A GEOCHEMICAL RECONNAISSANCE FOR GOLD IN EAST-CENTRAL GEORGIA

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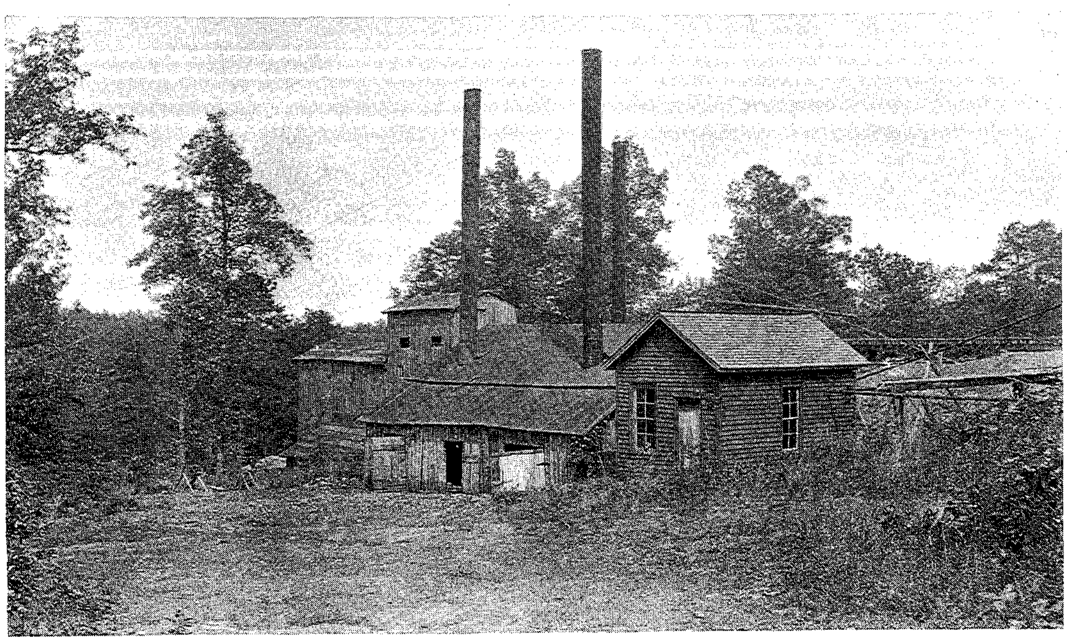

DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
GEORGIA GEOLOGIC SURVEY

INFORMATION CIRCULAR 83

Cover Photo:
Mining Plant, Seminole Gold and Copper Mine, Lincoln County, Georgia.

Photo courtesy of Georgia Department of Archives and History

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INTRODUCTION AND GEOLOGIC SETTING

This Information Circular describes the results of extensive sampling and analysis of gold from saprolite from the East-Central Gold District of Georgia. The East-Central Gold District is in the southeastern portion of the Georgia Piedmont and includes all or portions of the following counties: Elbert, Oglethorpe, Wilkes, Lincoln, Greene, Taliaferro, Columbia, McDuffie, and Warren (Figure 1). The East-Central Gold District was the scene of intermittent gold production, primarily during the middle and latter part of the nineteenth century.

This investigation was initiated in 1981, at a time when gold prices were relatively high and there was considerable interest in disseminated gold deposits in the southeastern United States. During this same time period (the early 1980's), at least three large and an unknown number of small gold exploration companies had active exploration programs in Georgia (William H. McLemore, 1988, personal communication). While to date there have been no mining permits filed with the Environmental Protection Division to mine gold in Georgia, permits currently are being reviewed for a proposed large mine (Ridgeway Mine) near Columbia, South Carolina. When considering that the East-Central Gold District has generally similar rocks (e.g., meta-volcanics) and is more or less along strike and equivalent to the rocks at the proposed Ridgeway Mine, the potential for a commercial deposit of gold in the East-Central District appears to be enhanced.

There are two underlying assumptions behind the present investigation, namely:

(1) The nineteenth century miners directed their efforts exclusively toward visible or "free" gold; such visible gold, for practical purposes, has been completely recovered. Considering the rural, agrarian character of the ninteenth century population and that much of the land was open and being actively farmed by "mule and plow" techniques, there is relatively little likelihood of a significant, undiscovered ore body occurring at the surface; such an occurrence, most likely, would have been "seen" and mined by the local population.

(2) The volcanic rocks of East-Central Georgia contain disseminated or non-visible gold in commercial quantities.

Inasmuch as all previous studies of the East-Central Gold District were directed at visible gold, the potential for disseminated gold deposits is unknown. With the above in mind, a geochemical survey of the district was undertaken to establish background gold values; to better appraise the extent to which gold values correlate with lithology and with geologic structure; to determine whether background values rise or fall in the vicinity of existing mines; to better define auriferous zones and, thus, to delineate the more favorable areas for detailed evaluation; and to discover whether there are high-gold anomalies not previously recognized.

As a companion to this Information Circular, the Geologic Survey is also publishing a Bulletin (Hurst, in press) describing the overall occurrence of gold in East-Central Georgia. Reading of this manuscript is necessary for a complete understanding of the geochemical gold anomalies described herewith.

In many parts of the world, gold deposits are associated with volcanics and associated sediments, or their metamorphic equivalents. Such rocks underlie most of the East-Central Georgia District. Though spatially related to volcanic rocks, epigenetic gold deposits typically postdate most or all of the volcanism. Frequently, they appear to be related to thermal waters that pervaded the rocks and extracted gold, which subsequently was deposited along fissures or other small openings (Boyle, 1979). In other words, epigenetic gold deposits appear to relate more often to metamorphism than to magmatism.

Few gold deposits appear to have been localized in the great fault or fractured zones of the world (Boyle, 1979). Instead, they were localized in intermediate-size and smaller structures. Examples are (1) the dilatant zones occupied by small gold-quartz lenses and veins in the crests of anticlines and (2) mineralized local fracture systems within volcanic dikes and plugs.

The wide distribution in the East-Central Georgia District of traces of gold and the proven existence of several workable deposits attest to significant gold mineralization; but detailed information about the extent and localization of the gold and what might guide the search for new deposits has not been available. As mentioned earlier, early search focused on quartz veins or places where relatively coarse "free" gold could be panned from saprolite or alluvium. This investigation focuses, however, on low-grade, large-volume deposits, which offer a much larger target for prospecting.

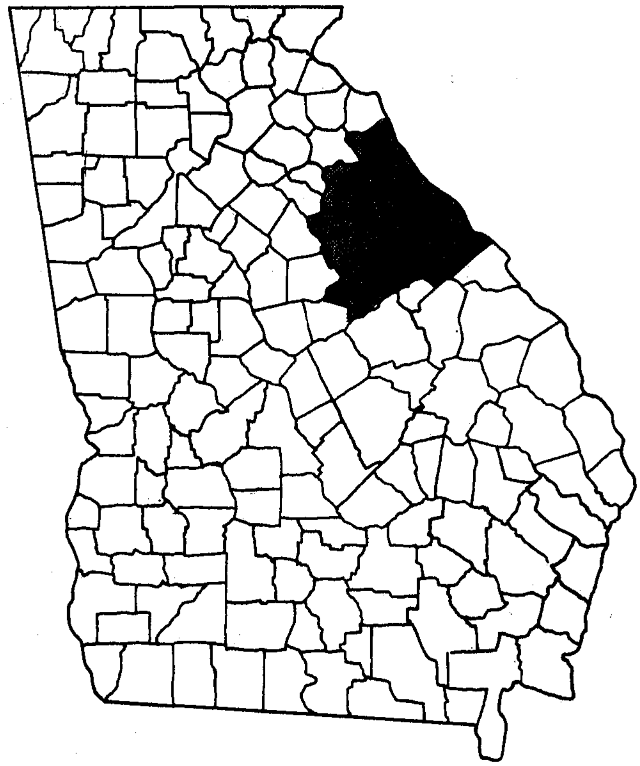

Figure 1. Study Area: A geochemical reconnaissance for gold in east-central Georgia.

SAMPLING AND ANALYTICAL PROCEDURE

A regular sampling grid was impractical. An attempt was made to maintain a one-mile sampling interval, but the sites initially chosen for sampling often had to be shifted due to the vagaries of access and intent to see that all rock types were represented. Still, the sampling was essentially random. The sampling interval was a compromise between the cost of the geochemical survey and the lower detection limit of expected anomalies. A total of 1,968 samples were collected from southern Elbert, eastern Oglethorpe, Wilkes, Lincoln, eastern Greene, Taliaferro, Columbia, McDuffie, and Warren Counties. Their locations (and the measured gold values in parts-per-billion, ppb) are shown on Plate A. (Note: USGS 7½ - minute quadrangles showing sampling locations are available for inspection in the technical files of the Georgia Geologic Survey). Most samples were collected from immature or C-horizon saprolite, which well preserves the gold content of the parent rock. At a few places, fresher rock had to be sampled.

