or Y-shaped in section or in plan (Heinrich and others, 1953).

MINERALOGY

The pegmatites and the immediately surrounding host rocks are commonly deeply weathered and were poorly exposed at the time of this investigation. The pegmatite mineralogy (Appendix VII) is derived almost entirely from the work of Smith (1931-1933), Furcron and Teague (1943) and Heinrich and others (1953) with minor supplemental information from the current study.

The pegmatites are composed predominantly of muscovite, smoky and milky quartz, plagioclase, and perthitic microcline. Biotite, beryl, tourmaline, garnet, apatite, pyrrhotite, sericite, and graphite may be present as accessory minerals (Heinrich and others, 1953). All tourmalines seen during this investigation are black and are presumed to be schorl. Most of the feldspars analyzed in this study are potash-rich. Plagioclase may have originally been more abundant, but weathering has altered the plagioclase to clays.

Regional mineralogical zoning is illustrated by a map of the recorded mineral occurrences within this district (Figure 8). The map is simplified to indicate the unusual mineral occurrences and not the presence of quartz, muscovite and feldspar in each pegmatite. Beryl- and schorl tourmaline - bearing pegmatites are concentrated near the approximate geographic center of this district which is just to the west of Yatesville.

INTERNAL ZONING OF THE PEGMATITES

The pegmatites in the Thomaston-Barnesville district are unzoned, poorly zoned, or distinctly zoned with two to five zones (Figures 9A and 9B). Heinrich and others (1953) indicate that two or more zones are developed in approximately 80 percent of the best exposed pegmatites. Studies by Jahns and others (1952) relate the zoning in the pegmatites in the Thomaston-Barnesville district to the distribution and lithology of zones characteristic of pegmatites within the southeastern Piedmont. Because of poor exposures or the lack of exposures at the time of the present investigation, and the lack of detailed studies in previous work, this investigation does not attempt to elaborate on the pegmatite zoning in the district presented by Jahns and others (1952) and Heinrich and others (1953) and discussed by Cameron and others (1949) and Jahns (1955; 1982).

Pegmatites with two zones contain an inner core of medium-grained granitoid rock and an outer core of (a) finer-grained granitoid rock, (b) burr rock composed of

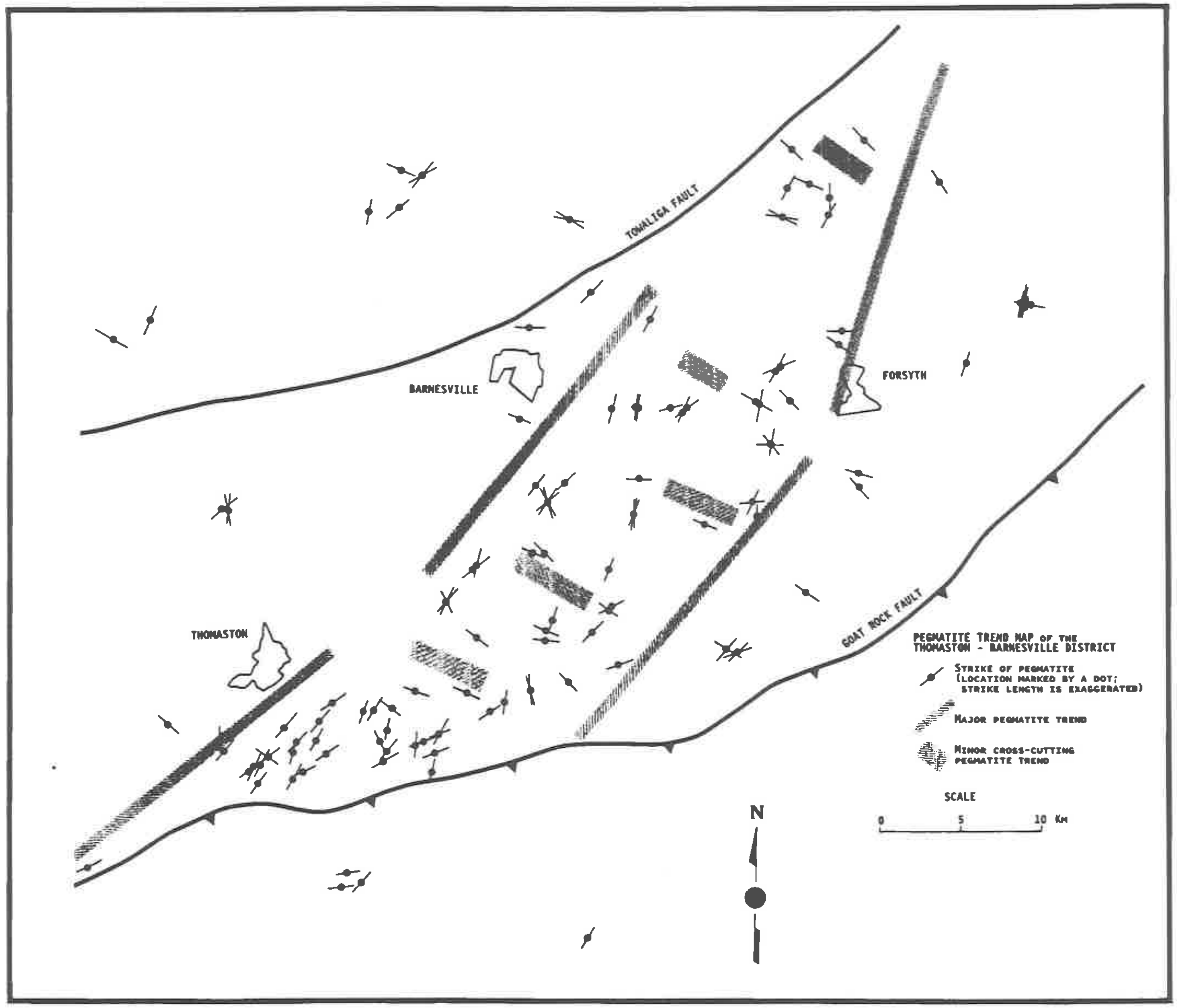

Figure 6. Pegmatite trend map of the Thomaston-Barnesville district. The main trend of the pegmatites in the Thomaston-Barnesville district and the trend of the main group of pegmatites is outlined by the narrow shaded pattern. It strikes obliquely across the Pine Mountain terrain between the Towaliga and Goat Rock Faults. Pegmatites in the northeastern part of the district generally strike in a more northerly direction. Several northwesterly trends (wide shaded pattern) extend across the main pegmatite trend.

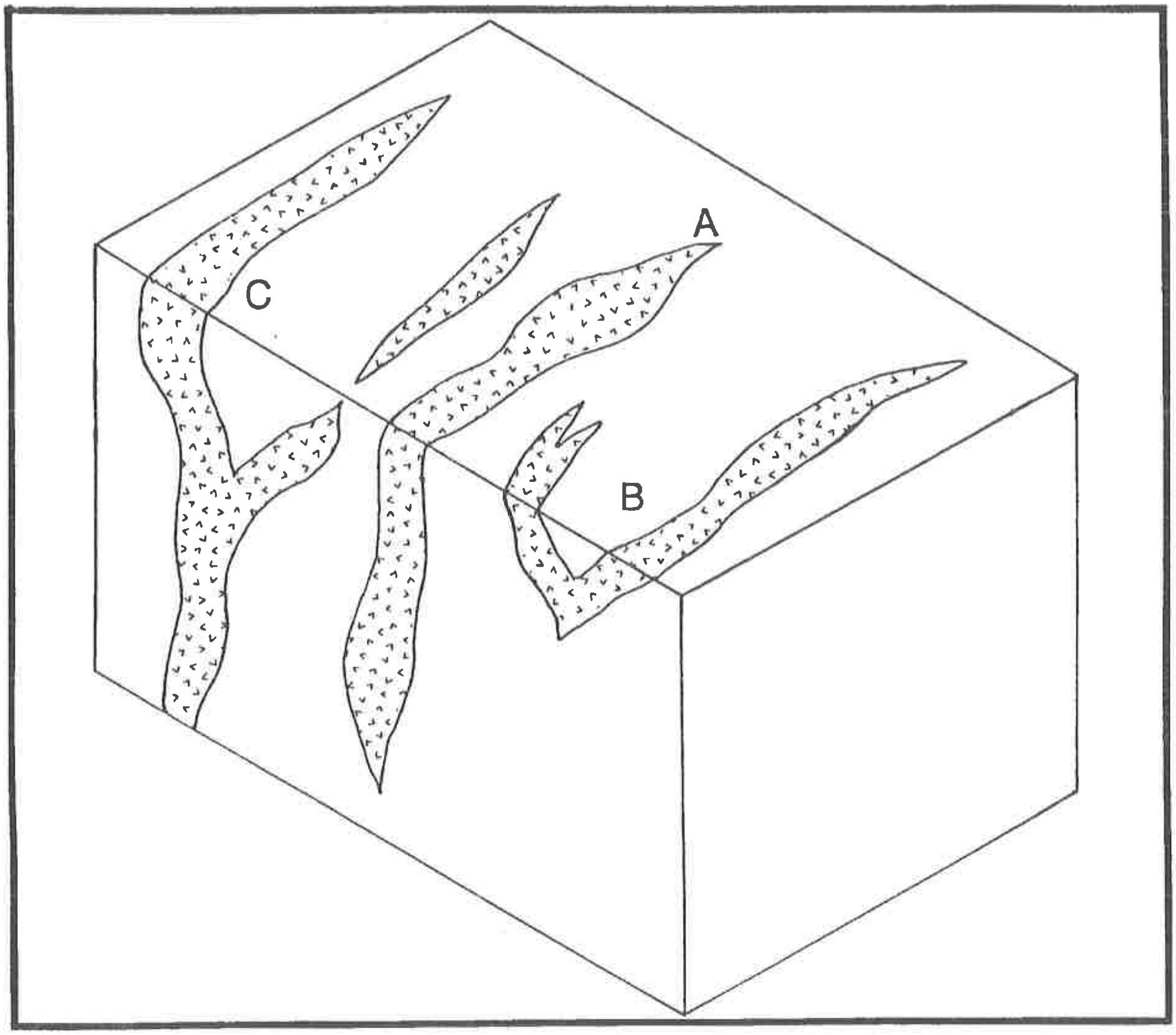

Figure 7. Primary forms of pegmatites in the Thomaston-Barnesville district. Block diagram illustrates the lens shape (A) of most of the pegmatites in this district and the U-shape (B) or T- or Y-shape (C) of a few of the others. (Modified from Jahns and others, 1952).

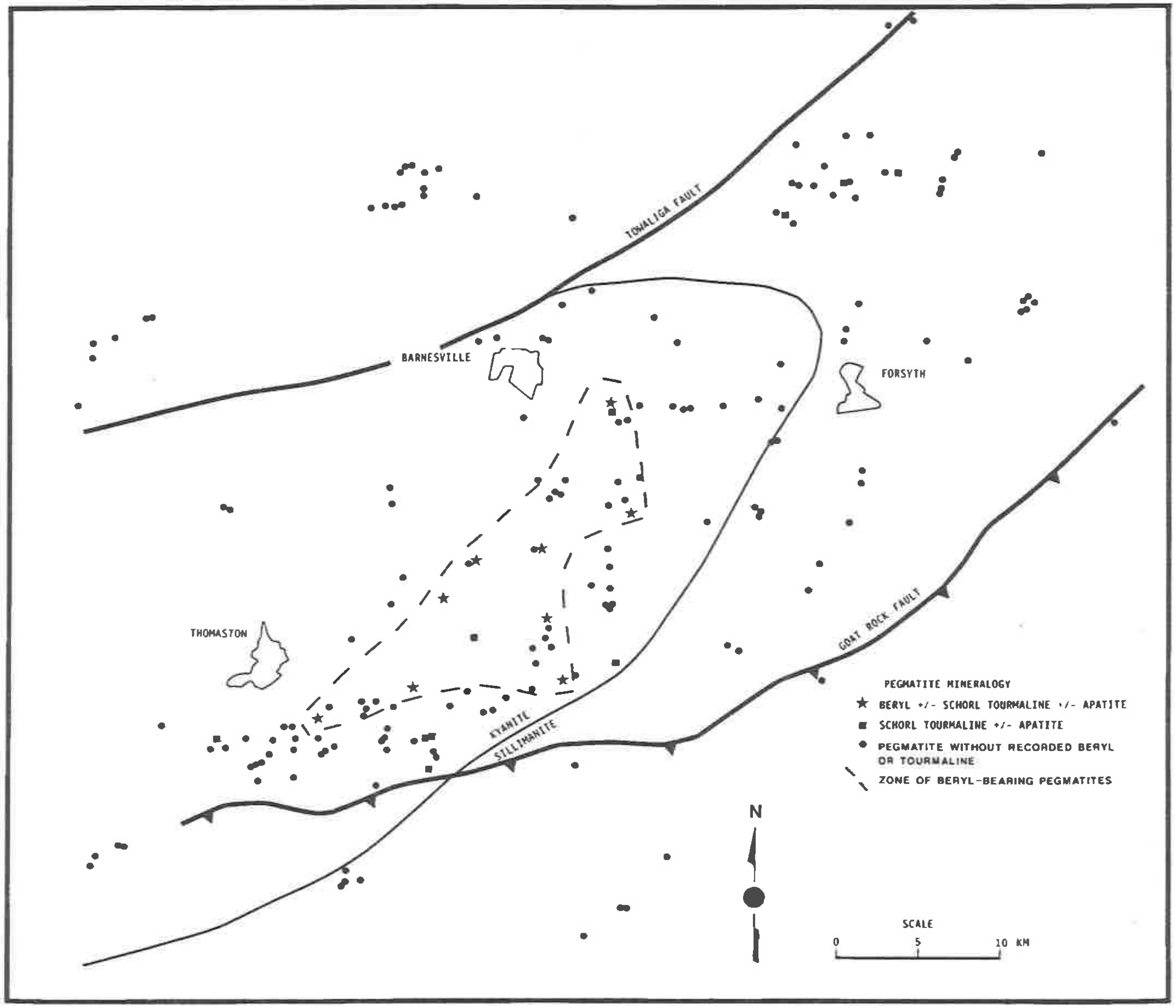

Figure 8. Regional mineralogical zoning in the Thomaston-Barnesville district. This map shows the location of pegmatites with recorded beryl, schorl tourmaline and apatite and those pegmatites which do not contain these minerals. Most pegmatites in this district also contain quartz, muscovite and feldspar. The zone of beryl-bearing pegmatites is located within the central portion of the district. (Mineralogy based on Smith, 1932-33, Furcron and Teague, 1943; and Heinrich and others, 1953). Kyanite-sillimanite isograd is from Smith and others (1969).

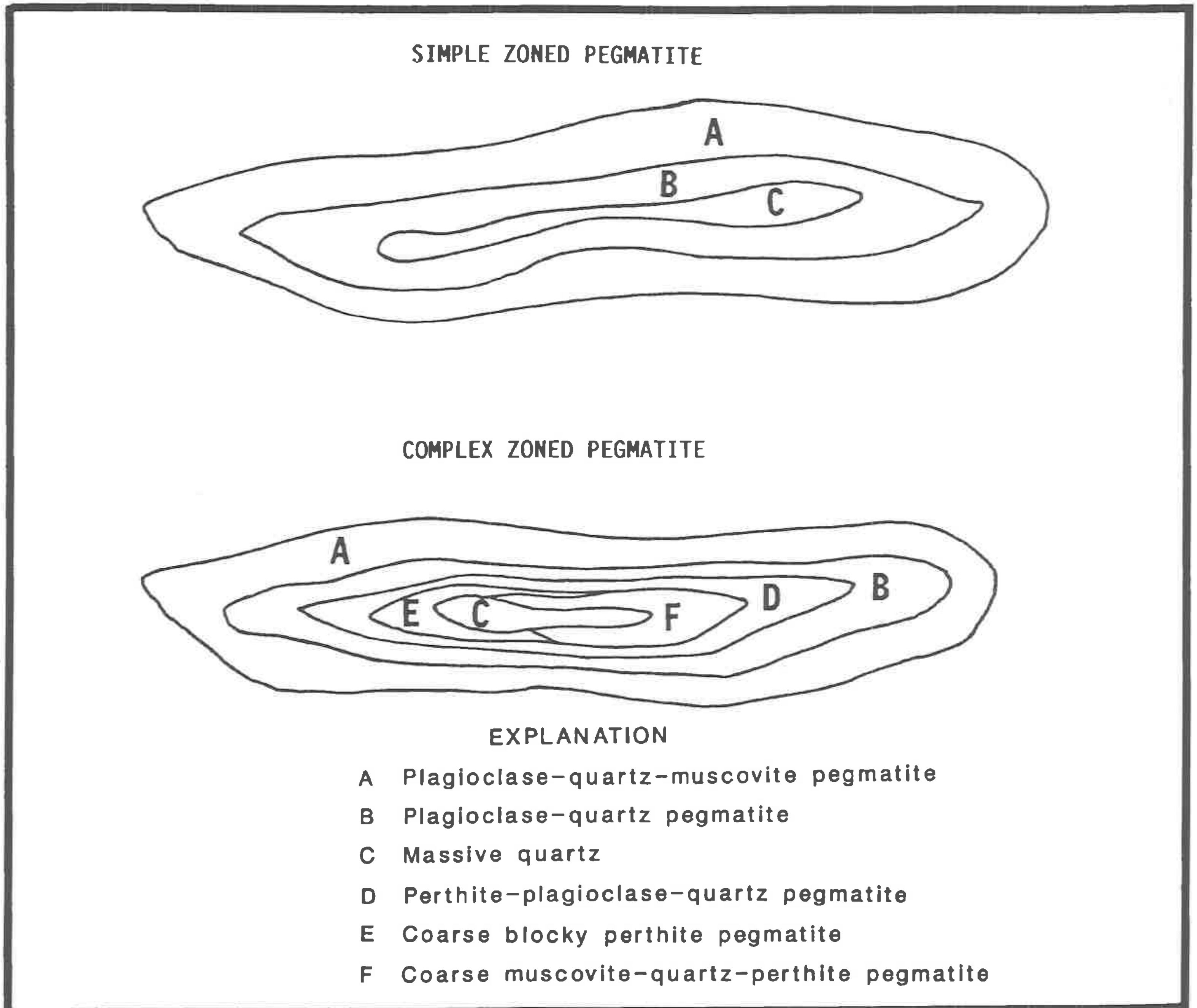

Figure 9. Generalized zoning in muscovite-bearing pegmatites. A) Simple zoned pegmatites. B) Complex zoned pegmatites. The most common types of zoning in pegmatites in this district are illustrated. The size and shape as well as presence of individual zones shown in this figure are variable.

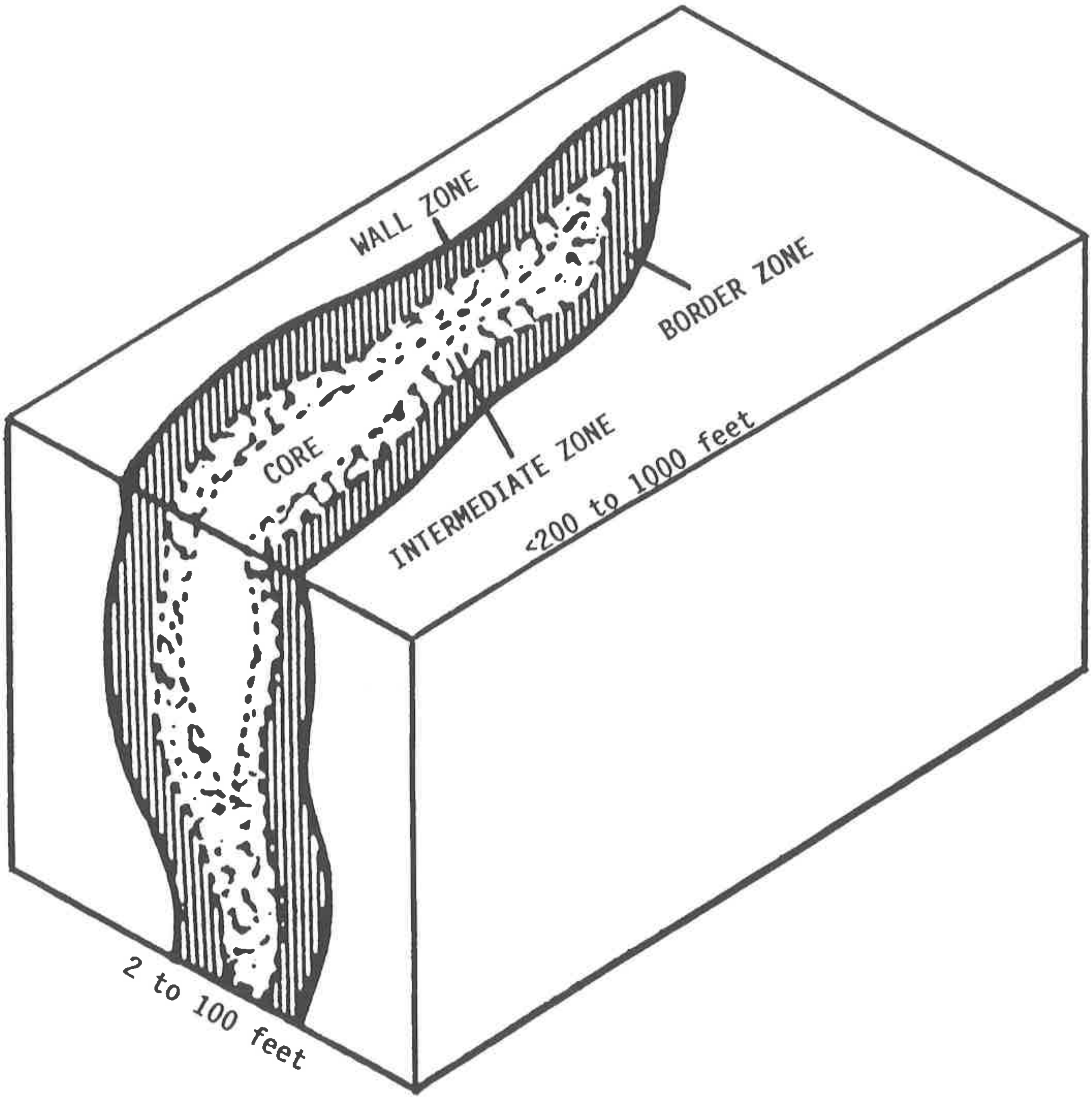

Figure 10. Types of mica deposits within the Thomaston-Barnesville district. Mica deposits may occur in the wall zone, the intermediate zone or disseminated throughout the pegmatite. Range of pegmatite dimensions are indicated.

intergrown quartz and mica, or (c) mica-rich pegmatite (Heinrich and others, 1953). Simple zoned pegmatites with more than two zones (Figure 9A) typically have a monomineralic massive quartz core or bimineralic core of quartz and blocky K-feldspar encompassed by a plagioclase-quartz pegmatite and an outer zone plagioclase-quartz-muscovite pegmatite. Complex zoned pegmatites may contain the additional zones shown in Figure 9B.

In the Thomaston-Barnesville district, mica was mined from three types of deposits: 1) disseminated mica in unzoned or poorly zoned pegmatites, 2) wall-zone mica (Figure 10), and 3) core-margin (intermediate zone) mica (Figure 10). Although core-margin deposits are the most abundant in this district, wall-zone deposits accounted for a large portion of this district's mica production (Heinrich and others, 1953).

Large quantities of perthite in several of the district's mines apparently were recovered. Perthite recovered during post-World War II operations was probably mined from perthite-rich zones developed in some of the complex zoned pegmatites (Figure 9).

GEOCHRONOLOGY

Cross-cutting relations indicate that the pegmatites in the Thomaston-Barnesville district are distinctly younger than any of the rocks in which they intrude. The absence of penetrative deformation in the pegmatites also indicates that they are younger than the host rock's metamorphic foliation. These pegmatites are enclosed in Grenville-age rocks within the Pine Mountain terrane and within the early Paleozoic(?) rocks of the southern part of the Inner Piedmont terrane, as well as those of the Piedmont terrane and Berner mafic complex to the east. Because this district overlaps all four of these terranes where they are adjacent to each other, it is suggested that the pegmatites of the Thomaston-Barnesville district were probably emplaced subsequent to the juxtaposition of these terranes. This statement is based on the assumption that all the pegmatites in this district are the same approximate age.

Field relations indicate that the Inner Piedmont terrane, the Piedmont terrane, the Pine Mountain belt, the Uchee belt, and the Berner mafic complex were joined together during one major episode of progressive thrusting. Thrust faulting occurred before, after, and possibly during the peak metamorphism to amphibolite grade. Isotopic age determinations suggest that youngest recorded peak metamorphism in this part of the Georgia Piedmont occurred about 360 m.y. (Odum and others, 1982).

Isotopic age determinations suggest that the pegmatites and granitic plutons in the southeastern Piedmont and Blue Ridge formed during two periods of igneous/metamorphic activity: 350-340 m.y. and 325-265 m.y. (Fullagar and Butler, 1979). The late Paleozoic granitic plutons, which are located southeast of the Brevard Zone (Figure 11), have yielded Rb-Sr age determinations of 325 to 265 m.y. (Fullagar and Butler, 1979).

Deuser and Herzog (1962) define two distinct periods of pegmatite formation in the Blue Ridge and the Piedmont terranes in North Carolina: 350 m.y. and 500 m.y. using the Rb-Sr method. In the Cherokee-Pickens district, Gunow and Bonn (1989) report K-Ar ages of 356 +/- 20 m.y. and 338 +/- 5 m.y. for muscovites. Gunow and Bonn suggest that these pegmatites were emplaced subsequent to or near the peak of regional metamorphism in the Blue Ridge terrane.

In the Piedmont terrane, ages are more consistent with the younger period of plutonic igneous activity. Rb-Sr age determinations of muscovites and biotites in Piedmont pegmatites average 285 m.y. (Deuser and Herzog, 1962). In the Thomaston-Barnesville district, muscovite from the Mauldin mine had an apparent age of 296 +/- 16 m.y. and biotite had an apparent age of 256 +/- 12 m.y. (Deuser and Herzog, 1962). Apparent K-Ar ages of 288 +/- 9 m.y., 360 +/- 11 m.y., and 233 +/- 7 m.y. were obtained from muscovite, albite, and orthoclase, respectively, from a pegmatite in the Jasper district in the Berner mafic complex (Jones and others, 1974). The albite age is suspect as the K content is very low. A Rb-Sr isochron date of that pegmatite yielded an apparent age of 339 +/- 16 m.y. (Jones and others, 1974).

PEGMATITE GEOCHEMISTRY

PEGMATITE FRACTIONATION AND TRACE ELEMENT GEOCHEMISTRY

Granitic pegmatites are, in general, similar in composition to granite. Most granitic pegmatites have lower CaO and higher Al_2O_3 than the average granite with a variable alkali feldspar content controlling the K_2O/Na_2O ratio (Cerny, 1982a). The highly peraluminous nature of these pegmatites is reflected principally by the high mica contents. The typical components of granitic pegmatites (Cerny, 1982a) in decreasing order of abundance are:

1. O, Si, Al, K, Na, Ca, Li
2. Rb, Cs, Ba, Mg, Fe, B, F, P
3. Sr, Mn, Be, Sn, Ti, Zr-Hf, Nb-Ta, Y, rare earth elements (REE), U, Th, Cl, C
4. Sc, Mo, W, Bi, As, Sb, Zn, Cd, Cu, Pb, Tl, Ga, Ge

Except for the main rock-forming components listed in group 1 above, most of the other components are usually less than 1 weight percent.

