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GRANITIC ROCKS OF THE WESTERN CAROLINA PIEDMONT*

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ABSTRACT. The rocks in the western Piedmont of North and South Carolina that had been identified as Whiteside granite by earlier workers were discovered by J. B. Mertie, Jr., in 1945 to include two different granitic rocks, neither of which is related to the Whiteside. Work since 1948 has confirmed this. One of these rocks, here named the Toluca quartz monzonite, is best developed near Toluca, North Carolina; the other rock, here called the Cherryville quartz monzonite, is broadly exposed near Cherryville, North Carolina, east of Toluca.

The Cherryville quartz monzonite and related pegmatites were formed after the last strong deformation of the region, and hence are probably of post-Carboniferous age. The Toluca quartz monzonite is older, but its age is unknown.

INTRODUCTION

GRANITIC rocks are shown on the Geologic Map of the United States (Stose, 1932) and the Tectonic Map of the United States (King, 1944) to underlie large areas in the southeastern half of the crystalline rock belt of the southern Appalachians. Similar rocks are widespread in the northwestern part of the crystalline belt, but they occur in comparatively small bodies. Most of these smaller bodies occur in a belt that is shown on the tectonic map as bounded on the northwest by the Brevard overthrust and 65 miles to the southeast by another overthrust. Only a few small bodies of granitic rock occur northwest of the Brevard overthrust.

This paper deals only with the granite of Carboniferous age at Whiteside Mountain in Transylvania County, N. C., and the granitic rocks of various ages in Cleveland, Gaston, and Lincoln

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Counties, N. C., and Cherokee County, S. C. The intrusive at Whiteside Mountain is northwest of the Brevard overthrust. The others are between that and the southeastern overthrust.

The more detailed maps of Keith and Sterrett (1931) and Sterrett (1912) show several reverse faults (said to have caused as much as 2,000 feet displacement) along the line that represents the southeastern overthrust. The maps show that the faults occur along, or a few miles east of, the boundary that separates a series of muscovitic schists, quartzites, and marbles on the east from a series of biotitic schists on the west. The rocks on the east side are, in general, less highly metamorphosed than those on the west.

The granitic rocks of the Shelby-Gaffney-Kings Mountain area of the Piedmont of North and South Carolina have been mentioned and described briefly by several geologists in reports on the tin, monazite, or gold resources of the region. Among the later of these are reports by Graton (1906), Sterrett (1908), Keith and Sterrett (1917), and Kesler (1942). The first attempt to show the distribution of granitic rocks in detail was made by D. B. Sterrett and Arthur Keith, who mapped the Gaffney, Kings Mountain, and Lincolnton quadrangles between 1907 and 1912 (Keith and Sterrett, 1931; Sterrett, 1912). They included the granitic rocks of the western parts of these three quadrangles in one unit and assigned this unit to the Whiteside granite which had been defined by Keith (1907) and considered of late Carboniferous (?) age. Two other granites, the Yorkville granite and the Bessemer granite, were mapped in the eastern parts of the same quadrangles but, as they have nothing to do with the subject of this paper, they will not be discussed.

Little more work was done on the granitic rocks of this area until 1945, when J. B. Mertie, Jr., of the U. S. Geological Survey, investigated the monazite deposits of the southeastern Atlantic States. He found two distinctive suites of heavy minerals when he panned weathered rocks obtained from different bodies that have been mapped as Whiteside granite (Mertie, oral communication, 1945). A monazite-bearing suite was obtained from a western belt of rocks, such as those well exposed near Toluca, N. C., and a monazite-free suite was obtained from the rocks in an eastern belt that is well developed near Cherryville, N. C.

Work done by R. G. Yates and W. C. Overstreet since 1948 in the Shelby quadrangle and by W. R. Griffiths since 1949 in the Shelby, Kings Mountain, and Lincolnton quadrangles has provided strong evidence to support Mertie's view that the granitic rocks, mapped as the Whiteside granite in this area by Keith and Sterrett (1931), should be divided into two units. The authors are introducing for these units the new names Toluca quartz monzonite and Cherryville quartz monzonite. The new names were first applied as field designations by J. B. Mertie, Jr., in 1945 (oral communication) and have been used by the authors since that time. As is shown below, the rocks in these new units differ in distribution, texture, mineral composition, content of trace elements, geologic relations, and age.

