NORTH CAROLINA
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
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Information Circular 13

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PETROGRAPHY AND ECONOMIC ASPECTS OF THE

# MISCELLANEOUS COMMERCIAL ROCKS OF NORTH CAROLINA

BY

RICHARD J COUNCILL

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# PETROGRAPHY AND ECONOMIC ASPECTS OF THE MISCELLANEOUS COMMERCIAL ROCKS OF NORTH CAROLINA

By

Richard J. Councill

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## INTRODUCTION

Miscellaneous commercial rocks in North Carolina include a wide variety of rocks which, because of origin as well as physical and mineralogical properties, are not closely related to the general rock classifications of granite, slate, or limestone. Specifically, this group classification includes the gneissic and schistose rocks with highly variable mineral compositions; quartzites and other moderately to greatly altered or metamorphosed sedimentary rocks, largely of mixed compositions; sandstones; and an unusual variety of granitoid rock, known as unakite. Of these diversified rock types, the gneisses and schists have been utilized in past years in the production of large volumes of crushed rock products, while the metasedimentary rocks, notably the quartzites, have been quarried for use as building stone in many parts of Piedmont and Western North Carolina for more than fifty years. The building-stone quarries represent the principal commercial production among the miscellaneous rocks in these areas, but production is small and, as in the past, supplies local markets principally.

Because diversified types of building stone are being used in increasing volume, there exists in North Carolina and outlying areas large markets for specialty stones such as are discussed in this report. With the markets a reality, the producers of miscellaneous rocks in the State are in a position to supply native stone to many areas in the Southeast.

However, in order to gain these markets, the various rocks must be presented to and accepted by the architects and builders who are largely responsible for the success or failure in popularity of any building stone placed on the market.

## Purpose and Scope

This circular is the last in a series of three reports designed to present current information relating to the noncalcareous rock deposits of North Carolina, namely, the granites and related rocks, the slates and slaty volcanic rocks, and the miscellaneous rocks. It has been the purpose in the two previous reports (Councill, 1954) to consider in some detail the physical, chemical, and structural properties, geologic occurrence, mineralogical composition, uses, and general distribution of these rocks in North Carolina. This report has a similar purpose, and the information obtained during the investigation is presented in a corresponding manner.

During the fieldwork and preparation of this report, the more important localities of past, present, and potential production were visited, representative specimens of the various rocks were collected, and structural conditions were noted at all quarries. Thin-section analyses were made of a few of the rocks, and others were obtained from publications of the Division of Mineral Resources of the North Carolina Department of Conservation and Development. Production data are given for the operating and sporadically operated quarries where available. Noncommercial quarries utilizing miscellaneous rocks in the production of crushed stone are operated in many areas of North Carolina by the North Carolina State Highway and Public Works Commission but are not discussed in this report.

## Acknowledgments

Grateful acknowledgments for their unlimited cooperation during the fieldwork for this report are due Messrs. T. A. Slagle, T. K. Pease, A. P.

Causby, B. S. Ledbetter, F. T. Taylor, and Julian and John Green. The fieldwork and preparation of the report were done under the general supervision of Dr. Jasper L. Stuckey, state geologist. Mr. S. D. Broadhurst, assistant state geologist, contributed much valuable information concerning quarry locations in the western part of North Carolina. For this information, the author is greatly indebted. Publications of the Division of Mineral Resources and of the United States Geological Survey were consulted frequently during the preparation of this circular and are listed in the bibliography.

## LOCATION OF QUARRIES

The quarries and potential quarry sites described in this report are located for the most part in the Blue Ridge and Western Piedmont sections of the State, in areas underlain by gneisses, schists, and various types of metasedimentary rocks. Considered briefly, however, are a granite-gneiss quarry and two abandoned sandstone quarries in the Eastern Piedmont.

The counties of North Carolina in which miscellaneous stone production is presently made or was of some importance in past years include Anson, Avery, Buncombe, Burke, Henderson, Lee, Madison, McDowell, Swain, and Wake. Limited production has been made at various times from quarries in Cherokee, Watauga, and Mitchell Counties. The location, with reference to a principal town or city, the type of stone available, and the principal product from each of the quarries discussed in this report are shown in Table I. Two areas of potential commercial production are also listed in the table.

## GEOLOGIC ASPECTS

With the exception of the sandstone deposits of Triassic age in Anson and Lee Counties, the rocks discussed in this report have been

TABLE I - MISCELLANEOUS COMMERCIAL STONE IN NORTH CAROLINA

| Quarry | Location | Rock Type | Product | Page |
|---|---|---|---|---|
| Needmore* | Swain County near Bryson City | Quartzite | Building and Flagstone | 7 |
| Causby* | Burke County near Morganton | Quartzite | Building Stone | 10 |
| Dula | Burke County near Morganton | Quartzite | Building Stone | 12 |
| Teaster | McDowell County near Woodlawn | Quartzite | Building and Flagstone | 12 |
| Parkway* | Avery County near Linville | Quartzite | Building Stone | 14 |
| Green & Taylor* | Avery County near Linville | Quartzite | Building Stone | 16 |
| Spivey Mountain* | Yancey County near Ramseytown | Quartzite | Building and Flagstone | 17 |
| Sutton* | Wake County near Raleigh | Granite-gneiss | Building and Flagstone | 18 |
| "Balfour"** | Henderson County near Hendersonville | Augen-gneiss | Crushed Stone | 19 |
| Montford** | Buncombe County near Asheville | Mica-gneiss | Crushed Stone | 20 |
| McKinney | Mitchell County near Spruce Pine | Hornblende-gneiss | Building Stone | 21 |
| Blowing Rock*** | Watauga and Caldwell Counties | Mica-gneiss | - | 22 |
| Bluff*** | Madison County near Hot Springs | Unakite | - | 23 |
| Brownstone** | Anson and Lee Counties | Sandstone | Building Stone | 24 |