Each sample, weighing about 10 pounds (4500 grams) as collected, was dried under infrared light; comminuted if necessary; reduced with a Jones splitter to a representative 100 gram sample; and stored in a zip-lock plastic bag, pending analysis. Regular fire assay was precluded by the necessity for parts-per-billion (ppb) accuracy. Based on ease of analysis, cost, and requisite accuracy, a USGS procedure was chosen. It combined pre-concentration of the metal by fire assay fusion with determination of the metal by atomic absorption. A complete description of the procedure is in USGS Bulletin 1445 (Haffty, et al., 1977).

RESULTS

The frequency distribution and range of gold values in saprolite and weathered rock samples from east-central Georgia are presented in Figure 2. The solid line delineates a fitted Gaussian curve, calculated with an equation from Smith, et al., (1983), after slight modification:

$$O \doteq \frac{2\sqrt{\ln 2}}{w\sqrt{\pi}} A \exp\left(-4 \ln 2 \,(x/w)^2\right), \text{ where}$$

O = ordinate value on curve,
W = width of Gaussian peak at half-height,
A = integrated area of the peak, and
X = abscissa distance from peak median

All values below 7 ppb fall exactly on the Gaussian curve and are background. Values greater than 8.5 ppb stand a 70% chance of being anomalous, and values greater than 12 ppb are strongly anomalous. The highest value is 260 ppb. All sample assays were plotted, and contour lines were drawn through values of 6, 8.5 and 12 ppb gold. The resulting map (Plate B) reveals seven significant anomalies.

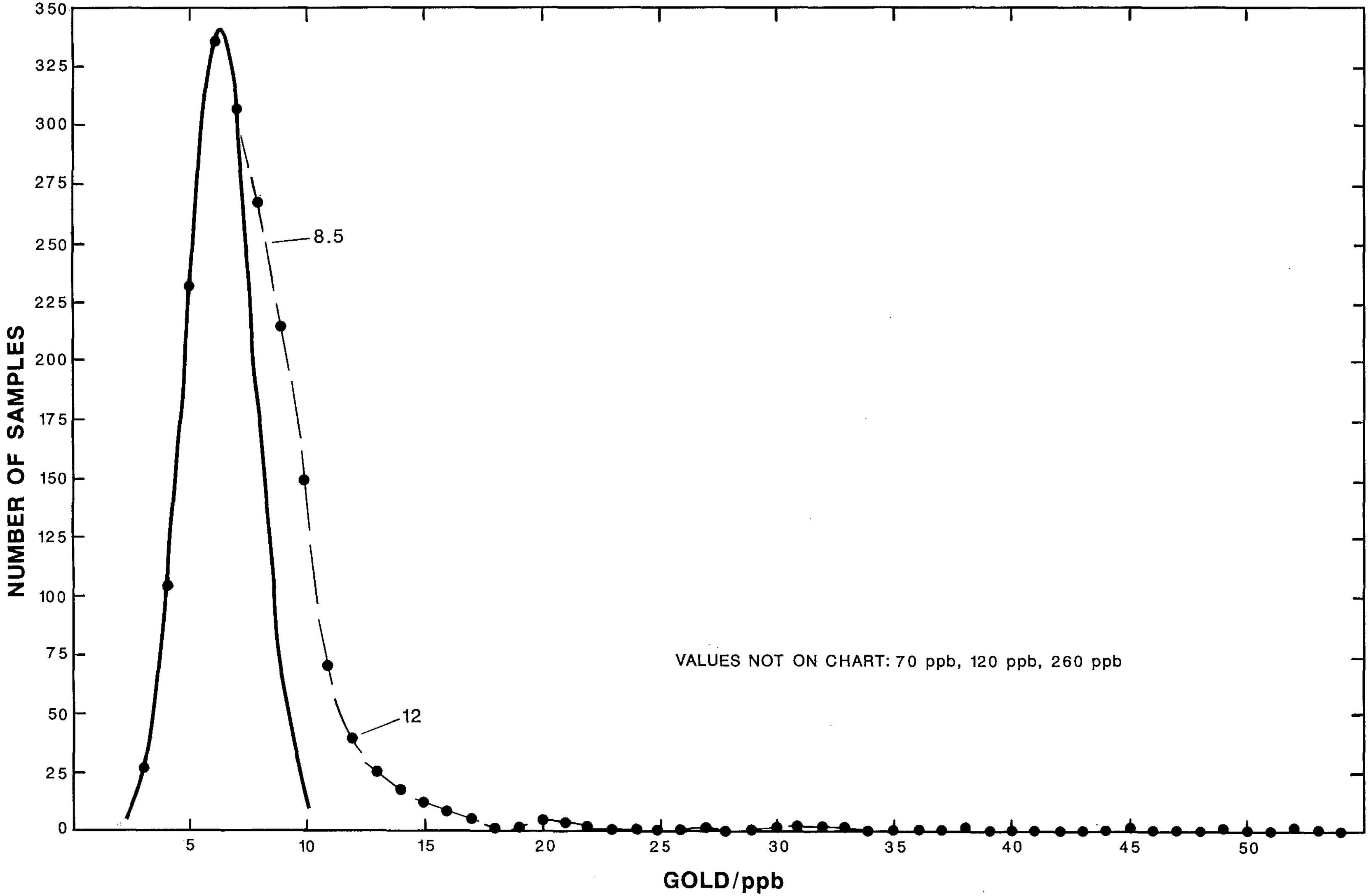

Figure 2. Frequency distribution of gold values in saprolite and weathered rock samples from east-central Georgia.

INTERPRETATION

Many reported analyses from previous studies show that the mean gold content of common rock-forming minerals is only a few ppb, and that variations from the mean generally are small (Table 1). The gold content of most rock-forming silicates is less than 5 ppb. Acidic volcanic rocks generally average less than 10 ppb gold; mafic volcanic rocks somewhat more. The sedimentary rocks associated with volcanic rocks typically contain more gold than the volcanic rocks, and their gold content typically increases as their grain size decreases. Volcanic ashes and associated tuffaceous sediments commonly are enriched to several hundred ppb gold. Some carbonaceous shales contain more gold than tuffs. Some Precambrian carbonaceous sediments contain more than 5,000 ppb gold (Gapon, 1970), equivalent to 0.14 ounce/ton, which currently is ore grade. The Green River shale in Wyoming has been reported to contain 300-600 ppb gold (Varley, 1922).

The measured background gold values from the East-Central Gold District are close to those reported for other areas of similar rocks (refer to Boyle, 1979). They are double the mean values reported for the common rock-forming minerals. This suggests that much of the gold in these rocks resides in intergranular spaces or in minor phases that generally have higher background gold, such as sulfides (Table 1). This conclusion is similar to that reached by Gottfried and others (1972) for igneous rocks.

Above the general background of 4-8 ppb gold, the frequency curve (Figure 2) shows a pronounced shoulder at 6-11 ppb, probably the background of intermediate to mafic metavolcanics which are common lithologic units in east-central Georgia and which generally have a higher gold background. Consistent with this conclusion, the general distribution of intermediate gold values correlates well with the distribution of a sequence of rocks containing notable intermediate to mafic metavolcanics (Hurst, in press). Since the scale of lithologic changes is small compared to the sampling interval, a less than striking correlation might be expected between lithology and gold values; nevertheless, the correlation is clearly perceptible, particularly with respect to low and intermediate gold values.

TABLE 1

GOLD CONTENT OF COMMON MINERALS AND ROCKS PARTS-PER-BILLION

	Range	Mean
Quartz	0.8 - 2	1.7
Feldspars	0.3 - 2	1.7
Biotite	2 - 7	1.8
Hornblende	0.5 - 3	1.6
Epidote		2.5
Pyroxene	0.5 - 4	
Olivine	1 - 10	
Sphene	2 - 9	2.7
Magnetite	3 - 10	3.6
Pyrite	up to 500	
Acidic extrusives	0.1 - 113	3.7
Intermediate extrusives	0.1 - 65	13
Basic extrusives	0.1 - 230	18
Acidic intrusives	0.2 - 2900	11
Modern sediments	generally 3-6	
Mean values for metamorphic rocks:		
Quartzite	0.2 - 1150	32
Slates, phyllites	0.9 - 15	2.2
Acidic gneisses	0.2 - 300	3.1
Amphibolites	0.1 - 100	7.1

From Boyle (1979)

Comparison of Plate B with Hurst's geologic map in press, however, shows that not all of the gold anomalies are lithology-related. In northwestern Warren County, a v-shaped gold anomaly crosses the regional trend, suggesting either a pre-Ordovician anomaly that survived regional metamorphism or post-Ordovician gold migration. A more definitive relationship is revealed in northern Wilkes and Lincoln Counties, where a gold concentration gradient is superimposed over the Danburg granite. In the western half of this 8-km wide pluton, the concentration of gold is twice as great as in the eastern half. This connotes considerable mobility of gold after crystallization of the Danburg magma 295 $\pm$ 2 m.y. ago (Fullager and Butler, 1974), as recently as Alleghenian. Notably, the background gold values generally increase in the vicinity of the larger known gold deposits.

