COMMONWEALTH OF VIRGINIA

STATE COMMISSION ON CONSERVATION AND DEVELOPMENT

VIRGINIA GEOLOGICAL SURVEY

ARTHUR BEVAN, *State Geologist*

Bulletin 33

Pegmatite Deposits of Virginia

BY

ARTHUR A. PEGAU

UNIVERSITY, VIRGINIA

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LETTER OF TRANSMITTAL

COMMONWEALTH OF VIRGINIA
VIRGINIA GEOLOGICAL SURVEY
UNIVERSITY OF VIRGINIA

CHARLOTTESVILLE, VA., January 16, 1930.

To the State Commission on Conservation and Development:

GENTLEMEN:

I have the honor to transmit and to recommend for publication as Bulletin 33 of the Virginia Geological Survey series of reports a manuscript and illustrations of a report on the *Pegmatite Deposits of Virginia,* by Dr. Arthur A. Pegau, Assistant Professor of Geology, University of Virginia, and Survey Mineralogist.

This report discusses chiefly the mica and feldspar deposits of economic importance in the Piedmont region. It treats of their distribution, geologic relations, origin, and value. Suggestions are given for prospecting and mining these deposits. Associated minerals of economic value are briefly discussed.

This report will be of value to all interested in the mica and feldspar resources of the State, as well as in the geology of the southern part of the Piedmont province. It should be helpful in directing prospecting and mining operations.

Respectfully submitted,

ARTHUR BEVAN,
State Geologist.

Approved for publication:
State Commission on Conservation and Development,
Richmond, Virginia, January 16, 1930.
E. O. FIPPIN, *Executive Secretary.*

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ILLUSTRATIONS

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ABSTRACT

Numerous minerals have been produced in commercial quantities from the pegmatite deposits of Virginia. They are: Mica (muscovite), feldspar (microcline), titanium minerals (rutile and ilmenite), apatite, quartz, kaolin, rare earth minerals (allanite, sipylite, and others), and gem minerals (Amazon stone chiefly and, to a less extent, hyacinth stone, topazolite, moonstone, beryl, microlite, and amethyst).

Pegmatite dikes occur in nearly every county in the Piedmont province of Virginia, but the most productive ones are limited mainly to the following 11 counties which have produced the minerals listed after each: Amelia County, mica, feldspar, and gem minerals; Amherst County, allanite, sipylite and associated minerals, as well as rutile, ilmenite, and apatite; Bedford County, feldspar, kaolin, and mica; Franklin County, mica and, to a less extent, titanium minerals; Hanover County, rutile, ilmenite, and apatite; Henry County, mica, feldspar, and kaolin; Nelson County, rutile, ilmenite, and apatite; Pittsylvania County, mica, feldspar, kaolin, emery, and associated minerals; Roanoke County, rutile and ilmenite; and Rockbridge County, cassiterite and associated minerals.

The pegamites occur generally as dikes or dikelike bodies, that vary in width from a few inches to 125 feet, and in length from a few hundred feet to several miles. Most of them extend to great depth, though many pinch out from a few feet to 30 feet below the surface. These pegmatite dikes are commonly composed mainly of feldspar (microcline and albite), quartz, and muscovite, with minor amounts of tourmaline, garnet, and beryl. Exceptions to this common composition are found in Amelia County, where more than 30 mineral species have been reported from the pegmatites; in Amherst County, where allanite, sipylite, and related minerals are found; in Pittsylvania County, where emery and the rare mineral hoegbomite have been reported; and in Goochland, Hanover, and Nelson counties, where rutile and ilmenite occur in a plagioclase feldspar of intermediate composition and where titanium minerals and apatite are found in a rock called nelsonite.

The pegamites have been formed as the end product of the crystallization of a magma with the composition of a granite or of a quartz monzonite. The original composition of many of the pegmatite bodies has been profoundly changed by liquids and gases emanating from the parent magma.

The enclosing rocks are highly metamorphosed schists and gneisses of pre-Cambrian age, belonging to the Baltimore gneiss, Lynchburg gneiss, and the Wissahickon and granitized Wissahickon formations. These metamorphic rocks have been intruded later by magmas of acid to basic composition, producing chiefly granites, quartz monzonites, and hornblende gabbros.

Pegmatite Deposits of Virginia

By Arthur A. Pegau

INTRODUCTION

The numerous pegmatite deposits of Virginia are in the crystalline rocks of the Piedmont Plateau. They are of important commercial value as a source of economic minerals, chiefly mica and feldspar, as well as of rutile, ilmenite, quartz, kaolin, emery, cassiterite, and, to a lesser extent, of gems and rare-earth and specimen minerals.

SCOPE OF REPORT

This report contains a discussion of the distribution, mode of occurrence, composition, economic value, origin, and probable age of the pegmatite deposits of Virginia. It includes also a brief description of the geology and petrography of the associated rocks, followed by a brief description of the Amelia, the Goochland, the Altavista, the Axton, the Ridgeway, the Moneta-Bells, and the Chestnut Mountain areas, which are the 7 producing areas, and of several smaller areas. Finally, the economic geology of the pegmatite deposits is discussed.

FIELD AND LABORATORY WORK

The field work was done during the summers of 1922, 1924, and 1928. A part of the laboratory investigations was made at Cornell University during 1922 to 1924. The remainder was completed at the University of Virginia.

Topographic maps prepared by the United States Geological Survey were used as a base for the geologic maps of the several pegmatite areas.

ACKNOWLEDGMENTS

The writer wishes to express his indebtdness to the late Dr. Thomas L. Watson who suggested this problem and supervised the field work during the first two field seasons. He wishes to acknowledge also the assistance of Professors H. Ries and A. C. Gill in the laboratory investigations at Cornell University, and of Professor G. D. Harris, of Cornell University, and Professor Joseph K. Roberts, of the University of Virginia, in making many

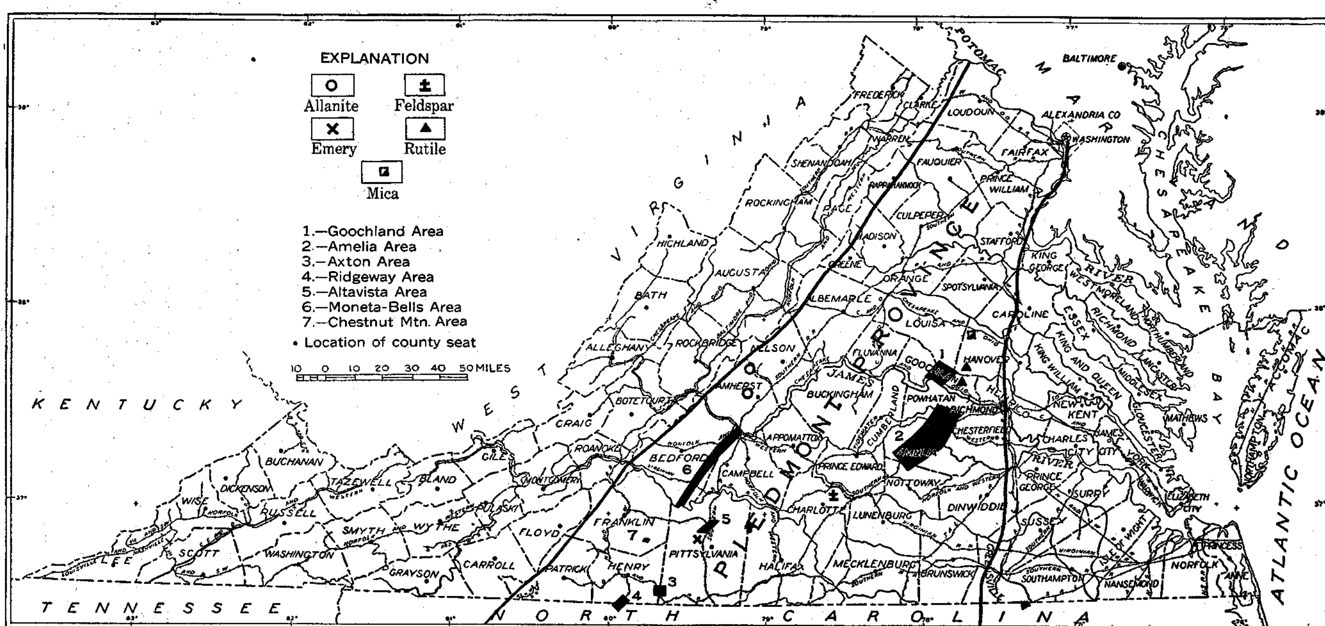

Figure 1.—Index map showing location of the known pegmatite deposits of Virginia.

of the photographs. He is further indebted to Professor Wilbur A. Nelson, former State Geologist, who authorized the work during the field season of 1928; to Dr. Arthur Bevan, State Geologist, and Mr. William M. McGill, Assistant State Geologist, who prepared the report for publication; and to Mr. Linwood H. Warwick who, as Acting Head of the Virginia Geological Survey from September 1, 1928, to June 1, 1929, assisted in editing the manuscript and illustrations. Finally, he wishes to express his appreciation to the many citizens of the State whose cordial cooperation greatly facilitated the field work.

LOCATION OF DEPOSITS

Pegmatite deposits are abundant in the Piedmont province of Virginia. Commercial deposits, however, are largely limited to two districts which may be called the Amelia-Goochland and the Martinsville-Lynchburg districts.

The Amelia-Goochland district comprises portions of Nottoway, Amelia, Chesterfield, Powhatan, Goochland, Hanover, and Louisa counties, near the central-eastern border of the Piedmont province. (See Fig. 1.) The district extends from the Amelia-Nottoway county line on the southwest to the Goochland-Louisa county line on the northeast. It is 32 miles long and 13 miles wide. The Amelia area is in the southwestern part, and the Goochland area is in the northeastern part, of the district.

The Martinsville-Lynchburg district is in Henry, Pittsylvania, Franklin, and Bedford counties, in the south-central part of the Piedmont province. It extends northwest from the Virginia-North Carolina line, 4 miles south of Ridgeway, Henry County, to James River a few miles west of Lynchburg, and is 76 miles long and 32 miles wide. It includes these producing areas: Ridgeway in Henry County; Axton, partly in Henry County and partly in Pittsylvania County; Chestnut Mountain in Franklin County; and Moneta-Bells in Bedford County.

Isolated pegmatite deposits of commercial importance occur near Hewlett in Hanover County, near Cuckoo in Louisa County, near Abilene in Charlotte County, near Alhambra in Amherst County, near Whittles in Pittsylvania County, and on Irish Creek in Rockbridge County. Deposits known in many other localities had not proved to be of economic value at the time this field work was completed.

TOPOGRAPHY AND DRAINAGE

GENERAL FEATURES

As the topography of the individual pegmatite areas is that of the particular part of the Piedmont province they occupy, details are given under the description of the individual areas. In general, the relief is less pronounced and the elevations are more subdued in the eastern and southern parts than in the western and northern parts of the Piedmont region. As the topography becomes more subdued, the mantle of residual material becomes deeper and fresh exposures of the bedrock are less common. In the eastern and southern parts of the Piedmont region, as in the Amelia, Goochland, Altavista, and Axton areas, the pegmatite deposits rarely crop out.

AMELIA-GOOCHLAND DISTRICT

The surface of this area is well dissected and the elevations are subdued. The district viewed as a whole is a gently rolling plain. The elevation ranges from 400 to 450 feet along the divides to slightly less than 150 feet along James River, the average being about 250 feet.

This district is drained by three rivers, the Appomattox, James, and South Anna, and their tributaries. The general direction of drainage is slightly south of east.

MARTINSVILLE-LYNCHBURG DISTRICT

The topography of the southeastern part of this area is similar to that of the Amelia-Goochland district, but that of the western and northern parts is distinctly rougher. Here the surface is undulatory, the hills have moderate to steep slopes, and the valleys have steep slopes. The elevation ranges from less than 600 feet along the streams to more than 1,000 feet on some divides. The mean elevation here is greater than in the Amelia-Goochland district, and the maximum relief is considerably greater.

The principal rivers draining this district are the Dan, James, Otter, Roanoke (Staunton), and the Smith. Some of the main tributaries are Goose Creek, Leatherwood Creek, Little Otter River, Matrimony Creek, and Snow Creek. The general direction of drainage is to the east.

HISTORY OF DEVELOPMENT

Pegmatite deposits in Virginia have yielded chiefly mica, next feldspar, and, to a less extent, quartz, kaolin, emery, cassiterite, and gem and rare minerals. For convenience this discussion is divided into the history of the mining of (1) mica, (2) feldspar, and (3) miscellaneous minerals.

MICA MINING

The mica mining industry in Virginia has been summarized by Sterrett[1] who states that the Virginia mica mines, like those of other states, have been operated intermittently, a few having been worked four or five different times. This fact is well illustrated by data on the annual production of mica. (See Table 8.) Two factors have stimulated mica mining in Virginia, namely, (1) the opening of an unusually rich deposit, and (2) a sudden rise in the price of mica. The first factor caused unusual activity following the opening of the Rutherford mine in Amelia County in the late seventies or the early eighties. The second factor increased mica production at the beginning of and during the World War.

Mica is reported to have been first mined in Virginia by the Indians. Some of the early settlers in Amelia County claim to have seen evidences of mica mining carried on in that area by the Indians. The first mine on record is the Saunders mine near Hewlett, Hanover County, which, according to Watson,[2] was operated by Barr, Johnson and Company, of Erie, Pennsylvania, from 1867 to 1870. The next operations were near Amelia, Amelia County, where the Jefferson mine was opened in 1873. The Berry, Pinchback, Rutherford, and Winston mines near Amelia, and the Schlegal mine near Jetersville, were started soon afterwards. Much excitement was caused by the opening of the Rutherford mines, not only because of the quantity and quality of the mica they produced, but also on account of the number of rare and unusual minerals found therein. The opening of these mines, particularly, stimulated the mica industry in this area to such an extent that the most productive deposits were soon exhausted. The mines were then abandoned and allowed to fill with water, and little work has been done in this area since the eighties, with the exception of a slight resumption of the industry during the World War.

[1] Sterrett, D. B., Mica deposits of the United States: U. S. Geol. Survey Bull. 740, pp. 307-330, 1923.

[2] Watson, T. L., Annual report on the mineral production of Virginia during the calendar year 1908: Virginia Geol. Survey Bull. 1A, p. 104, 1909.

The first mines in the Goochland area were opened about 1880, at which time the Irwin mine and several smaller ones were operated. Operations were resumed during and immediately following the World War, but they were never comparable to those in the Amelia area.

During the period 1880 to 1885, there was prospecting for mica in many of the Piedmont counties, but no deposits comparable to those in the Amelia area were found.

Little mica was produced during the remainder of the nineteenth century, but from 1900 to 1902 there was a considerable increase in the production of both sheet and scrap mica. Another lull occurred from 1903 until 1907, when the deposits in the Ridgeway area were first worked. Operations here were suddenly stopped by a fire which burned the plant. This area, however, became one of the chief producers 8 to 10 years later.

Very little mica was mined in Virginia from 1908 to 1913. During the next 10 years a second period of activity caused the production of mica to exceed that of any other similar period. Many new mines were opened, numerous old ones were reworked, most of the dumps of previous workings were overhauled for scrap mica, and almost all the Piedmont counties were prospected. New mines and prospects were operated in the Ridgeway, Axton, Chestnut Mountain, and Goochland areas. Some of the older workings were reopened in the Amelia area, although most of the mica was obtained from the dumps. In 1918, the production of sheet mica reached its greatest value, being $46,200.00. In 1920, it reached its greatest quantity (179,339 pounds), which was more than twice as great as that in 1918 (78,500 pounds), but it was worth a little more than half as much, being worth $26,189.00 in 1920 and $46,200.00 in 1918. In 1918, the average price of sheet mica was approximately 58 cents a pound, but in 1920 it was only 15 cents a pound. As a result of this small margin of profit, many operations were abandoned so that, in 1921, there were only 3 operators in the State. In 1922, production increased, and in each year since 1922 there has been a small production. It is hoped that, with the use of improved methods of mining and with the application of geologic principles to development, the mica industry will be revived. The deposits of the State are by no means exhausted, but the crude methods of mining employed in the past will never prove profitable unless there arises a demand for mica comparable to that during the World War.

FELDSPAR MINING

Feldspar mining has, until recently, been incidental to mica mining in Virginia. Watson[3] stated that, before 1907, the principal area in the State was in Amelia County, where feldspar was mined in connection with mica. He[4] stated in 1909 that, during 1907, three quarries were operating in the State, namely, near Bells in Bedford County, near Prospect in Prince Edward County, and near Amelia in Amelia County. In 1908, only the quarry near Prospect, Prince Edward County, was operating.

In 1910, Bastin[5] stated that feldspar practically unmixed with quartz might be obtained from the Pinchback mine, and that the associated quartz was also of good commercial grade.

In 1911, the Old Dominion State Mines Corporation, of Prospect, was the only producer of feldspar in the State. A large shipment of feldspar from here analyzed 13 per cent of potash. Only one quarry produced feldspar in Virginia in 1912, from which a small quantity was shipped for experimental potash extraction. No feldspar from quarries in Virginia was sold during 1913. All quarries were idle, except for the shipment of less than a ton for experimental purposes. An analysis showed 14.92 per cent potash, 18 per cent alumina, and 0.33 per cent ferric oxide. Virginia in 1914 reported a production of feldspar larger in quantity than that from any other state and exceeding in value that of any state except Maine and New York. This production was made by one quarry in Prince Edward County. All other quarries which had in the past produced or given promise of the production of feldspar were idle in 1914. In 1915, a small quantity of feldspar was produced in Amelia and Pittsylvania counties. In 1916, mines in Bedford and Henry counties produced feldspar.

No feldspar production was reported during the years 1917 to 1922. In 1923, two quarries were operating, one at Axton, Henry County, and one at Moneta, Bedford County.

During the years 1924, 1925, and 1926, two feldspar quarries were operated near Moneta, Bedford County. The product has been described as a high grade potash feldspar, which was used in the manufacture of soap and high tension insulators.

In addition to the two quarries near Moneta, another was operated during 1927 near Winterham, Amelia County. This quarry yielded Amazon stone which was shipped for gem material.

[3] Watson, T. L., Mineral resources of Virginia: Virginia-Jamestown Exposition Commission, p. 276, 1907.

[4] Watson, T. L, Annual report on the mineral production of Virginia during the calendar year 1908: Virginia Geol. Survey Bull. 1-A, p. 106, 1909.

[5] Bastin, E. S., Quartz and feldspar: U. S. Geol. Survey Mineral Resources, 1910, pt. 2, p. 972, 1911.

In 1928, the three quarries that were operated in 1927 continued operations. It was reported that a modern grinding mill was being installed at Brookneal for grinding the feldspar from the Moneta mines. It began to operate in 1929.

Considerable activity was reported in the feldspar industry during 1929. In addition to the Seaboard Feldspar Company, which began operations about 1924, and the General Mines Corporation, which first reported production in 1927, two other companies, the Virginia Feldspar Company, of Bedford, and the Mica Production Company, of Norfolk, were organized. Feldspar was mined during this year near Moneta in Bedford County, near Axton in Pittsylvania County, and near Winterham in Amelia County.

MISCELLANEOUS MINERALS

EMERY

Production of emery was first reported from Virginia in 1917, near Whittles in the north-central part of Pittsylvania County. The production of emery continued from that time until November 1, 1929, when the Niagara Emery Mills, Inc., reported that it had gone out of business in Virginia. Due to the fact that there was only one producer, it is not possible to publish statistics of production.

QUARTZ

Quartz is one of the principal constituents of pegmatite deposits. Many of the dikes grade into quartz veins. Small production has been reported from time to time in connection with mica mining, but no serious attempt has been made, on a large scale, to mine quartz from pegmatites.

KAOLIN

Deposits of kaolin have been prospected in many areas, chiefly in the Altavista and the Ridgeway areas. In the Altavista area, kaolin has been prospected on R. T. Jackson's property about 2½ miles west of Altavista, and on the property of a Mr. Broomfield, near Brights, Pittsylvania County. A large deposit was exposed along the Southern Railway, 1 mile south of Motley station, in the same county. In the Ridgeway area, a rather promising deposit was prospected on the Garrett property in Henry County. Each deposit of kaolin has been too impure and in too small quantities to warrant development. So far as known, none has been shipped except for experimental purposes.

RUTILE

Rutile has been prospected at various places in Goochland and Hanover counties, but production to date has been only from the deposits in Nelson County. The deposits have been fully described by Watson and Taber.[6]

CASSITERITE

Cassiterite has been prospected and mined, to some extent, on Irish Creek, Rockbridge County. These deposits have been discussed by Ferguson.[7]

RARE-EARTH MINERALS

Allanite, helvite, fergusonite, and a few other rare minerals occur in the pegmatites. Allanite is the chief one. It has been produced mainly from Amherst County and slightly from Amelia County.

GEMS AND PRECIOUS STONES

Production of gem minerals which, until recently, has been entirely from the Rutherford mines in the Amelia area, includes Amazon stone (green microcline), moonstone (translucent white albite), hyacinth spessartite, beryl, microlite, and chlorophane (phosphorescent fluorite). Amazon stone has been the most important, and large quantities are still available on the dumps. During 1930 and 1931, there has been quite a large production of Amazon stone and beryl from the Morefield mine near Winterham, Amelia County. The other gem minerals which have been reported have been used only for museum specimens. It is probable that further work will reveal other gem minerals.

PREVIOUS GEOLOGIC WORK

The literature pertaining to pegmatites in Virginia is extensive, but no detailed description of these deposits has been published. Most of the articles deal with the mineralogical and chemical character of the pegmatites, particularly of the dikes of unusual mineral composition upon which the Rutherford mines are located.[8] A few articles give a general survey of the geology and mineralogy of the deposits. The first of these geologic papers, by

[6] Watson, T. L., and Taber, Stephen, Geology of the titanium and apatite deposits of Virginia: Virginia Geol. Survey Bull. 3-A, pp. 248-261, 1913.

[7] Ferguson, H. G., Tin deposits near Irish Creek, Virginia: Virginia Geol. Survey Bull. 15-A, 1918.

[8] These articles appeared in the "Virginias," "Chemical News," and the "American Journal of Science," during the years 1880 to 1890. (See Bibliography.)

W. M. Fontaine,[9] discussed the pegmatites near Amelia Court House. He described the country rock as a thinly bedded, schistose, highly micaceous gneiss, alternating with and grading into mica schist. Of the occurrence of the pegmatites he wrote: "They form bosses of irregular and interrupted veins, that occur as well defined bands that do not extend over great distances." He further wrote: "Of the essential minerals, feldspar, mica and quartz, the mica was the first to crystallize, the feldspar came next, and the quartz was the last to assume the solid form." He gave a detailed description of the minerals, feldspar, beryl, fluorite, columbite, garnet, orthite, microlite, helvite, galena, stibnite, and pyrochlore.