* Principal Producers
** Abandoned
*** Undeveloped

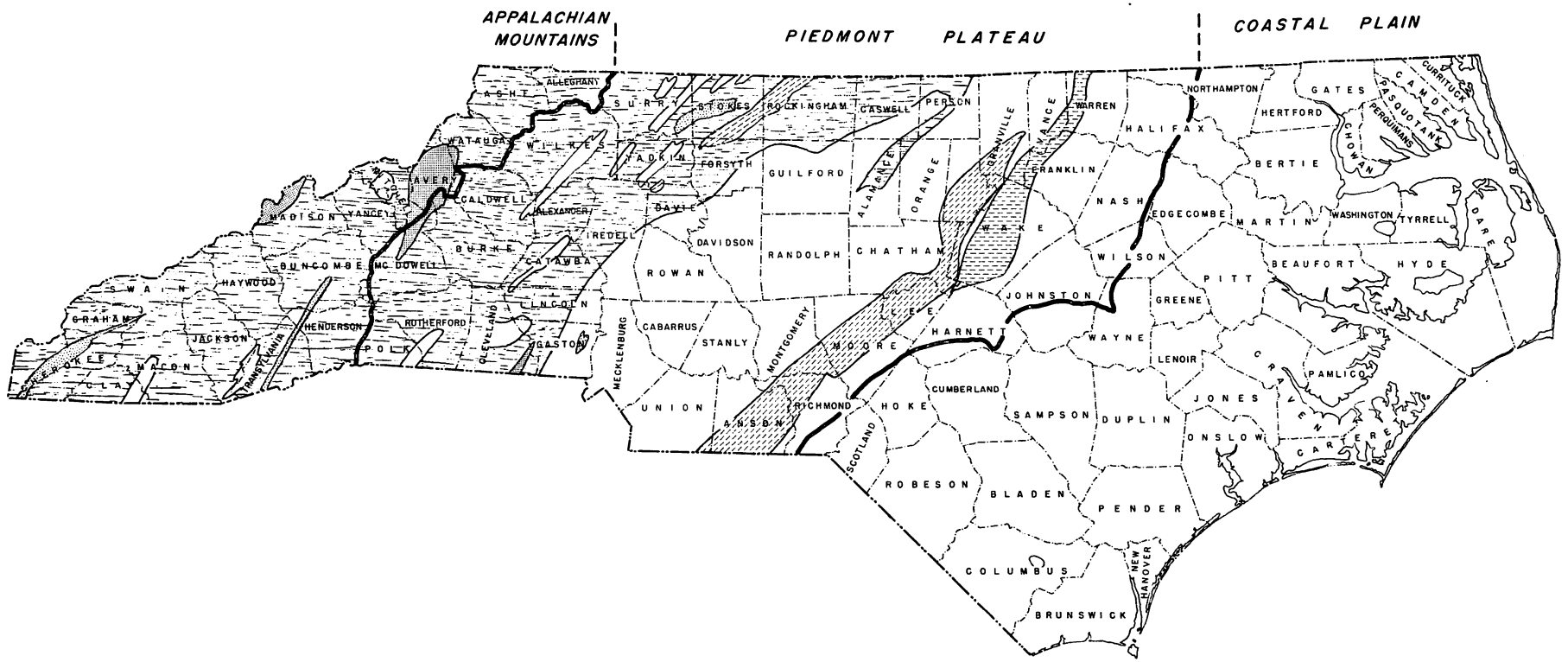
APPALACHIAN MOUNTAINS
PIEDMONT PLATEAU
COASTAL PLAIN
ALLEGHANY
ASHE
SURRY
STOKES
ROCKINGHAM
CASWELL
PERSON
WATAUGA
WILKES
YADKIN
FORSYTH
GUILFORD
ALAMANCE
ORANGE
GRANVILLE
VANCE
WARREN
HALIFAX
NORTHAMPTON
GATES
CURRITUCK
CAMDEN
PASQUOTANK
PERQUIMANS
CHOWAN
HERTFORD
BERTIE
AVERY
CALDWELL
ALEXANDER
DAVIE
FRANKLIN
NASH
EDGECOMBE
MARTIN
WASHINGTON
TYRRELL
DARE
MADISON
YANCE
IREDELL
DAVIDSON
RANDOLPH
CHATHAM
WAKE
WILSON
BEAUFORT
HYDE
BUNCOMBE
MC DOWELL
BURKE
CATAWBA
ROWAN
JOHNSTON
PITT
GREENE
SWAIN
HAYWOOD
LINCOLN
GRAHAM
JACKSON
HENDERSON
RUTHERFORD
POLK
CLEVELAND
GASTON
CABARRUS
STANLY
MONTGOMERY
MOORE
LEE
HARNETT
WAYNE
LENOIR
CRAVEN
PAMLICO
MECKLENBURG
UNION
ANSON
RICHMOND
CUMBERLAND
HOKE
SAMPSON
DUPLIN
JONES
ONSLOW
CARTERET
SCOTLAND
ROBESON
BLADEN
PENDER
COLUMBUS
NEW HANOVER
BRUNSWICK
TRANSYLVANIA
CHEROKEE
MACON
CLAY
PRE-CAMBRIAN, CAMBRIAN and TRIASSIC ROCKS
IN
NORTH CAROLINA
TRIASSIC
CAMBRIAN
PROBABLY CAMBRIAN
AGE UNKNOWN (pre-C?)
PRE-CAMBRIAN
S.D.B.