The less abundant elements are incompatible with the crystal structures of the silicate minerals formed during much of the crystallization history of a granitic magma. During the fractionation of a granitic magma, these incom-

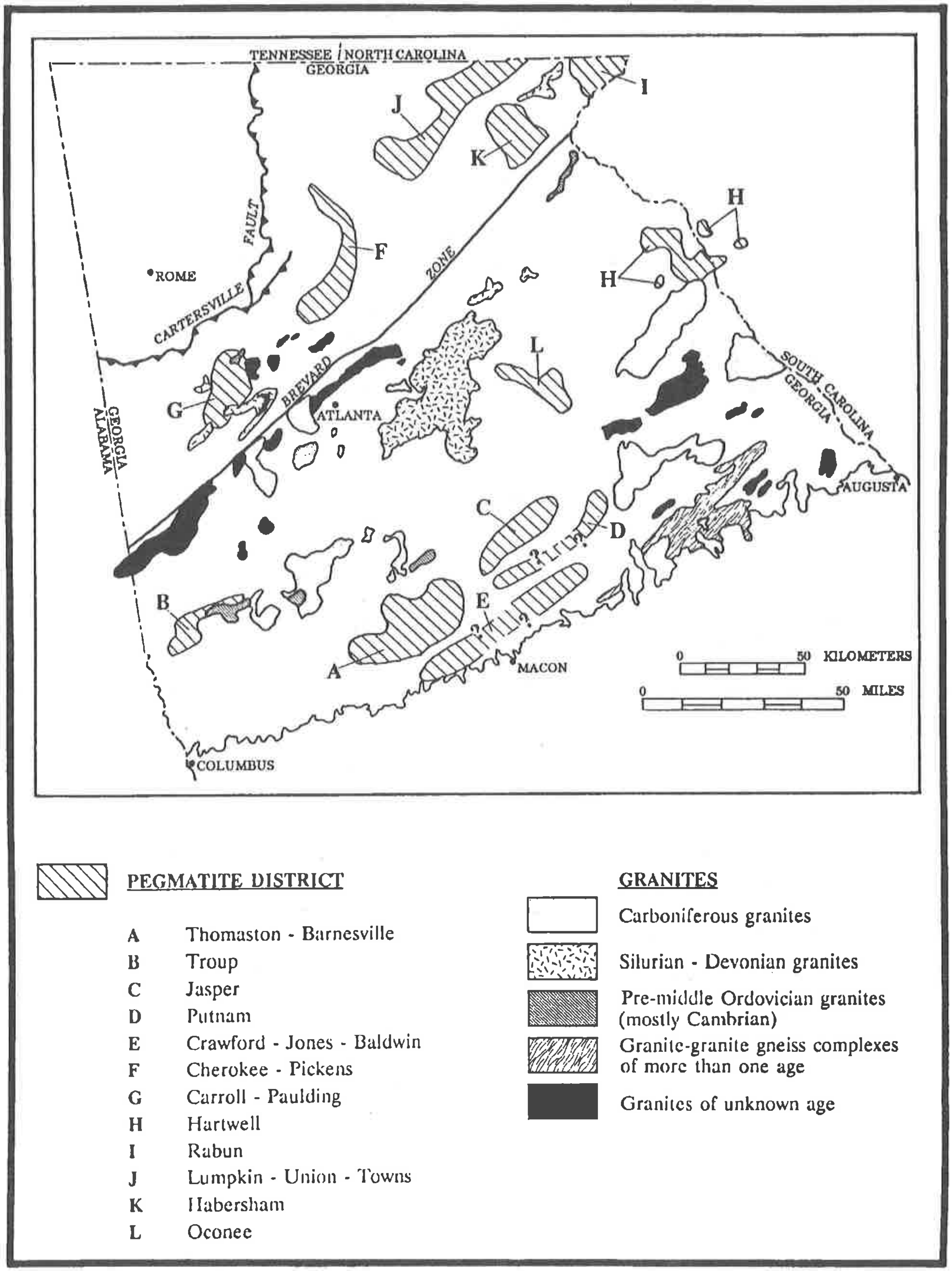

Figure 11. Pegmatite districts and granitic plutons in Georgia. Districts are the same as in Figure 1. The location of the granitic plutons are based on Higgins and others (1988).

patible elements are concentrated in a volatile-rich residual magma or magmatic vapor phase. Mechanisms for concentration of these incompatible elements include: partial melting of source rocks, crystal fractionation and liquid state diffusion in parental granites, and vapor fractionation and thermo-gravitational diffusion in regions of high geothermal gradients (Gunow and Bonn, 1989). Whichever process or processes are involved, the key result is the concentration of a volatile-rich residual magma or magmatic vapor phase.

The residual magma or vapor phase is commonly concentrated near the top of a cooling magma beneath the solidified carapace. Fracturing of the carapace allows the residual magma or vapor phase to escape into the carapace or into the surrounding country rocks. Generally, these fluids will cool and crystallize as dikes or veins depending on their composition and the enclosing physicochemical environment. The extent to which these fluids travel is dependent on their composition, the geothermal gradient and the fracture or plumbing system. Fluids which are rich in volatiles and which do not loose volatiles to the surrounding rocks have a lower viscosity and tend to be driven further away from the cooling, crystallizing magma.

Granitic magmas generated during regional high-grade metamorphism generally are volatile-poor because progressive metamorphism is a devolatilization process. This generally results in the formation of simple, dry pegmatites containing quartz and sodic and potassic feldspar. A rapid increase in the geothermal gradient in rocks which contain hydrous phases such as micaceous schist or mica- and amphibole-rich gneiss could result in the generation of a hydrous or volatile-rich granitic magma. Under these latter circumstances, a source rock anomalously high in incompatible elements might yield a rare-element bearing magma.

Rare-element pegmatites contain exceptionally high concentrations of Li, Rb, Cs, Tl, Be, Nb-Ta, Ga, Ge, B, F, and P. Mica-bearing pegmatites contain relatively high levels of Ca, Ba, Sr, Fe, Mn, Ti, B and P, and locally may contain rare earth elements (REE's) as well as actinides. The regional high-grade metamorphic pegmatites of the maximal depth group are typically enriched in Ca, Ba, Sr, Mg, Fe, and Ti; they rarely contain light REE's and rare elements (Cerny, 1982a).

The geochemical trends observed in pegmatite fractionation are similar to and extend those trends observed in plutonic granites. The ratios: K/Rb, K/Tl, Ba/Rb, Rb/Sr, and Nb/Ta all tend to decrease to extremely low values with increasing pegmatite fractionation (Cerny, 1982a). Plots of these ratios versus trace elements illustrate the differences in pegmatite groups and demonstrate trends in pegmatite fractionation.

In the U.S.S.R. and more recently in Canada (Cerny, 1982a, 1982b; Cerny and others, 1986; Trueman and Cerny, 1982), pegmatite investigations have emphasized regional mineralogical and geochemical zoning along with the petrogenesis of the different types of pegmatites as a means of locating and identifying potentially economic pegmatites. The trace element geochemistry of pegmatitic K-feldspar and muscovite has repeatedly demonstrated that trace element geochemistry is an effective means of determining fractionation trends within pegmatite districts and in assessing the economic potential of the individual pegmatites (Trueman and Cerny, 1982).

Trace element geochemical analysis of muscovite and feldspar is particularly useful in the southeastern United States because of the extensive weathering. Of the common minerals present in a typical pegmatite, muscovite is the only mineral structurally favorable to include a variety of the incompatible trace elements as substitutions in its structure. Also, muscovite is essentially unaffected by weathering and commonly is the only surface indicator of a mica-bearing pegmatite. In the uncommon pegmatites which are feldspar-rich and mica-poor, feldspar is unaffected by weathering, and can be used instead of muscovite. It is critical, however, to compare muscovite and feldspar analyses separately.

Current and recent investigations by the Georgia Geologic Survey have established that the trace-element geochemistry of pegmatitic muscovite is a powerful and practical tool in the economic evaluation of granitic pegmatites in Georgia (Gunow and Bonn, 1989; Cocker, 1990; Cocker, 1991). Gunow and Bonn (1989) demonstrated that muscovites within the more strongly fractionated pegmatites of the Cherokee-Pickens district are enriched in the rare elements (Be, Nb, Li, F and Rb/K). Also, the muscovite in the beryl-rich pegmatite of the Cochran mine in the Cherokee-Pickens district is geochemically distinct from the muscovite in other beryl-bearing and beryl-poor pegmatites within the same pegmatite field.

MUSCOVITE GEOCHEMISTRY

The following discussion is based on the geochemical results contained in Appendix II, scatter plots of trace elements, and district-scale geochemical maps. The scatter plots (Figures 12 to 21) illustrate the correlative variations between the trace elements and the relative amount of differentiation exhibited by each pegmatite. Where possible, the trace element chemistry from the Cherokee-Pickens district (Gunow and Bonn, 1989) is included in several of the scatter plots for a relative comparison. Use of that data (Gunow and Bonn, 1989) assumes the accuracy and precision of the geochemical data from the two different projects are approximately similar. Although some of the data obtained in this study was obtained from the same commercial geochemistry lab used by Gunow and Bonn (1989), several years separated the analyses and no duplicates of Gunow and Bonn's samples were available to correlate the results of their work with that of the present study.

The geochemical maps (Figures 22 to 32) illustrate

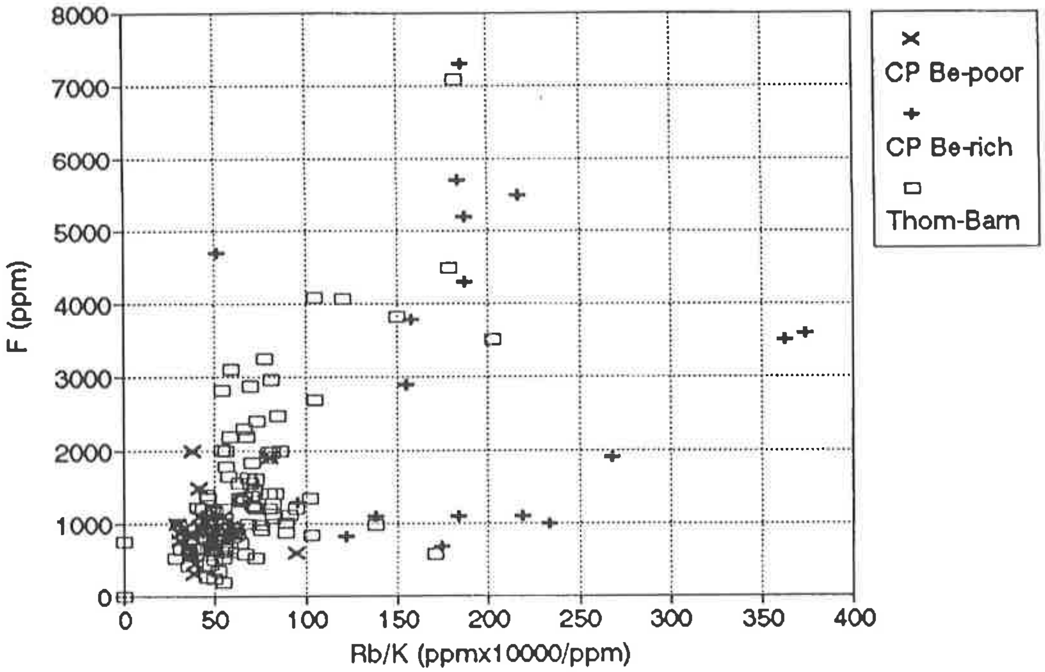

Figure 12. Scatter plot of F versus Rb/K in pegmatitic muscovite. Results (Appendix II) from the Thomaston-Barnesville district (boxes) are compared with beryl-absent and beryl-poor pegmatites (exes) and beryl-rich pegmatites (crosses) of the Cherokee-Pickens district (data from Gunow and Bonn, 1989).

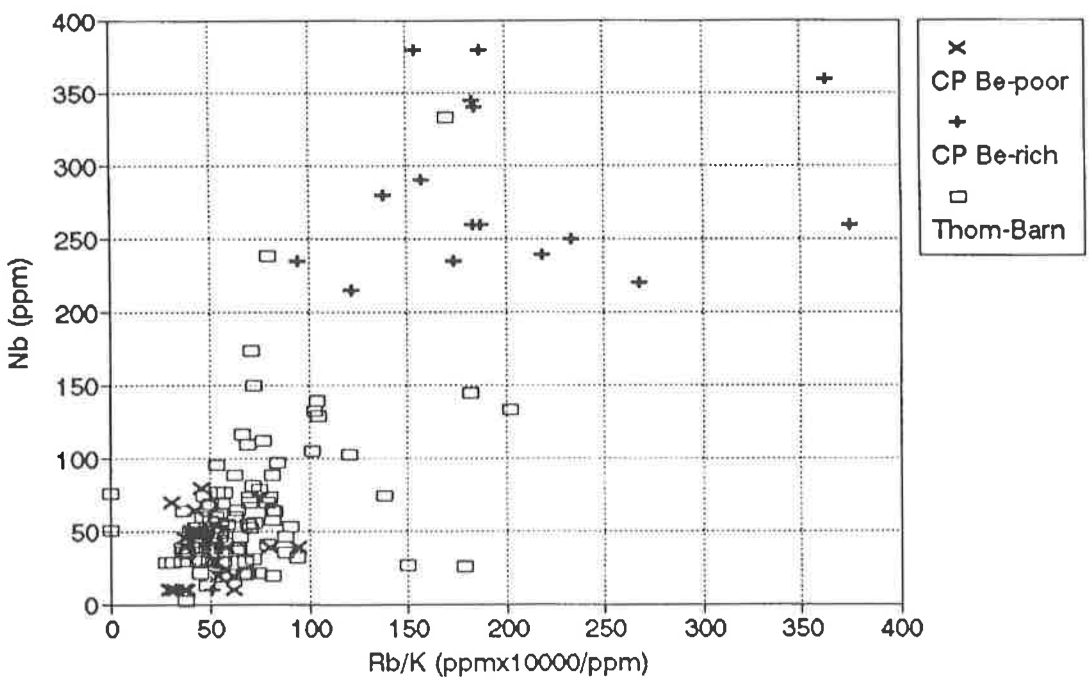

Figure 13. Scatter plot of Nb versus Rb/K in pegmatitic muscovite. Results (Appendix II) from the Thomaston-Barnesville district (boxes) are compared with beryl-absent and beryl-poor pegmatites (exes) and beryl-rich pegmatites (crosses) of the Cherokee-Pickens district (data from Gunow and Bonn, 1989).

geochemical values or ratios coded with symbols in order to simplify the appearance of each map and to focus attention on the location of geochemical anomalies and trends. Circles represent the lowest values; squares represent intermediate values; and stars are the highest values. Because of the extreme diversity in geochemical values, and these figures are not contoured. Groups of pegmatites containing the most anomalous values are outlined by dashed lines. The major faults on the north and south sides of the Pine Mountain terrane and the approximate location of the kyanite-sillimanite isograd (after Smith and others, 1969) are indicated.

The F and Nb concentrations in the muscovites from the Thomaston-Barnesville district overlap those of the beryl-absent pegmatites of the Holly Springs field and of the beryl-poor pegmatites of the Ball Ground field and extend across the range between those pegmatites and the beryl-rich pegmatites of the Ball Ground field (Figures 12 and 13). Muscovite from the beryl-bearing pegmatite of the Reynolds mine in the Thomaston-Barnesville district contains a similar Nb content (334 ppm) as that from the Cochran mine.

Muscovite in the beryl-rich pegmatites of the Cherokee-Pickens district are enriched in Be relative to pegmatites of the Thomaston-Barnesville district and the beryl-poor and beryl absent pegmatites of the Cherokee-Pickens district (Figure 14). The major implication of Figure 14 is that the potential for beryl-rich pegmatites in the Thomaston-Barnesville district is small.

The Li content of the muscovites in the Thomaston-Barnesville district is similar to that of the muscovites in most of the pegmatites of the Cherokee-Pickens district (Figure 15). The Cochran mine is enriched in Li relative to the other pegmatites in that district.

In the Thomaston-Barnesville district, Rb increases with increasing K_2O for Rb generally below 700 ppm (Figure 16). Enrichment of Rb relative to K_2O occurs above 700 ppm to over 1500 ppm Rb principally within the 8 to 9 weight percent K_2O range. Muscovite in the beryl-rich pegmatites of the Cherokee-Pickens district is enriched in Rb and K_2O relative to the most Rb-enriched muscovites in the Thomaston-Barnesville district.

Seven muscovite samples are distinctly enriched in Ta (95 to 189 ppm) compared to the other muscovite samples in the Thomaston-Barnesville district (Figure 17). Zn values progressively increase up to 120 ppm with increasing Rb/K (Figure 18). Zn values which range up to 226 ppm do not appear to be related to the Rb/K ratio. No Ta or Zn values are reported for the Cherokee-Pickens district (Gunow and Bonn, 1989).

The Ba concentration increases dramatically at low Rb/K ratios in muscovite from the Thomaston-Barnesville district, the Holly Springs field and the beryl-poor pegmatites of the Ball Ground field of the Cherokee-Pickens district (Figure 19). Muscovite samples which have low Ba contents have a significantly higher Rb/K ratio principally because of an increase in Rb. Although Ba and Rb compete for the same structural site in muscovite, the Ba concentration is significantly greater in muscovite from less fractionated or muscovite-bearing pegmatites (Shmakin, 1984; Gunow and Bonn, 1989) than from more highly fractionated or rare-element pegmatites. This relation is demonstrated by higher Ba concentrations in whole-rock analyses of less fractionated granites compared with more fractionated granites (El Bouseily and El Sokkary, 1975). Because V also competes for the same structural sites as K, Rb, and Ba, V is higher at low Rb/K ratios (Figure 20).

The Ba/Rb ratio is also used as an indicator of the degree of pegmatite fractionation. The Ba/Rb ratio is in the range 0.3-0.7 in muscovite-bearing pegmatites, and this ratio is in the range 0.002-0.02 in rare-element pegmatites (Shmakin, 1984). Muscovite from the Cochran mine in the Cherokee-Pickens district has a Ba/Rb ratio of 0.1 (Gunow and Bonn, 1989) which lies between the Ba/Rb ratios for muscovite-bearing and rare-element pegmatites (Shmakin, 1984). The Ba/Rb ratios for muscovites in the Thomaston-Barnesville district are in the range 0.02-5.59. Thirteen pegmatitic muscovite samples have a Ba/Rb ratio in the range 0.02-0.09 which overlap the range for rare-element pegmatites.

Geochemical data for a variety of pegmatite classes from around the world compiled by Cerny and Burt (1984) show that each pegmatite class appears to have distinctive trace element signatures. Most of the pegmatites in the Thomaston-Barnesville district, Holly Springs field and beryl-poor pegmatites of the Ball Ground field in the Cherokee-Pickens district lie in or near to the muscovite class of pegmatites as depicted on a scatter plot (Figure 21) of the log K/Rb ratio versus log Li (Cerny and Burt, 1984; Gunow and Bonn, 1989). A few pegmatites from the Thomaston-Barnesville district as well as the Cochran mine pegmatite (Gunow and Bonn, 1989) occur in or beyond the rare-element pegmatite field shown by Cerny and Burt (1984).

The geochemical maps (Figures 22 to 28) indicate that the highest concentrations of F (2000 to 7076 ppm), Be (10 to 266.5 ppm), Li (40 to greater than 100 ppm), Nb (70 to 334 ppm), Rb (600 to 1534 ppm), Ta (95 to 189 ppm), Zn (70 to 226 ppm) are concentrated in the central part of the district. The more highly fractionated pegmatites (higher Rb/K_2O ratios) are located within the central part of the district and in the northwestern part of the district (Figure 29). The highest Ba concentrations (400 to 1456 ppm) are located peripherally to the central part of the district (Figure 30). The more highly fractionated pegmatites (based on the lowest Ba/Rb ratios - 0.02 to 0.39 ppm) are mainly located within the central part of the district (Figure 31). A second zone of more highly fractionated pegmatites appears to be located in the northwestern part of the district.

Three northeast-trending zones containing the highest V values (30 to 186 ppm) extend along the center and edges of the Pine Mountain terrane (Figure 32). The higher V

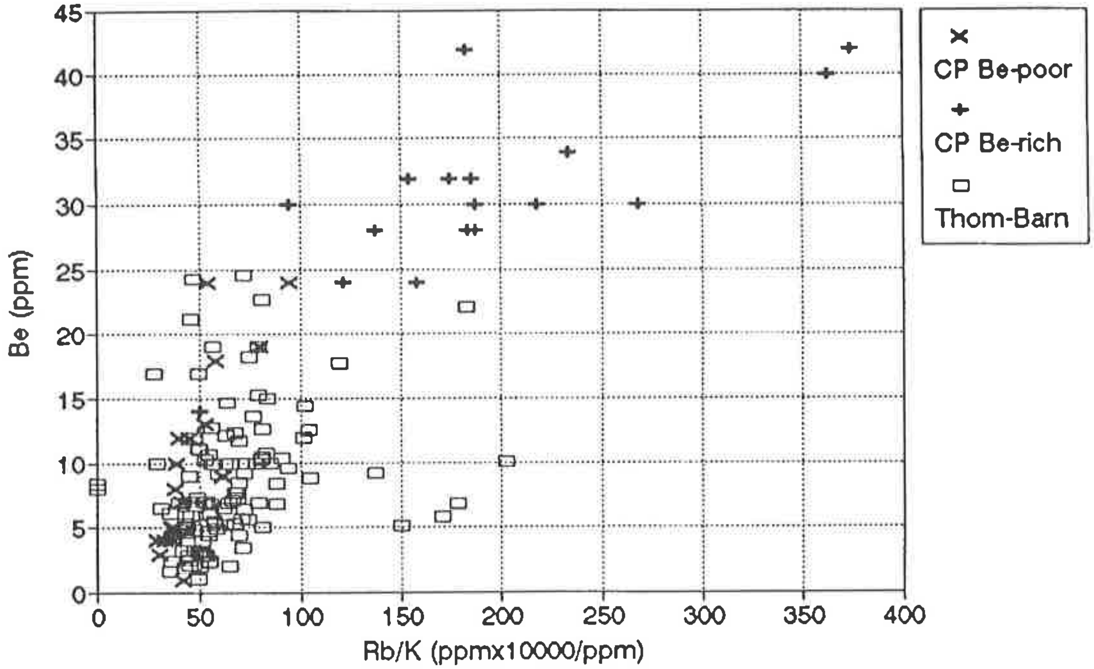

Figure 14. Scatter plot of Be versus Rb/K in pegmatitic muscovite. Results (Appendix II) from the Thomaston-Barnesville district (boxes) are compared with beryl-absent and beryl-poor pegmatites (exes) and beryl-rich pegmatites (crosses) of the Cherokee-Pickens district (data from Gunow and Bonn, 1989).

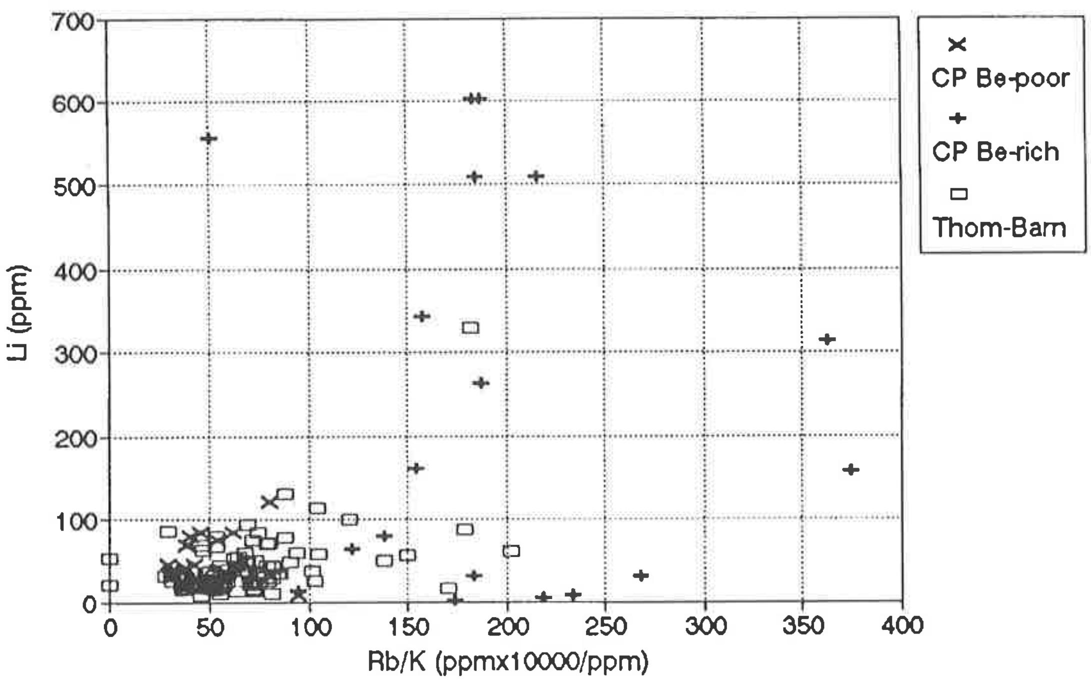

Figure 15. Scatter plot of Li versus Rb/K in pegmatitic muscovite. Results (Appendix II) from the Thomaston-Barnesville district (boxes) are compared with beryl-absent and beryl-poor pegmatites (exes) and beryl-rich pegmatites (crosses) of the Cherokee-Pickens district (data from Gunow and Bonn, 1989).