No comprehensive report on pegmatites in Virginia appeared until 1907, when Watson[10] stated that pegmatites had been mined or prospected in Amelia, Amherst, Bedford, Franklin, Goochland, Hanover, Henry, and Pittsylvania counties. Surface indications were noted also in Buckingham, Caroline, Cumberland, Powhatan, and Spotsylvania counties. Concerning these deposits Watson[11] wrote: "Of the many localities where mica is found in Virginia only one has yet been seriously mined, namely, near Amelia courthouse and near Jetersville, in Amelia County." Watson also gave a brief account of the geology and of some of the principal mines in the Amelia area. He described briefly quartz, garnet, beryl, apatite, allanite, fluorite, feldspar, microlite, and helvite, most of which came from the Rutherford mines in the Amelia area. In 1909, Watson[12] gave a brief history of mica mining in Virginia.

In a discussion of feldspar and quartz production for 1910, Bastin[13] described the Pinchback and the Rutherford mines in the Amelia area. He stated that all the pegmatite dikes probably belonged to one period of intrusion.

Watson and Taber[14] discussed certain rutile-bearing pegmatites in Goochland and Hanover counties. They described the country rock as a granite gneiss of variable composition, chiefly micaceous and, in places, containing hornblende. Although no chemical analysis of the gneiss was made, a study of thin sections led them to believe it was of quartz monzonitic origin, the banded structure being secondary. The rutile-bearing syenite near Rose-

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[9] Fontaine, W. M., Notes on the occurrence of certain minerals in Amelia County, Virginia: Am. Jour. Sci., 3d ser., vol. 25, pp. 330-339, 1883.

[10] Watson, T. L., Mineral resources of Virginia: Virginia-Jamestown Exposition Commission, pp. 275-285, 385-392, 1907.

[11] Idem, p. 279.

[12] Watson, T. L., Annual report on the mineral production of Virginia during the calendar year 1908: Virginia Geol. Survey, Bull. 1-A, pp. 101-105, 1909.

[13] Bastin, E. S., Quartz and feldspar: U. S. Geol. Survey Mineral Resources, 1910, pt. 2, pp. 972-973, 1911.

[14] Watson, T. L., and Taber, Stephen: Geology of the titanium and apatite deposits of Virginia: Virginia Geol. Survey Bull. 3-A, pp. 248-261, 1913.

land, Virginia, discussed in the same report, is considered by some to be a pegmatite deposit, although it was not considered so by Watson.

In 1915, a report by Sterrett[15] included a brief description of the geology and of the more important mines in Bedford, Franklin, Henry, and Pittsylvania counties. This was, at the time, the most detailed description of the pegmatite deposits of the State.

In 1917, Watson[16] added zircon to the list of minerals in the Rutherford mines.

In their report on the clays of the Piedmont province, Ries and Somers[17] mentioned briefly the occurrence of kaolin derived from pegmatites, near Motley, on the Southern Railway, and near Altavista, on the Virginian Railway, both in Pittsylvania County, and near Ridgeway, Henry County. They were of the opinion that the kaolin was of rather poor grade and not in sufficient quantity for profitable development.

The cassiterite deposits were described in some detail by Ferguson[18] in 1918. He brought up to date all literature bearing on these deposits.

Watson[19] published in 1923 the only description of the Virginia emery deposits. He had contemplated writing a more detailed description of this area at some later date, but was prevented from doing so by death. In describing the origin of these deposits, he stated that they resulted from replacement, the emanations responsible for the formation of the ores and the closely associated pegmatites coming from the same parent magma.

In 1923, Sterrett[20] wrote a more complete account of the mica-bearing pegmatites in the State, in which he included the most thorough description of the Goochland area to that time. He described the country rock as a biotite gneiss into which were injected streaks and lenses of pegmatite. The tendency of the pegmatite toward a lenticular form was emphasized.

Hoegbomite from Pittsylvania County, Virginia, was found and described by Watson.[21] This was a notable discovery, for this mineral had not been previously reported from the United States.

[15] Sterrett, D. B., Some deposits of mica in the United States: U. S. Geol. Survey Bull. 580, pp. 65-125, 1914.

[16] Watson, T. L., Zircon-bearing pegmatites in Virginia: Am. Inst. Min. Eng. Trans., vol. 55, pp. 936-942, 1917.

[17] Ries, H., and Somers, R. E., The clays of the Piedmont province, Virginia: Virginia Geol. Survey Bull. 13, pp. 75-76, 80, 1917.

[18] Ferguson, H. G., Tin deposits near Irish Creek, Virginia: Virginia Geol. Survey Bull. 15-A, 1918.

[19] Watson, T. L., A contribution to the geology of the Virginia emery deposits: Econ. Geology, vol. 18, pp. 53-76, 1923.

[20] Sterrett, D. B., Mica deposits of the United States: U. S. Geol. Survey Bull. 740, pp. 307-330, 1923.

[21] Watson, T. L, Hoegbomite from Virginia: Am. Mineralogist, vol. 10, pp. 1-9, 1925.

The writer[22] published in 1928 an article on the geology and mineralogy of the Rutherford mines in the Amelia area. He assembled the information on these unusual mines and pointed out that many of the minerals reported from near Amelia Court House are confined to the dikes upon which the Rutherford mines are located. The other pegmatite deposits in this area are similar to those in other parts of the State.

No attempt has been made to discuss all the articles bearing on many rare minerals in the Rutherford mines. They are listed in the Bibliography.

[22] Pegau, A. A., The Rutherford mines, Amelia County, Virginia: Am. Mineralogist, vol. 13, pp. 583-588, 1928.

GEOLOGY AND PETROGRAPHY

GENERAL FEATURES

The Piedmont province consists mainly of metamorphic rocks of sedimentary and igneous origin. The rocks associated with the pegmatite are very complex, and the various types can be accurately differentiated only through very detailed study. The metamorphic rocks are intruded by igneous rocks, ranging from those that are extremely acid, as the quartz-rich pegmatites, to those that are very basic, as the dikes of hornblende metapyroxenite.

The metamorphic rock types here recognized include the Wissahickon schist, the Amelia-Goochland quartz monzonite, the Moneta biotite-hornblende gneiss, hornblende metagabbro gneiss, hornblende-chlorite schist, and the Cockeysville marble. The marble occurs in the Altavista area, but, as it has no direct relation to the pegmatite deposits, it was not studied in detail.

The igneous rock types include the Leatherwood granite, diabase dikes, and pegmatite dikes.

The distribution of these rock types is shown on Plates 1 to 4 (in pocket). Each type is described briefly below.

WISSAHICKON SCHIST

The Wissahickon schist was shown for the first time in the State on the geologic map of Virginia published in 1928. It occupies an almost central position across the State, having an average width of about 15 miles. This schist comprises from two-thirds to three-fourths of the outcrops in the Altavista, Axton, and Ridgeway areas, and most of the outcrops in the Chestnut Mountain area.

The Wissahickon schist is described by Anna I. Jonas,[23] as follows: "A chlorite-muscovite schist with quartzite in lower part; contains thin greenstone lava flows near base; garnetiferous biotite schist locally containing staurolite, sillimanite, and kyanite."

The writer found that this rock in the above-mentioned areas is a schist-gneiss complex, which can be differentiated into three more or less distinct facies: (1) Garnetiferous mica schist, (2) biotite gneiss, and (3) hornblende schist. Chlorite and kyanite schist facies were found in a few places. The garnetiferous mica schist is the most abundant type. The biotite gneiss and the hornblende schist occur as bands of variable thickness along the foliae of the mica schist.

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[23] Geologic map of Virginia, Virginia Geol. Survey, 1928.

GARNETIFEROUS MICA SCHIST

General character and distribution.—This prevailing rock type crops out chiefly on the ridges and divides and, to a less extent, along streams. The less weathered portions resemble very closely the biotite gneiss, the two rocks in places being scarcely distinguishable. This rock is distinctly schistose with the strike ranging from N.20°E. to N.60°E. The dip ranges from 50° to 70°SE., though in places it is 45° to 75° NW. One prominent set of joints is developed with a strike of N.50°-70°W. and a dip ranging from 50° to 80°SW.

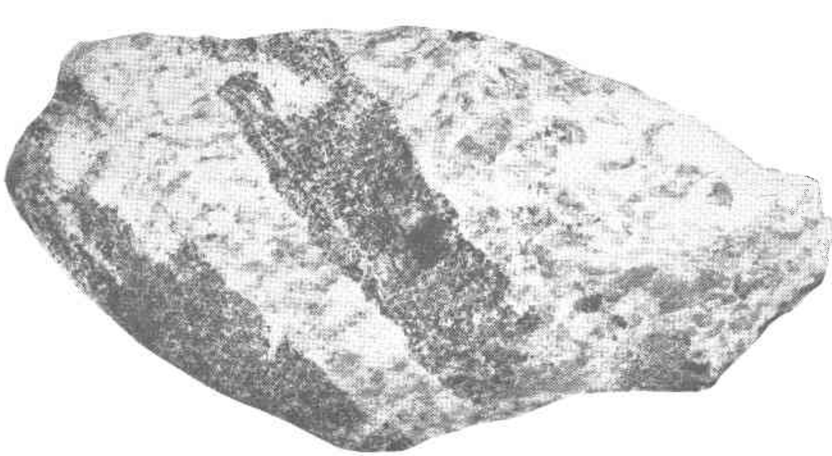
Megascopic character.—The appearance of this schist varies considerably from place to place, because of the variation in mineral content and differences in the degree of weathering. The fresh rock is light-gray, whereas the more weathered parts are reddish-gray with silvery luster. The chief mineral is muscovite, which occurs as well-developed scales whose cleavage planes are parallel to the schistosity of the rock. Quartz, the next most abundant mineral, occurs as gray to dark-gray grains distributed uniformly through the rock. Biotite is generally present but is commonly partly or wholly altered to chlorite and limonite. Garnet is generally present and, in some places, is very abundant. It occurs as partially weathered grains that range in size from 1 millimeter to 1 centimeter. These grains weather out in many places to form limonitic pebbles in the residual clay. Tourmaline occurs along the pegmatite contacts. Limonite is abundantly developed as a product of weathering. Narrow bands of chlorite and of amphibole asbestos are present in a few places.

Microscopic character.—Thin sections of the fresh rock show the following minerals in variable proportions: Muscovite, quartz, feldspar, biotite, garnet, graphite, iron hydroxides, rutile, tourmaline, zircon, epidote, and magnetite. Muscovite, which constitutes from 20 to 80 per cent of the rock, is present as well-developed crystals that show parallel orientation. Some of the muscovite is wrapped around grains of garnet. The amount of quartz in the rock ranges from 20 to 50 per cent. It occurs as irregular grains and ribbons, the largest being 5 millimeters long and 2 millimeters wide. Plagioclase, which ranges from albite to andesine, is generally present in variable amounts. It is commonly altered to secondary minerals, as epidote, kaolinite, and sericite. Biotite, which averages about 10 per cent of the rock, contains numerous inclusions. Alterations to chlorite and limonite are common. Garnet is usually present, being, in some thin sections, as much as

A. Amelia-Goochland quartz monzonite gneiss showing augen texture; near the Patterson mine, 2 miles northeast of Amelia, Amelia County. X ¾.

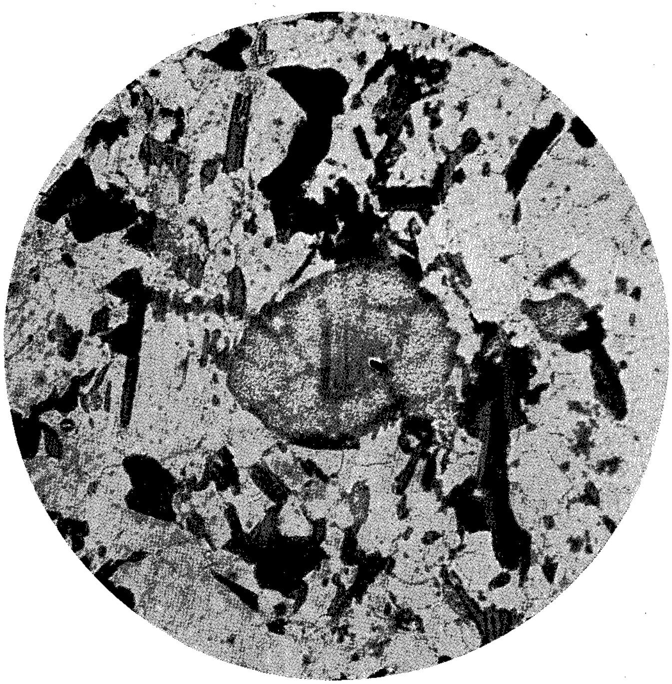
B. Inclusion of wall rock (biotite gneiss) in pegmatite at the Rutherford mines, 1¼ miles north of Amelia, Amelia County. X ¾.

A. Amelia-Goochland quartz monzonite gneiss showing augen texture; near the Patterson mine, 2 miles northeast of Amelia, Amelia County. X ¾.



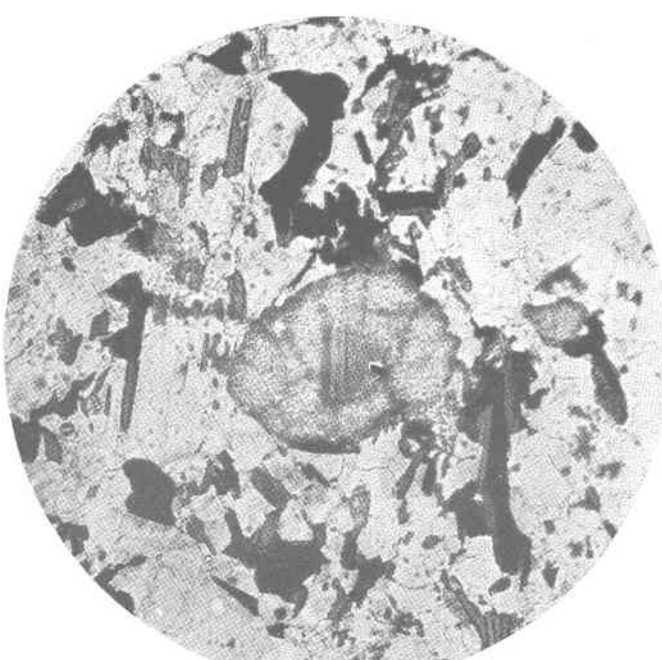
B. Inclusion of wall rock (biotite gneiss) in pegmatite at the Rutherford mines, 1¼ miles north of Amelia, Amelia County. X ¾.

A. Micrographic texture in the Leatherwood granite, Ridgeway area. X 45.



B. Inclusions of biotite (gray) and graphite (black) in garnet (center) in Amelia-Goochland quartz monzonite gneiss. X 45.

A. Micrographic texture in the Leatherwood granite, Ridgeway area. X 45.



B. Inclusions of biotite (gray) and graphite (black) in garnet (center) in Amelia-Goochland quartz monzonite gneiss. X 45.

20 per cent of the rock. It occurs as equidimensional grains that average 2 millimeters in diameter. Inclusions of other minerals in the garnet are numerous, and alteration of garnet to limonite is common. Epidote, magnetite, ilmenite, titanite, tourmaline, zircon, and rutile occur in variable but minor amounts.

BIOTITE GNEISS

General character and distribution.—Biotite gneiss is less abundant than garnetiferous mica schist, but more abundant than hornblende gneiss. Biotite gneiss occurs as tabular bodies along the foliae of the mica schist, which range in width from less than 1 foot to 500 feet, with an average of about 20 feet. This gneiss is best exposed in streams where the mica schist has been eroded away, and, to a less extent, in highway and railroad cuts. Through it is generally massive, the thinner bands show well-developed schistosity. The strike and dip of the biotite gneiss correspond to those of the enclosing mica schist. Two systems of joint planes are well developed in the biotite gneiss. One strikes N. 50°-60° E. and has a nearly vertical dip; the other strikes N. 15°-25° W. and dips 60° SW. Injections of pegmatitic material are common as bands and elliptical bodies a few inches to several feet wide. (See Fig. 2.)

Megascopic character.—The biotite gneiss has a characteristic salt and pepper appearance resulting from a uniform mixture of black and white minerals. It is commonly even-granular, in places porphyritic, and generally schistose. The minerals visible to the naked eye are chalky, white feldspar, gray quartz, glistening muscovite, specks of biotite, with hornblende and red garnet in some places.

Microscopic character.—Thin sections show an even-granular mixture of the dominant minerals feldspar, quartz, and biotite, with minor amounts of muscovite, epidote, garnet, apatite, zircon, magnetite, titanite, and pyrite.

Oligoclase and orthoclase, in nearly equal amounts, with scant microcline, comprise from 50 to 70 per cent of the rock. Inclusions of apatite, zircon, and epidote are common. Alteration of feldspar is very common and in some outcrops the original feldspar is hardly recognizable. The amount of quartz in the rock ranges from 15 to 20 per cent. Shattering and cementation are common and strain shadows are fairly common. Biotite composes 10 to 15 per cent of the rock and occurs in distinct crystals and shredded masses. Alteration to chlorite is common. Muscovite is sparingly intergrown with biotite and occurs also as sericite. Epidote is present in variable amounts, reaching a maximum of 5 per cent. The other minerals occur sparingly.

HORNBLENDE SCHIST

General character and distribution.—This rock type forms a relatively small per cent of the total volume of the Wissahickon schist-gneiss complex. It is, however, uniformly distributed and occurs

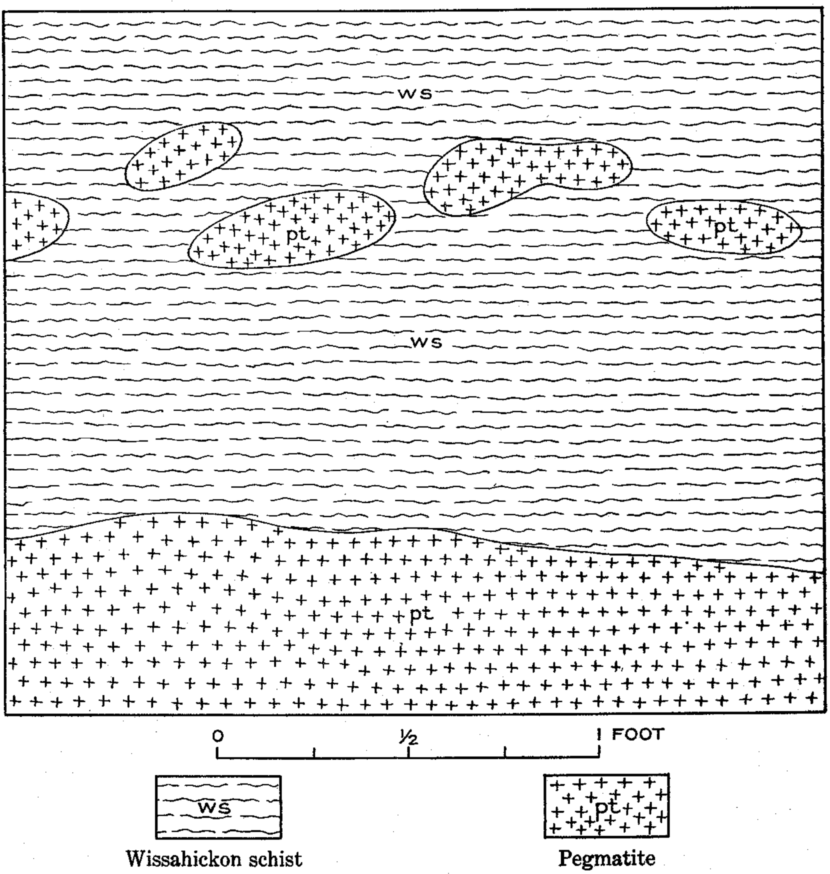


Figure 2.—Relation of lenticles of pegmatite to the main pegmatite, on the southeastern end of the dike at the Vicama mica mine, 4 miles southeast of Axton, Pittsylvania County.

in bands, a few inches to 20 feet thick, along the foliae of the garnetiferous mica schist.

Megascopic character.—The hornblende schist is a dark greenish-gray, thinly schistose, heavy, medium- to fine-grained rock. It is composed of thin bands of greenish-black fibrous hornblende, alternating with slightly thicker and lighter bands of chalky, white feldspar, gray quartz, yellowish-green epidote, and some garnet and biotite.

Microscopic character.—Hornblende comprises from two-thirds to three-fourths of the rock. It occurs as elongated, rather ragged, prismatic crystals that average 1 millimeter long, though some are 3 millimeters long. It is usually grass-green to blue-green and has strong pleochroism. Numerous inclusions of magnetite grains give much of it a smudgy appearance. Andesine and its alteration product, epidote, are the next most abundant minerals. Quartz, though generally present, is never abundant. Magnetite is the chief accessory mineral, but titanite, apatite, garnet, and pyrite are found.

Origin and age.—The Wissahickon schist, wherever exposed, appears to be older than the rocks associated with it. The marble, or crystalline limestone, in the Altavista area, which was not studied by the writer, may be a possible exception. The garnetiferous mica schist seems to be the oldest of the three facies of the Wissahickon schist, although the hornblende schist may represent a more basic phase of approximately the same age. The biotite gneiss, as evidenced by its occurrence along the foliae of the mica schist and by its more massive character, appears to be the youngest of the three facies.

The garnetiferous mica schist, as determined from its mineral composition, mostly muscovite and quartz, and the variability in mineral content, seems to represent an original mud or sand. It has been heavily injected with magmatic material of variable composition.

The hornblende schist appears to have been originally a more basic part of the sediment from which the mica schist was derived. The predominance of hornblende and quartz and the small percentage of feldspar would seem to preclude its being a part of the metagabbro intrusions.

The biotite gneiss presents a more difficult problem. It may represent a more resistant part of the original sediment, a later intrusion of monzonitic character, or the more heavily injected phases of the schist. The striking difference between its mineral composition and that of the mica schist, and the strong resemblance it bears to the numerous intrusive rocks of monzonitic character in the Piedmont province, all tend to show that the biotite gneiss is of igneous origin. It may be, however, an injected phase of the mica schist, the injected material being of monzonitic composition.

QUARTZ MONZONITE GNEISS OF THE AMELIA-GOOCHLAND AREA

General character and distribution.—This gneiss is the principal rock in the Amelia and Goochland areas and comprises about 90 per cent of the outcrops. It is well banded and in places is schistose. Much of the banding is secondary, having been produced by metamorphism, though some of it resulted from lit par lit injections of other material, chiefly pegmatitic. These foliation and injection bands generally strike northeast, averaging N. 33° E., and dip almost vertically.

The monzonite gneiss is intruded by dikes of metagabbro, diabase, and pegmatite. The metagabbro dikes are the largest, one in each area averaging about one-fourth mile wide and from 8 to 10 miles long. The enclosing rock shows greater schistosity near the contact, with a development of garnet. Pegmatite dikes are numerous in both areas, the dikelike form being more pronounced in some places and the lenticular form in others. The larger dikes, which generally cut the schistosity, send out numerous apophyses along the foliation planes of the enclosing rocks. Narrow dikes of diabase are numerous, especially in the vicinity of Winterham, Amelia County.