TOLUCA QUARTZ MONZONITE

The monazite-bearing granitic rock that is exposed near Toluca, N. C., is here named the Toluca quartz monzonite. Weathered rock underlies broad areas of light-gray soil in and near the village, and fresh rock is well exposed in the Acre Rock quarry, which is a few hundred feet north of a dirt road half a mile west of State Highway 18 at a point 0.8 miles southwest of Toluca. The eastern limit of the Toluca quartz monzonite in the recently studied area is shown in figure 1. The western, northern, and southern limits are not accurately known, although the rock probably does not extend more than 35 miles northwest of Shelby.

Most bodies of Toluca quartz monzonite that have been mapped lie parallel to the foliation of the biotitic and sillimanitic schists of the Carolina gneiss. Locally, contacts of the quartz monzonite cross the foliation, and a few bodies are dikes that clearly cross the planar structures of the host rocks. Individual bodies range from a few inches to several thousand feet in thickness and from a few feet to at least 10 miles in length. Most are lenticular but some are irregular. As they are parallel to the planar structures of the gneiss, which have been folded, the outcrop patterns are very complex in some places.

The Toluca quartz monzonite is typically a medium-gray moderately to strongly gneissic rock. Commonly the smaller sills are more strongly foliated than the larger, which, though

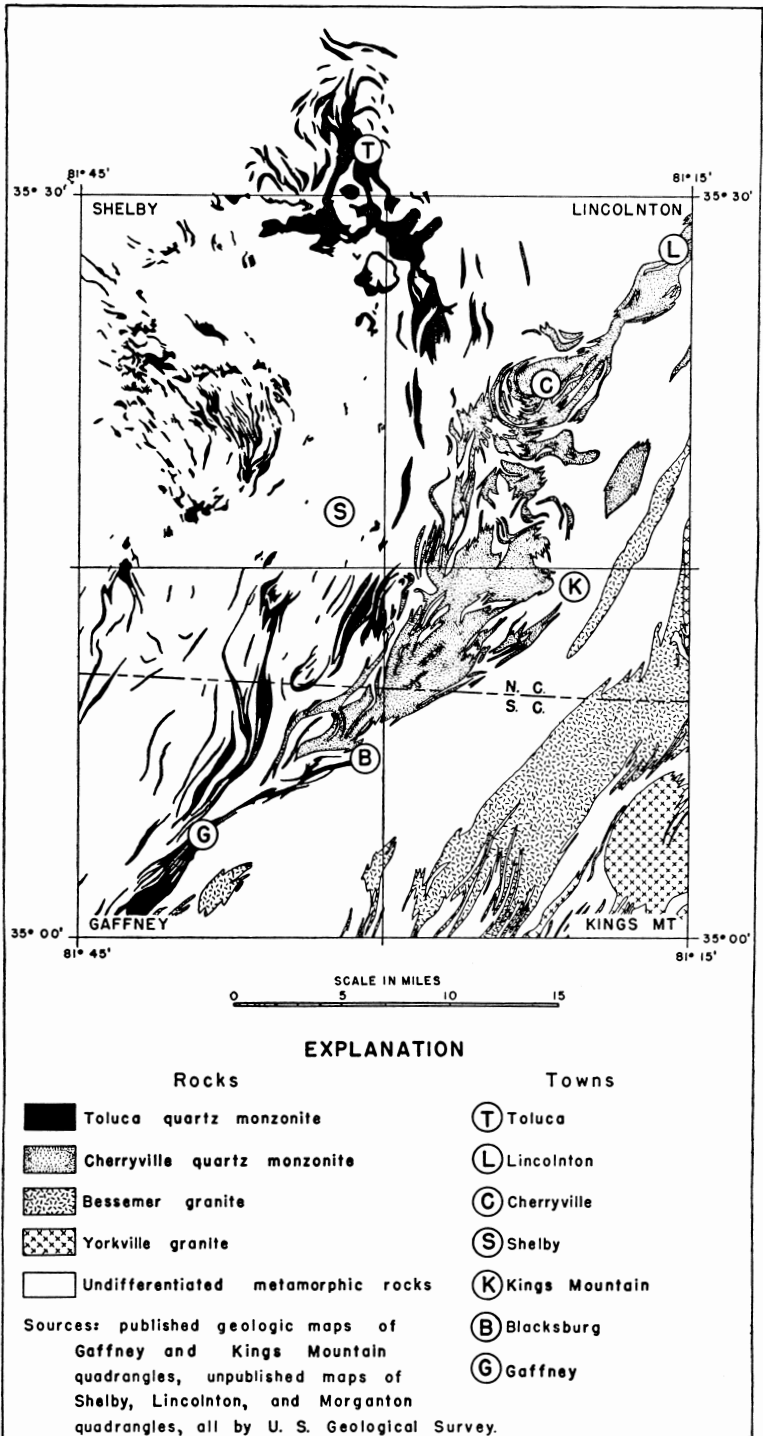


Fig. 1. Granitic rocks of the western Carolina Piedmont.

recognizably gneissic throughout, are most strongly foliated near the margins. The best-developed gneissic structure consists of layers that are rich in quartz or biotite separated by layers that are composed largely of feldspars, with only subordinate amounts of quartz and biotite. In the interior of the larger sills, where the segregation of minerals is not pronounced, the foliation is shown by a fair parallelism of mica flakes and small leaves of quartz. Linear structures are commonly well developed on the foliation planes. They include elongate, flat leaves of quartz and elongate clusters of biotite flakes set in quartz or feldspar. The quartz leaves exceptionally reach a maximum length of several inches; most are less than an inch long. Their width is usually about one-fifth of their length, and their thickness is only a small fraction of their width. In the Acre Rock quarry the foliation is folded and cut by faults, which apparently have caused only small displacement. Pegmatite and aplite have been introduced along some of these faults, as well as along other fractures on which there has been no apparent movement. All these fractures seem to have little directional relation to the foliation or lineation of the quartz monzonite.

