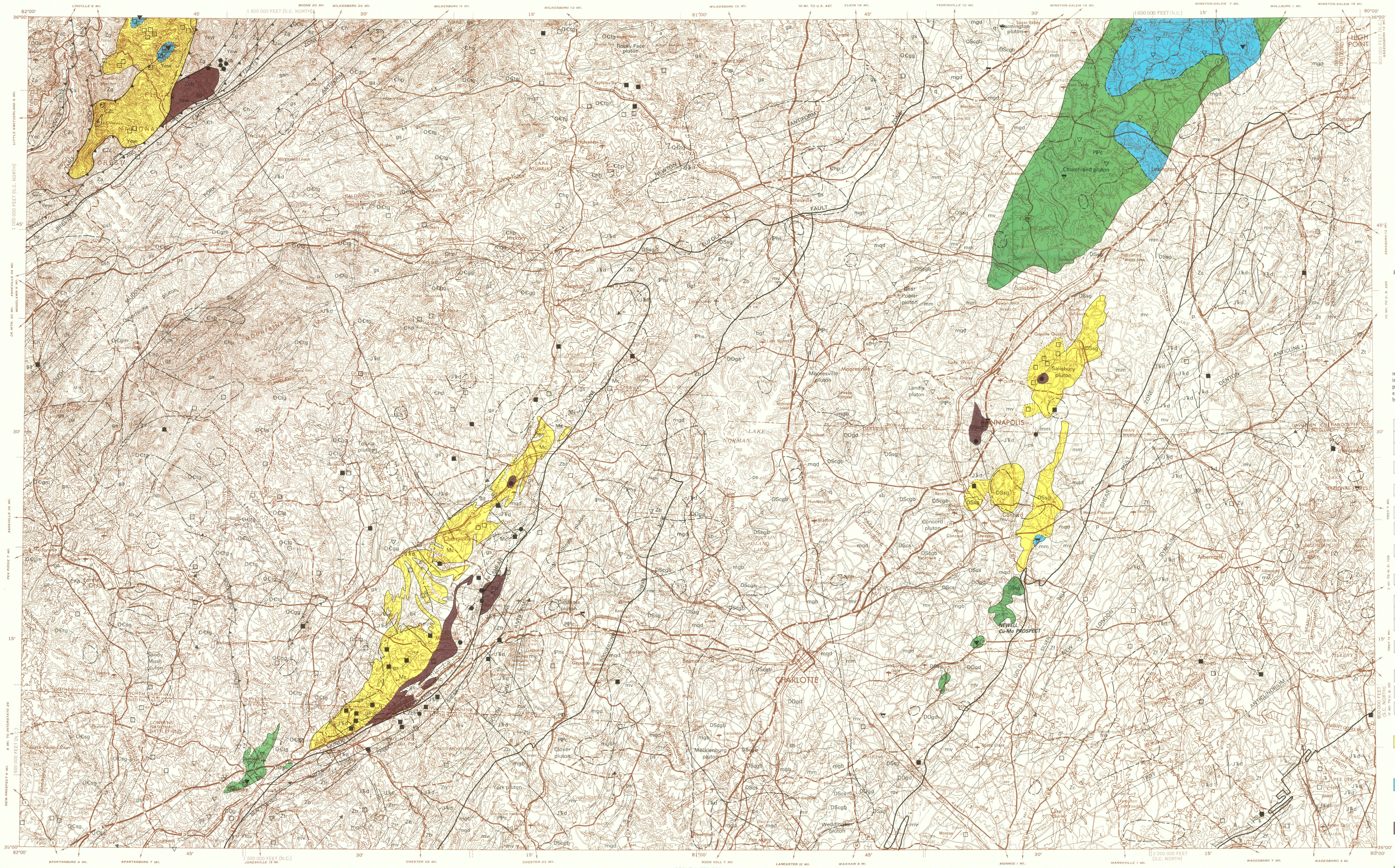
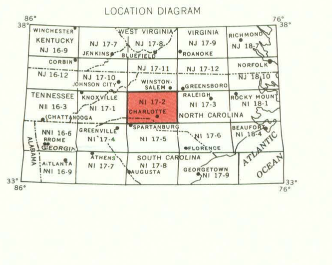


Base from U.S. Geological Survey, 1953
Photorevised as of 1974
100,000-foot grids based on North Carolina coordinate system and South Carolina coordinate system, north zone