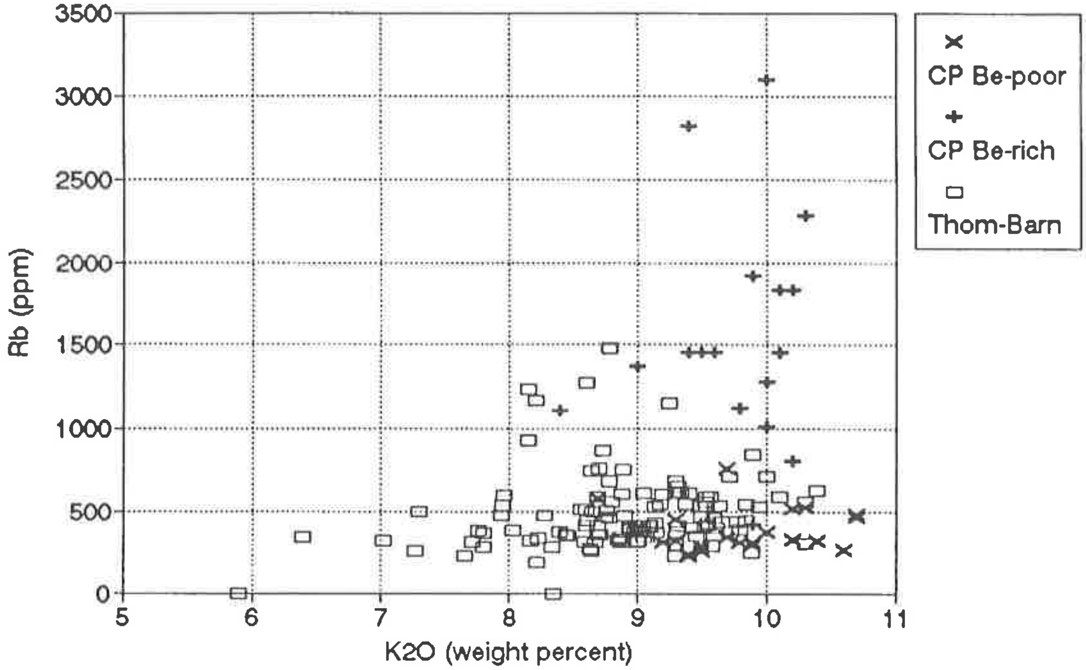

Figure 16. Scatter plot of Rb versus K_2O in muscovite. Results (Appendix II) from the Thomaston-Barnesville district (boxes) are compared with beryl-absent and beryl-poor pegmatites (exes) and beryl-rich pegmatites (crosses) of the Cherokee-Pickens district (data from Gunow and Bonn, 1989).

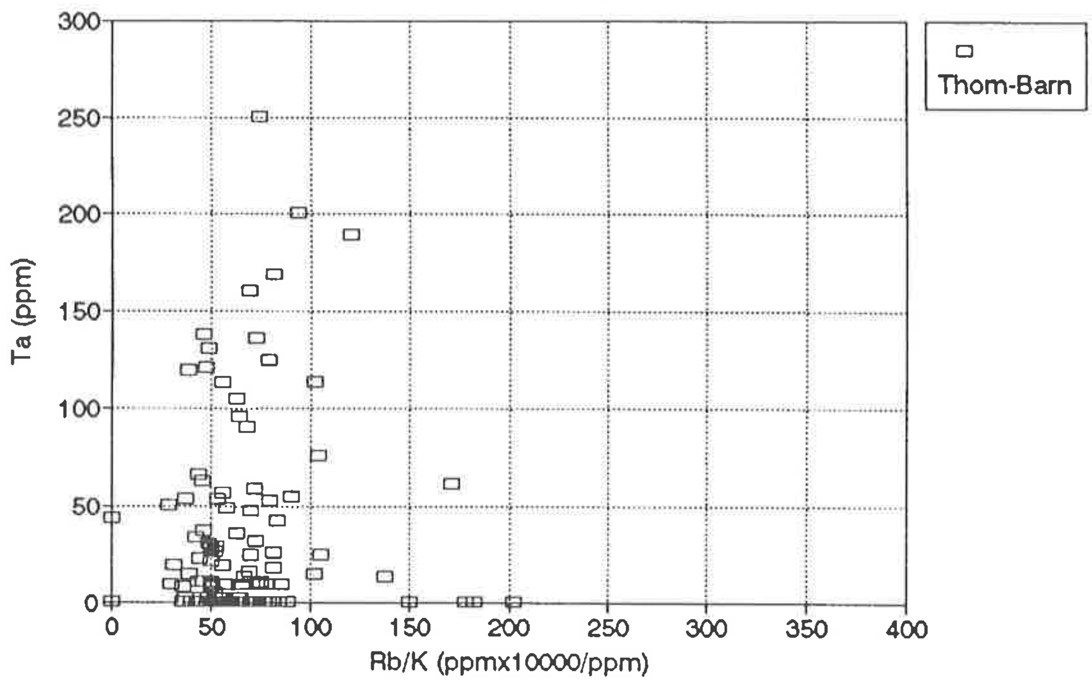

Figure 17. Scatter plot of Ta versus Rb/K in muscovite. Results (Appendix II) from the Thomaston-Barnesville district are indicated. No Ta analyses are available from the Cherokee-Pickens district for comparison.

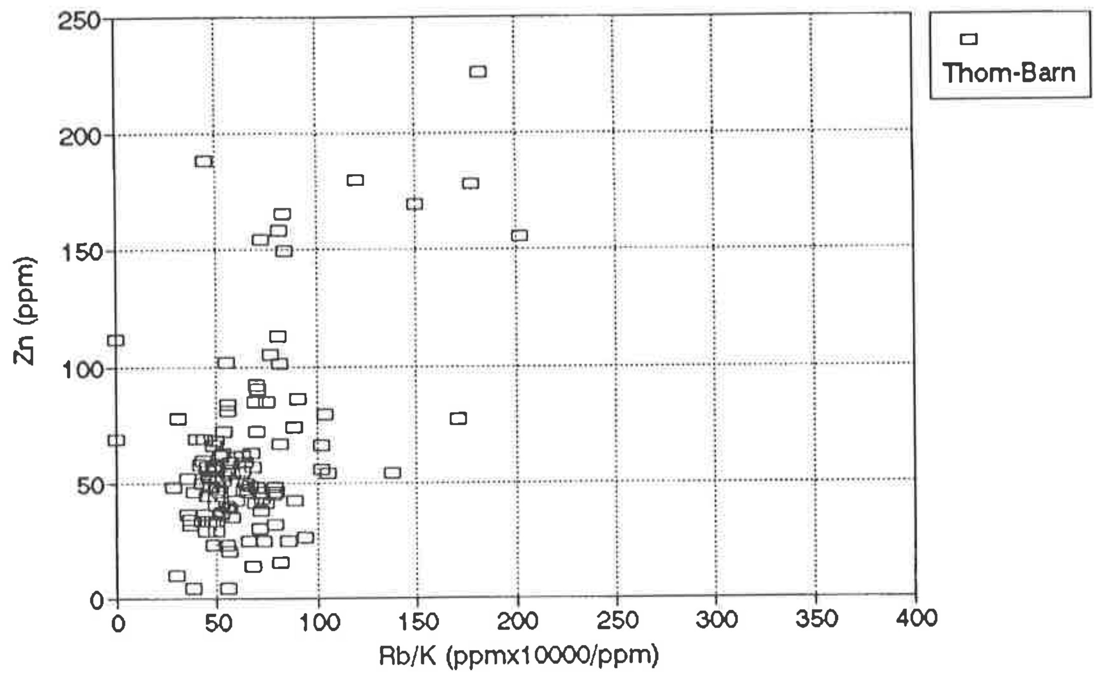

Figure 18. Scatter plot of Zn versus Rb/K in muscovite. Results (Appendix II) from the Thomaston-Barnesville district are indicated. No Zn analyses are available from the Cherokee-Pickens district for comparison.

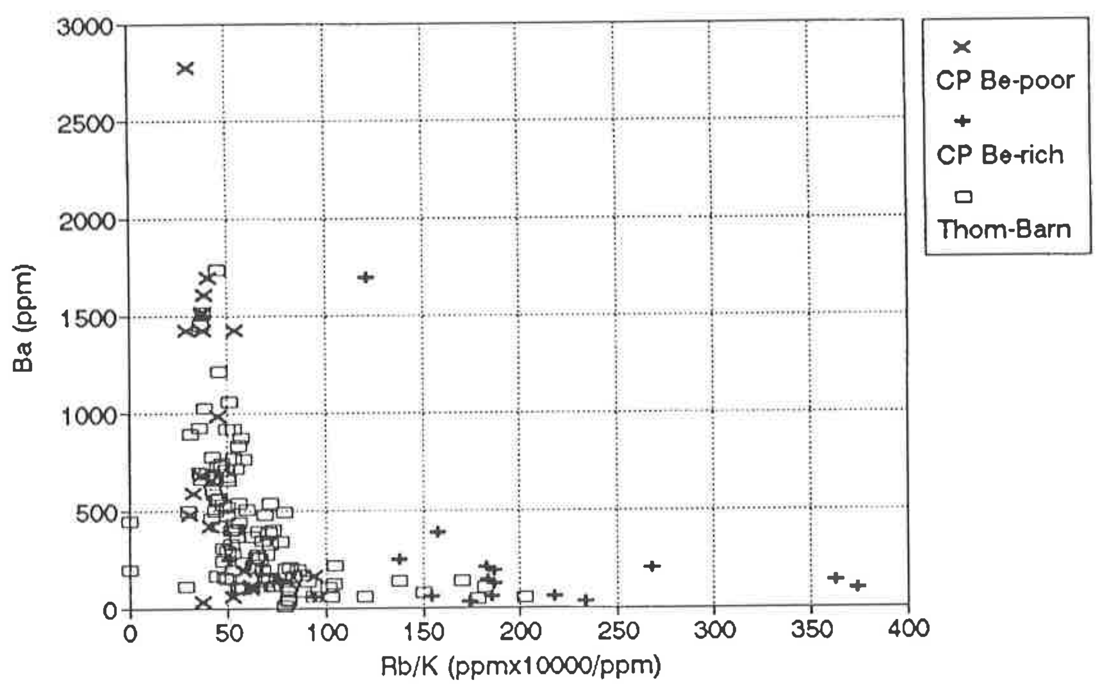

Figure 19. Scatter plot of Ba versus Rb/K in pegmatitic muscovite. Results (Appendix II) from the Thomaston-Barnesville district (boxes) are compared with beryl-absent and beryl-poor pegmatites (exes) and beryl-rich pegmatites (crosses) of the Cherokee-Pickens district (data from Gunow and Bonn, 1989).

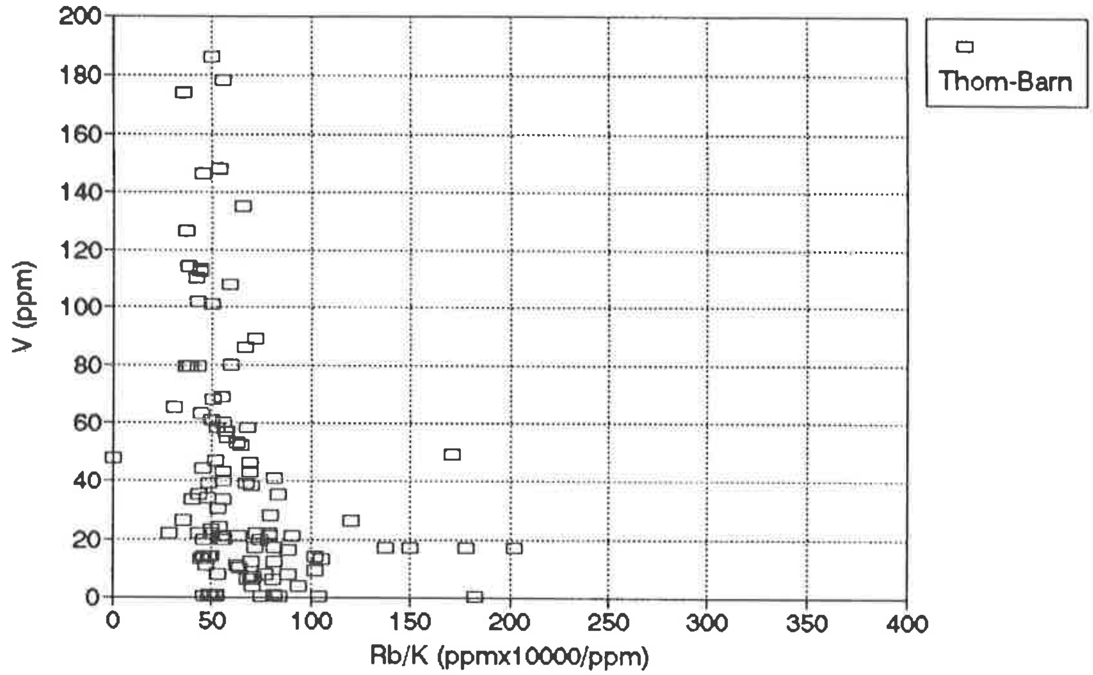

Figure 20. Scatter plot of V versus Rb/K in pegmatitic muscovite. Results (Appendix II) from the Thomaston-Barnesville district are indicated. No V analyses are available from the Cherokee-Pickens district for comparison.

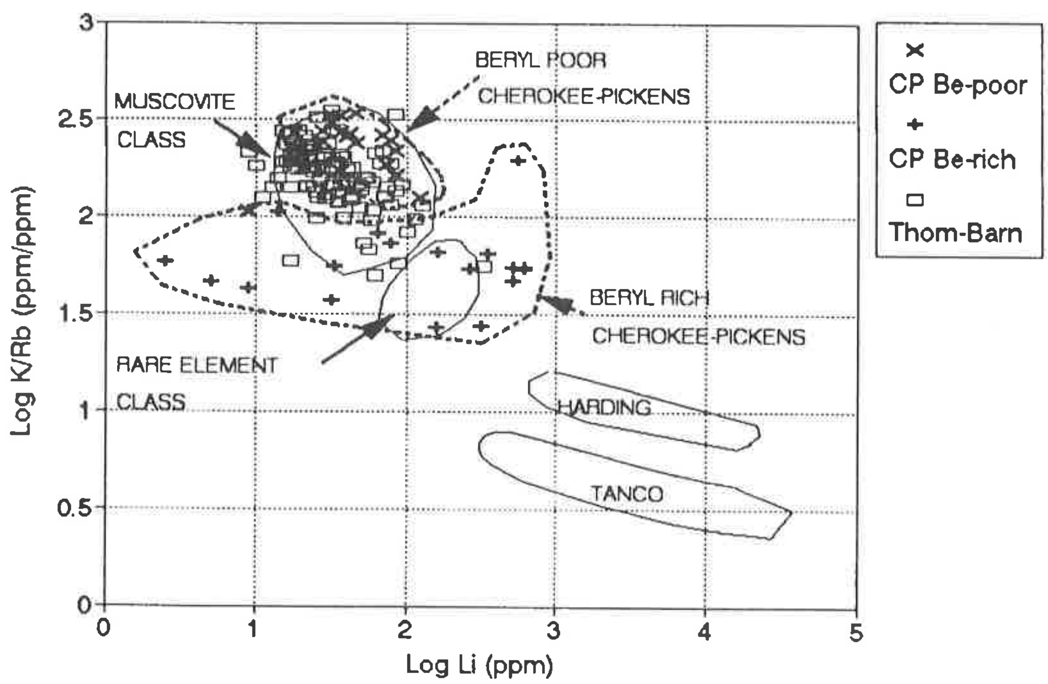

Figure 21. Scatter plot of log K/Rb versus Li in pegmatitic muscovite. Results (Appendix II) from the Thomaston-Barnesville district (boxes) are compared with beryl-absent and beryl-poor pegmatites (exes) and beryl-rich pegmatites (crosses) of the Cherokee-Pickens district (data from Gunow and Bonn, 1989). Also represented are fields for rare-element pegmatites, muscovite-rich pegmatites (after Cerny and Burt, 1984), and the rare-element Harding and Tanco pegmatites (data from Jahns and Ewing, 1976; Renaldi and others, 1972; diagram modified from Gunow and Bonn, 1989). The direction of increasing differentiation is from the upper left to the lower right in this diagram.

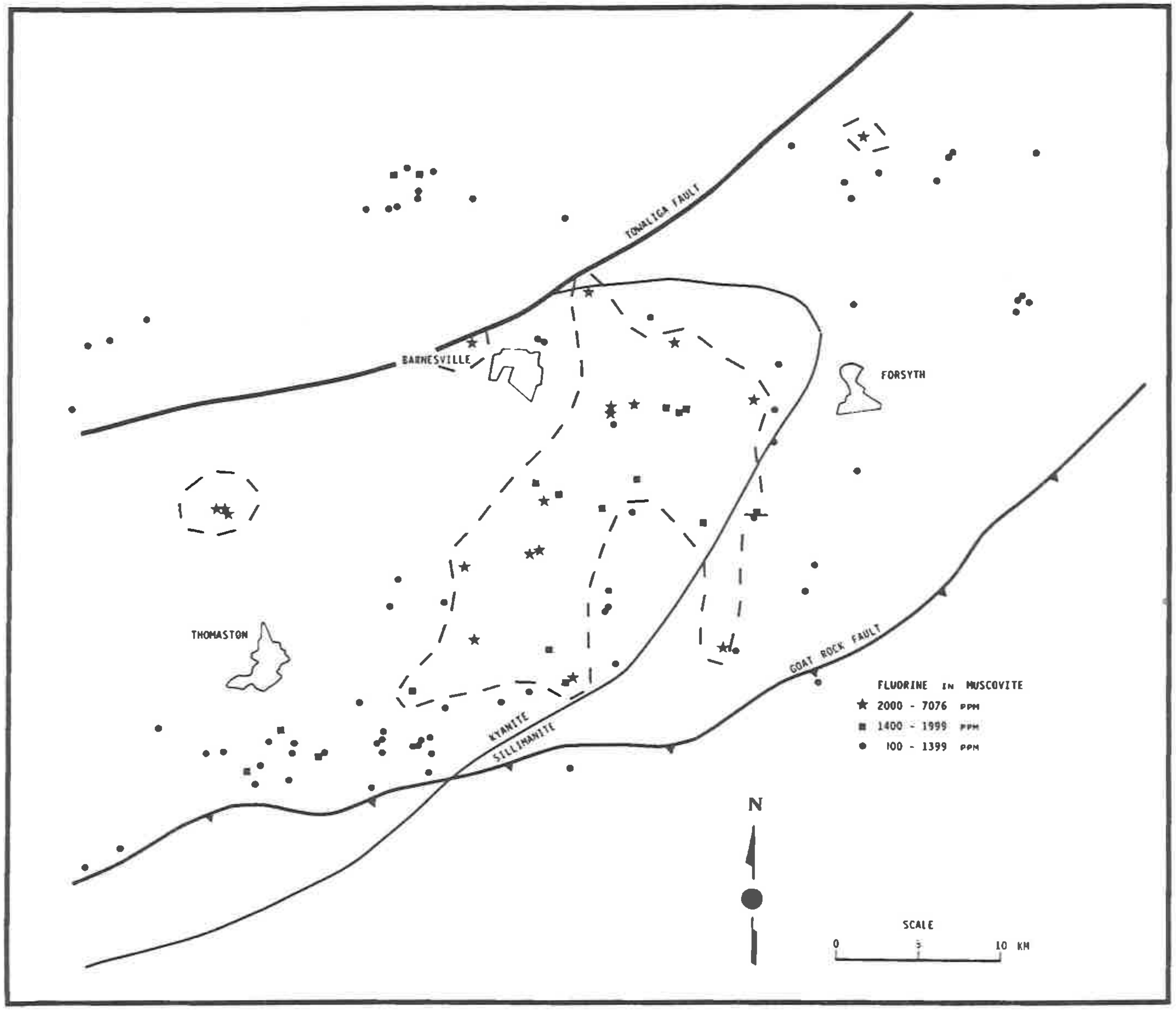

Figure 22. Map of the distribution of F in muscovite. Results (Appendix II) indicate that the highest F values (stars and squares outlined by the dashed line) occur mainly in the central part of the district and in the Indian Grave field to the northwest. The location of the kyanite-sillimanite isograd, the Towaliga and Goat Rock faults are shown for comparison.

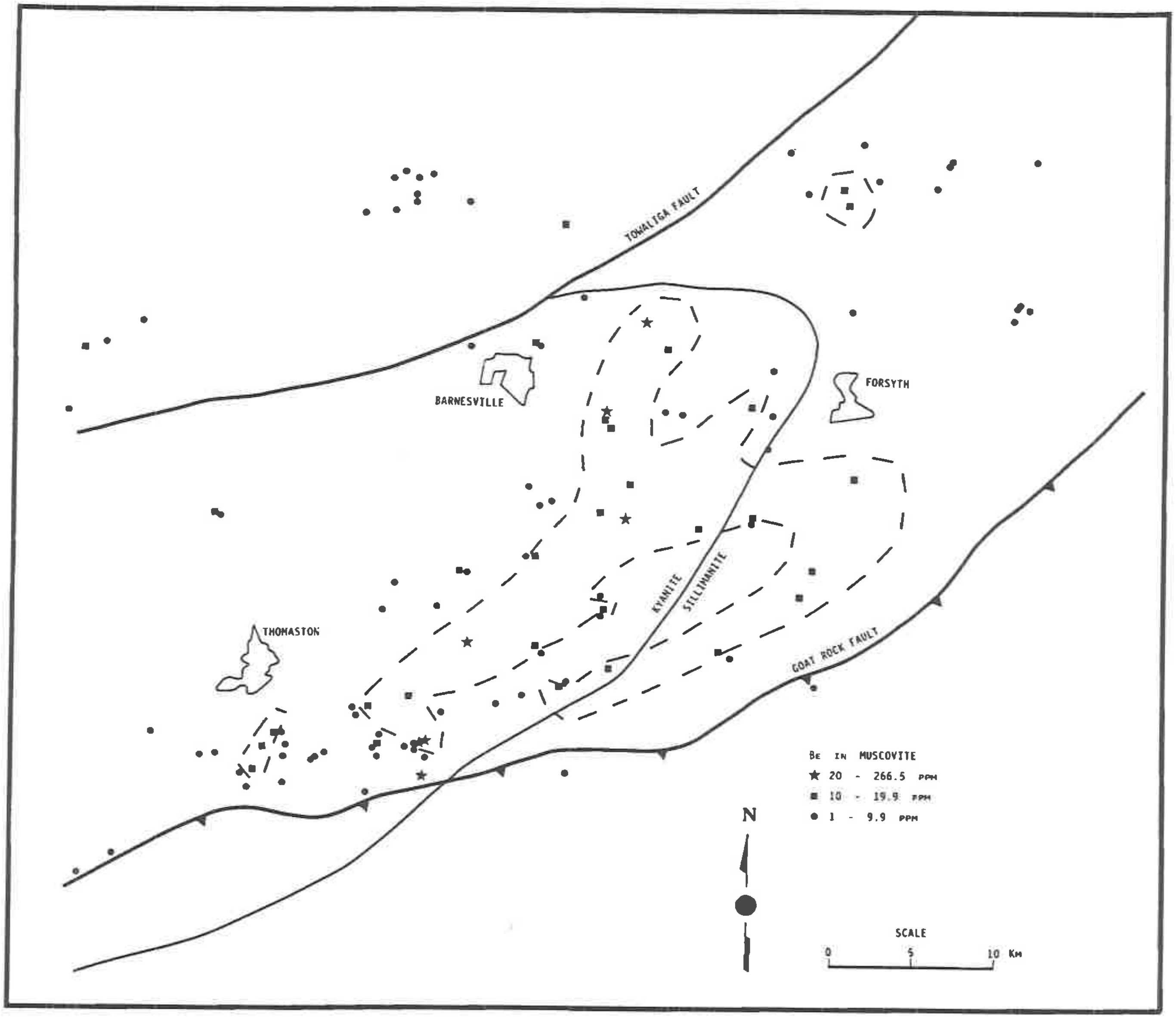

Figure 23. Map of the distribution of Be in muscovite. Results (Appendix II) indicate that the highest Be values (stars and squares outlined by the dashed line) occur mainly in the central part of the district and in the Russelville field to the southeast. The location of the kyanite-sillimanite isograd, the Towaliga and Goat Rock faults are shown for comparison.

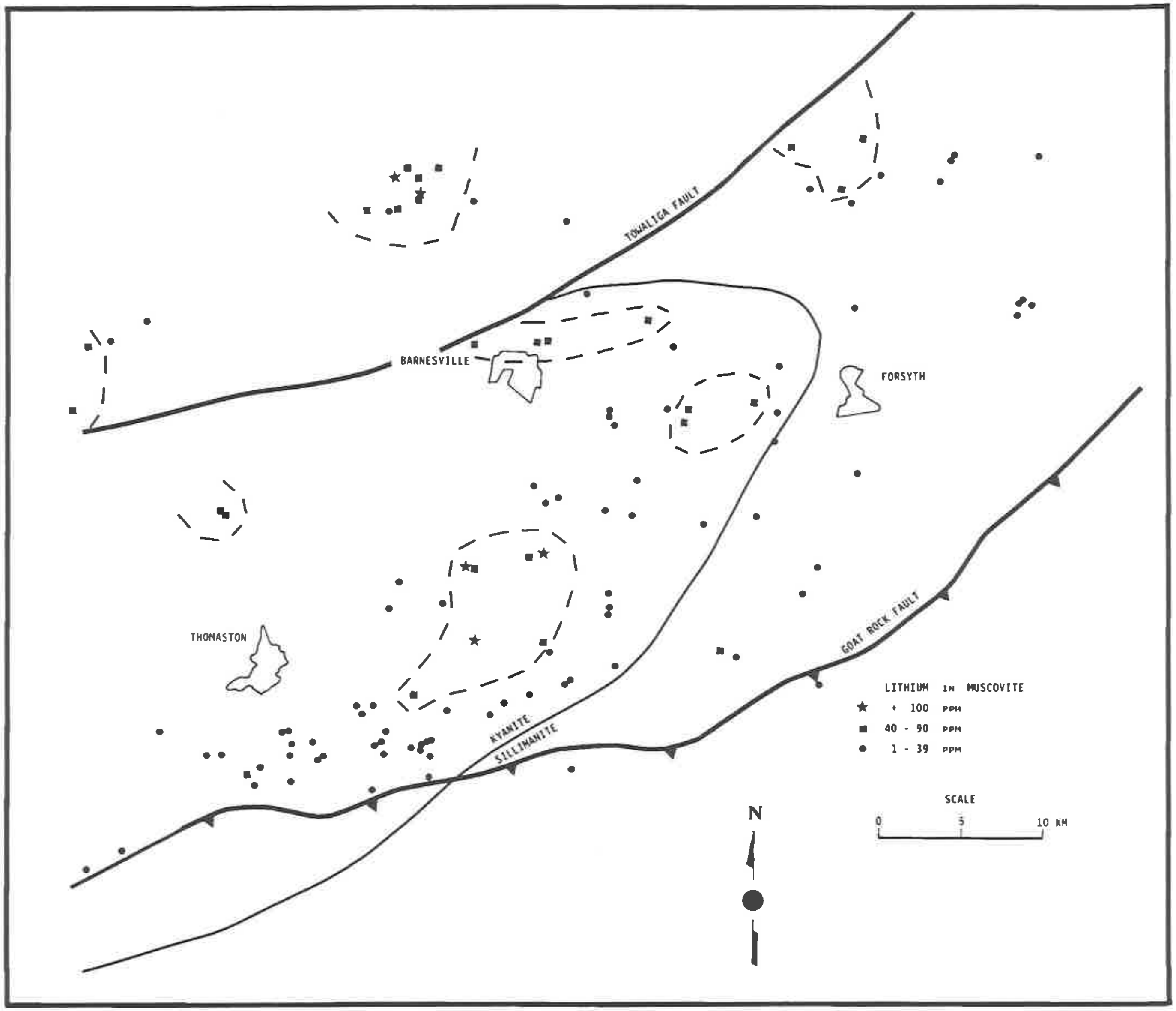

Figure 24. Map of the distribution of Li in muscovite. Results (Appendix II) indicate that the highest Li values (stars) occur mainly in the central part of the district and in the Lighthouse field to the northwest. The dashed outlines include pegmatites with the higher values of Li (stars and squares) The location of the kyanite-sillimanite isograd, the Towaliga and Goat Rock faults are shown for comparison.

