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THE GEOLOGICAL SURVEY OF GEORGIA
DEPARTMENT OF MINES, MINING AND GEOLOGY
J. H. AUVIL Jr., Director

A GEOCHEMICAL AND GEOPHYSICAL SURVEY OF THE GLADESVILLE NORITE JASPER COUNTY, GEORGIA

By
Robert H. Carpenter and Thomas C. Hughes

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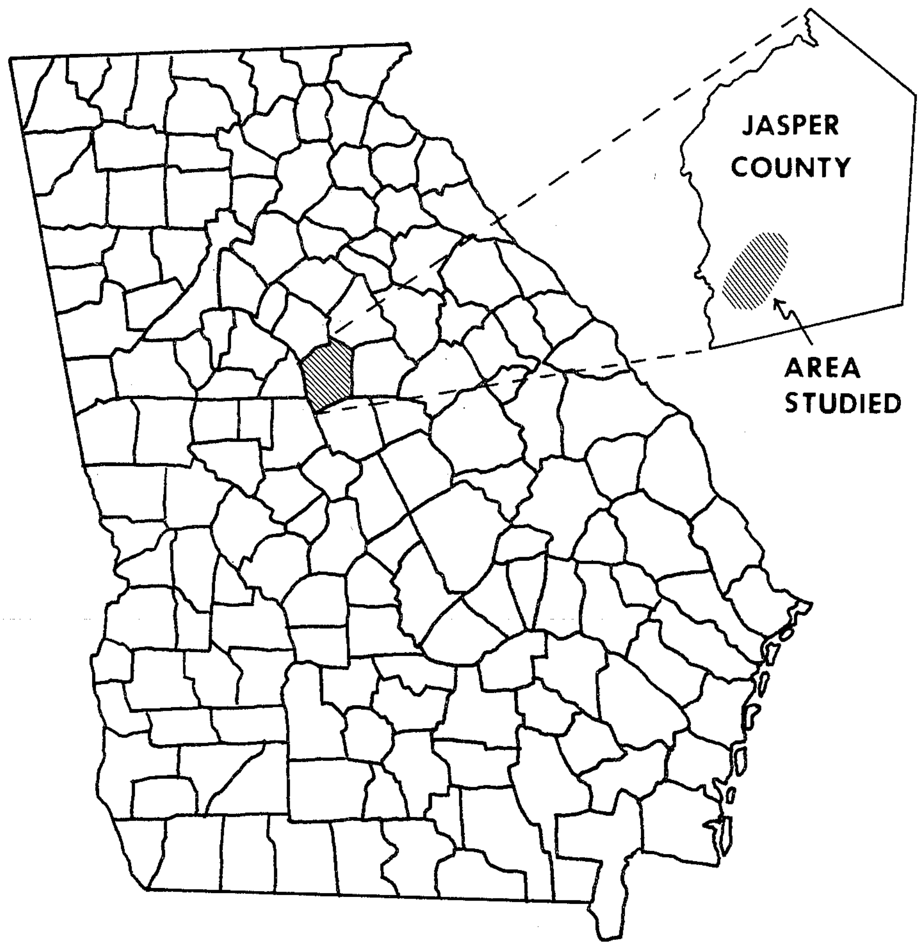

GEOCHEMICAL AND GEOPHYSICAL SURVEY OF THE GLADESVILLE NORITE, JASPER COUNTY, GEORGIA

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CONTENTS

PLATES

GEOCHEMICAL AND GEOPHYSICAL SURVEY OF THE GLADESVILLE NORITE, JASPER COUNTY, GEORGIA

INTRODUCTION

Gabbroic intrusive complexes contain major deposits of chromite, platinum group elements, nickel, copper, vanadium, and significant deposits of other metallic and nonmetallic commodities. Large basic intrusives such as the Bushveld Complex in South Africa or the Sudbury Complex in Canada generally contain the most important deposits. In the Piedmont Province of the southern Appalachians, several basic intrusives are known in Georgia and the Carolinas. The Gladesville Norite in southern Jasper County, Georgia, is the largest known basic intrusive in the state. According to Matthews (1967), the thickness of this intrusive may be comparable to that of other major basic igneous complexes.

The present study is a preliminary evaluation of the potential for mineralization associated with the Gladesville Norite based on reconnaissance geophysical and geochemical surveys. This intrusive was selected for study because of its relatively large size and because the geology of the area has been described in some detail by Matthews (1967). A gravity survey was conducted to gain information on the subsurface extent of the intrusive. Magnetic and geochemical surveys were made to determine whether or not mineralization exists in the exposed portion of the intrusive. This report describes the various surveys and areas of indicated potential mineralization. In addition, recommendations for future studies are summarized.