SCALE 1:250 000

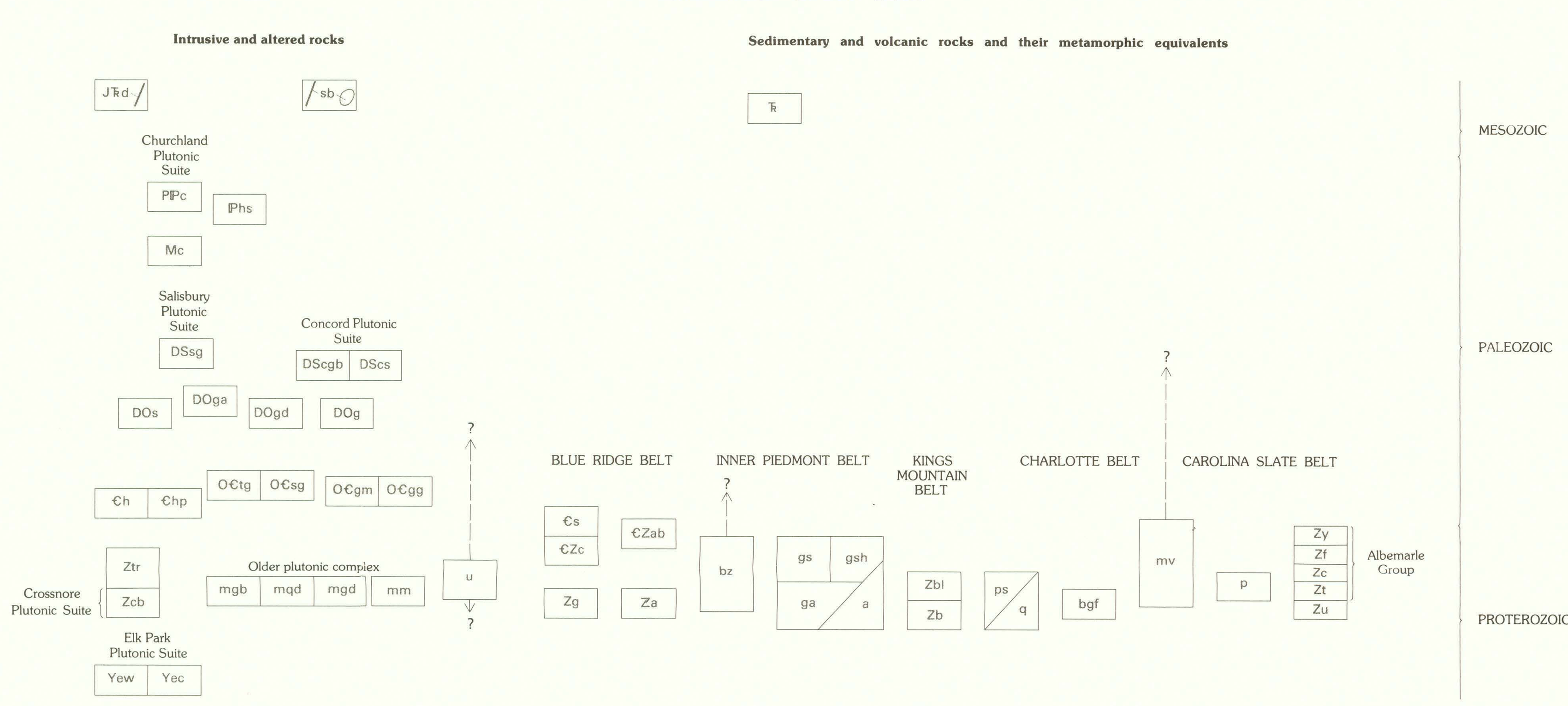
CONTOUR INTERVAL 100 FEET
WITH SUPPLEMENTARY CONTOURS AT 50 FOOT INTERVALS
NATIONAL GEODETIC VERTICAL DATUM OF 1929



INTERIOR—GEOLOGICAL SURVEY, RESTON, VA.—1986—G84242

Geologic base modified from Goldsmith and others (in press)
Beryllium, molybdenum, and niobium resource potential by J. E. Gair, 1982. Geochemistry by W. R. Griffitts, J. W. Whitlow, and D. F. Siems

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

This map is generalized from Goldsmith and others (in press) in order to make an appropriate base for mineral-resource assessment as part of a project in the Conterminous United States Mineral Assessment Program. Most of the plutonic rock units and all localities of ultramafic rock are shown. Minor stratiform rock units and subdivisions of major stratiform rock units have not been shown.