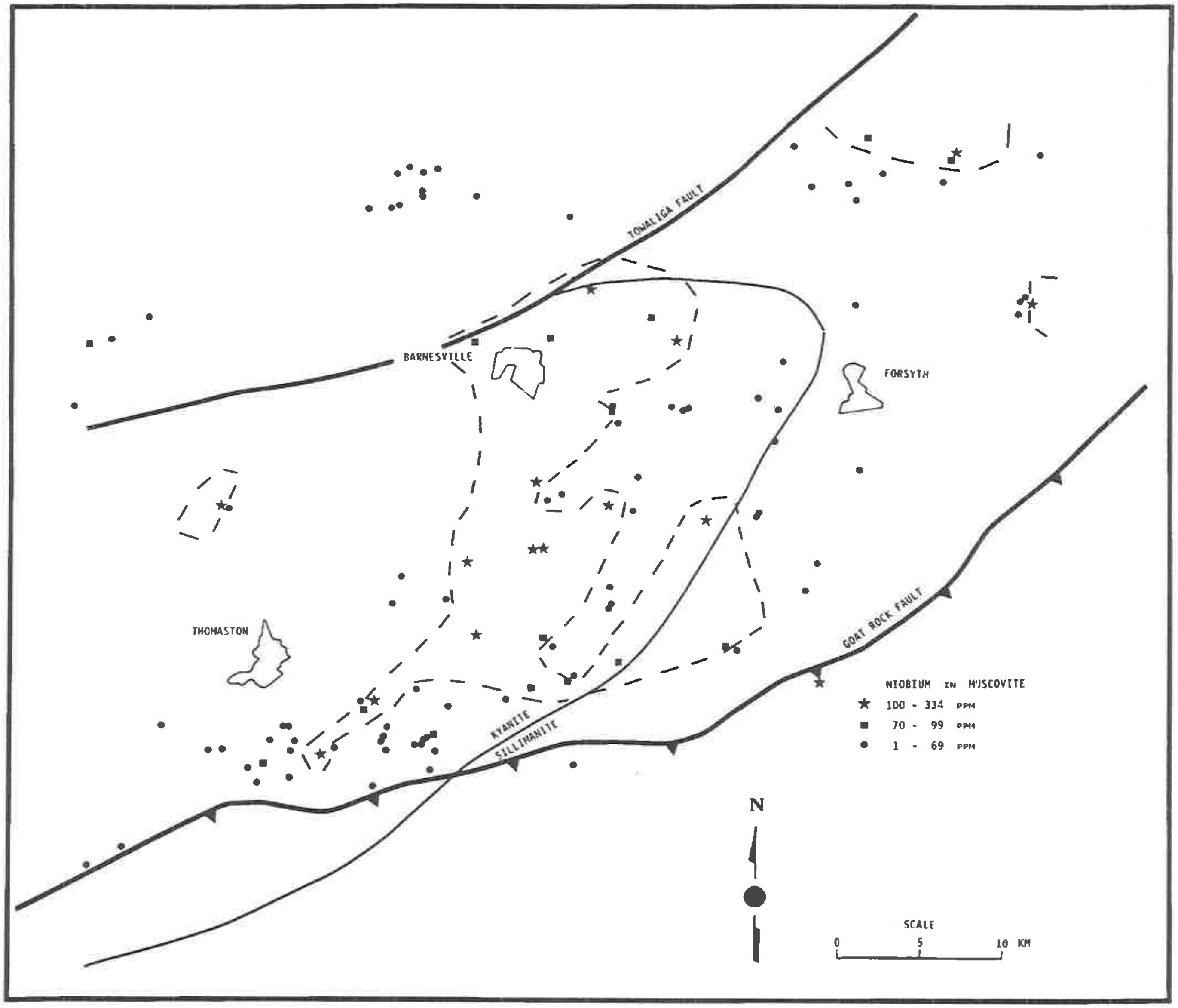

Figure 25. Map of the distribution of Nb in muscovite. Results (Appendix II) indicate that the highest Nb values (stars and squares outlined by the dashed line) occur mainly in the central part of the district. A few other high values are scattered in the remainder of the district. The location of the kyanite-sillimanite isograd, the Towaliga and Goat Rock faults are shown for comparison.

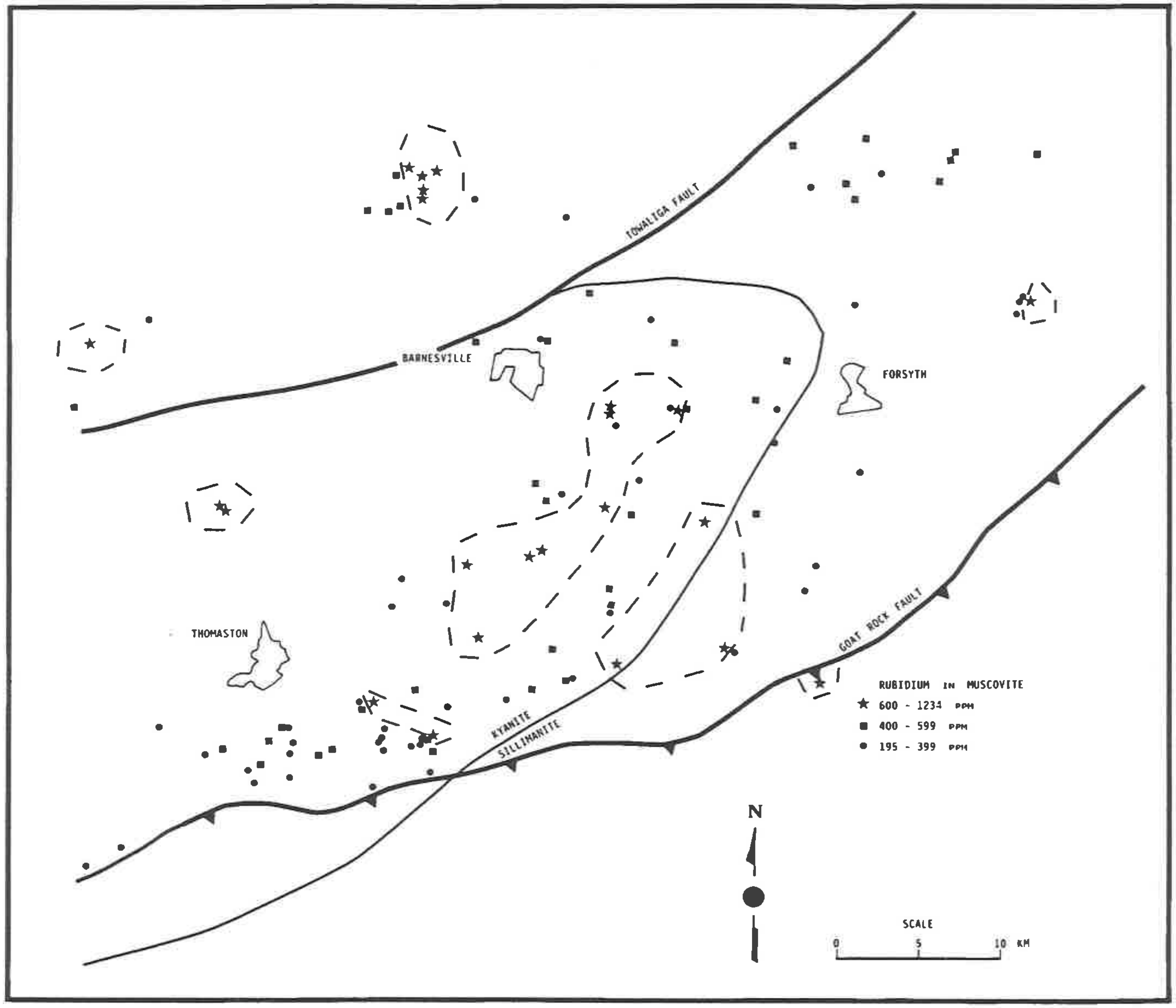

Figure 26. Map of the distribution of Rb in muscovite. Results (Appendix II) indicate that the highest Rb values (stars outlined by dashed lines) occur mainly in the central part of the district and in the Indian Grave field to the northwest. The location of the kyanite-sillimanite isograd, the Towaliga and Goat Rock faults are shown for comparison.

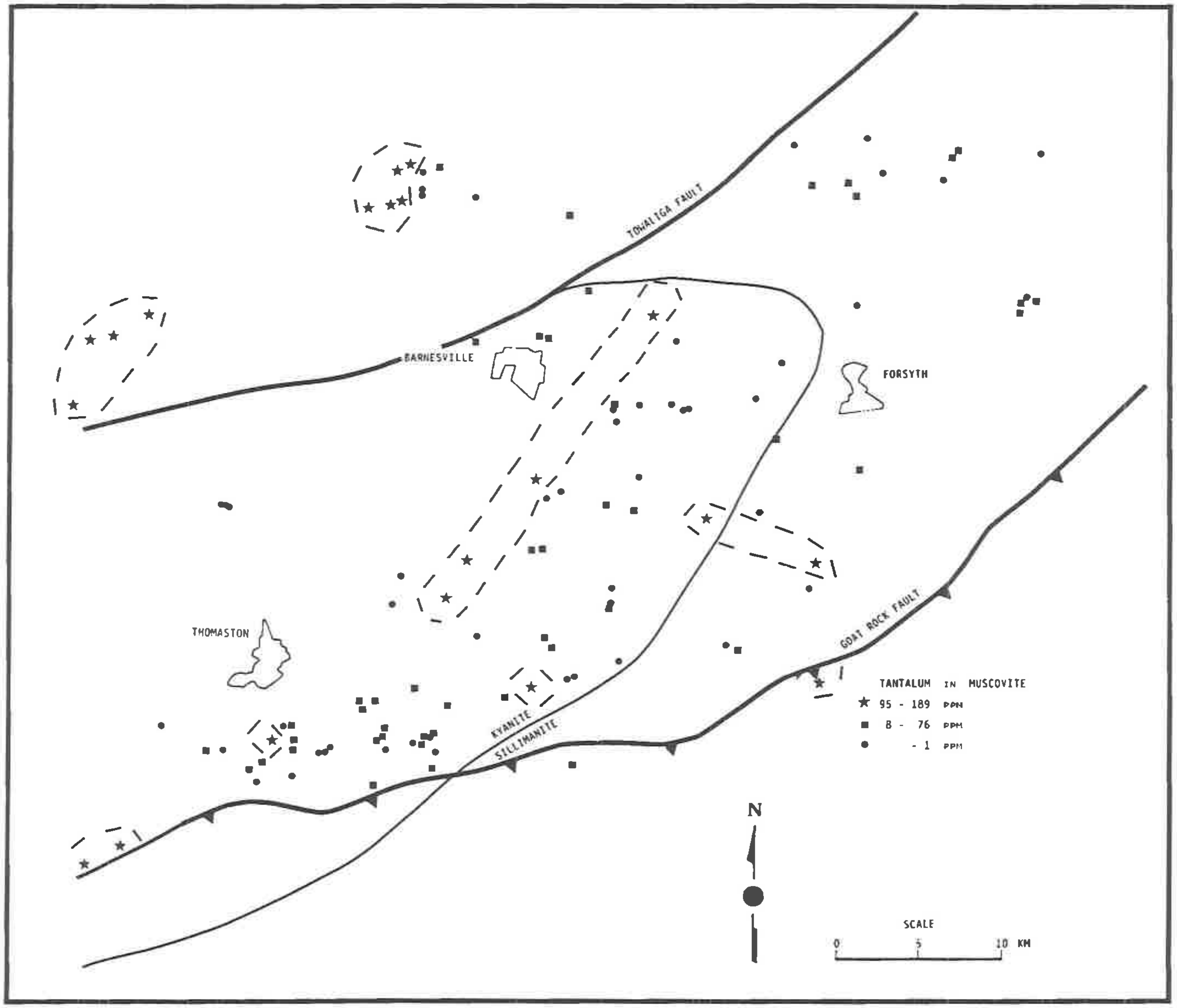

Figure 27. Map of the distribution of Ta in muscovite. Results (Appendix II) indicate that the highest Ta values (stars outlined by dashed lines) occur in a narrow band in the central part of the district. Other high values in the northwestern part of the map are from one geochemical report and may be erroneous. The location of the kyanite-sillimanite isograd, the Towaliga and Goat Rock faults are shown for comparison.

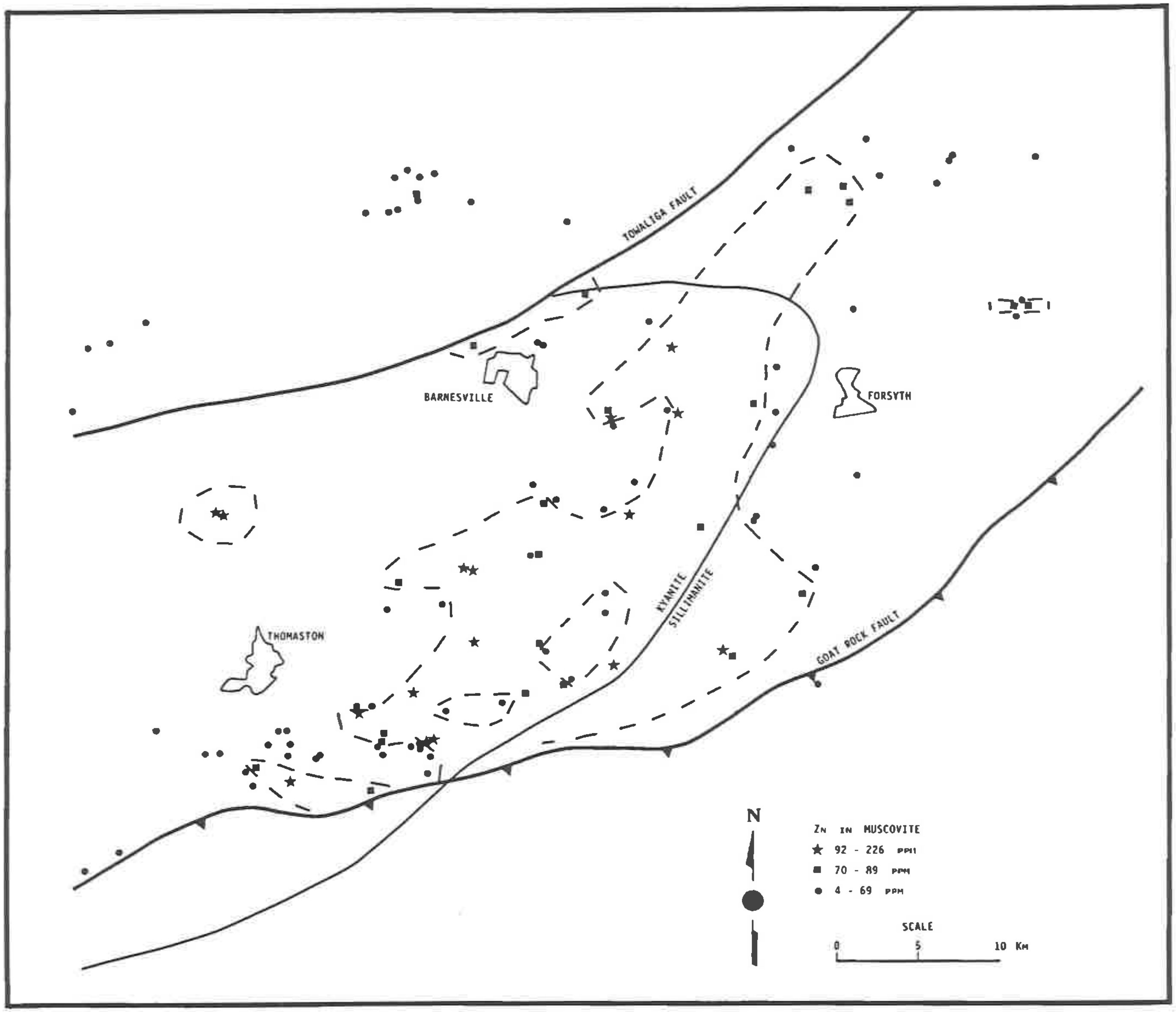

Figure 28. Map of the distribution of Zn in muscovite. Results (Appendix II) indicate that the highest Zn values (stars and squares outlined by the dashed lines) occur mainly in the central part of the district and in the Indian Grave field to the northwest. The location of the kyanite-sillimanite isograd, the Towaliga and Goat Rock faults are shown for comparison.

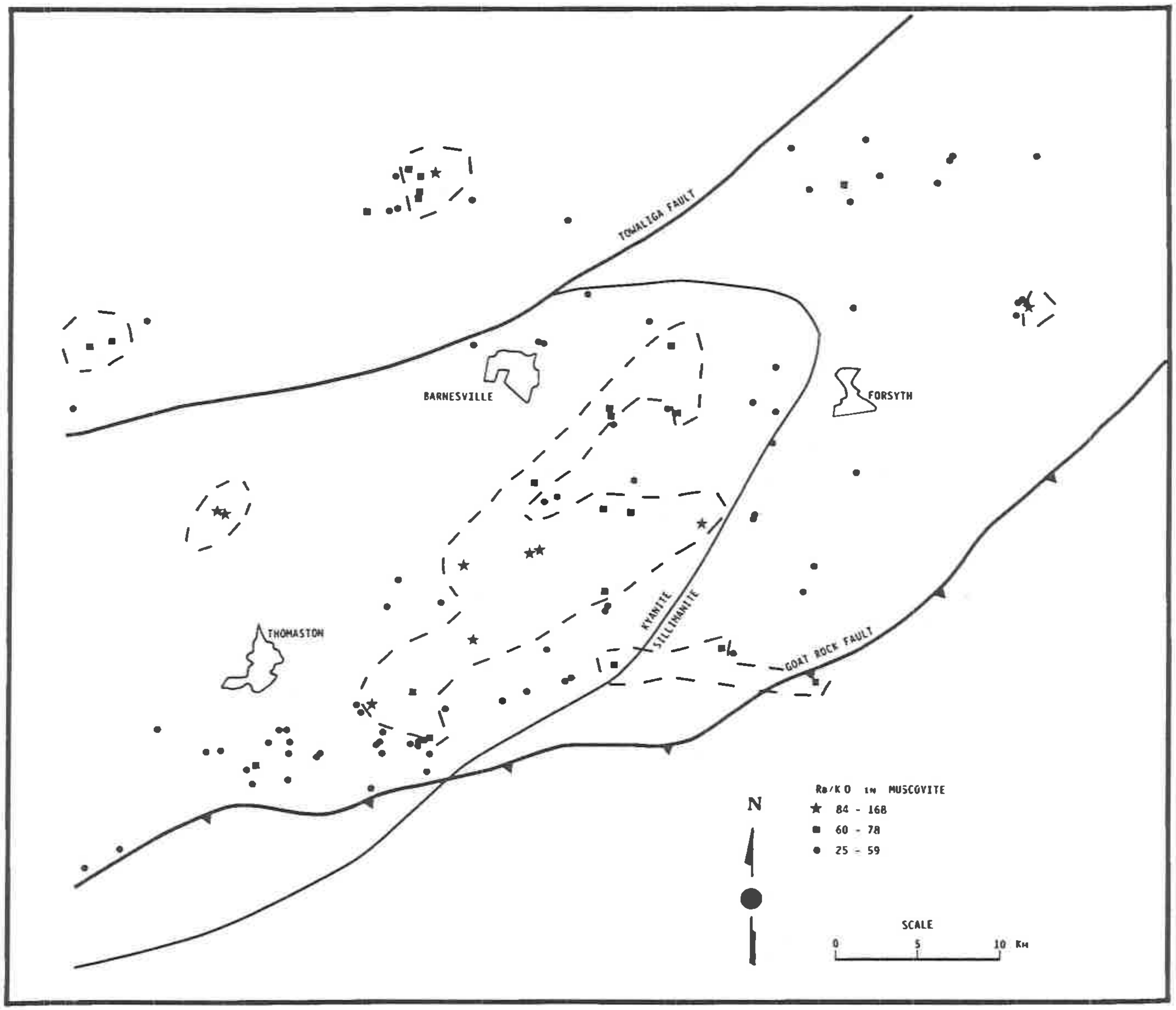

Figure 29. Map of the distribution of Rb/K_2O in muscovite. Results (Appendix II) indicate that the highest Rb/K_2O ratios (stars and squares outlined by the dashed lines) occur mainly in the central part of the district and in the Indian Grave field to the northwest. The location of the kyanite-sillimanite isograd, the Towaliga and Goat Rock faults are shown for comparison.

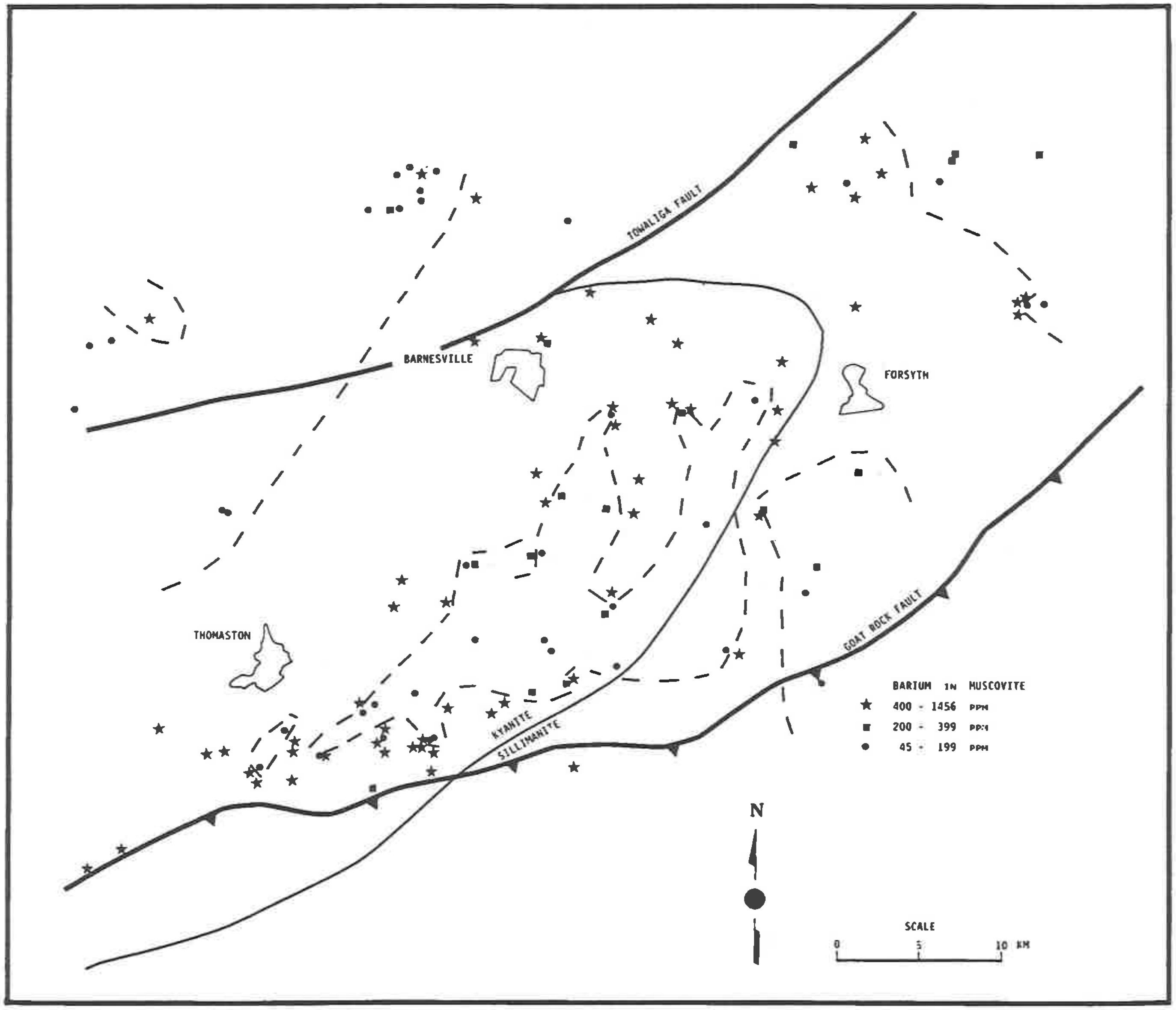

Figure 30. Map of the distribution of Ba in muscovite. Results (Appendix II) indicate that the highest Ba values (stars) occur mainly surrounding the central part of the district and several pegmatite fields to the northwest. The dashed lines outline areas of low Ba (circles and squares). The location of the kyanite-sillimanite isograd, the Towaliga and Goat Rock faults are shown for comparison.

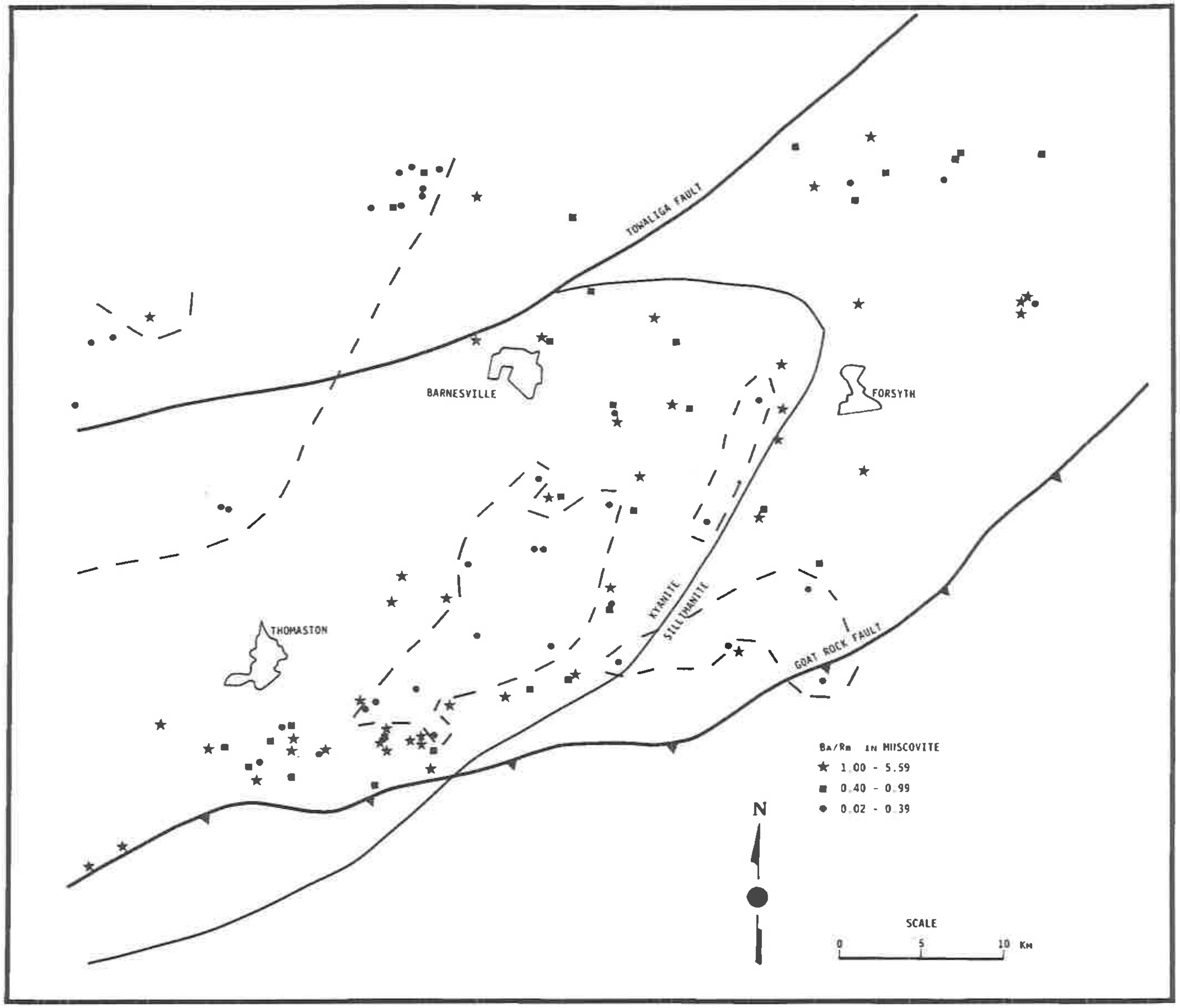

Figure 31. Map of the distribution of Ba/Rb in muscovite. Results (Appendix II) indicate that the highest Ba/Rb ratios (stars and squares) generally surround the central part of the district and several pegmatite fields to the northwest and southeast. The lower ratios are outlined by dashed lines. The location of the kyanite-sillimanite isograd, the Towaliga and Goat Rock faults are shown for comparison.