The frequency curve of Figure 2 approaches an abscissa at 18 ppb. Higher values were found in about thirty samples. Anomalies containing these higher values delimit three linear trends that roughly parallel or slightly cut across the regional structural trend. The northernmost anomaly-trend roughly parallels the Middleton-Lowndesville Fault but is a short distance southeast of it. The central anomaly-trend, which crosses central Wilkes County and northern Lincoln County, is along or just to the north of a fault zone at the northern edge of the Lincolnton metadacite. The southernmost anomaly-trend is within the zone of cataclasis which has been called the Modoc Fault. Toward the west, this trend cuts across the change from kyanite grade to sillimanite grade rocks.

The proximity of all three anomaly-trends to prominent local faults suggests the possibility of a genetic relationship and a post-Taconic development. If these gold anomalies formed during the youngest episode of gold mobilization, perhaps when low-level gradients developed across the Danburg granite, they might relate to the movement of hydrothermal fluids along older deformation zones reactivated by Alleghenian tectonism.

The linear trends of the gold anomalies also are compatible with, though hardly supportive of, a volcanogenic origin, as proposed by Worthington and Kiff (1970), Spence and others (1980), and Worthington and others (1980). According to these interpretations, the gold deposits originated by hot spring or fumarolic activity during the waning stages of Cambrian volcanism. High-alumina minerals associated with the gold (sericite, pyrophyllite, andalusite-kyanite-sillimanite) originated as early hydrothermal alteration products which recrystallized during Ordovician metamorphism, and much of the associated quartz originated as siliceous sinter.

Most of the higher anomalies are in a lithologic sequence that originated as felsic pyroclastics, intermediate to mafic flows, and associated sediments, which were transformed by regional metamorphism to quartz-sericite schists, felsic gneisses, metaargillite or metagraywacke, and amphibolites (Hurst, in press). The association of the higher anomalies with this sequence and the similarity of its background gold content to that reported for similar rocks in many other areas suggests that the overall pattern of background gold once might have been lithology-controlled, dating from the Cambrian Period, or older. Both field and laboratory evidence suggests that the gold, to some degree, was subsequently remobilized. The northernmost and southernmost higher-gold trends cross-cut lithologic trends established during Ordovician or younger tectonism. A high-gold anomaly in northwestern Warren County is athwart an Ordovician or younger structural trend. The gold gradients across the Danburg granite appear to be Alleghenian. At the Parks Mine and the Landers Prospect in northern McDuffie County and at the Latimer Mine in northwestern Wilkes County, the gold is mainly in or around quartz veins that cut across metamorphosed rocks. SEM examination of samples from these veins shows that the gold was deposited along the youngest micro-voids and shears (Hurst, in press).

The available evidence points to some early lithologic control of background gold and also to later gold mobility. It does not distinguish, unequivocally, whether some of the deposits might have originated volcanogenically, but it does point clearly to a metamorphic origin for most of them. The common association of gold mineralization with quartz-rich rocks and conspicuous high-alumina minerals may be reminiscent of volcanic hot spring or fumarolic deposits, with their associated sericitic, kaolinitic, or pyrophyllitic alteration. However, it is not clear from available information whether the bulk composition, where high-alumina minerals are with or near gold, originated during pre-metamorphic (volcanogenic) alteration or during much younger hydrothermal alteration at particular sites in an aluminous sequence of metasediments and metavolcanics.

In Summary: (1) Background gold values in the East-Central Georgia Gold District closely resemble those of similar rocks in other areas. The values from rocks of the study area are double the mean value reported for common rock-forming minerals. This implies that much of the gold in Georgia rocks is in intergranular spaces, micro-openings, or in trace minerals such as pyrite.

(2) The background gold values show a general correlation with lithology. Higher values correlate with a sequence containing notable intermediate to mafic metavolcanics and quartzose rocks. The common spatial coincidence of the higher anomalies with this lithologic sequence and the similarity between measured gold values for the sequence and values reported for similar rocks in many other areas suggest that part of the overall gold background pattern once was lithology-controlled. Some of the gold anomalies are not lithology-controlled because they cross-cut the metamorphic and tectonic fabric.

(3) The more intense anomalies fall mostly along three linear trends that are along or near, and roughly parallel to, major shear zones.

(4) The superimposition of gold concentration gradients over the 295 m.y. old Danburg granite suggests significant mobility of gold as recently as Alleghenian time.

(5) Background gold values generally increase in the vicinity of the larger known deposits. Not only do the higher anomalies include most of the larger known gold deposits, they also identify several promising areas where no mining has been reported.

GEOCHEMICAL SAMPLING INTERVAL VS EXPECTABLE SIZE OF ORE BODIES

The size and grade of known gold deposits ranges from bodies that contain hundreds of millions of tons of very low-grade ore to single veins that contain only a few tons of high-grade ore. A rough inverse relationship is apparent between size and grade. Bonanzas are rare. Most of the world's existing proven gold resources are in large, low-grade deposits. Most undiscovered deposits probably will be the same type. Fortunately, the more expectable type of deposit also is the larger target for exploration. The size and grade of deposits already developed and those being considered for development in other parts of the world are a good measure of what should be sought in the East-Central Georgia District (Table 2).

The expectable ore bodies are mostly smaller than the chosen geochemical sampling interval. As a consequence, some known gold deposits, and possibly others not yet discovered, could be between sample sites. The area within which an average-size deposit might be located and still not be sampled is about 90% of the total area; therefore, chances were about 1 in 10 that every intermediate-size gold deposit was directly sampled. For a major deposit, as large as Kidston in Australia, Homestake in South Dakota, or Pueblo Viejo in Dominican Republic, chances were about 1:1. With the chosen sampling interval, then, chances were very high for direct sampling of any major gold deposit; slim for direct sampling of any medium-size deposit; and relatively poor for direct sampling of small deposits. When gold deposits are enclosed by, or associated with, host rocks containing high background gold, a common relation in other areas, a sampling interval with low probability for direct sampling of medium-size and small deposits still could have high probability for the detection of most gold mineralization. Reducing the sampling interval could increase the detectability of smaller deposits, but also would escalate the cost. The chosen sampling interval, a compromise between cost and expectable information, appeared to be the largest that might accomplish this survey's principal aims, which were (1) to establish background gold values for the district, (2) to appraise the extent to which gold values correlate with lithology and with structure, (3) to determine whether background values rise in the vicinity of workable deposits, (4) to delineate the larger mineralized areas, (5) to disclose the pattern of mineralization, and (6) to reveal whether there are large gold anomalies not previously recognized.

While the chosen sampling pattern cannot provide sufficient resolution of gold anomalies for the delineation of every individual gold deposit, it has accomplished the study's principal aims and has delineated several relatively small areas that are promising for further gold exploration. The smaller gold anomalies are about 2500 feet across; whereas, the larger are 1-1.5 miles wide and several miles long. For comparison, the ore bodies belonging to a major gold deposit of the low-grade, high-volume type might lie within a roughly equant 1.5 x 1.4 mile area (Pueblo Viejo), an elongate 0.9 x 2.1 mile area (Jerritt Canyon), or a long contorted zone up to a thousand feet wide (Homestake) where the gold-bearing stratum is only 40-60 feet thick. A medium-size deposit of the same type might be 300 x 1000 feet (Clementine Property), 260 x 650 feet (Griffins Property, Wheat Belt Area, Australia), or a narrower and longer deposit. Any large deposit of the low-grade, high-volume type in this district probably is within one of the gold anomalies of Plate B. Chances also are good that any medium-size deposit of the same type is within one of the three major anomaly trends defined on Plate B. Small deposits would not be expected to fall always within the anomaly trends of Plate B. Consistent with this expectation, several known small deposits (and mines) occur outside the high anomalies.

During sampling, prospects, old mines, and, obviously, mineralized areas were shunned. Our intent was to collect representative samples of only the common lithologies. Accordingly, the gold assay values are a better measure of background and low-level anomalies where there has been no previous mining. The highest value obtained, 260 ppb, is much less than could have been obtained if old mines and prospects had been sampled.

EXPLORATION OF GOLD ANOMALIES

All of the anomalies recommended for exploration are multi-sample anomalies and are extensive enough to harbor a large deposit. Exploration should begin with detailed geologic mapping, augmented by a systematic investigation of both surficial and saprolitic residuum. A second step could be detailed geochemical mapping. The principal aim of the first step would be to verify that the anomaly might be due to large- scale mineralization. The aim of the second step would be to more accurately delineate the anomalous area(s). Favorable results from the first two steps would justify the third step, conventional drilling, and also would provide needed information for the layout of exploratory drilling.

All gold anomalies revealed by this study are shown on Plate B. Those regarded as more favorable for exploration, from the grade of the anomaly, its size, and its location with respect to major faults, are shown in Figures 3 through 10.