Sedimentary and volcanic rocks and their metamorphic equivalents

Unit	Description
TR	Sandstone, siltstone, and conglomerate
Ꞓs	Shady Dolomite (Early Cambrian)
ꞒZc	Chilhowee Group (Early Cambrian to Late Proterozoic)—Quartzite, arkosic quartzite, and phyllite
ꞒZab	Alligator Back Formation (Early Paleozoic and/or Late Proterozoic)—Laminated quartzofeldspathic gneiss, mica schist, and amphibolite
bz	Rocks of the Brevard zone—Variably sheared biotite gneiss, mica schist, quartzite, metavolcanic rocks, phyllite, and marble. Includes rocks of several formations
gsh	Muscovite schist, layered biotite gneiss, and subordinate quartzite and amphibolite; contains narrow zones of Henderson Gneiss
gs	Biotite gneiss, biotite-muscovite schist, sillimanite mica schist, and subordinate layers of calc-silicate rock, quartzite, meta-conglomerate, and many small masses of granite and pegmatite
bgf	Fine-grained biotite gneiss—Strongly foliated but commonly massive rock of granitic to tonalitic composition. Minor amphibolite and muscovite schist. Probably metamorphosed intermediate volcanic rock
ga	Biotite gneiss, amphibolite and hornblende gneiss; minor sillimanite and mica schist, and many small masses of granite and granite gneiss locally forming migmatite
a	Amphibolite
ps	Phyllite and mica schist; minor quartzite
q	Quartzite; subordinate mica schist and phyllite. Probably includes both metamorphosed sandstones and metamorphosed hydrothermally leached and silicified rock
mv	Metavolcanic rocks, undivided—Includes mafic, intermediate, and felsic volcanic rocks and Flat Swamp Member of the Cid Formation and metavolcanic rocks of the Battleground Formation.
Zg	Grandfather Mountain Formation (Late Proterozoic)—Arkose, siltstone, phyllite, conglomerate and felsic volcanic rocks
Za	Ashe Formation (Late Proterozoic)—Muscovite-biotite gneiss, commonly sulfidic; mica schist, and amphibolite
Zy	Yadkin Formation (Late Proterozoic)—Graywacke
Zf	Floyd Church Formation (Late Proterozoic)—Siltstone and argillite
Zc	Cid Formation (Late Proterozoic)—Mudstone member
Zt	Tillery Formation (Late Proterozoic)—Laminated siltstone and mudstone
Zu	Uwharrie Formation (Late Proterozoic)—Felsic volcanic rocks
p	Phyllite (Late Proterozoic)—Probably equivalent to Tillery Formation (Zt) and Cid Formation (Zc)
Zbl	Blacksburg Formation (Late Proterozoic)—Sericite phyllite or schist and subordinate beds of marble, micaceous quartzite, and amphibolite
Zb	Battleground Formation (Late Proterozoic)—Quartz-sericite schist and phyllite, and subordinate beds of quartz-pebble conglomerate, quartzite, kyanite or sillimanite quartzite, and manganiferous schist. Metavolcanic rocks of the Battleground Formation are included in mv