SUMMARY AND CONCLUSIONS

A gravity survey of southern Jasper County, Georgia, indicates that basic igneous rocks may be extensive in the subsurface of this area. The gravity anomaly reflecting these buried igneous rocks exceeds 44 milligals and may prove to be one of the major gravity features of the Piedmont. Apophyses from the buried mass are locally exposed by erosion. The largest known exposed body is the Gladesville Norite.

An area of potential mineralization in the northern portion of the Gladesville Norite is indicated by magnetic and geochemical surveys. Positive magnetic anomalies in excess of 1,000 gammas occur in this area. In one small area, a +10,000 gamma anomaly was identified. Stream sediment collected below the magnetic anomaly contains anomalous concentrations of nickel, copper, and zinc.

Positive magnetic anomalies were also identified in the southeastern margin of the Gladesville Norite; and about 2 miles southeast of this intrusive. A zinc anomaly and previously unreported occurrences of diorite-gabbro correlate with portions of the latter magnetic anomaly.

The potential for mineralization in the area is believed to be good. However, more detailed studies are required before the economic value of any mineralization can be assessed.

GENERAL GEOLOGY

On the Geologic Map of Georgia (1939) the study area is shown to be underlain by "Hornblende Gneiss." This term also includes lithologies such as diorite gneiss, gabbro, and injection gneiss which are not delineated separately on the map. Hopkins (1914) notes the occurrence of diorite and gabbro in the Elberton-Union Point-Monticello areas. Crickmay (1952) mentions the abundance of hornblende gneisses in Jasper and Putnam Counties.

Recent investigations by Matthews (1967) and Myers (1968) and current studies by D. Radcliffe and P. Prather (personal communication) demonstrate that hornblende-bearing gneisses in the Eatonton-Monticello areas are intruded by basic rocks which include diorite, gabbro, and norite. Delineation of these intrusives is complicated by the development of amphiboles either as primary or as late alteration minerals. Amphibole-rich intrusives are not easily distinguished from amphibolitic country rocks.

The Gladesville Norite is about 8 miles long. It maintains a uniform width of approximately 1 mile except in the northern segment where the width exceeds 3 miles (Matthews, 1967). Although the principal lithology is norite, olivine gabbro is also present. The dominant minerals in the intrusive are labradorite, orthopyroxene, clinopyroxene, and olivine. Common accessory minerals include actinolite, magnetite, ilmenite, corundum, spinel, and trace amounts of pyrite, pyrrhotite, chalcopyrite, and other sulfide minerals. The intrusive is cut by a series of later intrusive rocks. From oldest to youngest these are mafic dikes, pegmatites, and diabase dikes.

Matthews (1967) concludes that the surface dimensions of the Norite are small in comparison with the subsurface dimensions. Rhythmic layering presumably resulting from gravitational settling of cumulate minerals, strikes east-west and dips 60 degrees to the north. Assuming that the parallelism is not fortuitous, the indicated minimum thickness of the complex is approximately 23,000 feet. However, only 3 exposures were suitable for measuring the attitude of layering.

A thermal alteration zone occurs along the margin of the intrusive. This zone consists mainly of very dense, hornfelsic rocks. Locally, sillimanite schists are present. Principal minerals include plagioclase, quartz, hornblende, hypersthene, diopside, and garnet. Accessory minerals include magnetite, corundum, spinel, sphene, epidote, and apatite.

The country rocks intruded by the Gladesville Norite consist mainly of intimately interlayered quartzo-feldspathic and hornblende gneisses.

During the course of this investigation, outcrops of previously undescribed basic intrusives were identified on the Hillsboro Quadrangle east of the area mapped by Matthews (1967). Approximately 2 miles southeast of the Gladesville Norite outcrops of dioritic gabbro were identified. The outcrop distribution suggests a dioritic-gabbro complex trending northeast, parallel to the Gladesville Norite. The outcrop width may exceed a mile in some areas. Hornfelsic rocks occur along the margins of this intrusive. Outcrops of norite were also identified and interpreted from saprolite exposures in several areas but the surface extent of these intrusives was not investigated.

The most important mineral commodity obtained from the area is feldspar which is mined by the Feldspar Corporation. The feldspar is mined from pegmatites by open pit methods. Separation of feldspar from quartz, mica, and other pegmatite minerals is achieved by flotation of material ground to -20 mesh. All commercial pegmatites are confined to the Gladesville Norite. The dominant trend is north-south. In cross-section, they are irregular and complex in shape. Some are several hundred yards long and exceed a hundred feet in thickness. They have been mined to depths exceeding 50 feet. Small pegmatites occur in the country rocks.