The foliation of the Toluca quartz monzonite, where not folded, is parallel to the contacts of the rock mass; thus, in the conformable bodies, it is parallel to the foliation of the enclosing schists as well. The lineation of the quartz monzonite is parallel to the length of elongate aggregates of quartz and biotite grains in the schists, and inclined to or normal to other linear structures of the schists.

The major mineral constituents of the Toluca quartz monzonite are: oligoclase, microcline, orthoclase, quartz, and biotite. Muscovite, a minor constituent, commonly is intergrown with microcline, oligoclase, and quartz. Garnet is in nearly spherical grains, most of which have a diameter of about one-tenth inch. Biotite generally occurs in tiny flakes, less than one-fortieth inch in diameter; these flakes, where scattered through the lighter colored feldspar and quartz, give the rock a finely spotted appearance. The feldspar grains are commonly one-twentieth to one-fourth inch across. Quartz, as mentioned above, occurs both segregated in leaves and disseminated in feldspar-quartz layers. Because the quartz is commonly segregated into layers and leaves, the degree of foliation of the rock varies with its quartz content. Myrmekitic intergrowths of quartz and oligoclase

are common. Apatite, zircon, and monazite can be found in thin sections of the rock. As accessory minerals, ilmenite, zircon, and monazite can be recovered from weathered Toluca quartz monzonite nearly everywhere, by panning. Garnet, rutile, and sillimanite are widespread but are not nearly as universally present as the minerals mentioned above. Dark-blue spinel and green xenotime have been noted in a few samples.

One of the characteristics of the Toluca quartz monzonite is its wide variation in both texture and composition. The texture is nearly everywhere gneissic, but the size, shape, and arrangement of grains vary widely. Injection of varying amounts of the quartz monzonite and recrystallization of the country rocks further complicate the mapping of the rock masses, although wherever exposures are found the contact between the Toluca quartz monzonite and Carolina gneiss is sharp.

Spectroscopic analysis of Toluca quartz monzonite and the related pegmatite shows that both contain zirconium, strontium, and lead, as well as the commoner elements. Monazite and xenotime in the rocks indicate the presence of small amounts of phosphorus, thorium, and rare earths, although those elements were not detected spectroscopically.