Although a careful examination of surficial residuum sometimes can yield sufficient information for preliminary evaluation, a systematic investigation of residual materials in the saprolite is more likely to yield the needed information. This kind of investigation, which is much less costly than exploratory drilling, can provide leads to the type of mineralization and also can help to minimize more costly drilling. For a systematic investigation of residual materials, representative cross-strike channel samples should be collected from random sites at a spacing commensurate with the desired resolution. For a minimal investigation, the samples should be wet sieved through a 5 mesh screen; the +5 mesh fraction can be dried and examined particle-by-particle. Wet sieving cleans and concentrates the particles of interest, making them easier to identify and lowers the detection limit of trace materials. For a more detailed investigation, the

TABLE 2 - Approximate size and grade of several low-grade, large-volume gold deposits.

Deposit	Grade ppm	T. oz/ton	Outcrop Dimensions or Tonnage	Million Tons of Ore	Average grade oz./ton	Total T. oz.	Value at $445./oz., $Million
Freeport, Jerritt Canyon, 50 miles N. of Elko, Nevada (Jackson, 1982)	8.5	.05 avg.	12 million tons in 5 deposits	12	.05	600,000	267
Clementine Property, 20 miles NW of Phoenix, Ariz. (personal notes, 1983)	2-5	.078	1000' long x 300' wide	7.4	.078	579,000	257
Earth Sciences, Inc., 7 miles NE of San Luis, Colorado (E & MJ, 1981)	1.6	.078	1.5 million tons	1.5	.078	117,000	52
Pueblo Viejo, Dominican Republic (Russell, et al., 1981)	4.7	.136	27 million tons, at the beginning. Several ore bodies 1200' x 3000' x 250' thick		.136		1 billion+
Alaska, Juneau (Boyle, 1979)	1.4	.04	3 1/2 miles long, 1000'-2000' wide, 3000' deep				
Griffins Property, western Australia, Wheat Belt Area (E & MJ, 1981)	1.7	.03-.22	650' long, 260' wide 330' deep	4.6	.08	368,000	164
Homestake, South Dakota (Boyle, 1979)	9.9	.26	Original layer about 60' thick Currenty 15+ million tons		.26		1 billion+
Paddington, 35 miles N of Kalgoorlie, Australia (Todd, 1985)	3.3	.095	8.6 million tons	8.6	.095	817,000	363
Harbor Lights, western Australia,(Todd, 1985)	4.0	.117	5.5 million tons	5.5	.117	643,500	286
Kidston, North Queenland, Australia (Todd, 1985)	1.9	.054	40 million tons	40	.054	2,160,000	961
Prophyry, 200 km N of Kalgoorlie, Australia (Todd, 1985)	5.5	.16	2.6 million tons	2.6	.16	416,000	185

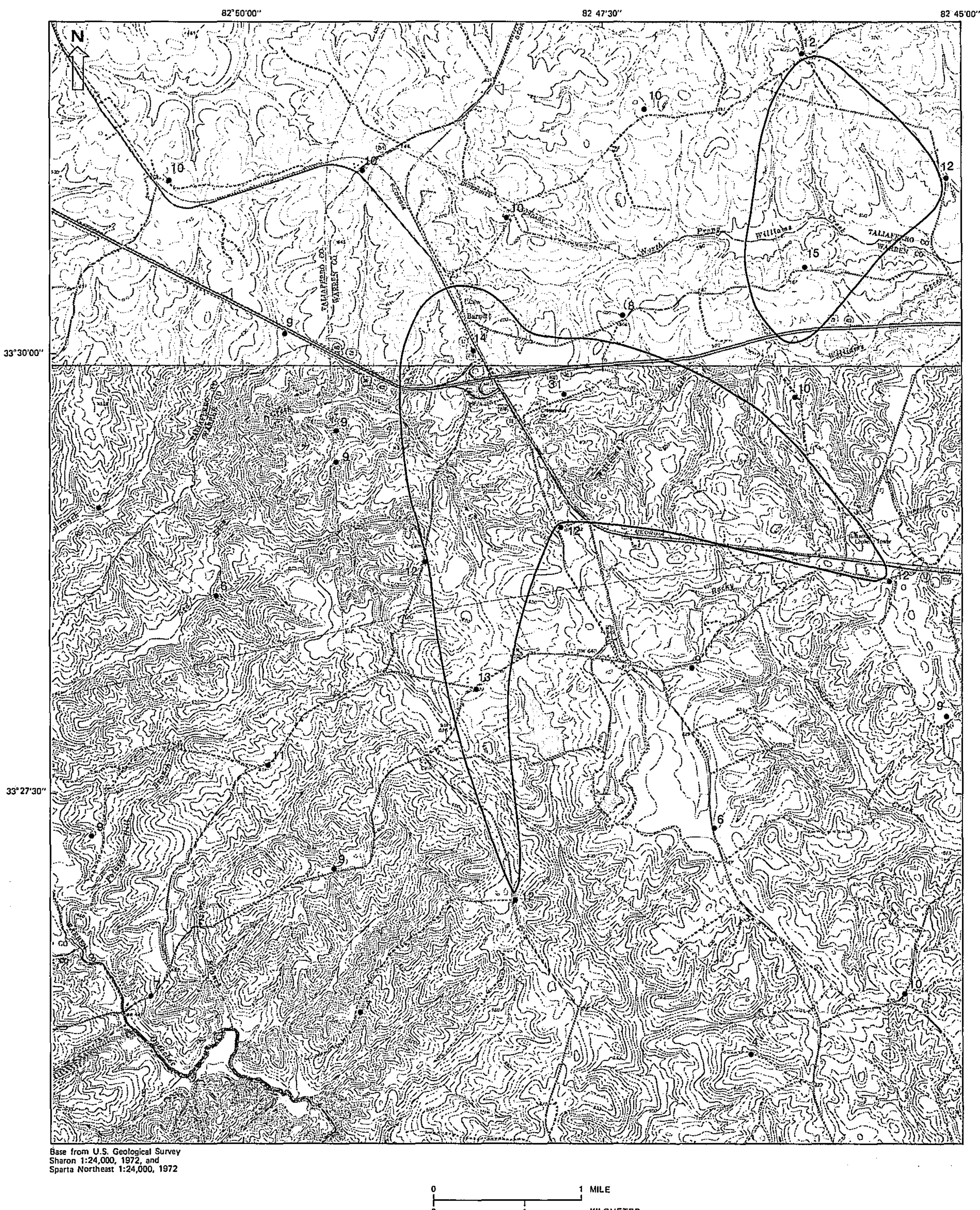

Figure 3. Greenwood gold anomaly, Warren County, showing sample localities with gold analyses in ppb.

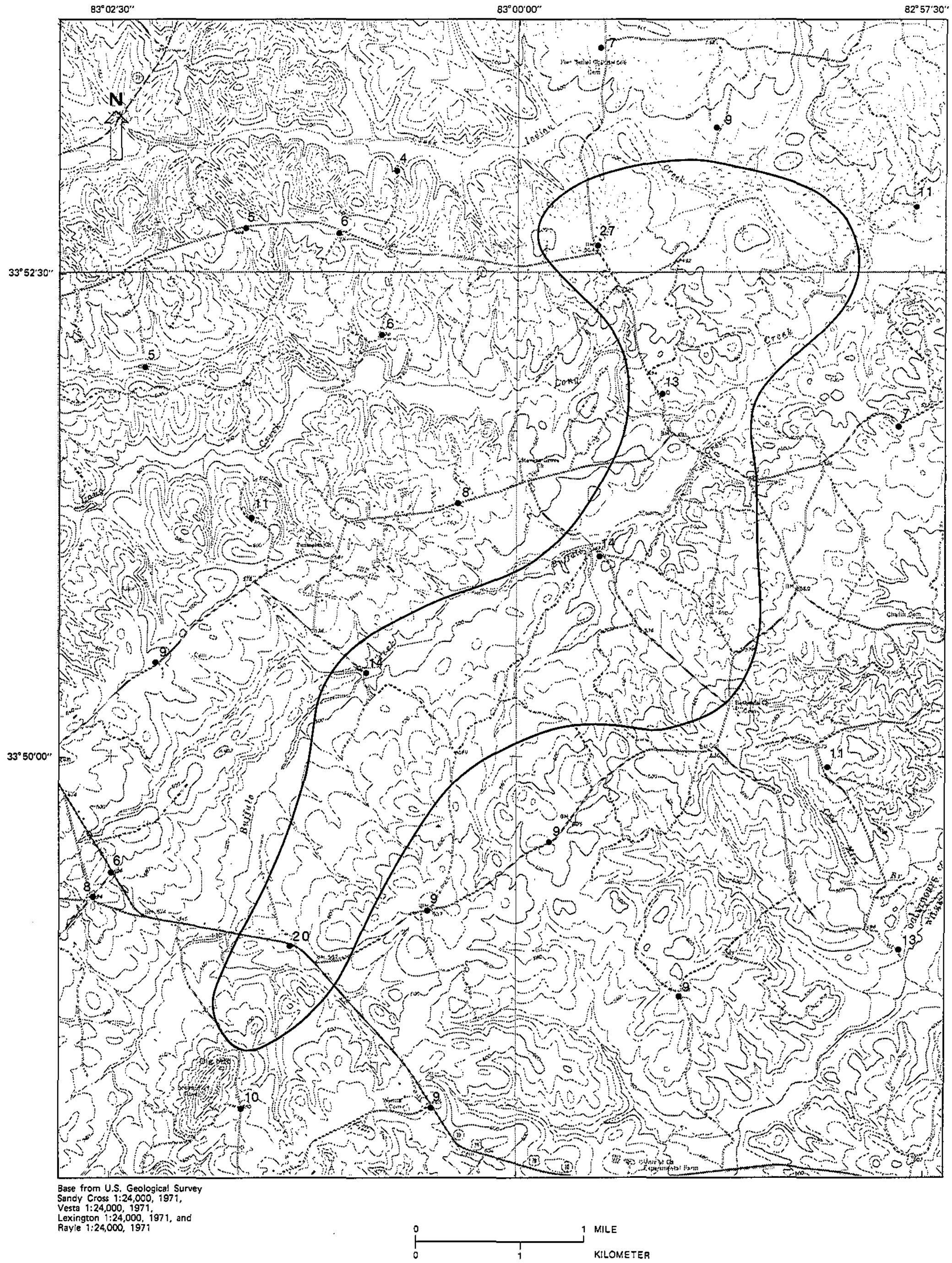

Figure 4. Buffalo Creek gold anomaly, Oglethorpe County, showing sample localities with gold analyses in ppb.