In addition to feldspar, Matthews (1967) describes other commodities associated with the Gladesville Norite and the hornfelsic rocks of possible commercial value. Anthophyllite asbestos occurs in hydrothermally altered gabbro. Portions of the norite may constitute a suitable source of dimension stone. Sillimanite and emery are locally concentrated in the hornfelsic rocks of the contact zone.

GRAVITY SURVEY

Method of Study. Measurements of gravity were obtained for 136 stations in southern Jasper County. A LaCoste and Romberg Model G Geodetic gravity meter was employed for measurement. This meter has a reading accuracy of ±0.01 milligals and a drift rate of less than 1 milligal per month. Bouguer anomaly values were determined for each station according to the equation:

Bouguer anomaly = Obs. grav.-(Theoretical grav. +free air corr.-Bouguer Corr.)

Individual terms in the equation are discussed below.

Observed gravity values are those measured directly with the instrument and corrected for drift. The values are relative to a base station established by the Coast and Geodetic Survey in the town square of Monticello. The value reported for this station is 979563.00 milligals (personal communication, J. A. Kozlosky). A minimum of 3 readings were taken at each station and the average value was determined. The base station at Monticello was reoccupied at approximately 3 hour intervals to determine the rate of instrumental drift. The maximum drift measured for the time interval between reoccupation of the base station was 0.13 milligals; normally the drift was less than 0.05 milligals. Observed gravity values corrected for drift are estimated to be accurate to ±0.02 milligals, assuming the calibration constants for the instrument have not changed since they were determined by the manufacturer.

At sea level, gravity decreases from the equator to the poles because of polar flattening and earth rotation. Theoretical gravity is the calculated gravity at sea level for any particular latitude according to the 1930 International Gravity Formula.

The free air correction is used to compensate for the vertical distance a gravity station stands above sea level. This correction (0.09406 milligals/ft.) involves only elevation and is based on the vertical gradient of gravity at the earth's surface.

The Bouguer correction is used to compensate for the effect of rock lying between the land surface and sea level. This correction requires an assumption of the density of the rock mass. In the present study a density of 2.70 gm/cc is assumed. The combined value of the Bouguer and free air corrections is 0.0596 milligals/ft.

Elevations were surveyed with a level to an accuracy of ±0.1 ft. in the immediate vicinity of the Gladesville Norite. Elsewhere in the study area, elevations were determined by altimeter survey or taken from survey points at road intersections presented on the topographic maps. These elevations are accurate to approximately ±2 ft.

The maximum error in the calculated Bouguer anomaly value resulting from error of measurement of the gravity meter, error of estimating latitude, and elevation error is estimated to be less than ±0.20 milligals.

Results. A Bouguer anomaly map for the study area is presented in Plate 1. The most remarkable feature of the map is the steep gravity gradient. Lowest values occur in the northwest and highest values in the southeast. The maximum variation across the area is 44.8 milligals in a distance of only 12 miles.

Contour lines show a marked northeast trend. The + 10 milligal contour lies close to the western boundary of the Gladesville Norite. A slight depression is indicated by the +12 and +16 milligal contours southeast of the Gladesville Norite.

Conclusions. The general parallelism of gravity contours to the regional strike, and the fact that areas underlain by known basic intrusives are characterized by positive Bouguer anomaly values, suggests that the subsurface distribution of basic igneous rocks accounts mainly for the distribution pattern of Bouguer anomaly values. If this interpretation is valid, basic intrusives are extensive in the subsurface southeast of the Gladesville Norite. Exposed intrusives, such as the Gladesville Norite, may represent apophyses from the parent intrusion at depth. This is consistent with the general interpretation of Matthews (1967) based on the attitude of rhythmic layering in the Gladesville Norite. However, the Gladesville Norite probably does not extend to the subsurface in the northwest as Matthews suggests, because Bouguer anomaly values are negative in this area.

The slight depression indicated by the + 12 and + 16 milligal contours appears to correspond with a band of quartzo-feldspathic amphibolite country rock separating the Gladesville Norite from a diorite-gabbro intrusive to the southeast. The latter may connect with the Gladesville Norite at depth.

Before any final conclusions can be made regarding the relationship between gravity and geology, the entire areal extent of the positive anomaly should be delineated. The indicated magnitude suggests that it is one of the major gravity features of the Piedmont.

MAGNETIC SURVEY

Method of Study. Measurements of the intensity of the vertical component of the earth's magnetic field were obtained at 500 stations in the vicinity of the Gladesville Norite. Measurements were made with a Scintrex (Model MF-11) flux-gate magnetometer. The reading precision of the instrument is ± 10 gammas on the 1,000x scale. Measurements are relative to a base station located on a side road which intersects Highway 83 in the central portion of the Gladesville Norite. The base station was reoccupied every 2 or 3 hours in order to determine instrumental and diurnal drift rates. The accuracy of magnetic values corrected for drift is estimated to be ± 20 gammas, except for values in excess of 1,000 gammas which required measurement on a less sensitive scale. For these measurements a maximum error of ± 50 milligals is estimated.