Monazite-bearing pegmatite is associated with the Toluca quartz monzonite in many places. It occurs both in the Toluca quartz monzonite and in the Carolina gneiss, in irregular or tabular masses and in nodules or knots a few inches to several feet thick that lie parallel to the foliation, as well as in dikes and sills that reach lengths of several hundred feet. Much of the pegmatite resembles a coarse-grained augen gneiss, with layers of fine-grained quartz and oligoclase wrapped around oblong "eyes" of microcline. The microcline grains have been deformed, as shown by fracturing and bending of the cleavage surfaces. Nonperthitic microcline, oligoclase, and quartz are the major constituents. In most places the microcline constitutes about one-third of the rock, plagioclase a little more than one-third, and quartz a little less than one-third. In two rather uncommon varieties, however, the microcline content is as much as 60 to 80 per cent and as little as 5 to 10 per cent. The oligoclase content varies inversely as the microcline content, and the quartz content remains in the range of 20 to 35 per cent. Biotite rarely constitutes more than 10 per cent of the pegmatite,

and in many places it is absent. Garnet is more uniformly distributed, but rarely occurs in amounts greater than 5 per cent. Small amounts of monazite, sillimanite, xenotime, zircon, ilmenite, tourmaline, and rutile can be recovered by panning.

A close genetic relationship between the pegmatite and the Toluca quartz monzonite is indicated by: the close spatial relations between them, the fact that both have been deformed to about the same extent and in the same manner, the fact that the structural behavior of the country rock seems to have been the same during the emplacement of both rocks, and the presence of monazite and xenotime in both rocks. These minerals are not characteristic of other rocks in the area. It is interesting to note that both the quartz monzonite and the pegmatite contain the same trace elements, although the major constituents may be different.

CHERRYVILLE QUARTZ MONZONITE

The monazite-free rock exposed near Cherryville, N. C., is here named the Cherryville quartz monzonite. It underlies a broad belt that is widest between Cherryville and Kings Mountain, N. C., but it forms few large outcrops of hard rock in that area. The best exposures found so far are in and alongside Muddy Creek at a bridge 4 miles southeast of Elizabeth Church and 6 miles east of Shelby, N. C., and in a small quarry about half a mile east of Long Creek Church and 4 miles northeast of Kings Mountain. The last-mentioned exposure is in a small satellitic body rather than in the main batholith, but it is of typical Cherryville quartz monzonite.

The Cherryville quartz monzonite belt lies parallel to the layering of the enclosing rocks between Blacksburg, S. C., and Cherryville, N. C. To the north, however, it bends eastward, crossing the structure of the older rock. The quartz monzonite contains many concordant inclusions and septa of country rock, the contacts of which are generally parallel to their foliation, and only locally cross-cutting. These inclusions may reach a length of several miles. The quartz monzonite of the belt may conveniently be considered as a batholith containing much included country rock.

Three distinct and uniform varieties of Cherryville quartz monzonite have been recognized. The commonest variety is a

gray even-grained massive to faintly gneissic muscovite-biotite rock. Phenocrysts of potash feldspar occur in this type rock in a small area near Lincolnton but the contrast in grain size between them and the groundmass is not great. A second variety of the Cherryville quartz monzonite, moderately widespread through the batholith, contains muscovite but not biotite; this muscovite-quartz monzonite is a minor component of the batholith, probably not amounting to more than 10 or 15 per cent of it. A third variety, perhaps as abundant as the muscovite-quartz monzonite, seems to occur mainly at the south end of the batholith, near Blacksburg, S. C., and in scattered small bodies near the western margin of the batholith. It is very strongly lineated rock, with streaks and spindles of quartz and biotite. Planar structures are commonly poorly developed. None of the three varieties of quartz monzonite varies greatly in character.

Dikes of the light-colored muscovite-quartz monzonite in the darker muscovite-biotite rock, and intrusive breccias with fragments of the dark-colored rock imbedded in the light-colored, indicate a difference in age between the two varieties. The lineated rock may differ somewhat in age from the other varieties, but its relations are not well known.