Intrusive and altered rocks

Unit	Description
JTRd	Diabase (Jurassic and Triassic?)
sb	Silicified breccia zones
PIPc	Churchland Plutonic Suite (Permian and Pennsylvanian)—Predominantly porphyritic granite containing microcline phenocrysts
IPhs	High Shoals Granite (Pennsylvanian)—Porphyritic gneissic granite
Mc	Cherryville Granite (Mississippian)—Biotite-muscovite granite; some associated pegmatites contain spodumene
DSsg	Salisbury Plutonic Suite (Devonian and Silurian)—Leucocratic granite
DScgb	Concord Plutonic Suite (Devonian and Silurian)—Gabbro, norite, gabbro-norite, and hornblende gabbro
DScs	Syenite of Concord Plutonic Suite
DOga	Alaskitic granite, fine-grained
DOgd	Granodiorite, non- to weakly foliated
DOg	Gneissic metagranite—Medium- to coarse-grained gneissic biotite granite
DOs	Spruce Pine Alaskite (Early Devonian to Late Ordovician)—Biotite-muscovite granite and granodiorite; associated pegmatites are a source for feldspar and muscovite
OꞒtg	Toluca Granite (Early Ordovician and Cambrian)—Medium-grained gneissic to non-gneissic granite and granodiorite; garnet and monazite common accessories
OꞒsg	Granite of Sandy Mush—Porphyritic gneissic granite probably genetically related to the Toluca Granite
OꞒgm	Migmatitic granitoid gneiss and quartz-diorite gneiss containing inclusions and screens of biotite gneiss amphibolite and metagabbro, and masses of gneissic and non-gneissic granite to quartz diorite similar to the Toluca Granite
OꞒgg	Granitoid gneiss—Layered gneissic biotite granite to hornblende-biotite quartz diorite
Ꞓh	Henderson Gneiss (Cambrian)—Inequigranular, granitic to granodioritic biotite gneiss. Typically contains lensoid microcline mega crysts and microcline-plagioclase aggregates parallel to foliation
Ꞓhp	Garnetiferous phase of Henderson Gneiss—Granitic to granodioritic biotite gneiss containing tabular to lensoid feldspar megacrysts in garnetiferous matrix
Ztr	Metamorphosed trondhjemite and biotite tonalite (Late Proterozoic)
mgb	Metamorphosed gabbro, diorite, and diabase
mqd	Metamorphosed quartz diorite, diorite, and tonalite; locally porphyritic
mgd	Metamorphosed granodiorite; locally porphyritic
mm	Mafic and ultramafic complex—Metamorphosed gabbroic and ultramafic intrusives, hypabyssal and probably extrusive basalts
u	Ultramafic rocks, variably altered to soapstone and serpentinite
Zcb	Brown Mountain Granite (Late Proterozoic)—Medium- to coarse-grained leucocratic granite, locally blastomylonitic
Yew	Wilson Creek Gneiss and Blowing Rock Gneiss (Middle Proterozoic)—Equigranular granite to diorite gneiss; coarse-grained granite augen gneiss
Yec	Cranberry Gneiss (Middle Proterozoic)—Equigranular granite and layered granite, granodiorite, and biotite gneiss

EXPLANATION OF MAP SYMBOLS

- Contact
- High angle fault, dashed where inferred
- Reverse fault, teeth on upthrown plate, dashed where inferred
- Reverse fault, overturned
- Thrust fault, teeth on overriding plate, dashed where inferred
- Anticline or antiform, showing direction of plunge
- Syncline or synform, showing direction of plunge
- Overturned anticline, or antiform showing direction of dip of limbs
- Overturned syncline or synform, showing direction of dip of limbs

EXPLANATION

Areas of resource potential

Beryllium
- Wilson Creek Gneiss (Yew)
- Cherryville Granite (Mc)
- Devonian and Silurian Granite of the Salisbury Plutonic Suite (DSsg)

Beryllium and Molybdenum
- Wilson Creek Gneiss (Yew)
- Churchland granite pluton of the Churchland Plutonic Suite (PIPc)
- Devonian and Silurian Granite of the Salisbury Plutonic Suite (DSsg)

Beryllium and Niobium
- Brown Mountain Granite (Zcb)
- Cherryville Granite (Mc)
- Devonian and Silurian granite of the Salisbury Plutonic Suite (DSsg)

Molybdenum
- Toluca Granite (OꞒtg)–Also includes bordering areas
- Churchland granite pluton of the Churchland Plutonic Suite (PIPc)–Porphyritic granite
- Devonian and Silurian granite of the Salisbury Plutonic Suite (DSsg)–Abandoned copper-molybdenum prospect and observed molybdenite
- Disseminated molybdenite flakes in granite

