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Pegmatites of the Cashiers and Zirconia Districts, North Carolina

By

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PRESENTING THE RESULTS OF A COOPERATIVE UNDERTAKING
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Raleigh, North Carolina
March 13, 1952

To His Excellency, HONORABLE W. KERR SCOTT
Governor of North Carolina

SIR:

I have the honor to submit herewith manuscript for publication as Bulletin 64, "Pegmatites of the Cashiers and Zirconia Districts, North Carolina." This Bulletin is another in the series being made possible by the cooperation of the U. S. Geological Survey.

This report covers two districts in which pegmatites contain interesting and valuable minerals. It is believed that the information contained herein will be of considerable value to those interested in the pegmatites of the Cashiers and Zirconia districts.

Respectfully submitted,

GEORGE R. ROSS,
Director

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PEGMATITES OF THE CASHIERS AND ZIRCONIA DISTRICTS, NORTH CAROLINA

By J. C. OLSON

ABSTRACT

The Cashiers pegmatite district occupies an area of about 265 square miles, mostly in Transylvania and Jackson Counties, North Carolina. The Zirconia district is an area of about 14 square miles lying 30 miles to the east in Henderson County. Both are in a region composed predominantly of gneisses and schists intruded by granitic rocks. The pegmatites are believed to be genetically related to intrusions that are probably Paleozoic in age.

Sixty pegmatite mines were studied in the Cashiers district, of which 10 pegmatites are in granite and 50 in metamorphic rocks. About 40 of the pegmatite bodies are broadly concordant with the wall-rock foliation. The bodies range from 1 to 75 feet in thickness, but at least 80 percent of them are less than 15 feet thick. The pegmatites are composed chiefly of perthite, plagioclase, quartz, muscovite, and garnet. Biotite occurs in 20 of the deposits; beryl in 7; black tourmaline in 5; pink tourmaline in 1; samarskite in 3; allanite in 1; and uraninite, autunite, and uranophane in 1. The pegmatites that have been mined are commonly zoned inward from the walls, as shown by varying proportions of feldspar, quartz, and mica. Movements that probably occurred during emplacement modified the zoning of some of the pegmatite bodies and produced conspicuous streaky or gneissoid structures.

Most of the muscovite that has been mined in the Cashiers district is green or brown, and much of it is stained. During World War II ruby mica was obtained from the Farlow Gap and Bee Tree No. 1 mines, and small quantities were produced at several other deposits. Feldspar was mined from the L. M. McCall and Bald Rock mines in 1948, and previously had been sold from the Puncheon Camp and Sheep Cliff mines. A little beryl has also been produced at the Sheep Cliff mine. Feldspar production is small, because of the long haul to grinding mills, but could be somewhat increased if grinding facilities were established in the vicinity.

The pegmatites studied in the Zirconia district occur near the contact between granite and inclusions or pendants of mica gneiss and schist. These pegmatites are well known for their uncommon minerals, such as anatase (xanthithane), sphene, zircon, polycrase, allanite, auerlite, monazite, xenotime, and cyrtolite. Microcline is by far the dominant constituent, and the pegmatites could be classified as syenites or quartz syenites in bulk composition. The pegmatites of the Jones and Freeman mines are 70 to 100 feet thick. The cores of these pegmatites are rich in microcline; the wall zones are characterized by microcline with conspicuous vermiculite and anatase; and the 6-inch border zone consists of the same minerals, but in places is more than 50 percent vermiculite. The distribution of minor elements, determined by spectrographic analyses of 13 samples from the Jones and Freeman mines, reflects the zoning of the pegmatites. Small quantities of zircon were mined at the Jones and Freeman mines about 1888 and early in the present century, and the Jones mine was prospected for feldspar in 1944.

INTRODUCTION

The Cashiers district, in southwestern North Carolina, straddles the boundary between Transylvania and Jackson Counties, and occupies an area of 11 by 24 miles; the long dimension of the district is N. 45°E. (See index map, fig. 1) The Zirconia district, 30 miles to the east in Henderson County, is an area of about 14 square miles, near the center of which are the settlements of Tuxedo and Zirconia. Both the Cashiers and Zirconia districts are near the crest of the Blue Ridge at altitudes ranging from 2,000 to 6,275 feet.

This reconnaissance study of the pegmatites of the Cashiers and Zirconia districts was made as part of a cooperative program of pegmatite investigations in North Carolina, sponsored by the North Carolina Department of Conservation and Development and the United States Geological Survey, Department of the Interior. The purpose of the investigation was to appraise the pegmatites of the Cashiers and Zirconia districts as potential sources of feldspar, mica, beryl, and other pegmatite minerals, and to study the geology of these pegmatites in the light of knowledge acquired in recent investigations in other pegmatite districts of North Carolina and other states.

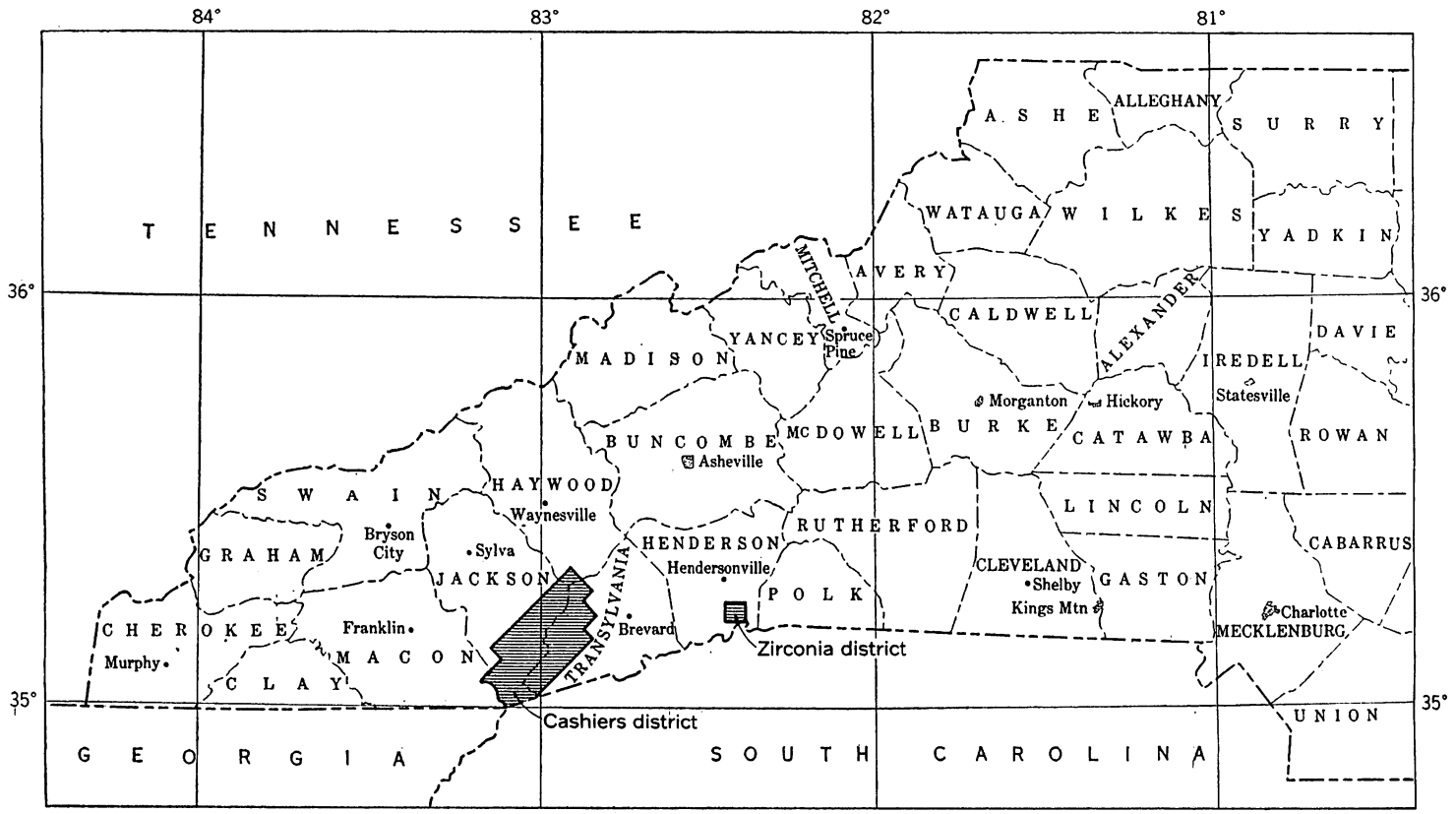


FIGURE 1.—INDEX MAP OF WESTERN NORTH CAROLINA SHOWING LOCATIONS OF THE CASHIERS AND ZIRCONIA DISTRICTS

The Cashiers district is in the Pisgah and Cowee quadrangles, and the general geology is described in the Pisgah folio (Keith, 1907). The pegmatites of the Zirconia district have been described briefly by Pratt (1916, pp. 15-16). In 1906 D. B. Sterrett (1923, pp. 214-220, 265-268) examined some of the mica deposits in the Cashiers district. Other published mineralogic notes are referred to in the text.

Mica has been mined intermittently in the Cashiers district since at least 1880. Feldspar and beryl have been produced since about 1940. The mica and feldspar produced in the Cashiers district comprise less than 5 percent of the total production of these minerals in North Carolina. The only mining in the Zirconia district took place about 1888 and again early in the present century, when small quantities of zircon were mined for use in lighting apparatus.

During World War II the increased demand for muscovite spurred the reopening of numerous deposits in the Cashiers district. At that time geologic studies of the mica deposits in the nearby Franklin-Sylva district were made by the Geological Survey in cooperation with the North Carolina Department of Conservation and Development (Olson and others, 1946), and during those investigations Wm. E. Heinrich, R. W. Lemke, and the writer examined a few of the deposits in the Cashiers district and obtained some of the data used in the summary of mines and prospects at the end of this report. Field engineers of the Colonial Mica Corporation, a Government-financed organization formed to stimulate mica production during the War, also gathered data on these mica deposits.

This report is based on nearly 3 months of field work in the spring of 1948 by J. C. Olson and H. S. Johnson, Jr. Sixty pegmatite deposits in the Cashiers district were examined; four of them, as well as two deposits in the Zirconia district, were mapped on scales of 20 or 40 feet to the inch. L. R. Page, under whose general supervision the work was done, spent 3 days with the field party. The spectographic analyses were made by Mrs. Janet D. Fletcher of the U. S. Geological Survey. The writer is also indebted to Dr. J. L. Stuckey, State Geologist, for his interest and cooperation in the work.

GENERAL GEOLOGY

The Cashiers district, as shown in the Pisgah folio (Keith, 1907), and the Zirconia district are underlain predominantly by metamorphic rocks that consist chiefly of muscovite-biotite-garnet gneiss and schist and quartz-mica schist. Hornblende gneiss and schist occur as layers, from a fraction of a foot to many feet in thickness, in the micaceous rocks. The areas where micaceous gneiss and schist predominate have been mapped as Carolina gneiss by Keith, whereas the dominantly hornblendic rocks have been mapped as Roan gneiss by Keith. The composition and layering of the Carolina gneiss indicate that it is mainly of metasedimentary origin. The hornblendic rocks of the Roan gneiss are possibly metamorphosed extrusive rocks or sills.

A third metamorphic formation mapped by Keith—the Brevard schist of Cambrian (?) age—occupies a northeast-trending strip between the Cashiers and Zirconia districts, but does not occur near any of the pegmatites studied. These metamorphosed sedimentary rocks consist mainly of fine-grained quartz and muscovite, with a few small garnet crystals, and are typically dark-colored, owing to abundant iron oxide grains. Graphite is common as small disseminated grains. Quartz-rich layers and limestone or marble lenses are interbedded with the schist. The Brevard schist was considered by Keith to occupy a syncline, and the presence of Carolina gneiss on the northwest and Henderson granite on the southeast side was explained by faulting. The fault and the adjacent rocks were not studied during the present investigation, but it might be noted that all the pegmatites mined in the Cashiers district lie northwest of the Brevard schist, whereas no large pegmatite bodies are known in the Henderson granite southeast of the Brevard schist in the Pisgah quadrangle. The pegmatites of the Zirconia district, 12 miles southeast of the Brevard schist, do not appear to be closely related to those of the Cashiers district.

The foliation of the metamorphic rocks has a general northeasterly strike and a southeasterly dip, and is highly folded. The gneiss and schist have been deformed by intrusions of granite that commonly form sills or laccolithic bodies; consequently the foliation near the intrusive bodies deviates from the normal northeasterly strike.

The dominant igneous rocks of the region are granites and closely related rocks, but small areas of ultramafic rocks, such as dunite, serpentine, and soapstone, also occur. Keith divided the granitic rocks into the Henderson granite, which he considered pre-Cambrian in age, and the Whiteside granite of late Paleozoic (?) age. The Henderson granite, as mapped by Keith, forms a band 6 to 8 miles wide that extends at least 50 miles both northeast and southwest of the Pisgah quadrangle. It is bounded on the northwest by the thin strip of Brevard schist and on the southeast by large masses of Whiteside granite. The main body of Henderson granite lies between the Cashiers and Zirconia districts. It is composed chiefly of potash feldspar, plagioclase, quartz, muscovite, and bioitite. Augen-gneiss and porphyritic granite with potash feldspar phenocrysts are common. Pegmatitic varieties are much less common than in the Whiteside granite.

The Whiteside granite, named by Keith from its occurrence in the bold cliffs of Whiteside Mountain in the Cashiers district, includes a wide variety of granitic rocks of late Paleozoic (?) age in the Blue Ridge and Piedmont areas of the Carolinas. The granite is mostly medium-grained, but in a few places it is porphyritic and in many places pegmatitic in texture. It is composed of potash feldspar, plagioclase, quartz, muscovite, biotite, and minor amounts of magnetite, ilmenite, pyrite, and garnet. In the Cashiers district the Whiteside granite generally forms large and small sills or laccolithic bodies that dip moderately southeastward (plate 2). According to Keith (1907, p. 4) the schistose layers of the Carolina gneiss arch over and dip away from the granite bodies in the Cashiers district, as if they were domed up by the granite. Southeast of the Brevard schist and Henderson granite areas the Whiteside granite occurs in larger bodies that contain irregularly oriented inclusions of gneiss and schist that appear to be remnants of the original roof of the intrusive bodies.

The Whiteside granite has a well-developed foliation in places, especially near Lake Toxaway in the Cashiers district, where Keith indicates that some schistose and gneissoid Whiteside granite is as much deformed as the Henderson granite. The Whiteside granite is probably the source of the pegmatites in the Cashiers district because pegmatite is abundant near it but is relatively rare in and near the Henderson granite.

The pegmatites of the Cashiers district differ markedly from those of the Franklin-Sylva district to the northwest (Olson and others, 1946) from which it is separated in most places by an area several miles

PLATE 2—*Map showing relation between Cashiers and Franklin-Sylva Districts, North Carolina*

wide in which no pegmatites have been mined. In the Cashiers district, gently to moderately dipping sill-like pegmatites predominate, whereas in the Franklin-Sylva district steeply dipping dikes are typical. Mineralogically the pegmatites of the Cashiers district contrast with those of the Franklin-Sylva district in that (1) the quartz is commonly darker gray; (2) the muscovite is typically green or brown, is commonly stained, and has "A" reeves in contrast to the red (ruby) or light-brown, flat muscovite of the Franklin-Sylva district; (3) there is less biotite; and (4) there are more of the uncommon minerals, such as beryl, tourmaline, samarskite, and uraninite, that are extremely scarce in the Franklin-Sylva district. It has been suggested that the Whiteside granite may be the source of both the Cashiers and the Franklin-Sylva pegmatites and that the mineralogical differences of pegmatites in these districts may be partly due to distance from the source.

In many places, particularly near pegmatites or sill-like bodies of granite, the metamorphic rocks have been impregnated with granitic or pegmatitic material to form migmatites. These transitional rock types produced by the introduction of varying quantities of granitic material have been studied by Sharpe and Allen (1938).

The migmatite, granite, and pegmatite are cut by granite dikes mostly less than 5 feet thick that are finer-grained than the typical Whiteside granite. These dikes are composed of quartz, potash feldspar, plagioclase, biotite, and muscovite. They are either not foliated or faintly foliated parallel to their walls, and where these dikes are discordant they show no foliation parallel to that of the enclosing gneiss or schist. Keith states that the dikes are more abundant near bodies of Whiteside granite, are of similar composition, and therefore probably came from the same source.

Weathering is deep and outcrops are sparse in most of the area studied. Some bold cliffs and knobs provide good exposures, as on Whiteside Mountain, Bald Rock, Chimneytop, and Hogback Mountain. The depths of weathering are related to the complex structural and erosional history of the southern Appalachians and seem to be almost independent of rock types. In areas of deep weathering, mining is done by pick and shovel or by bulldozer, and underground workings cave quickly after they are abandoned.