Measurements were taken along all roads in the area generally at intervals of about 100 yards. In addition, measurements were taken at variable spacings along traverses through wooded areas. Readings were not made near fances, buried cables and pipelines, powerlines, galvanized roof buildings, and railroad tracks as the natural magnetic field is disturbed in the vicinity of these features.

Local variations in the earth's magnetic field result from contrasts in the concentrations of magnetic minerals in the rocks. In general, variations result from differences in magnetite (Fe_3O_4) content; however, local concentrations of ilmenite ($FeTiO_3$), monoclinic pyrrhotite (Fe_7S_8), maghemite (Fe_2O_3 - Fe_3O_4), and limonite (Fe_2O_3 nH_2O) can produce positive magnetic anomalies.

Results. The magnetic field in southwestern Jasper County is extremely variable over both the country rocks and the Gladesville Norite. Variations in excess of 100 gammas were commonly encountered at points separated by only 2 or 3 paces. Plate 2 shows the variation in vertical magnetic intensity at a contour interval of 1,000 gammas.

Three large positive anomalies and several smaller ones are present. The most continuous anomaly is developed on the western portion of the Gladesville Norite. This anomaly bifurcates and envelopes a large magnetic low over the northern portion of the intrusive. Values are in excess of +10,000 gammas. A second anomaly occurs on the southeastern margin of the Gladesville Norite. A third anomaly forms a broad belt southwest of Adgateville. The limits of this anomaly are not defined.

Negative values characterize most of the area surveyed. Well developed negative troughs are present southeast of McElheney's Crossroads, southeast of the northern segment of the Gladesville Norite, and in the northern part of the Norite where values less than -2,000 gammas lie adjacent to the intense positive anomaly described above.

Conclusions. The Gladesville Norite and the contact zone contain significant quantities of magnetic minerals and pronounced positive anomalies follow portions of this intrusive and the marginal hornfels zone. Polished sections of specimens from the intrusive and contact zone commonly contain several per cent magnetite and ilmenite. Pyrrhotite is locally present.

The anomaly southwest of Adgateville may reflect the occurence of a diorite-gabbro complex. Thin sections of specimens from several outcrops within this anomaly range from diorite to gabbro in mineral composition. Hornfels were also identified in this area. Magnetite and ilmenite were identified in these rocks.

GEOCHEMICAL SURVEY

Stream sediment has been collected and analyzed from 37 localities in the vicinity of the Gladesville Norite. This study was initiated to determine if abnormal concentrations of nickel, copper, or zinc are contained in portions of the intrusive that are exposed to weathering. Several hundred additional stream sediment and soil samples will be taken from the area to provide comprehensive coverage and to reduce the chances of overlooking mineralization of potential economic interest.

Method of Study. Stream sediment samples were collected and stored in polyethylene bags and subsequently dried under infrared lamps. Next, hardened clumps were disaggregated and the material was screened to -80 mesh with stainless steel screens.

For analysis, 0.1 grams of each sample was mixed with 0.5 grams of lithium metaborate and fused at 950° C. for 15 minutes. The fused sample was dissolved in 50 ml. of 4% nitric acid while hot and the sample solution was diluted to 100 ml. with a solution consisting of 4% nitric acid and 1% dissolved lithium metaborate.

These solutions were analyzed on a Perkins Elmer Atomic Absorption Spectrometer (Model 303) against zinc, copper, and nickel standards. The concentration of standard solutions was 0.25, 0.50, 1.0, and 2.0 micrograms/ml. The absorbance measurements and background were taken directly from the chart print-out of a recording galvanometer. The absorption curve for the standards was linear over the concentration range tested.

Results. Background values for nickel range from 131 to 208 ppm (Plate 3). Samples containing over 210 ppm are judged to be anomalous (line pattern). Values in excess of 300 ppm are considered to be "distinct" anomalies which may reflect mineralization of potential economic significance (cross-hatched pattern, Plate 3).

The majority of streams draining the Gladesville Norite contain anomalous concentrations of nickel. Highest concentrations occur in the northern segment. This anomaly is of particular interest because it lies within the area of the most intense magnetic anomaly identified in the study. Verification of this anomaly is required, however, because the anomalous streams receive the effluent of the processing plant of the Feldspar Corporation. A soil sample collected from the southern portion of the intrusive is above the background extablished for streams; however, relative to other soil samples in the area, it may not be anomalous.