The major constituents of the Cherryville quartz monzonite are oligoclase, microcline, quartz, biotite, and muscovite. The feldspar grains are commonly one-sixteenth to one-fourth inch across, and the mica flakes are one-thirty-second to one-sixteenth inch in diameter. Zircon, ilmenite, and apatite are the accessory minerals, but are uncommon. The nonlineated varieties of Cherryville quartz monzonite characteristically yield only a very small heavy mineral concentrate upon panning; zircon and ilmenite are the only two heavy minerals that are ordinarily found.

Spectroscopic analysis of the Cherryville quartz monzonite and related pegmatites has shown the presence of gallium, phosphorus, copper, and the commoner elements. The contrast between the suites of trace elements in the Cherryville and Toluca quartz monzonites is shown in table 1.

Several varieties of pegmatite are related to the Cherryville quartz monzonite. Spodumene-bearing pegmatites are restricted to a belt known as the tin-spodumene belt (Kesler, 1942) that is close to the eastern margin of the batholith, most commonly

in the schist or gneiss, but in a few places in the Cherryville quartz monzonite. These pegmatites are composed largely of nonperthitic microcline, albite, quartz, muscovite, and spodumene, with beryl, tourmaline, and cassiterite as common accessory minerals. Most of the pegmatite bodies north of Kings Mountain are well zoned but not gneissic, whereas many of those to the south are gneissic but not especially well zoned. Other pegmatite dikes occur farther west, within the batholith; they contain perthite, oligoclase, quartz, and muscovite. These dikes range in width from a few feet to about 20 feet; most are tabular and sharply bounded bodies, but irregular masses of pegmatite and isolated perthite crystals imbedded in the quartz monzonite accompany the dikes in places. Some dikes in the quartz monzonite are well zoned, others are not.

Mica-bearing pegmatites in the northwestern part of the Lincolnton quadrangle and in the Shelby quadrangle apparently are related to the Cherryville quartz monzonite. They form dikes and lenses that cross the foliation of the enclosing schists and of the Toluca quartz monzonite. They are well zoned and contain no monazite and little ilmenite, even though the enclosing rock may contain those minerals in moderately large amounts. The content of heavy minerals other than apatite is exceedingly low. The major constituents are perthite, oligoclase, quartz, and muscovite. Biotite is not uncommon but rarely is abundant.

All of these pegmatites are thought to be related to the Cherryville quartz monzonite. The evidence for this varies, naturally, depending upon the type and occurrence of the pegmatite. It is obvious that the spodumene-bearing and mica-bearing pegmatites that cut the Cherryville quartz monzonite cannot be older than it. In a few places the quartz monzonite was readily recrystallized during pegmatite emplacement, which suggests that it may have been at a temperature not far below that of its consolidation and therefore probably was then quite young. The similar pegmatite dikes in the schist and gneiss bordering the batholith are probably of the same age as the dikes within the batholith.

The behavior, during panning, of kaolinized Cherryville quartz monzonite from the type area differs from that of kaolinized Toluca quartz monzonite. Mr. Mertie has told the authors that the clay of the weathered Cherryville quartz monzonite

is dispersed in water with more difficulty than that of other weathered granites he has examined (oral communication, 1951). The quartz residue is small, which might be attributed either to an unusually low quartz content of the rock or to the friability of the quartz, which causes it to break up and drift away with the clay during washing. The gummy texture of the clay may result from some peculiarity in the composition of the feldspar.

GEOLOGIC RELATIONS AND RELATIVE AGES

Inasmuch as the bodies of Toluca quartz monzonite are parallel to the foliation of the Carolina gneiss they partake of the folding of the gneiss. The folds whose attitudes are known plunge gently, most commonly southward, less commonly northward. The body of Cherryville quartz monzonite, on the other hand, may plunge steeply to the west or southwest.

There is, unfortunately, no direct method of dating the quartz monzonites. The indirect evidence itemized below strongly indicates that the Toluca quartz monzonite is the older.

1. Folds are the structures characteristically associated with bodies of Toluca quartz monzonite, whereas fractures are characteristically associated with the Cherryville quartz monzonite bodies. This indicates that the Toluca quartz monzonite was emplaced under conditions of flowage, and the Cherryville quartz monzonite was emplaced under conditions of fracture. As both rocks are in the same area, this difference in environment strongly suggests a difference in age.