PEGMATITES OF THE CASHIERS DISTRICT

SIZE AND SHAPE

Of the 60 pegmatites examined, 50 are sufficiently exposed to permit an estimate of their maximum thicknesses. Of these, 18 (36 percent) are 1 to 5 feet thick, 22 (44 percent) are 5 to 15 feet thick, and 10 (20 percent) are 15 to 75 feet thick. The pegmatites that have been mined for mica are 1 to 60 feet thick. Six pegmatites have been mined for feldspar, and the four that have been most productive are 25, 35, 65, and 75 feet thick. No pegmatite is exposed for its full length, but the longest group of workings, comprising the Jake Rice and Proffitt mines, extends for about a quarter of a mile and probably consists of two or three parallel or echelon pegmatites. Most of the pegmatites appear to be sills or dikes whose lengths at the surface, and probably also whose depths, are many times their thicknesses.

WALL ROCKS

Ten of the pegmatite bodies studied in the Cashiers district are in granite, four are in hornblende gneiss, and the rest are in mica schist and gneiss. The wall rocks were altered through impregnation by pegmatitic and granitic materials, the recrystallization of wall-rock minerals, and the development of new minerals, such as biotite from hornblende. The most striking example of the development of biotite at the expense of hornblende is at the Little Hogback Creek prospect (no. 33, pl. 1). Here a 1- to 5-inch band of schist composed almost entirely of biotite and brown muscovite has been formed from the hornblende gneiss at the contact with an irregular pegmatite body that is about 10 feet thick. Similar mica flakes occur in thinner bands, several feet from the pegmatite, along fractures in the hornblende gneiss.

The Island Ford mica mine illustrates the introduction of various proportions of granite, pegmatite, and quartz as small pods or streaks in the different layers of the wall rock. The pegmatite mined for mica is in several concordant imbricate lenses, from 1 to 3 feet thick, near one horizon in the biotite-muscovite-garnet gneiss or migmatite. Some pods or stringers near this horizon are entirely gray quartz. Coarse muscovite books several inches in diameter, in contact with little if any pegmatite, appear to have formed in

the migmatite from the pegmatitic solutions that permeated the rock. One sill of coarse granite occurs 5 to 8 feet below the pegmatite, and two others within 50 feet beneath it are 4 and 15 feet thick. Finer-grained, faintly foliated granite dikes, a foot or less thick, cut the migmatite at a low angle. They are believed to be slightly younger than the pegmatite and coarse granite, although contacts with these rocks are not exposed.

MINERALOGIC COMPOSITION

Nearly all the pegmatites of the Cashiers district are of relatively simple composition, consisting chiefly of perthite, plagioclase, quartz, muscovite, and garnet. The quartz in pegmatites of the Cashiers district is gray to white; smoky quartz occurs in a very few places, where it apparently is closely associated with radioactive minerals. Perthite is coarse-grained[1] and hence is the variety of feldspar that is mined. The fine-grained feldspar is commonly plagioclase, although some potash feldspar also is fine-grained, as at the L. M. McCall mine, where thin sugary streaks are composed of both plagioclase and potash feldspar. Plagioclase from the Bald Rock and L. M. McCall mines was examined by oil-immersion methods and found to be oligoclose (An_{15-20}).

Biotite occurs in about a third of the pegmatites studied. The mines and prospects in which beryl was found include the Sheep Cliff, Rice, an unnamed prospect southwest of Toxaway Mountain (no. 34, pl. 1), Tallow Face, Reid, Thomas Grimshawe, and Edwards. Beryl from the Sheep Cliff mine and prospect no. 34 was checked microscopically, and the index of the ordinary ray of all the material examined was found to range from 1.585 to 1.587, indicating a moderately high alkali content and a BeO content of about 12.3 to 12.5 percent according to curves by Schaller (U. S. Geol. Survey unpublished manuscript report). Black tourmaline occurs at mines numbered 4, 7, 8, 27, and 32 on plate 1, and pink tourmaline at the Thomas Grimshawe (no. 27, pl. 1). Apatite was noted at numbers 4, 7, and 8 (pl. 1); pyrrhotite, pyrite, and perhaps minor quantities of other sulfides, at numbers 51, 55, 56, and 58 (pl. 1); and late epidote in fractures at the Puncheon Camp (no. 53, pl. 1), and at no. 34 (pl. 1). Uraninite, autunite, and uranophane occur with smoky quartz at the Wolf Creek mine (no. 41, pl. 1). Uraninite is also reported in a mica prospect, not examined by the writer, southwest of Toxaway Mountain and north of U. S. Highway 64. Bismutite has been reported from an unspecified location in Cashiers Valley, where it occurs in small masses in a narrow vein, "associated with dark red or black garnet, white mica and quartz, and rarely black tourmaline, the bismutite forming the matrix of the other minerals" (Chester, 1887, p. 290).

DISTRIBUTION OF MINERALS IN THE PEGMATITES

Many pegmatites in the Cashiers district have not been mined because no concentrations of valuable minerals are exposed. Such pegmatites are comparatively homogeneous and simple in mineral composition, consisting of fine- to medium-grained potash and soda feldspars, quartz, and muscovite, and possibly garnet and biotite. In pegmatites that have been mined, the valuable constituents are generally localized in certain parts of the body. These richer parts are mined selectively, although pegmatite bodies less than 5 feet thick are commonly mined from wall to wall. The zoning, or localization of minerals within the pegmatite bodies, is not known for all the deposits in the Cashiers district because exposures at most mines are poor, but a few general statements may be made.

The most striking evidence of zoning in the Cashiers district is in the many pegmatite bodies that have quartz cores. These bodies commonly have feldspar-quartz-muscovite wall zones. Although deep weathering makes the distinction between the various feldspars difficult in many places, the ratio of potash feldspar to plagioclase doubtless differs considerably in the pegmatites and in different parts of individual zoned pegmatites. Coarse-grained perthite is common in the central part of the pegmatite, or in an intermediate zone between the core and the wall zone, rather than near the walls. Coarse-grained perthite-quartz pegmatite is mined in the central part of the Bald Rock pegmatite, for example, and in the intermediate zone surrounding the quartz core at the Sheep Cliff mine. Plagioclase, on the other hand, is conspicuous in many

[1] In describing pegmatite textures, the following grain-size classification is used in this report:
Fine-grained—less than 1 inch in maximum dimension.
Medium-grained—1 to 4 inches in maximum dimension.
Coarse-grained—4 to 12 inches in maximum dimension.
Very coarse grained—greater than 12 inches in maximum dimension.

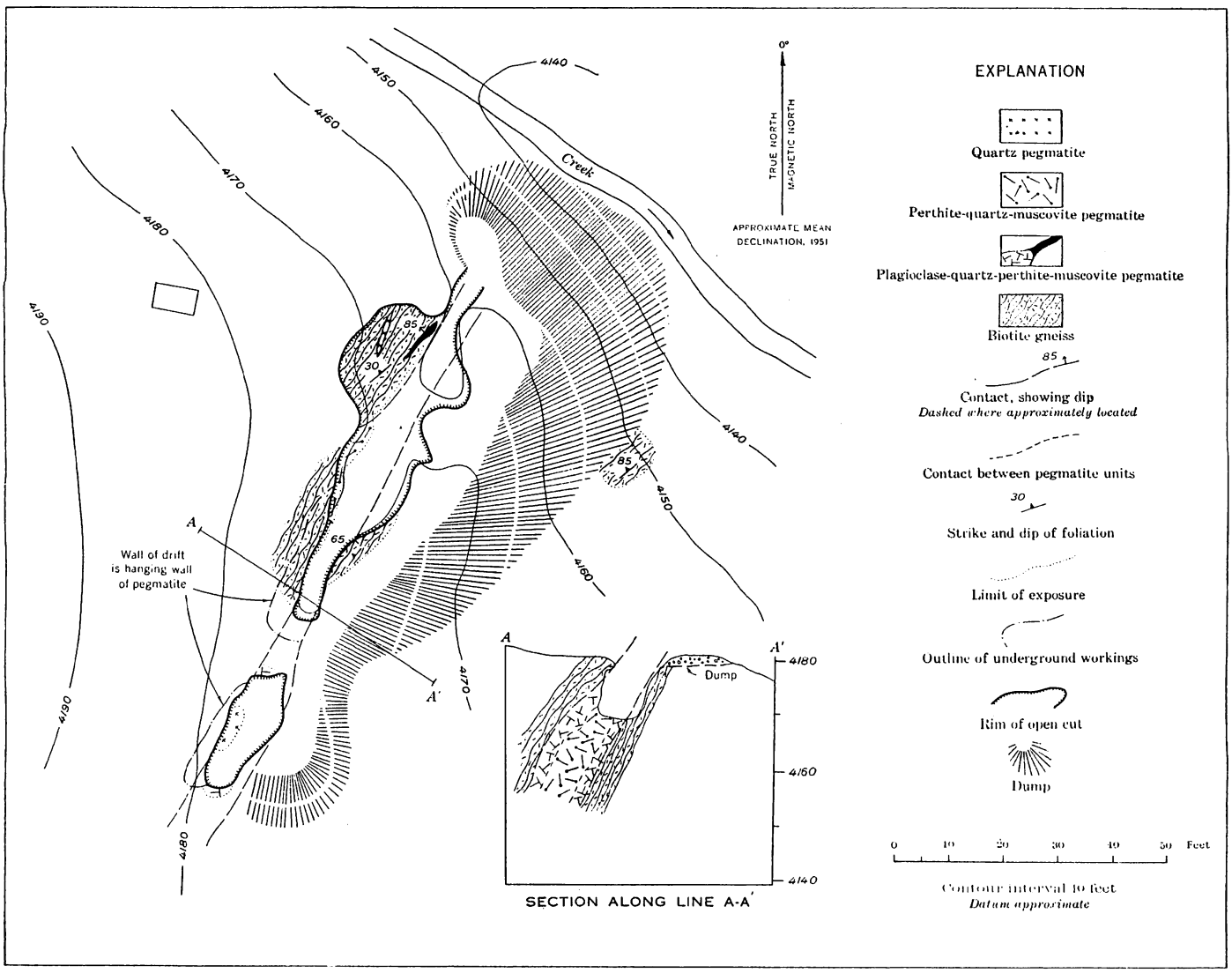


FIGURE 2.—MAP AND SECTION OF THE FARLOW GAP MICA MINE, TRANSYLVANIA COUNTY

wall or border zones. It also occurs in the central parts of some pegmatites, such as the L. M. McCall, in streaks or layers of quartz-plagioclase-muscovite pegmatite, some of which probably formed as fracture fillings after the adjoining rock had solidified.

Graphic intergrowths of quartz and perthite are found in many of the thick pegmatite bodies, but are inconspicuous in many of the thin ones. Graphic granite is not restricted to any one part of the pegmatite body but is probably most abundant in an intermediate position between the wall zone and the core. Coarse muscovite rarely occurs in close association with graphic granite.

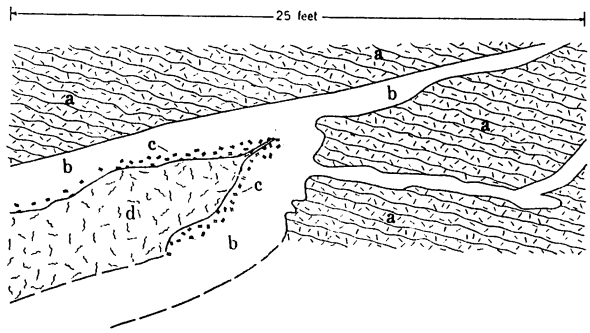
The Farlow Gap mine (fig. 2) has a typical zoned pegmatite. The average thickness of this pegmatite is 7 feet. The core, which is 3 to 5 feet thick, consists principally of blocky perthite and quartz, with scattered large books of muscovite. The 1- to 2-foot wall zone, which makes up the remainder of the pegmatite, consists of plagioclase, perthite, quartz, and both coarse- and fine-grained muscovite. Probably most of the commercial muscovite was mined from the wall zone but some was also obtained from the core.

Large mica books are rarely exposed in place in mines that are not in operation, but the position of workings and the examination of small exposures and rock from the dumps indicate that most of the muscovite is (1) in feldspar-quartz-muscovite pegmatite at the margins of quartz cores; (2) in feldspar-quartz-muscovite wall zones; (3) in quartz-muscovite pegmatite, known locally as "burr" or mica "capping," which

forms irregular layers or streaks in various positions in the pegmatites; and (4) in thin quartz-muscovite-feldspar-garnet pegmatite streaks in which the feldspar is chiefly plagioclase. These streaks may have formed as fracture fillings, possibly accompanied by some replacement of earlier-formed pegmatite minerals, after the bulk of the pegmatite body had solidified. Layers of both the third and the fourth types occur in some pegmatites that are believed to have been deformed by rock movements during emplacement.

Where two or more types of muscovite are present in the same pegmatite, they are commonly localized in different parts of the body. For example, the mica at the margins of quartz cores is likely to be "A" or reeved, green, and is either clear or stained; whereas the mica near the walls of the pegmatite is more likely to be brown and is commonly stained.

The Chestnut Ridge mine is an example of a pegmatite containing several types of mica. This pegmatite cuts across the foliation of the mica-garnet gneiss at a low angle, and it contains small irregular inclusions of the wall rock. Most of the feldspar, particularly in the fine-grained pegmatite near the contacts, is plagioclase, but considerable perthite is also present. Biotite is concentrated near the walls of the pegmatite (see fig. 3), and particularly in the thin apophyses extending from the thick mass of pegmatite.



a. Mica-garnet gneiss.
b. Feldspar-quartz-biotite-muscovite pegmatite. Muscovite small, light reddish brown. Biotite most abundant near walls.
c. Larger muscovite, commonly green, stained, reeved; most abundant on upper side of quartz core.
d. Quartz core.

FIGURE 3.—DIAGRAMMATIC SECTION OF PART OF PEGMATITE AT CHESTNUT RIDGE MINE TRANSYLVANIA COUNTY

Small reddish-brown muscovite books, generally with light-colored edges and with good crystal form, occur in the biotite-bearing pegmatite; mica books as large as 4 by 6 inches occur near the quartz core, particularly along its upper edge. These larger books are mottled green, or have a color-branding parallel to the outline of the crystal. They are commonly reeved; most are stained, but some clear sheets could be recovered.

STRUCTURE

Schistosity was a dominant factor controlling the structure of the pegmatites. Two-thirds of the pegmatite bodies are broadly concordant with their wall rocks, and one-third are markedly discordant. Evidence of plunge could be obtained for only three of the pegmatite bodies. The pegmatites at the Tallow Face and Nicholson mines have a nearly horizontal plunge. The L. M. McCall pegmatite probably plunges about 15° SW., parallel to the crest of the pegmatite body, which is exposed at the southwest end of the workings, and parallel to the plunge of rolls in the contacts.

Several features suggest that some of the pegmatites were deformed during and after their emplacement. The orientation of mineral grains is commonly subparallel to the walls, rather than perpendicular to them as in parts of many zoned pegmatites that crystallized under conditions of little shearing stress. Layerlike bodies of quartz or of plagioclase-quartz pegmatite, commonly with associated muscovite, occur in outer zones of some pegmatite, as though they were introduced into fractures in partly solidified pegmatite. Many of the textures are similar to those in the Spruce Pine district, which have been described and illustrated by Maurice (1940, pp. 59-63, 71-72) and probably originated by similar processes, such as protoclastic deformation, filter pressing, some replacement, and less commonly cataclastic deformation.

The pegmatite at the Tallow Face mine, for example, appears to have been deformed during and after solidification. The plunge of the lineation in the mica gneiss, shown by the axes of small folds and crumples in the planes of schistosity, is N. 25° E. and nearly horizontal, and is the same as that of the pegmatite body. Rolls in the pegmatite contact are also parallel to the lineation in country rock. The correspondence of these features indicates that the lineation and foliation of the gneiss developed either before or during the introduction of the pegmatite. Deformation during the period of selidification of the pegmatite at the Tallow Face mine is suggested by fractures in the quartz core, into which a little mica and feldspar were introduced. Minute corrugations of these fracture surfaces are coated with tiny mica flakes, which are arranged in rows parallel to the lineation of the wall rocks; hence the forces that produced the lineation in the wall rocks may also have been effective during consolidation of the pegmatite. Other evidences of shearing in the pegmatites are the tabular streaks rich in quartz and book muscovite, with eye-shaped feldspar grains; the parallelism of small muscovite flakes in the wall zone; and the smooth "polished" surfaces and bent cleavages of the muscovite books.

Post-pegmatite fracturing is evident in many of the pegmatites. Fracturing of some of the quartz cores was recognized by Sterrett (1923, pp. 216-217) at the Thomas Grimshawe mine and the Chink Knob prospect.

The pegmatite at the Nicholson mine resembles that at the Tallow Face in that the micas have a parallel orientation, the feldspar grains are eye-shaped, and the plunge is probably almost horizontal. Some of the quartz is fractured like that at the Thomas Grimshawe mine. Other pegmatites, such as those at the Bryson, Brushy Hollow, and Morning Star mines, have a streaky or foliated appearance caused by nearly parallel orientation of mica books, streaks of quartzose pegmatite parallel to the contacts, and eye-shaped feldspar grains.