FIGURE 1

classified as Cambrian and pre-Cambrian by earlier writers. Rocks of these ages underlie most of the Blue Ridge Province and a large portion of the Piedmont Plateau in North Carolina, those rocks of pre-Cambrian age being far more widespread than the Cambrian units. (See Figure 1, page 5.) The pre-Cambrian rocks consist principally of gneisses and schists largely of unknown genesis but sometimes containing interbeds and lenses of marble, dolomitic crystalline limestones, and other types of metasediments. Pre-Cambrian basic intrusives and pre-Cambrian and Paleozoic intrusives are common in these rocks. The gneissic and schistose rocks and larger granite bodies were subdivided into several major units in most of the Blue Ridge by Keith (Keith, A. and others, 1901, 1903, 1904, 1905), who proposed the names Carolina gneiss, Roan gneiss, Flattop schist, Blowing Rock gneiss, Max Patch granite, Cranberry granite, etc., to certain reasonably distinct lithologic units. Of these, the Carolina gneiss and Roan gneiss are in general use but are now rather loosely applied to many varieties of mica gneisses and schists and hornblende gneisses and schists, respectively. Though the Carolina and Roan designations are often misused in referring to the gneissic and schistose rocks in general, they yet remain of great significance in bringing to mind most of the varied rock types proposed under Keith's original classification.

The Cambrian rocks consist of quartzites of varying purity, metagraywache, shale, argillite, slate, marble, dolomitic and siliceous limestone, sandstone, and metaconglomerate. In some instances they contain interbedded gneissic and schistose units, thin lava flows, and Paleozoic granitic intrusives. Cambrian rocks occupy comparatively small areas in the Blue Ridge but are present as far east as Stokes County. The stratigraphic names applied to the diversified Cambrian units generally are those first used in Tennessee and Southwest Virginia. Most of them were assigned by Keith. Among the more important of these are: Erwin

quartzite, Hampton shale, Unicoi formation, Honaker limestone, Chilhowee group, Shady limestone, and Snowbird formation. The assignment of these rocks in North Carolina to the Cambrian system is based largely upon similarities to the type lithologies and stratigraphic position, as fossil evidence is almost wholly lacking.

In practically all of the geologic formations and groups mentioned above, at least thin zones of commercially exploitable rocks are available. This results mainly from the presence of secondary cleavage, jointing, and the strong degree of induration produced by variable but often intense dynamic and thermal metamorphism.

## QUARTZITES

Quartzites are those sand rocks composed largely of quartz which are metamorphosed into dense, hard, coherent rocks. In this report they include quartzose rocks of variable composition in which feldspar and mica are prominent constituents.

### Needmore Quarry

A distinctly flaggy, impure quartzose rock, roughly classified as quartzite, is quarried in the extreme southern portion of Swain County, 1.75 miles south of the community of Needmore. The quarry, located on the west bank of the Little Tennessee River, has been a source of flagstone and building stone for many years. Present production of both cut and uncut flagstone and building stone averages about 600 cubic yards annually; and, although most of the stone is sold locally, considerable amounts have been shipped to points in South Carolina, Virginia, and Florida.

The Needmore Quarry deposit consists of thin- to thick-bedded, impure quartzite, separated by thin interbeds of micaceous material, which apparently represents metamorphosed alumina and potash-rich, fine-grained sediments. These micaceous beds average less than one inch in thickness

throughout the quarry. Bedding in the deposit is readily apparent and is accentuated by the well defined cleavage developed along parallel planes, predominantly along contacts of the quartzite and thin micaceous beds. Both the bedding and cleavage strike N. 26° E. and, except where minor folding has resulted in local variations, dip to the southwest at 30° to 32°. Near-vertical joints cut the deposit at fairly closely spaced intervals along strikes of N. 55° W. and N. 55° E. Quartz veins are common throughout the deposit and in some places they contain considerable amounts of feldspar. In the Needmore Quarry, as in most flagstone deposits, the spacing of the cleavage (in this instance a fracture cleavage at intervals of 2 inches to 6 inches) and joints determines the thickness and horizontal dimensions of the quarried stone.

The quarry is developed into the side of a large hill, the slope of which corresponds roughly to the dip of the bedding in the rock. A working face, ranging in height from 10 feet to 75 feet, and a quarry floor, 15 to 50 feet in width and parallel to the dip of the rock, have been developed during quarrying. Overburden ranges from less than 1 foot to about 8 feet, but the rock immediately below this soil cover is in most instances sufficiently sound for marketing. Quarrying is accomplished by drilling small-diameter holes perpendicular to the cleavage to a depth of 2 to 3 feet and detonating small powder charges in the holes. The force of the explosion acts to loosen the rock along the tight cleavage and joint planes, thus allowing it to slide downward along the dip slope of the deposit to the quarry floor. This quarrying procedure is used in most of the quarries described in this report, though minor variations are made to satisfy local conditions. The rough quarried stone usually is one to several feet in horizontal dimension and 2 to 6 inches in thickness. Stone thicker than 6 inches is split along the cleavage, using a hammer and chisel, while trimming to market specifications is accomplished with a hydraulically operated stone trimmer.