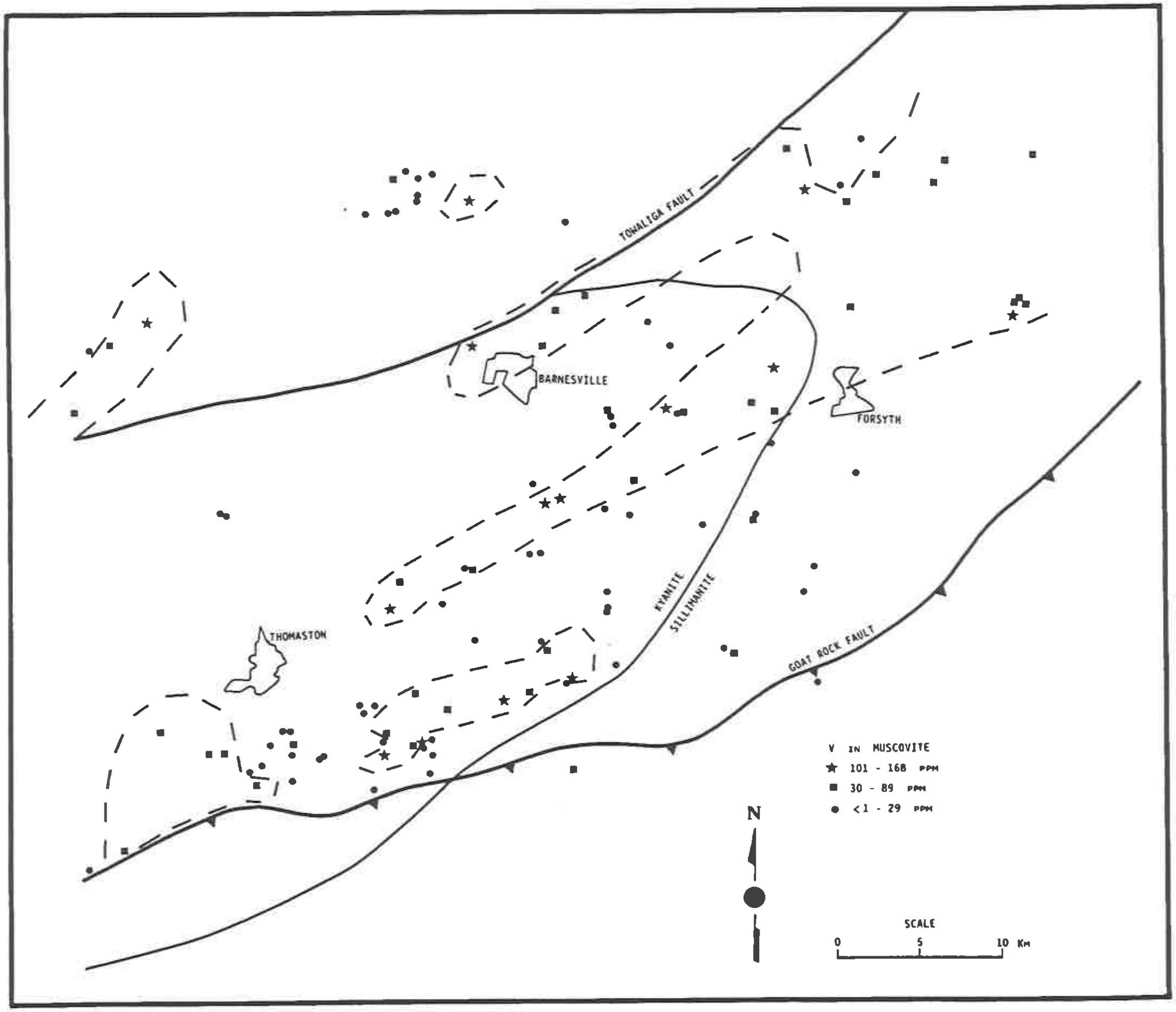

Figure 32. Map of the distribution of V in muscovite. Results (Appendix II) indicate that the highest V values (stars and squares outlined by dashed lines) occur mainly in three northeast-trending bands through the central part of the district and adjacent to the Towaliga and Goat Rock faults. The location of the kyanite-sillimanite isograd, the Towaliga and Goat Rock faults are shown for comparison.

values are concentrated towards the northeast corner of the district.

DISCUSSION OF PEGMATITIC MUSCOVITE GEOCHEMICAL ZONING

The regional geochemical maps of the Thomaston-Barnesville district appear to show three distinct trends. Two trends indicate a district-scale zoning which is centered on a "core" of beryl- and schorl tourmaline-bearing pegmatites. One group of elements (F, Li, Rb, Nb, Ta, Zn and Be) are enriched in pegmatitic muscovite in the core of the district, with the lowest geochemical values distributed distally to the core (Figures 22 to 28). A second zone consisting of several scattered pegmatite fields in the northwestern part of the district is also generally enriched in these elements. The predominant orientation of the anomalously high central zone is to the northeast and is generally parallel to the kyanite - sillimanite isograd (Cocker, 1991). A second pattern which is illustrated by Ba (Figure 30), is essentially opposite to that of the above trend with higher values peripheral to the core. The third pattern is that of higher V which trends northeast across the kyanite - sillimanite isograd (Figure 32).

The two centrally zoned patterns that are discussed above may reflect a relationship of pegmatite chemistry with pressure-temperature conditions reflected by the kyanite - sillimanite isograd. The trend toward greater enrichment in F, Li, Rb, Nb, Ta, Zn and Be in pegmatitic muscovite from sillimanite grade conditions to kyanite grade conditions is in agreement with the trends shown in Figure 33 as suggested by Cerny (1982a) and Gunow and Bonn (1989). Because of uncertainties in the absolute ages of the kyanite-sillimanite metamorphism and of the pegmatites, however, these spatial relationships do not prove a genetic relationship.

The more northeasterly-trending pattern exhibited by V may reflect a host-rock compositional influence. The refolded nappe structures suggested by Schamel and others (1980) and Sears and Cook (1984) for the Pine Mountain terrane may extend along the V trends.

The geochemical trends depicted on the Rb/K_2O and the Ba/Rb maps may be related to: 1) the increasing concentration of Rb in pegmatitic fluids with increasing fractionation, 2) the removal of Ba in pegmatitic fluids in the earlier formed pegmatites, and 3) the relatively constant removal of K_2O to form feldspar and muscovite.

A variety of factors suggested by Cerny (1982b) may control regional pegmatite zoning:

1. Volatiles such as Li, P, B, and F lower the solidus temperatures of granitic melts significantly more than the solidus temperature of a H_2O-saturated granitic magma. The simultaneous injection of volatile-rich and volatile-poor pegmatitic magmas along a temperature gradient will result in the more fractionated pegmatites crystallizing at lower temperatures, farther from the source.

2. The immiscibility of F-rich and normal granitic melts may cause the differentiation of a single injection into immiscible liquids with the most mobile, generally the most F-rich magma, migrating the farthest distance down a temperature or pressure gradient.

3. Progressive fracturing around a cooling pluton, either due to cooling or to an increase in magmatic or fluid pressure may be accompanied by multiple episodes of pegmatitic melt injection. The continued differentiation of the source magma will produce increasingly fractionated residual pegmatitic melts.

4. Resurgent boiling in the source magma will result in a tremendous increase in the partial vapor pressure of the volatile-oversaturated, highly fractionated pegmatite melts producing a major driving mechanism to move the fractionated melt out and away from the crystallizing magma.

As a source intrusion for the pegmatites has not been either identified or proven, the factors which controlled the pegmatite fractionation in the Thomaston-Barnesville district cannot be identified beyond those suggested above by Cerny (1982b).

FELDSPAR GEOCHEMISTRY

This discussion of feldspar geochemistry is based on geochemical analyses of 44 feldspar samples which are contained in Appendix III. Scatter plots and geochemical maps for the feldspar analyses were not constructed. Most of the feldspar samples are K_2O-rich (8 to 14 weight percent) and Na_2O- (0.5 to 3.2 weight percent) and CaO- (0.01 to 0.5 weight percent) poor. A few samples are sodic-rich (up to 8.0 weight percent) and contain up to 4.3 weight percent CaO. Samples which contain relatively low K_2O, Na_2O and CaO values relative to the other feldspar samples apparently reflect the effects of chemical weathering on those feldspar samples.

GENESIS OF THE THOMASTON-BARNESVILLE PEGMATITES

PHYSICAL CONDITIONS

Silicate melts of granitic composition may be derived by anatexis of high-grade metamorphic rocks or by igneous fractionation from granitic intrusions. While it is generally assumed that granites are the sources for most pegmatites, a source granite is commonly not readily apparent for the mica-bearing pegmatites and the maximal depth pegmatites

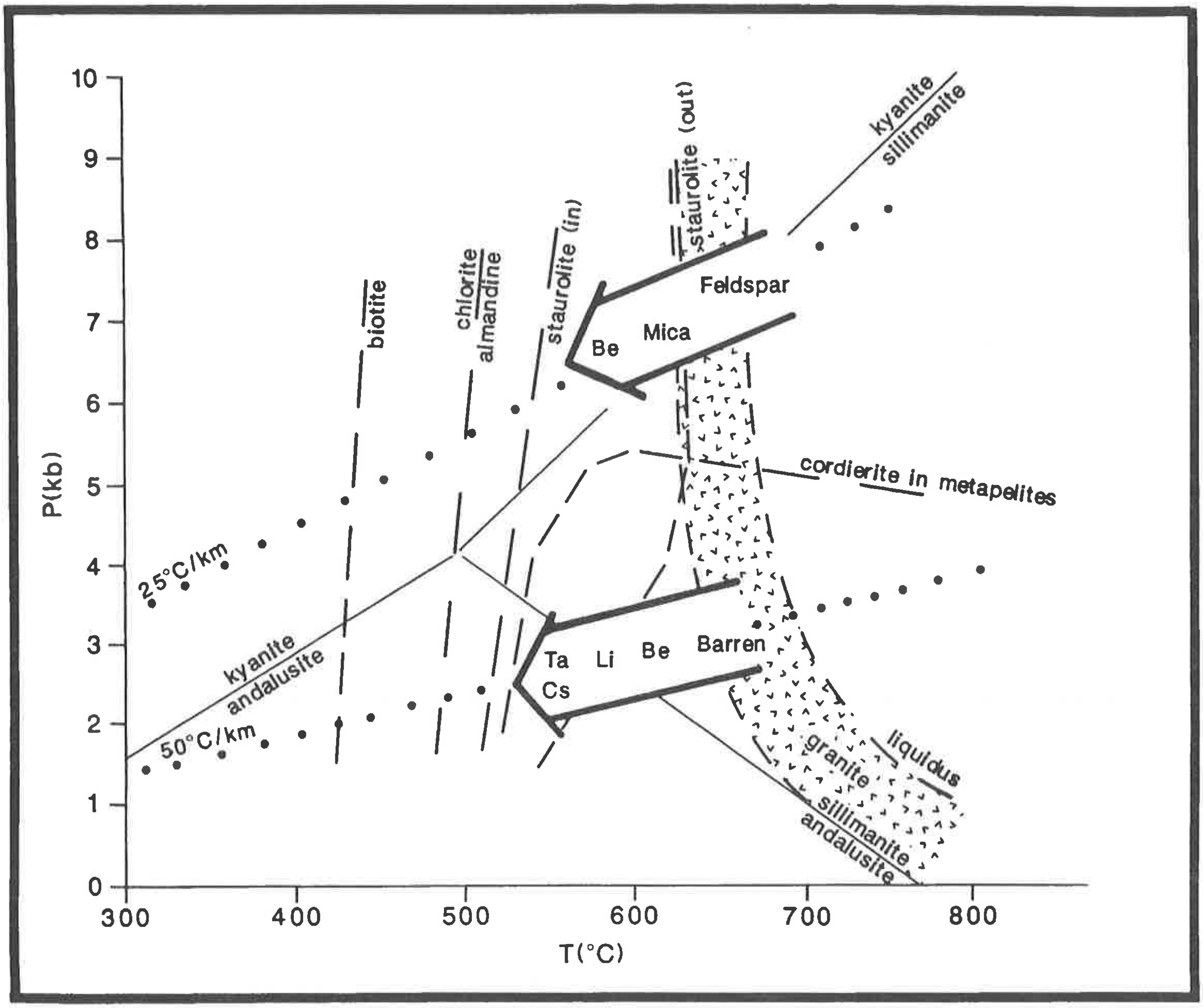

Figure 33. Relation of pegmatites to metamorphic facies series. The most common location of the various types of pegmatites are shown in relation to the various metamorphic index minerals, the granite liquidus and solidus, the pressure and temperature conditions defined by the metamorphic index minerals, and two geothermal gradients (25^{O}C/km and 50^{O}C/km). The upper arrow shows the general position of the maximal depth (feldspar), the beryl-poor muscovite, and the beryl-rich muscovite (Be) pegmatites. The lower arrow depicts the locations of the rare-element pegmatites (Be, Li, Ta, Cs) generally occurring under lower pressure conditions than the maximal depth and muscovite pegmatites. Miarolitic pegmatites would occur at still lower temperatures beneath the rare-element arrow. Diagram is modified from Cerny (1982b), Gunow and Bonn (1989) and Cocker (1992).

(Cerny, 1982b). A nearby granite is commonly misidentified as being the source intrusion for the mica-bearing pegmatites and the maximal depth pegmatites.

Maximal depth pegmatites and mica-bearing pegmatites are principally developed in high-grade metamorphic terranes, and can be related to each other within a metamorphic series (Figure 33). Maximal depth pegmatites may be formed during anatexis associated with upper amphibolite and granulite grade metamorphism. Mica-bearing pegmatites are believed to be distal to pegmatoid granites located in the cores of migmatite domes in Barrovian-type metamorphic terranes. These granites are believed to be anatectic, near-autochthonous rocks. Igneous fractionation within these granites is thought to be minimal (Cerny, 1982b). Derivation of a pegmatitic liquid that produced the rare-metal Greenbushes pegmatite (Partington, 1990) suggests that igneous fractionation may be important in some cases.

The rare-element pegmatites are commonly related to equigranular to porphyritic, generally small to moderate size, late- to post-tectonic granites of calc-alkaline intrusive sequences. Geochemical and mineralogical compositions indicate that the source granites are derived from considerably fractionated melts (Cerny, 1982b). These pegmatites are generally developed in lower pressure, high temperature Abukuma-type metamorphic terranes (Figure 33). The giant rare-metal Greenbushes pegmatite in Western Australia was emplaced under higher pressure conditions more indicative of the muscovite class of pegmatites (Partington, 1990). The Greenbushes pegmatite has not been associated with any granitoid intrusion. This notable exception suggests that other rare-metal pegmatites may occur within high-pressure metamorphic terranes.

SOURCE OF THE PEGMATITES

Prior to the current availability of geochemical and isotopic data and the introduction of the Russian expertise on regional pegmatite zoning (Cerny, 1982a, 1982b), the close spatial relationship of a granitic body to pegmatites was considered to be convincing evidence of a genetic link. Jahns and others (1952) noted that some mica-bearing pegmatites are spatially close to granitic intrusions in the southeastern Piedmont of the United States. However, within the Georgia Piedmont and Blue Ridge pegmatite belts, the pegmatite districts are not spatially associated with any of the exposed granitic intrusions (Figure 11). Because no granitic intrusions are exposed within the Thomaston-Barnesville district, the source of the pegmatites is unknown.

The similarity in ages (256 to 296 m.y.) of the pegmatites in the Thomaston-Barnesville district (Deuser and Herzog, 1962) and the ages (265 to 325 m.y.) of presently exposed granitic intrusions in the southeastern Piedmont (Fullagar and Butler, 1979) suggest that the pegmatites in the Thomaston-Barnesville district may be related to the same period of late Paleozoic granitic activity.

The geochemical and mineralogic zoning in the Thomaston-Barnesville district are apparently spatially related to the regional metamorphic zoning, but no direct genetic or temporal links are apparent. The overlapping of the district's geochemical and mineralogic zoning across the major terrane boundaries, and the cutting of pegmatites across the metamorphic fabric of the district indicate that the pegmatites are younger than the tectonic and metamorphic events represented by those features. Although the precise ages of the pegmatites is unknown, the available age dates for the pegmatites support an age for the pegmatites which is clearly younger age than the youngest peak metamorphic event dated at about 360 m.y. (Odum and others, 1982).

The relationship between the district mineralogic and geochemical zoning and the metamorphic zoning may suggest that the pressure and temperature conditions which existed during peak metamorphism continued at or near those levels up to the time of pegmatite emplacement. Another explanation may be that similar pressure and temperature conditions were attained during the emplacement of a source granitic intrusion for the pegmatites. Neither of these two explanations can be substantiated with the presently available data.

ECONOMIC POTENTIAL OF THE THOMASTON-BARNESVILLE PEGMATITE DISTRICT

RARE METALS

District-scale mineralogic and geochemical zoning indicates that significant fractionation occurred during the development of the pegmatites within the Thomaston-Barnesville district. Pegmatites contain higher concentrations of incompatible trace elements and rare metals within the central part of this district. Despite the greater fractionation trends exhibited by these pegmatites, most muscovites from the Thomaston-Barnesville district have lower Be, Li, Nb, and Rb concentrations than muscovites from beryl-rich pegmatites within the Ball Ground field of the Cherokee-Pickens district (Gunow and Bonn, 1989). Muscovite from the Cochran mine in the Ball Ground field is generally higher in Be, Li, Nb and Rb than other muscovite reported from the Cherokee-Pickens district. The Cochran mine has yielded a considerable amount of beryl ore (J. Connor, personal communication, 1990).

The pegmatites in the Thomaston-Barnesville district which appear to have the greatest potential for rare metals based on the trace-element content of their muscovite appear to be the Adams, Battles, Colbert, Earley Vaughn, Partridge, Phinazee, Reynolds, and Walker mines, the Manrey, Redding and Thompson prospects.

MICA

Pegmatites within the Thomaston-Barnesville district have been the best source of sheet mica in the southeastern Piedmont of the United States. The potential exists for additional development of these pegmatites for their mica content. Many of the larger pegmatite mines appear to have a significant volume of scrap mica on their dumps. Many pegmatites in this district have been mined only to the lowest level of saprolite development and have not been mined out. In addition, concentrations of the large pegmatites suggests that other large pegmatites may be found nearby.

The largest or more important mines in the district, based on the recorded size or the present pit or dump size, appear to be concentrated in two principal areas and several scattered singular occurrences. The two largest groups occur mainly within Upson County. One group consisting of the Adams, Stevens Rock, Johnson, Reynolds, Battle, Rev. Thadeus Persons, and Herron mines forms a rough oval in the Yatesville field generally centered on Yatesville. The other group consisting of the Brown, Mauldin, Old Atwater, Swift Creek, Dallas, Watson, Bennie Baron, Mitchell Creek, Boyt, Wheeles, Duke, and Joe Persons mines in the Waymanville field forms an east-northeast trending belt approximately 5 kilometers south of Thomaston. The other mines (the Doc Irwin, Earley Vaughn, Thurman, New Ground and Old Walker Smith, Brooks, and Fletcher mines) occur in the vicinity of other pegmatites which have not been exploited to the extent of the larger mines. The New Ground and Old Walker Smith mines, which occur in close proximity to each other in the Juliette field, do not appear to have been prospected during the World War II era.

Location of additional pegmatites along the trends of the two large groups would appear favorable. Mica-rich pegmatites occur up to at least 20 kilometers to the southwest of the Brown mine at the southwestern end of the belt south of Thomaston. This area is sparsely inhabited, has few roads and appears not to have been the subject of any mica investigations. The area near Yatesville also would appear to have the potential for additional mica-rich pegmatites.

FELDSPAR

In addition to quartz and muscovite, pegmatites within the Thomaston-Barnesville district contain minor amounts of feldspar. The feldspar is generally weathered to clay at least to the lowest level of mining. Occasionally, fresh feldspar is present at or near the surface and could be mined. The relatively small size of most of the pegmatites which contain fresh feldspar would not appear to support a major development effort at this time.

SUMMARY

The Thomaston-Barnesville district in central Georgia is the largest pegmatite district in Georgia and has produced the largest amount of sheet mica in the southeastern Piedmont of the United States. The present investigation focussed on the evaluation of the rare-metal bearing potential of the pegmatites in the Thomaston-Barnesville district. Ratios, scatter plots and district-scale geochemical maps of trace elements in muscovite were used: 1) to evaluate each individual pegmatite within the district; 2) to evaluate the district as a whole geochemical system to determine if this district could contain important rare-element bearing pegmatites; and 3) to identify the location of undiscovered important rare-element bearing pegmatites within the district.

The relatively pronounced increases in the concentrations of F, Li, Be, Ga, Nb, Ta, Rb and Zn in muscovite in the Thomaston-Barnesville district indicates an increase in the degree of fractionation of the pegmatites. District-scale geochemical maps indicate higher concentrations of the trace elements: F, Li, Be, Ga, Nb, Ta, Rb and Zn in muscovite occur within a central zone of pegmatites that also contain beryl and commonly schorl tourmaline. Other trace elements, such as Ba, are concentrated peripherally to the central part of the district. The distribution of V and other trace elements may be influenced by lithologic or structural controls.

The regional geochemical zoning is superimposed on the presently known regional metamorphic gradient. The central zone, with high F, Li, Be, Ga, Nb, Ta, Rb and Zn, is generally contained within the kyanite facies. The outer high Ba and high V zones overlap the kyanite - sillimanite isograd. The lack of any visible granitic intrusions within this district and the spatial relation of the regional geochemical zoning and the metamorphic gradient suggests that the pegmatites within this district may be related to a regional thermal metamorphic event. Because this district's pegmatites extend beyond the major structural boundaries enclosing the Pine Mountain terrane, and the pegmatites cross-cut the regional metamorphic foliation, the pegmatites were probably emplaced after the latest episode of penetrative deformation. The few age dates available for pegmatites within the Thomaston-Barnesville district appear to correlate with the timing of post-orogenic granitic activity elsewhere in Georgia. It is suggested that the pegmatites within the Thomaston-Barnesville district are related to a still buried, late-stage or post-orogenic granitic batholith.

The results of this investigation suggest that the Thomaston-Barnesville district has a reasonably high potential for additional sheet mica, and scrap or punch mica deposits, but has a marginal potential for rare-element pegmatite deposits. When compared to other pegmatites in Georgia and pegmatites in other parts of the world which

have economic concentrations of trace elements, the geochemical signatures of the most fractionated pegmatites in the Thomaston-Barnesville district indicate that local enrichment occurred; however, economic concentrations may not have been achieved. The feldspar potential of this district is low because of: 1) the extensive near-surface weathering; 2) the relatively small size of most of this district's pegmatites; and 3) the pegmatites in this district are in the muscovite class and rather than the maximal depth (feldspar-rich) pegmatite class.

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APPENDICES

APPENDIX I.

LOCATIONS OF PEGMATITE MINES, PROSPECTS, SAMPLES

Mine/Prospect/Location	Sample Number	Easting	Northing
Pike Co. roadcut	348-1	756120	3669980
Pike Co. roadcut	348-2	756120	3669980
Pike Co. roadcut	348-3	756120	3669980
Pike Co. roadcut	348-4	756120	3669980
Mrs. Taylor prospect	349-1	768180	3669800
Mrs. Taylor prospect	349-2	768180	3669800
Brown property	349-3	759270	3670940
Brown property	349-4	759270	3670940
Lamar Co. roadcut	349-5	759240	3671250
Doc Irwin mine	349-6	759330	3672320
Doc Irwin mine	349-7	759330	3672320
Lamar Co. roadcut	349-8	762550	3670900
Coggins prospect	349-9	760150	3672550
Coggins prospect	349-10	760150	3672550
Coggins prospect	349-11	760150	3672550
Coggins prospect	349-12	760150	3672550
Lamar Co. roadcut	349-13	758400	3672720
Lamar Co. roadcut	349-14	758400	3672720
Lamar Co. roadcut	349-15	758400	3672720
Lamar Co. roadcut	349-16	757900	3672720
Lamar Co. roadcut	349-17	757700	3672260
Lamar Co. roadcut	349-18	757700	3672260
Lamar Co. roadcut	349-19	757830	3670290
Lamar Co. roadcut	349-20	757830	3670290
Lamar Co. roadcut	349-21	757400	3670220
Lamar Co. roadcut	349-22	756950	3670230
Lamar Co. roadcut	349-23	756950	3670230
Lassiter Rd. outcrop	351-1	227600	3674850
Lassiter Rd. outcrop	351-2	227600	3674850
Lassiter Rd. outcrop	351-3	227600	3674850
Monroe Co. roadcut	351-4	225680	3674900
MV mine	351-5	225800	3672140
MV mine	351-6	225800	3672140
unnamed mine	351-7	226150	3671150
Goggins prospect	351-8	231600	3672100
Goggins prospect	351-9	231600	3672100
Goggins prospect	351-10	231600	3672100
Butts Co. roadcut	351-11	228580	3681930
Butts Co. roadcut	351-12	229980	3682080
Butts Co. roadcut	351-13	229980	3682080
Westbrooks prospect	351-14	223100	3674560
Westbrooks prospect	351-15	223100	3674560
Westbrooks prospect	351-16	223100	3674560
Westbrooks prospect	351-17	223100	3674560
Westbrooks prospect	351-18	223100	3674560
Monroe Co. roadcut	351-19	222670	3671990
Monroe Co. roadcut	351-20	222670	3671990

APPENDIX I. (cont.)