PEGMATITE MINERAL DEPOSITS

Muscovite, feldspar, and beryl are the principal pegmatite minerals considered in this report; a little kaolin has been found in the district, as at the Tennessee Creek mine, but little if any has been produced. The mines are small and have been worked intermittently. In the spring of 1948 the only active mines were the L. M. McCall and Bald Rock feldspar mines.

The greater part of the mica in the Cashiers district has been obtained from two areas, (1) a narrow belt about a mile wide and 8 miles long extending northeastward from the southernmost corner of Jackson County to Sapphire Post Office, and (2) a few square miles around Pinhook Gap near the northeast end of the district, in the headwaters of the French Broad and Tuckasegee Rivers. Mica has been the dominant product from 54 of the 60 mines and prospects described in table 1.

The muscovite of the Cashiers district is dominantly of the type classed commercially as stained mica. The stains or inclusions are chiefly iron oxide, although in a few places the specks are probably tiny biotite flakes intergrown with the muscovite. Clear mica predominates over stained in less than a third of the deposits examined, and in these the product is partly stained. Most of the mines that have produced stained mica could, by careful trimming, yield some clear mica, probably less than 25 percent of the total sheet mica. The muscovite is green or brown predominantly, light brown ("rum") less commonly, and red ("ruby") in no more than half a dozen of the localities examined.

The Cashiers district was only a minor contributor of "strategic" grade muscovite during World War II because of staining and the prevailing green and dark-brown color of much of the muscovite. Even though part of the product of nearly every mine would be clear if prepared carefully, the high proportion of stained mica at many of the mines makes it unprofitable to work them for clear mica alone. This is particularly true if "ruby" mica is specified, because in all but a few of the known mica deposits of the district green or dark-brown mica predominates. A few deposits produced high-quality mica during World War II, and the success of these operations encouraged the prospecting of at least 30 other deposits throughout the district. Future prospecting to find deposits containing dominantly clear mica, such as at the Farlow Gap and Bee Tree mines, would be justified under favorable market conditions, although most of the deposits found probably would contain green and brown stained mica.

The Sheep Cliff, Bald Rock, L. M. McCall, and Puncheon Camp have been the only productive feldspar mines in the Cashiers district. Only 10 of the 60 pegmatites studied in the Cashiers district are more than

15 feet thick. Inasmuch as pegmatites less than 15 feet thick rarely can be mined profitably for feldspar, the number of potentially large feldspar deposits among the pegmatites studied is small. Three of the productive mines are near the northeast end of the district, in the vicinity of Pinhook Gap, where large pegmatites are not uncommon. The fourth productive feldspar mine—the Sheep Cliff—is in a large pegmatite body in the southwestern part of the district. A prospect southwest of Toxaway Mountain (no. 34, pl. 1), appears to be in a relatively large pegmatite body containing massive quartz and blocky perthite, but the quantity of coarse perthite could not be determined from the exposures available. The Thomas Grimshawe mine was prospected for feldspar in the summer of 1947, but the size of the body and the proportion of recoverable feldspar were not sufficient to encourage further development of the deposit. This pegmatite body is 25 feet thick over a distance of about 80 feet.

The feldspar recovered from the Bald Rock mine was estimated by the foreman to be 50 percent of the rock mined, an exceptionally high recovery. The L. M. McCall mine is estimated to have a recovery of 33 to 40 percent, which also is very good. The Sheep Cliff mine was probably comparable to these in productivity when it was in operation. The Puncheon Camp deposit may contain a somewhat lower percentage of recoverable feldspar, because of the presence of thick masses of quartz, but there was sufficient coarse-grained feldspar, relatively free of impurities, to encourage the reopening of the mine in June 1948.

Inasmuch as transportation is an important factor in the production of a low-priced commodity, feldspar mining in the Cashiers district is hindered by the long distance to grinding mills. Even with this handicap, it has been feasible to mine the high-grade potash feldspar at the Bald Rock and L. M. McCall mines. The gradual depletion of deposits of coarse-grained potash feldspar in other districts has led to increased production of more sodic feldspar by flotation methods. If the more sodic feldspar produced in other districts does not fulfill the requirements for the potash variety in certain uses, other deposits of coarse potash feldspar in the Cashiers might be explored.

Beryl has been found in the Cashiers district in seven pegmatites—the Sheep Cliff, Thomas Grimshawe, Reid, Tallow Face, Edwards, Rice mica-beryl, and an unnamed prospect southwest of Toxaway Mountain (no. 34, pl. 1). None was observed at the Reid, Tallow Face, Edwards, and Rice mica-beryl mines during the reconnaissance examination. Beryl has been produced at the Sheep Cliff mine as a byproduct of feldspar mining, but none is now exposed in place and the dump probably contains only 1 or 2 tons. One small beryl crystal was found in a brief visit to the Thomas Grimshawe mine, where gem beryl is reported to have been encountered previously in mining for mica. At the unnamed prospect southwest of Toxaway Mountain (no. 34, pl. 1), four small beryl crystals make up 0.03 percent of a pegmatite exposure 3 by 15 feet in area. These observations indicate that the beryl occurs mostly in the southwestern part of the Cashiers district, but none can be produced economically under present conditions except as a byproduct of mining for other pegmatite minerals.

SELECTED MINES

The Tallow Face, Sheep Cliff, Bald Rock, and L. M. McCall mines provide the best exposures of pegmatite in the district, and they will be described in some detail. Data on the wall rocks, workings, mineralogy, and economic features of the 60 pegmatite mines studied in the Cashiers district are summarized at the end of this report.

TALLOW FACE MICA MINE

The workings of the Tallow Face mica mine are in a narrow area 320 feet long that trends N. 25° E. The half of the workings that lies south of the crest of a low ridge is shown in figure 4. A shallow open cut was excavated in this area late in 1944 by bulldozer. Two connected drifts extend northward from the open cut for 85 and 46 feet respectively. The older workings described by Sterrett (1923, p. 267) are north of the crest of the ridge and include an open cut 60 feet long, a 60-foot caved shaft, three pits, and three caved drifts about 200 feet in combined length.

These workings expose a pegmatite body that strikes N. 25° E. and dips 10°-80° NW. In most places the pegmatite is concordant with the foliation of the enclosing mica gneiss, which dips 60°-70° NW. on the average. The gneiss is enriched by coarse muscovite and quartz for about 2 feet outward from the contact. The mica-rich part of the pegmatite body probably has a nearly horizontal plunge and extends beneath the ridge between outcrops on the north and south sides.

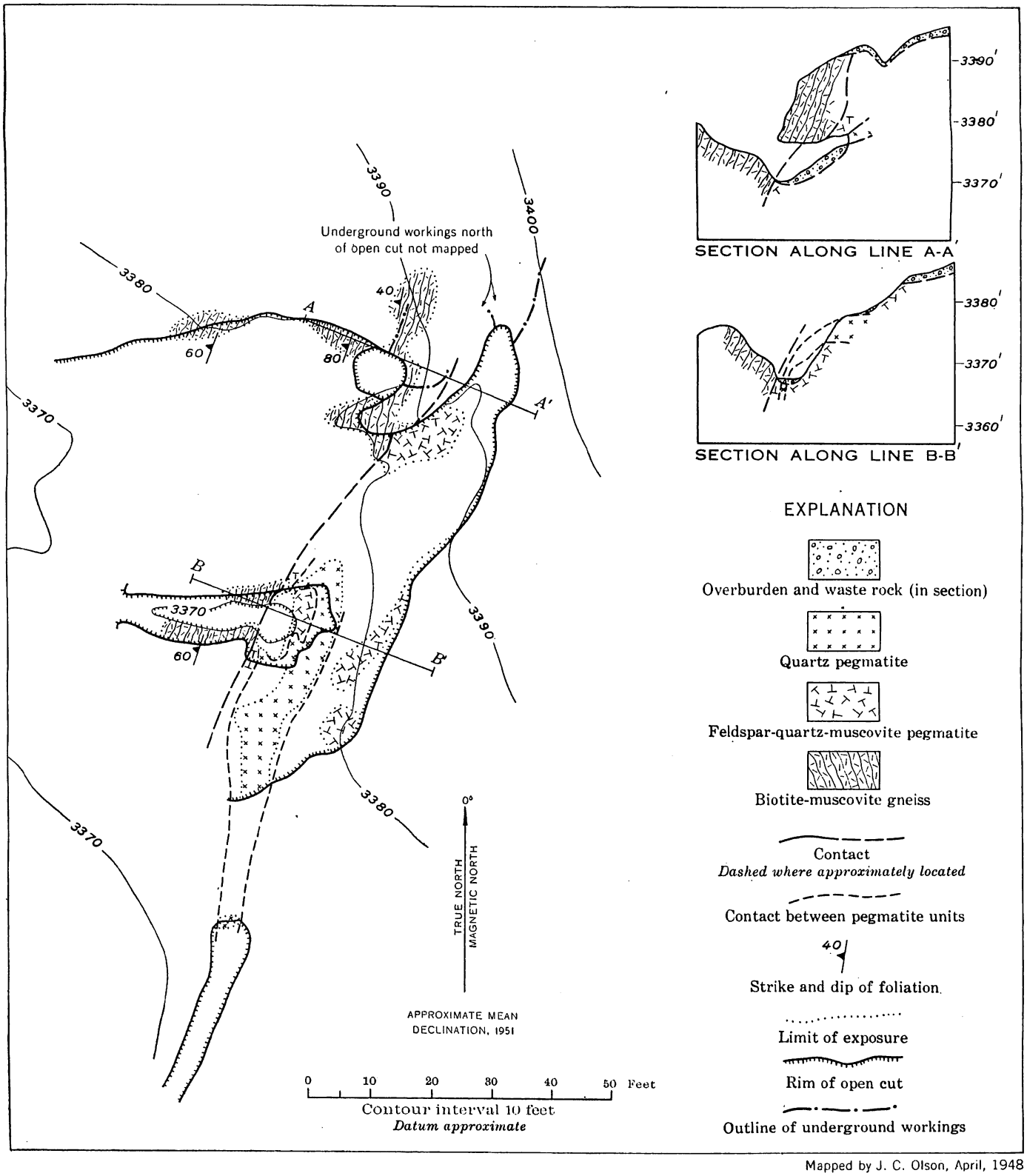


FIGURE 4.—*Sketch map of the open cut, Tallow Face mica mine, Transylvania County, N. C.*

The pegmatite is composed of quartz, plagioclase, perthite, garnet, and beryl. It contains a quartz core that is 1 to 5 feet thick in the open cut (fig. 4). The workings for mica in the southern half of the mine are mostly in the 3-foot wall zone above the quartz core; the footwall zone does not appear to have been mined.

The wall zone above the quartz core consists of fine- to medium-grained feldspar and quartz, scattered flakes and books of muscovite, and garnet crystals as much as three-fourths inch in diameter. The feldspar is mostly plagioclase. The muscovite occurs in several thin tabular streaks in the hanging-wall zone and at the hanging-wall contact. The general parallelism of tabular elements in the body is also shown by streaks of quartz and the parallel orientation of eye-shaped feldspar grains.

The mica-rich part of the pegmatite is inferred to be relatively narrow, to strike N. 25° E., and to have a nearly horizontal plunge. It seems likely that the mica-rich hanging-wall zone has been practically mined out in the area north of the open cut shown in figure 4, and has been eroded south of that point. It is possible that other rolls or other mica concentrations might be found up- or down-dip from the workings, or in unmined parts of the footwall zone. A band of gneiss in the east wall of the underground workings separates the pegmatite into two parts, suggesting that the body may pinch out in that direction.

The sheet mica in this deposit is either green, partly clear and partly stained, or greenish brown and heavily stained. "A" mica is common, and a large proportion of the total product is stained. Light-green beryl crystals as much as 6 inches long were found during the mining, but beryl was not seen by the writer.

SHEEP CLIFF FELDSPAR MINE

Feldspar, with byproduct mica and beryl, was produced at the Sheep Cliff mine in 1942 and again in 1945 or 1946. The workings, shown in figure 5, consist of an open cut 100 feet long and 70 feet in maximum

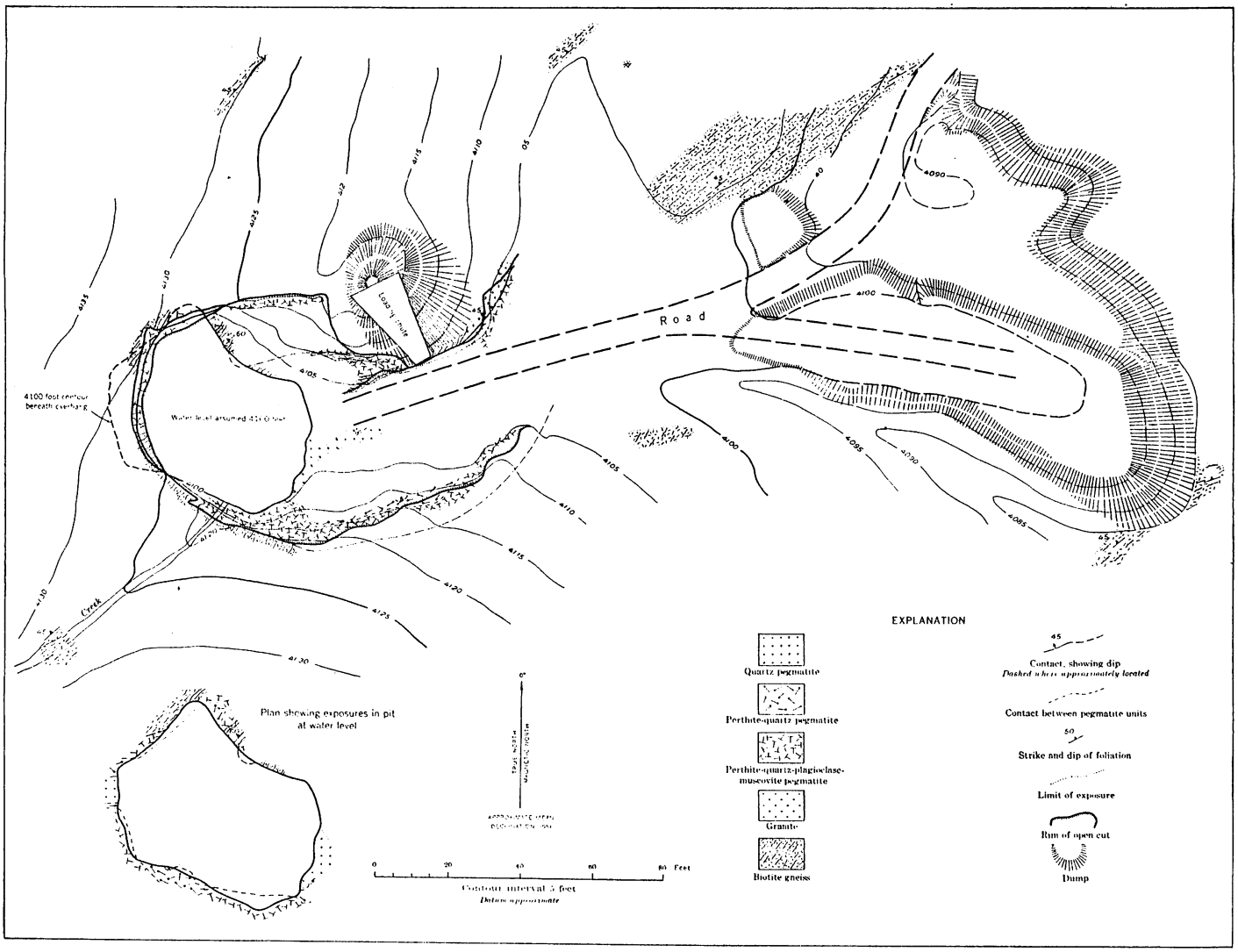


FIGURE 5.—PLAN OF THE SHEEP CLIFF FELDSPAR MINE, JACKSON COUNTY

width. The westernmost 50 feet of the open cut is flooded. The water level was 30 feet below the rim of the cut at the time of this examination. The open cut extends steeply downward to the west under water that is at least 20 feet and not more than 50 feet deep.

The pegmatite at the Sheep Cliff mine is an irregular body in both plan and section. It trends a few degrees north of east and dips steeply. The thickness, including irregular pendants or projections of gneiss, is about 65 feet. The foliation of the biotite gneiss strikes N. 50° E. and dips 45° NW. A granite dike about 4 feet thick cuts the gneiss.

The pegmatite is composed of microcline-perthite, quartz, plagioclase, muscovite, beryl, garnet, biotite, and samarskite. The quartz core, 7 feet thick, is exposed in the floor of the cut and is a conspicuous unit of the pegmatite body. The quartz is clear, gray, smoky, and pale rose. A perthite-quartz unit, which was mined for feldspar, adjoins the quartz core. It is composed of perthite blocks as much as 3 feet long, gray quartz, minor white plagioclase, and small green mica flakes. One grain of samarskite was found in this zone adjacent to the quartz core, and the zone presumably also contains beryl, although none was seen in place. The outer unit, or wall zone, consists of perthite, quartz, plagioclase, and muscovite; graphic intergrowths of quartz and perthite are common. Garnet occurs in aggregates as much as 5 inches long. The contact between the two perthite-bearing units is gradational and indistinct.