Megascopic character.—The monzonite gneiss is a light- to dark-gray micaceous augen gneiss, with an irregular banding. Some of it is conglomeratic. The bands range in width from less than 1 centimeter to 15 centimeters. The "eyes" (Pl. 5, A) range in size from 0.5 centimeter long and 0.2 centimeter wide to 3 centimeters long and 1 centimeter wide. They consist of white glassy feldspar with Carlsbad twinning. The visible minerals in the ground-mass include feldspar, quartz, biotite, muscovite, garnet, magnetite, graphite, hornblende, and chlorite.

Microscopic character.—Thin sections show a total of 20 minerals, with 10 being the largest number in a single slide. In descending order of abundance they are feldspar, quartz, biotite, muscovite, garnet, hornblende, zircon, apatite, epidote, titanite, magnetite, ilmenite, pyroxene, chlorite, limonite, kaolinite, rutile, pyrite, graphite, and sillimanite. The approximate mineral percentages, as determined by micrometer measurements, are: Feldspar 60 per cent, quartz 24 per cent, biotite 11 per cent, muscovite 3 per cent, garnet 1 per cent, and other minerals 1 per cent.

Feldspar is rarely less than 50 per cent. It is in subhedral to anhedral grains that average 0.5 millimeter by 0.3 millimeter. It consists of the potash and plagioclase varieties in nearly equal amounts. The potash variety is chiefly orthoclase with some microcline. The plagioclase is generally albite-oligoclase, but some of it is andesine. Inclusions are numerous and alteration is almost invariable.

Quartz is a constant constituent which ranges from 10 to 30 per cent of the rock, the lower percentages occurring in the more hornblendic facies. It occurs as irregular grains and ribbons that show undulatory extinction.

Biotite is fairly constant in amount and is present as well-developed crystals and shreds that show a distinct parallel orientation. It is reddish-brown and has strong pleochroism. Inclusions of graphite, as needles parallel to the cleavage of the biotite, are common.

Muscovite and garnet are irregular in occurrence, the garnet being most abundant along the contacts with other rocks. Pyroxene, as a rule partly altered to hornblende, was observed in a few places.

Of the minor constituents, graphite, rutile, and sillimanite are the most interesting, in that the last two, and probably the graphite also, have apparently resulted from pegmatitic juices.

Chemical composition and classification.—The chemical composition of quartz monzonite gneiss in the Amelia-Goochland area is shown in the two analyses given below.

TABLE 1.—*Analyses and norms of the Amelia-Goochland quartz monzonite gneiss*

(Penniman and Browne, Analysts)

Analyses	1	2	Norms	1	2
SiO_2	60.78	66.86	Quartz	15.36	23.46
Al_2O_3	18.58	17.76	Orthoclase	21.68	10.48
Fe_2O_3	1.06	1.58	Albite	24.63	36.68
FeO	4.32	2.18	Anorthite	18.63	18.63
TiO_2	1.26	.68	Corundum	2.96	1.73
MnO_2	.08	.02	Hypersthene	10.80	3.89
CaO	4.15	3.89	Magnetite	1.62	2.32
MgO	2.13	1.12	Ilmenite	2.43	1.37
K_2O	3.71	1.88	Apatite	2.17	1.21
Na_2O	2.93	3.38	Water	.75	.45
P_2O_5	.29	.19			
H_2O	.75	.45		101.03	100.22
CO_2	----	----			
	100.04	99.99			

1.—Near the Patterson mine, Amelia area.
2.—In a stream bed northeast of Goochland.

The position of the rock in the quantitative system of classification is as follows:

(1) II. 4-5. 2. 3. Adamellose or monzonose.
(2) I. 4. 2. 4. Lassenose.

No. 1 is intermediate between a sodipotassic dacase with the subrang name adamellose and a sodipotassic monzonase with the subrang name monzonose. No. 2 is a dosodic tosconase with the subrang name lassenose.

Origin and age.—The analyses calculated in terms of standard minerals show a large predominance of plagioclase, which indicates a rock of the composition of quartz monzonite. This is in accord with the general character of the granites and granite gneisses of the southern Piedmont province.[24] The chemical composition, the field evidence, and the mineral composition determined by microscopic study indicate an original porphyritic biotite-quartz monzonite. The rock has been profoundly affected by anamorphism.

This is the oldest rock type in the area. It is intruded by dikes of hornblende metagabbro gneiss, pegmatite, and diabase. On the geologic map of Virginia, published in 1928, Anna I. Jonas assigned it to the pre-Cambrian.

MONETA BIOTITE-HORNBLENDE GNEISS

DEFINITION

This rock type occurs in the area mapped as Lynchburg gneiss on the geologic map of Virginia (1928). It is described as mica gneiss and mica schist, in part garnetiferous. The gneiss in the Moneta-Bells area differs so much from the general character of the Lynchburg gneiss that the writer has named it the Moneta gneiss, from Moneta, Bedford County, where it is best known.

CHARACTER AND DISTRIBUTION

This rock is the prevailing type in the Moneta-Bells area. It consists of two distinct lithologic types, biotite gneiss and hornblende gneiss, so intimately associated that they can not be mapped separately. They are in parallel, alternating bands (Fig. 3), with one or the other predominating in different places.

[24] Watson, T. L., Granites of the southeastern Atlantic States: U. S. Geol. Survey Bull. 426, 1910.

BIOTITE GNEISS

Megascopic character.—The biotite gneiss is a gray to dark-gray, medium- to fine-grained, commonly schistose rock. The texture is generally even-granular, though some of the rock is porphyritic. Visible minerals are feldspar, quartz, biotite, muscovite, garnet, and locally hornblende.

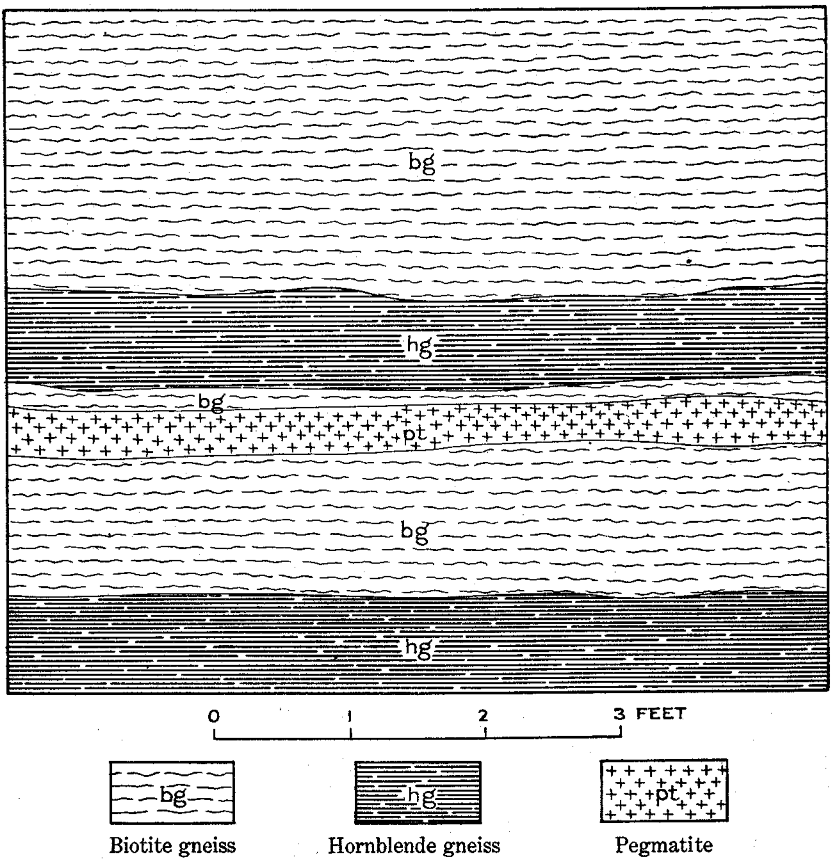


Figure 3.—Relation of hornblende gneiss, pegmatite, and biotite gneiss at Haydens Bridge, Bedford County.

Microscopic character.—The minerals visible under the microscope are: Feldspar and quartz predominant, biotite and muscovite subordinate, with minor amounts of garnet, apatite, zircon, titanite, magnetite, epidote, chlorite, kaolinite, sericite, and limonite.

Feldspar and quartz compose from 80 to 90 per cent of the rock. The feldspar is chiefly oligoclase, with some orthoclase and microline. It occurs as subhedral to anhedral grains, many of which have a poikilitic texture, resulting from numerous inclusions of other minerals with high indices of refraction. Some of the feldspar has a smudgy appearance because of dustlike inclusions of magnetite. Quartz is present as anhedral and elongated ribbon-like grains. It occurs (1) intergrown with feldspar, (2) as an interstitial filling, and (3) as inclusions, chiefly in feldspar. Biotite, the characteristic femic mineral, is generally present, forming about 10 per cent of the rock. It occurs as tabular, reddish-brown crystals with strong pleochroism. Most of the crystals show parallel orientation. Muscovite is common, either as isolated scales or intergrown with biotite. In a few places it equals biotite in amount, although it is generally subordinate to it. Biotite is the most abundant of the minor minerals, and epidote is next.

The mineral content indicates a rock of biotite-quartz monzonitic composition, which is similar to most of the granitic rocks in the Piedmont province of Virginia.

Chemical composition and classification.—The chemical composition of the biotite gneiss facies of the Moneta gneiss is shown in the analysis given below.

TABLE 2.—*Analysis and norm of the biotite gneiss facies of the Moneta gneiss from Moneta*

(Penniman and Browne, Analysts)

Analysis		Norm	
SiO_2	76.83	Quartz	41.58
Al_2O_3	11.86	Orthoclase	19.74
Fe_2O_3	.26	Albite	22.53
FeO	2.38	Anorthite	8.06
TiO_2	.66	Corundum	.92
MnO_2	.03	Hypersthene	5.01
CaO	1.58	Magnetite	.38
MgO	.71	Ilmenite	1.30
K_2O	3.35	Water	.74
Na_2O	2.65		
H_2O	.74		100.26
	101.05		

The position of the rock in the quantitative system is shown by the symbol I.3.2.3, which classifies the rock as a sodipotassic alsbachase with the subrang name tehamose.

HORNBLENDE GNEISS

Character and distribution.—The hornblende gneiss has the composition of a hornblende diorite. It occurs as bands ranging from a few feet to 60 feet wide, lying in the foliation planes of the biotite gneiss. The bands, as well as the schistosity, strike N. 30°-60° E. and have a variable dip. The gneiss is especially abundant along Goose Creek in the Stone Mountain area, in Bedford County.

Megascopic character.—The gneiss is an even-granular to fine-grained greenish-gray rock. Large chalky feldspar grains produce in places a mottled appearance. Parallelism of the fibrous crystals of hornblende causes a distinctly schistose structure. The other visible minerals are feldspar, quartz, epidote, biotite, magnetite, garnet, and limonite.

Microscopic character.—Thin sections show the principal mineral to be hornblende, the subordinate minerals to be feldspar, quartz, epidote, and rarely biotite, and the accessory minerals to be titanite, garnet, magnetite, and limonite.

Hornblende occurs as subhedral to anhedral grains that have a pronounced prismatic habit. It is grass-green to yellow-green with strong pleochroism. The borders of the more weathered grains are stained with limonite. Poikilitic texture, because of inclusions of feldspar and quartz, is common. The hornblende is found also as rodlike inclusions in quartz and feldspar. Feldspar, which comprises from 10 to 25 per cent of the rock, is intermediate between oligoclase and andesine. Alteration to epidote is common. Epidote varies from negligible amounts to 25 per cent. It occurs as pyramidal crystals several inches in diameter and as irregular grains. It varies from colorless zoisite to yellowish-green, pleochroic pistacite. Titanite is generally present and is abundant in some places. It forms ellipsoidal grains and alteration rims around ilmenite. When garnet occurs, which is rarely, it is near pegmatite contacts. Biotite is also a contact mineral, derived evidently by the action of pegmatitic juices on hornblende. Quartz occurs sparingly. Magnetite and ilmenite occur in constant but minor amounts.

ORIGIN AND AGE

The origin of the Moneta biotite-hornblende gneiss is difficult to determine. The two lithologic types (1) may represent different beds in the original sediments, (2) may both be of igneous origin, or (3) one may be of igneous origin and the other of sedimentary origin. Detailed field study, together with chemical analyses of the different types, would be necessary to determine the origin. Several data, however, suggest an igneous origin for both types. The biotite gneiss is very similar in appearance and in mineral composition to many of the gneisses of monzonitic composition in the Piedmont province of Virginia. The hornblende gneiss, on the other hand, closely resembles, in mineral composition, the hornblende metagabbro. The two types are intimately related, and there is no evidence of contact metamorphism along their contacts. It is the writer's belief that the two are genetically related and have probably been derived from the same magma. It is probable that the parent magma of the biotite gneiss was intruded first and then, soon after, the magma from which the hornblende gneiss was derived. A similar relation between the Leatherwood granite, of somewhat monzonitic character, and the hornblende metagabbro exists in the Ridgeway area.

HORNBLENDE METAGABBRO GNEISS

Character and distribution.—This rock type is very widespread in the Piedmont province and was found in most of the areas studied. Its common mode of occurrence is as dikes, which range from a few feet wide and several hundred feet long to one-fourth of a mile wide and 8 to 10 miles long. The dikes strike prevailingly northeast and dip from 60° to 90°, as a rule to the northwest. Banding, where developed, parallels the strike and dip of the dike.

Megascopic character.—The hornblende metagabbro gneiss is greenish-gray to nearly black, even-granular to porphyritic, and more or less distinctly banded. The chief visible minerals are greenish-black to black hornblende, more or less chalky feldspar, green pyroxene, and yellowish-green epidote. Some of the gneiss contains quartz, biotite, magnetite, and garnet. The specific gravity of the rock is 3.00 to 3.20.

Microscopic character.—Thin sections show the principal minerals to be hornblende and feldspar, with variable but minor amounts of quartz, epidote, titanite, magnetite, zircon, rutile, and apatite. Hornblende and feldspar comprise 85 per cent or more of the rock. Hornblende, the chief constituent, is present as flattened and prismoid crystals and rodlike grains. Some of the larger crystals measure 2 millimeters by 0.5 millimeter. Many of the smaller grains occur as inclusions in the feldspar. Hornblende is also secondary after pyroxene, as rims and along cleavage planes.

The color ranges from light-green with faint pleochroism to blue-green with deep pleochroism. In the latter variety, α = blue-green, β = clear green, and γ = greenish yellow. Inclusions of variable shape and size are feldspar, quartz, magnetite, apatite, titanite, and rutile.

The feldspar is chiefly andesine, but there are some labradorite and orthoclase. The grains average 0.5 millimeter in diameter. Evidence of pressure is shown by the elongation of crystals, the bending of twinning striae (Pl. 11, A), and recrystallization. Alteration to epidote is most common (Pl. 11, B), and to kaolinite and sericite less so.

Monoclinic and orthorhombic pyroxenes occur sparingly and show all stages of alteration to hornblende. It is probable that much of the hornblende represents original pyroxene.

Biotite occurs sparingly and appears to have been formed by the action of pegmatitic juices on hornblende. The epidote appears to have been formed in the same way from plagioclase. Some of the gneiss contains rutile, but its relation to the pegmatites could not be determined.

Origin and age.—The original rock has been greatly altered, both mineralogically and structurally, yet its dikelike occurrence, granular texture, uniformity of mineral composition, and the minerals themselves suggest an igneous origin. The feldspar was basic, as evidenced by considerable epidote, and the hornblende appears to have been derived largely from pyroxene. This would suggest a parent rock of the composition of gabbro.

The hornblende metagabbro gneiss is younger than the Wissahickon schist and the quartz monzonite gneiss. Its relation to the Leatherwood granite could not be definitely established. Wherever the two are in contact, they seem to be of about the same age. The relation between the hornblende metagabbro and Leatherwood granite in the Ridgeway area is very similar to that of the two facies of the Moneta gneiss. It is probable that some of the monzonitic granites and some of the metagabbros are genetically related. The extent of this relationship and its exact nature can be determined only by more detailed study.

HORNBLENDE-CHLORITE METAPYROXENITE

Character and distribution.—This rock type was found in the Axton and Ridgeway areas, in Pittsylvania and Henry counties, being most abundant in the Ridgeway area. It occurs as dikes intruding the Wissahickon schist, the hornblende metagabbro, and the Leatherwood granite, but it is older than the pegmatite and the diabase. The strike of these dikes generally ranges from N. 10° E. to N. 60° E., but a few dikes strike approximately east. They do not conform to the schistosity of the enclosing rock. The dip ranges from 65° NW. to vertical. As this schist strongly resists weathering, it is commonly exposed in narrow ridges from one-fourth of a mile to half a mile long and from 10 to 60 feet wide.

Megascopic character.—The hornblende-chlorite metapyroxenite is a medium-grained, apple-green schistose rock with a mottled appearance, resulting from partly weathered magnetite. It is composed of apple-green, platy chlorite, green fibrous hornblende, and partly altered magnetite.

Microscopic character.—Thin sections of the rock show the principal constituents to be amphibole and chlorite, with minor amounts of magnetite, pyroxene, talc, muscovite, and limonite.

Amphibole, which is generally the most abundant mineral, occurs as needles, fibrous masses, and irregular grains. It includes the non-aluminous varieties, tremolite and actinolite, and the aluminous one, hornblende. Tremolite occurs as well-defined, colorless acicular needles that grade, even in a single crystal, into actinolite. The hornblende appears to be secondary, as is shown by its grass-green to blue-green color, deep pleochroism, and fibrous form.

Chlorite in places composes 50 per cent of the rock, although it is generally subordinate in amount to amphibole. It is found in tabular platy crystals, some of which are 5 millimeters long. It is colorless to green, with a pleochroism that increases with depth of color. Chlorite does not appear to have been derived secondarily from hornblende, but it seems that both chlorite and hornblende were derived from some other preexisting mineral, probably a pyroxene. Pyroxene, where present, is as a rule partly altered to hornblende and chlorite.

Talc, magnetite, muscovite, and limonite constitute less than 1 per cent of the rock.

Origin and age.—The dikelike mode of occurrence and the mineral composition of the hornblende-chlorite metapyroxenite indicate an igneous rock of very basic composition, probably a pyroxenite. The original minerals have been largely metamorphosed to secondary minerals.

The foliated character of the rock rather belies its age relation to the other rocks, for it cuts rocks, such as the Leatherwood granite, which are more massive. It is younger than the Wissahickon schist, the hornblende metagabbro, and the Leatherwood granite. On the other hand, pegmatitic material has been injected into the metapyroxenite. The schistose character of the rock results from the chlorite.

LEATHERWOOD GRANITE

Character and distribution.—The Leatherwood granite is named from Leatherwood, the home of Patrick Henry near Martinsville, Henry County. It occurs as irregular bodies of variable size intruding the Wissahickon schist in the southwestern part of the area. It occupies about 25 square miles in the northern part of the Axton area, being a part of a large body mostly north of the Axton area. Detached bodies are found also in the Ridgeway area and in the emery area in Pittsylvania County. This granite, according to Watson,[25] is responsible for the emery deposits and the closely associated pegmatites. It is considerably younger than the Wissahickon schist, for it is much more massive and almost devoid of foliation and banding. It is intruded by dikes of metapyroxenite, pegmatite, and diabase. In the Ridgeway area this granite occurs with the hornblende metagabbro and is apparently of the same age.

Megascopic character.—Hand specimens show the Leatherwood granite to be of coarse to medium texture, even-grained to porphyritic, light-gray to pinkish-gray, and generally massive, though some of it is schistose along contacts with pegmatite dikes. The visible minerals are feldspar, quartz, biotite, muscovite, epidote, hornblende, and magnetite. The feldspar and quartz commonly are found in sugary masses, but some of the feldspar is in clear, tabular crystals showing Carlsbad twinning. Biotite occurs as disseminated flakes and radiating masses.

Microscopic character.—Micrometer measurements show the following minerals: Feldspars 60-80 per cent, quartz 5-20 per cent, biotite 5-25 per cent, epidote 2-20 per cent, with variable but small percentages of hornblende, muscovite, zircon, apatite, ilmenite, magnetite, titanite, kaolinite, sericite, and chlorite.

The feldspars include oligoclase, orthoclase, and microcline, whose exact proportions are difficult to determine, though oligoclase decidedly predominates. The feldspars occur as subhedral to anhedral grains, and as microperthitic and micropegmatitic intergrowths. (Pl. 6, A.) Alteration to epidote is common, and to kaolinite and sericite is less common. Much of the quartz shows strain shadows under crossed nicols. Biotite occurs as euhedral

[25] Watson, T. L., A contribution to the geology of the Virginia emery deposits: Econ. Geology, vol. 18, p. 74, 1923.

crystals up to 3 millimeters long and in radiating masses. It is reddish-brown to greenish-brown and is commonly altered wholly or partly to chlorite. The other primary minerals, hornblende, augite, muscovite, magnetite, and ilmenite, do not exceed 5 per cent of the rock. Epidote is the most abundant secondary mineral, occurring as an alteration product of feldspar, in colorless to light-yellow and faintly pleochroic irregular grains. Other secondary minerals, such as kaolinite, sericite, chlorite, and limonite, occur in small amounts.

Chemical composition and classification.—The chemical composition of the Leatherwood granite from the Ridgeway area in Henry County is shown in the analysis given below.

TABLE 3.—*Analysis and norm of the Leatherwood granite from the Ridgeway area, Henry County*

(Penniman and Browne, Analysts)

Analysis		Norm	
SiO_2	75.02	Quartz	45.62
Al_2O_3	14.02	Orthoclase	5.56
Fe_2O_3	1.04	Albite	23.58
FeO	1.37	Anorthite	18.35
TiO_2	.08	Corundum	1.63
MnO	.06	Hypersthene	3.02
CaO	3.93	Magnetite	1.39
MgO	.52	Ilmenite	.15
K_2O	.91	Apatite	-----
Na_2O	2.81	Water	.10
P_2O_5	-----	Calcite	.35
H_2O	.10		
CO_2	.15		99.75
	100.01		

The position of this rock in the quantitative system of classification is as follows:

I. 3. 2-3. 4. Alsbachose or susquehannose.

This rock is intermediate between a dosodic alsbachase, with the subrang name alsbachose, and dosodic riesanase, with the subrang name susquehannose. The analysis indicates a rock of granitic composition in which plagioclase predominates over potash feldspars, illustrated by the following table of feldspars calculated from the foregoing analysis.