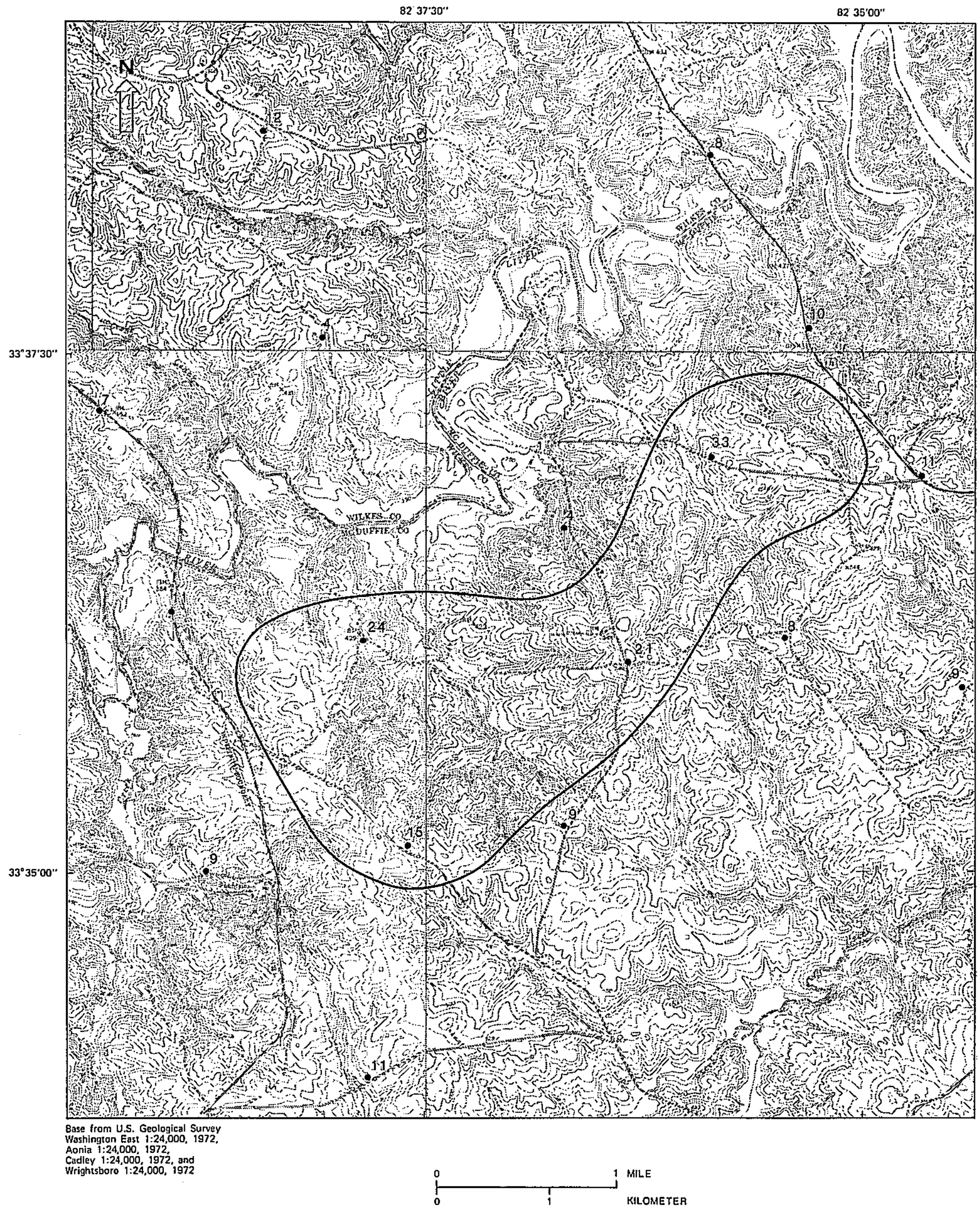

Figure 5. Northwest McDuffie County gold anomaly, showing sample localities with gold analyses in ppb.

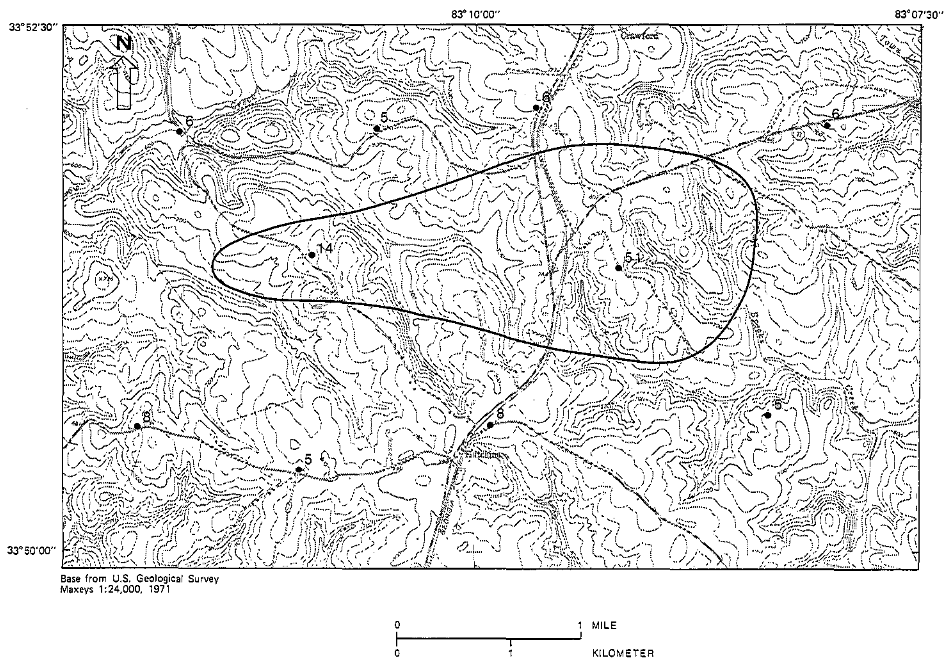

Figure 6. Brooks Creek gold anomaly, Oglethorpe County, showing sample localities with gold analyses in ppb.