The beryl found in the dump is yellowish- to bluish-green. One crystal showed color zoning. The index of refraction of the ordinary ray is 1.585 to 1.587, indicating a BeO content of about 12.4 percent and moderately high alkali content. It is estimated that the beryl produced during the feldspar mining was less than 0.1 percent of the rock mined, perhaps about 0.01 to 0.03 percent, and that there are 1 or 2 tons of beryl in the dumps. No beryl was exposed in the walls of the open cut in 1948.

The muscovite is dark green, commonly of "A" type, with numerous magnetite specks and garnet intergrowths. Although books as much as 6 inches in diameter were exposed at the mine, the proportion of sheet mica recoverable from them is relatively low. It is doubtful that muscovite could be produced profitably, except as a byproduct of the feldspar mining.

BALD ROCK FELDSPAR MINE

The Bald Rock mine was opened by the Feldspar Milling Company on May 1, 1947, and had been operated a year at the time it was examined in May 1948. As shown in figure 6, an open cut, 20 to 35 feet deep and 55 by 90 feet in plan, has been excavated in the central part of a pegmatite body.

The pegmatite strikes N. 30°-50° E. and dips 45° NW. At the northeast end of the open cut it is 75 feet thick, and it may be even thicker to the northeast, where it is obscured by alluvium. The west contact of the pegmatite body is well exposed at the open cut, but the east contact is visible at only one place, as shown in figure 6. The strike of these contacts and the thinning of the feldspar-rich central part of the pegmatite at the south end of the open cut suggest that the body thins rapidly southwestward. About 500 feet southwest of the main cut two small pits about 50 feet apart expose a pegmatite body at least 20 feet thick that strikes N. 50° E. and dips 50° NW. This pegmatite closely resembles that in the main open cut in attitude and internal structure. The exposed pegmatites are so similar that the 500-foot interval between the workings, in which there are no exposures, should be prospected to determine the continuity of the feldspar deposits.

The pegmatite at the main cut is enclosed in granite, and is approximately concordant with foliation that strikes N. 30° E. and dips 50° NW. Fragments of hornblende gneiss are common in the soil near the mine, and quartz-mica schist is exposed at one of the small cuts 500 feet to the southwest. At least one granite dike, 4 to 12 inches thick, cuts sharply across the zonal structure of the pegmatite at the main pit.

The pegmatite is composed of perthite, quartz, muscovite, oligoclase, biotite, and garnet. It is inconspicuously zoned, and the contacts between zones are gradational. The wall zone is composed predominantly of perthite, quartz, and muscovite. Graphic intergrowths of quartz and feldspar are common, and disseminated quartz in much of the wall zone makes it impractical to mine and cob the feldspar. The wall zone, as shown on the map, is not uniform in mineral composition. Graphic granite appears to be more abundant near the hanging wall than in the footwall part of the zone. The mica content is variable, and the inner 5 feet of the hanging-wall part of the zone contains numerous strips or seams of muscovite and biotite several feet in length, which appear to have formed in fractures. The strips are mostly of air-stained mus-

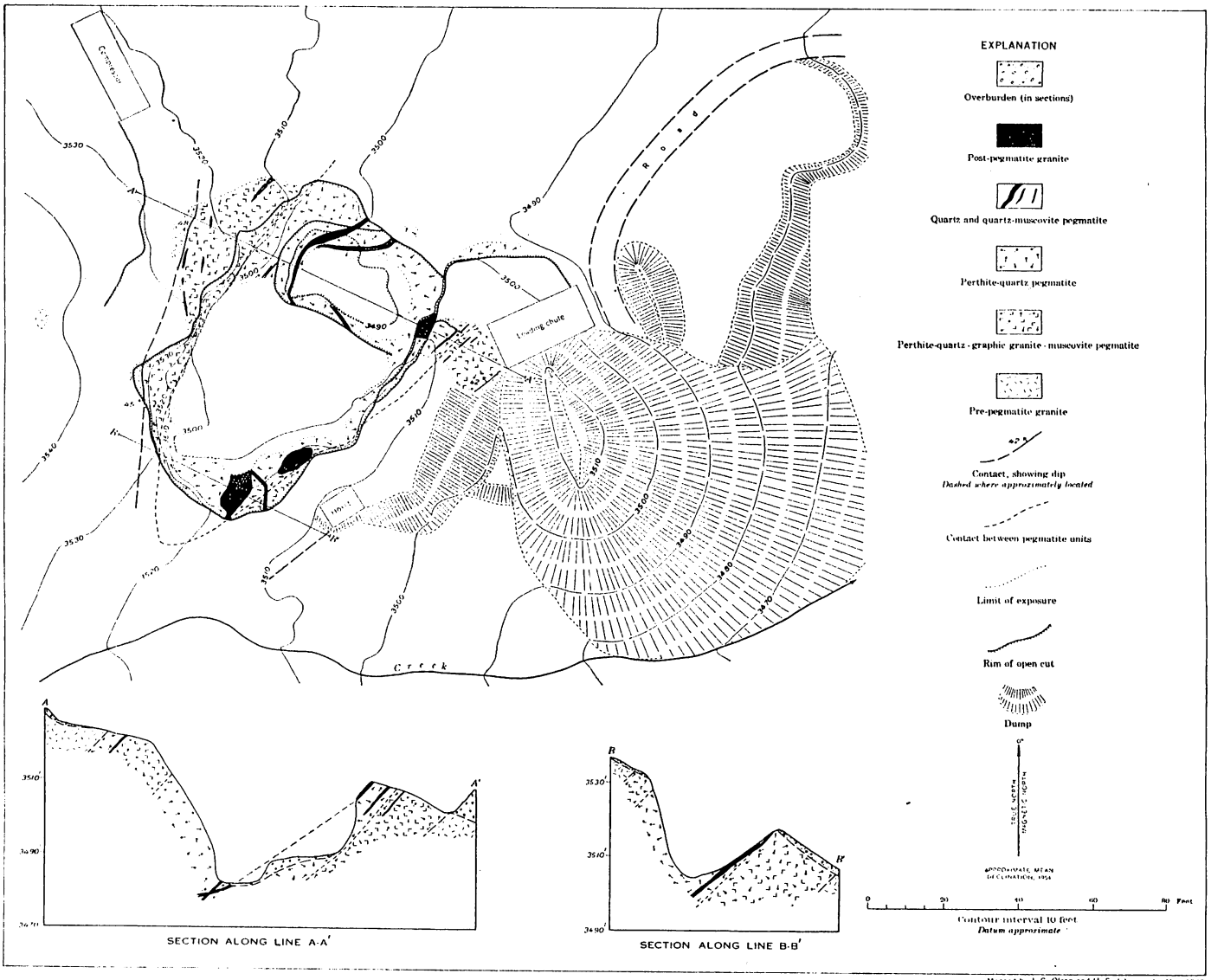


FIGURE 6.—MAP AND SECTIONS OF THE BALD ROCK FELDSPAR MINE, TRANSYLVANIA COUNTY

covite. Biotite appears to be localized near the middle of the west wall of the open cut. No mica strips or seams were exposed near the footwall at the time the mine was studied.

The large central unit of the pegmatite consists of the same minerals as the wall zones, but graphic granite is less abundant, and quartz and muscovite are less widely disseminated. The perthite is coarser grained in this zone, and crystals relatively free from impurities can be mined.

Several thin, roughly parallel streaks of gray quartz, associated with fine granular perthite and oligoclase, garnet, and in places coarse muscovite, occur in the pegmatite. The thickest of these, 6 to 18 inches thick, is in the middle of the dike. Other thin quartz-rich layers, containing some granular feldspar and muscovite, are common, and are probably more abundant in the wall zones than in the zone mined for feldspar. They may have crystallized in fractures formed by deformation after most of the pegmatite had solidified. Muscovite occurs in and at the margins of these quartz-rich layers, and is most abundant in the middle of the pegmatite body adjacent to the thickest quartz-rich layer. The muscovite is commonly light greenish brown, wavy, mottled, air-stained, and black-stained. The books are as large as 6 by 8 inches, but the general quality is not high.

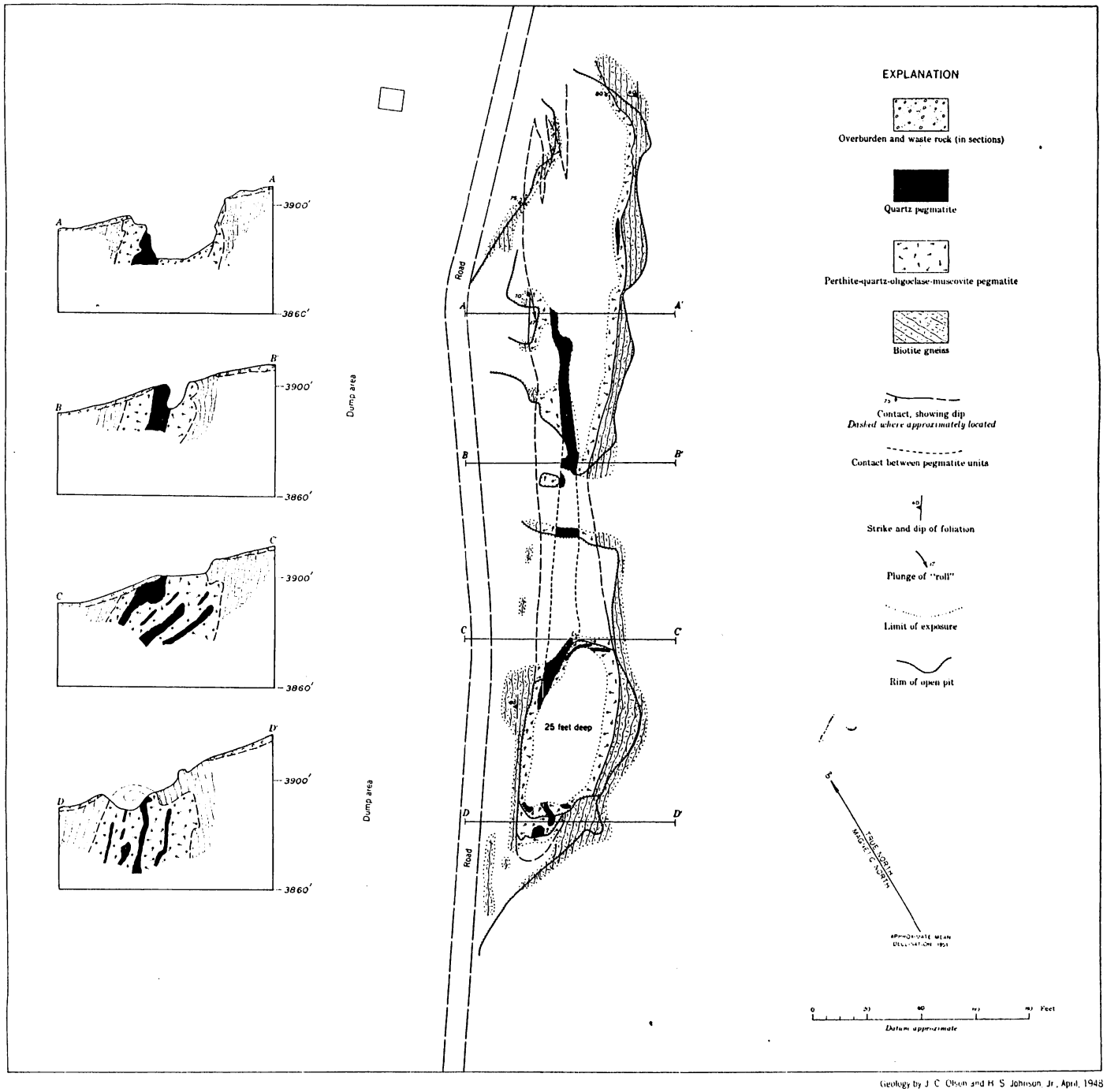
Oligoclase (An15) is markedly subordinate to potash feldspar in the Bald Rock pegmatite, and is not noticeably concentrated in any particular zone. The miners estimate the recovery of potash feldspar to be

about 50 percent. This high recovery makes it possible to develop the property economically even though the feldspar has to be hauled by truck to the Bowditch mill, nearly 100 miles by road to the northeast.

In the two pits 500 feet southwest of the main workings, the pegmatite has a streakiness parallel to the contacts caused by the orientation of tabular minerals such as muscovite and perthite and by bands of sugary quartz-feldspar-muscovite-garnet pegmatite.

L. M. McCALL FELDSPAR-MICA MINE

The L. M. McCall mine consists of two open cuts, one 65 by 40 feet, and 25 feet deep; the other 140 feet long, 30 to 50 feet wide, and 25 feet in maximum depth (see plate 3). The southwestern cut was being deep-



Geology by J. C. Olson and H. S. Johnson, Jr., April, 1948

PLATE 3.—*Map and sections of the L. M. McCall feldspar-mica mine, Jackson County*

ened in feldspar mining in 1948. The two cuts are in a pegmatite body 35 feet thick and at least 300 feet long that strikes N. 30° E. and dips about 80° NW. The pegmatite is enclosed in gray biotite gneiss the foliation of which strikes N. 30° E. and dips 80° NW. on the average. At the southwest end of the workings the pegmatite appears to pinch out abruptly, and at the northeast end it splits into several fingers.

The east contact of the pegmatite body is scalloped, as shown in the cross sections in plate 3. Some of the "rolls" appear to plunge down the dip of the body, but others plunge southwestward at angles of 10° to

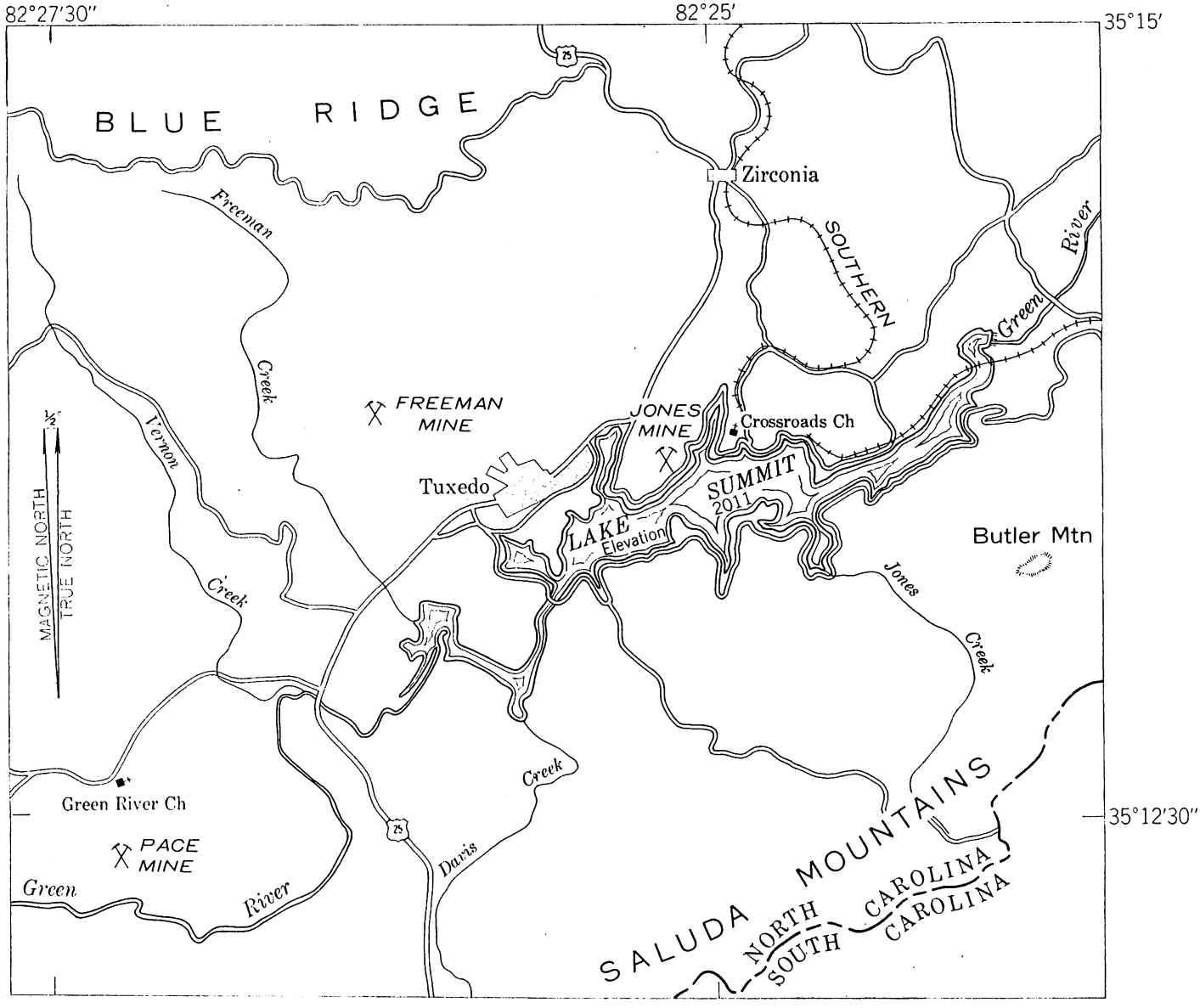


FIGURE 7.
MAP OF THE ZIRCONIA DISTRICT, NORTH CAROLINA SHOWING LOCATIONS OF THE JONES, FREEMAN, AND PACE MINES

0 ½ 1 2 3 Miles

20°. The crest of the pegmatite body, where it pinches out at the southwest end of the workings, also appears to plunge southwestward at a low angle. One sharp roll in the west contact of the body plunges southwestward at an angle of 17°. The direction and angle of plunge of the pegmatite body may become more clearly established as the open cuts are deepened. If the pegmatite splits into several fingers at depth beneath the open cuts, as it does at the northeast end of the workings, it will provide further evidence of a southwesterly plunge of about 15°.