Background for copper ranges from 97 to 198 ppm (Plate 4). Values exceeding 200 ppm are judged to be anomalous. A single anomalous area is represented by 3 samples in streams draining the northern segment of the Gladesville Norite. This anomaly corresponds to the one described above for nickel. The sample containing 215 ppm is from a stream that does not receive effluent from the Feldspar Corporation processing plant.

Background for zinc ranges from 140-239 ppm (Plate 5). Values exceeding 250 ppm are judged to be anomalous. Three anomalous areas are indicated: The largest anomaly occurs in two drainages located about 2 miles southeast of the Gladesville Norite. The sample containing 510 ppm may not be very meaningful. It was collected from a swamp in which iron and manganese oxide residues have precipitated with clay and the clastic component of the sample is minimal. The anomalous drainage includes outcrops of diorite-gabbro mentioned previously. Another anomalous area is located on the northern segment of the Gladesville Norite. This drainage is also anomalous for nickel and copper. A soil sample collected from the southern part of the intrusive exceeds the background value determined for stream sediments; however, relative to other soils in the area, it may not be anomalous.

Conclusions. A preliminary stream sediment geochemical survey of southern Jasper County for nickel, copper, and zinc has disclosed anomalous concentrations of these elements. More comprehensive coverage is required to provide a statistical basis for determining more precisely the anomaly threshold.

Streams in the northern segment of the Gladesville Norite are anomalous for nickel, copper, and zinc. The likelihood of economic mineralization is judged to be greatest in this area. The degree of contamination must be determined for certain streams in this area which receive effluent from the Feldspar Corporation plant.

RECOMMENDATIONS FOR FUTURE STUDY

The following projects are proposed to further evaluate the mineral potential of the Gladesville Norite and associated rocks.

1. More comprehensive coverage by stream sediment geochemistry. (The magnetic anomaly on the southeastern margin of the Gladesville Norite is not included in the drainage area of current samples.)
2. Detailed stream sediment and soil geochemistry survey of the northern portion of the Gladesville Norite.
3. Detailed magnetic survey of the northern portion of the Gladesville Norite.
4. Reconnaissance survey for chromite, platinum-group minerals and other heavy minerals of potential economic value. (Thirty-seven alluvial samples have already been collected for this purpose but they have not been processed.)
5. Regional gravity coverage to delineate the large gravity anomaly disclosed in the present study.
6. Diamond core drilling, if mineralization is indicated substantially in subsequent work.