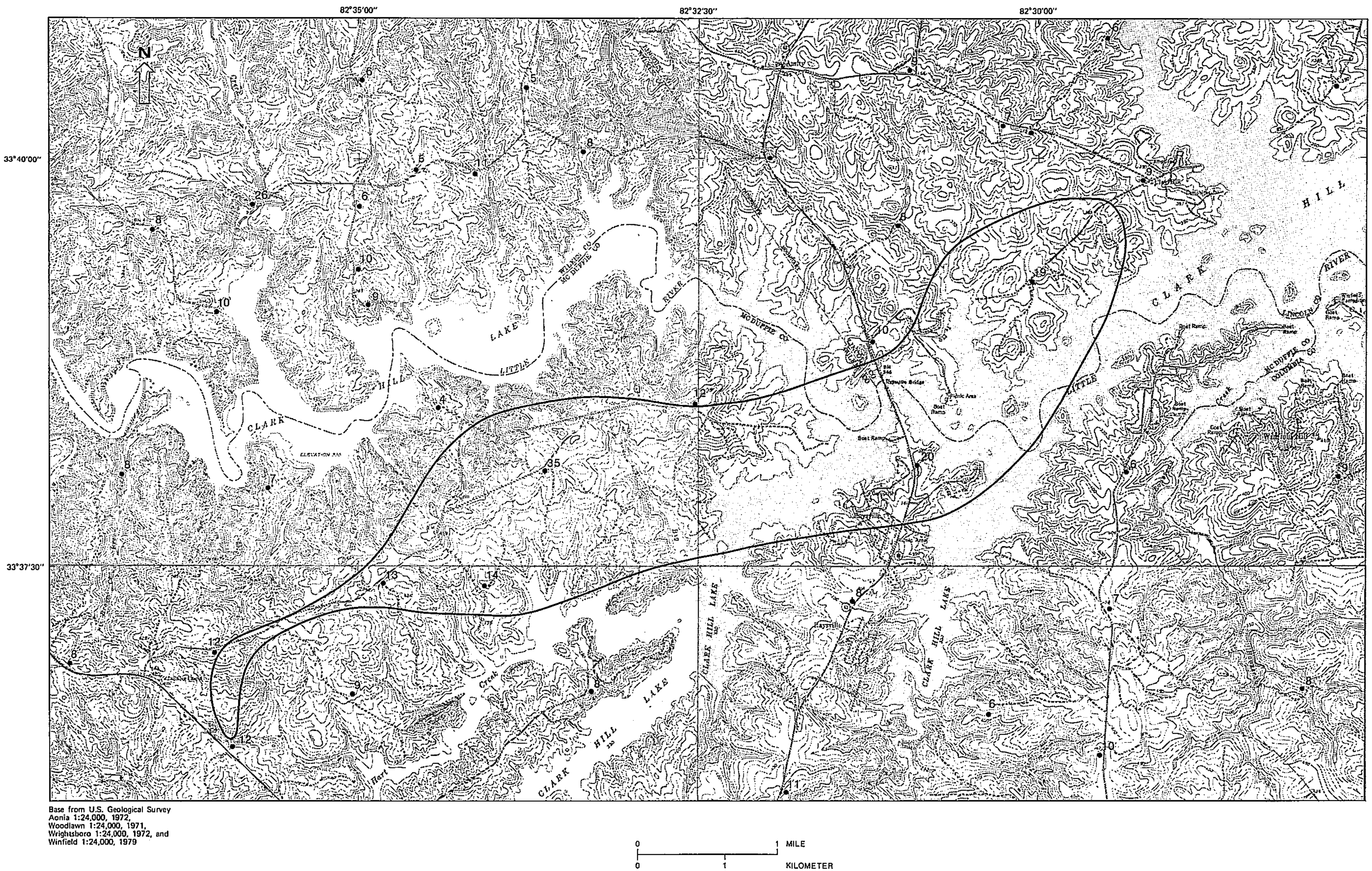

Figure 7. Raysville gold anomaly, McDuffie County, showing sample localities with gold analyses in ppb.

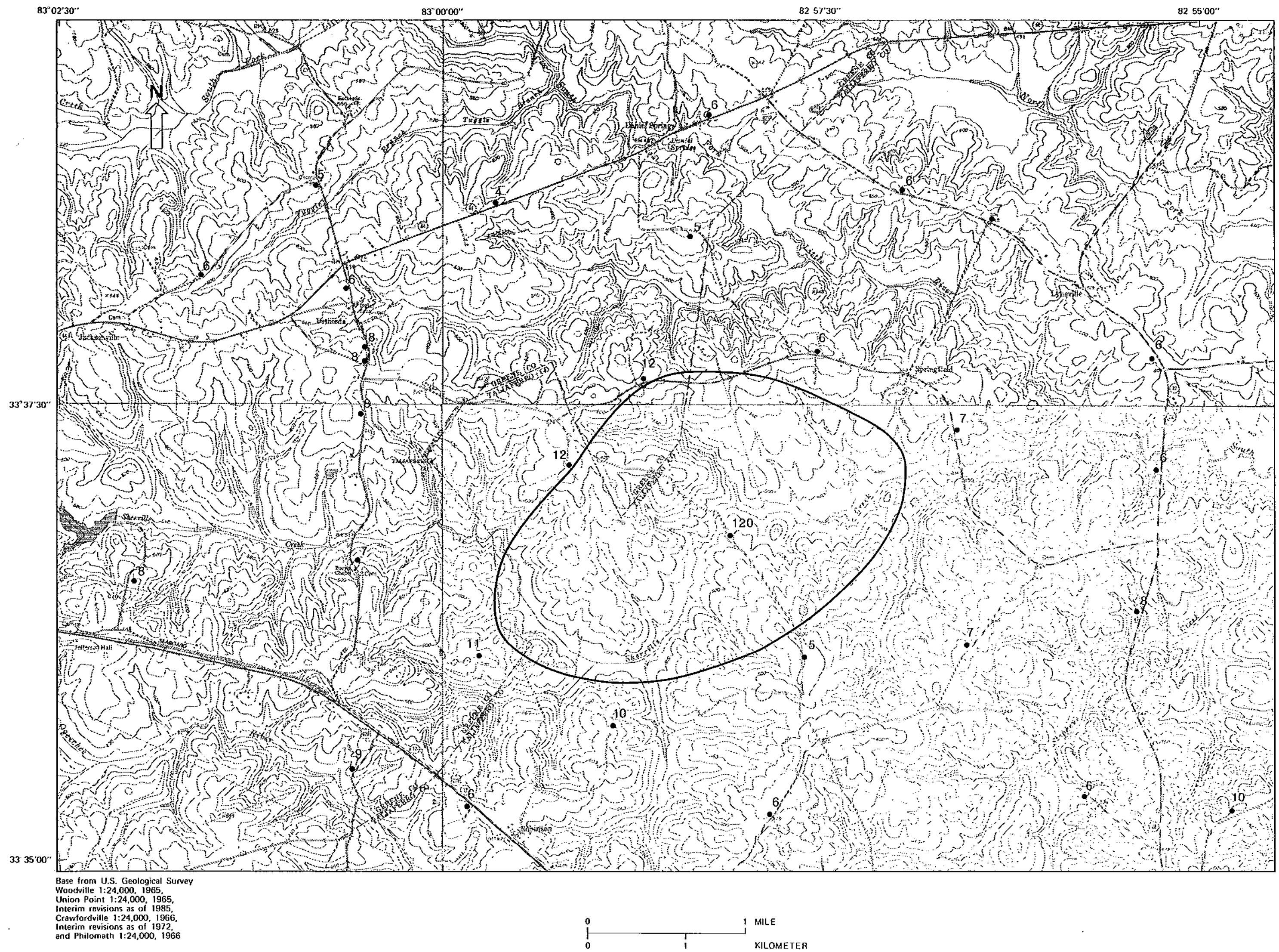

Figure 8. Sherrills Creek gold anomaly, Taliaferro County, showing sample localities with gold analyses in ppb.

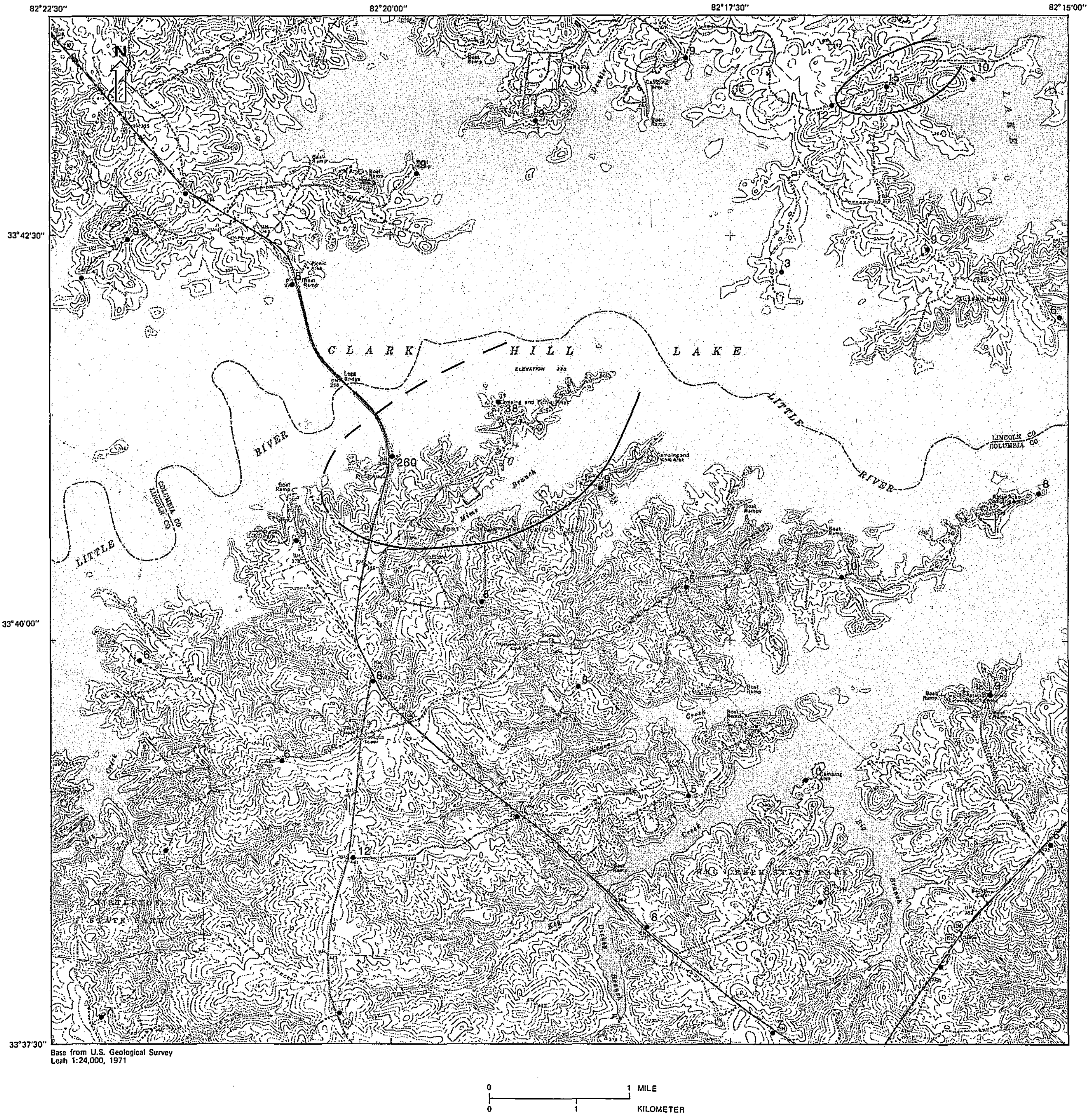

Figure 9. Leah gold anomaly, Columbia-Lincoln County, showing sample localities with gold analyses in ppb.