PETROGRAPHY: Quartzite from the Needmore Quarry is a light to medium grey, medium-grained rock, containing clear and smoky quartz, muscovite, biotite, and feldspar, with magnetite and apatite as accessory minerals. The rock is strongly indurated, making it a highly desirable stone from the standpoint both of attractiveness and durability. A thin section, cut from a representative sample of the rock, shows the following mineral composition and physical characteristics:

Mineral Composition:

| | |
|---|---|
| Quartz | 59% |
| Orthoclase | 20% |
| Plagioclase | 9% |
| Biotite | 11% |
| Muscovite | 1% |
| Magnetite and apatite | <0.5% |

Occurrence and Habit of Minerals:

Quartz is recrystallized into a fine mosaic, showing rough parallel orientation. Undulatory extinction is common but is most prevalent in the few large grains present. The grains are moderately interlocked with each other as well as with large feldspar grains. Quartz in general is not replaced by either muscovite or biotite.

Orthoclase and plagioclase occur principally as outsized grains, however small grains of orthoclase are not uncommon. Almost all of the large grains show corroded boundaries, with biotite and muscovite extensively replacing them. Plates of muscovite partially replace plagioclase at an angle oblique to the twinning lamellae. Some euhedral to subhedral grains, zoned individuals, and a few subrounded grains are present in the section. Biotite replaces the edges and in many instances has worked far inward toward the center of the grain. Sericitization and kaolinization are manifest only slightly in the section.

Biotite occurs through the section as interstitial filling, often wrapping around and replacing feldspars and wrapping around quartz mosaics. It lies parallel to bedding but in places is arranged in a haphazard manner.

It grows side by side with muscovite and is common as short, stubby plates or as a mosaic of short length.

Muscovite occurs in the same manner as biotite.

Apatite is the principal minor constituent of the rock. It occurs as very small, rounded-to-perfect euhedral grains, uniformly distributed through the section.

Magnetite is present in very small amounts as tiny octahedra.

Texture: Medium-grained; more or less granoblastic to faintly lepidoblastic. Grain size ranges from 0.03 mm. to 1.0 mm., with an average of 0.5 mm.

Classification: Arkosic quartzite.

Geologic Age: Lower Cambrian (Keith); a part of the Great Smoky conglomerate.

## Causby Quarry

A flaggy, impure quartzite, quite similar in appearance and physical properties to rock from the Needmore Quarry, is quarried 12 miles northwest of Morganton, about 100 feet west of North Carolina Highway 181, adjacent to Steels Creek. This quarry, about the same size as the Needmore Quarry and also developed into the side of a hill, is operated by The Causby Concrete Company of Morganton. Most of the production from this quarry is contracted for and laid as building stone in Morganton and its environs.

Rock from the Causby Quarry is an impure, much altered quartzite of fine- to medium-grained size and light-to-medium gray color, often having a faint greenish-gray cast. Bedding has been practically obliterated by metamorphism, however it is apparently a thick-bedded quartzite. The portion of the rock body exposed during quarrying is moderately sheared and possesses a prominent fracture cleavage which lies parallel to the apparent bedding planes at intervals of one inch to one or more feet. Thickness of the quarried stone, therefore, ranges from one inch to a foot or more but will average about 4 to 6 inches. The bedding and cleavage strike

N. 67° E. and dip 39° to the southwest. Inclined joints cut the deposit at moderately spaced intervals along a strike of N. 85° E. and a dip of 67° to the northeast. Vein quartz fills a few of the joints, and fine veinlets of quartz are rather common throughout the rock.

PETROGRAPHY: This rock contains much quartz and relatively large amounts of muscovite, along with feldspar, magnetite, and minor amounts of zircon and ilmenite. Muscovite- sericite is prominently developed as very thin laminae along planes of cleavage. It is strongly indurated, thus presenting a stone of great durability. A thin section, cut from a representative sample of the stone, shows the following mineral composition and physical characteristics:

Mineral Composition:

| | |
|---|---|
| Quartz | 67% |
| Orthoclase and microcline | 7% |
| Plagioclase | 2% |
| Muscovite and sericite | 23% |
| Magnetite | 1% |
| Zircon and ilmenite | <0.5% |

Occurrence and Habit of Minerals:

Quartz occurs as fine, recrystallized grains, forming a dense mosaic. A faint suturing of the quartz grains is common, and all grains show pronounced strain shadows upon rotation. Inclusions of muscovite are rare, as are intergrowths with grains of feldspar. The quartz constituent of the rock shows pronounced parallel orientation.

Orthoclase and microcline occur as fine grains, about equal in size to the quartz, and as outsized grains, which seem to retain some of the original shape of the detrital grains, that is, subangular to subrounded. Most are very slightly sericitized but are otherwise fresh. Large grains show tangential contacts with each other and with grains of quartz.

Plagioclase occurs both as fine and outsized grains and often is slightly replaced by muscovite-sericite. The original shape of the detrital grains is suggested. Most of this feldspar is oligoclase.

Muscovite in the rock acts as an interstitial filling between the grains of quartz and feldspar. It commonly wraps around the grains but seldom replaces them, although very slight sericitization of the feldspar is fairly common. The muscovite shows preferred orientation parallel to the bedding. A slight greenish tint, characteristic of this constituent, accounts for the frequent greenish cast of the rock.

Magnetite occurs as fine-to-medium grains, showing no oxidation. It is sometimes recrystallized with quartz. The grains are usually very irregular in outline, but a few subhedra are present.

Zircon and ilmenite are rare in the section. Zircon occurs as fine, subrounded-to-rounded grains; ilmenite, as irregular grains partially altered to leucoxene.