The pegmatite is composed of white perthite, quartz, oligoclase, muscovite, biotite, pyrite, and pyrrhotite. The relatively fine grained oligoclase (An18) -quartz border zone which ranges from a thin film to 6 inches in thickness (not delineated on map), is believed to have been the first part of the pegmatite to crystallize; then followed the major portion of the pegmatite that consists of perthite, graphic granite, quartz, and minor muscovite and biotite. The perthite is fine- to coarse-grained, and some is graphically intergrown with quartz. A few small flakes and strips of biotite occur near the walls. Several subparallel layerlike bodies of quartz, or of sugary grained oligoclase-quartz pegmatite, are believed to have crystallized in fractures after much of the rest of the pegmatite. The largest streak of massive quartz is near the middle of the dike, but parallel streaks occur between it and the walls. Muscovite in pegmatite adjacent to the massive quartz makes up as much as 50 percent of small volumes of rock. Pyrite and pyrrhotite are in both the massive quartz and the oligoclase-quartz pegmatite.

Most of the mica is associated with the quartz and oligoclase-quartz streaks in the interior of the pegmatite. Most of this mica, which is green, is lightly specked, and "A" structure is strongly developed. Smaller amounts of muscovite occur near the walls of the pegmatite body. This mica is dark greenish brown, partly stained, and has less "A" structure than the mica in the interior of the pegmatite. The percentage of scrap mica in the total mica is large.

The McCall mine was worked in 1940 by Messrs. Young and Cox and was reopened in September 1947 by the Feldspar Milling Company. High-quality potash feldspar and byproduct muscovite were being produced at the time the mine was examined in May 1948.

PEGMATITES OF THE ZIRCONIA DISTRICT

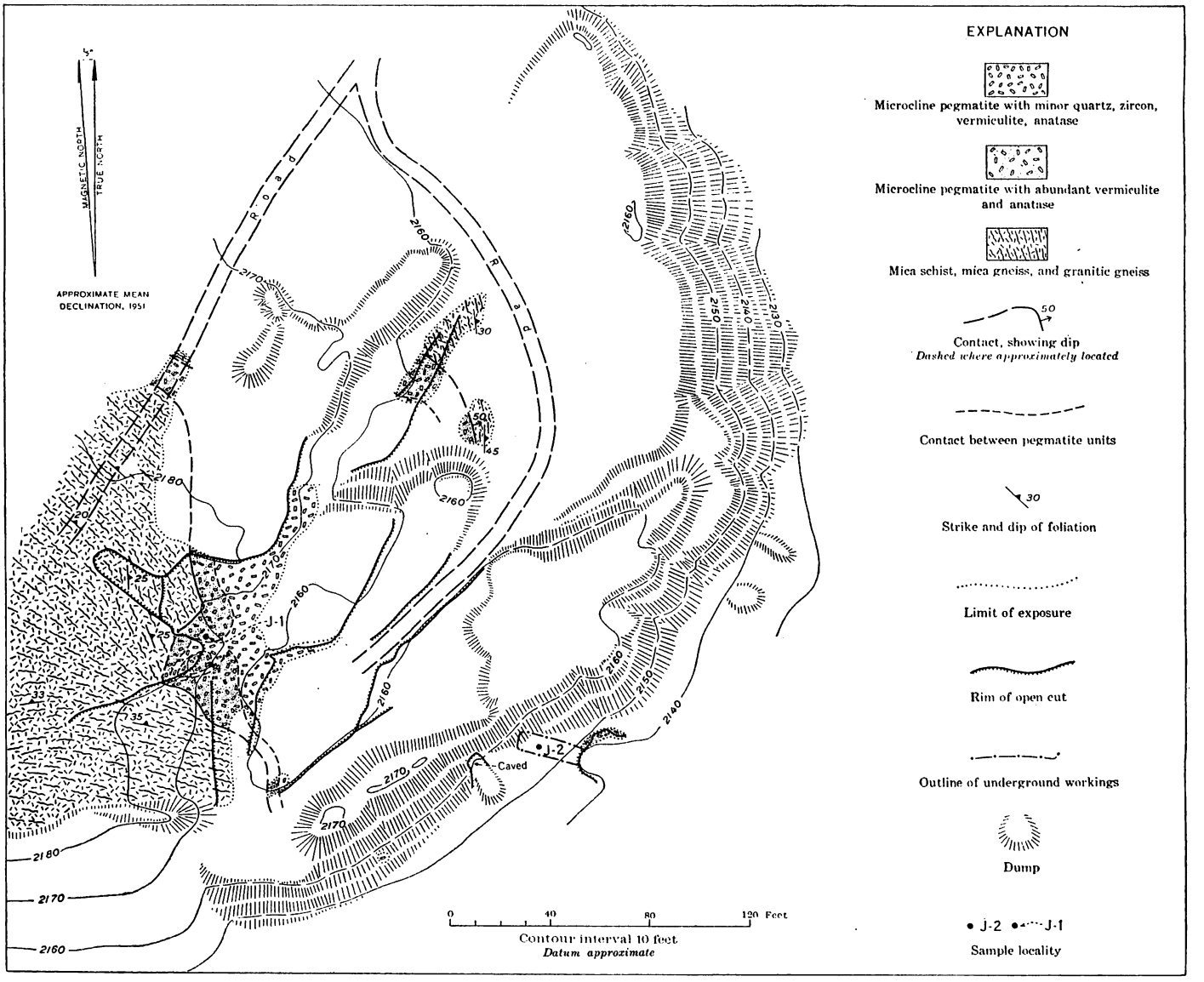
The variety of pegmatite minerals of the rare-earth type has made the Zirconia district well known to mineralogists and the district has been mentioned in various publications as being near Green River, Tuxedo, Zirconia, and Flat Rock (fig. 7).

HISTORY AND PRODUCTION

Zircon was apparently first mined in the Zirconia district in 1869, when General Clingman obtained 1,000 pounds of crystals in a few weeks (Genth, 1891, p. 49). W. E. Hidden is reported to have obtained 25 tons of zircon from the Freeman mine in 6 months during 1888 to supply zirconium for use in the manufacture of mantles for incandescent lights. Genth (1891, p. 49) reports that by 1891 more than 30 tons had been taken from this region. The use of thorium in the mantles began about this time, and zircon production ceased. It was resumed in 1902 with the introduction of the Nernst lamp, in which zirconium was used. Pratt (1916, p. 19) states that 20,512 pounds of zircon, valued at $4,096, was produced from North Carolina, chiefly if not entirely from the Freeman and Jones mines, during the years 1902-1914. The Freeman mine was reopened in 1911 by W. E. Hidden and, according to Pratt, it produced small amounts of zircon until shortly after 1915.

About 1888 and during the period 1902-1915, the zircon was mined in weathered parts of the pegmatites at the Freeman and Jones mines by pick-and-shovel methods. Such mining was confined to rich pockets or streaks, and resulted in small, scattered, irregular-shaped holes to a maximum depth of 30 feet. In 1911, according to Pratt (1916, p. 16), Hidden introduced hydraulic methods for obtaining zircon at the Freeman mine and constructed a ditch 6,000 feet long for water. Hydraulic mining was done to a depth of nearly 40 feet.

In 1944 the Jones mine was prospected by steam shovel and bulldozer, chiefly for feldspar, by Messrs. Uzzell, Johnson, and Goodman of Asheville, N. C., but there has been no other mining in the area since



Mapped by J. C. Olson and H. S. Johnson, Jr., June, 1948

FIGURE 8.—MAP OF THE JONES MINE, HENDERSON COUNTY

about 1916. In the 1944 operations at the Jones mine an area measuring about 150 by 200 feet, in which most of the previous work had been done, was stripped by steam shovel to a depth of 10 to 30 feet, and an area 200 feet in dameter southwest of the main excavation was stripped to a depth of 3 to 6 feet (fig. 8).

DISTRIBUTION AND GEOLOGIC OCCURRENCE

Numerous pegmatites occur in the area shown in figure 7. The pegmatites at the Jones and Freeman mines, which are the only ones that have been worked extensively, will be described briefly. In addition to the Jones, Freeman, and Pace properties, the locations of which are shown on the index map, similar deposits containing unusual pegmatite minerals have been reported from the Price farm, about 3 miles southwest of the Freeman mine; and the Davis farm, about 4 miles from Green River Post Office on the east side of the road to Greenville by way of Poinsett Spring.

The pegmatites, judging from a brief reconnaissance of the area, are most numerous in or near a large inclusion or pendant of gneiss and schist in the granite that underlies most of this part of Henderson County. This inclusion or pendant is half a mile to a mile wide, and is at least 3 miles long in a northerly direc-

tion. Zirconia Station is at the northeast edge of this pendant or inclusion. The mass of metamorphic rocks is made very irregular in shape by numerous thin granite bodies near its margin. In the exposures along the shores of Lake Summit, where Green River has cut through most of the metamorphic rocks, granite is the dominant rock. Many smaller areas of metamorphic rock, separate from the Zirconia pendant or inclusion, also occur in the granite.

Most of the pegmatites examined are in the foliated granite near the pendants or inclusions of metamorphic rock. The wall rock of the Freeman pegmatite is granite gneiss. At the Jones mine, which is near the edge of the pendant of metamorphic rocks, the wall rocks are sillimanite-bearing mica gneiss and schist interlayered with the granitic gneiss. At both the Jones and the Freeman mines the gneissic foliation strikes northwest and dips 20°-50° NE. Although the pegmatite bodies conform broadly to the strike and dip of the gneissic foliation, the contacts are for the most part discordant.

The pegmatites at the Jones and Freeman mines, shown in figures 8 and 9, are each at least 225 feet long and about 70 to 100 feet thick. They strike northwest and dip 35°-50° NE. Only a small part of each pegmatite is exposed, and both are weathered deeply.

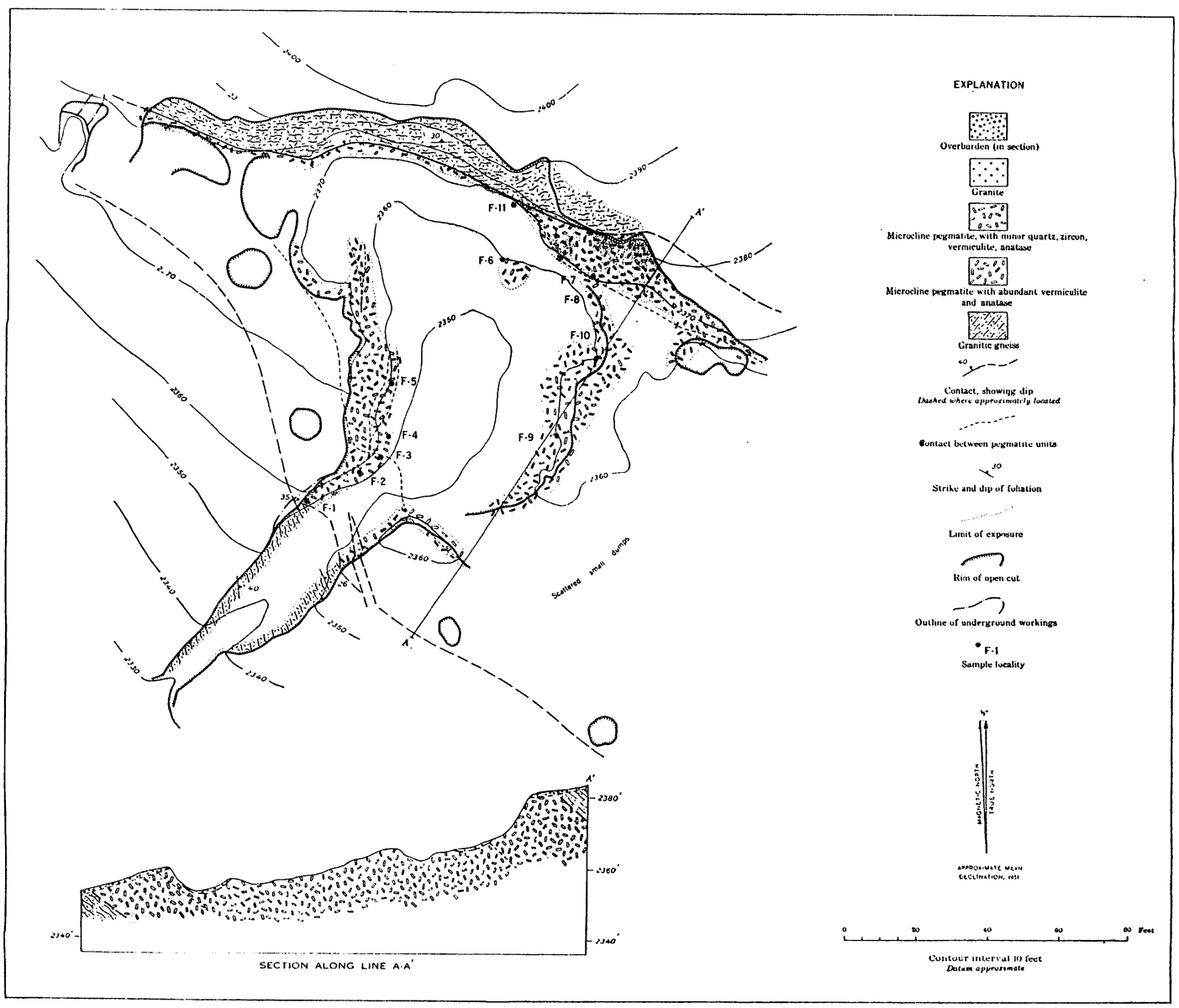


FIGURE 9.—MAP AND SECTION OF THE FREEMAN ZIRCON MINE, HENDERSON COUNTY.

MINERALOGY

The pegmatites at the Jones and Freeman mines consist mainly of pink microcline. Minor quantities of albite (An4) occur as tiny colorless crystals or small veinlets. Quartz occurs as small grains or blebs, about 4 inches in maximum thickness. A few small clear and smoky quartz crystals occur in cavities. Graphic granite was not observed. Exposures are inadequate to estimate the average percentage of quartz in the entire pegmatite, but the relatively little quartz in many of the exposures suggests the classification of syenite pegmatite, or possibly quartz syenite for some of the more quartzose portions.

The minerals that have been reported from the pegmatites of the Zirconia district include microcline, quartz, xanthitane (anatase), sphene, zircon, titaniferous garnet, polycrase, allanite, auerlite, monazite, xenotime, cyrtolite, epidote, stilbite, apatite, muscovite, granular calcite, kaolin, iron oxides, and decomposed hydrated mica that will be called vermiculite in this report, although its true nature has not been definitely determined. Genth (1891, p. 46) also reports green beryl on Green River in Henderson County, but the locality is not specified and no beryl has been found at the Jones or the Freeman mine. The present investigation did not include detailed mineralogic studies, and the information concerning the rare minerals has been obtained mainly from the literature.

Anatase (xanthitane) and sphene. The xanthitane of the Zirconia district was named by Shepard (1856, p. 96), later examined by Eakins (1888, p. 418), and recently reported to be anatase, according to X-ray powder study by Frondel (Palache, Berman, and Frondel, 1944, p. 587). It is remarkably abundant as a yellowish-white alteration product of sphene. It has the characteristic crystal form of sphene, and unaltered sphene occurs as a nucleus of some of the anatase at the Jones mine.

Zircon. Gray to brown zircon crystals, mostly 0.1 to 0.25 inch in diameter, make up as much as 3 percent of very small parts of the pegmatites at the Jones and Freeman mines, but they are considerably less than 1 percent of the total rock excavated at these two deposits. A rough comparison of the amount of pegmatite mined at the Freeman mine with the recorded production indicates a zircon content of less than 0.5 percent. The common crystal faces are the prism and pyramid. In one part of the Freeman mine, cruciform twins of zircon, superficially resembling twinned staurolite crystals, have been reported (Hidden and Pratt, 1898).