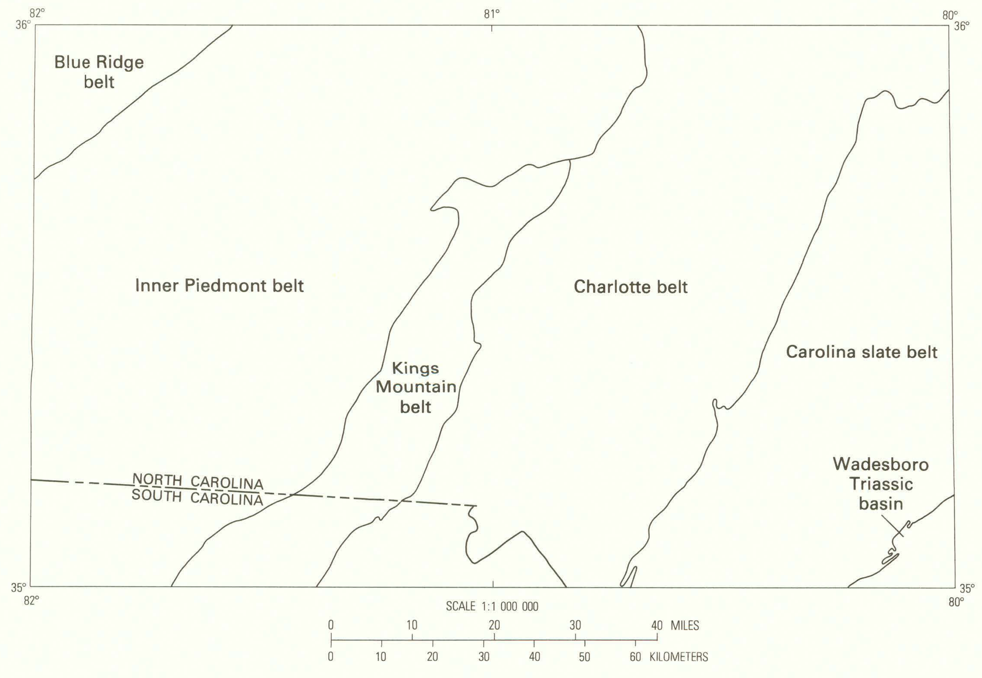
Geologically favorable formation for mineral deposits—Dashed line indicates area extended by favorable geochemical anomalies

National Uranium Resource Evaluation (NURE)—Areas determined using minus 100–mesh sediment samples (Ferguson, 1979)
- Outline of area which has >50 ppm beryllium
- Outline of area which has 20–50 ppm beryllium
- Outline of area which has 10–15 ppm molybdenum

Tin-spodumene belt of Kesler (1942)

Boundary of major lithotectonic belt

Isolated sample site where anomalous amount of element found in pan concentrate
- ■ Beryllium >100 ppm in nonmagnetic fraction
- □ Beryllium 50–100 ppm in nonmagnetic fraction
- ▼ Molybdenum ≥30 ppm in nonmagnetic fraction
- ▽ Molybdenum 20 ppm in nonmagnetic fraction
- ▽ Molybdenum 10–15 ppm in nonmagnetic fraction
- ● Niobium 2000–5000 ppm in magnetic fraction (Frantz magnetic separator set at 0.5 amperes)
- ○ Niobium 2000–5000 ppm in nonmagnetic fraction



Index map showing major lithotectonic belts in the Charlotte 1° x 2° quadrangle (Belts outlined but not labeled on large map)

INTRODUCTION

The mineral resources of the Charlotte 1° x 2° quadrangle, North Carolina and South Carolina, were assessed between 1978 and 1982 under the Conterminous United States Mineral Assessment Program (CUSMAP). The mineral-resource assessments were made on the basis of geologic and geophysical investigations, the presence of existing or abandoned mines, mapped mineral occurrences, and, where appropriate, on heavy-mineral occurrences seen in pan concentrates or detected by geochemical analysis of pan concentrates. The data sources and resource assessments for all commodities studied are listed in a U.S. Geological Survey Circular (Gair and others, in press).