Texture: Fine-grained, lepidoblastic. Grain size ranges from 0.05 mm. to 0.5 mm. and will average 0.2 mm.

Classification: Micaceous quartzite (or quartz-mica schist).

Geologic Age: Pre-Cambrian (Keith); a unit of the Carolina gneiss.

### Dula Quarry

Micaceous quartzite of the type described above is quarried and shaped into flagstone and building stone at a small quarry located about one-half of a mile east of the Causby Quarry. The entire production, which according to Mr. Wayne Dula, owner and operator, is small, is contracted for and laid in Morganton and the surrounding area.

### Woodlawn (Teaster) Quarry

Dense, hard quartzite, underlying a large area in the northeastern part of McDowell County, is well exposed along U.S. Highway 221, north of Marion. In most places the rock is moderately to badly weathered, but in an area approximately 2.5 miles south of the community of Woodlawn the rock is fresh and suitable for quarrying. For several years, small amounts of flagstone and building stone have been produced from a small quarry in

this area and sold locally by Mr. H. R. Teaster.

The quartzite is a fine-grained, strongly indurated, thin-bedded rock containing an abundance of quartz, some feldspar, and varying amounts of dark silicates, magnetite, and micaceous material. Though intense metamorphism has greatly altered the rock, bedding is readily discernible because of a concentration of the dark mineral along planes of bedding. Superimposed upon the bedding is a well developed fracture cleavage, with partings at intervals ranging from less than one inch to a maximum of about 6 inches. Frequently, thin laminae of black slate are present along the cleavage planes, but these units were not seen to exceed one-half centimeter in thickness. Cleavage and bedding in the deposit strike N. 57° W. and dip 37° to the southwest, while a complex system of joints penetrating the deposit in almost every conceivable direction acts to limit the size of stone available. Reddish-brown iron stains are common along these surfaces.

PETROGRAPHY: The Woodlawn rock ranges from a buff colored, comparatively pure quartzite to a dark gray, iron-rich rock containing sericite, magnetite, tourmaline, and hornblende. Sericite is an important mineral along cleavage planes in all color phases of the deposit. A thin section, cut from a representative sample of the buff-colored rock, shows the following mineral composition and physical characteristics:

Mineral Composition:

| | |
|---|---|
| Quartz | 87% |
| Orthoclase and microcline | 6% |
| Muscovite | 7% |
| Tourmaline, zircon, magnetite, ilmenite, and hornblende | <0.5% |

Occurrence and Habit of Minerals:

Quartz is recrystallized into a fine-grained mosaic, showing strong orientation with a more or less exaggerated long axis of grains lying in parallel directions. Undulatory extinction is rather common but by no means abundant. Grain contacts are both tangential and interlocking, and some grains are cut by thin plates of muscovite.

Orthoclase and microcline occur in a manner similar to the quartz, but a few outsized grains are present. These represent the largest grains in the section. A partial replacement by muscovite is common.

Muscovite is well distributed through the section as small, elongated plates showing an orientation parallel to bedding. Approximately half the total amount of muscovite in the thin section occurs as a thin layer (0.35 mm. thick) of 90 percent muscovite and 10 percent quartz and feldspar. This lamina is perfectly outlined by a train of quartz grains. Iron staining of the muscovite is common, being especially pronounced in the lamina described above.

Other minerals are distributed uniformly through the section generally as fine grains, although one grain of tourmaline represents the largest particle in the section.

Texture: Fine-grained, lepidoblastic. Grain size ranges from less than 0.05 mm. to 0.2 mm. but will average about 0.1 mm.

Classification: Quartzite.

Geologic Age: Lower Cambrian (Keith).

## Grandfather Stone

Building stone used in the construction of bridges and abutments on the Blue Ridge Parkway between Blowing Rock and the Mount Mitchell area comes largely from several small quarries in Avery County 4 miles east-northeast of Linville along the United States Forest Service road leading from the parkway to the community of Edgemont, Caldwell County. From time to time during development and improvement of the parkway, these quarries are leased to contractors for the purpose of securing suitable stone for bridge and abutment construction. During the past few years three openings have been made along the Forest Service road and considerable amounts of stone removed.

The "Grandfather Stone," as it is called by stonecutters and masons, is a moderately to strongly indurated quartzite of greenish-white to green-

ish-gray color and is rather uniformly fine-grained, the green color being due to evenly distributed tinted muscovite and sericite. Bedding in the deposit is difficult to detect, but it is reported to range from 6 inches to 6 feet in thickness (Keith, A., 1903). A fracture cleavage, appearing at intervals of one inch to a foot or more, lies parallel to the bedding and permits with facility the quarrying of stone of almost any desired thickness. Bedding and cleavage in the quarry examined strike N. 67° E. and dip 39° to the southeast. Inclined joints, along which iron staining is common, cut the deposit at moderately wide-spaced intervals along a strike of N. 85° E. and a dip of 67° to the northeast. Overburden in the quarry area is negligible, thus permitting the removal of fresh, hard stone from the surface downward.

PETROGRAPHY: "Grandfather Stone" contains much quartz and feldspar, considerable amounts of faintly green muscovite, small amounts of epidote, the principal minor constituent, and magnetite, zircon, and apatite. A thin section cut from a representative sample of the light greenish-gray rock shows the following mineral composition and physical characteristics:

Mineral Composition:

| | |
|---|---|
| Quartz | 59% |
| Orthoclase | 29% |
| Plagioclase | 1% |
| Muscovite and sericite | 10% |
| Epidote and apatite | 1% |
| Zircon and magnetite | <0.5% |

Occurrence and Habit of Minerals:

Quartz is present as a fine-grained mosaic, with most grains showing undulatory extinction. Quartz-grain contacts are tangential to loosely interlocked, while contacts between quartz and feldspar almost always are tangential. An occasional grain shows transection by muscovite, but otherwise the quartz constituent is not replaced.