TABLE 4.—*Composition of the feldspars in the Leatherwood granite from the Ridgeway area, Henry County*

Orthoclase	5.56
Albite	23.58
Anorthite	18.36
Total plagioclase	41.93
Total feldspar	47.49
Ab_nAn_m ratio	1+ :1
Or.-plag. ratio	1:7+

Origin and age.—The Leatherwood granite appears to represent a more or less metamorphosed granitic type of rock in which the predominant feldspar is plagioclase. This is shown by (1) the field relations, (2) mode of occurrence, (3) mineralogical composition, and (4) chemical composition.

This rock is considerably younger than the Wissahickon schist which it intrudes. It appears to be of the same age as the hornblende metagabbro and to be older than the pegmatites, which in this area were probably derived from the same magma.

DIABASE

Character and distribution.—Diabase is widely distributed through the Piedmont province, mostly as dikes. In many places the rock is so thoroughly weathererd that it can be identified only by the deep red residual soil or by the spheroidal boulders of decomposition. It intrudes all the other rocks in the region. The strike of the dikes is very irregular, being either along the foliation or joints, or cutting them. The dikes are commonly less than 10 feet wide. Some can be traced for half a mile, whereas others are exposed for only a few hundred feet.

Megascopic character.—The diabase is greenish-black to black, massive, heavy, and very dense. The hand lens reveals irregular to rather fibrous masses of greenish-black pyroxenes, and tabular crystals of dark-gray to nearly black feldspar. Much of the rock is irregularly stained by yellow to reddish-brown hydrous iron oxide.

Miscroscopic character.—The miscroscope shows the usual association of minerals in this type of rock, arranged to form the typical ophitic or diabasic texture. The chief mineral is labradorite, which occurs as intergrown laths that have a maximum length of 1 millimeter. It shows Carlsbad twinning, combined with albite and pericline twinning. The next most abundant mineral is light-brown to colorless augite which occurs as irregular grains filling the spaces between the feldspars. Many of the grains are altered to hornblende and chlorite. The minor constituents include variable amounts of quartz, orthoclase, magnetite, pyrite, biotite, apatite, chlorite, and serpentine.

Origin and age.—The diabase is an igneous rock derived from a basaltic magma. It has been only slightly altered. It belongs to the Newark series of Triassic age.

PEGMATITE

General features.—The pegmatites of Virginia are very similar in their general characteristics to most other pegmatites. They are essentially acid pegmatites and their paragenesis seems to be the same as that of all deposits of this type described in recent years.

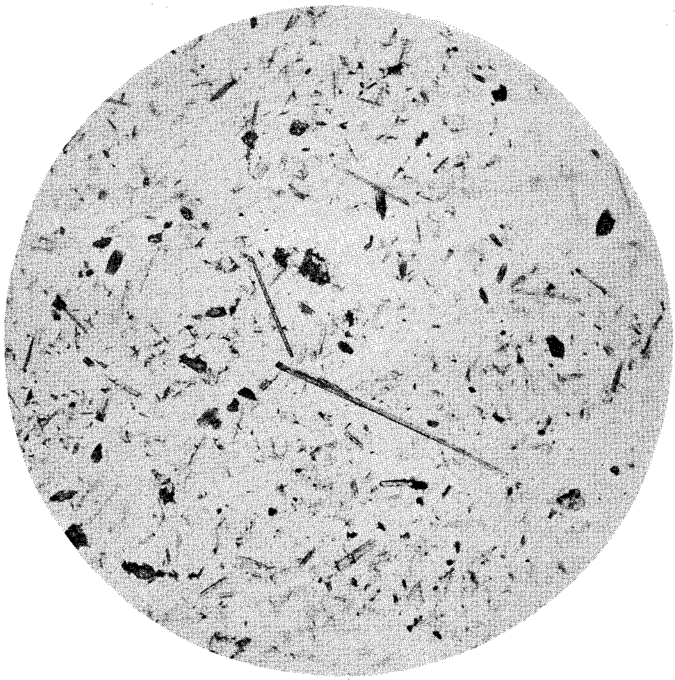
Mode of occurrence.—The pegmatites of Virginia occur chiefly in dikelike masses and, to a less extent, as lenslike bodies and lit par lit injections.

The pegmatite dikes range in width from a few inches to 125 feet, with an average width of 15 to 20 feet. Most of the dikes persist along the strike. One dike in the Moneta-Bells area, as revealed by rather closely spaced prospecting, is several miles long. Lengths of half a mile are common, and from 200 to 300 feet is a fair average. Certain mine pits indicate that some of the dikes are very deep, but others pinch out at depths of 20 to 30 feet below the surface.

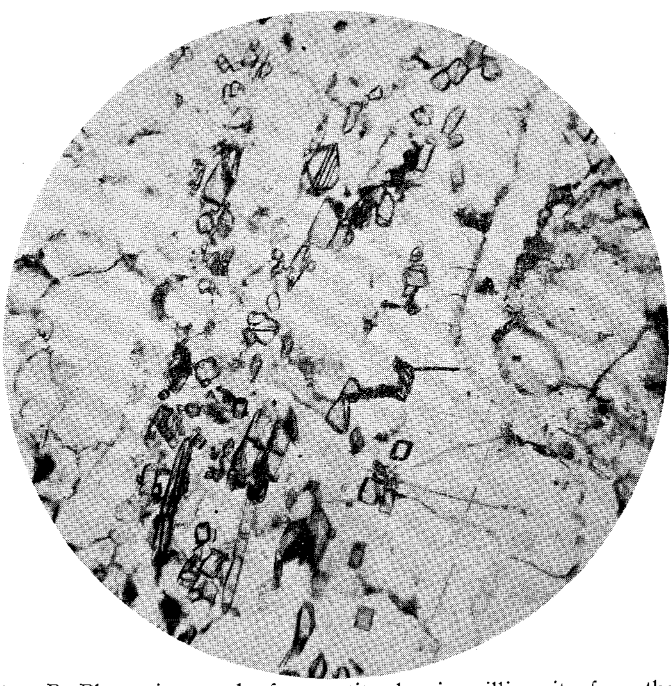
Many of the pegmatite deposits of Virginia show a strong tendency toward a lenticular form. This gives rise to "pinches and swells" along both the strike and dip of the body. (See Fig. 4.) The dike at the Wheatly mine in the Moneta-Bells area has a maximum width of 125 feet, but narrows to 50 feet in a distance of 300 feet. Many of the dikes in the Amelia area, which are 30 feet wide at the surface, pinch out at a depth of 20 to 30 feet. This factor has added greatly to the uncertainty in the development of the deposits.

Great variations in the strike of the dikes exist in a single area. In general, the larger dikes in the Amelia-Goochland district occupy joints which cut across the banding of the massive gneiss, whereas in the Martinsville-Lynchburg district they lie along the foliae of the highly cleavable schist. The strike of the smaller dikes is less consistent.

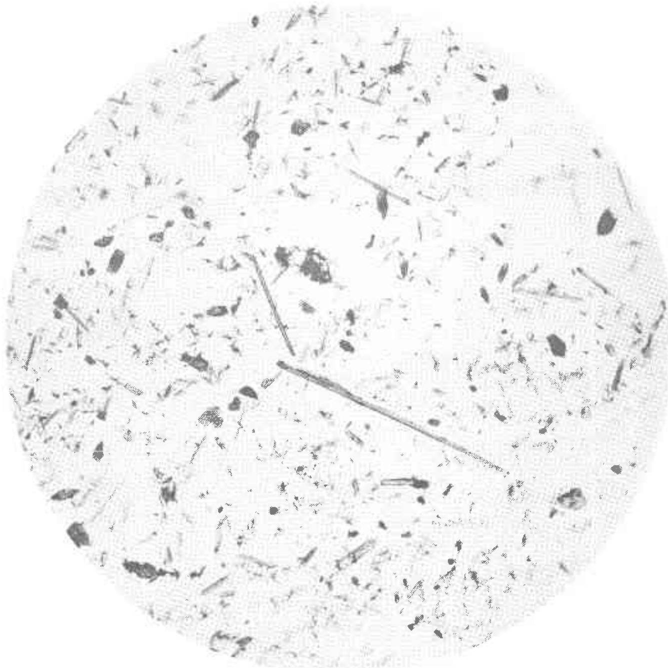
Lenslike bodies, many of which are isolated from any main body, occur in many places. The lenses range from 50 feet long



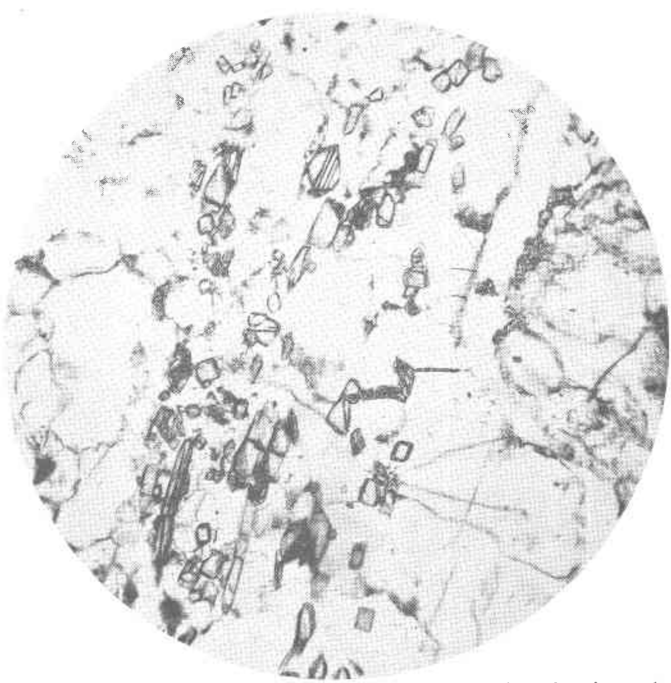
A. Photomicrograph of smoky quartz showing inclusions of tourmaline; from Rutherford mines, 1¼ miles north of Amelia, Amelia County. X 80.



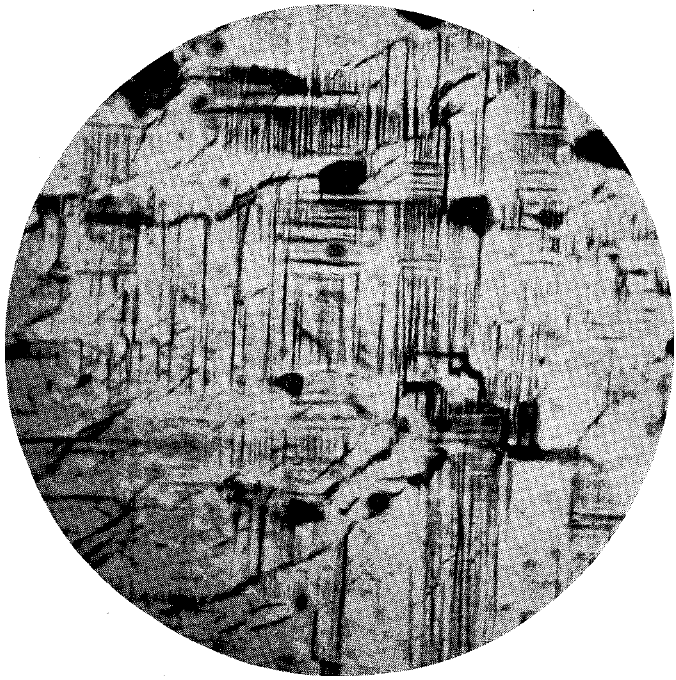
B. Photomicrograph of pegmatite showing sillimanite, from the Salter prospect; near Goochland Court House, Goochland County. X 80.



A. Photomicrograph of smoky quartz showing inclusions of tourmaline; from Rutherford mines, 1¼ miles north of Amelia, Amelia County. X 80.

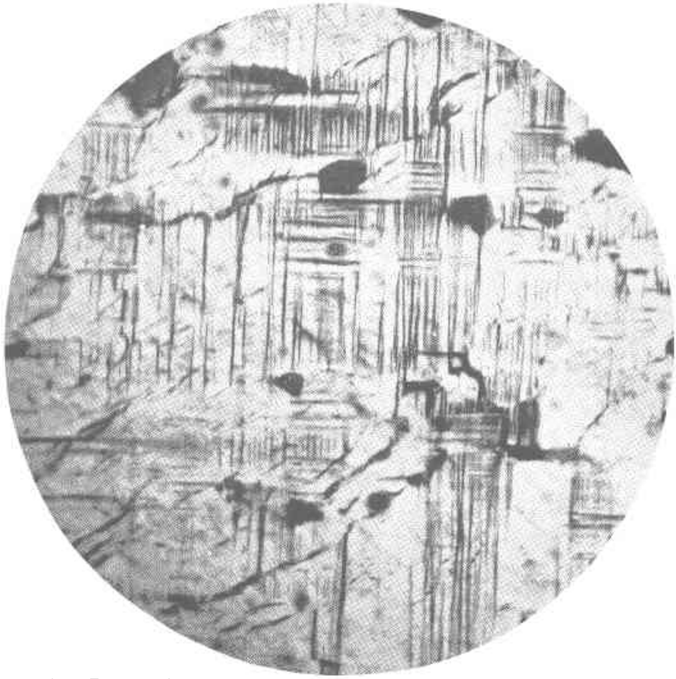


B. Photomicrograph of pegmatite showing sillimanite, from the Salter prospect; near Goochland Court House, Goochland County. X 80.



A. Photomicrograph of feldspar showing orthoclase reverting to microcline; from the Young mine, 1 mile south of Moneta, Bedford County. X 60.

B. Photomicrograph of microcline showing perthitic intergrowth of the microcline with albite; from Bells prospect, 1 mile south of Bells, Bedford County. X 80.



A. Photomicrograph of feldspar showing orthoclase reverting to microcline; from the Young mine, 1 mile south of Moneta, Bedford County. X 60.

B. Photomicrograph of microcline showing perthitic intergrowth of the microcline with albite; from Bells prospect, 1 mile south of Bells, Bedford County. X 80.

by 10 feet wide by 20 feet thick down to those that form "eyes" only a few inches in diameter.

Lit par lit injections are abundant in most of the areas. Some of them have been formed from apophyses of the larger dikes which have been intruded along the foliae of the enclosing rocks. These injection bands vary from a few inches to 5 feet wide.

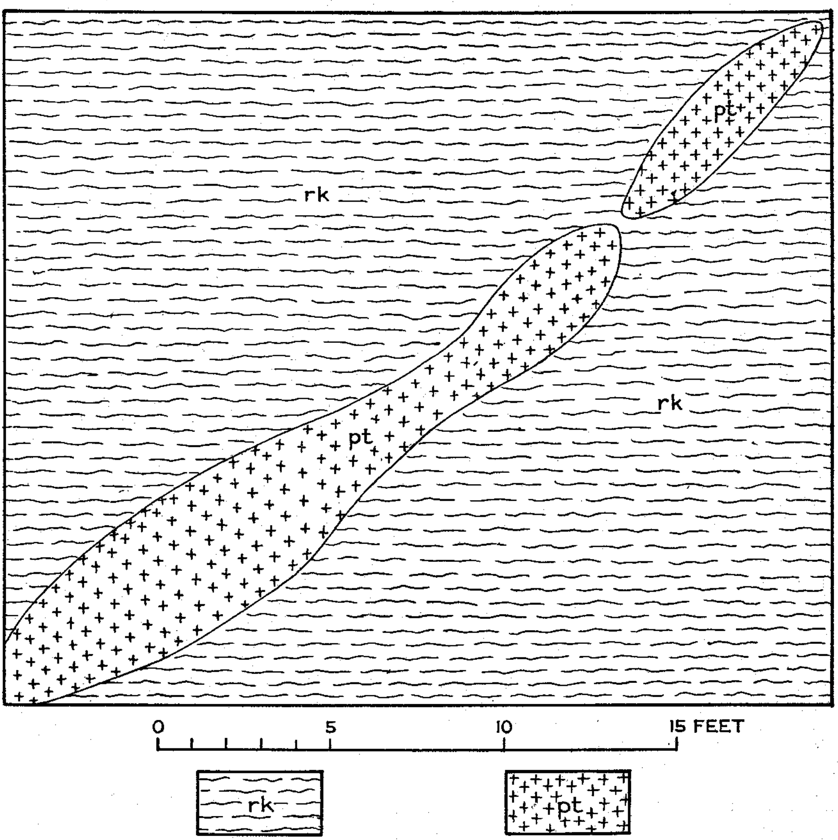


Figure 4.—Diagram of a pegmatite dike showing the tendency toward the lenticular form.

Texture.—The pegmatites are commonly coarsely granular although they have many other textures. The size of the crystals varies greatly. In some dikes crystals of muscovite 3 by 6 by 6 feet have been reported, and blocks of mica weighing 700 pounds have been reported from others. A crystal of feldspar 2 by 2 by 3 feet, and a crystal of beryl 1 foot in diameter and several feet long were obtained from the Rutherford mines. In some dikes the minerals average less than an inch in diameter. A relatively finer grained dike 50 feet wide was found in the Ridgeway area. Porphyritic textures exist, for example, a crystal of microcline 6 inches in diameter is surrounded by a fine-grained mixture of quartz, feldspar, and mica. The coarsest grained pegmatites were found in the Amelia area, and the finest grained dikes were found in the Ridgeway area.

The average size of the mineral units is about 6 inches. The size of crystals is a very important factor in the development of these deposits. The large size of the feldspar masses, 2 to 3 feet in diameter, in the dikes of the Moneta-Bells area, makes the development of these deposits profitable.

Graphic texture, which is an intergrowth of feldspar and quartz, commonly characterizes dikes which cut the hornblende metagabbro gneiss, many of the smaller pegmatite dikes, and some of the larger ones. Deposits with this texture are rarely of economic value.

The most striking texture is found in the dikes at the Rutherford mines in the Amelia area, where a snow-white albite has formed reticulated growths of bladed crystals, whose interstices contain rare minerals, such as microlite and columbite. Large masses of albite having this texture make handsome specimens.

A cellular texture has been developed in some of the dikes on the Jefferson property in the Amelia area. Albite forms the walls of the cells, which measure several inches across, and tiny booklets of muscovite partly fill the cells.

Bands of quartz occur near the middle of many of the dikes, with feldspar, or a mixture of feldspar, quartz, and mica, flanking either side. (See Fig. 5.) In some places the middle band of quartz occupies only a small part of the dike, but in others it forms most of the dike.

Many of the dikes in the Ridgeway area and some in the Axton area are distinctly schistose, because of the parallel arrangement of plates of light-green muscovite. They are commonly fine-grained and porphyritic.

Miarolitic cavities were found in many pegmatites in the Amelia area, but only rarely in the pegmatites in other areas.

Certain textures of microscopic size were also found, most of them being in the microcline. Perthitic texture is best developed in deposits in the Moneta-Bells area. Micrographic intergrowths, chiefly between feldspar and quartz and, to a less extent, between other minerals, are most abundant in some of the pegmatites in the Ridgeway area. Poikilitic texture with sillimanite in feldspar occurs in the pegmatites of the Goochland area, and with tourmaline in quartz, in those of the Amelia area.

Nature of contacts.—The walls of the pegmatites are rarely parallel, and the wall rock in many places partly or entirely pinches out the pegmatite body. The contacts are commonly sharp and can

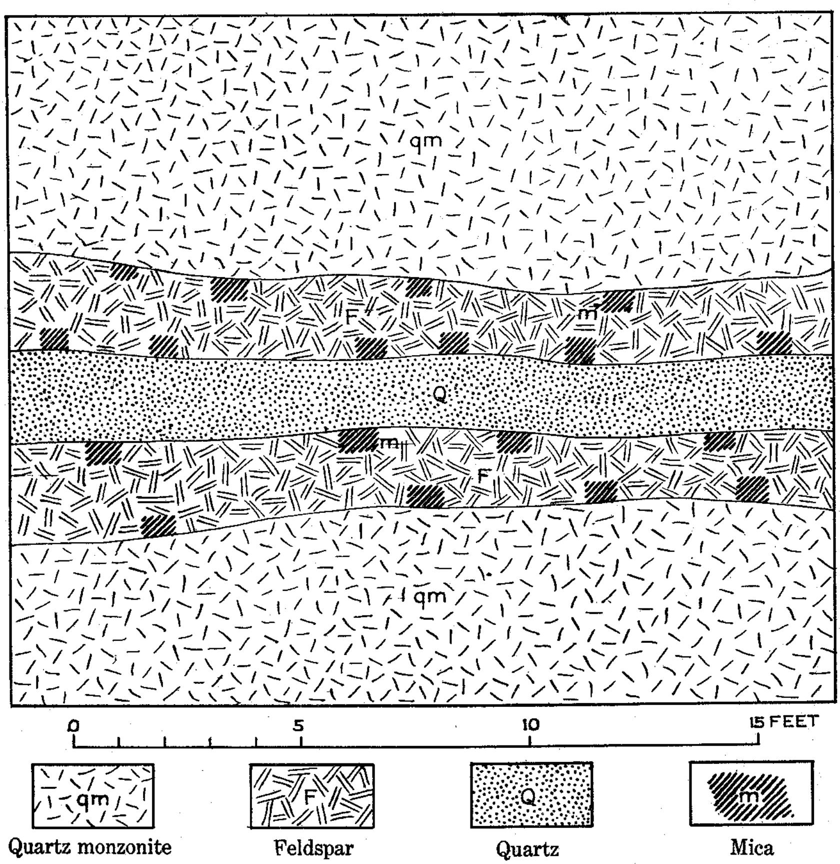


Figure 5.—Plan of the relations between the chief minerals of the pegmatite at the Pinchback mine, 3½ miles northeast of Amelia, Amelia County.

be seen in hand specimens. In some places there are inclusions of country rock in the pegmatite, generally near the contact. Some of these detached fragments of wall rock are unaltered, but, as a rule, they are partially absorbed by the pegmatite. Examples of this were seen at the Rutherford mine in the Amelia area, at the Ridgeway mine at Ridgeway, and at the Otter River prospects in the Moneta-Bells area. Pegmatitic soaking of the wall rock occurs, although not commonly. At the Irwin mine, in the Goochland area, all gradations are found from pure pegmatite through thoroughly soaked wall rock to unaffected gneiss. A narrow contact zone, commonly a few inches and rarely over a few feet wide, has been developed in many places. It consists of a granular mixture of quartz and muscovite, with tourmaline and garnet commonly present. Sillimanite was observed only at the Salter prospect in the Goochland area. It was found in both the pegmatite and the wall rock, and appears to be of contact origin. Graphite was found in gneiss in the Amelia area and in both gneiss and pegmatites in the Goochland area. It could not be determined whether the graphite in the gneiss was of contact origin. The wall rock is in places more schistose along the contacts, but in general, it is unaffected by the pegmatite.