Auerlite. Auerlite was first described and named by Hidden and Mackintosh (1888). At that time it had been found only at the Freeman mine and on the Price property. According to Hidden and Mackintosh, it is intimately associated with crystals of zircon, often implanted upon them as a later growth in parallel position, and the largest mass found measured 1 cm through the prism. When Hidden searched diligently to collect a quantity of the mineral, he obtained not quite 100 grams in mining more than 200 kg of zircon. Pratt (1916, p. 31) states that while Hidden was working the Freeman mine in 1912 he made a special effort to separate the auerlite from the zircon, and obtained 1 kg of auerlite.

Xenotime, zircon, and polycrase on the Davis Property. Some of the interesting minerals on the Davis property were described by Hidden (1888, pp. 381-382) and Hidden and Mackintosh (1890). A cubic yard of partly kaolinized material from a weathered outcrop yielded nearly an ounce of a mixture of zircon, monazite, xenotime, cyrtolite, and polycrase. According to Hidden and Mackintosh, the xenotime is intergrown with the cyrtolite.

Apatite occurs as tiny white or pale green needlelike crystals, in cavities or enclosed in feldspar, in the pegmatite at the Jones mine. Yellowish-green **epidote** is common in parts of the Jones mine along fractures in the pegmatite and associated with apatite and albite in cavities in the microcline. Dark reddish-brown **garnet** is relatively uncommon. Bluish-green fibers of an asbestiform mineral were not identified. They appear to be in fractures and seams of late origin in parts of the pegmatites that also contain epidote.

ZONING OF THE PEGMATITES AT THE JONES AND FREEMAN MINES

A striking feature of the pegmatites at both the Jones and the Freeman mine is the abundance of vermiculite near the contacts with wall rocks. At the Freeman mine the vermiculite-bearing wall zones are 15 to 20 feet thick. In the border zones, within 6 inches of the contact, relatively fine grained vermiculite

commonly makes up more than half of the rock. Inward from this border zone feldspar is the principal constituent, and vermiculite is coarser-grained than in the border zone but gradually decreases in quantity to the inner part of the wall zone. The high vermiculite content of the border and wall zones does not appear to be due to reaction between the pegmatite and its immediate wall rocks, which are light-colored gneisses of generally granitic composition.

Anatase is relatively uncommon in the border zone of the pegmatite, but is abundant in the inner part of the wall zone and the outer part of the feldspar-rich core, where vermiculite is a comparatively minor constituent. Neither vermiculite nor anatase is abundant in the core of the pegmatite.

Microcline comprises less than half of the 6-inch border zone but is the dominant constituent of other parts of the pegmatite. The proportion of microcline in the pegmatite increases inward in the wall zones, and it is by far the most abundant mineral in the core of the pegmatite body. The principal constituent of the core is microcline; other constituents are zircon, quartz, vermiculite, anatase, and albite. Quartz is inconspicuous in the border and wall zones, but is more common in the feldspathic core.

Small streaks rich in vermiculite and anatase, similar mineralogically to the wall zones, also occur in the interior of the pegmatites. Two small bodies of evenly banded or layered feldspar-vermiculite-xanthitane rock, of uncertain origin, are exposed near the middle of the pegmatite at the Freeman mine.

Below the mantle of weathered material the Jones and Freeman mines probably have abundant potash feldspar and relatively little quartz. Iron-bearing minerals such as epidote, vermiculite, and iron oxides are widely disseminated and have hindered exploitation of feldspar. The quantities of zircon and vermiculite appear too small to mine as principal products at current prices.

SPECTROGRAPHIC ANALYSES

Thirteen samples were collected from the different zones of the weathered pegmatites at the Jones and Freeman mines for spectrographic analysis to determine the distribution of the minor elements within the pegmatite bodies. The localities from which the samples were taken are shown on the maps, figures 8 and 9. The analyses are given, by zones, in table 1.

The zonal structure of the pegmatites, which is conspicuous megascopically in the distribution of the principal minerals, is also reflected in the percentages of certain minor elements. This is brought out clearly by table 2, in which the averages of the analyses of table 1 are arranged according to pegmatite zones. Ba and Sr are more abundant in the cores, but Be, Ti, Fe, Mg, Mn, Zr, V, Ni, Co, Y, La, Cr, Cu, Pb, and P are more abundant in the samples from border and wall zones.

Some of the minor elements are in certain rare minerals that are found in only minute quantities in the pegmatites, but many of the minor elements probably occur in the abundant minerals such as the vermiculite, feldspar, zircon, and anatase. In a common mineral the minor elements may occur in microscopic inclusions or they may occupy places in the crystal structure ordinarily occupied by other atoms that are abundant and represented in the chemical formula of the mineral. This substitution is most likely where the ion of the minor element and the replaced ion have similar valence and similar ionic radius, of which the more important is the ionic radius. From these properties and the distribution of the minor elements as shown by analyses, inferences may be made as to the minerals most likely to harbor certain minor elements.

The Ba and Sr, which are more abundant in feldspar-rich cores than in wall or border zones, probably occur in the feldspar, where they presumably substitute for potassium. Minor elements that show a preference for the border and wall zones are mostly of such a nature that they could occupy positions in the structure of the vermiculite-like mineral, presumably as substitutes for magnesium and iron chiefly. In this group may be included, in addition to the essential Mg and Fe, such elements as Ni, Co, Cu, and possibly Cr, V, Mn, and Ti. Some of the minor elements could occur in the interlayer spaces of the vermiculite.

The mineral zircon accounts for most of the Zr and possibly some rare earths and Nb in the analyses. Small amounts of garnet probably account for most of the Mn, some Ti (Pratt, 1916, p. 15), and perhaps other elements. Anatase accounts for most of the Ti and perhaps some of the Mn, V, Nb, and rare earths. Sample J-2, taken from the walls of the short adit in the hanging-wall zone of the Jones pegmatite, is relatively rich in La, Ca, and Th, which probably are in allanite and monazite. Some of the Ca and P and rare earths in this analysis may be in apatite. The La and Y in other analyses may indicate minute amounts of

TABLE 1. *Spectrographic analyses of samples from the Jones and the Freeman mine, in percent.*

Sample[a]	Zone	Be	Ba	Sr	Mn	Ti	Ga	Zr	V	Cr	Ni	Co
F-1	Border	0.004	0.8	0.2	0.06	1–10	0.002	0.05	0.02	0.002	0.02	0.01
F-11	do	0.002	0.4	0.1	0.08	1–10	0.004	0.06	0.04	0.03	0.02	0.008
J-1	Wall	0.004	0.4	0.2	0.09	1–10	0.003	0.07	0.02	0.002	0.02	0.006
J-2	do	0.004	0.4	0.2	0.06	1–10	0.003	0.2	0.02	0.01	0.01	0.004
F-2	do	0.005	0.3	0.1	0.1	1–10	0.004	0.09	0.02	0.001	0.01	0.004
F-3	do	0.002	0.5	0.2	0.06	1–10	0.004	0.2	0.02	0.001	0.006	0.003
F-7	do	0.904	0.2	0.01	0.2	1–10	0.004	0.06	0.02	<0.001	0.004	0.008
F-4	Core	<0.001	0.9	0.2	0.02	1–10	0.003	0.02	0.02	0.005	0.006	0.002
F-6	do	<0.001	0.6	0.2	0.02	0.3	0.003	0.04	0.01	0.001	0.003	0.002
F-8	do	.....	0.8	0.4	0.01	0.07	0.002	0.003	0.007	<0.001	0.002	<0.001
F-9	do	<0.001	0.5	0.2	0.02	0.07	0.002	0.004	0.005	0.001	0.003	0.001
F-10	do	<0.001	0.5	0.2	0.02	0.07	0.002	0.03	0.007	0.001	0.003	0.003
F-5	Core *b*	<0.001	0.6	0.2	0.02	0.1	0.002	0.002	0.007	0.001	0.006	0.002

		Cu	Y	La	Nb	Pb	Ag	Ng	Ca	Fe	P	Th
F-1	Border	0.008	0.02	0.09	.....	0.02	.....	3–6	<0.1	<10	0.X	.....
F-11	do	0.01	0.009	0.03	.....	0.02	.....	1–2	<0.1	>10	.....	.....
J-1	Wall	0.01	0.04	0.20	.....	0.03	0.001	6–10	<0.1	>10	0.X	.....
J-2	do	0.006	0.02	>1.0	0.01	0.01	.....	3	0.3	>10	X	0.0X
F-2	do	0.03	0.02	0.07	.....	0.07	.....	6–10	<0.1	>10	0.X	.....
F-3	do	0.003	0.02	0.03	0.02	0.003	.....	3	<0.1	>10	.....	.....
F-7	do	0.02	0.02	0.2	.....	0.05	.....	3–6	<0.1	>10	.....	.....
F-4	Core	0.003	0.01	0.02	0.02	0.001	.....	1–3	<0.1	6–10	.....	.....
F-6	do	0.001	0.008	0.02	.....	0.001	.....	1–3	<0.1	1–3	.....	.....
F-8	do	0.002	0.002	0.01	.....	0.005	.....	0.1–0.3	<0.1	0.6–1	.....	.....
F9	do	0.004	0.003	0.009	.....	0.002	.....	5–6	<0.1	1–3	.....	.....
F-10	do	0.002	0.004	0.01	.....	0.005	.....	3–4	<0.1	3	.....	.....
F-5	Core *b*	0.004	0.004	0.008	.....	<.001	.....	1–3	<0.1	3–6	.....	.....

The special region examined is not suitable for detecting small amounts of alkalies. However, Na and Li can be said to be <0.1% in all samples.
Looked for but not found: As, Sb, Ge, Bi, Tl, Zn, Cd, Ta, Mo, Sn, B.
Analyses by JANET D. FLETCHER.
a Location of samples is shown on figures 8 and 9.
b Banded vermiculite—microcline pegmatite in central part of Freeman mine.

TABLE 2. *Averages of spectrographic analyses from table 1 arranged according to pegmatite zones, in percent.*

Zone	Number of Samples	Be	Ba	Sr	Mn	Ti	Ga	Zr	V	Cr	Ni	Co
Border.....	2	0.003	0.6	0.15	0.07	1–10	0.0030	0.055	0.030	0.016	0.020	0.009
Wall.....	5	0.004	0.36	0.14	0.10	1–10	0.0036	0.140	0.020	0.003	0.010	0.005
Core.....	6	<0.001	0.66	0.24	0.02	0.27–1.77	0.0024	0.017	0.009	0.002	0.004	0.002

		Cu	Y	La	Nb	Pb	Ag	Mg	Ca	Fe	P	Th
Border.....	2	0.009	0.015	0.060	.....	0.020	.....	2–4	<0.1	>10	0.X	.....
Wall.....	5	0.014	0.024	>0.3	0.006	0.033	<0.001	4.2–6.4	<0.1–0.3	>10	0.X–X	<0.0X
Core.....	6	0.003	0.005	0.013	0.003	0.003	.....	1.8–3.2	<0.1	2.4–4.3	.....	.....

allanite or other rare-earth mineral, or they may substitute for other atoms in apatite or the more common minerals.

The scarcity of Ca in all the analyses indicates that the sphene, believed to have been originally much more abundant in the rock, has been almost completely altered to anatase. The small amounts of Na and Ca in all the samples indicate the low content of plagioclase, which occurs in small quantity as tiny colorless crystals of albite (An4) in cavities.

SUMMARY OF DATA ON SIXTY PEGMATITE MINES AND PROSPECTS OF THE CASHIERS DISTRICT

The following is a compilation of the workings, wall rock, pegmatite, and economic features of 60 pegmatite mines and prospects examined in the Cashiers district. The reference numbers are the same as those used to designate locations of the mines and prospects on plate 1.

1. **High Lonesome (mica)**

An adit leads to caved underground workings of undetermined extent that are probably all in an area 50 by 60 feet. Smaller openings lie to the northeast. The wall rock is quartz-mica schist, with thin pegmatite streaks. The pegmatite body is not exposed in place, but the dump has fine-grained feldspar-quartz-muscovite pegmatite and quartz-muscovite pegmatite. The muscovite is brownish green and partly clear. A little mica was produced, probably before 1900.

2. **Wilson (mica)**

The pit, 20 by 80 feet, is 15 feet deep. At both the east and the west end of the pit are caved underground workings in areas 40 feet square. The wall rocks are mica gneiss and hornblende gneiss. The pegmatite, composed of weathered feldspar, quartz, and mica, probably strikes N. 65° E. Its full thickness is not exposed. The muscovite is green, much of it is stained, and some has "A" structure.

3. **New Wolff (mica)**

The narrow open cut is 60 feet long, 25 feet deep, and small stopes extend down dip. The biotite gneiss wall rock encloses a pegmatite body 2 feet thick that strikes N. 20° E. and dips 40° SE. The upper half of the pegmatite is fine-grained quartz, feldspar, and muscovite; the lower (footwall) half is mainly quartz, but mica books are concentrated along the upper side of this quartzose part. Garnet is present. The mica is dark brown, commonly black-stained, with "A" and wedge structure. The deposit was prospected about 1944.

4. **Wolff-Jones (mica)**

A small open cut was dug in 1944 in an irreguar-shaped pegmatite body enclosed in biotite gneiss. The pegmatite is probably the same body as prospected at the New Wolff. It is dominantly feldspar, with quartz, red garnet, tourmaline, apatite, and streaks of fine-grained greenish muscovite. Little block mica was observed.

5. **Zeb Jones (mica)**

Three open cuts in a steplike series are each about 25 feet long, 10 feet wide, and 5 to 15 feet deep. The wall rock is biotite gneiss. The pegmatite, exposed at only one place, is at least 4 feet thick, strikes N. 22° E., and dips 65° SE. The exposure is of fine-grained feldspar-quartz-muscovite-garnet pegmatite. A small quantity of muscovite is exposed in thin sheetlike zones parallel to the contacts.

6. **Lusk (mica)**

Small underground workings extend from the bottom of a pit 10 feet in diameter and 18 feet deep. The wall rock is biotite gneiss. Pegmatite is not exposed in the pit, but the dump has quartz-muscovite and fine-grained quartz-feldspar-muscovite pegmatite. The mica is of two types: (1) brownish green, clear, and (2) brown, stained. The mine has not been worked for at least 40 years.

7. **Jake Rice (mica)**

The series of workings comprises pits, shallow open cuts, and drifts probably as much as 200 feet long, over a total length of 700 feet. The mica gneiss wall rock, with some hornblendic layers, strikes N. 35° E. and dips 40°-60° SE. Two or three parallel or echelon pegmatites, slightly discordant, strike N. 35° E. and dip 50° SE. The best exposure of pegmatite is 2½ to 4 feet thick. The pegmatites are composed of quartz, plagioclase, muscovite, apatite, biotite, garnet, tourmaline, and probably some perthite. The muscovite books are mostly in or near quartz-muscovite pegmatite that occurs as streaks in the quartz-plagio-

clase-muscovite pegmatite. Most of the mica is brown and clear, but some is stained, and a small proportion is green "A" mica. Haircracks in the mica sheets are common. The mine was last worked during parts of 1943 and 1944.

8. **Proffitt (mica)**

This series of workings, a southwestward extension of the Jake Rice mine, is 550 feet long and comprises pits, 10 to 20 feet wide, with short drifts and adits, to a maximum reported depth of 50 feet. The country rock, pegmatite, and mica are similar to those described at the Jake Rice mine. The main pegmatite mined becomes thinner at the southwest end of the workings. The mine has been idle for many years.

9. **Turkey Pen Ridge (mica)**

Small pits, to a maximum depth of 25 feet, and a 60-foot drift lie in an area 100 feet square. The wall rock is mica gneiss. The pegmatite is poorly exposed, but it appears to strike N. 45° E., to dip 30° S.E., and to be about 6 feet thick. Clear green muscovite, with "A" reeves, probably occurs alongside the quartz core, which is 1 to 2 feet thick. Flat, stained, brown mica probably is associated with thin quartz-muscovite streaks in the pegmatite.

10. **Big Bend (mica)**

Drifts, pits, and caved shafts to a depth of about 20 feet, lie in an area about 70 feet square. The mica gneiss wall rock encloses a weathered pegmatite about 6 feet thick that strikes N. 50° E. and dips 30° SE. Clear green "A" mica is mostly at the margins of the quartz core, which is 1 to 2 feet thick. Flat, stained, brown mica books of smaller average size than the green are mostly in thin quartz-muscovite streaks in the feldspathic pegmatite.

11. **Chestnut Creek (Big Hole) (mica)**

A pit 10 by 100 feet, and 5 to 10 feet deep, trends N. 15° E. A short adit and minor underground workings down dip from the south end of the pit are caved. The pegmatite is poorly exposed. It is probably concordant with the hornblende gneiss wall rock that strikes N. 30° E. and dips gently southeastward. The dump consists of fine-grained feldspar-quartz-muscovite pegmatite, quartz-muscovite pegmatite, and mas sive quartz. Mica on the dump is ruled, "A"-reeved, and splits poorly. Some books are moderately stained. The mine was worked intermittently about 1943-44.