BERYLLIUM, MOLYBDENUM, AND NIOBIUM RESOURCE POTENTIAL

Beryllium, molybdenum, and niobium have not been produced in the quadrangle. Known mineral occurrences are scarce except for the beryllium mineral, beryl, which occurs in minor amounts in the pegmatites of the tin-spodumene belt of Kesler (1942), along the southeast side of the Inner Piedmont belt. The mineral-resource assessment, therefore, is made almost totally on the basis of geochemical data obtained from pan-concentrate samples collected during CUSMAP, and, to some extent, on the basis of data from a sampling program of the National Uranium Resource Evaluation (NURE) (Ferguson, 1979). Other mineral-assessment maps of this folio show combinations of data for favorable geologic formations, mineral occurrences (particularly sites of production), and geochemical anomalies which have been utilized to define areas of high, moderate, and low resource potential for each commodity. On this map, because of the availability only of geochemical data and the general uncertainty about the very existence of these resources, the areas of resource potential are shown without attempting to qualify them. The areas shown probably have low potential at best. Some areas which coincide with geologic formations, as mapped by Goldsmith and others (in press), are identified as favorable because they contain or are adjacent to groups of samples which have high values of beryllium, molybdenum, or niobium. The geochemical distributions of beryllium and molybdenum are discussed by Griffitts, Duttweiler, Whitlow, Siems and Hoffman (1985a, b); the geochemical distribution of niobium is discussed by Griffitts, Whitlow, Duttweiler, Seims and Wilch (in press). Many other sample sites on the map where pan concentrates contain high beryllium or molybdenum contents have no apparent association with specific geologic formations and are shown on the map only as data points. These points, however, could represent local "spots" of low resource potential. Areas of resource potential that contain anomalous amounts of beryllium and molybdenum in minus 100-mesh samples of stream sediment, collected during NURE (Ferguson, 1979), are outlined on the map as well. Overlap occurs in places between the areas of CUSMAP and NURE anomalous data.

Beryllium resource potential may be associated with some geologic formations. In particular, it may be associated with a pegmatite zone that occurs along the southeast side of the Cherryville Granite pluton and makes up much of the tin-spodumene belt of Kesler (1942) (Griffitts, Duttweiler, Whitlow, Siems and Hoffman, in press). Beryllium potential is also associated with rocks of the Salisbury Plutonic Suite in the Charlotte belt. Beryllium resource potential has been deduced from NURE-derived anomalies, especially above the Churchland pluton in the Charlotte belt. Scattered high geochemical values for beryllium occur widely within the Carolina slate belt, but do not seem to be related to any particular formation.

The principal areas of molybdenum resource potential are associated with some plutons of the Charlotte belt and a small body of Toluca Granite near Gaffney, South Carolina. Minor occurrences of molybdenite are known in a few places in these plutonic rocks. Porphyry-type, copper-molybdenum, vein-disseminated sulfide mineralization in quartz monzonite at the Newell prospect, south of Concord, North Carolina was drilled between 1965 and 1967 (Worthington and Lutz, 1975). The average of the richest grades of material encountered during the drilling (0.03 to 0.04 percent copper and 0.01 to 0.02 percent molybdenum) was in an area of about 600 m (2,000 feet) in diameter. Other places in the Charlotte belt where occurrences of molybdenite have been reported are the Woodleaf Quarry about 16 km northwest of Salisbury, in association with zeolites along a contact between diorite and granite (Privett, 1974), and the northern part of the Salisbury pluton, disseminated in adamellite and in shear zones cutting this rock (English, 1984). The maximum content of molybdenite in samples from the latter occurrence is 0.025 percent. The extent of molybdenum mineralization at the Woodleaf Quarry and in the Salisbury pluton is unknown and the resource potential at these places is considered low to moderate. In a few places within the area underlain by the Wilson Creek Gneiss, there is a low potential for molybdenum resources where pan concentrates contain anomalous amounts of molybdenum (Griffitts and others, 1985b).

Niobium is associated with several granite bodies in the quadrangle, particularly the Brown Mountain pluton and the pegmatite zone along the southeast side of the Cherryville pluton. One of the Silurian and Devonian granite bodies south of Salisbury, North Carolina, in the Charlotte belt has potential for niobium resources, but ixiolite [(Ta, Fe, Sn, Nb)O_2] instead of the common niobium mineral, columbite, is present there (Griffitts and others, in press). Niobium values in the range of 200 to 1,000 ppm are associated with some anomalous values for beryllium and molybdenum in the northern part of the Wilson Creek Gneiss body (Crandall and others, 1982). Other anomalous amounts of beryllium and niobium in pan concentrates of the Kings Mountain belt probably result from transport of material by streams draining the adjacent part of the Inner Piedmont belt.

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MINERAL RESOURCE POTENTIAL FOR BERYLLIUM, MOLYBDENUM AND NIOBIUM IN THE CHARLOTTE 1° x 2° QUADRANGLE, NORTH CAROLINA AND SOUTH CAROLINA

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1986

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