Mineral composition.—The mineral composition of the pegmatites is commonly monotonously simple, being essentially microcline, quartz, and muscovite, with variable but minor quantities of tourmaline, garnet, beryl, and biotite. Local exceptions are as follows: The Rutherford mines (Fig. 6, Nos. 26 and 43) in the Amelia area contain the largest assemblage of minerals found in the State. More than 30 mineral species have been reported from the two dikes upon which these mines are located. They are albite (three varieties), microcline (two varieties), orthoclase, oligoclase, muscovite (three varieties), biotite, quartz (three varieties), garnet (three varieties), tourmaline, beryl, topaz, fluorite, zircon, ilmenite, columbite, allanite, fergusonite, microlite, manganotantalite, monazite, helvite, galena, stibnite, pyrite, cerussite, anglesite, hatchettolite, cryptolite, leverrierite, and pyrochlore.

The pegmatites in Goochland and Hanover counties contain rutile, ilmenite, zircon, graphite, and sillimanite, in addition to the typical minerals. In Pittsylvania County, pegmatites which contain the rare mineral hoegbomite are associated with emery deposits. The pegmatites in Rockbridge County contain cassiterite and associated minerals. (See Bulletin 15A of the Virginia Geological Survey.)

Allanite, tcheffkenite, sipylite, samarskite, zircon, and associated rare minerals characterize some of the pegmatites in Amherst County. Barite was found in some of the pegmatite deposits in Carroll County. The nelsonite dikes in Nelson and Amherst counties are regarded by some as pegmatites. They invariably contain apatite, commonly ilmenite, in many places rutile, and in some places magnetite and other minerals. All of the pegmatite deposits carry also variable amounts of secondary minerals, such as sericite, kaolinite, and other hydrous aluminum silicates.

About 50 mineral species have been reported from the pegmatites of Virginia. Feldspars, quartz, and muscovite constitute 90 to 95 per cent of the volume of the pegmatites. Feldspars comprise 50 to 60 per cent of the pegmatites, and include microcline chiefly and, to a less extent, albite. Oligoclase has been locally observed, but orthoclase has never been positively identified.

Microcline has the following theoretical composition: Silica (SiO_2), 64.7 per cent, alumina (Al_2O_3), 18.4 per cent, and potash (K_2O), 16.9 per cent, corresponding to the formula $KAlSi_3O_8$. In Virginia, as elsewhere, it is rarely free from albite. Five analyses of microcline from different parts of the State indicate that albite constitutes about 25 per cent of the feldspar, which is apparently not detrimental to its commercial use. The albite occurs as (1) intergrowths with microcline, (2) spindles, (3) lenticular bodies, and (4) subhedral crystals. The largest crystals are 0.5 mm. in diameter. Under the microscope, the albite is easily distinguished from microcline by the polysynthetic twinning, which shows alternate extinction. The origin of this perthitic intergrowth is discussed under the origin of the different textures in pegmatites.

Microcline is more abundant than orthoclase, although much of it may have been originally orthoclase. According to Schaller[26] the orthoclase has reverted to microcline.

Microcline occurs as granular consertal to graphic intergrowths, chiefly with quartz and, to a less extent, with muscovite. It is developed as irregular masses that range from microscopic size to several feet in diameter. The commercial feldspar masses average between 6 and 12 inches in diameter. The color is commonly white to light creamy-white. Other colors are salmon-pink, buff, gray-green, and bluish-green. A bluish-green color is characteristic of Amazon stone, a gem variety. The inclusions are quartz, which is most common, muscovite, garnet, tourmaline, and beryl. Much of the quartz forms micrographic textures, chiefly with orthoclase and microcline.

The chief alteration products are sericite, kaolinite, and other hydrous aluminum silicates. Feldspars become chalky-white when weathered, and in places are stained yellow and brown with limonite.

The commercial varieties of feldspars are best developed in the Moneta-Bells area. (See pp. 81-90.) Potential sources are found in the Altavista, Amelia, Axton, and Ridgeway areas.

The chemical composition of 5 samples of potash feldspar from the Piedmont province, Virginia, follows:

[26] Schaller, W. T., Mineral replacements in pegmatites: Am. Mineralogist, vol. 12, pp. 59-63, 1927.

TABLE 5.—*Analyses of potash feldspars in the Piedmont province of Virginia*

	1	2	3	4	5
SiO_2	64.12	53.67	53.12	60.94	63.13
Al_2O_3	16.84	29.72	29.74	21.44	18.67
Fe_2O_3	2.28	.57	2.92	.80	.26
CaO	.32	------	------	------	------
MgO	.26	1.49	1.54	1.25	.77
K_2O	13.34	10.44	9.52	12.07	11.23
Na_2O	1.88	2.35	2.59	1.80	3.51
H_2O	-----	.22	.16	.06	.11
	99.04	98.46	99.59	98.36	97.68

1. Rutherford mine, Amelia area. Analyst, C. C. Page, 1885.
2. Pinchback mine, Amelia area. Analyst, John H. Yoe, Virginia Geol. Survey, 1929.
3. Farmer prospect, Altavista area. Analyst, John H. Yoe, Virginia Geol. Survey, 1929.
4. Otter River prospect, Moneta-Bells area. Analyst, John H. Yoe, Virginia Geol. Survey, 1929.
5. Wheatly mine, Moneta-Bells area. Analyst, John H. Yoe, Virginia Geol. Survey, 1929.

Analyses 2 and 3 were made from partly weathered specimens, which probably accounts for the low silica and the high alumina content.

The plagioclase is albite, albite-oligoclase, and rarely oligoclase. Pure albite is rare. A careful study of the indices of refraction of the intergrowths shows a plagioclase on the border line of albite and oligoclase, as computed by Johannsen's[27] table of feldspars.

The plagioclase has three distinct modes of occurrence: (1) As perthitic intergrowths with potash feldspar, comprising 25 per cent of the mass, (2) as granular intergrowths with potash feldspar, quartz, and muscovite, and (3) as reticulated growths associated with rare minerals. In the third case nearly pure albite comprises the main part of the dike. This is the characteristic occurrence in the lower Rutherford mine (Fig. 6, No. 42).

Perthitic intergrowths are best developed in the pegmatite dikes of the Moneta-Bells area. The dikes in the Altavista area also contain them.

Granular intergrowths of plagioclase, commonly intermediate between albite and oligoclase, with other minerals, characterize many of the dikes in the Ridgeway area, and, to a less extent,

[27] Johannsen, Albert, Essentials for the microscopical determination of rock-forming minerals and rocks in thin sections, 2d ed., Chicago, 1928.

in the Moneta-Bells area. Some dikes in the Ridgeway area are composed largely of plagioclase feldspar. On the Jefferson property in the Amelia area, the dikes contain a considerable proportion of plagioclase.

Reticulated and platy growths are found only in the Rutherford mines in the Amelia area, where they are peculiar to the southern dike (Fig. 6, No. 42). The plagioclase is pure, or nearly pure, albite. Three distinct varieties occur. The first is composed of snow-white and nearly transparent masses of considerable size, many of which contain rare minerals which represent later crystallizations in the interstices. The second form is a pea-green platy albite. The first and second forms are known as cleavelandite. The third form is a pure white albite, with a blue sheen called chatoyant. As indicated by microscopic study of crushed fragments, the peculiar luster is caused by numerous minute gaseous inclusions. The refractive indices of the three varieties of albite, as determined from rock powders and index liquids, are as follows: $\alpha = 1.528$, $\beta = 1.532$, $\gamma = 1.539$.

Three analyses of albite from the Amelia area have been published:

TABLE 6.—*Analyses of albite from the Amelia area*

	1	2	3
SiO_2	68.94	67.06	68.22
Al_2O_3	19.35	21.72	19.06
Fe_2O_3	-----	-----	.15
CaO	-----	1.59	.40
K_2O	.43	.39	.20
Na_2O	11.67	10.01	11.47
H_2O	-----	-----	.69
MgO	-----	.03	-----
	100.39	100.80	100.19
Sp. gr.	2.605	2.618	------

1. Analyst, R. N. Musgrave, Chem. News, vol. 46, p. 204, 1882.
2. Analyst, Robert Robertson, The Virginias, vol. 6, p. 24, 1885.
3. Analyst, E. T. Allen, U. S. Geol. Survey Bull. 590, p. 300, 1915.

The purity of the analyzed albite is seen by comparing these analyses with the theoretical composition of albite which is 68.7 per cent silica, 19.5 per cent alumina, and 11.8 per cent soda, corresponding to the formula $NaAlSi_3O_8$. The specimen used for analysis No. 2 was evidently slightly weathered, as indicated by the silica being slightly less, the soda less, and the alumina more than the theoretical percentage.

Soda feldspar has never been used commercially in Virginia, although Singewald[28] states that it has been mined in Maryland. Deposits comparable to those in Maryland are not known in Virginia.

Quartz is invariably present in the pegmatites and ranges from 30 to 60 per cent of most deposits. It is almost the only mineral in a few deposits. It occurs as irregular grains and masses, some of which measure 2 feet across, intergrown with other minerals, and as crystals, some of which weigh 100 pounds. It forms a band in the middle of many of the dikes, the largest one observed being about 20 feet wide and 200 feet long. At this place the quartz is massive and pure. Veins of pure quartz 20 to 30 feet wide were also found. The quartz occurs also as graphic intergrowths, some being of microscopic size. The color is commonly light smoky-gray, although variations occur. Beautiful specimens of smoky quartz are common. Amethyst has been reported from some of the Amelia mines. Many of the specimens of quartz are clear and colorless, resembling ice. In the Moneta-Bells area the quartz frequently has a waxy translucent appearance resembling paraffin. Thin sections show numerous minute fractures. Inclusions are chiefly tourmaline (Pl. 7, A), but other minerals, as pyrite, also occur. In outcrops the quartz is commonly granulated and discolored with clay and hydrous iron oxides.

Muscovite is the most important constituent of the pegmatites from an economic viewpoint. It is the most irregular in quantity and in mode of occurrence of the major constituents. It is present in almost all deposits, occurring as blocks, and as irregular distributed flakes. The blocks have excellent cleavage, and some have hexagonal outlines. The largest masses, generally called books, because their shape and cleavage resemble a book, are along the contact of the feldspar and quartz, partly intergrown with each mineral and also along the contact of the pegmatite and the wall rock. Some of the books are large, one 3 by 6 by 6 feet being reported from the Pinchback mine in the Amelia area and another which weighs more than 700 pounds being reported from the Ridgeway mine in the Ridgeway area. Distinct orientation of the muscovite imparts a schistose appearance to some of the fine-grained dikes. The proportion of muscovite in a dike is difficult to determine. The largest amount of muscovite reported from a single mine was 200,000 pounds, but the amount of gangue involved is not known.

[28] Singewald, J. T., Jr., Notes on feldspar, quartz, chrome, and manganese in Maryland: Maryland Geol. Survey, vol. 12, pt. 2, pp. 91-194, 1928.

The size of the sheet that can be cut from a book depends upon the size, shape, and structure of the crystal. Sheets measuring 22 by 24 inches have been reported, although sheets 4 by 6 inches and 6 by 8 inches are considered to be the average size.

Muscovite in thin sheets is colorless and transparent, but thicker masses show various shades of yellow and brown, with smoky-amber predominant. Some specimens from the Axton area are light-green. Muscovite from the Chestnut Mountain area has peculiar designs and patterns due to deposition of hydrous manganese and iron from oxides on the cleavage surfaces. A pink muscovite and a light-green muscovite are found in the Rutherford deposits, usually in the interstices of cleavelandite. The crystals are rarely more than a centimeter in diameter.

Most of the muscovite shows peculiar structures, the chief one being the "A," or chicken breast structure. Tangle sheet, ruling, and other objectionable structures are found. These structures reduce greatly the size of sheet obtainable, and make some of the crystals fit only for scrap mica.

Inclusions are garnet, which has penetrated the cleavage sheets, feldspar, and quartz. Infiltrations of quartz and feldspar along cleavage surfaces were observed at several places. Seepage of foreign material, as clay and iron oxide, along cleavage planes is common in deposits near the surface.

Tourmaline is the most common accessory mineral. It occurs as (1) radiating masses in massive quartz, which in places is interstitial, and (2) hairlike inclusions in some of the smoky quartz crystals in the Amelia area. The tourmaline is jet-black and is in columnar, three-sided striated crystals. Some of the larger crystals are several feet long and 6 inches in diameter.

Garnet of a wine-red to brownish-red color is the next most abundant accessory mineral. It is developed along the contact zones, in the pegmatite, and in the wall rock. It occurs also as isolated grains in the feldspars, and, to a less extent, in quartz and muscovite. In some deposits it is found along the cleavage planes of the feldspar, generally albite, indicating later crystallization. The crystals are commonly only a few millimeters in diameter, although some have diameters of several centimeters. The common variety is almandite, although spessartite of gem quality has been reported from the Rutherford mines. Inclusions are chiefly biotite, with some feldspar and quartz. The garnet weathers to chlorite, limonite, and clay.

Biotite is only sparingly present, being associated as a rule with plagioclase. In the Moneta-Bells area it was observed along joint planes, chiefly in quartz and to some extent in feldspar. Some of the biotite may have been derived from the wall rock through absorption.

Minerals of local occurrence only are discussed under particular localities.

Weathering.—Most of the pegmatites are extensively weathered, many to a depth of 30 feet. The weathered material, admixed with clay and stained with limonite, is scarcely distinguishable from the soil of the bordering rocks. In many places pegmatite dikes can be traced only by residual quartz and muscovite and, in some places, they can not be observed on the surface.

The major constituents show differential weathering, the feldspars being most attacked, quartz and muscovite least. All gradations from slightly altered to completely decomposed feldspars are observable. Of the minor constituents, garnet readily alters to limonite, biotite breaks down easily to limonite and kaolinite, and tourmaline is very resistant to decay. Alteration of feldspars to sericite is observed in numerous thin sections. Some epidote and chlorite are present.

The resulting soil is kaolin containing comminuted quartz grains and relatively unaltered flakes of muscovite. Attempts have been made to use this material, but generally the deposits are too small and very impure.

Structure and metamorphism.—The pegmatite dikes are essentially massive and show but slight evidence of anamorphism. Joints are prominently developed, at some places the joint planes being only a few feet apart. Three systems of joints are common, the strike and dip of which vary in the different areas.

Crushing has not occurred, except on a small scale. At the Gib Smith mine in the Altavista area, the pegmatite contains "eyes" of feldspar, 6 inches in diameter, surrounded by a granulated mixture of quartz and feldspar.

Thin sections show slight anamorphic effects. Slicing in the feldspar is shown by the displacement of twinning bands and cleavage lines. The cross-hatch pattern in some of the microcline is distorted and confused. Some of the quartz and feldspar show granulation. Undulatory extinction is developed in some of the quartz, while warping is observed in both feldspar and muscovite. On the other hand, some of the most fragile textures, as the cellular and reticulated texture in albite, have been perfectly preserved.

Origin and paragenesis.—The chief difference in the mode of occurrence of the pegmatites is that in the Amelia-Goochland district the dikes cut across the banding or schistosity of the enclosing rock, whereas in the Martinsville-Lynchburg district they lie along the well-defined foliae of the wall rock. The reason for this difference appears to be that in the Amelia-Goochland district the prevailing rock types are rather massive gneisses with well-defined joint planes along which the pegmatitic material readily penetrated, whereas in the Martinsville-Lynchburg district the prevailing rock types are schists, in which the pegmatitic material entered most readily along the well-defined foliae.

In the Ridgeway area many of the pegmatite dikes occur along the contact between hornblende metagabbro and mica schist, because the intrusion of the metagabbro developed planes of weakness along its contacts.

The lenticular form assumed by many of the pegmatites may be explained in two ways: (1) The pegmatitic material was forced in from below with sufficient pressure to push the walls apart, or (2) the pressure was exerted by the crystallization and growth of the minerals in the pegmatite. The chief argument against the first hypothesis, according to Taber,[29] is the symmetrical and, in places, almost spherical shape of the lenses. If the expansion of the openings had been due to pressure exerted by the material forced in from below, the pressure at all points would probably have been about the same. Under these conditions flat lenticular or tabular bodies would have been formed. According to the second hypothesis the solutions entered along narrow openings; crystallization began at favorable points and, as the crystals grew, the walls were pushed apart. At first a growing lens may have consisted of a single crystal, but, as the foliae of the enclosing rock began to separate, other crystals would form in the space thus created around the original crystal.

The greatest textural difference between pegmatites and other igneous rocks is the relatively greater size of the crystals in the pegmatites. The crystals in other igneous rocks are rarely more than an inch in diameter and are generally much less, whereas many crystals in pegmatites are several feet in diameter. A single crystal of spodumene in the pegmatite from the Etta mine at Keystone, South Dakota, was 3 feet by 6 feet by 42 feet. Two rather distinct hypotheses have been advanced to account for these large crystals: (1) They have resulted from slowly cooled aqueo-igneous magma, or (2) they have been formed by the slow replacement of the original materials in the dike by hydrothermal solutions from the parent magma.

[29] Taber, Stephen, Geology of the gold belt in the James River basin, Virginia: Virginia Geol. Survey Bull. 7, pp. 225-230, 1913.

The term aqueo-igneous was introduced by Crosby and Fuller,[30] who stated that the pegmatite magma was the extreme form of the granite magma. Kemp[31] regarded pegmatites as differentiates in which there was a concentration of gases from the parent magma. He thought this fluidity, aided by convection currents, was favorable to the growth of large crystals. The presence of certain mineralizers, as water, hydroxyl, fluorine, and boron was thought by some to increase the fluidity of the magma. Pirsson[32] stated that mineralizers, together with water under pressure and at high temperature, kept the silicates in solution and allowed large crystals to form.

Barus[33] demonstrated experimentally that the fusion point of a rock could be lowered by the addition of water. He found that obsidian in the presence of water fused at 1,250°C. and pumice without water fused at 1,650°C. Wright and Larsen,[34] as a result of their investigation, reached the conclusion that coarse-grained siliceous pegmatites were formed below 575°C., whereas graphic and the finer grained pegmatites and granites crystallized above 575°C.

Many features of the pegmatites in Virginia suggest an aqueo-igneous origin. One of the strongest evidences is apophyses, or stringers, only a few inches thick, from pegmatite dikes 20 to 50 feet wide, penetrating the wall rock along the foliae. This suggests a very attentuated magma. The lack of pronounced metamorphism along the contacts of even the largest dikes suggests that the pegmatites must have crystallized at low temperatures. The presence of mineralizers in the pegmatitic magma is attested by the occurrence of such minerals as tourmaline, apatite, beryl, fluorite, and topaz in the pegmatites.

Hess, Schaller, Larsen, and others present evidences and arguments which explain the large crystals as resulting from replacement. Hess[35] cited numerous examples to support this view. He stated further that, accompanying and following the intrusion of the pegmatite, a great quantity of fluid was squeezed out and flowed from the parent magma as it froze. This fluid was a part of the molten magma and may be conceived to have held pegmatitic material in solution and to have carried other elements. This fluid follows the path taken by the pegmatitic material and

[30] Crosby, W. O. and Fuller, M. L., Origin of pegmatite: Am. Geologist, vol. 19, pp. 147-180, 1897.

[31] Kemp, J. F., The pegmatites: Econ. Geology, vol. 19, pp. 697-723, 1924.

[32] Pirsson, L. V., Rocks and rock minerals, New York, pp. 175-178, 1908.

[33] Barus, Carl, Hot water and soft glass in their thermodynamic relations: Am. Jour. Sci., 4th ser., vol. 9, pp. 161-175, 1900.

[34] Wright, F. E., and Larsen, E. S., Quartz as a geologic thermometer: Am. Jour. Sci., 4th ser., vol. 27, pp. 446-447, 1909.

[35] Hess, F. L., The natural history of the pegmatites: Eng. and Min. Jour.-Press, vol. 120, pp. 296-297, 1925.

flows through the hottest part of the pegmatite, dissolving minerals soluble at that temperature and carrying them to a cooler place for redeposition. Quartz apparently is held in solution longest and hence is carried farthest, forming quartz veins and masses. This may explain the absence of any considerable amount of hydrothermal alteration of the wall rock; also the gradation of pegmatite dikes into quartz veins. Hess thinks also that the huge crystals and the great masses of single minerals can be explained in only one way, namely, by the long-continued flow of these replacing solutions.

Schaller[36] believes that the minerals found in pegmatites did not crystallize from the magma but resulted from the replacement, probably by hydrothermal alteration, of a preexisting rock. He suggested also that the order of events was: (1) Original orthoclase reverted to microcline; (2) this microcline and, to some extent, quartz were replaced by albite, and (3) this process was accompanied or followed by the introduction of other minerals.

There are many evidences of replacement in the Virginia pegmatites; for example, cleavelandite at the Rutherford mines occurs as thin blades penetrating microcline and quartz. In some places bluish-green microcline grades into pea-green albite. Other evidences suggesting that the pegmatites have resulted from a replacement process acting through a long period of time are their massive character and fragile texture, whereas the parent rock, as the Leatherwood granite, wherever seen, is metamorphosed.

Perthitic intergrowths, according to Anderson,[37] may have been produced largely through three processes: (1) Simultaneous crystallization, (2) exsolution, and (3) replacement. This texture is explained by Alling[38] as resulting from exsolution, that is, the unmixing of two compounds in solid solution. He states that the term does not mean unmixing, but that it is really the opposite of "passing into solution." He states further that the examination of a large number of perthitic feldspars reveals the fact that most of them are not of eutectic origin but have assumed their present form through the agency of exsolution. However, perthitic feldspars found on the margins of the grains and in interstices represent eutectic mixtures.

Schaller[39] maintains that perthitic texture results from replacement, the proportions of albite and microcline varying from very

[36] Schaller, W. T., The genesis of lithium pegmatites: Am. Jour. Sci., 5th ser., vol. 10, pp. 269-279, 1925.
[37] Anderson, Olaf, The genesis of some types of feldspar from granite pegmatites: (Review), Am. Mineralogist, vol. 14, pp. 41-42, 1929.
[38] Alling, H. L., The mineralography of the feldspars; Part I: Jour. Geology, vol. 29, pp. 222-223, 1921.
[39] Op. cit., pp. 274-275.

little albite to 100 per cent albite. Barth[40] cited some instances in which the crystallizing potash feldspar had hemmed in tiny deposits of oligoclase.[41]

Graphic intergrowths have been explained by Vogt[42] as a eutectic in which the ratio of 72.5 per cent orthoclase to 27.5 per cent quartz would be constant. On the other hand, Schaller[43] is of the opinion that graphic intergrowths represent the replacement of an earlier rock. The writer thinks that they result from the simultaneous crystallization of quartz and microcline, but not necessarily in eutectic proportions. No clear evidences of replacement were observed in the graphic intergrowths.

Reticulated texture as explained by Schaller[44] results from the variable orientation of platy crystals of cleavelandite, and albite that has replaced earlier minerals.

The schistose texture exhibited by some of the pegmatite dikes in the Ridgeway area results from the parallel arrangement of muscovite flakes. It is primary, for none of the minerals associated with muscovite show anamorphism sufficient to have produced schistosity.