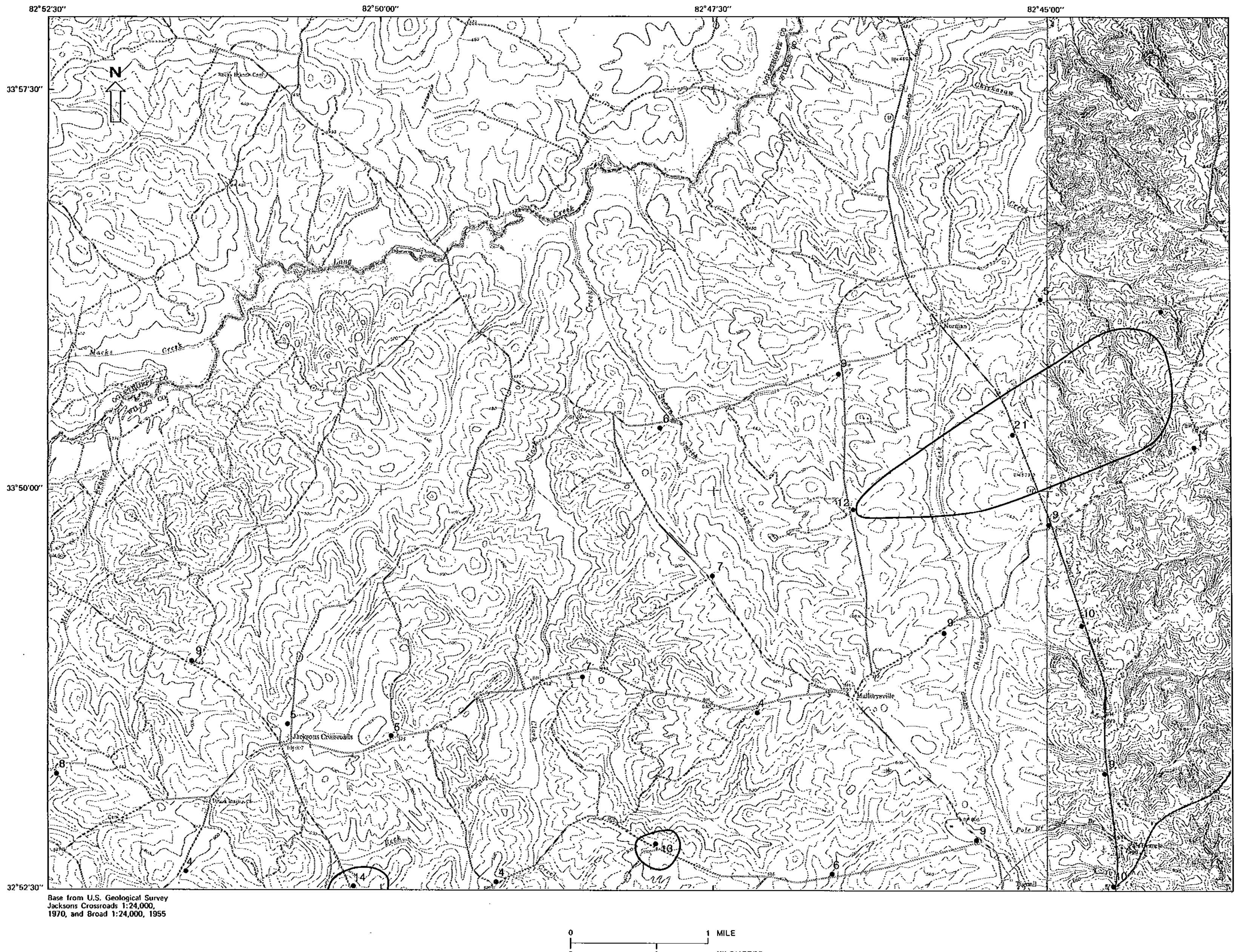

Figure 10 A. Latimer Zone gold anomalies, Wilkes County, showing sample localities with gold analyses in ppb.

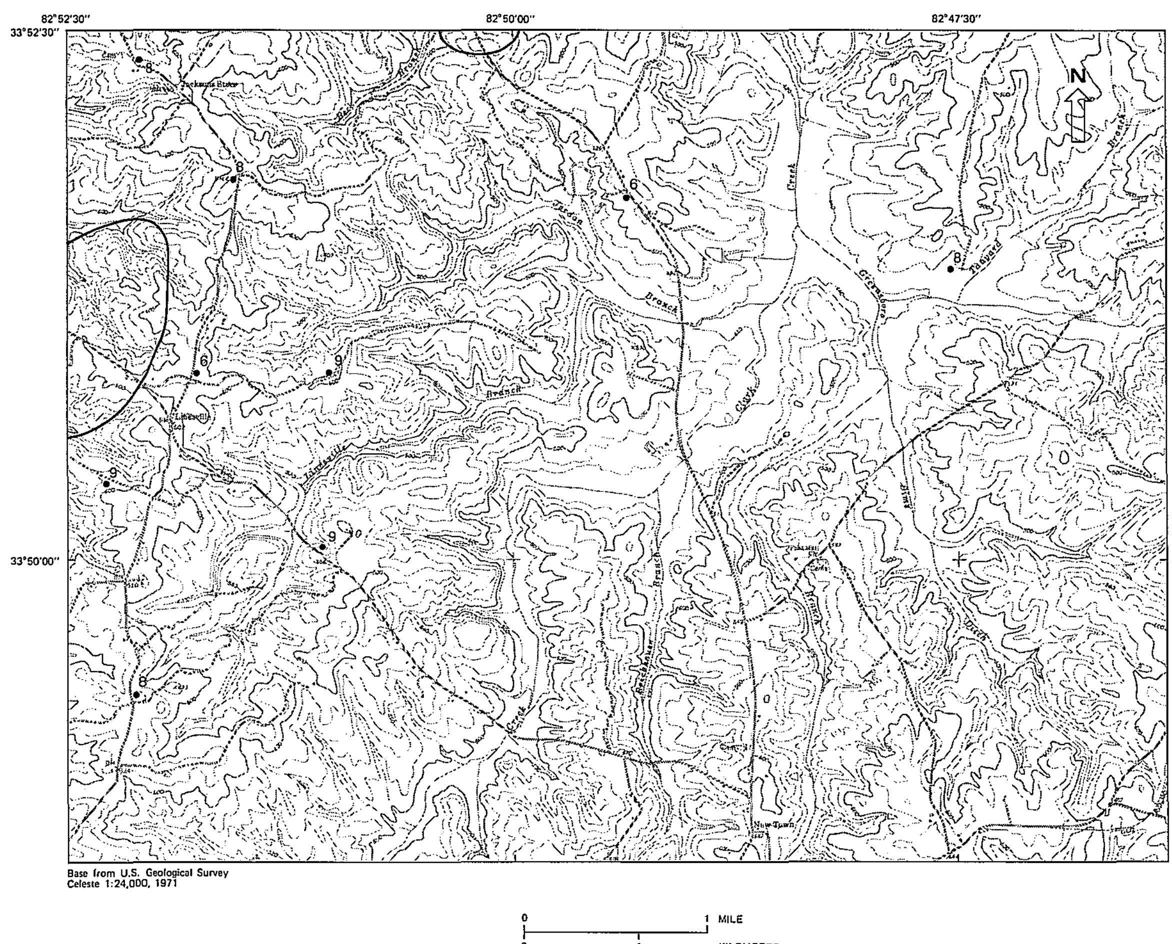

Figure 10 B. Latimer Zone gold anomalies, Wilkes County, showing sample localities with gold analyses in ppb.