12. **Nicholson (mica)**

The series of workings, which is 175 feet long and trends north, consists of pits and drifts to a depth of 25 feet. Mica-garnet gneiss encloses a pegmatite body at least 3 feet thick that strikes N. 10° E. and dips 10°-20° E. A nearly horizontal plunge is indicated by the position of workings and by the lineation of intersections of fractures in the quartz. The pegmatite is composed of quartz, feldspar, muscovite, and garnet. It is streaky in appearance because of parallel orientation of mica books, eye-shaped feldspar grains, and bands of quartz. The greenish-brown mica is mostly stained. Clear "A" mica is minor.

13. **Brushy Hollow (mica)**

The thin flat pegmatite was mined by "rooms" in an area 30 by 40 feet. Other small caved drifts and pits are mostly within 100 feet of the accessible opening. The mica gneiss wall rock strikes N. 45° E. and dips 10° SE. It encloses a concordant pegmatite, 1½ to 2 feet in exposed thickness, composed of quartz, weathered feldspar, muscovite, and garnet. The quartz core is as much as 1½ feet thick. Mica flakes and quartz streaks in the pegmatite are oriented parallel to the walls. Some of the mica is clear green, with "A" structure; some is flat, greenish brown, stained, and tanglesheet. A little mining was done about 1943-44.

14. **Jumbo (Little Jumbo) (mica)**

A 60-foot drift extends from an open cut 40 feet long and 20 feet deep. A crosscut was driven 50 feet to intersect the pegmatite about 25 feet below the drift. The wall rock is biotite gneiss with some horn-

blendic layers, and the foliation is variable in attiude. The pegmatite occurs as a series of lenses, pods, and stringers, striking N. 20° W. and dipping from vertical to steeply northeastward. It is composed mostly of fine-grained plagioclase and quartz, with muscovite and garnet. The proportion of quartz is greatest in the central part of the body. The green mica is commonly stained and cracked. A little mica was produced during the first half of 1944.

15. **Bryson (Big Jumbo) (mica)**

The workings comprise a pit, 50 feet long and 7 feet deep, and an adjoining trench that is also 50 feet long. A prospect pit was dug 500 feet N. 35° E. of these workings. The mica gneiss wall rock strikes N. 35° E. and dips 30° SE. The concordant pegmatite is about 10 feet thick and is composed of abundant quartz, feldspar (mostly perthite?), muscovite, and garnet. Tabular elements, such as mica books, eye-shaped feldspar grains, and quartz-rich streaks, are oriented parallel to the walls. The mica is of two types: green "A" mica that is both clear and stained; and flat, brown, stained mica. The mine has not been worked for at least 40 years.

16. **Morning Star (mica)**

The workings comprise several old caved drifts and an open cut 40 feet long and 20 feet deep made by bulldozer in 1944. The wall rock is mica gneiss with some interlayered hornblende gneiss. The pegmatite is 1 to 6 feet thick, averaging about 3 feet. It strikes N. 25° E. and dips 25°-70° SE. The few exposures of pegmatite consist of fine-grained quartz, feldspar, and muscovite. The coarse muscovite is associated with several parallel quartz-rich streaks 1 to 12 inches thick. The mica is both green and brown. Some mica is stained, and "A" structure is common. Sterrett (1923, p. 267) states, "It was worked by C. Grimshawe during 1880 and 1884 during which time 8,000 lbs. of cut mica was mined."

17. **Tallow Face (mica)**

Described on pages 10, 11 and 12.

18. **Reid (mica)**

The workings comprise several drifts and adits, all caved. One drift is reported to be 100 feet long. The mica gneiss and interlayered hornblende gneiss strike north and dip 30° W. The poorly exposed pegmatite is reported to strike from north to N. 35° E., to dip about 35° W., and to be about 6 feet in average thickness. It is composed of quartz, weathered feldspar (probably mostly plagioclase), and muscovite. Beryl is reported. Massive white quartz is abundant on the dump, and at one exposure a 5-foot pegmatite has a 2½-foot core of quartz. The mica is brown and dark green, mostly stained, with much "A" structure. The mine was worked about 1895, 1911, and for a short time in 1944.

19. **Will Crowe (mica)**

The larger of two pits is about 25 feet square and 7 feet deep. The mica gneiss wall rock strikes N. 15° E. and dips 70° W. Three pegmatites, 6, 2, and at least 20 feet thick occur in the gneiss and are generally concordant with the foliation. They are cut by small faults. The fine- to medium-grained pegmatites are composed of perthite, quartz, muscovite, plagioclase, and garnet. A quartz mass 1 foot thick is exposed. The mica is mostly clear and light brown, with some "A" structure. Little mica was found during the prospecting done about 1943.

20. **Rice (mica-beryl)**

The workings, in an area 80 by 30 feet, comprise several pits and small caved underground workings. The hornblende gneiss wall rock strikes N. 30°-50° E. and dips 50°-80° SE. The pegmatite is poorly exposed, but appears to be vertical and to strike N. 5° E. It is at least 10 feet thick, and is composed of perthite, quartz, plagioclase, muscovite, and garnet. Gem beryl is reported to have been found, but no beryl was seen when the mine was visited in 1948. Coarse-grained blocky perthite is present. The brown and green muscovite is mostly clear, and much of it has "A" structure. The mine was worked by Will Rice before 1900.

21. **Will Rice (mica)**

In an area 60 by 125 feet, the long dimension of which trends N. 70° W., four adits were driven northward into nearly horizontal underground workings and one 30-foot shaft was sunk. All the workings are now caved. The foliation of the mica gneiss is nearly horizontal, and it encloses a poorly exposed concordant pegmatite body. The dumps consist of quartz, weathered feldspar, muscovite, biotite, and garnet. Most of the muscovite is stained, but some is clear. A little garnet is intergrown with the green "A" mica, and a little biotite with the flat brown mica.

22. **Unnamed prospect near Highway 106 (mica)**

A small prospect in the road cut exposes biotite gneiss that encloses many thin pegmatite stringers in a zone about 15 feet thick. The pegmatite stringers are vertical and strike N. 35° E. They are composed of fine-grained quartz-feldspar-muscovite pegmatite in which small muscovite books are disseminated. The mica is brown, mostly stained, and little, if any, has been produced.

23. **Ridge (Red, Dillard) (mica)**

Flooded workings, about 25 feet deep, extend below two pits each 15 by 75 feet. A concordant pegmatite 1 to 2 feet thick is exposed. It is enclosed in biotite gneiss with foliation striking N. 35° E. and dipping 25°-40° SE. The fine- to medium-grained pegmatite is composed of feldspar, quartz, muscovite, biotite, and garnet. The muscovite is brown, but some books have greenish edges. Some of the books are stained and some are intergrown with biotite. The mine was worked from April to June 1944, and a small quantity of sheet and punch mica was produced.

24. **Big Terrapin (Wade Crowe) (mica)**

The open cut is 170 feet long, 8 to 10 feet wide, and 20 feet deep to the floor covered with backfill. Biotite gneiss, striking N. 45° E. and dipping 50° SE., encloses a concordant pegmatite 4 feet in average thickness. The maximum thickness is 8 feet, and the body appears to thin at the north end of the cut. The pegmatite is composed of quartz, feldspar, and muscovite. It is fine-grained where exposed at the south end of the cut, but was coarser where mined. Both brown and green muscovite occur. The mine is reported to have been worked first in 1929, and again in late 1943 and early 1944.

25. **Autrey (mica)**

Three shallow pits have been dug in an area 40 by 15 feet, which trends N. 45° E. The pegmatite, not exposed in the pits, probably trends about N. 30° E. The dumps contain feldspar, quartz, and clear mica flakes 1 inch in diameter.

26. **Little Terrapin (mica)**

The open cut is 90 feet long, 5 to 10 feet wide, and 5 to 30 feet deep. Pits and trenches have been dug for about 250 feet N. 40° E. from the main pit. The wall rocks are granite and biotite gneiss, with foliation striking N. 45° E. and dipping 60° SE. Concordant pods and stringers of pegmatite, less than 2 feet thick, lie at or near the contact between granite and gneiss. The pegmatite is composed of plagioclase, quartz, biotite, and muscovite. The dump is mostly wall rock. The mica in the dumps is brown and mostly stained. Some of the books are cracked and wedge-shaped. The mine was worked first about 1915, and recently for 7 months in 1943-44.

27. **Thomas Grimshawe (mica-feldspar)**

The workings consist of an L-shaped open cut 100 feet long, 25 feet wide, and 25 feet deep. The foliation of the granite gneiss country rock strikes east and dips 20° N. The irregular-shaped, steeply dipping discordant body of pegmatite is 25 feet thick for a length of about 80 feet. It is weathered and is composed of perthite, quartz, plagioclase, muscovite, biotite, black tourmaline, and garnet. One small crystal of beryl was observed. Pink tourmaline and samarskite are reported. Graphic granite is abundant. The mica is brown and green, flat, and mostly stained. The deposit was mined for mica about 1880 and was prospected for feldspar in 1947. Feldspar mining was apparently discontinued because of low feldspar recovery and the insufficient size of the pegmatite body.

28. **Whiteside Cove (mica)**

A row of small pits dug to a maximum depth of 6 feet trends N. 80° W. The wall rock is gneissic granite. Exposures are few, but the pegmatite appears to be at least 6 feet thick and to trend about N. 80° W. It is composed of quartz, perthite grains as much as 8 inches in diameter, graphic granite, muscovite, and minor amounts of biotite. The muscovite is green, of both flat and "A" types; some is stained.

29. **Edwards (mica)**

The workings comprise a pit 30 feet long and 12 feet deep, and two other small pits less than 80 feet to the west. The irregular-shaped pegmatite body is enclosed in granite. It is 6 feet thick at the best exposure, probably strikes east, and dips 70° N. It is composed of quartz, perthite, graphic granite, plagioclase, muscovite, biotite, and garnet; beryl is reported. The wall zones are feldspar-quartz-muscovite-biotite pegmatite, and the largest mica books are adjacent to the 1½-foot quartz core. The muscovite is green, mostly stained, and commonly of "A" type. The deposit was prospected for mica about 1885-1890.

30. **Sheep Cliff (feldspar-mica-beryl)**

Described on pages 12-13.

31. **Fairfield Lake (mica)**

An open cut 50 feet long, 20 feet wide, and 20 feet deep, trending N. 20° E., was excavated by bulldozer in about 1944. The country rock is mica-garnet gneiss and granite gneiss. The irregular lens of pegmatite, 10 to 15 feet thick, is generally concordant with the gneissic foliation, which strikes N. 70° E. and dips 65° S. The pegmatite consists of perthite, quartz, plagioclase, muscovite, and biotite. It has a feldspar-biotite-muscovite wall zone 1½ to 2 feet thick, an intermediate zone 1 to 2 feet thick containing blocky perthite, a quartz core 3 feet thick, and a mica-rich core-margin zone as much as 1 foot thick. The mica is green "A," stained, and contains a little intergrown garnet.

32. **Unnamed prospect near Sapphire Lake (mica)**

An open cut 70 feet in diameter and 15 feet in maximum depth was excavated by bulldozer about 1944. The foliation of the mica schist country rock strikes N. 80° E. Exposures are poor, but one pegmatite is 2 to 3 feet thick and generally concordant with the schist. It is composed of quartz, plagioclase, perthite, muscovite, garnet, and tourmaline. The mica is green and light brown. It is mostly stained, but a small proportion is clear.

33. **Little Hogback Creek (mica)**

An open cut 80 feet long, 20 feet wide, and 20 feet deep, trending N. 80° E., was made by bulldozer about 1944. Other smaller pits are nearby. An irregular pegmatite about 10 feet thick occurs in hornblende gneiss near the east contact of a large body of granite. The exposed pegmatite consists of quartz, weathered feldspar, biotite, muscovite, and garnet. The muscovite is brown and stained. The wall rock from 1 to 5 inches outward from many of the contacts is a schist rich in biotite and muscovite.

34. **Unnamed prospect southwest of Toxaway Mountain (mica-feldspar)**

A north-trending open cut 100 feet long, 60 feet wide, and 4 feet deep was made by bulldozer about 1944. The pegmatite is enclosed in biotite gneiss. The body may be relatively large, but the only exposure is in an area about 3 by 15 feet. It is composed of quartz, perthite grains as much as 1½ feet in diameter, plagioclase, muscovite, garnet, beryl, and samarskite. Most of the exposure is graphic granite. Quartz masses 3 feet thick lie in the dump. Beryl appears to be about 0.03 percent of the small exposure of pegmatite. The small mica books are green.

35. **Unnamed prospect southwest of Toxaway Mountain (mica)**

A shallow open cut 80 feet long and from 20 to 50 feet wide was made by bulldozer about 1944. Bodies of pegmatite mostly less than 1½ feet thick are exposed in mica gneiss. At one place the pegmatite body is 4 feet thick and is composed of quartz, feldspar, and muscovite. It is fine-grained near the walls, but the feldspar grains are as much as 3 inches in diameter near the center. The mica is brownish green, "A," and commonly tanglesheet.

36. Unnamed prospect southwest of Toxaway Mountain (mica)

Bulldozer prospecting has excavated three steplike open cuts 40 to 90 feet long, 15 to 20 feet wide, and 5 feet deep. The wall rock is mica gneiss. Exposures are few, but in one cut a gently dipping pegmatite body at least 10 feet thick is exposed. The pegmatite consists of perthite, plagioclase, quartz, and muscovite. The dump contains much quartz-muscovite pegmatite. Small mica books are exposed in feldspathic pegmatite adjacent to a band of quartz 6 inches thick. Most of the mica books are less than 1 inch in diameter.

37. Unnamed prospect on Ravenrock Mountain (mica)

The overburden has been stripped by bulldozer from an area 80 by 90 feet. The wall rock is mica gneiss. The pegmatite is poorly exposed but appears to be several feet thick and to consist of plagioclase, perthite, quartz, muscovite, and garnet. The mica is flat, light brown, and mostly less than 1 inch in diameter. The prospecting was done about 1944.

38. Unnamed prospect on Ravenrock Mountain (mica)

Two subparallel cuts, each about 90 feet long, 20 feet wide, and 5 feet deep, were excavated by bulldozer about 1944. Mica gneiss, with very little pegmatite, is exposed. Mica flakes are abundant on the surface, but they are small, tanglesheet, and of "A" type.

39. Unnamed prospect on Ravenrock Mountain (mica)

During bulldozer prospecting about 1944, two cuts were made: (1) an open cut 70 by 15 feet and 10 feet deep, trending N. 70° W.; and (2) adjoining it to the south, an open cut 60 by 25 feet and 8 feet deep, trending N. 27° E. The country rock consists of gently dipping mica gneiss. No pegmatite is exposed in the south cut, but the north cut exposes a steeply dipping, 2½-foot dike that trends north. It is composed of graphic granite, feldspar, quartz, muscovite, and garnet. The wall zone is quartz-muscovite pegmatite, and the core is feldspar-quartz-muscovite pegmatite. The mica books are as much as 4 inches in diameter. They split freely and are commonly clay stained and "A" reeved.

40. Island Ford (mica)

The workings comprise a narrow open cut 220 feet long and as much as 25 feet deep, stopes that extend 40 feet down dip from the open cut, and a 70-foot adit into the stopes. The wall rock is a mica-garnet gneiss. It encloses a series of lenses and pods of pegmatite. The principal body mined pinches and swells and is 1 to 3 feet thick. It strikes about N. 75° E. and dips 25°-40° N. The pegmatite is a medium-grained rock composed of feldspar, quartz, muscovite, and garnet. Most of the mica is brown and stained. About one-fourth of the mica is of "A" type, much of which is clear or lightly stained.

41. Wolf Creek (Jim Wood) (mica)

A flooded 50° incline extends to a depth of 85 feet from an open cut 75 feet long and 15 feet wide. The country rock is biotite gneiss, with foliation striking N. 65° E. and dipping 35° NW. Sterrett (1923, p. 217) reports a layer of gritty talc schist a few feet southeast of the pegmatite body. The pegmatite body is concordant with the foliation and is 13 feet thick. Part of this thickness is a relatively fine grained foliated granite composed of feldspar, quartz, muscovite, and garnet. The pegmatite consists of blocky perthite, plagioclase, gray and smoky quartz, muscovite, garnet, and minor amounts of uraninite, autunite, and uranophane. The muscovite occurs in coarse-grained pegmatite chiefly near the hanging wall of the body. The mica is brown and most of it is clear and of good quality. Stained, cracked, "A," and wedge books are common. The mine was last worked in the latter part of 1944.

42. Lambert Owens (mica)

A shallow pit 30 feet long was dug about 1944; it is now caved, and no pegmatite is exposed in place. The country rock is granite gneiss. Quartz fragments a foot thick in the soil are probably from the core of the weathered pegmatite.

43. **Sam Owens (mica)**

Four small pits, 5 to 8 feet deep, have been dug in an area 40 by 60 feet. The country rock is granite gneiss, with foliation striking N. 55° E. and dipping 25° NW. Concordant streaks or layers of pegmatite 1 to 12 inches thick are exposed in the gneiss. These are composed of quartz-muscovite pegmatite, fine-grained feldspar-quartz-muscovite pegmatite, massive quartz, and feldspar-quartz pegmatite with feldspar grains 2 inches long. The muscovite is green and clear, some is "A" reeved, but most is small and ruled.