Banded structure has been explained by Sterrett[45] as resulting from aqueous deposition. It is in part, if not wholly, of vein origin. In many of the pegmatites of Virginia, the quartz band persists beyond the pegmatite dike as a quartz vein or mass. It appears to have formed by replacement as explained by Hess.[46]

The pegmatites of Virginia generally have a simple mineral composition, similar to that of an acid granite, with a relatively larger proportion of high-temperature minerals, as tourmaline and beryl, and rare-earth minerals, as columbite, microlite, and allanite. They appear to represent in Virginia, as elsewhere, the final fractions of the crystallizing magma, in which there was a greater quantity of the more uncommon elements. The larger proportion of microcline in some of the pegmatites, as in the Amelia area, suggests a parent magma relatively high in potassium, whereas the larger proportion of albite or albite-oligoclase in the pegmaties of the Ridgeway area suggests a parent magma relatively higher in sodium. The presence of cleavelandite and rare-earth minerals at the Rutherford mines seems best explained as repre-

[40] Barth, T. F. W., Mineralogy of the Adirondack feldspars: Am. Mineralogist, vol. 15, pp. 129-143, 1930.

[41] The writer is making a special study of the feldspars of Virginia, the results of which may be published in the near future.

[42] Vogt, J. H. L., Die Silikateschmelzlosungen, pp. 117-135, 1903.

[43] Op. cit., p. 276.

[44] Schaller, W. T., Mineral replacements in pegmatites: Am. Mineralogist, vol. 12, pp. 59-63, 1927.

[45] Sterrett, D. B., Mica deposits of western North Carolina: U. S. Geol. Survey Bull. 315, p. 419, 1907.

[46] Op. cit.

senting a late stage in replacement. The dike at the Patterson mine, which is between the Rutherford mines and the dikes high in microcline in the northeastern part of the Amelia area, contains much albite and albite oligoclase, but very few accessory minerals. It seems to represent an intermediate stage in replacement.

The paragenesis of the minerals in the pegmatites of Virginia is similar to that of the minerals in pegmatites described from other regions. Landes[47] recognized five stages in the mineralization of the pegmatites of Maine: (1) A mass crystallization stage, in which the accessory minerals crystallized first, then feldspar and quartz; (2) a high-temperature, hydrothermal stage; (3) a stage in which rare lithium-manganese phosphate minerals appeared; (4) a final hydrothermal stage; and (5) a stage of mineral alteration in which such minerals as kaolinite and other secondary minerals were formed by the action of ground water.

The paragenesis of the minerals in the pegmatites of Virginia appears to be as follows: Some of the accessory minerals, as tourmaline, beryl, apatite, garnet, and probably a few sulphides, were the first to crystallize. Orthoclase, which later reverted to microcline, was formed next. (See Pl. 8, A.) Quartz crystallized at various stages; some of it formed simultaneously with microcline, but some of it was later, for it occurs lining vugs, as thin bands between sheets of mica, and as a part of the narrow zone along the contacts of the pegmatites. Albite was next, replacing microcline and, to a less extent, quartz, by a process known as albitization. The stage at which muscovite crystallized is not so easily ascertained, but some of it at least was introduced at a very early stage, for it occurs as inclusions in microcline, quartz, and beryl. It is found also in large crystals along the contact of quartz and microcline, and along the contact of the pegmatite and the wall rock. The muscovite was probably formed by solutions entering along planes of weakness formed at these contacts, replacing or partially replacing minerals already formed. It occurs also (1) as parallel growths with tourmaline, (2) intergrown with quartz in relatively finer grained bodies along the contact of pegmatite with the wall rock, and (3) as parallel growths with microcline and with albite. A later hydrothermal stage is probably indicated by the crystallization of quartz, tourmaline, muscovite, and garnet along the pegmatite contacts, and of garnet, chiefly along the cleavage planes of feldspars in the pegmatites. The pegmatites at the Rutherford mines apparently underwent a more extreme

[47] Landes, K. K., The paragenesis of the granite pegmatites of central Maine: Am. Mineralogist, vol. 10, pp. 355-411, 1925.

form of replacement. The original minerals were more thoroughly albitized and many accessory minerals were formed after this more extreme albitization, for they occur in the interstices of the reticulated cleavelandite. A still later stage is represented at the Rutherford mines by fine-grained hydrous micas, as leverrierite and sericite, and calcite. Calcite was probably the last mineral to form, for it occurs as massive or finely crystallized bodies in the interstices of cleavelandite and has assumed the form of the interstices. It occurs also as schistose or platy masses, enveloping both microcline and albite, and as crystals encrusting other minerals, chiefly albite. A small pegmatite dike, on the Charlottesville-Lynchburg road about 3 miles southwest of Charlottesville, passes into a narrow quartz vein about 3 inches wide. On either side of this vein there is a narrow band of cleavable calcite, one-half to one inch wide.

The ultimate source of the pegmatitic material has been much debated. The two possible sources are (1) from the enclosing rock and (2) from intrusions. In the first case, the pegmatites may have been precipitated from an aqueous solution of material leached out of the country rock. Or they may have been produced by recrystallization of material that had become segregated during anamorphism. Such evidence as mode of occurrence, texture, and mineral composition points toward an igneous origin of the pegmatites, in which they represent the end phase of crystallization of the magma.

In a discussion of the pegmatites of western North Carolina, Sterrett[48] states that, where much feldspar is present, the solutions were of magmatic origin and a granite intrusion is generally near. Field study of the pegmatites of Virginia was not extensive enough to establish the parent mass from which all the pegmatites were derived. It appears, however, that they represent residual portions of a granitic magma, but not the same magma in the several areas, as shown by the differences in the analyses of the Petersburg and Leatherwood granites. The potassium-rich pegmatites have been derived from a granite magma relatively richer in potassium, whereas the sodium-rich pegmatites came from a granitic magma relatively richer in sodium.

The deposits of the Amelia-Goochland district resemble, in composition and texture, those occurring in, and derived from, the granites in the eastern part of the Piedmont province, in which the potash feldspars exceed the soda feldspars. The pegmatites in the Ridgeway area appear to have come from the same magma

[48] Sterrett, D. B., Mica deposits of western North Carolina: U. S. Geol. Survey Bull. 315, pp. 400-422, 1907.

A. Hornblende metagabbro showing hornblende (dark gray) and feldspar (white), from the Amelia area. X 10.

B. Hornblende metagabbro showing alteration of feldspar to epidote (center), from the Amelia area. X 45.

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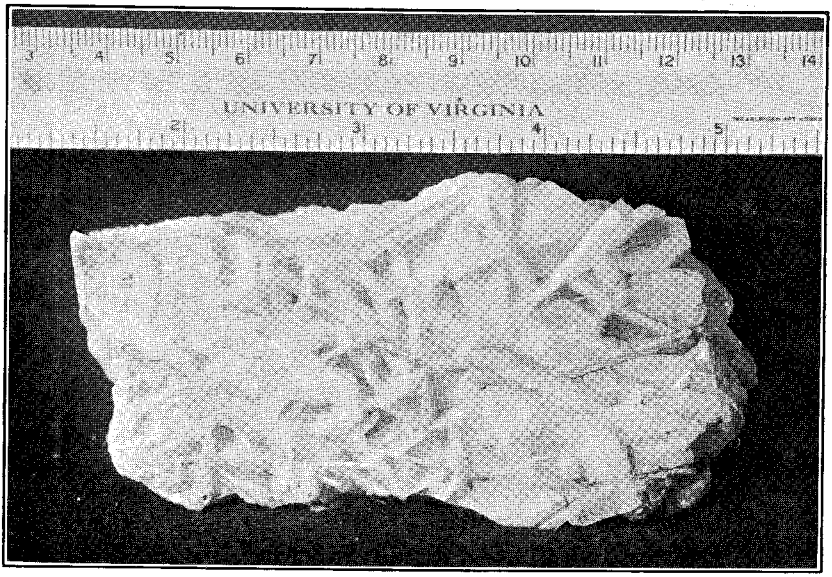
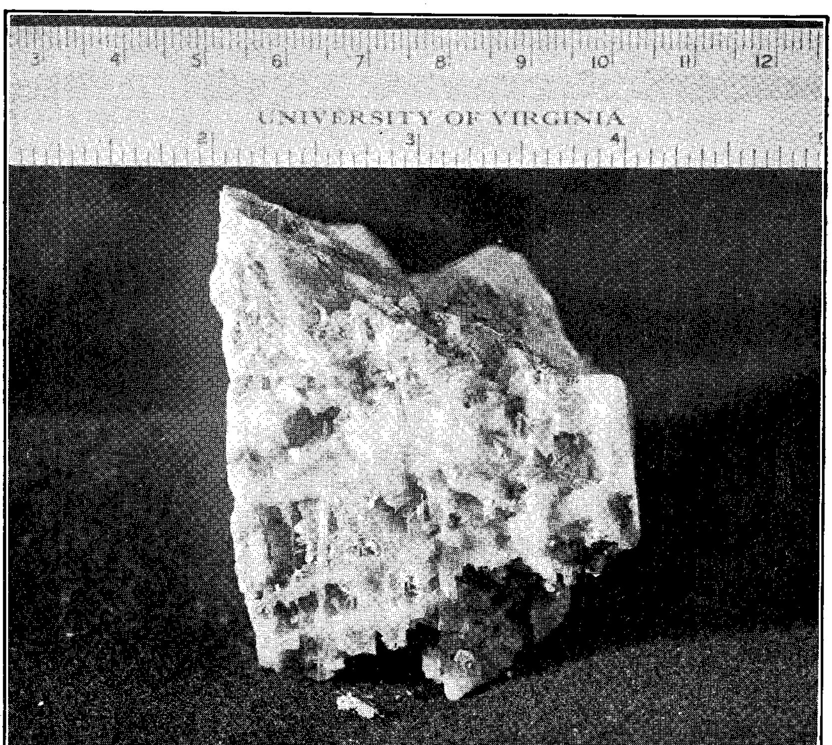
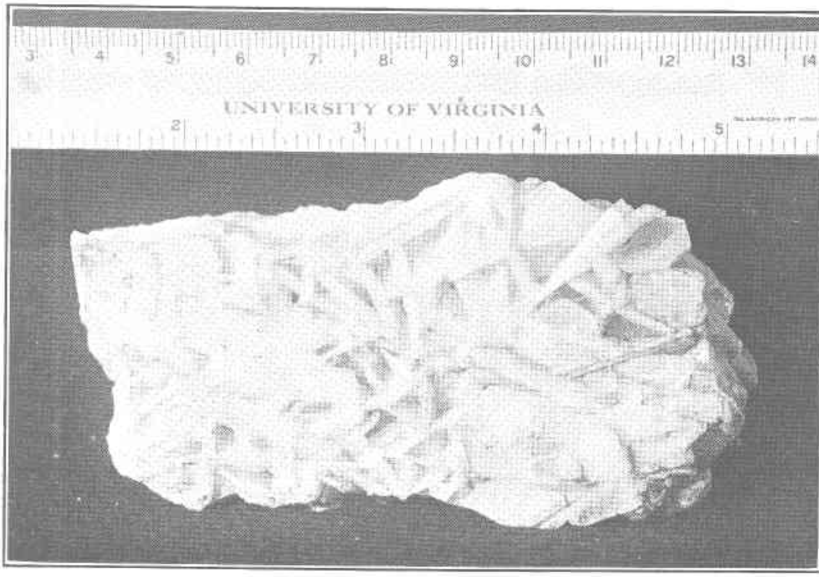
B. Hornblende metagabbro showing alteration of feldspar to epidote (center), from the Amelia area. X 45.



A. White reticulated feldspar (cleavelandite), Rutherford mines, 1¼ miles north of Amelia, Amelia County.



B. Albite showing cellular texture with muscovite in the cells, Bland mine, 2½ miles northeast of Amelia, Amelia County.



A. White reticulated feldspar (cleavelandite), Rutherford mines, 1¼ miles north of Amelia, Amelia County.

B. Albite showing cellular texture with muscovite in the cells, Bland mine, 2½ miles northeast of Amelia, Amelia County.

as the Leatherwood granite. A chemical analysis of this granite shows a predominance of sodium over potassium, and the Ridgeway pegmatites are more sodic than is common for pegmatites in other areas. The parent magma of the pegmatites in the Axton area and in the area containing the emery deposits seems to have been also that of the Leatherwood granite. The source in the other areas could not be established. Many of the pegmatites may represent injected zones of the roofs of granite batholiths, as suggested by Bastin,[49] with the parent mass not yet exposed.

Age.—The age of the pegmatites can not be determined closely because of the lack of direct evidence. As the pegmatites are essentially massive and show very little metamorphism, it seems evident that they were intruded after times of extreme regional metamorphism. Moreover, they intrude all rock types in the region except the Triassic diabase. On the other hand, boulders of pegmatitic material in Triassic conglomerate near Cascade, Pittsylvania County, show that some of the pegmatite dikes are older than the Upper Triassic sediments. In discussing the age of the gold-quartz veins in the northeastern Piedmont of Virginia, Lonsdale[50] concluded that they are younger than Ordovician. He stated also that some of the quartz veins are traceable into pegmatites, which indicates that some of the pegmatites, at least, are younger than Ordovician. It is probable that the pegmatites in the several areas are not all of the same age.

[49] Bastin, E. S., Origin of the pegmatites of Maine: Jour. Geology, vol. 18, p. 297, 1910.

[50] Lonsdale, J. T., Geology of the gold-pyrite belt of the northeastern Piedmont, Virginia: Virginia Geol. Survey Bull. 30, pp. 100-101, 1927.

ECONOMIC GEOLOGY OF INDIVIDUAL AREAS

GENERAL STATEMENT

A description of the several areas, including the characteristics peculiar to each area, is given in this section. The material of a general nature that has been discussed under the general description of the pegmatite deposits is omitted, unless its inclusion is necessary for a clear understanding. For each area the following topics are treated: Location, topography and drainage, rock types, pegmatites, and mines and prospects. The areas discussed in order are: Amelia, Goochland, Ridgeway, Axton, Altavista, Moneta-Bells, Chestnut Mountain, and miscellaneous areas.

AMELIA AREA

LOCATION AND ACCESSIBILITY

The Amelia area is shown on the index map (Fig. 1) and the geologic maps (Pl. 1 and Fig. 6). This area is named from Amelia Court House in the south-central part. The mapped area is rectangular in shape and comprises about 300 square miles, with its longest dimension of 25 miles extending N.30°E. It is almost wholly in Amelia and Powhatan counties, with small parts in Nottoway County on the southeast and in Chesterfield County on the east. The Richmond-Danville line of the Southern Railway crosses the eastern part of the area from Moseley Junction to Jetersville. Two macadam highways cross the area, one of which roughly parallels the railway. The other crosses the northern part of the area from east to west through Powhatan Court House. Many other improved roads are found in this area.

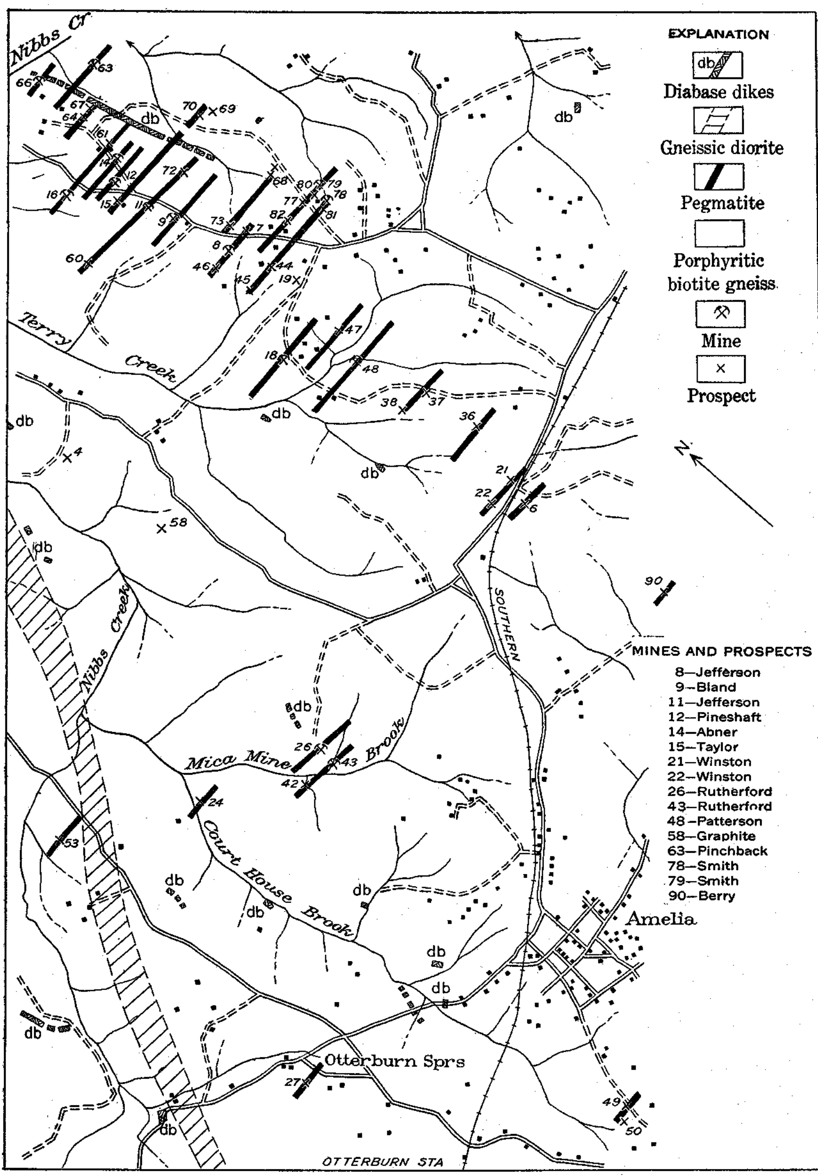
TOPOGRAPHY AND DRAINAGE

The Amelia area is part of the eastern Piedmont province. It has no outstanding elevations. The range in elevation is from less than 200 feet along Appomattox River to almost 400 feet in the vicinity of Amelia, with an average of about 300 feet for the entire area.

Appomattox River and its tributaries drain the area, in general toward the east.

ROCK TYPES

The prevailing rock type in this area is quartz monzonite gneiss which has been described in detail. (See pp. 20-22.) It is intruded by dikes of hornblende metagabbro, diabase, and pegmatite.



GEOLOGIC MAP OF THE AMELIA AREA, AMELIA COUNTY, VA.

0 ¼ ½ 1 Mile

Figure 6.

The hornblende metagabbro occurs as a dike in the central part of this area. This dike is 5 miles long and 200 feet wide. It strikes N.20°E. and dips 45°-50°NW. It consists essentially of hornblende and andesine, with minor amounts of quartz, epidote, garnet, magnetite, ilmenite, and titanite. (Pl. 9, A and B.)

Diabase dikes are numerous in all parts of the area. They average 10 feet wide, strike N. 10°-40°W., and are almost vertical.

PEGMATITES

General statement.—The pegmatites of the Amelia area have received more than usual attention, because of the large amount of mica and the rare and unusual minerals they have yielded. The mica has come chiefly from a narrow belt 1 mile wide and 2½ miles long. The unusual assemblage of minerals is limited entirely to the two dikes on which the Rutherford mines are located.

The main producing belt extends from prospect[51] No. 6 on the Southern Railway, 1 mile northeast of Amelia, north to prospect No. 66 on the Pinchback property. (See Fig. 6.) In this small area there are 21 producing dikes and about 40 mines and prospects. The dikes are about one-tenth of a mile apart. This is probably the most highly pegmatized area in the State.

Beyond this narrow belt the main deposits include the famous Rutherford deposits 1 mile north of Amelia, the dike near Jetersville on which the Schlegal mine is located, and the deposit revealed by the Lawrence mine on Appomattox River, 6 miles from Amelia. The other deposits are small and have been prospected in the hope of finding a productive area comparable to that near Amelia.

Occurrence.—The pegmatites in this area occur chiefly as dikes, but many are lenticular in habit. Lenses and lit par lit structures are common. The lit par lit structure represents, in many places, apophyses from the main dike which have penetrated along the schistosity of the enclosing rocks. Otherwise the dikes are in joints, which are at angles of 50° to 75° with the strike of the foliation of the enclosing rocks. The dikes near Amelia generally strike east, at right angles to the trend of the most productive belt. Variations from the east strike were noted for many of the smaller dikes in other parts of the area, but extensive weathering made the determinations very uncertain.

The width of the dikes is variable, ranging from 5 to 50 feet for the productive dikes, with an average of about 15 feet. The

[51] The numbers used to indicate prospects and mines are those given for reference purposes on the geologic maps of the several areas (Pls. 1-4 and Figs. 6 and 10).

average width of the dikes in the narrow belt from prospect No. 6 to prospect No. 66 (Fig. 6) is about 25 feet.

Pinches and swells commonly occur along both the strike and dip of the dikes. Pinches between mines located on the same dike are common, and many dikes disappear at a depth of 30 feet. Some dikes, however, have been worked to a depth of 100 to 150 feet. Most of the dikes have been traced along the strike for one-fourth to half a mile.

Texture.—The prevailing texture is coarsely granular, with the individual minerals averaging 6 inches in diameter. The largest minerals are found in this area, especially in the vicinity of Amelia. One crystal of mica measured 3 by 6 by 6 feet. A crystal of feldspar 1 by 2 by 3 feet was found. Crystals of beryl and tourmaline are several feet long and 6 to 12 inches in diameter. Masses of quartz crystals weighing 100 pounds were found. Other textures are shown as follows: (1) Banding in the Pinchback mine (Fig. 6, No. 63), (2) cellular texture in the Bland mine (Fig. 6, No. 9), (3) reticulated forms in the Rutherford mines (Fig. 6, Nos. 26 and 43), and (4) miarolitic cavities in the Schlegal (Pl. 1, No. 97) and Rutherford mines (Pl. 1, Nos. 26 and 43). Graphic textures occur in many of the smaller dikes, and in dikes in the hornblende metagabbro. Perthitic textures are found here in the potash feldspars but not as commonly as in the feldspars in the Moneta-Bells area. Schistose structures were not found in the Amelia area.

Mineral composition.—Except in the Rutherford and Morefield mines, the pegmatites in this area are of simple composition, being composed chiefly of feldspar (microcline and albite), quartz, and muscovite, with minor amounts of tourmaline and garnet. Biotite was found in one or two places. Graphite occurs in the enclosing gneiss but was not found in the pegmatites.

The dominant feldspar is microcline, which is especially abundant in the northern part of the chief producing area. The green variety, Amazon stone, is found in mine No. 26 of the Rutherford area. Microcline is also most abundant in the dikes on the Smith property (Fig. 6, Nos. 78, 79, and 80) and the Morefield mine. Albite and albite-oligoclase compose a large part of the deposit in the Rutherford mine (Fig. 6, No. 43) and are found also in the Bland mine (Fig. 6, No. 9) and the Patterson mine (Fig. 6, No. 48).