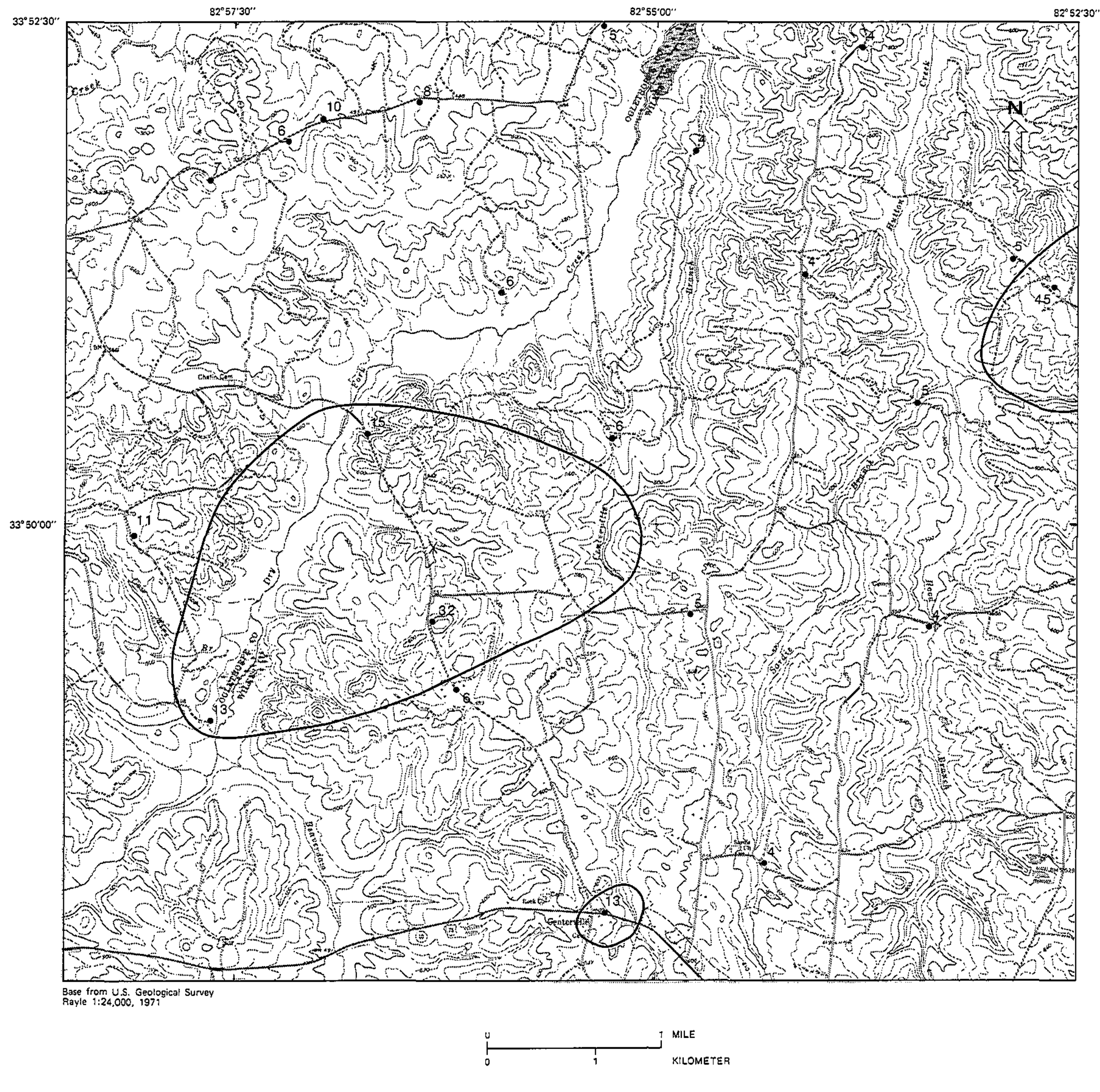

Figure 10 C. Latimer Zone gold anomalies, Wilkes County, showing sample localities with gold analyses in ppb.

-32+60 mesh fraction should be separated for examination with a petrographic microscope. A -115 mesh fraction can be saved for assay or analysis. A plot of the percentage and distribution of various nodules, gossan fragments, quartz, and other diagnostic mineral can delineate mineralized areas much more accurately than examination of rock and saprolite outcrops. The residual materials also offer clues to the type of deposit that might be disclosed by drilling. They may not be mutually exclusive, nor invariant for one type of deposit, but several features taken together may indicate the probable type. In the list below some common materials are listed beneath the type of gold deposit for which they appear to be most characteristic:

OLDER, METAMORPHIC SYNGENETIC

(Possibly volcanogenic, initially)

Abundant quartz
Dense, fine-grained quartz
Topaz
Coarse aluminosilicates
Absence of vuggy micro-openings
Fragments of sulfide gossan

YOUNGER METAMORPHIC EPIGENETIC

(Probably Alleghenian)

Abundant quartz
Medium to coarse vein quartz
Fuchsite
Propylitized fragments
Presence of vuggy micro-openings in addition to primary fluid inclusions
Fragments of sulfide gossan

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See separate envelope

for Plates A and B.

GEOCHEMICAL SAMPLE LOCATION MAP
Distribution of Background Gold in East-Central Georgia

LEGEND

•8.3 Sampling locality with gold analysis in parts per billion

Compilation
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Vernon J. Hurst
1990

Base Map Constructed from USGS 1:100,000 Topographic Maps

DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
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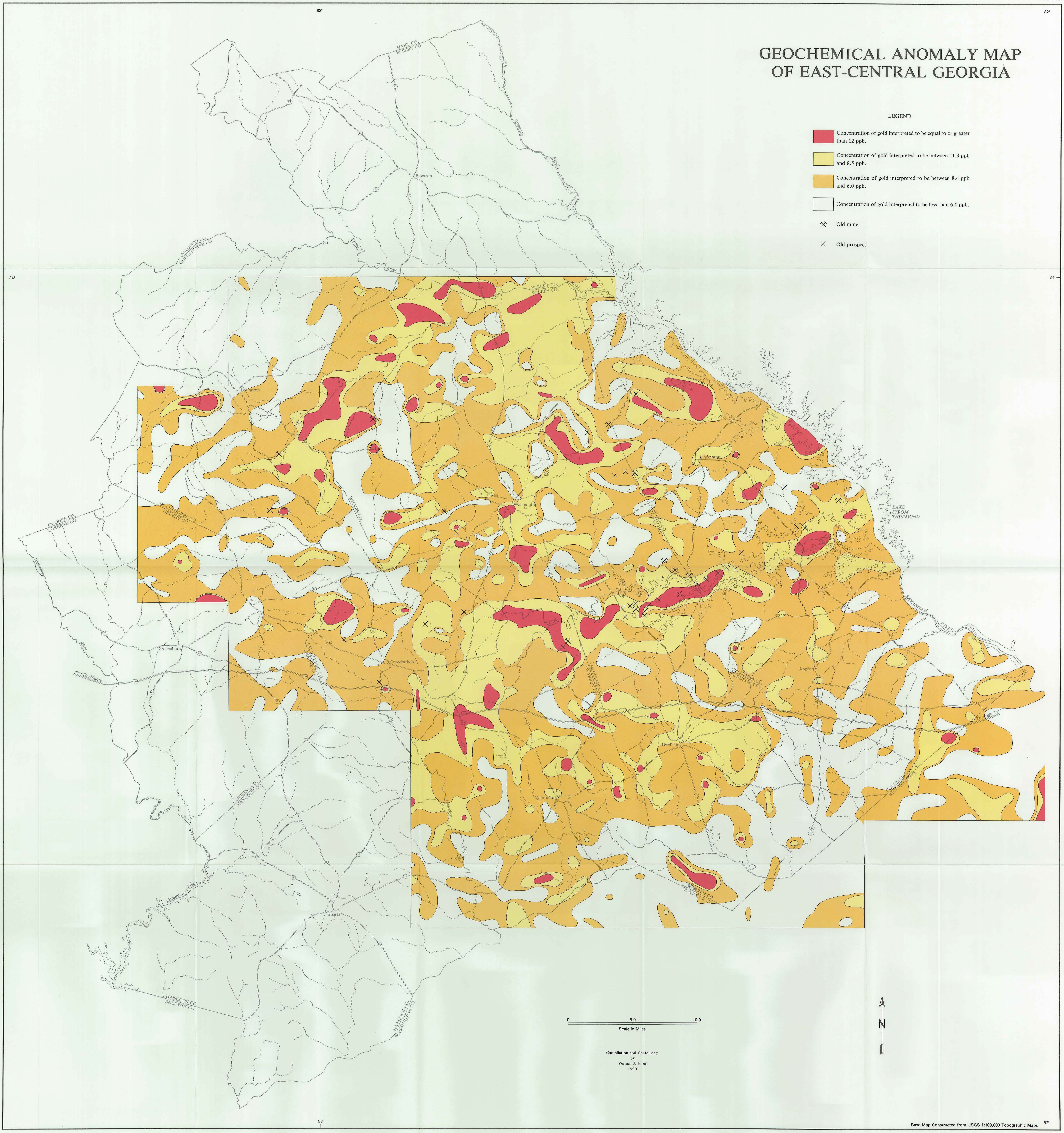
PLATE B

GEOCHEMICAL ANOMALY MAP OF EAST-CENTRAL GEORGIA



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