Monroe Co. roadcut	351-21	222670	3671990
Monroe Co. roadcut	351-22	222230	3672100
Monroe Co. roadcut	351-23	222230	3672100
Marie Vaughn mine	351-24	221920	3670330
Marie Vaughn mine	351-25	221920	3670330
Marie Vaughn mine	351-26	221920	3670330
Sutton prospect	351-27	223800	3671950
Sutton prospect	351-28	223800	3671950
Monroe Co. roadcut	351-29	224200	3673150
Monroe Co. roadcut	351-30	228200	3672800
Monroe Co. roadcut	351-31	228200	3672800
Goddard + Watson prospect	352-29	232510	3673670
Goddard + Watson prospect	352-30	232510	3673670
Goddard + Watson prospect	352-31	232510	3673670
Goddard + Watson prospect	352-32	232510	3673670
Goddard + Watson prospect	352-33	232440	3673600
Goddard + Watson prospect	352-34	232440	3673600
Jasper Co. roadcut	352-35	240850	3675230
Jasper Co. roadcut	352-36	240850	3675230
Jasper Co. roadcut	352-37	240850	3675230
Jasper Co. roadcut	352-38	240850	3675230
Jasper Co. roadcut	352-39	240850	3675230
Jasper Co. roadcut	352-48	242030	3677180
Jasper Co. roadcut	352-49	242030	3677180
Jasper Co. roadcut	352-50	242030	3677180
Jasper Co. roadcut	352-51	243400	3678250
Jasper Co. roadcut	352-52	243400	3678250
Jasper Co. roadcut	352-53	243400	3678250
Jasper Co. roadcut	352-54	243400	3678250
Jasper Co. roadcut	352-55	233250	3671800
Jasper Co. roadcut	352-56	233250	3671800
Pike Co. roadcut	376-1	742700	3662950
Pike Co. roadcut	376-2	742430	3662870
Pike Co. roadcut	376-3	740650	3661650
Pike Co. roadcut	376-4	740650	3661650
Pike Co. roadcut	376-5	740600	3661650
Pike Co. roadcut	376-6	740600	3661650
Pike Co. roadcut	376-7	739220	3661430
Pike Co. roadcut	376-8	739220	3661430
Pike Co. roadcut	376-9	739220	3661430
Pike Co. roadcut	376-10	739220	3661430
Pike Co. roadcut	376-11	739170	3660430
Pike Co. roadcut	376-12	738400	3657470
Pike Co. roadcut	376-13	738400	3657470
Hog Mtn. roadcut	378-1	766920	3662400
H.S. Worsham prospect	378-2	767220	3662400
Lamar Co. roadcut	378-3	768000	3664510
Lamar Co. roadcut	378-4	768000	3664510
Lamar Co. roadcut	378-5	764200	3662400
Lamar Co. roadcut	378-6	762780	3662180
Lamar Co. roadcut	378-7	762780	3662180
Means prospect	379-1	771380	3658200

APPENDIX I. (cont.)

Means prospect	379-2	771380	3658200
Means prospect	379-3	771380	3658200
Means prospect	379-4	771380	3658200
Earley Vaughn mine	379-5	771350	3658370
Earley Vaughn mine	379-6	771350	3658370
Earley Vaughn mine	379-7	771350	3658370
Earley Vaughn mine	379-8	771350	3658370
Earley Vaughn mine	379-9	771350	3658370
Earley Vaughn mine	379-10	771350	3658370
Earley Vaughn mine	379-11	771350	3658370
Lamar Co. roadcut	379-12	769570	3665570
Lamar Co. roadcut	379-13	769570	3665570
Lamar Co. roadcut	379-14	769570	3665570
Lamar Co. roadcut	379-15	769570	3665570
Lamar Co. roadcut	379-16	769570	3665570
Lamar Co. roadcut	379-17	773610	3663930
Lamar Co. roadcut	379-18	773610	3663930
H.P. Manrey prospect	379-19	775300	3662270
H.P. Manrey prospect	379-20	775300	3662270
H.P. Manrey prospect	379-21	775300	3662270
Lamar Co. float	379-22	771620	3657340
Lamar Co. float	379-23	772250	3657660
Old Childs mine	379-24	775030	3658570
Old Childs mine	379-25	775030	3658570
Monroe Co. float	379-26	778100	3658600
Ingraham prospect	379-27	775780	3658350
Ingraham prospect	379-28	775780	3658350
Ingraham prospect	379-29	775780	3658350
Lamar Co. roadcut	379-30	773000	3658540
Thurman mine	380-1	220940	3656270
Thurman mine	380-2	220940	3656270
Thurman mine	380-3	220940	3656270
Thurman mine	380-4	220860	3656300
Thurman mine	380-5	220860	3656300
Thurman mine	380-6	220860	3656300
Monroe Co. roadcut	380-7	221670	3661340
Phinazee mines west	380-8	219880	3659000
Phinazee mines west	380-9	219880	3659000
Monroe Co. roadcut	380-10	226120	3664560
Goodwin prospect	380-11	221350	3658640
Goodwin prospect	380-12	221350	3658640
Goodwin prospect	380-13	221350	3658640
Redding prospect	381-1	237020	3664550
Redding prospect	381-2	237020	3664550
Redding prospect	381-3	237020	3664550
Redding prospect	381-4	237020	3664550
New Ground mine	381-5	236500	3664670
New Ground mine	381-6	236500	3664670
Old Walker Smith mine	381-7	236550	3664870
Old Walker Smith mine	381-8	236550	3664870
Monroe Co. roadcut	381-9	236500	3664670
Monroe Co. roadcut	381-10	236550	3664100

APPENDIX I. (cont.)

Monroe Co. roadcut	381-11	236550	3664100
Monroe Co. roadcut	381-12	236500	3664060
Monroe Co. roadcut	381-13	241820	3656130
Thompson prospect	408-1	747500	3651370
Thompson prospect	408-2	747500	3651370
Thompson prospect	408-3	747500	3651370
Thompson prospect	408-4	747500	3651370
Thompson prospect	408-5	747500	3651370
Partridge mine	408-6	747470	3651400
Upsom Co. roadcut	408-7	747300	3651520
Parteidge mine	408-8	747470	3651400
Adams mine	409-1	767480	3649420
Adams mine	409-2	767480	3649420
Adams mine	409-3	767480	3649420
Adams mine	409-4	767480	3649420
Adams mine	409-5	767480	3649420
Adams mine	409-6	767480	3649420
Walker prospect	409-7	766800	3649230
Colbert mine area	409-8	763260	3648300
Colbert mine area	409-9	763260	3648300
Upson Co. roadcut	409-10	758000	3652000
Upson Co. roadcut	409-11	758640	3647450
Upson Co. roadcut	409-12	758640	3647450
Stevens Rock mine	409-13	761370	3646130
Stevens Rock mine	409-14	761370	3646130
Stevens Rock mine	409-15	761370	3646130
Stevens Rock mine	409-16	761370	3646130
Stevens Rock mine	409-17	761370	3646130
Stevens Rock mine	409-18	761370	3646130
Upson Co. roadcut	409-19	762820	3648180
Upson Co. roadcut	409-20	762850	3648150
Upson Co. roadcut	409-21	762880	3648130
Upson Co. roadcut	409-22	758250	3645680
Walker prospect	409-23	766800	3649230
Walker prospect	409-24	766800	3649230
Clay Cheek mine	409-25	766830	3653650
Clay Cheek mine	409-26	766830	3653650
Clay Cheek mine	409-27	766830	3653650
Upson Co. outcrop	409-28	768120	3652900
Upson Co. outcrop	409-29	768120	3652900
Upson Co. outcrop	409-30	767610	3652350
Johnson mine roadcut	409-31	768040	3643540
Johnson mine roadcut	409-32	768040	3643540
Reynolds mine	409-33	763470	3643900
Reynolds mine	409-34	763470	3643900
Reynolds mine	409-35	763470	3643900
Reynolds mine	409-36	763470	3643900
Johnson mine	409-37	767570	3644040
Kelley O'Neal prospects	409-38	767590	3652350
Peters mine	410-1	777300	3651420
Peters mine	410-2	777300	3651420
Peters mine	410-3	777300	3651420

Peters mine	410-4	777300	3651420
Peters mine	410-5	777300	3651420
Peters mine	410-6	777300	3651420
Florida Rock Indus. quarry	410-7	770200	3647400
Battle mine	410-8	769140	3641380
Battle mine	410-9	769140	3641380
Battle mine	410-10	769140	3641380
Battle mine	410-11	769140	3641380
Battle mine	410-12	769140	3641380
Battle mine	410-13	769140	3641380
prospect pit	410-14	769220	3641370
prospect pit	410-15	769425	3641740
prospect pit	410-16	769425	3641740
Holmes mine	410-17	772150	3642650
Holmes mine	410-18	772150	3642650
Holmes mine	410-19	772150	3642650
Holmes mine	410-20	772150	3642650
Holmes mine	410-21	772150	3642650
Persons NE prospect	410-22	771620	3646080
Persons NE prospect	410-23	771620	3646080
Persons NE prospect	410-24	771620	3646080
Persons NE prospect	410-25	771620	3646080
Rev. Thadeus Persons mine	410-26	771520	3646020
Rev. Thadeus Persons mine	410-27	771520	3646020
Persons west prospect	410-28	771420	3646050
Persons west prospect	410-29	771420	3646050
J.T. Means mine	410-30	772900	3651940
J.T. Means mine	410-31	772900	3651940
Monroe Co. roadcut	410-32	773220	3654160
Monroe Co. roadcut	410-33	771220	3652280
Monroe Co. roadcut	410-34	771220	3652280
Homer Hardin mine	410-35	778850	3643620
Homer Hardin mine	410-36	778850	3643620
Homer Hardin mine	410-37	778850	3643620
Homer Hardin mine	410-38	778850	3643620
Holloway mine	410-39	780550	3643500
Holloway mine	410-40	780550	3643500
O.B. Clements property	410-41	771450	3646140
Brooks mine	411-1	226120	3654480
Brooks mine	411-2	226120	3654480
Brooks mine	411-3	226120	3654480
Brooks mine	411-4	226120	3654480
Brooks mine	411-5	226120	3654480
Brooks mine	411-6	226120	3654480
Brooks mine	411-7	226120	3654480
Fletcher mine	411-8	219750	3651950
Fletcher mine	411-9	219750	3651950
Fletcher mine	411-10	219750	3651950
Ruffin prospect	411-11	222650	3647230
Ruffin prospect	411-12	222650	3647230
Fletcher mine north	411-13	219760	3652000
Fletcher mine north	411-14	219760	3652000

APPENDIX I. (cont.)

Monroe Co. roadcut	411-15	223200	3641680
Monroe Co. roadcut	411-16	223200	3641680
Monroe Co. roadcut	411-17	223450	3641800
Monroe Co. roadcut	411-18	223450	3641800
Talbot Co. roadcut	437-1	728770	3627330
Talbot Co. roadcut	437-2	728770	3627330
Upson Co. roadcut	438-1	744050	3637860
Upson Co. roadcut	438-2	744050	3637820
Talbot Co. roadcut	438-3	741870	3630380
Talbot Co. roadcut	438-4	741630	3630400
Talbot Co. roadcut	438-5	740160	3629610
Talbot Co. roadcut	438-6	740160	3629610
Talbot Co. roadcut	438-7	740000	3629090
Brown mine	439-1	749750	3635300
Brown mine	439-2	749750	3635300
Brown mine	439-3	749750	3635300
Brown mine	439-4	749750	3635300
Brown mine	439-5	749750	3635300
unnamed mine	439-6	750100	3634630
unnamed mine	439-7	750100	3634630
unnamed mine	439-8	750100	3634630
unnamed mine	439-9	750100	3634630
King-Thurston mine	439-10	750710	3635350
King-Thurston mine	439-11	750710	3635350
King-Thurston mine	439-12	750710	3635350
Mauldin mine	439-13	752380	3636600
Mauldin mine	439-14	752380	3636600
Mauldin mine	439-15	752380	3636600
Old Atwater mine	439-16	754250	3636520
Old Atwater mine	439-17	754250	3636520
Old Atwater mine	439-18	754250	3636520
Old Atwater mine	439-19	754250	3636520
Old Atwater mine	439-20	754120	3636460
Old Atwater mine	439-21	754250	3636520
Corley mine	439-22	756350	3639730
Corley mine	439-23	756350	3639730
Corley mine	439-24	756350	3639730
Corley mine	439-25	756350	3639730
Old Atwater mine	439-26	754250	3636520
Watson mine	439-27	752330	3634990
Watson mine	439-28	752330	3634990
Watson mine	439-29	752330	3634990
Atwater mine roadcut	439-30	754780	3636720
Atwater mine roadcut	439-31	754780	3636720
Atwater mine roadcut	439-32	754780	3636720
Dallas mine/prospect	439-33	751660	3637975
Dallas mine/prospect	439-34	751660	3637975
Grace prospect	439-35	748000	3636510
Grace prospect	439-36	748000	3636510
Grace prospect	439-37	748000	3636510
Gordon Scool roadcut	439-38	746990	3636350
Gordon Scool roadcut	439-39	746990	3636350

APPENDIX I. (cont.)

Po Biddy Rd. roadcut	439-40	749950	3635450
Po Biddy Rd. roadcut	439-41	749950	3635450
Po Biddy Rd. roadcut	439-42	749950	3635450
Mauldin Rd. prospect	439-43	752250	3637110
Mauldin Rd. prospect	439-44	752250	3637110
Mauldin Rd. prospect	439-45	752250	3637110
Mauldin Rd. prospect	439-46	752250	3637110
Mauldin Rd. prospect	439-47	752250	3637110
Corley prospects	439-48	756600	3639550
Corley prospects	439-49	756600	3639550
Corley prospects	439-50	756600	3639550
Corley prospects	439-51	756600	3639550
Swift Creek mine	439-52	757100	3639600
Swift Creek mine	439-53	757100	3639600
Swift Creek mine	439-54	757100	3639600
Swift Creek mine	439-55	757100	3639600
Corley prospects	439-56	756500	3638700
Zorn prospect area	439-57	757180	3634480
Nottingham prospect area	439-58	755390	3628200
Nottingham prospect area	439-59	755440	3628250
Nottingham prospect area	439-60	755670	3629170
Upson Co. roadcut	439-61	756480	3628550
Upson Co. roadcut	439-62	756480	3628550
Upson Co. roadcut	439-63	756480	3628550
Upson Co. roadcut	439-64	756480	3628550
Cumbie prospect area	439-65	750500	3636450
Dallas prospects	439-66	751890	3636800
Dallas prospects	439-67	751890	3636800
Dallas prospects	439-68	751890	3636800
Dallas prospects	439-69	751890	3636800
Dallas prospects	439-70	751890	3636800
Mitchell Creek mine area	440-1	760200	3637270
Mitchell Creek mine area	440-2	760200	3637270
Mitchell Creek mine	440-3	760280	3637450
Mitchell Creek mine	440-4	760280	3637450
Mitchell Creek mine	440-5	760280	3637450
Bennie Baron mine	440-6	758000	3638120
Bennie Baron mine	440-7	758000	3638120
Bennie Baron mine	440-8	758000	3638120
Boyt mine	440-9	757620	3637350
Boyt mine	440-10	757620	3637350
Boyt mine	440-11	757620	3637350
Boyt mine	440-12	757620	3637350
Boyt mine	440-13	757620	3637350
prospect pit	440-14	761070	3636430
prospect pit	440-15	761070	3636430
Wheeles Mine	440-16	761050	3636720
Wheeles Mine	440-17	761050	3636720
Wheeles Mine	440-18	761050	3636720
Wheeles Mine	440-19	761050	3636720
Wheeles Mine	440-20	761050	3636720
Tomlin mine	440-21	760920	3635650

Tomlin mine	440-22	760920	3635650
Tomlin mine	440-23	760920	3635650
Blount #1 mine	440-24	759750	3640600
Blount #1 mine	440-25	759750	3640600
Upson Co. roadcut	440-26	757850	3637520
Duke mine	440-27	759800	3637075
Duke mine	440-28	759800	3637075
Maze prospect	440-29	758420	3636870
Upson Co. roadcut	440-30	757800	3637520
Upson Co. roadcut	440-31	757800	3637520
Upson Co. roadcut	440-32	766900	3640750
Upson Co. roadcut	440-33	766900	3640750
Upson Co. roadcut	440-34	766900	3640750
Short Mitchell mine	440-35	765250	3640120
Short Mitchell mine	440-36	765250	3640120
Short Mitchell mine	440-37	765250	3640120
Upson Co. roadcut	440-38	759650	3640660
Upson Co. roadcut	440-39	759650	3640660
Upson Co. roadcut	440-40	759650	3640660
Upson Co. roadcut	440-41	759650	3640660
Triune Mills prospect	440-42	762100	3639100
Joe Persons mine	440-43	760400	3637700
Joe Persons mine	440-44	760400	3637700
Joe Persons mine	440-45	760400	3637700
Joe Persons mine	440-46	760400	3637700
Joe Persons mine	440-47	760400	3637700
Joe Persons mine	440-48	760400	3637700
Joe Persons mine	440-49	760400	3637700
Joe Persons mine	440-50	760400	3637700
Crawford Co. roadcut	441-1	773100	3627200
Crawford Co. roadcut	441-2	772950	3627250
Crawford Co. roadcut	441-3	769600	3636050
Crawford Co. roadcut	441-4	769600	3636050
Crawford Co. roadcut	441-5	769600	3636050
Crawford Co. roadcut	441-6	775500	3630550
Crawford Co. roadcut	441-7	773300	3627220
Crawford Co. roadcut	442-1	219880	3641060
Crawford Co. roadcut	442-2	219880	3641000
Crawford Co. roadcut	442-3	219950	3641210
Crawford Co. roadcut	442-4	226800	3633430
Crawford Co. roadcut	442-5	226800	3633430
Talbot Co. roadcut	468-1	729680	3625150
Talbot Co. roadcut	468-2	729680	3625150
Talbot Co. roadcut	468-3	729080	3623470
Talbot Co. roadcut	468-4	729080	3623470
Crawford Co. roadcut	472-1	770700	3625480
Crawford Co. roadcut	472-2	770700	3625480

APPENDIX I. (cont.)

Mines and prospects not sampled or located during this investigation. Locations are estimated from descriptions in earlier studies noted in text.

Old Martin prospect	735800	3663550
D.C. Ellerbee prospects	737500	3644250
T.J. Reeves prospect	744450	3637950
Old Bell mine	748210	3637050
Joe McKinley prospect	753200	3635200
L.M. Brooks prospect	753750	3638075
B.S. Gibson prospects	753850	3638500
F.E. Thomson prospect	754100	3637450
Emmit Trice prospects	754670	3639700
Bentley propsect	755800	3643650
Young mine	757600	3639500
J.M. Bevell deposit	757680	3652900
S.P. Cronheim prospects	758150	3639520
outcrop	759240	3670250
J.W. Brown deposit	759240	3669940
outcrop	762550	3669900
Charlie Nims mine	762800	3640720
Cliff Middlebrooks deposit	762850	3648150
Colbert mine	763250	3648300
Pennyman mine	764000	3638800
Howard mine	765750	3663150
Williams and Holmes prospects	765850	3657550
Hellen McDonald prospect	767680	3644470
Carter mine	767900	3652960
Herron mine	767900	3645300
Taylor prospect	768180	3669880
Perdue prospect	768500	3653650
Haygood prospect	770550	3644500
Sugar Hill No. 2 prospect	770800	3650720
Sugar Hill No. 1 prospect	771200	3649250
Col. A. J. Thomas mine	771350	3648500
A.N. Moye property	771600	3653900
L.D. Owen prospect	780300	3652400
Goolsby prospect	230200	3662200

Cities or towns

Barnesville City	765600	3660730
Yatesville City	767200	3645150
Thomaston City	750075	3641775

Sample numbers are keyed to the 7.5" quadrangle map numbers of the Georgia Geologic Survey.

Number	Quadrangle Name
348	Griffin South
349	Orchard Hill
351	Indian Springs
352	Berner

APPENDIX I. (cont.)

376	Concord
378	Barnesville
379	Johnstonville
380	Forsyth
381	East Juliette
408	Thomaston
409	Yatesville
410	Strouds
411	Smarr
437	Manchester
438	Roland
439	Lincoln Park
440	Logtown
441	Culloden
442	Moran
468	Talbotton
472	Roberta

APPENDIX II.

MUSCOVITE GEOCHEMISTRY

SAMPLE	K2O	Rb	Sr	Li	F	Be	Ba	Ba/Rb	Ga
348-1	9.57	590	21	84	973	5.6	119	0.20	73
349-1	8.22	195	11	32	520	16.9	106	0.54	20
349-3	9.3	681	5	78	1017	8.4	172	0.25	46
349-5	9.72	712	6	129	881	6.8	89	0.13	58
349-6	9.32	609	10	43	1429	6.9	492	0.81	44
349-8	7.66	228	11	35	420	6.1	696	3.05	38
349-11	8.15	932	7	51	981	9.2	137	0.15	56
349-13	8.79	685	5	59	1201	9.6	58	0.08	48
349-17	8.28	476	6	94	1548	7.7	135	0.28	43
349-19	9.54	539	5	40	996	5.3	195	0.36	45
349-21	11.9	476	7	36	1151	11.9	308	0.65	33
351-1	9.78	434	6	67	2010	2.9	769	1.77	102
351-5	7.96	598	11	49	1121	10.3	135	0.23	82
351-7	8.94	409	9	23	1021	10.6	367	0.90	68
351-8	8.6	412	8	19	663	5.5	114	0.28	41
351-14	8.91	476	11	55	1314	6.9	259	0.54	67
351-27	7.27	263	12	22	670	5.3	499	1.90	46
351-30	8.23	332	8	19	652	6.7	156	0.47	79
352-16	9.66	442	10	10	184	2.3	367	0.83	85
352-29	9.84	544	13	37	573	7.1	253	0.47	71
352-33	8.7	417	14	30	608	5.4	235	0.56	58
376-1	8.64	271	27	17	667	4.2	1516	5.59	30
376-3	7.95	537	3	29	1274	5	89	0.17	60
376-7	9.3	609	2	71	1215	15.3	14	0.02	66
376-12	9.04	415	3	43	646	6.1	101	0.24	53
378-01	9.3	230	45	85	1000	10	500	2.17	32
378-2	9.18	544	14	74	1225	3.4	388	0.71	84
378-6	9.55	424	25	79	2822	7.0	918	2.17	55
379-03	10	710	5	35	2000	10	200	0.28	60
379-3		5	26		18.6	88		50	
379-04	9.4	610	5	30	1900	10	150	0.25	48
379-05	10.3	560	10	40	2300	10	390	0.70	50
379-06	9.6	460	15	40	2200	10	100	0.22	50
379-08	10.4	630	20	50	2400	10	400	0.63	44
379-8		10	41		25.9	643		57	
379-10	7.8	365	15	40	2000	10	440	1.21	46
379-12	8.76	504	17	37	2869	7.3	480	0.95	79
379-17	8.17	321	10	63	426	24.3	747	2.33	44
379-19	8.81	562	6	35	3236	13.6	341	0.61	82
379-21	8.69	362	14	28	894	11	921	2.54	52
379-24	9.6	362	10	23	1392	2.6	727	2.01	63
379-27	9.49	536	5	47	1615	7.7	345	0.64	57
379-29	8.89	602	5	43	1991	12.6	210	0.35	41
380-1	8.59	309	13	19	941	5.9	653	2.11	62
380-7	9	415	7	34	1053	6.8	542	1.31	46
380-8	9.64	540	9	59	2188	12.3	192	0.36	63
380-10	8.65	263	23	15	581	4.2	666	2.53	29

APPENDIX II. (cont.)

SAMPLE	K2O	Rb	Sr	Li	F	Be	Ba	Ba/Rb	Ga
380-11	9.78	315	14	20	1364	3.7	495	1.57	58
381-1	8.21	1162	12	17	585	5.8	134	0.12	89
381-5	8.45	362	49	18	345	3.2	1056	2.92	33
381-7	8.85	331	23	18	264	2.9	563	1.70	14
381-12	7.72	319	4	18	244	1.1	676	2.12	47
408-1	9.25	1152	6	56	3828	5.1	77	0.07	86
408-4	8.6	1274	6	87	4505	6.8	45	0.04	109
408-6	8.78	1476	4	61	3509	10.1	48	0.03	96
409-1	8.65	749	<1	113	4098	12.5	124	0.17	119
409-7	8.71	760	<1	58	2672	8.7	212	0.28	100
409-9	5.9	IS	16	53	IS	8.4	200		58
409-12	8.34	279	17	22	1223	6.9	690	2.47	65
409-14	8.88	341	22	19	1039	5.9	1212	3.55	57
409-19	8.74	871	3	100	4079	17.7	58	0.07	89
409-22	8.67	317	14	18	826	5	673	2.12	53
409-25	7.94	475	1	22	1606	6.4	107	0.23	77
409-28	6.4	347	9	27	1375	2.1	278	0.80	56
409-30	9.5	463	13	24	3088	4.9	761	1.64	66
409-32	8.66	500	5	50	1385	4.4	150	0.30	87
409-33	8.15	1234	<1	330	7076	22.1	103	0.08	115
409-37		8	42	IS	16	131		75	
410-1	8.9	750	<1	38	1353	11.9	103	0.14	96
410-13	9.38	545	1	32	1839	11.7	274	0.50	66
410-16	7.8	277	11	16	643	1.9	612	2.21	58
410-17	9.33	649	<1	35	2472	15	167	0.26	69
410-22	9.15	533	5	22	1258	10	111	0.21	69
410-26	9.02	388	6	16	808	3.9	331	0.85	70
410-30	8.57	512	8	13	522	24.6	329	0.64	50
410-32	8.03	381	15	22	1643	19	875	2.30	42
410-33	9.2	607	5	26	1970	19	202	0.33	104
410-35	9.34	625	3	72	2960	10.2	46	0.07	69
410-39	9.89	256	10	26	651	6.5	892	3.48	43
410-41	8.6	513	10	17	1210	9.1	537	1.05	34
411-2	8.99	71	4	19	927	11.1	292	0.79	58
411-8	9.09	412	9	25	1201	4.7	718	1.74	78
411-12	9.62	395	4	32	1015	16.9	149	0.38	45
411-13	9.95	523	<1	45	1560	12.1	223	0.43	41
411-15	9.92	746	3	31	675	8.5	55	0.07	70
411-17	9.89	363	5	32	1340	10.6	208	0.57	51
437-1	8.7	589	3	43	1086	10.5	106	0.18	71
438-1	7.76	384	7	34	820	9.2	510	1.33	60
438-3	10.36	261	27	15	1110	9.7	1215	4.66	39
438-7	9.97	261	10	9	765	7.7	734	2.81	33
439-1	8.78	458	7	53	1349	5.2	364	0.79	82
439-7	9.31	371	10	17	624	4.8	533	1.44	66
439-10	9.54	595	<1	25	911	18.3	150	0.25	73
439-13	8.47	352	12	38	755	5.2	518	1.47	68
439-16	9.33	412	18	34	948	3	410	1.00	75
439-20	9.53	562	3	24	1458	5.7	154	0.27	83
439-23	8.72	360	10	25	1169	7	482	1.34	48

APPENDIX II. (cont.)