Orthoclase and microcline occur largely as outsized grains which show various stages of sericitization and, to a lesser extent, kaoliniza-

tion. Most grains are subangular to rounded in outline, strongly suggesting original shape. Some grains show minor intergrowth with quartz. Corroded boundaries are common, and most grains are partially replaced by muscovite.

Plagioclase has an occurrence and habit similar to orthoclase.

Muscovite occurs as interstitial filling, often separating individual trains of quartz mosaics. It has a pronounced tendency to wrap around the quartz and feldspar grains and partially replace the feldspar. A greater part of the muscovite lies parallel to bedding, but sometimes it segregates as ragged clusters. It is tinted a light green color and possesses moderate pleochroism.

Epidote is scattered through the section as fine, angular to subangular grains, commonly in close association with muscovite.

Apatite, magnetite, and zircon occur as grains scattered through the rock. Some subhedra of magnetite and euhedra of apatite are present. Zircon is commonly fine-grained and subrounded.

Texture: Fine-grained, granoblastic to faintly lepidoblastic. Grain size ranges from 0.03 mm. to 0.5 mm., with an average of 0.15 mm.

Classification: Arkosic quartzite or arkosite.

Geologic Age: Lower Cambrian (Keith); a part of the Unicoi formation.

## Green and Taylor Quarry

A quarry operated by Green and Taylor Nurseries of Newland is located 1.5 miles northeast of Linville, Avery County, adjacent to old U.S. Highway 221. For the past five years approximately 1,000 cubic yards of stone have been produced annually from this quarry. Most of the stone is sold locally, but some has been sold in Eastern Tennessee, in the Johnson City area. Specimens of the stone show it to be a slightly darker greenish-gray phase of the "Grandfather Stone," described previously. According to Mr. Taylor, the thickness of quarried stone ranges from one-half inch up to 6 or 7 inches, and sheets as much as 6 to 7 feet in horizontal dimension are obtained during

quarrying. Stone from this quarry was used in the exterior construction of the Museum of North Carolina Minerals, located at Gillespie Gap on the Blue Ridge Parkway, 6 miles south of Spruce Pine.

### Spivey Mountain Quarry

The Spivey Mountain Quarry, operated by the Ledbetter Stone Company of Asheville, is located 3 miles east of the North Carolina-Tennessee state line, on the north side of U.S. Highway 19-W in Yancey County. This locality, in which several small quarries are worked, was not visited; however, specimens of the stone given to the writer by Mr. B. S. Ledbetter show a very dense, medium-grained quartzite in which pebble-size quartz segregations(?) and veinlets are common. Well developed fracture cleavage, which in some instances gives way to bedding cleavage, is in evidence in some of the specimens. According to the quarriers, sheets of stone one-half inch to one foot are easily removed during quarrying; therefore, the stone is used for both flagging and building purposes.

Quartz is the principal mineral ir the rock, while feldspar, magnetite, and ferromagnesian(?) minerals can be seen in hand specimens. Magnetite is finely disseminated in certain layers and along with other dark minerals renders a dark gray color to these zones. Color of individual beds, which range in thickness from about one-fourth inch to about one inch, varies from buff to dark gray with many intervening colors such as tan, light gray, and medium gray. The stone is reported to work well and has found a good market in East Tennessee and Western North Carolina.

According to Keith (Keith, A., 1907), rock from this area belongs to the Unicoi formation of lower Cambrian age.

### Other Localities

Madison County: Strongly indurated quartzitic rocks of Cambrian age in past years have been used to some extent for building purposes in Hot Springs, Madison County. Although no systematic quarrying of significance has been carried on in the area, such rocks are abundant and offer

opportunities for development, depending upon suitable markets.

The quartzites range generally from gray to almost white, thin-bedded, fine- to medium-grained units to gray, thick-laminated, fine- to coarse-grained rocks. Mineral composition varies considerably from place to place, and working qualities of the rocks are reported to be poor. (Oriel, 1950).

Stokes County: Thin-bedded itacolumnite, or flexible sandstone, is quarried on a small scale near the community of Gap, in Stokes County, and sold as mineral collectors' specimens. Thin, long pieces of the stone are easily flexed by hand, making it an oddity of both scientific andnonscientific interest. The flexibility of the rock is probably due to its micaceous cement.

## GNEISSES

Gneiss is a rock consisting of hard layers which are often of different colors, thus giving the rock a banded appearance. Mica and/or hornblende, feldspar, and quartz are the principal mineral components of gneiss.

### Wakestone (Sutton Quarry)

Wakestone, the name applied to a type of granite-gneiss which underlies much of central and eastern Wake County, has been quarried intermittently in the vicinity of Raleigh for more than a hundred years. Decidedly gneissic, this rock is a hard, durable material, having the mineral composition of granite (quartz-monzonite) and possessing a light gray to grayish-tan color which upon exposure weathers to a pleasing mottled tan (Councill, 1954). It has good working qualities and is well suited for all types of building and trim-stone purposes.

In recent years a small quarry has been operated near Lassiter's Mill, just outside the northern corporate limits of Raleigh, by Mr. D. A. Sutton, and stone from this operation has been shipped to many parts of

North Carolina and more recently to South Carolina.