Many of the dikes on the Jefferson property (Fig. 6, Nos. 8 and 11) and the Smith property (Fig. 6, Nos. 78, 79, and 80), grade into quartz veins, some of which are 15 to 30 feet wide. In all of the deposits, 30 to 50 per cent of the mass consists of quartz. Its occurrence as a band near the middle of the dike in the Pinchback mine has been noted. The smoky variety, cairngorm, was observed at several places.

Muscovite, the most important economic mineral, is found in all of the deposits but is especially abundant in the dikes between prospect No. 6 and prospect No. 66. (See Fig. 6.) It occurs as books, some being of large size. The largest sheets, 22 by 24 inches, were cut from deposits in this area. The prevailing color is dark-amber. Some of the mines are reported to have produced 200,000 pounds, of which 15,000 pounds was sheet mica.

Tourmaline and garnet are found near the contact, both in the pegmatite and in the enclosing rock. Tourmaline is found also as inclusions in quartz, that vary from those hairlike in form up to those several feet long. Garnet is generally wine-red almandite, some of which is 1 centimeter in diameter. The variety topazolite, in places of gem quality, has been reported from the Rutherford mines.

The rare and unusual minerals, some of gem quality, found here, are of considerable interest. Most of them have come from the Rutherford mines. In addition to Amazon stone, already described, a gem variety of garnet has been reported. It is a reddish-brown spessartite. The largest specimen found measured 3 inches in diameter.[52]

Microlite is the most abundant of the rare minerals. Fontaine[53] reported it as occurring in masses, some of which weighed 18 pounds. Some of the largest crystals measured almost 2 inches in diameter. The microlite is pale-yellow to brown. Small octahedral crystals of this mineral, occurring in the interstices of the reticulated platy albite, may still be obtained on the dumps. Columbite has been noted by Fontaine,[54] who described it as an aggregate of friable and easily broken crystals. Some of the crystals measured 11 by 11.5 by 12 centimeters. Manganotantalite occurs as reddish-brown to black bladelike crystals. Specimens of this mineral are still obtainable. Allanite, a rare-earth epidote, was reported by Fontaine as occurring in thin bladed crystals embedded in the other minerals. Fergusonite is commonly associated with it. Helvite occurs similar to allanite. Monazite resembles microlite, in appearance and occurrence. Apatite has been reported from these mines as translucent, white crystals tinged with violet. The mineral was very fragile and phosphoresced with a yellow light when heated. Kunz[55] described fluorite as follows: "In a dark room

[52] A gem cut from this mineral has been illustrated in "Gems and precious stones of North America," by G. F. Kunz.

[53] Fontaine, W. M., Notes on the occurrence of certain minerals in Amelia County, Virginia: Am. Jour. Sci., 3d ser., vol. 25, p. 333, 1883.

[54] Idem.

[55] Kunz, G. F., Chlorophane from Amelia County, Virginia: Am. Jour. Sci., 3d ser., vol. 28, p. 235, 1884.

at a temperature of about 80° F. the Amelia County mineral shows a white, luminous light, which by the warmth of the hand is intensified. When placed in water it becomes green, and on a heated plate it becomes intense green. Most of the material is more or less flawed so as to render it very friable to the touch; this variety seems to phosphoresce at even a lower temperature than the compact form, and is either a light green or a yellowish green." Small purple to blue crystals are still obtainable. Galena, stibnite, pyrite, and the sulphate and carbonate of lead were reported by earlier writers but have not been reported in recent years.

Beryl, of a bluish-green to dingy yellow color, has been reported as crystals 3 to 4 feet long and 18 inches in diameter. Smaller and less perfect specimens are still obtainable. Beryl has recently been discovered in the Morefield mine near Winterham, Amelia County. It is white to green in color, and one of the largest crystals is reported to have weighed 125 pounds. Topaz was observed by the writer in colorless grains, 1 millimeter in diameter, intergrown with muscovite and pink microcline. Ilmenite has never been reported from these mines, although a specimen which was said to have been obtained here was presented to Dr. T. L. Watson. Zircon was reported from these mines by Watson,[56] but no analyses were made. Pink and pale-green muscovite occurring as thin bladelike bodies in the interstices of albite were noted by the writer. Calcite was noted by the writer as an amber-colored filling in the interstices of the crystalline masses of bladed pea-green cleavelandite, and as cleavable, almost schistose masses with both cleavelandite and Amazon stone. A few encrusting crystals were noted.

Leverrierite, sericite, and other hydrous micaceous minerals are common as fine-grained scaly masses partly filling interstices or coating the white reticulated albite.

PRINCIPAL MINES AND PROSPECTS

General features.—The deposits of the Amelia area have been worked almost exclusively for muscovite. Feldspar, quartz, gems, and rare minerals have been produced from time to time as a byproduct of mica mining. Operations, beginning with the opening of the Bland mine (Fig. 6, No. 9) in 1873, were vigorously pursued until 1883, then intermittently until the beginning of the World War. During the World War, and for a few years later, many new mines were opened and old ones reworked. From 1920 until 1930, there has been slight activity. Future production will be

[56] Watson, T. L., Zircon-bearing pegmatites in Virginia: Am. Inst. Min. Eng. Trans., vol. 55, pp. 936-942, 1917.

through working the old mines, many of which were abandoned at water level, and through further exploitation of the dikes on which the old mines are located.

This area contains approximately 100 mines and prospects, half of which are in a belt 2½ miles long and 1 mile wide, extending from a point on the Southern Railway 2 miles northeast of Amelia, north to Nibbs Creek. (See Fig. 6.)

Pinchback property.—This property is on the north end of the main producing belt, 3½ miles northeast of Amelia. A dozen or more openings have been made on this place, three of which (Fig. 6, Nos. 12, 14, and 63) were productive.

Mine 63 was worked for 40 years. In 1922 it had been operated to a depth of 75 feet. No work has been done since then. The opening is 60 feet wide and 280 feet long. The exposed dike, which is 50 feet wide, strikes N.85°E. and is vertical. It is composed of a band of quartz 15 feet wide, flanked on either side by feldspar, chiefly microcline. Some of the largest books of mica, 3 by 6 by 6 feet, were obtained here.

Large quantities of mica, feldspar, and quartz are still available. An analysis of the feldspar is given on page 38. A crystal of manganotantalite, several inches in diameter, was found in a field on the strike of this dike. Mine 12 is similar to Mine 63 (Fig. 6), but the dike is not more than 10 feet wide.

Mine 14 (Fig. 6) is one-third of a mile south of Mine 63. It has been worked by an open cut 150 feet long, 40 feet wide, and 100 feet deep. The dike exposed here is 35 feet long and strikes N.85°W. It is lenticular, pinching out toward each end and in depth. Quartz and feldspar are intergrown with muscovite, which occurs as books and tabular masses, chiefly in the feldspar. Some of the masses are 3 to 4 feet in diameter. The deposit is practically exhausted.

The other opening on this property reveals pegmatites similar to the ones described. Lit par lit injections are common, giving the gneiss a banded appearance. Nodules of graphite were found at several places in the decomposed country rock.

Jefferson property.—This property adjoins the Pinchback property on the south and is 2½ to 3 miles N.10°E. of Amelia. The large mines 8, 9, and 11, and prospects 19, 44, 45, and 46 are here. (See Fig. 6.)

Mine 9, called the Bland mine, was the first mine in this area. It was first worked by an open cut and later by shafts and tunnels to a depth of 150 feet. Because the workings are caved in, little could be learned of the width and strike of the dike. The feldspar is largely plagioclase. Some of the richest deposits of mica were found here. The mine is reported to have produced 200,000 pounds, from which 15,000 pounds of sheet mica was trimmed, the remainder being used for punch and scrap mica. Some of the largest sheets trimmed 12 by 12 inches.

Mine 11 is 200 yards north of the Bland mine on a parallel dike that strikes N.72°E. and dips vertically. It has been worked by an open cut 80 feet long, 30 feet wide, and 30 feet long. The feldspar is chiefly albite. The mica yielded sheets averaging 4 by 6 inches.

Mine 8 is one-fourth of a mile south of the Bland mine. The dike here is 20 feet wide and strikes N.75°W. It consists chiefly of a medial band of quartz. Mica occurs in the narrow band of feldspar on either side. The deposit has been worked by trenches dug along both sides of the dike.

Prospect 18 exposes a dike composed of quartz, which is 15 feet wide, strikes N.85°E., and dips 45°NW. Muscovite occurs along the sides of the dike, embedded in the wall rock.

Smith property.—This property contains the continuation of many of the dikes on the Jefferson property which it adjoins on the east. It is peculiar that the feldspar here is chiefly microcline, although the western extension of the same dikes on the Jefferson property contains a large amount of plagioclase, chiefly albite.

Mine 78 (Fig. 6) was worked by an open cut 200 feet long and 40 feet wide on the west bank of a small stream, exposing a dike 20 feet wide, which strikes N.80°E. and has a nearly vertical dip. At the west end of the opening the dike narrows to 5 feet; at the eastern end it splits into two members, each 5 feet across. The feldspar, strongly kaolinized, is microcline and contains books of muscovite yielding sheets that cut 8 by 10 inches.

Mine 79 is on a dike just to the south. It has been worked by a cut 150 feet long and 30 feet wide, on a dike 25 feet wide, which strikes N.85°E. and dips nearly vertically. This dike is similar in composition to the dike just north of it. It has numerous tongues that form lit par lit injection bands, some being 3 feet wide. Prospect 82 is on the west extension of the dike containing Mine 79. It shows a dike of almost pure quartz, 20 feet wide, which strikes N.85°E. and dips nearly vertically. This pegmatite dike grades into a quartz vein. A more interesting example of this gradation is illustrated by prospects 69 and 70, half a mile north of the Smith mines, both being on the same dike, which is the eastern continuation of the dike that contains prospect 15. (Fig. 7.) The dike at prospect 15 consists chiefly of a medial band of quartz, but at prospects 69 and 70 it is composed almost entirely of quartz. At this locality there are three veins 100 feet apart, each 20 feet wide, composed of massive, white translucent quartz. These deposits offer one of the best possibilities in the State for commercial quartz from pegmatites.

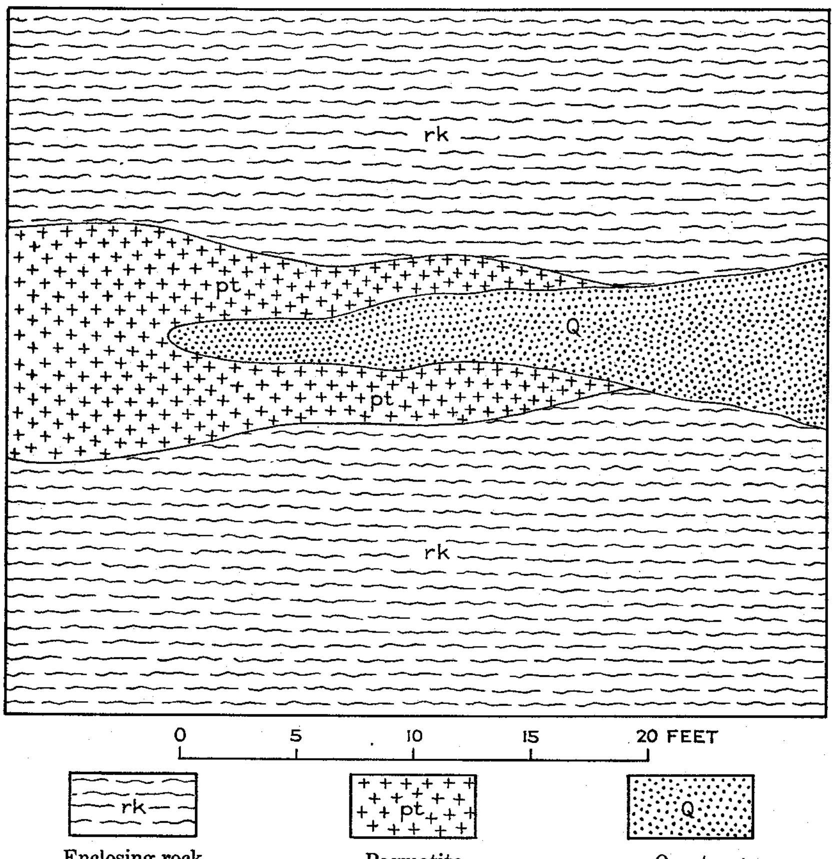


Figure 7.—Plan of relations between the pegmatite and a quartz vein on the Smith property, about 2½ miles east of north of Amelia, Amelia County.

Mine 48 (Fig. 6), known as the Patterson mine, is on the south bank of a small stream, half a mile south of the Pinchback mine and 2 miles N.20°E. of Amelia. It consists of an open cut, now filled with water, that is 120 feet long, 40 feet wide, and strikes N.85°W. The feldspar is chiefly plagioclase (albite and oligoclase). A large quantity of muscovite of a good grade was reported from here. The pegmatite contains small amounts of allanite and apatite. The wall rock at this point is porphyroblastic, that is, it contains "eyes" of microcline. (See Pl. 5, A.) A specimen of this rock has been analyzed. (See p. 21.)

South of this point, the dikes in this belt are farther apart, narrower, and contain a large amount of plagioclase. The production of mica has been small.

Rutherford property.—This property has changed hands several times since the opening of these famous mines, but the mines are still known as the Rutherford mines. There are two large mines here on two parallel dikes, 1¼ miles north of Amelia and 1 mile southwest of the main producing belt of this area. (See Fig. 6, Nos. 26 and 43.)

Mine 26, called No. 1 by Fontaine, is the northern one. It is on a low hill and consists of a pit 75 feet long and 40 feet wide. In 1928, the large pit was nearly filled, leaving accessible only two smaller pits 30 feet deep and 20 feet wide. This dike is characterized by the prevalence of the green microcline, Amazon stone, which was being recovered in 1928 from the dumps. (See Pl. 17, A.)

Mine 43, just south of Mine 26, is Fontaine's No. 2. It is close to a small stream and in 1928 was a pond of water 150 feet long and 50 feet deep. It strikes almost east. It is reported that the workings were 150 feet deep. The characteristic mineral is albite, which forms beautifully reticulated masses with many rare and unusual minerals in the interstices. (See Pl. 10, A.) Muscovite, yielding sheets 22 by 24 inches, the largest reported from the State, was found here. A description of the rare and unusual minerals found in this deposit is given on pp. 36-40. These minerals have also been described elsewhere by the writer.[57]

OTHER MINES AND PROSPECTS

Prospecting has been done on a small scale in the southern part of the area.

Ponton prospect.—This prospect is about 6 miles south of Amelia. (See Pl. 1, No. 96.) A small shaft was dug on a dike which strikes N.50°E. At a depth of 10 feet work was discontinued because of water. Some of the books of mica cut 4 inches square. Mica is still available here.

Schlegal mine.—This mine, 1 mile west of Jetersville (Pl. 1, No. 97), is the oldest mine in the Jetersville area. It is on a dike 10

[57] Pegau, A. A., The Rutherford mines, Amelia County, Virginia: Am. Mineralogist, vol. 13, no. 12, pp. 583-588, 1929.

feet wide, which is composed chiefly of feldspar with some quartz and muscovite. The feldspar is white, buff, and salmon-colored microcline. Some has been shipped for use in pottery manufacture. Feldspar of commercial grade is still obtainable here, although the deposit is small.

Ligon prospect.—This prospect is in the north-central part of the Amelia area, 9 miles north of Amelia. (See Pl. 1, No. 100.) It has been recently prospected, though work was discontinued in the spring of 1928. The dike is 15 feet wide and strikes N.60°W. It is composed largely of microcline, some of the crystals being 2 feet in diameter. Beryl crystals, 18 inches long and 6 inches in diameter, occur in the quartz. This mineral has recently been reported to occur in considerable quantities.

Miller mine.—This mine, 3 miles slightly north of east of Lilburn, is the only one in Powhatan County. It was operated 20 years ago. The workings, which are reported to have been extensive, have caved in. The pegmatite is thoroughly disintegrated to quartz, muscovite, and biotite intermixed with kaolin. An unusual feature is the large amount of biotite which is intergrown with the other minerals as books a few inches in diameter.

Morefield mine.—This mine is located about 1½ miles southeast of Winterham, Amelia County. (See Pl. 1, No. 101.) It was opened in 1929 by S. V. Morefield, who operated it until the summer of 1931, when he leased it to the Seaboard Feldspar Company. Mr. Morefield reports that he shipped about 3 carloads of Amazon stone and 2½ tons of beryl.

The workings in November, 1931, consisted of an open cut 3 to 5 feet deep, for several hundred feet along the strike of the dike, and several cross-cuts. A shaft has been recently sunk into the dike to a depth of 50 feet. The dike strikes N.50°E. and has a steep dip to the northwest. Its width is estimated to be about 15 feet. It can be traced along the strike for 500 yards.

The pegmatite here is made up chiefly of green to bluish-green microcline, white cleavable albite, quartz, having occasionally a purplish shade, muscovite, and white to green beryl. One crystal of beryl is reported to have weighed 125 pounds. There are also small amounts of rare minerals, such as microlite, columbite, and spessartite. Further study will no doubt reveal many others.

The large quantity and excellent grade of Amazon stone and beryl make this deposit one of unusual interest. W. Catesby Jones,[58] Chief Chemist of the Department of Agriculture and Immi-

[58] Personal communication, November 13, 1931.

gration, Richmond, Virginia, has identified the following minerals from this mine: Albite, orthoclase, microcline, labradorite, muscovite, biotite, phlogopite, clear quartz, smoky quartz, agate, spessartite, andradite, mangano-columbite-tantalite, zircon, monazite, rutile, ilmenite, tourmaline, beryl, galena, and kaolin. Chrysoberyl, phenacite, topaz, and helvite are also thought to be present but have not been definitely identified. C. S. Ross,[59] of the United States Geological Survey, reports the following minerals from this mine: Microcline, albite, beryl, microlite, garnet (spessartite), columbite-tantalite (appears to be near tantalite), tourmaline (black), muscovite, biotite, quartz (colorless and smoky), monazite, secondary manganese oxides, and ilmenite.

GOOCHLAND AREA

LOCATION AND ACCESSIBILITY

The Goochland area is shown on the index map (Fig. 1) and the geologic map (Pl. 1). It is chiefly in Goochland County, but a small part at the north is in Louisa County. Goochland Court House is in the south-central part of the area. The mapped area is rectangular and comprises about 45 square miles. Isolated deposits in Goochland, Hanover, and Louisa counties are included here. The James River division of the Chesapeake and Ohio Railway traverses the southern border of the area. Two excellent highways, the River Road and the Three Chopt Road, cross the area from east to west. Fairly good roads traverse it from north to south.

TOPOGRAPHY AND DRAINAGE

The topography is similar to the Amelia area on the south. The average elevation is about 250 feet, with a range from less than 150 feet along James River to more than 300 feet on some of the divides between the tributaries of the James.

The general direction of drainage is to the south into James River. Beaverdam Creek and its tributaries, the largest of which is Court House Creek, drain most of the area. A small area is drained by small streams that flow directly into James River. The area in Louisa County is drained by tributaries of South Anna River.

ROCK TYPES

General features.—The country rock, wherever exposed, is chiefly gneiss. It is of two types, namely, (1) a porphyritic biotite gneiss which is part of the Amelia-Goochland quartz monzonite gneiss,

[59] Personal communication, November 16, 1931.

and (2) hornblende metagabbro. Banding and foliation in these gneisses strike northeast and dip northwest. Both gneisses are cut by pegmatite dikes of variable size. Weathering is very deep here, so that fresh rock is exposed only along streams and in railway and road cuts.

Quartz monzonite gneiss.—This rock comprises about 90 per cent of the outcrops. Secondary banding and porphyritic facies are common. The strike of the bands ranges from N.20°E. to N.40°E. The dip is as a rule 50°-75°NW., though in places it is 60°-80°SE. In addition to the typical minerals of this rock type, sillimanite and rutile were also found.

Hornblende metagabbro.—This type of rock occurs as a dike in the eastern part of the area. It is one-fourth of a mile wide, strikes N.20°-30°E., and dips 50°-70°N.W. Banding is parallel to the strike of the dike. This rock type here is characterized by labradorite, a low-iron hornblende, and clinozoisite, indicating an original gabbro high in calcium and low in iron. (Pl. 11, A.)

PEGMATITES

General features.—Pegmatite deposits are sparingly developed in the Goochland area, as compared with the Amelia area. Most of them are confined to a belt 5 miles wide, extending from Goochland Court House northeastward through the central part of the area to Perkinsville on the Goochland-Louisa county line. A few deposits occur in the southwestern and western parts of the area. Isolated deposits, two of which contain rutile, occur beyond the mapped area in Goochland, Hanover, and Louisa counties.

Occurrence.—These pegmatite deposits are similar to those in the Amelia area, but are more lenticular. The dikelike form is the most common. These dikes range from a few inches to 10 feet wide. The general strike is N.40°W., cutting across the schistosity of the enclosing rocks. Some of the smaller dikes are parallel to the foliation of the wall rock.

The lenticular form is common, with lenses ranging in size from 6 by 12 inches to 10 by 50 feet. Many lenses appear as "eyes" in the enclosing gneiss. These "eyes" are exposed along the highway from Maidens Station to Goochland Court House.

Texture.—The texture is not as varied in these pegmatites as in those of the Amelia area. The common type is coarsely granular consertal, with some graphic intergrowths. At places, as at the Amber Queen mine (Pl. 1, No. 7), parallel growths are developed, in which quartz forms layers about 2 millimeters thick along the cleavage planes of the muscovite. A few of the smaller dikes, as at the Salter prospect (Pl. 1), are fine-grained, and some of them contain crystals of pink garnet 5 millimeters in diameter. Microscopic grains of sillimanite in the feldspar produce a poikilitic texture. Indistinct schistosity, observed in the pegmatite at the Irwin mine (Pl. 1, No. 1), has been caused by the pegmatitic material soaking the biotite gneiss along the foliae.

Nature of contacts.—The contacts are commonly sharp, though marked in a few places by a narrow zone containing muscovite, tourmaline, quartz, and garnet. Evidence of soaking was observed at a few places.

Mineral composition.—The kinds of minerals in the pegmatites of the Goochland area are neither as abundant nor as varied as in the pegmatites of the Amelia area. They include microcline, albite, quartz, muscovite, biotite, garnet, tourmaline, sillimanite, and graphite. Rutile, ilmenite, and zircon are found in some of the near-by isolated deposits.

The feldspar content ranges from 50 to 80 per cent of the deposit. Microcline and albite are intergrown, with microcline on the whole being more abundant. The feldspars show mashing, slicing, and strain shadows. Cream-white to salmon-pink microcline occurs commonly in well-developed crystals, the largest being 6 inches in diameter. Much of it contains perthitic intergrowths of albite. It is also intergrown with quartz and mica. Albite, rather commonly grading into oligoclase, occurs as coarse to fine crystals intermixed with quartz, mica, and the other feldspars. It is commonly associated with biotite. Some contains needle-like inclusions of sillimanite. It occurs also as perthitic intergrowths with microcline, comprising in places 25 per cent of the mass.