SAMPLE	K2O	Rb	Sr	Li	F	Be	Ba	Ba/Rb	Ga
439-27	9.46	353	5	19	785	7	165	0.47	54
439-34	9.15	427	4	17	1790	12.7	104	0.24	54
439-35	9.53	413	5	33	789	3	398	0.96	72
439-38	9.03	370	6	17	711	7.3	710	1.92	56
439-45	9.44	399	7	22	804	2.1	654	1.64	66
439-48	10.1	586	10	33	1828	8.5	156	0.27	85
439-52	9.9	842	5	25	840	14.4	58	0.07	77
439-57	9.8	392	<1	29	910	3.3	244	0.62	36
439-65	8.75	464	<1	14	736	14.7	203	0.44	37
439-66	8.95	390	<1	20	855	7	283	0.73	33
440-1	10.3	306	11	19	628	1.7	924	3.02	47
440-5	9.58	292	12	17	590	2.5	1456	4.99	56
440-6	9.01	324	17	24	1207	4.6	581	1.79	56
440-9	9.73	370	11	21	891	2.2	416	1.12	72
440-19	9.84	446	16	26	779	4.5	410	0.92	87
440-22	9.05	346	10	9	1121	21.2	568	1.64	35
440-25	7.3	503	7	42	1422	10.7	156	0.31	69
440-28	9	317	12	23	671	3.2	778	2.45	63
440-29	9.16	379	11	18	514	3.1	710	1.87	59
440-30	8.4	369	7	15	617	10.2	199	0.54	59
440-32	8.62	448	4	27	864	6.5	206	0.46	73
440-35	8.88	308	8	30	647	4.8	462	1.50	54
440-42	9.3	300	<1	21	812	4.6	1024	3.41	33
440-43	9.05	611	<1	11	1131	22.7	42	0.07	24
440-48	9.1	415	22	18	528	266.5	113	0.27	30
441-3	8.35	IS	15	21	752	7.9	446		51

APPENDIX II. (cont.)

SAMPLE	Sn	Ce	Ta	Nb	Ta/Ta+Nb	Rb/K2O	Rb/Sr	K/Rb
348-1	36		251	22	0.92	61.65	28.10	134.61
349-1	57	15	51	29	0.64	23.72	17.73	349.82
349-3	23	<5	<1	36	0.01	73.23	136.20	113.33
349-5	37	<5	<1	46	0.01	73.25	118.67	113.29
349-6	34	9	<1	41	0.01	65.34	60.90	127.00
349-8	<20	14	<1	30	0.02	29.77	20.73	278.81
349-11	42	10	14	74	0.16	114.36	133.14	72.57
349-13	53		201	32	0.86	77.93	137.00	106.49
349-17	37		161	22	0.88	57.49	79.33	144.36
349-19	28		91	21	0.81	56.50	107.80	146.88
349-21	46		131	13	0.91	40.00	68.00	207.47
351-1	<20	65	<1	95	0.01	44.38	72.33	187.01
351-5	32	23	55	54	0.50	75.13	54.36	110.47
351-7	<20	29	20	49	0.29	45.75	45.44	181.40
351-8	<20	30	<1	42	0.01	47.91	51.50	173.23
351-14	<20		2.5	38	0.06	53.42	43.27	155.34
351-27	<20		23	30	0.43	36.18	21.92	229.40
351-30	<20		2.5	68	0.04	40.34	41.50	205.72
352-16	<20	<5	<1	29	0.02	45.76	44.20	181.37
352-29	<20	109	14	117	0.11	55.28	41.85	150.11
352-33	<20	74	49	77	0.39	47.93	29.79	173.14
376-1	10		120	2.5	0.98	31.37	10.04	264.58
376-3	32		169	65	0.72	67.55	179.00	122.86
376-7	78		125	70	0.64	65.48	304.50	126.73
376-12	113		114	53	0.68	45.91	138.33	180.77
378-01	1		10		1	24.73	5.11	335.56
378-2	<20	19	59	82	0.42	59.26	38.86	140.04
378-6	<20	39	2.5	77	0.03	44.40	16.96	186.92
379-03	1		10		1	71.00	142.00	116.88
379-3	<20	81	<1	73	0.01			
379-04	1		10		1	64.89	122.00	127.88
379-05	1		10		1	54.37	56.00	152.64
379-06	1		10		1	47.92	30.67	173.19
379-08	1		10		1	60.58	31.50	137.00
379-8	<20	87	<1	51	0.01			
379-10	1		10		1	46.79	24.33	177.34
379-12	<20	91	16	109	0.13	57.53	29.65	144.24
379-17	<20	70	121	74	0.62	39.29	32.10	211.22
379-19	<20	73	<1	112	0.00	63.79	93.67	130.09
379-21	<20	132	<1	45	0.01	41.66	25.86	199.22
379-24	<20	42	<1	31	0.02	37.71	36.20	220.08
379-27	<20	8	<1	30	0.02	56.48	107.20	146.93
379-29	<20	16	<1	20	0.02	67.72	120.40	122.55
380-1	<20	57	11	52	0.17	35.97	23.77	230.70
380-7	<20	14	<1	19	0.03	46.11	59.29	179.97
380-8	<20	11	<1	22	0.02	56.02	60	148.15
380-10	<20	39	2.5	36	0.06	30.40	11.43	272.94
380-11	10		138	9	0.94	32.21	22.50	257.66
381-1	<20	60	62	334	0.16	141.53	96.83	58.63
381-5	<20	183	6	44	0.12	42.84	7.39	193.71

APPENDIX II. (cont.)

SAMPLE	Sn	Ce	Ta	Nb	Ta/Ta+Nb	Rb/K2O	Rb/Sr	K/Rb
381-7	<20	22	2.5	22	0.10	37.40	14.39	221.89
381-12	<20	44	30	37	0.06	41.32	79.75	200.84
408-1	206	19	<1	27	0.02	124.54	192	66.63
408-4	253	12	1	26	0.04	148.14	212.33	56.02
408-6	265	12	<1	133	0.00	168.11	369	49.37
409-1	<20	62	76	139	0.35	86.59	1498	95.84
409-7	<20	72	25	129	0.16	87.26	1520	95.11
409-9	<20	138	<1	76	0.01			
409-12	<20	126	<1	49	0.01	33.45	16.41	248.07
409-14	<20	48	138	61	0.69	38.40	15.50	216.11
409-19	30	34	189	102	0.65	99.66	290.33	83.27
409-22	<20	126	<1	43	0.01	36.56	22.64	226.97
409-25	<20	68	136	150	0.48	59.82	475	138.72
409-28	<20	100	<1	46	0.01	54.22	38.56	153.06
409-30	<20	118	<1	55	0.01	48.74	35.62	170.28
409-32	57	23	48	55	0.47	57.74	100	143.73
409-33	34	74	<1	144	0.00	151.41	2468	54.81
409-37	<20	87	12	81	0.13			
410-1	<20	71	114	105	0.52	84.27	1500	98.48
410-13	<20	67	<1	73	0.01	58.10	545	142.83
410-16	56	9	<1	38	0.01	35.51	25.18	233.68
410-17	<20	79	<1	97	0.01	69.56	1298	119.30
410-22	<20	71	<1	52	0.01	58.25	106.6	142.46
410-26	<20	65	27	52	0.34	43.02	64.67	192.92
410-30	<20	33	32	56	0.36	59.74	64	138.91
410-32	<20	43	<1	30	0.02	47.45	25.4	174.91
410-33	<20	37	53	238	0.18	65.98	121.4	125.78
410-35	<20	<5	<1	73	0.01	66.92	208.33	124.02
410-39	<20	26	20	29	0.41	25.88	25.6	320.60
410-41	46	<5	<1	31	0.02	59.65	51.3	139.12
411-2	<20	66	11	57	0.16	41.27	92.75	201.09
411-8	<20	62	<1	47	0.01	45.32	45.78	183.10
411-12	<20	<5	<1	38	0.01	41.06	98.75	202.11
411-13	<20	44	2.5	37	0.06	52.56	1046	157.88
411-15	28		139	123	0.53	75.20	248.67	110.35
411-17	10		140	39	0.78	36.70	72.60	226.10
437-1	66	13	18	58	0.24	67.70	196.33	122.58
438-1	<20	18	<1	21	0.02	49.48	54.86	167.70
438-3	10		110	16	0.87	25.19	9.67	329.41
438-7	10		139	10	0.93	26.18	26.10	317.01
439-1	<20	59	36	61	0.37	52.16	65.43	159.09
439-7	<20	76	<1	53	0.01	39.85	37.10	208.25
439-10	<20	67	11	79	0.12	62.37	1190	133.06
439-13	<20	74	22	58	0.28	41.56	29.33	199.69
439-16	<20	120	<1	51	0.01	44.16	22.89	187.93
439-20	<20	54	<1	174	0.00	58.97	187.33	140.72
439-23	<20	44	8	69	0.10	41.28	36	201.01
439-27	<20	5	<1	39	0.01	37.32	70.60	222.40
439-34	<20	8	<1	69	0.01	46.67	106.75	177.83
439-35	<20	19	<1	42	0.01	43.34	82.60	191.49

APPENDIX II. (cont.)

SAMPLE	Sn	Ce	Ta	Nb	Ta/Ta+Nb	Rb/K2O	Rb/Sr	K/Rb
439-38	<20	<5	28	30	0.48	40.97	61.67	202.53
439-45	<20	16	10	42	0.19	42.27	57	196.34
439-48	<20	55	25	70	0.26	58.02	58.60	143.03
439-52	<20	78	15	132	0.10	85.05	168.40	97.57
439-57	<20	35	31	38	0.06	40.00	784.00	207.47
439-65	24	28	96	65	0.04	53.03	928.00	156.50
439-66	<20	28	30	38	0.06	43.58	780.00	190.45
440-1	<20	<5	8	38	0.17	29.71	27.82	279.34
440-5	<20	53	54	64	0.46	30.48	24.33	272.27
440-6	<20	66	66	46	0.59	35.96	19.06	230.78
440-9	<20	44	37	48	0.44	38.03	33.64	218.23
440-19	<20	59	<1	63	0.01	45.33	27.88	183.09
440-22	<20	60	11	38	0.22	38.23	34.60	217.06
440-25	<20	33	43	64	0.40	68.90	71.86	120.44
440-28	<20	23	<1	52	0.01	35.22	26.42	235.61
440-29	<20	37	<1	46	0.01	41.38	34.45	200.57
440-30	<20	57	54	61	0.47	43.93	52.71	188.91
440-32	<20	25	105	88	0.54	51.97	112	159.68
440-35	<20	17	34	50	0.40	34.68	38.50	239.26
440-42	<20	47	15	35	0.07	32.26	600	257.26
440-43	49	38	26	89	0.03	67.51	1222	122.92
440-48	<20	24	2.5	51	0.26	45.60	18.86	181.97
441-3	<20	56	44	51	0.46			

APPENDIX II. (cont.)

SAMPLE	Cu	Pb	Zn	Mo	Ni	Co	Cr	As
348-11	6	50	41	65	23	2.3	39	227
349-1	23	20	48	12	11	6	104	30
349-3	10	22	42	3	6	3	23	45
349-5	37	16	74	5	10	3	59	8
349-6	15	22	48	1	8	8	35	11
349-8	145	56	52	14	10	24	112	2.5
349-11	15	11	54	7	15	2	61	2.5
349-13	4	1	26	8	5	1	50	46
349-17	9	1	41	3	17	1	42	15
349-19	2	1	14	<1	3	1	21	7
349-21	5	1	23	1	6	1	52	7
351-1	<1	8	53	<1	<1	<1	19	2.5
351-5	7	14	86	<1	9	9	52	2.5
351-7	6	24	84	2	8	4	98	2.5
351-8	11	9	54	6	10	7	69	45
351-14	15	14	50	18	16	3	42	17
351-27	14	10	69	1	13	2	113	38
351-30	9	13	58	4	11	3	87	14
352-16	10	18	54	3	13	4	46	19
352-29	19	2	49	4	8	<1	20	11
352-33	25	4	54	2	11	6	50	2.5
376-1	5	1	4	<1	5	1	39	11
376-3	11	1	15	<1	4	1	83	2.5
376-7	<1	1	32	<1	2	1	20	2.5
376-12	11	1	4	<1	2	1	56	19
378-01			10					
378-2	13	5	38	7	8	3	80	37
378-6	7	2	72	2	6	<1	30	30
379-03			25					
379-3	16	34	122	4	4	<1	3	53
379-04			45					
379-05			25					
379-06			35					
379-08			25					
379-8	12	35	74	3	8	4	14	17
379-10			20					
379-12	19	12	85	8	6	6	60	2.5
379-17	<1	21	48	<1	<1	3	37	2.5
379-19	<1	16	105	<1	<1	6	37	12
379-21	16	19	57	5	6	3	40	14
379-24	24	19	57	3	6	3	113	19
379-27	6	19	57	<1	5	5	47	2.5
379-29	6	20	101	2	5	4	27	2.5
380-1	<1	10	52	<1	<1	6	78	7
380-7	11	21	56	3	11	4	72	2.5
380-8	8	18	63	7	5	3	19	2.5
380-10	6	1	32	<1	5	2	57	57
380-11	2	1	17	<1	5	1	36	2.5
381-1	<1	10	77	<1	<1	3	26	2.5

APPENDIX II. (cont.)

SAMPLE	Cu	Pb	Zn	Mo	Ni	Co	Cr	As
381-5	18	3	62	5	6	6	44	10
381-7	<1	1	29	<1	1	5	25	25
381-12	11	1	29	<1	2	5	90	90
408-1	7	27	169	3	4	1	13	2.5
408-4	8	23	178	3	10	<1	26	2.5
408-6	6	23	155	2	3	<1	18	2.5
409-1	<1	10	79	<1	<1	1	22	2.5
409-7	<1	12	54	<1	<1	1	19	6
409-9	41	27	112	42	27	5	823	26
409-12	19	27	69	6	12	5	56	2.5
409-14	<1	23	55	<1	<1	<1	52	2.5
409-19	6	12	179	<1	6	6	115	<1
409-22	15	15	36	5	10	4	56	21
409-25	9	11	43	<1	<1	<1	86	2.5
409-28	19	22	46	11	14	4	175	2.5
409-30	16	28	61	4	13	8	65	2.5
409-32	8	28	48	6	7	6	145	<1
409-33	<1	3	226	<1	<1	3	37	2.5
409-37	19	23	70	26	18	4	481	8
410-1	<1	10	66	<1	<1	4	44	16
410-13	<1	8	72	<1	<1	3	28	2.5
410-16	5	2	33	<1	6	5	132	<1
410-17	<1	19	149	<1	<1	5	35	2.5
410-22	13	30	90	<1	5	1	7	2
410-26	<1	15	46	<1	<1	2	21	2.5
410-30	7	20	154	1	7	3	16	2.5
410-32	8	27	59	3	8	12	62	2.5
410-39	20	20	78	1	8	2	75	12
410-41	8	22	46	1	5	<1	37	2.5
411-2	7	16	56	<1	18	52	48	2.5
411-8	<1	11	40	<1	<1	3	60	2.5
411-12	13	15	68	<1	4	4	57	2.5
411-13	<1	1	47	<1	<1	3	14	14
411-15	5	1	9	<1	5	1	106	7
411-17	3	1	33	<1	6	1	23	2.5
437-1	12	2	67	4	5	<1	65	37
438-1	8	9	42	2	10	1	84	2.5
438-3	4	1	17	<1	4	1	36	23
438-7	<1	1	20	<1	2	1	24	2.5
439-1	<1	10	55	<1	<1	1	50	2.5
439-7	<1	1	33	<1	<1	2	29	2.5
439-10	<1	1	85	<1	<1	2	12	2.5
439-13	<1	1	44	<1	<1	3	86	2.5
439-16	12	25	51	<1	8	5	16	29
439-20	<1	11	30	<1	<1	<1	1	2.5
439-23	2	13	49	<1	<1	<1	73	2.5
439-27	21	20	188	<1	12	6	65	2.5
439-34	11	25	39	<1	3	<1	43	15
439-35	10	7	37	3	2	<1	23	2.5
439-38	11	1	33	4	4	<1	67	2.5

APPENDIX II. (cont.)

SAMPLE	Cu	Pb	Zn	Mo	Ni	Co	Cr	As
439-45	10	1	47	2	2	<1	28	2.5
439-48	22	1	92	<1	6	4	38	15
439-52	19	20	56	<1	2	<1	22	13
439-57	<1	1	66	<1	<1	<1	52	52
439-65	<1	1	59	<1	<1	<1	52	52
439-66	<1	1	36	<1	<1	<1	18	18
440-1	3	10	36	4	4	5	38	<1
440-5	<1	4	34	<1	<1	2	61	2.5
440-6	3	8	60	<1	<1	4	85	2.5
440-9	<1	1	33	<1	<1	<1	6	17
440-19	<1	8	23	<1	<1	<1	17	2.5
440-22	<1	17	53	<1	<1	3	31	15
440-25	5	13	165	3	3	2	131	2.5
440-28	5	10	50	4	6	4	54	2.5
440-29	6	13	40	4	5	5	34	2.5
440-30	6	22	63	3	7	3	106	2.5
440-32	14	7	62	2	6	3	51	43
440-35	13	3	58	3	10	6	40	2.5
440-42	<1	1	46	<1	<1	<1	51	51
440-43	<1	1	158	<1	<1	<1	40	40
440-48	24	20	102	17	18	6	40	40
441-3	13	32	69	12	12	9	376	2.5

APPENDIX II. (cont.)

SAMPLE	V	La	Zr	Y	Sc	Cd	Bi
348-1	20	37	2.5	2.3	2.5		
349-1	22	12	20	8	<1	<1	2.5
349-3	16	2	4	6	22	<1	2.5
349-5	8	3	6	4	<1	<1	2.5
349-6	21	3	8	<1	<1	<1	2.5
349-8	174	1	25	6	44	<1	2.5
349-11	17	5	13	4	2	2	6
349-13	4	2.5	2.5			1	2.5
349-17	43	2.5	2.5			1	2.5
349-19	6	2.5	2.5			1	2.5
349-21	14	2.5	2.5			1	2.5
351-1	24	<1	60	<1	36	<1	2.5
351-5	21	2	26	7	<1	<1	2.5
351-7	60	<1	17	4	<1	<1	2.5
351-8	57	4	6	8		<1	2.5
351-14	52	11	2.5	2.5		2.5	7
351-27	112	7	13	2.5		0.25	5
351-30	39	8	34	2.5		0.25	2.5
352-16	33	2	<1	7	<1	<1	2.5
352-29	86	<1	29	7	57	<1	2.5
352-33	55	1	17	3	70	<1	2.5
376-1	114	2.5	2.5			1	2.5
376-3	41	2.5	2.5			1	2.5
376-7	22	2.5	2.5			1	2.5
376-12	40	2.5	2.5			1	2.5
378-01							
378-2	89	<1	5	<1	17	<1	2.5
378-6	148	2.5	2.5	2.5	50	0.25	2.5
379-03							
379-3	4	<1	28	2	<1	<1	2.5
379-04							
379-05							
379-06							
379-08							
379-8	79	3	130	5	43	<1	2.5
379-10							
379-12	46	7	57	4	<1	<1	2.5
379-17	11	<1	64	<1	<1	<1	14
379-19	8	<1	69	1	<1	<1	9
379-21	23	4	17	6	<1	<1	2.5
379-24	146	10	<1	5	22	<1	2.5
379-27	58	<1	<1	9		<1	2.5
379-29	17	2	1	2		<1	2.5
380-1	22	<1	61	2	35	<1	2.5
380-7	178	3	4	5		<1	2.5
380-8	39	4	<1	5		<1	2.5
380-10	79	2.5	23	2.5	24	0.25	2.5
380-11	52	2.5	2.5			1	2.5
381-1	49	<1	55	2	92	<1	14
381-5	47	2	19	8	32	<1	6

APPENDIX II. (cont.)

SAMPLE	V	La	Zr	Y	Sc	Cd	Bi
381-7	63	2.5	6	2.5	25	0.25	2.5
381-12	186	2.5	23	2.5	68	0.25	2.5
408-1	17	5	6	9		<1	2.5
408-4	17	4	<1	6		<1	10
408-6	17	<1	<1	2		<1	2.5
409-1	<1	<1	55	1	21	<1	2.5
409-7	13	<1	55	1	9	<1	14
409-9	48	36	58	15	7	<1	2.5
409-12	33	2	29	3	16	<1	2.5
409-14	14	<1	55	<1	<1	<1	23
409-19	26	2	30	1	<1	<1	24
409-22	113	3	25	2	32	<1	2.5
409-25	22	<1	58	<1	<1	<1	2.5
409-28	135	13	35	9	65	<1	2.5
409-30	108	<1	13	3	55	1	2.5
409-32	38	1	31	<1	<1	<1	8
409-33	<1	<1	68	3	<1	<1	13
409-37	22	5	40	5	1	<1	2.5
410-1	9	<1	64	<1	<1	<1	13
410-13	6	<1	64	6	<1	<1	2.5
410-16	102	2	12	<1	<1	5	2.5
410-17	<1	<1	65	2	<1	<1	9
410-22	4	<1	34	<1	<1	<1	2.5
410-26	<1	<1	66	<1	<1	<1	2.5
410-30	22	<1	22	4	<1	<1	2.5
410-32	57	6	29	5	<1	<1	2.5
410-33	28	<1	62	7	<1	<1	2.5
410-35	6	1	7	3	9	<1	2.5
410-39	65	1	2	1	16	<1	2.5
410-41	17	2	2	3		<1	6
411-2	<1	<1	65	1	<1	<1	10
411-8	69	<1	51	<1	3	<1	7
411-12	14	<1	11	<1	21	<1	2.5
411-13	21	2.5	11	2.5	23	0.25	2.5
411-15	17	2.5	2.5			1	2.5
411-17	29	2.5	2.5			1	2.5
437-1	12	<1	16	<1	<1	<1	2.5
438-1	80	6	8	7		<1	2.5
438-3	79	2.5	2.5			1	2.5
438-7	7	2.5	2.5			1	2.5
439-1	11	<1	57	2	<1	<1	6
439-7	34	<1	58	<1	17	<1	13
439-10	<1	<1	65	<1	<1	<1	2.5
439-13	22	<1	73	6	6	<1	9
439-16	8	<1	36	<1	27	<1	2.5
439-20	7	<1	202	<1	<1	<1	8
439-23	14	<1	88	4	<1	<1	18
439-27	13	1	5	<1	28	<1	2.5
439-34	20	4	14	3	16	<1	2.5
439-35	58	<1	<1	5	<1	<1	2.5

APPENDIX II. (cont.)

SAMPLE	V	La	Zr	Y	Sc	Cd	Bi
439-38	61	<1	4	3	<1	<1	2.5
439-45	68	<1	<1	2	6	1	2.5
439-48	12	2	5	2	45	<1	6
439-52	14	2	26	9	46	<1	10
439-57	1	2.5	2.5	2.5	25	0.25	2.5
439-65	10	2.5	16	2.5	22	0.25	2.5
439-66	1	2.5	2.5	2.5	20	0.25	2.5
440-1	26	<1	22	<1	<1	<1	14
440-5	126	<1	59	<1	<1	<1	16
440-6	35	<1	66	1	29	<1	7
440-9	20	<1	25	<1	28	<1	8
440-19	21	<1	107	2	13	<1	20
440-22	<1	<1	64	<1	<1	<1	2.5
440-25	35	2	23	3	<1	<1	2.5
440-28	79	<1	14	2	5	<1	8
440-29	101	<1	12	3	<1	<1	2.5
440-30	30	5	32	6	<1	<1	2.5
440-32	53	<1	6	<1	<1	2	2.5
440-35	110	<1	<1	<1	8	2	2.5
440-42	79	2.5	2.5	2.5	37	0.25	2.5
440-43	1	2.5	2.5	2.5	23	0.25	2.5
440-48	20	18	23	2.5	5	4.2	2.5
441-3	48	5	27	10	<1	<1	2.5

APPENDIX III.