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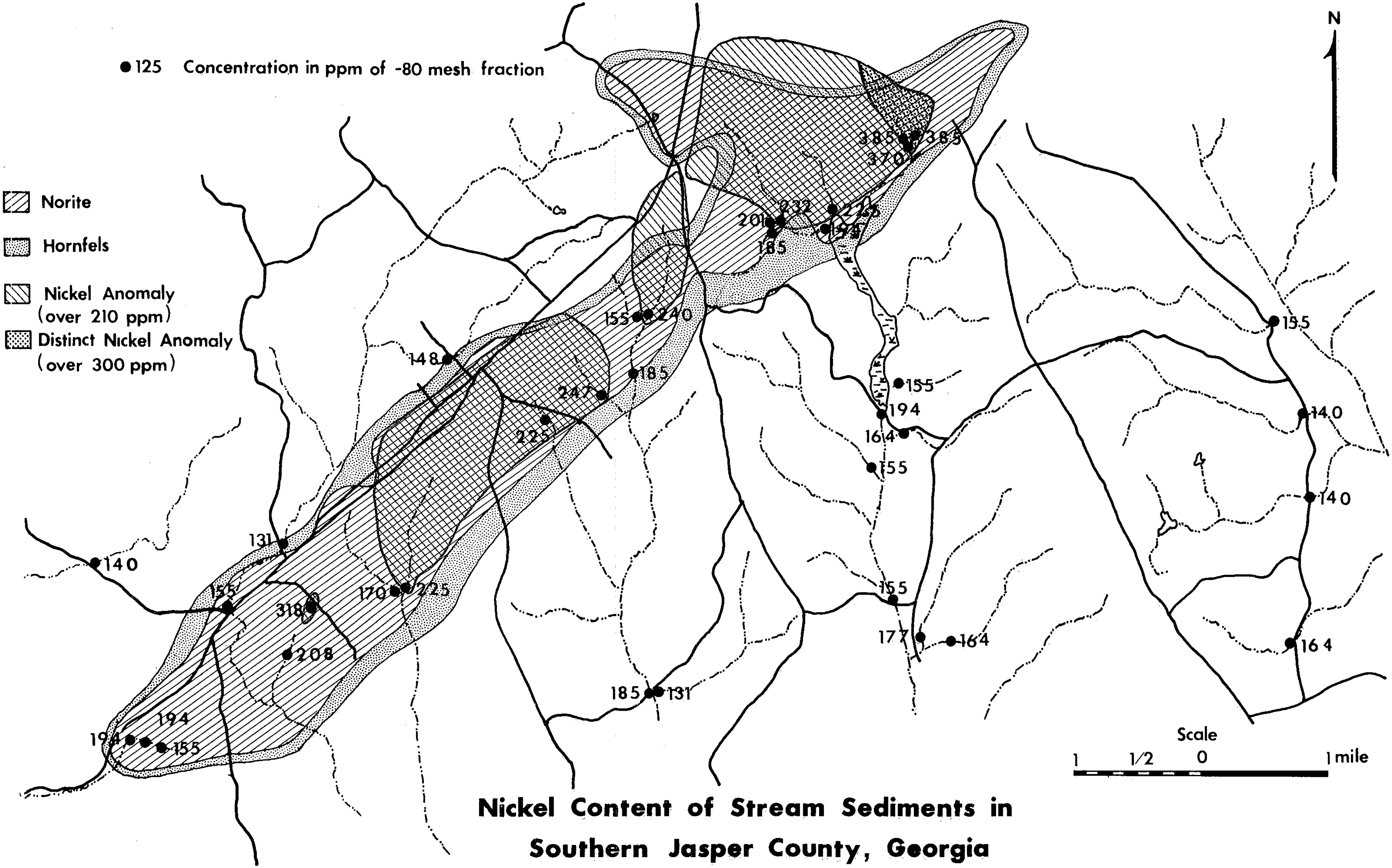
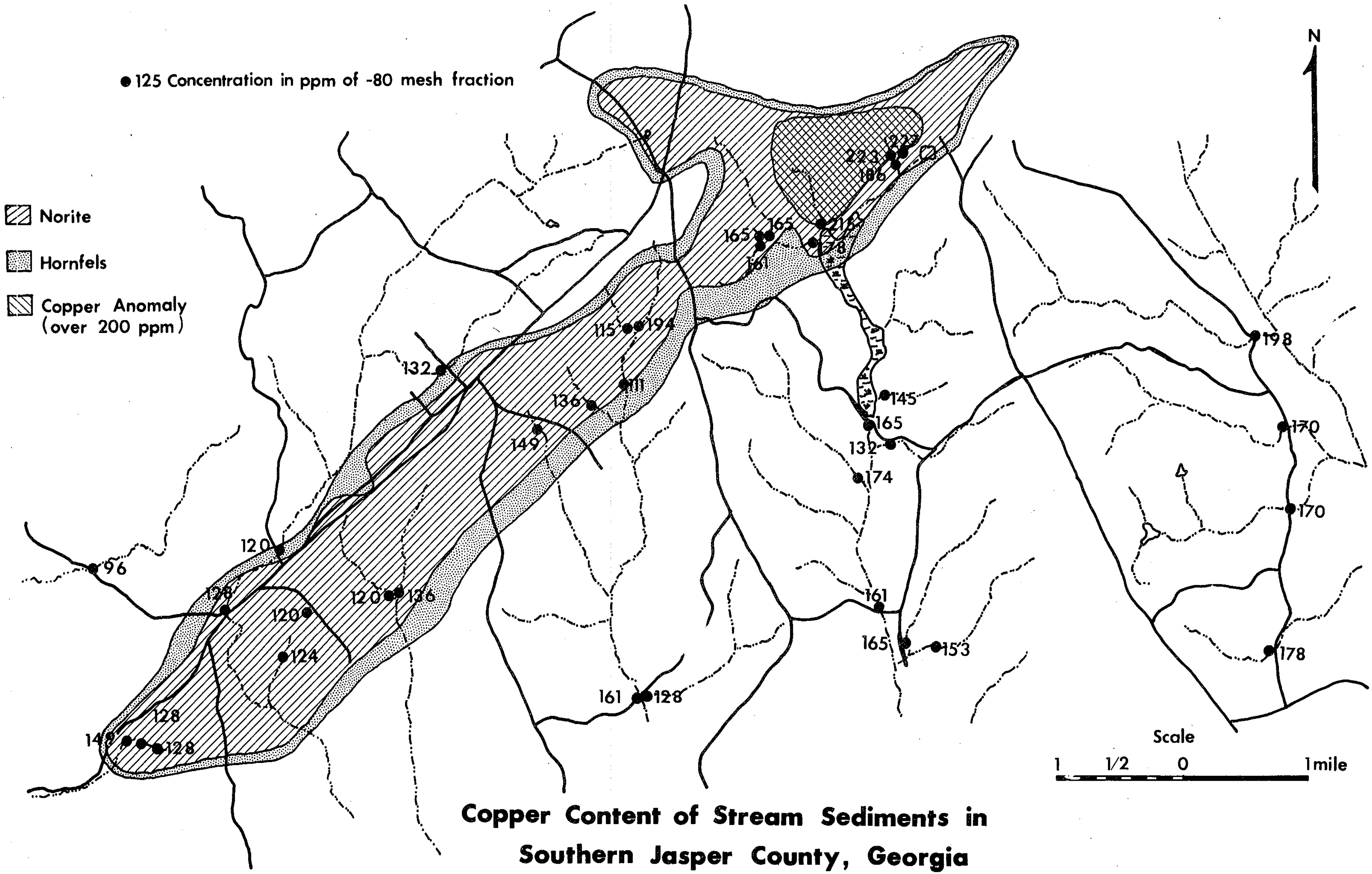