Augen-Gneiss

The gneissic rocks of the Blue Ridge and Piedmont include many varieties, but perhaps the most unique is the pre-Cambrian augen, or "eye," gneiss which underlies large areas of Henderson and Transylvania Counties. This most unusual rock was used in past years as a source of stone for crushing but could well be utilized as a trim or building stone wherever interior or exterior decorative stone is required. Two small quarries, situated approximately 1.7 miles north of Hendersonville, Henderson County, were operated by the Balfour Granite Company early in the present century, and a considerable amount of rock was crushed for use as road metal and railroad ballast. Although it is reported that blocks of stone of fairly large dimensions could be easily quarried (Watson and Laney, 1906, p. 170), no attempt has been made to shape the stone into building or trim blocks. The working qualities of the rock are also reported good; so that, with the tools necessary for the quarrying and finishing of granitic rocks, the augen-gneiss would present a stone well suited to the manufacture of building and trim materials of both rough-cut and polished types.

PETROGRAPHY: This very distinctive gneiss is light to medium gray in color, with a decidedly gneissic biotite-quartz-feldspar groundmass containing outsized grains, ½" to 3/4", of white to light gray feldspar which have grown parallel to the gneissic structure of the rock. The feldspars, apparently porphyroblastic, have assumed elipsoidal and tabular forms in the rock. They are very evenly distributed through the otherwise medium-grained rock, thus presenting a stone of unusual texture and appealing color. A thin section of this rock has been described as follows (Watson and Laney, 1906, p. 170):

> "... a biotite granite-gneiss composed of quartz, orthoclase, microcline, microperthitic intergrowths, plagioclase, light and dark micas, zircon, apatite, epidote, and chlorite ... feldspar grains are completely enveloped in a fine-grained

> mosaic ... as a result of dynamic metamorphism... The feldspar shows the usual alteration to muscovite and some kaolin ..."

Augen-gneiss has been quarried and crushed for use as road metal near Penrose, in eastern Transylvania County, by the North Carolina State Highway and Public Works Commission. The rock utilized is texturally similar to the Henderson County stone, but the feldspars are light pink rather than gray and give this rock an even more desirable color than that described above; however, the deposit is cut by closely spaced joints and a well developed fracture cleavage, which combine to limit the size blocks available. A similar rock has also been quarried commercially for crushing south of Morganton in Burke County, but the quarry is now abandoned.

Gneisses in the Vicinity of Asheville (Carolina Gneiss)

Miscellaneous rocks in the Asheville area vary from mica-schist and mica-gneiss through intermediate phases to biotite granite-gneiss and interlayered units of both the schistose-gneissic rocks and granite-gneisses. In many localities in the immediate environs of Asheville, rocks of the mica (biotite) gneiss and granite-gneiss varieties have been quarried commercially for crushing and to some extent for working into rough building stone for use principally in bridge construction. These commercial quarries were abandoned many years ago; and, although some may offer suitable rock for fashioning into trim stone, the principal potential use lies in their accessibility for the production of crushed stone. Other sources of crushed and pebble aggregate will, however, probably limit their further development as raw material for crushed products.

Among the largest of the half-dozen or more abandoned workings in the vicinity of Asheville is the Montford Quarry, formerly operated by the Balfour Granite Company and located on the west side of the French Broad River at the city limit. The quarry furnished large tonnages of railroad ballast and some road metal during its operation prior to and for some

years after 1903. Most of the products were sold locally.

PETROGRAPHY: Rock from the Montford Quarry is typical of the gneissic rocks in the area and has been described petrographically (Watson and Laney, 1906, p. 166), as follows:

> "... a very fine-grained biotite-gneiss in which the parallel arrangement of the minerals into bands is marked. The mineral grains complexly interlock and are composed of quartz, potash and plagioclase feldspars, and biotite ... chlorite ... a colorless mica and some epidote. Much iron oxide, some pyrite and an occasional zircon inclusion complete the list."

The rocks of the Asheville area usually show a characteristic layered structure and more often than not are cut by rather closely spaced, near-vertical joints. Colors exhibited by the various rock units range from light to dark gray. Cleavage in these rocks is sometimes well developed, and in some areas the rocks could be utilized as low-grade flagstone and building stone.

## Roan Gneiss

Roan gneiss is quarried on a small scale by Mr. Jeeter McKinney in the community of Estatoe, 3 miles west of Spruce Pine, Mitchell County. At the time of the investigation, stone from this small opening was being used in the enlargement of a church in Spruce Pine. Other small abandoned openings in the general area around Spruce Pine are reopened at various times as the local market for building stone and flagging material demands. Hornblende gneiss seems to be the most widely used rock type in the area.

The rock quarried at Estatoe is a strongly foliated, dark gray to nearly black hornblende gneiss, containing hornblende (75 percent), along with quartz, feldspar, and rarely garnet. The rock cleaves quite erratically, but careful selection of the quarried stone yields pieces which split reasonably well and work satisfactorily under the hammer. Joints in the quarry are rather closely spaced, limiting to some extent the size of stone available. Thin quartz veins and veinlets are commonly found in the rock.