FELDSPAR GEOCHEMISTRY

SAMPLE	K2O	SiO2	CaO	Na2O	Al2O3	Fe2O3	LOI	MgO	MnO	P2O5	TiO2
351-10	12.3	66.2	0.07	1.25	16.9	0.36	0.82	0.06	0.005	1.25	0.03
351-12	9.54	69.6	0.01	0.32	15.8	0.98	2.68	0.06	0.005	0.03	0.12
351-16	13.6	63.2	0.09	1.14	17.7	0.3	1.47	0.02	0.005	0.76	0.03
351-19	14.2	64.4	0.06	0.57	16.7	0.44	1.06	0.01	0.005	0.71	0.04
352-31	13	65.2	0.03	0.63	17.5	0.33	1.48	0.03	0.005	0.18	0.04
379-01	11.1	68.2	0.029	0.66							
379-02	11.3	69	0.028	0.75							
379-09	6.9	48.2	0.53	2.7							
379-11	0.8	64.8	4.3	8							
379-14	15	63.9	0.04	0.89	17.4	0.33	0.6	0.01	0.005	0.24	0.04
379-30	5.33	70.6	0.97	2.79	14.4	1.83	1.73	0.49	0.02	0.18	0.37
380-6	8.99	58.1	0.05	0.56	25.1	0.14	6.67	0.01	0.005	0.16	0.01
381-2	11.6	66	0.24	2.34	18	0.2	0.69	0.01	0.005	0.1	0.01
408-5	1.33	47.2	0.07	0.06	34.6	2.92	13.12	0.16	0.02	0.18	0.4
408-8	0.68	47.1	0.09	0.07	35.3	0.75	13.81	0.08	0.03	0.15	0.11
409-6	5.02	66.5	1.1	6.68	19.1	0.19	0.39	0.01	0.005	0.13	0.01
409-17	7.03		0.51	5.84							
409-34	10.3	66.1	0.45	3.02	18.5	0.37	0.43	0.05	0.04	0.15	0.04
410-5	12.6	63.8	0.03	2.06	19.2	0.26	0.85	0.02	0.005	0.13	0.03
410-10	11	65.7	0.22	3.25	18.1	0.24	0.2	0.02	0.005	0.14	0.03
410-20	11.3	65.3	0.08	1.28	18	0.27	1.57	0.05	0.02	0.18	0.02
410-25	0.59	65	1.49	7.27	21.1	0.23	3.01	0.02	0.005	0.48	0.005
410-34	12.5	65.5	0.04	1.52	17.7	0.23	0.99	0.02	0.005	0.23	0.02
410-36	9.37		0.005	0.36	22.1	0.3	5.63	0.03	0.02	0.15	0.03
411-1	12	63.7	0.01	0.69	19.4	0.16	2.05	0.005	0.005	0.23	0.02
439-4	9.52	72.9	0.01	0.54	13.2	0.55	1.05	0.005	0.005	0.24	0.01
439-24	13	64	0.04	1.04	19	0.44	1.41	0.03	0.005	0.11	0.04
439-44	5.09	70.9	0.09	0.36	16.3	0.43	4.8	0.07	0.02	0.22	0.05
439-54	10.2	67.2	0.26	3.06	17.2	0.2	0.3	0.02	0.005	0.14	0.01
439-58	9.4	66	0.3	2.05	15.6	6	0.53	0.03	0.005	0.24	0.02
439-60	11.7	64	0.04	0.99	15.3	6.53	0.73	0.02	0.005	0.32	0.03
439-61	11.4	65	0.06	1.51	15	6	0.62	0.02	0.005	0.33	0.01
439-68	0.88	57.2	0.06	0.15	18.3	6.34	13.88	0.05	0.04	0.24	0.02
440-3	11.4	66.5	0.18	2	17.4	0.23	0.45	0.04	0.005	0.26	0.04
440-18	13.5	62.9	0.04	0.81	19	0.35	1.24	0.05	0.005	0.05	0.06
440-39	12.4	65.7	0.07	0.71	17.7	0.49	1.36	0.04	0.005	0.18	0.02
440-47	8	65.4	0.58	4.7	14.4	6.34	0.78	0.01	0.005	0.16	0.005
414-1	13.6		0.11	1.59							
441-1	10.7		0.19	2.35							
441-2	5.17		1	5.31							
441-4	3.25	72.2	0.74	5.81	15.1	0.54	0.59	0.05	0.03	0.2	0.03
468-1	5.24	71.7	0.07	0.35	16.6	0.48	4.69	0.03	0.01	0.11	0.05
472-1	5.54	60.7	0.92	4.79	15.2	0.29	0.29	0.04	0.005	0.03	0.01

SAMPLE	Rb	Sr	Li	F	Be	Ba	Ga	Sn	Ce	Ta
351-10	413	46	5	43	2.4	345	1	<20	<5	<1
351-12	192	343	4	48	1	2500	12	<20	417	<1
351-16	391	78	5	80	1.9	1446	16	<20		5
351-19	349	53	3	33	1.7	1055	20	<20		5
352-31	150	173	2	27	2.7	984	14	<20	124	16
379-01	360	135	5							
379-02	355	165	5							
379-09	410	65	30							
379-11	20	130	5							
379-14	499	191	3	63	1.5	1725	4	<20	116	23
379-30	380	79	18	652	2.4	617	22	<20	113	<1
380-6	181	179	5	90	1.2	1942	16	<20	179	9
381-2	682	191	<1	37	2	1981	17	<20	209	<1
408-5	156	15	15	331	4.5	83	31	20	22	<1
408-8	66	15	24	225	11.4	230	23	<20	14	<1
409-6	478	33	<1	76	19.8	192	22	<20	66	<1
409-17	395	40	5	62	13.8	86	1	<20		<1
409-34	890	39	2	66	6.8	320	15	<20	56	<1
410-5	767	56	4	53	3.5	498	22	<20	69	<1
410-10	550	53	2	38	5.2	239	14	<20	62	<1
410-20	529	56	2	50	3.5	437	13	<20	68	<1
410-25	13	66	15	64	1000	21	14	<20	13	<1
410-34	455	110	2	96	2.4	1016	19	<20	15	30
410-36	745	8	4	134	3.6	66	22	<20	<5	<1
411-1	322	138	<1	52	6.2	706	11	<20	63	<1
439-4	312	131	5	44	2.1	716	10	<20	110	<1
439-11	536	69	<1	37	3.1	490	10	<20	59	<1
439-24	343	232	1	54	1.5	1532	7	<20	154	<1
439-44	173	21	7	57	0.9	95	17	<20	24	58
439-54	386	49	4	45	4.5	135	12	<20	30	63
439-58	217	346	1	27	0.8	2000	5	<20	<5	5
439-60	279	443	1	23	0.25	2000	5	<20	<5	5
439-61	346	125	1	22	0.25	734	5	<20	<5	5
439-68	35	7	8	135	3.1	184	12	<20	80	5
440-3	218	256	<1	65	1.1	3800	7	<20	358	<1
440-18	296	360	2	42	1.4	1765	16	<20	92	<1
440-39	447	98	1	32	0.9	1120	13	<20	<5	95
440-47	366	45	5	33	9.7	127	5	<20	<5	97
414-1	199	448	2	10	1	2000	1	<20		34
441-1	277	363	<1	10	0.6	2000	1	46		<1
441-2	122	419	<1	41	1.5	1338	3	99		61
441-4	128	186	1	53	6.1	569	12	<20	<5	26
468-1	176	13	6	62	0.6	93	14	<20	<5	54
472-1	112	337	3	79	1.9	2000	10	<20	<5	<1

APPENDIX III. (cont.)

SAMPLE	Nb	Cu	Pb	Zn	Mo	Ni	Co	As	Cr	V
351-10	2	6	98	9	5	9	4	35	165	5
351-12	7	14	48	23	4	5	<1	36	114	12
351-16	5	5	92	6	5	5	2	34	68	4
351-19	<5	4	126	26	5	5	1	14	96	4
352-31	4	15	82	12	3	6	<1	<5	58	5
379-01										
379-02										
379-09										
379-11										
379-14	12	13	186	4	6	5	<1	<5	60	3
379-30	4	5	42	82	<1	7	6	<5	41	19
380-6	5	23	169	9	4	14	6	<5	42	1
381-2	5	14	105	3	6	7	<1	8	43	3
408-5	11	15	52	38	4	26	3	<5	44	39
408-8	40	16	214	53	2	20	9	9	37	8
409-6	5	14	51	7	6	5	<1	29	50	4
409-17	6	2	302	<1	<1	3	2	<1	133	1
409-34	6	12	92	2	7	6	2	44	45	2
410-5	7	12	143	1	3	5	<1	14	25	1
410-10	7	17	204	7	10	12	2	8	51	7
410-20	4	14	158	7	8	12	3	43	55	4
410-25	6	12	78	39	4	17	<1	<5	77	2
410-34	16	3	96	23	2	1	1	<5	58	2
410-36	9	10	147	13	<1	14	11	15	70	3
411-1	3	13	252	9	4	13	2	38	41	2
439-4	4	15	125	5	8	10	<1	38	130	8
439-11	3	12	128	3	3	7	<1	33	18	2
439-24	4	16	250	3	5	7	4	15	28	3
439-44	3	10	44	15	3	11	15	17	83	<1
439-54	4	10	272	6	5	3	<1	<5	75	<1
439-58	<5	<1	25	1	<1	<1	<1	<5	75	1
439-60	<5	<1	28	1	<1	<1	<1	17	74	1
439-61	<5	<1	56	1	<1	<1	<1	6	68	1
439-68	9	2	26	22	<1	47	38	64	20	1
440-3	3	11	152	2	5	7	<1	29	63	4
440-18	3	12	256	3	3	6	2	38	35	3
440-39	3	12	117	3	<1	2	<1	<5	92	3
440-47	5	21	248	20	19	19	5	45	98	19
414-1	4	3	61	<1	<1	4	<1	<1	120	1
441-1	4	2	51	1	<1	<1	3	<1	151	3
441-2	4	3	32	2	1	3	3	<1	145	3
441-4	9	4	58	10	3	3	<1	<5	192	7
468-1	1	10	47	16	<1	14	17	13	80	<1
472-1	6	6	31	21	1	2	<1	7	100	3

APPENDIX III. (cont.)

SAMPLE	Y	Sc	Cd	Bi	W	Sb	La	Zr
351-10	9		2	<5	5	<5	<1	5
351-12	5	40	<1	<5	5	6	28	11
351-16	<5		1.9	<5	10	9	<5	11
351-19	<5		0.8	<5	10	<5	<5	9
352-31	4	42	<1	13	5	24	5	11
379-01								
379-02								
379-09								
379-11								
379-14	6	<1	<1	<5	5	<5	21	7
379-30	14		<1	<5	5	<5	68	80
380-6	7	<1	2	<5	5	<5	41	6
381-2	2	<1	<1	<5	5	<5	2	20
408-5	<1		<1	<5	11	<5	15	8
408-8	15		<1	<5	5	<5	7	12
409-6	7	47	<1	<5	5	<5	3	16
409-17	<1	<1	2	7			<1	11
409-34	4	7	2	<5	5	<5	3	24
410-5	4	8	<1	<5	5	<5	2	17
410-10	6	15	<1	<5	5	<5	6	26
410-20	<1	3	<1	<5	5	<5	4	23
410-25	6	60	1	<5	5	<5	<1	11
410-34	<1	<1	<1	<5	5	6	1	16
410-36	2	13	<1	<5	5	<5	7	8
411-1	2	<1	<1	<5	5	<5	7	17
439-4	<1	40	<1	<5	5	<5	17	19
439-11	5	<1	1	<5	5	<5	2	18
439-24	<1	31	<1	<5	5	<5	3	22
439-44	<1	<1	<1	13	5	<5	13	21
439-54	4	48	<1	<5	5	14	<1	10
439-58	48	23	<0.5	<5	10	<5	<5	<5
439-60	<5	12	<0.5	<5	10	<5	<5	6
439-61	<5	22	<0.5	<5	10	<5	<5	5
439-68	16	5	<0.5	<5	10	<5	<5	36
440-3	2	15	1	<5	5	<5	3	14
440-18	1	<1	<1	<5	5	<5	4	15
440-39	<1	<1	2	6	5	<5	<1	11
440-47	<5	5	4.5	<5	10	<5	18	20
414-1	<1	<1	1	<5			1	14
441-1	<1	5	1	10			<1	31
441-2	4	<1	2	16			<1	23
441-4	3	<1	<1	<5	5	<5	<1	13
468-1	2	<1	2	<5	5	<5	6	21
472-1	2	32	<1	<5	5	<5	<1	10

SAMPLE	K	Ba/Rb	Rb/K2O	Rb/Sr	K/Rb
351-10	102075	0.84	33.58	8.98	247.15
351-12	79170	13.02	20.13	0.56	412.34
351-16	112863	3.70	28.75	5.01	288.65
351-19	117842	3.02	24.58	6.58	337.66
352-31	107884	6.56	11.54	0.87	719.23
379-01	92116		32.43	0.03	255.88
379-02	93776		31.42	0.03	264.16
379-09	57261		59.42	0.02	139.66
379-11	6639		25.00	0.04	331.95
379-14	124481	3.46	33.27	2.61	249.46
379-30	44232	1.62	71.29	4.81	116.40
380-6	74606	10.73	20.13	1.01	412.19
381-2	96266	2.90	58.79	3.57	141.15
408-5	11037	0.53	117.29	10.40	70.75
408-8	5643	3.48	97.06	4.40	85.50
409-6	41660	0.40	95.22	14.48	87.15
409-17	58340	0.22	56.19	9.88	147.70
409-34	85477	0.36	86.41	22.82	96.04
410-5	104564	0.65	60.87	13.70	136.33
410-10	91286	0.43	50.00	10.38	165.98
410-20	93776	0.83	46.81	9.45	177.27
410-25	4896	1.62	22.03	0.20	376.64
410-34	103734	2.23	36.40	4.14	227.99
410-36	77759	0.09	79.51	93.13	104.37
411-1	99585	2.19	26.83	2.33	309.27
439-4	79004	2.29	32.77	2.38	253.22
439-11	107884	0.91	41.23	7.77	201.28
439-24	107884	4.47	26.38	1.48	314.53
439-44	42241	0.55	33.99	8.24	244.17
439-54	84647	0.35	37.84	7.88	219.29
439-58	78008	9.22	23.09	0.63	359.49
439-60	97095	7.17	23.85	0.63	348.01
439-61	94606	2.12	30.35	2.77	273.43
439-68	7303	5.26	39.77	5.00	208.65
440-3	94606	17.43	19.12	0.85	433.97
440-18	112033	5.96	21.93	0.82	378.49
440-39	102905	2.51	36.05	4.56	230.21
440-47	66390	0.35	45.75	8.13	181.39
414-1	112863	10.05	14.63	0.44	567.15
441-1	88797	7.22	25.89	0.76	320.57
441-2	42905	10.97	23.60	0.29	351.68
441-4	26971	4.45	39.38	0.69	210.71
468-1	43485	0.53	33.59	13.54	247.08
472-1	45975	17.86	20.22	0.33	410.49

APPENDIX IV.

Analytical Parameters

Samples analyzed by Bondar-Clegg were by inductively coupled plasma spectroscopy, direct coupled plasma spectroscopy, atomic absorption spectroscopy, gravimetric analysis, x-ray fluorescence, and specific ion analysis.

ELEMENT		LOWER DETECTION LIMIT	EXTRACTION METHOD	ANALYSIS METHOD
Cu	Copper	1 ppm	MATD	ICP
Pb	Lead	2 ppm	MATD	ICP
Zn	Zinc	2 ppm	MATD	ICP
Mo	Molybdenum	2 ppm	MATD	ICP
Ni	Nickel	1 ppm	MATD	ICP
Co	Cobalt	1 ppm	MATD	ICP
Cd	Cadmium	2 ppm	MATD	ICP
Bi	Bismuth	5 ppm	MATD	ICP
As	Arsenic	5 ppm	MATD	ICP
Sb	Antimony	5 ppm	MATD	ICP
Te	Tellurium	10 ppm	MATD	ICP
Ba	Barium	5 ppm	MATD	ICP
Cr	Chromium	2 ppm	MATD	ICP
V	Vanadium	2 ppm	MATD	ICP
Sn	Tin	20 ppm	MATD	ICP
W	Tungsten	20 ppm	MATD	ICP
Li	Lithium	2 ppm	MATD	ICP
Be	Beryllium	0.5 ppm	MATD	AA
Ga	Gallium	10 ppm	MATD	ICP
La	Lanthanum	5 ppm	MATD	ICP
Ce	Cerium	0.5 ppm	NONE	INA
Ta	Tantalum	5 ppm	MATD	ICP
Sc	Scandium	0.2 ppm	MATD	INA
Nb	Niobium	5 ppm	MATD	ICP
Sr	Strontium	1 ppm	MATD	ICP
Y	Yttrium	5 ppm	MATD	ICP
Zr	Zirconium	5 ppm	MATD	ICP
F	Fluorine	20 ppm	KHF	SI
Rb	Rubidium	5 ppm	NONE	XRF
Al_2O_3	Alumina	0.01 %	MATD	DCP
CaO	Calcium Oxide	0.01 %	MATD	DCP
Fe_2O_3	Total Iron	0.01 %	MATD	DCP
K_2O	Potassium	0.01 %	MATD	DCP
LOI	Loss on Ignition	0.01 %	MATD	GRAVIMETRIC
MgO	Magnesium Oxide	0.01 %	MATD	DCP
Na_2O	Soda	0.01 %	MATD	DCP
P_2O_5	Phosphorous Oxide	0.01 %	MATD	DCP
SiO_2	Silica	0.01 %	MATD	DCP
TiO_2	Titanium Oxide	0.01 %	MATD	DCP
TOTAL	Whole Rock Total	0.01 %		
BaO	Barium Oxide	0.001 %	MATD	DCP
Cr_2O_3	Chromium Oxide	0.01 %	MATD	DCP

APPENDIX IV. (cont.)

EXPLANATION :

MATD = multi-acid total digestion
KHF = potassium hydroxide fusion
ICP = inductively coupled Argon plasma
SI = specific ion
XRF = x-ray fluorescence
DCP = direct coupled plasma
AA = atomic absorption

Samples analyzed by Skyline Labs, Inc. were by inductively coupled plasma spectroscopy.

ELEMENT		LOWER DETECTION LIMIT	EXTRACTION METHOD	ANALYSIS METHOD
Zn	Zinc	5 ppm	MATD	ICP
Ba	Barium	50 ppm	MATD	ICP
Li	Lithium	2 ppm	MATD	ICP
Be	Beryllium	2 ppm	MATD	ICP
Cs	Cesium	10 ppm	MATD	ICP
Ga	Gallium	10 ppm	MATD	ICP
Ta	Tantalum	5 ppm	MATD	ICP
Nb	Niobium	5 ppm	MATD	ICP
Sr	Strontium	1 ppm	MATD	ICP
Sn	Tin	2 ppm	MATD	ICP
F	Fluorine	100 ppm	KHF	ICP
Rb	Rubidium	5 ppm	NONE	XRF
CaO	Calcium Oxide	0.01 %	MATD	ICP
K_2O	Potassium	0.01 %	MATD	ICP
Na_2O	Soda	0.01 %	MATD	ICP
SiO_2	Silica	0.01 %	MATD	ICP
TiO_2	Titanium Oxide	0.01 %	MATD	ICP

EXPLANATION :

MATD = multi-acid total digestion
KHF = potassium hydroxide fusion
ICP = inductively coupled Argon plasma
SI = specific ion
XRF = x-ray fluorescence
AA = atomic absorption

APPENDIX V.

ATTITUDES OF PEGMATITES

Mine	Strike	Dip	Reference
UPSON COUNTY			
Adams mine	135	60 SW	1,2
Atwater mine	055	SE	1,2
	050		3
Barron mine	010	75 SE	1
	020 to 035		3
Bell	000		1
	040		1
Bentley prospects			
J.M. Bevell deposit			
Blount No.1 mine	160	65WSW	2
Boyt mine	NNW	WSW steep	2
L.M. Brooks prospect	090	40S	1,2
Brown mine	055	60 to 70 SE	1
Mica pit S of Brown mine	035		3
Carter mine	010	61 NW	1
	090	66 S	1
Colbert mine	015	75 SE	1,2
Corley mine			
Corley prospects	020	steep	2
S.P. Cronheim prospect	127	38 NE	1,2
Cumbie prospects	052		1,2
	124	50SW	1,2
Cunningham prospect			
W.M. Dallas prospects	041		1
Duke mine	005	SE steep	1,2
D.C. Ellerbee prospect	145		
B.S. Gibson prospects	040	78 NW	1,2
	090	66S	1,2
	055	85SE	1,2
Grace prospect	040		2
Herron mine	018	90	2
Johnson mine	095	70 to 80N	2
King and Thurston mine	030	ESE	1,2
Mauldin mine	016	73 SE	1
Mauldin Road prospect	045		2
Maze prospects	040	40SE	2
Helen McDonald prospect	110	NNE	1,2
Joe McKinley prospect	065		1,2
Cliff Middlebrooks deposit	052	83 NW	1,2
Mitchell Creek mine	070	20-30 SE	1
Short Mitchell mine	010		1
Charlie Nims mine	112		1,2
Nottingham prospects	080	39 SE	1,2
	035	67 SE	1,2
	040	SE	1
Kelly O'Neal prospects	NNW to NNE	W steep	2
	152	57 SW	1

APPENDIX V. (cont.)

Mine		Strike	Dip	Reference
		165	65W	2
		035	70SE	2
		050	SE	2
Partridge mine		050	70 NW	1,2
Pennyman mine				
Joe Persons mine		030	SE moderate	2
		070		2
T.J. Reeves prospect		140	90	1,2
Reynolds mine		125	SW	1,2
Stevens-Rock mine		040	90	1,2
		025	75 SE	1,2
	and	155	80 SW	1,2
Thompson prospect		170	77 NE	1
		005	75W	3
		008	80W	3
F.E. Thompson prospect		028	65 SE	1,2
Tomlin mine		015		2
Emmit Trice		056	NW steep	1,2
Triune Mills No.1 prospect				
Unnamed prospect		015	82E	2
Walker prospect		156	90	1,2,3
Watson mine		NE	SE mod. to steep	2
Wheeles mine		068	90	2,3
Young mine		090	N shallow	2
Zorn mine		060		2
439-35				
439-39		035		3
439-40		025	55E	3
Swift Creek mine 439-52				3
439-58		082		3
439-64		165	90	3
440-33		175	64E	3
		165		3
440-40		055		3
LAMAR COUNTY				
J.W. Brown deposit		040		3
Clay Cheek mine		038	90	2
Old Childs prospect		075		1,2
Coggins prospect		030	75 to 80 WNW	2
Howard mine			30N	2
Ingraham prospects		025		1,2
		055	90	1,2
Doc Irwin prospect		040		1,2
		060	75 SE	1,2
H.B. Manrey prospect				
Means prospect				
J.T. Means mine		020	75E	2
		010	35W	2

APPENDIX V. (cont.)

Mine	Strike	Dip	Reference
	00	52 NW	1
Perdue prospect	045	SE	1,2
Sugar Hill prospects			
Taylor prospect		60E	2
J.I. Taylor prospects	170		1,2
	150	45 SW	1,2
Thomas mine	020	45 SW	1,2
Early Vaughn mine	015	WNW steep	1,2
Williams and Holmes prospects	110		1
H.S. Worsham prospect	090	45N	1,2
349-16	112		3
349-19	050		3
379-12 to 16	045	65NW	3
379-17,18	030		3
379-30	007	20W	3
	007	25E	3
410-32	090		3
PIKE COUNTY			
348-1	010	90	3
376-1	025	90	3
376-3	120	90	3
TALBOT COUNTY			
438-7	065		3
MONROE COUNTY			
Battles mine	136	85 SW	1,3
Willie Bowdoin prospect	020	30 E	1,2
Brooks mine	105		3
E.B. Butler prospect	030	65 ESE	1,2
Calloway mine	090		2
Old Callaway prospect	125	70 NE	1,2
Chatfield mine			
O.B. Clements prospect			2
Coleman prospect	00 to 030	30 E to ESE	1,2
Cox prospect			
C.A. Ensign mine	030	45 to 50 ESE	1,2
380-7	070		3
Fletcher mine	00	45W	1,2
Rosa Fletcher prospect	131	90	1,2
E.J. Goggins propsect	155	75 ENE	1,2
L.P. Goodwin prospect	138	75 to 80 NE	1,2
Homer Hardin mine	040	64 SE	1,2
	150	75 NE	1
Haygood prospect	045		1,2
Holloway mine	045 to 070		2

APPENDIX V. (cont.)

Mine	Strike	Dip	Reference
Holmes mine	070	60-70 SE	1,2
New Ground mine	015	74 E	1,2
	00		
L.D. Owen prospect	085	45S	1,2
	025	45 SE	1
Owl Hollow prospect	010	70 E	1,2
Rev. Thaddeus Persons mine	125		1,2
	110		3
Persons northeast prospect	062	steep	1,2
	070		3
Persons west prospect			
Peters mine	160	90	2
Phinazee mines	150		1,2
	010	75 SE	1
A.T. Redding prospect	100		3
Ruffin prospects	122	90	1,2
Mattie Smith mine	008	75 to 80 SE	1,2
Wallker Smith mine	010	45 E	1,2
	020	60SE	3
C.M. Sutton prospects	159	90	1,2
Thurman mine	090		1
	010		3
	140		3
Marie Vaughn deposit	170		1,2
	154		1,2
Westbrooks prospect	120 to 140	SW to SSW	1,2
F.B. Willingham prospect	030	50 to 70 ESE	1,2
Worsham and Goodwin prospect	052	60 SE	1,2
Lassiter Rd. prospect	135	steep	3

Explanation:

Strikes are given in degrees azimuth
Dips are given in degrees (var = variable)
Reference

1 = Furcron and Teague (1943)
2 = Heinrich and others (1953)
3 = This investigation

APPENDIX VI.

ATTITUDES AND LITHOLOGIES OF COUNTRY ROCKS

Mine	Strike	Dip	Rock Type	Reference
UPSON COUNTY				
Adams mine	140	70 SW	garbgg	1,2
Atwater mine	070	var	bg,g	1,2
Bell	042	40 SE	bg	1
L.M. Brooks prospect	050	50-70 SE		1,2
Brown mine	055	60-70SE	bg	1
Mica pit S of Brown mine 439-6,7	143	57NE	bg	3
Cumbie prospects	055	50 SE	bg	1,2
W.M. Dallas prospects	080		garbag	1
	047	60 SE	ms	1
B.S. Gibson prospects	040	78 NW	bgg	1,2
	090	66 SE	s	1
King and Thurston mine	030	SE	bg	1,2
Mauldin mine	016	73 SE	bg	1
Cliff Middlebrooks deposit	070	20-30SE	garbg	1,2
Charlie Nims mine	090	30 N	bg,bs,g,s	1,2
Nottingham prospects	080	39 SE	bg	1,2
	040	65 SE	granbg	1
Kelly O'Neal prospects	070	50 SE	ms	1,2
	060	52 SW	bg	1
Reynolds mine			bgg	1,2
Stevens-Rock mine			garbgg	1,2
Thompson prospect	012	60 SE	ms	1
F.E. Thompson prospect			s	1,2
Tomlin mine			gbg	1,2
Walker prospect			baugg	1,2
439-39	055			3
LAMAR COUNTY				
H.B. Manrey prospect	026	90	bg,s,bag1	
J.T. Means mine	046	60 SE	gr,bg	1
J.I. Taylor prospects	090	90	grms	1,2
Thomas mine			grbg	1,2
Early Vaughn mine			garbg	1,2
Williams & Holmes prospects	030	70SE	grgarbg	1
H.S. Worsham prospect			ms	1,2
379-12 to 16	102	30NE	bg	3
379-17,18	010	60E	ss	3
379-29	073	80N	garbg	3
MONROE COUNTY				
Battle mine			bg,gr	1
Willie Bowdoin prospect			grbg	1,2
Brooks mine	160	50W	bg	3

APPENDIX VI. (cont.)

Mine	Strike	Dip	Rock Type	Reference
E.B. Butler prospect	030	65 SE	bg	1,2
Calloway mine			augg	1,2
Old Callaway prospect	125	70 NE		1,2
O.B. Clements prospect			grms	2
Coleman prospect	00-030	30 E,SE	bg	1,2
Cox prospect			bg	1
E.J. Goggins prospect	155	75 NE	s	1,2
Homer Hardin mine			s	1,2
Holmes mine			bg,gr	1,2
L.D. Owen prospect	025	45 SE	ms	1,2
Owl Hollow prospect			hg,gr	1,2
Rev. Thaddeus Persons mine	050	20-50 SE	bgrg	1,2
Persons northeast prospect	152	18 SW	bg	1,2
Ruffin prospects			bg	1,2
Mattie Smith mine	016	40 SE	ms	1,2
Walker Smith mine			gr?	1,2
C.M. Sutton prospects	040	51 SE	ms	1,2
Thurman mine	146	60 SW	bg,gr	1
Westbrooks prospect			ms	1,2
F.B. Willingham prospect	010	30-60 SE	bg	1,2
Worsham &Goodwin prospect	065	80 SE		1,2
PIKE COUNTY				
352-32	030	90	hg	3
348-4	025	75W	ms	3

Explanation:

<u>Strikes</u> are given in degrees azimuth
<u>Dips</u> are given in degrees (var = variable)
<u>Rock type</u>
bg = biotite gneiss
ms = muscovite schist
gr = granite
bgrg =
hg = hornblende gneiss
baugg = biotite augen gneiss
gbg = granitic biotite gneiss
s = schist
bag = biotite augen gneiss
garbag = garnet biotite augen gneiss
g = gneiss

<u>Reference</u>

1 = Furcron and Teague (1943)
2 = Heinrich and others (1953)
3 = This investigation

Notes

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