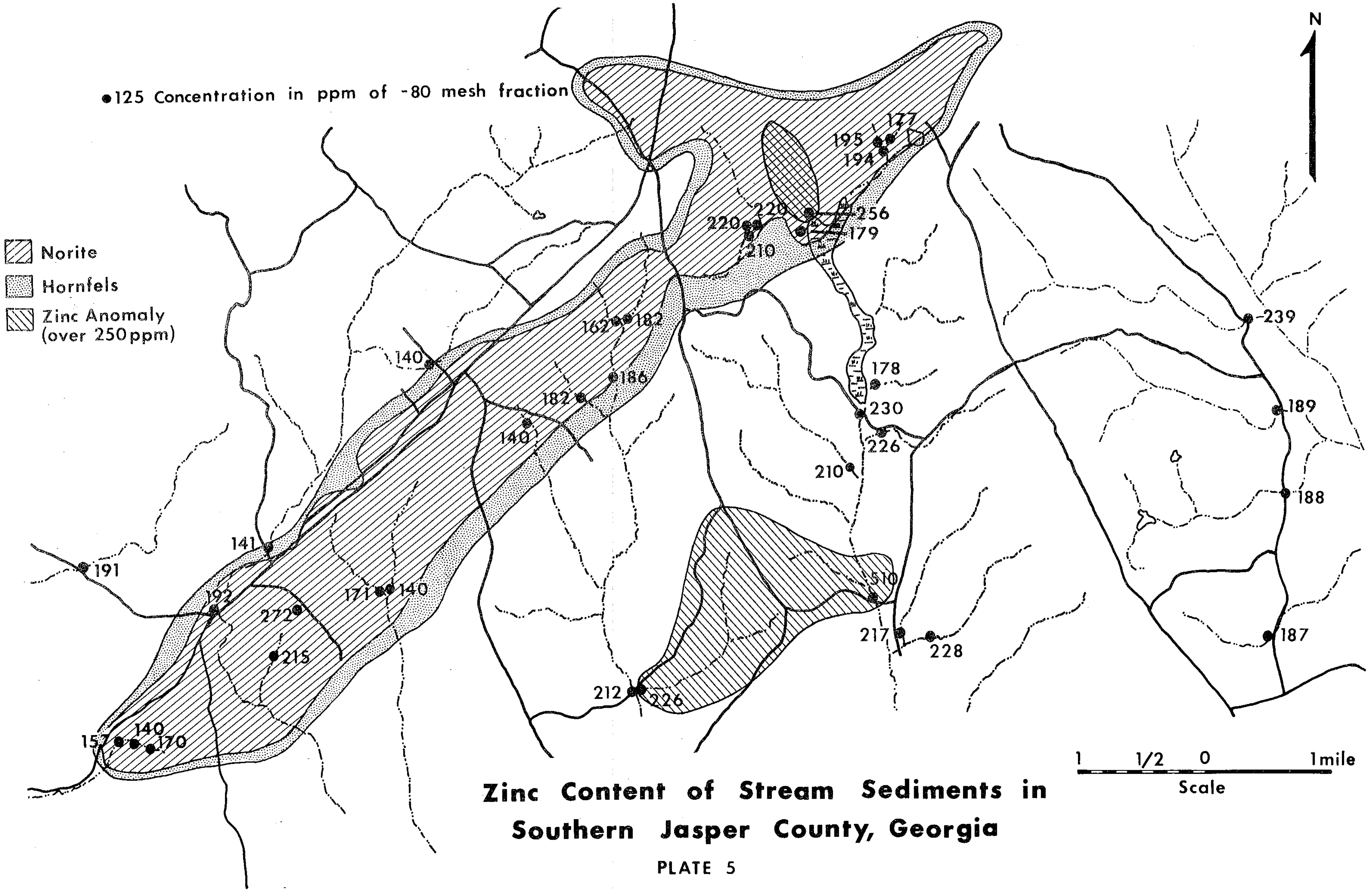
Nickel Content of Stream Sediments in Southern Jasper County, Georgia