44. **Fleming McCall (feldspar)**

A pit 15 feet in diameter and 4 feet deep was excavated in a pegmatite body at least 15 feet wide. The country rock is not exposed at the pit, but nearby outcrops are of hornblende-garnet gneiss and foliated granite. The medium-grained pegmatite is composed of perthite, quartz, plagioclase, muscovite, and garnet. The largest mica book exposed is about an inch square.

45. **The Glass mine (mica)**

The workings consist of two pits, each about 12 feet in diameter and 4 feet deep, and a trenchlike depression 100 feet long. The poorly exposed pegmatite is at least 10 feet thick and is probably concordant with the foliation of the enclosing mica gneiss, which strikes N. 75° W. and dips 35° NE. The pegmatite is composed of perthite, quartz, muscovite, garnet, and plagioclase. The clear green muscovite is commonly reeved and of small size.

46. **Robertson (mica)**

A pit 12 feet long and 6 feet deep was dug in weathered pegmatite and granite gneiss. The pegmatite body is 2½ feet thick. It strikes N. 40° E. and dips 80° SE., cutting across the gneissic foliation, which strikes N. 65° E. and dips 60° SE. The pegmatite is composed of perthite, quartz, plagioclase, and muscovite. The core is mostly feldspar. Green muscovite, with "A" reeves and minor staining, occurs in wall zones about 5 inches thick. A few books are as much as 5 inches in diameter, but the mica-bearing zones are too thin to encourage further prospecting.

47. **Charlie Norris (feldspar)**

A pit 20 feet long and 4 feet deep was dug in weathered pegmatite that is at least 4 feet thick, strikes N. 15° E., and dips 65° W. The pegmatite is poorly exposed, but the dump contains feldspar, quartz, muscovite, and garnet. Zoning is not evident. The mica is green and brown, and occurs mostly as flakes less than half an inch in diameter.

48. **Bald Rock (feldspar-mica)**

Described on pages 13-15.

49. **Tennessee Creek (kaolin-mica)**

The workings consist of a pit 50 feet long, 5 to 12 feet wide, and 10 feet deep; an adit, caved at its intersection with old workings; a partly filled drift; and seven small pits. The irregular-shaped discordant pegmatite is at least 10 feet thick and contains inclusions of the mica-garnet gneiss wall rock. The pegmatite has a quartz core as much as 3 feet thick and a wall zone of relatively fine grained kaolinized feldspar and quartz. Probably most of the muscovite occurred near the quartz core. The mica is dark greenish-brown and heavily stained. A few small books are clear. Mica of punch and small sheet size is rather common in the dumps. The mine was first worked for kaolin and mica.

50. **Pinhook Creek (mica-feldspar)**

Shallow workings in an area 40 by 60 feet include an open cut 15 feet in diameter, with a 16-foot drift from it trending N. 35° E. The country rock is interlayered mica gneiss and hornblende gneiss, with some granite. The foliation strikes N. 35° E. and dips steeply northwest. The pegmatite is weathered, and its exact size and attitude are not known. It probably strikes N. 35° E. The pegmatite is composed of perthite, quartz, muscovite, and biotite. The presence of a quartz core and a core-margin mica zone is indi-

cated by quartz masses on the dump that are 2 feet thick. Strips of biotite in the pegmatite are as large as 6 by 18 inches. The muscovite is brown, stained, and is in books as much as 5 inches in diameter. Prospecting to determine size and feldspar content of the body might be worth while.

51. **L. M. McCall (feldspar-mica)**

Described on pages 15-17.

52. **Pinhook Gap (mica)**

The workings comprise a pit 125 feet long, 80 feet in maximum width, and 35 to 40 feet deep; a 30-foot crosscut; and several small pits, three 20-foot shafts, and a 100-foot adit that lie about 100 feet northeast of the main pit. The country rock is biotite-garnet gneiss; its foliation strikes N. 50° E. and dips 35°-70° NW. The pegmatite body has an exposed length of 350 feet and is 40 to 60 feet thick. It strikes N. 45° E. and dips from vertical to steeply northwest. It is slightly discordant to the foliation of the gneiss, although many of the contacts appear concordant. The weathered pegmatite has a quartz core 7 feet thick that is separated from the hanging wall by 4 to 8 feet of kaolinized feldspathic pegmatite. Feldspar-quartz-muscovite pegmatite occurs between the core and the footwall. Most of the muscovite occurs in feldspar-quartz-muscovite pegmatite adjoining the quartz core. There are coarse garnet crystals nearly 2 inches in diameter. Deep weathering has discouraged exploration underground for feldspar, although masses of coarse-grained feldspar may occur at depth. The dark-brown and green mica is mostly stained.

53. **Puncheon Camp (feldspar-mica)**

About 1200 tons of rock has been mined from an open cut 40 feet square and 10 feet deep. Two small pits were dug 100 feet southwest of the main cut, in the same pegmatite, and three small pits northeast of it. The gray mica gneiss wall rock strikes N. 15° W. and dips 35° NE. The pegmatite is 20 to 25 feet thick for a strike length of at least 175 feet. It strikes N. 25° E. and is vertical, cutting across the foliation of the gneiss. The pegmatite is composed of quartz, perthite, plagioclase, muscovite, and allanite. Epidote occurs in fractures. The mine was worked for feldspar several years ago and is reported to have been reopened in 1947. The byproduct mica is green, somewhat reeved, and is heavily stained and specked.

54. **Owens and Davis (mica)**

A pit 20 feet long and 3 feet deep exposes a pegmatite body 5 feet thick that strikes N. 65° E. and dips 40° SE. in biotite-muscovite gneiss. The coarse-grained pegmatite is composed of quartz, perthite, biotite, and muscovite. The mica books exposed are less than 2 inches in diameter and are mostly within 1½ feet of the hanging wall. The mica is brown and is lightly stained.

55. **Bee Tree No. 2 (mica)**

The workings consist of a pit 40 feet long and 20 feet deep, from which a flooded incline extends for a reported distance of 50 feet. The mica gneiss country rock strikes northeast and dips moderately northwest. The irregular-shaped pegmatite body is about 10 feet thick, strikes about N. 80° E., and dips northward. The pegmatite is composed of quartz, feldspar (mostly plagioclase), muscovite, garnet, and pyrrhotite. The core is quartz-feldspar pegmatite. The wall zones are composed of quartz and quartz-muscovite pegmatite, with a little plagioclase. The mica is light brown and flat, with some cracks and "A" structure, and is of good general quality but the books are probably of small average size. The mine is said to have been discovered about 1910, and was worked for a short time in 1943-44.

56. **Bee Tree No. 1 (mica)**

The workings consist of an open cut 140 feet long, 10 to 50 feet deep, and 10 to 35 feet wide. The foliation of the mica gneiss wall rock strikes N. 60° E. and dips about 50° NW. Granite dikes 2 to 4 feet thick cut both pegmatite and wall rock. The pegmatite body ranges in thickness from 2 to 20 feet and averages about 7 feet. Its irregular strike averages about N. 75° E., and its dip is vertical to steeply southeast. The pegmatite is composed chiefly of quartz, with some feldspar (mostly plagioclase), muscovite, pyrrhotite, pyrite, and garnet. The muscovite probably is mostly near the south contact. The mine was opened before 1900 by Tarry McCall, and was last worked in the period 1942-1943. The mica is rum, or light brown, in color and of good general quality. Much of the mica is clear, but some is lightly stained or mottled.

57. **Uncle Doctor McCall (Tarry McCall) (mica)**

The workings comprise an open cut 80 feet long, 10 to 15 feet wide, and 5 to 20 feet deep; stopes that extend about 25 feet down dip along the hanging wall; and several small pits. The foliation of the mica gneiss is contorted near the pegmatite, striking about N. 70° W. and dipping 50° SW. The irregular discordant body of pegmatite, 12 feet in maximum thickness strikes N. 20° E. and dips 60°-80° SE. It has wall zones of feldspar-quartz-muscovite pegmatite and a quartz core 6 feet thick. The mining was done mostly in weathered pegmatite near the hanging wall, where mica occurs near the contact with wall rock. The mica is light brown, some is stained, and a little has "A" reeves. The mine was discovered and first worked by Tarry McCall; it has been inactive for many years.

58. **Chestnut Ridge (mica)**

A pit 10 by 30 feet, with a maximum depth of 20 feet, has been excavated in an area 40 by 80 feet, which was stripped by bulldozer in 1944. The dump covers older small workings. The foliation of the mica-garnet gneiss wall rock strikes about N. 60° E. on the average and dips 15°-25° N. The pegmatite is an irregular, branching, discordant body about 10 feet in maximum and 6 feet in average thickness. It strikes N. 5°-20° E. and dips about 25° W. The pegmatite is composed of plagioclase, perthite, quartz, muscovite, biotite, pyrite, and pyrrhotite. It contains a quartz core 4 feet thick. The zoning is described briefly on page 8. The smaller ruby or light-brown mica books in the biotite-bearing wall zone are mostly clear. The larger books near the quartz core are green or mottled and mostly stained, but some clear sheets could be trimmed from them.

59. **Farlow Gap (mica)**

Pits have been dug over a distance of 100 feet to a maximum depth in 1944 of 9 feet (See map, fig. 2, p. 7). Most of the work was done in 1944-45. The pegmatite body is exposed in the workings for a length of 100 feet and an average thickness of 7 feet. It is concordant with the foliation of the biotite gneiss wall rock, which strikes N. 25° E. and dips 35° SE. The mineralogy and zoning are described on page 7. The mica is green, but some is light reddish brown, and some is mottled green and reddish brown. About 25 percent of the books are stained. "A" structure and color zoning are common. Mica was abundant in the pegmatite mined in 1944, and some books were as much as 1½ feet in diameter.

60. **Stringfield (mica)**

The workings comprise a drift 50 feet long that extends S. 50° W. from an open cut 20 feet long. Several echelon pegmatite lenses, 1 to 5 feet thick, are exposed and are generally concordant with the foliation of biotite-garnet gneiss wall rock, which strikes N. 15° E. and dips 70° W. These lenses have quartz cores 1 to 18 inches thick and wall zones composed of fine-grained feldspar (probably plagioclase), quartz, muscovite, and a little biotite. Mica occurs mostly alongside the quartz core. It is brown, and about 75 percent of it is stained. The books are commonly bent and some have "A" structure.

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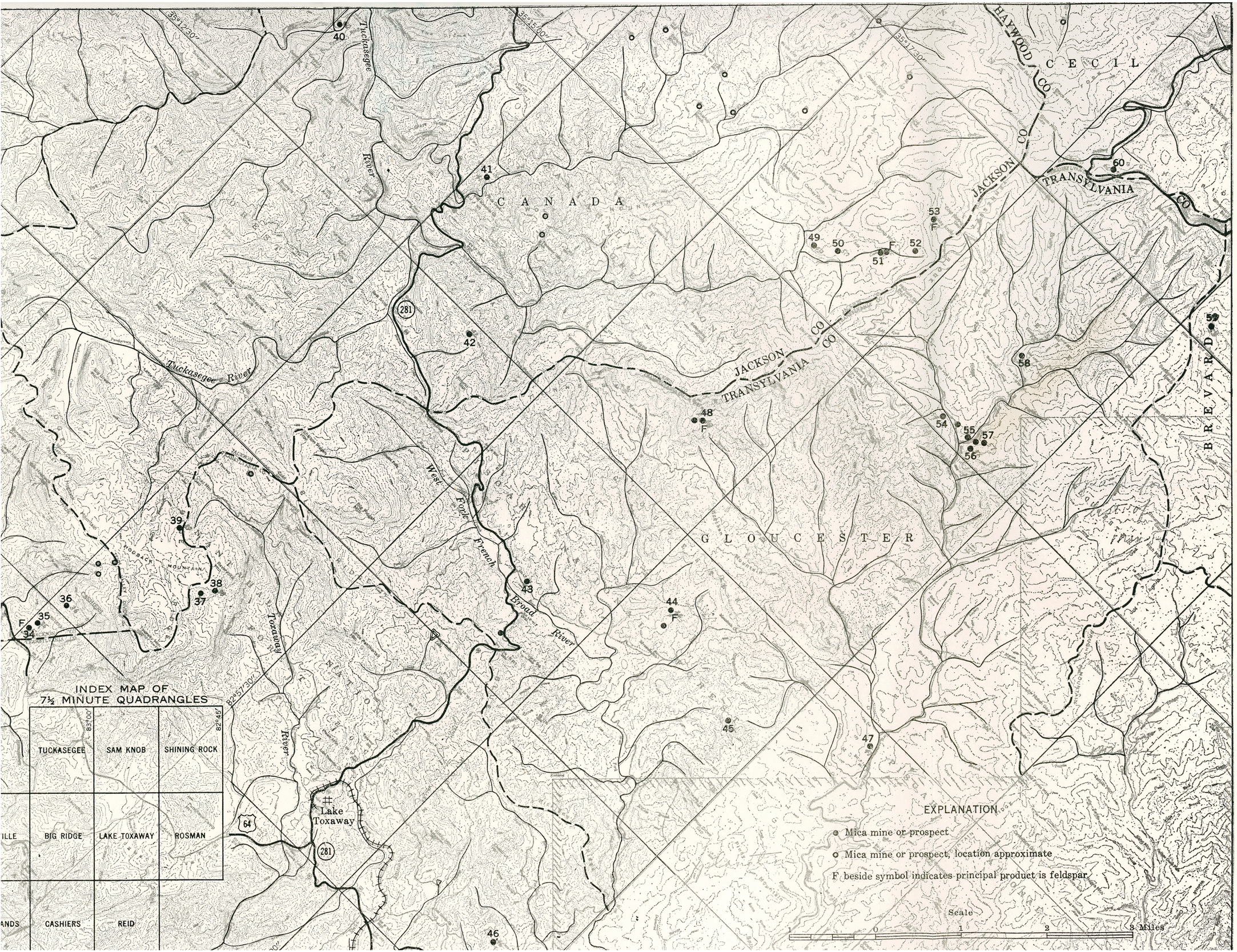
Glenville Lake
HAMBURG
Webb Lake
Hurricane Lake
Cashiers Lake
Lupton Lake
Cashiers
High Hampton
Hampton Lake
Horsepasture River
Fairfield Lake
CASHIERS
Tuckasegee River
Tuckasegee River
West Fork French Broad River
Chattooga River
Sapphire Lake
JACKSON CO
TRANSYLVANIA CO
MACON CO
NORTH CAROLINA
SOUTH CAROLINA
TRANSYLVANIA CO
JACKSON CO
HOGBACK MOUNTAIN
HOGBACK
Toxaway River
Lake Toxaway
83°07'30"
83°10'00"
83°05'00"
35°07'30"
35°10'00"
35°12'30"
35°15'00"
82°57'30"
82°45'
35°00'

INDEX MAP OF 7½ MINUTE QUADRANGLES

	TUCKASEGEE	SAM KNOB	SHINING ROCK
GLENVILLE	BIG RIDGE	LAKE TOXAWAY	ROSMAN
HIGHLANDS	CASHIERS	REID	



NUMERICAL LIST OF MICA MINES IN THE CASHIERS DISTRICT

No.	*Name of Mine*
1.	High Lonesome
2.	Wilson
3.	New Wolff
4.	Wolff-Jones
5.	Zeb Jones
6.	Lusk
7.	Jake Rice
8.	Proffitt
9.	Turkey Pen Ridge
10.	Big Bend
11.	Chestnut Creek
12.	Nicholson
13.	Brushy Hollow
14.	Jumbo (Little Jumbo)
15.	Bryson (Big Jumbo)
16.	Morning Star
17.	Tallow Face
18.	Reid
19.	Will Crowe
20.	Rice mica-beryl
21.	Will Rice mica
22.	Unnamed prospect near highway 106
23.	Ridge (Red, Dillard)
24.	Big Terrapin (Wade Crowe
25.	Autrey
26.	Little Terrapin
27.	Thomas Grimshawe
28.	Whiteside Cove
29.	Edwards
30.	Sheep Cliff
31.	Fairfield Lake
32.	Unnamed prospect near Sapphire Lake
33.	Little Hogback Creek
34.	Unnamed prospect southwes of Toxaway Mountain
35.	do
36.	do
37.	Unnamed prospect on Ravenrock Mountain
38.	do.
39.	do.
40.	Island Ford
41.	Wolf Creek
42.	Lambert Owens
43.	Sam Owens
44.	Fleming McCall
45.	The Glass mine
46.	Robertson
47.	Charlie Norris
48.	Bald Rock
49.	Tennesse Creek
50.	Pinhook Creek
51.	L. M. McCall
52.	Pinhook Gap
53.	Puncheon Camp
54.	Owens and Davis
55.	Bee Tree No. 2
56.	Bee Tree No. 1
57.	Uncle Doctor McCall
58.	Chestnut Ridge