### Blowing Rock Gneiss

Gneiss of a rather unusual character underlies and outcrops frequently over wide areas of southern Watauga and central Caldwell Counties, and although heretofore not extensively utilized, it presents a rock of unique texture and beauty for building purposes. The economic potential of this rock for use as building material was recognized more than 50 years ago by Keith (Keith, A., 1903), who wrote:

> "An ornamental building stone for special uses can be obtained in great abundance from the Blowing Rock gneiss, and the separation of the granitic and schistose from the porphyritic portions in distinct layers renders easy the work of taking out the porphyry in layers of any thickness required. The rock is very striking in appearance, the white feldspar crystals standing out from the black, glistening groundmass of mica, and its durability is manifest in the huge ledges that it forms in stream cuts and the high cliffs on the mountain sides."

Excellent exposures of the Blowing Rock gneiss can be seen along U.S. Highway 321, a few miles northeast of the town of Blowing Rock, Watauga County, and south of Blowing Rock into central Caldwell County.

### Other Areas

Gneisses of highly variable physical properties and mineral compositions are available for quarrying and use as rough building stone, crushed stone, and flagging material in many parts of Western North Carolina. In many localities rocks of this type have been used for foundations, chimneys, walls, and flagging material, but little systematic quarrying has been carried out. Many retaining walls along the Blue Ridge Parkway in North Carolina are constructed of gneissic rocks, dislodged during the construction of the highway; and along the northern and extreme southern portions of the route, small quarries were opened to obtain stone for bridges and abutments. These openings are now inaccessible.

## UNAKITE

Unakite is the rock name applied to a unique variety of granitoid

rock containing, other than the usual minerals present in granite, relatively large amounts of the bright yellowish-green silicate mineral epidote. The unusual amounts of this mineral, together with much pink and red feldspar, quartz, and evenly distributed dark accessory minerals combine to form a rock of exceptional beauty and durability.

Madison County

In an area of unknown extent around Bluff, a small community 5.5 miles southwest of Hot Springs, unakite occurs as late differentiate masses within faintly pinkish-green epidote granite. The unakite is a bright pinkish- to reddish-green-gray rock of medium to coarse texture in most places observed, but 2 miles southwest of Bluff the rock is present as an augen-gneiss. At this locality, 0.5 of a mile west of the entrance of Roaring Fork Creek into Meadow Fork Creek, unakite is a dense, foliated, fine-grained rock in which red feldspars occur as grains up to 0.4 of an inch in diameter. The ground mass is composed of microcrystalline quartz, titaniferous magnetite(?), and olive green epidote, which has a tendency to wrap around the grains of feldspar and to a large extent replace them. This variety of unakite has an exceptional beauty but seems very limited in areal extent. Whether or not the medium- and coarse-textured phases in the vicinity of Bluff could be quarried on a commercial basis cannot be determined prior to detailed mapping of the area in which it occurs most prominently. Should the rock be present in sufficient quantities and possess good working qualities, it would offer a stone readily adaptable for both exterior and interior decoration purposes.

PETROGRAPHY: Thin sections were not prepared from specimens of unakite, however it has been described by Watson and Laney (1906, pp. 172-173) in their thesis on North Carolina building stones, as follows:

> "... a moderately coarse-grained granite composed of orthoclase, quartz, and epidote with titaniferous iron oxide largely altered to leucoxene, rutile inclusions and secondary muscovite ... It (epidote) occurs in large masses composed of minute microscopic granules, replacing the entire feldspar

> individuals in many instances; and as continuous and irregularly disconnected bands and areas of both large and small size, following the fractures in both the feldspars and the quartz, but more extensively developed in the feldspar ... Hardly any of the feldspar in the sections examined was entirely free from some epidotization ... No plagioclase and no ferromagnesian minerals were recognized in any of the sections of unakite."

Should the unakite prove too limited, the epidote host rock offers some commercial possibilities. It is a medium- to coarse-grained granite, displaying a faint pinkish-gray color. Exposures of this rock are prevalent along streams and ridges in the area southwest of Hot Springs, and undoubtedly it could be developed at a number of places should a market arise.

Jointing in the unakite and host rock is not closely spaced enough to limit appreciably the size and shape of quarried blocks, and both varieties of the "granite" are capable of a high polish.

## SANDSTONE

Sandstones of a reddish-brown to chocolate-brown color occur in two belts of Triassic rocks in North Carolina, the first and larger of the two extending almost entirely across the eastern Piedmont section of the State along a northeast-southwest axis and the second belt occupying small areas of Rockingham, Stokes, and Forsyth Counties, in the central and western portions of the Piedmont Plateau along a similar trending axis. (See Figure 1.) During the latter part of the nineteenth and early part of the present century, these sandstones were quarried rather extensively for building stone in the larger belt in several localities in Lee and Anson Counties. Large volumes of the stone were used for building and trim purposes, stoops, window stools and sills, and coping material; however, the sudden loss in popularity of the so-called brownstone forced the closing of commercial quarries near Wadesboro, in Anson County, and Sanford, in Lee County, early in

the present century, and it is doubtful that sandstone of this type will be quarried again in North Carolina. The loss of interest in brownstone is due primarily to the availability of stones more attractive in appearance and possessing greater resistance to weathering.

PETROGRAPHY: The Triassic sandstones are generall arkosic, containing relatively large amounts of feldspar, silt, and clay when compared with quartz, the principal mineral component. Microscopic examinations of various Triassic sandstones by earlier writers (Watson and Laney, 1906) show medium-sized angular and subangular grains of quartz, feldspar, and biotite, loosely to moderately well bound by a ferruginous, clayey cementing agent.

## SUMMARIES OF BUILDING-STONE RESOURCES

Excellent summaries of the building and ornamental stone potential in most areas of Western North Carolina are available in publications of the United States Geological Survey by Arthur Keith. (See Bibliography.)

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