PLATE 3



Copper Content of Stream Sediments in Southern Jasper County, Georgia

PLATE 4



Zinc Content of Stream Sediments in Southern Jasper County, Georgia

PLATE 5

PLATE 1

Bouguer Anomaly Map of Southern Jasper County, Georgia

Contour Interval 2 Milligals

Combined Bouguer and Free Air Correction 0.0596 Milligals/Foot

Assumed Density 2.70

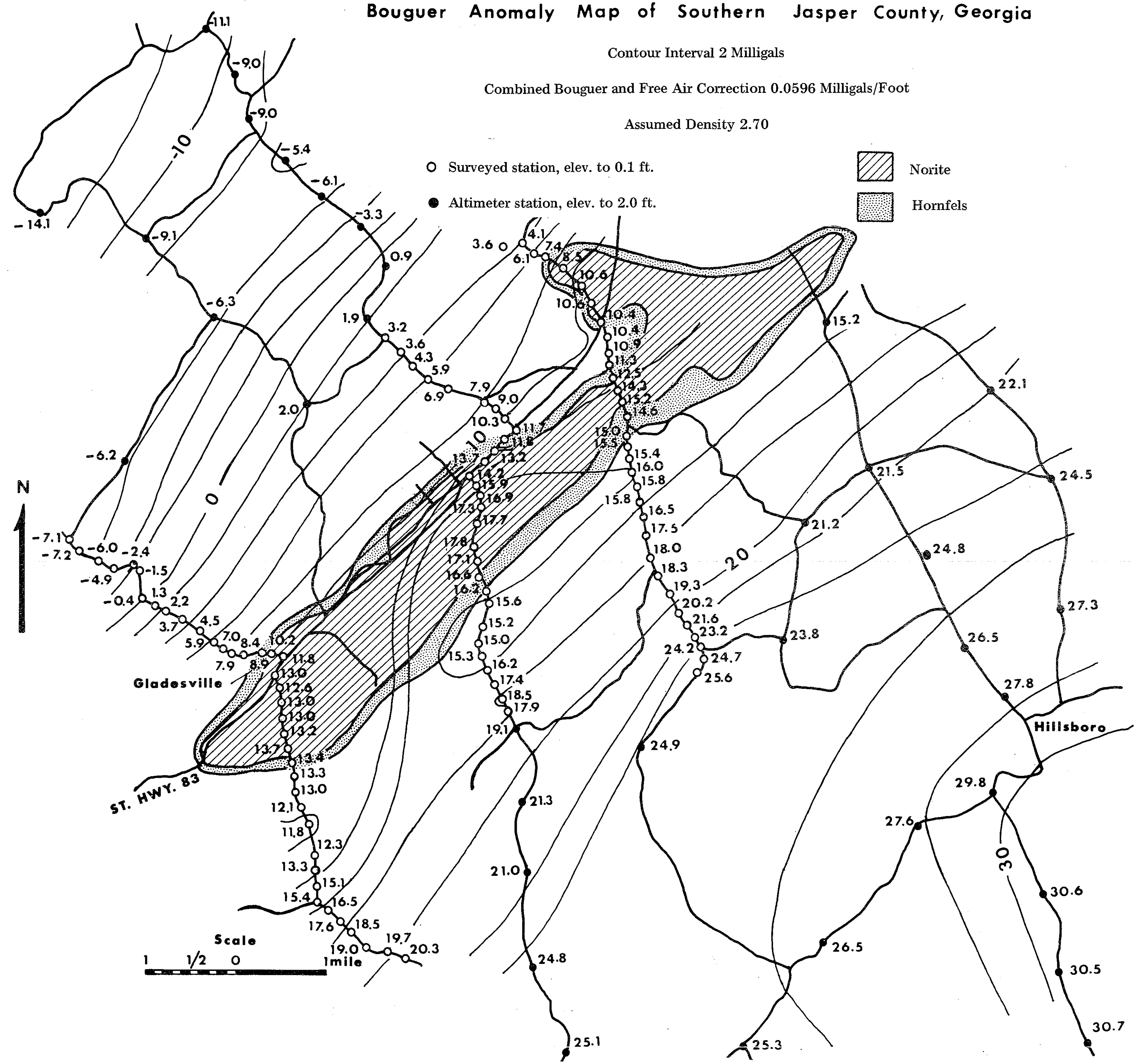


PLATE 2

Vertical Magnetic Intensity Map of the Gladesville Norite