2. The faults that controlled the emplacement of pegmatites related to the Cherryville quartz monzonite offset typical Toluca quartz monzonite and related pegmatite, and pegmatite dikes related to the Cherryville quartz monzonite cut Toluca quartz monzonite. It is recognized, however, that the pegmatites might differ slightly in age even if the quartz monzonites were essentially contemporaneous.

3. The Toluca quartz monzonite and related pegmatite have been deformed and the Cherryville quartz monzonite and most of its related pegmatites have not.

Indirect evidence suggests that the Cherryville quartz monzonite is of very late Paleozoic age. Coarse muscovite books, being easily cleaved along the rays of the pressure figure and

easily bent or buckled, are very sensitive indicators of post-crystallization deformation. The mica in the pegmatites related to the Cherryville quartz monzonite has not been deformed. Hence, it must have been emplaced since the last intense orogeny of the area. The pegmatites are cut by diabase dikes that are considered to be of Triassic age. The mica-bearing pegmatites, therefore, were probably emplaced after most of the movements of the Appalachian revolution had taken place, but before the intrusion of the Triassic diabase dikes. A close relationship exists between the Appalachian structures and the distribution of pegmatites, which indicates that the pegmatite formation was closely related to that revolution. The Cherryville quartz monzonite, like some of the other granitic rocks that are related to the mica-bearing pegmatites, presumably also is of late Paleozoic age. The Toluca quartz monzonite is older than the Cherryville quartz monzonite and its age is therefore considered to be Carboniferous (?) or pre-Carboniferous (?).

The Toluca quartz monzonite and Cherryville quartz monzonite are sufficiently different to be distinguished in the field, and differ enough in age and origin to be considered distinct units and assigned different names. Keith and Sterrett (1931) included both rocks in one unit only because of a general similarity between them, and assigned them to the Whiteside granite. The Whiteside granite at its type locality is in part a medium-grained biotite-muscovite-quartz monzonite, having a composition that is common in granitic rocks through much of the Southeast. It also includes a coarse-grained pegmatitic rock dissimilar to the Toluca and Cherryville quartz monzonites. It contains few accessory minerals—as does the Cherryville quartz monzonite—but the mode of occurrence more closely resembles the Toluca quartz monzonite. The term “Whiteside granite” should not be used in this area, but should be restricted to the granite at and near Whiteside Mountain, the type locality.

The main features of the Toluca and Cherryville quartz monzonites are shown in table 1. The two rocks are obviously different even though their chemical compositions are known to be quite similar. For comparative purposes the available data on Whiteside granite (from its type locality) are included. In view of the general close resemblance between granitic rocks of the Southeast, the differences between these three rocks are sufficiently well marked to permit a distinction.

TABLE 1

Characteristics of the Toluca and Cherryville quartz monzonites and the Whiteside granite

	Toluca quartz monzonite	Cherryville quartz monzonite	Whiteside granite
Distribution ...	Western part of area of figure 1	Eastern part of area of figure 1	West of area of figure 1, in Blue Ridge
Broadest relation to country rock	Parallel	Crosscutting	Parallel
Texture	Gneissic	Massive	Massive
Mineral composition:			
Major minerals	Muscovite, biotite, oligoclase, microcline, quartz, garnet	Muscovite, biotite, oligoclase, microcline, quartz	Muscovite, biotite, oligoclase, microcline, quartz
Minor minerals..	Ilmenite, monazite, zircon, apatite	Ilmenite, zircon, apatite	Ilmenite, pyrite, zircon, garnet, local monazite (?)
Content of heavy minerals	Moderate	Very low	Very low
Chemical composition:			
Major elements	Normal quartz monzonite	Normal quartz monzonite	Normal quartz monzonite (?)
Characteristic minor elements	Sr, Zr, Pb, Th, rare earths	Ga, P, Cu, Sn, B	
Amount of injection of country rock	Moderate to large	Little	Moderate
Time of emplacement:			
Relation to deformation	Contemporaneous	After	After
Relation to other intrusives in vicinity* ..	Next to last	Last	Next to last?
Age	Carboniferous (?) or pre-Carboniferous (?)	Post-Carboniferous (?)	Late Carboniferous (?)

* Excluding diabase dikes of probable Triassic age.

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