Quartz is invariably present in irregular masses and crystals that are as large as 3 by 6 inches. It occurs also as parallel growths with muscovite and with tourmaline. It is smoky-gray to colorless.

Most of the deposits contain muscovite in flakes and books, intergrown with the other constituents, up to 1 foot in diameter. It is commonly of a clear-amber color, but some is light-green and much of it is stained brown by limonite. Some crystals contain microscopic grains of apatite and garnet.

Biotite is very scarce and appears to have been derived from the wall rock through a soaking process. It occurs as small tabular crystals one-eighth to one-fifth of an inch in diameter, which are commonly partly altered to chlorite.

Pink garnet was found in a few places, generally along the contact, but also in some of the fine-grained pegmatites. The largest crystals are almost half an inch in diameter. Many crystals contain inclusions of biotite. Tourmaline is sparingly developed as typical columnar, three-sided, jet-black crystals. Graphite was reported to have been dug at a point one-fourth mile northwest of the Amber Queen mine on the strike of the dike there. It occurred in irregular masses up to 16 centimeters in diameter.

Sillimanite was observed only in this area, and only at the Salter prospect. It is in a fine-grained pegmatite which contains quartz, feldspar, and garnet. The sillimanite occurs as rodlike grains that are 1 by 3 millimeters, and as irregular grains of microscopic size that show a parallel orientation. The crystals are more or less segregated into bands. The mineral has a moderate index, positive elongation, and a birefringence of 0.021. It shows cleavage parallel to the length, and parting at right angles to it.

Rutile and ilmenite were found on the Bowe farm near Gouldin on the north side of South Anna River, in Hanover County, and 8 miles south on the Nuckols farm in Goochland County. These deposits have been described by Watson.[60] Some of the masses are reported to have weighed 300 pounds. Specimens weighing 25 to 30 pounds are found on the dumps. The two minerals, intergrown commonly with feldspar, occur in a pegmatite. The rutile is cherry-red to dark-red, and the ilmenite is black with a metallic luster. Zircon was reported by Watson,[61] from the Goochland-Hanover pegmatites. An irregular crystal, with a resinous to pitchy luster, yellowish-brown color, and distinct pyramidal faces, was shown to the writer by a Mr. Brown, who stated that it was found in a pegmatite near the Bowe deposit.

MINES AND PROSPECTS

General features.—The pegmatite dikes of the Goochland area have been worked almost exclusively for muscovite. The first work done in Virginia was reported to have been near Hewlett, Hanover County, with the opening in 1873 of the Saunders mine. The Irwin mine was first operated about 1880, but most of the work in this area was done during the World War and immediately thereafter. All operations ceased in 1922 and nothing has been done since.

There are about 15 mines and prospects in this area, as compared with 102 in the Amelia area.

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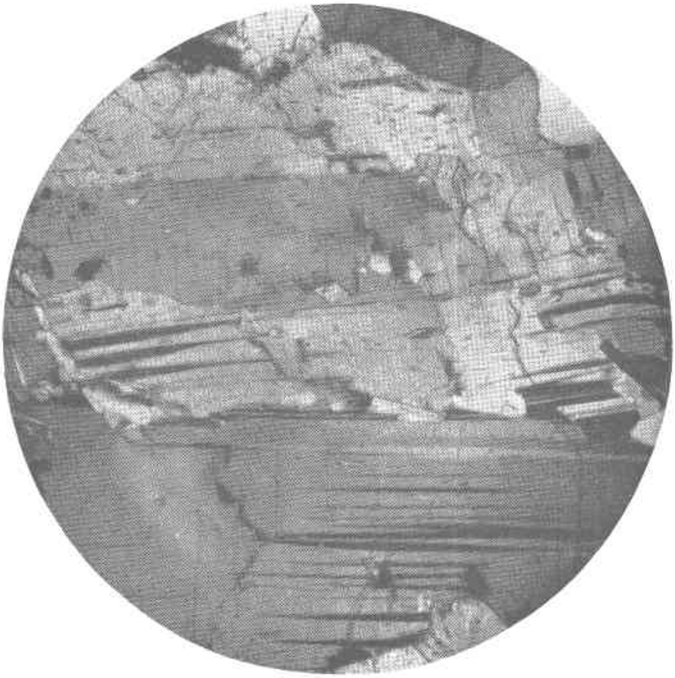
[60] Watson, T. L., and Taber, Stephen, Geology of the titanium and apatite deposits of Virginia: Virginia Geol. Survey Bull. 3-A, pp. 255-261, 1913.

[61] Watson, T. L., Zircon-bearing pegmatites in Virginia: Am. Inst. Min. Eng. Trans. vol. 55, pp. 936-942, 1917.

A. The effect of metamorphism shown by bending of the twinning striae of the feldspar in the hornblende metagabbro, Goochland area. X 40.

B. Alteration of feldspar, along the basal (001) cleavage, to epidote and kaolinite, in hornblende metagabbro, Amelia area. X 45.



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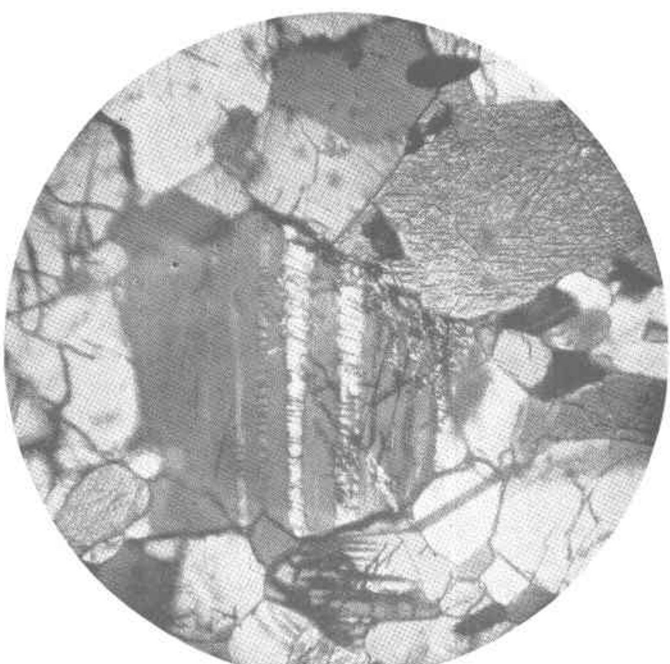
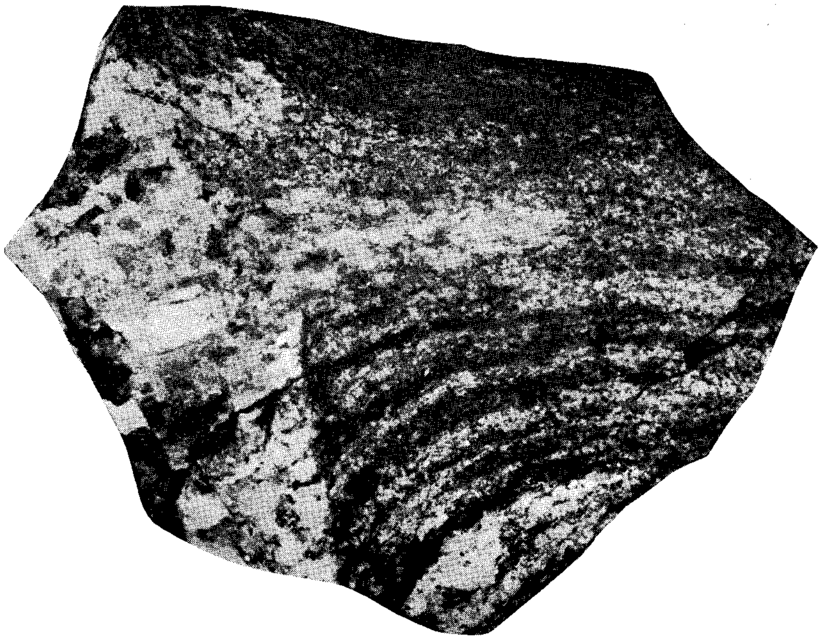
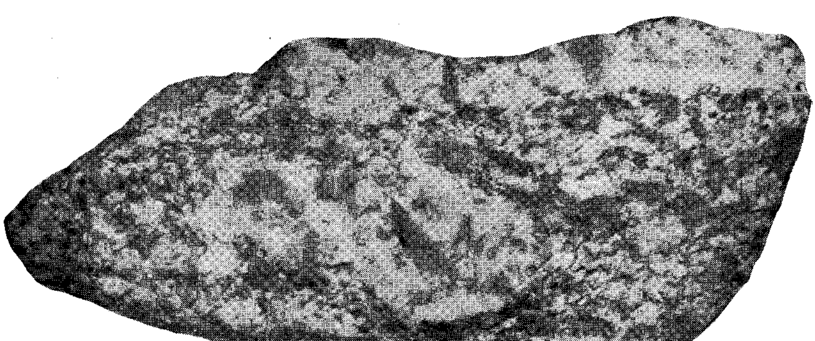


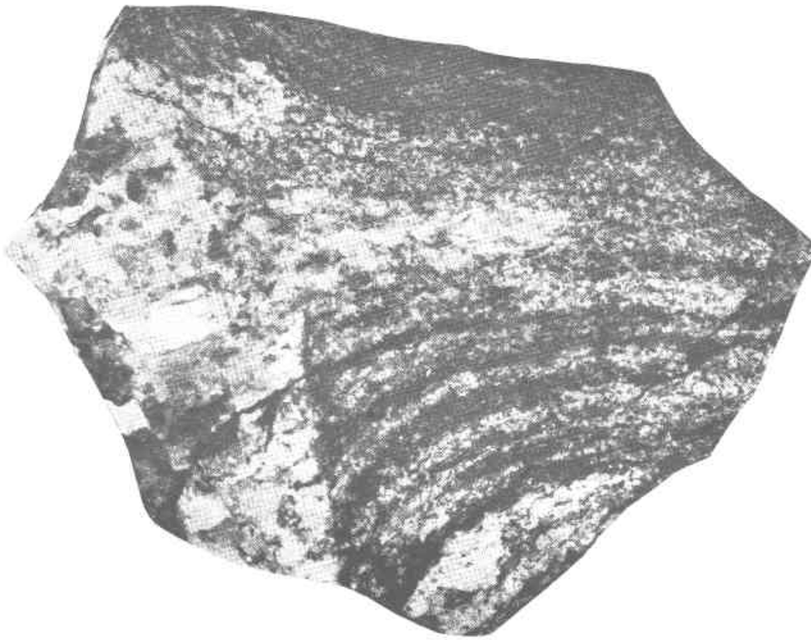
B. Alteration of feldspar, along the basal (001) cleavage, to epidote and kaolinite, in hornblende metagabbro, Amelia area. X 45.



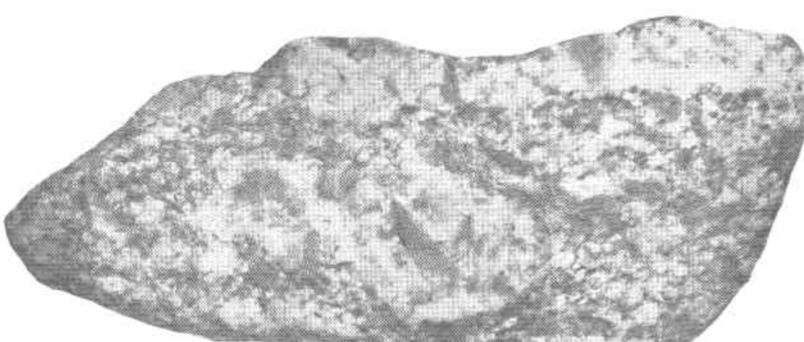
A. Relation between the pegmatite and the biotite gneiss facies of the Wissahickon schist; shown in a stream below the Grindstaff mine, 2 miles southwest of Ridgeway, Henry County. X ¾.



B. Medium-grained pegmatite with a phenocryst of microcline; from a dike on the Norfolk and Western Railway, one-fourth mile south of Ridgeway station, Henry County. X ¾.



A. Relation between the pegmatite and the biotite gneiss facies of the Wissahickon schist; shown in a stream below the Grindstaff mine, 2 miles southwest of Ridgeway, Henry County. X ¾.



B. Medium-grained pegmatite with a phenocryst of microcline; from a dike on the Norfolk and Western Railway, one-fourth mile south of Ridgeway station, Henry County. X ¾.

Irwin mine.—This mine is 2 miles N. 60° W. of Goochland Court House. (See Pl. 1, No. 1.) The workings consist of an open cut 25 feet wide and 20 feet deep, and a shaft reported to be 50 feet deep. The deposit appears to have been largely worked out here. This dike had an east strike and was composed of chalky, white feldspar, smoky-gray quartz, and muscovite of fairly good grade. The wall rock is altered by pegmatitic soaking at the contacts and contains streaks and stringers of pegmatite.

Amber Queen mine.—This mine is on the Montero tract 3½ miles N.40°E. of Goochland Court House. (See Pl. 1, No. 7). It was first operated in 1916, and was worked by shafts and tunnels to a depth of 50 feet. The pegmatite dike exposed here is 10 feet wide, strikes N.40°W., has a vertical dip, and can be traced along the strike for half a mile. It is composed of feldspar, chiefly orthoclase, smoky-gray quartz, and amber-colored muscovite, which yielded sheets that cut 5 by 6 inches. The mine is reported to have produced 12 tons of mica. Graphite masses as large as 3 by 6 inches were found along the strike of the dike, one-fourth of a mile northwest of this mine.

Nicholas prospect.—At this place, which is 1 mile S.40°E. of Perkinsville and 5½ miles N.50°E. of Goochland Court House (Pl. 1, No. 9), prospecting was done in 1916, which yielded 1 ton of mica. A trench was dug along the strike of the dike for 20 feet and to a depth of 22 feet. The dike is 5 feet wide, strikes N.30°E., and dips 60°SE. The dike, although small, persists along the strike for half a mile. The pegmatite is composed of a weathered feldspar, chiefly microcline, with some albite, gray to colorless quartz, and amber-colored muscovite that yielded sheets which cut 5 by 6 inches.

Wiltshire prospect.—This prospect is on the Wiltshire tract half a mile west of Perkinsville. (See Pl. 1, No. 11.) It was operated 30 years ago and again in 1915. The workings consist of an open cut 20 feet long, 20 feet deep, and 10 feet wide, revealing a dike 5 feet wide, which strikes N.45°W. and is almost vertical. At the northwest end of the cut the dike splits into two lenticular bodies, one lying 5 feet above the other. Bands of pegmatite 2 feet wide in the gneiss are lit par lit injections. The pegmatite is similar in composition to that on the Nicholas property.

Salter prospect.—This prospect (Pl. 1, No. 2) is of interest in that small dikes, evidently offshoots of the main dike, contain sillimanite. The main dike, not more than 5 feet wide, is reported to have yielded a small amount of good mica. This deposit, like many others in this area, is too small to be of commercial value.

Saunders mine.—This mine, reported to be the oldest mica mine in Virginia, is on the south bank of Little River, 4½ miles S.30°E. of Hewlett in Hanover County. It consists of an east-west trench 15 feet wide, 100 feet long, and of unknown depth. On the north side of the cut to the east, a lens of pegmatite 10 feet wide and 25 feet long is composed of an intimate mixture of feldspar, quartz, and mica, in which the minerals average 2 to 3 inches in diameter. Most of the deposit consists of clear, transparent, glassy quartz and feldspar, of a buff to cream color, which is chiefly orthoclase, with some albite. Light amber-colored muscovite occurs sparingly. Nothing could be learned of the amount or grade of mica found here. The wall rock is a garnet-bearing biotite gneiss, with well-developed banding that strikes N.30°E. and dips 60°NW.

Childress mine.—This mine is in Louisa County about 3 miles southeast of Cuckoo and 300 yards south of State Highway No. 39. It is reported to have been worked about 20 years ago, when it produced muscovite that cut sheets measuring 8 to 10 inches. The mine consists of a shaft 50 feet deep and of trenches 100 feet long on both sides of the dike. The dike is 10 feet wide and strikes N.15°E. It consists chiefly of quartz containing books of mica. Very little feldspar was seen. The muscovite is of good grade, although some of it contains objectionable structures.

RUTILE DEPOSITS

Deposits of rutile in Goochland and Hanover counties have been fully discussed by Watson and Taber,[62] who regarded them as promising, and who suggested that more systematic and extensive exploratory work was warranted. This work had not been done up to 1928, when the actual workings were the same as in 1912. These deposits, though small, offer potential sources of titanium ores.

RIDGEWAY AREA

LOCATION AND ACCESSIBILITY

The Ridgeway area is partly in Henry County, Virginia, and partly in Rockingham County, North Carolina. It is shown on the index map (Fig. 1) and on a geologic map of the area (Pl. 2). The mapped area is rectangular and comprises 45 square miles, with its longest dimension of 10 miles in a northeast direction.

[62] Op. cit., pp. 248-261.

The greater part of the district is easily accessible from Ridgeway, Virginia, and Price, North Carolina, both on the Norfolk and Western Railway, which traverses the central part of the area. A concrete highway parallels the railroad.

TOPOGRAPHY AND DRAINAGE

This area is in a rather strongly dissected part of the Piedmont province. The surface is undulatory, the hills have moderate to steep slopes, and the streams have steep banks. The elevation ranges from less than 600 feet along Smith River to 1,000 feet along some divides. The area roughly parallels the divide between Matrimony Creek and its tributaries to the northwest, and Marrowbone Creek and its tributaries to the southeast. Both creeks flow into Smith Creek.

ROCK TYPES

The rocks of this area comprise highly metamorphosed schists and gneisses and acid and basic intrusives. The most abundant rock is the Wissahickon schist which occupies about two-thirds of the area. It is described on pages 15-19. The next most abundant rock type is hornblende metagabbro, which comprises one-fourth of the outcrops. It occurs as dikes that range from a few hundred feet to one-fourth of a mile wide and from a few thousand feet to 5 miles long. Some of the largest pegmatites have been intruded along the contact of the hornblende gneiss and the schist. At one place 5 irregularly spaced pegmatite dikes, ranging from 5 to 20 feet in width, occur within a distance of 300 feet. The Leatherwood granite occupies an elliptical area 2 miles long and 1 mile wide in the western part of this area. A chemical analysis of it is given on page 30.

About a dozen dikes of hornblende-chlorite metapyroxenite are rather uniformly distributed through the area. They range from 10 to 30 feet wide and from a few rods to 1 mile long. This rock is described on pages 27-29. Six dikes of diabase are distributed irregularly through the area. They are of variable size, the largest being 60 feet wide and 2 miles long.

The general strike of the schistosity of the country rock ranges from N.20°E. to N.60°E., and the dip is generally 45°-75°NW. The dikes of metagabbro and of pegmatite generally follow the schistosity, but the strike of the dikes of diabase and hornblende-chlorite metapyroxenite is very irregular.

The relative ages of the rocks in this area seem to be as follows: (1) Wissahickon schist, the oldest, (2) Leatherwood granite and hornblende metagabbro, (3) hornblende-chlorite metapyroxenite, (4) pegmatites, and (5) diabase.

PEGMATITES

General features.—Pegmatite deposits of simple composition are abundant in this area. They differ from those of the Amelia-Goochland belt in being relatively finer grained and more sodic, indicating that they were formed at a higher temperature and from a more sodic magma. Moreover, they tend to follow planes of the schistosity rather than prominent joints, probably because the prevailing rock is a highly cleaveable schist, and the borders of the older gabbroic dikes are zones of weakness. The relation between some of the pegmatite dikes and the hornblende metagabbro is closer than in any of the other areas discussed. The similarity of the feldspars in the pegmatites and in the Leatherwood granite suggests that both have been derived from the same magma.

Occurrence.—The pegmatites of the Ridgeway area occur mainly as dikes, generally with irregular sides, which pinch and swell along the strike and dip. They range from a few inches to 60 feet wide, with the average width being about 25 feet. Some of the larger dikes are traceable along their strike for half a mile, but most of them are only a few hundred feet long. Some seem to be very deep, whereas others wedge out not far below the surface. The dike exposed by the Ridgeway mine (Pl. 2, No. 19) is 30 feet wide at the surface and only 6 feet wide at a depth of 80 feet. The strike of the dikes commonly conforms to that of the enclosing rock, ranging from N.10°E. to N.60°E. A few dikes strike northwest. Stringers and apophyses in many places cut across the schistosity of the wall rock. Lit par lit injections were rarely observed, being mostly in the hornblende metagabbro gneiss. Although many of the dikes have a rudely lenticular form, distinct lenses are rather rare.

Texture.—The pegmatites in this area are generally very coarse-grained, although individual crystals rarely measure more than 2 feet in diameter. Some have a porphyritic texture in which the groundmass is a medium-grained mixture of quartz, feldspars, and mica, with phenocrysts of microcline up to 1 foot in diameter. (Pl. 12, B.) Miarolitic cavities were not observed. Banded structure is found in a few places, as in the Lovelace mine. The dike here is 20 feet wide, with a band of quartz 2 feet wide flanked by bands composed of quartz, feldspar, and mica, with scattered nests of garnet.

Distinct schistosity has been developed in many of the finer grained dikes by the parallel orientation of muscovite flakes. This texture appears to be primary, as the other minerals show no evidence of metamorphism or recrystallization.

Nature of contacts.—Several dikes do not have the same rock in both walls, one being mica schist and the other hornblende gneiss. Most of the contacts are sharp, but in a few places a narrow contact zone is developed, as a rule in the wall rock, with parallel growths of muscovite, tourmaline, and quartz. Garnet occurs along the contacts, both in the wall rock and in the pegmatite. In some places the hornblende of the wall rock is partly changed to a deep-brown, pleochroic biotite.

Mineral composition.—The pegmatites are of the acid type, though more sodic than common. They consist of feldspar, quartz, and muscovite, with variable but minor amounts of garnet, tourmaline, and biotite. The constituents have no relation to the enclosing rock.

Feldspars are the chief constituents, being commonly 50 to 80 per cent of the pegmatites, occurring in irregular grains and masses that range from less than one-tenth of an inch to more than 1 foot in diameter. Many grains show crystal outlines and excellent cleavage. Microcline and plagioclase occur in approximately equal amounts, although either may predominate in different places. Buff is the prevailing color. Perthitic intergrowths of albite occur, but not as extensively as in the feldspars of the Moneta-Bells area. Micropegmatitic intergrowths with quartz are common in the finer grained dikes. The plagioclase, of pure white to grayish-white color, as determined by crushed fragments immersed in index liquids, is an albite-oligoclase. The highest index is 1.539, a medium one is 1.532, and the lowest is 1.528. The plagioclase occurs as visible grains intergrown with the other minerals and as microscopic spindles included in the microcline.

From 20 to 30 per cent of the rock consists of quartz. It occurs (1) in irregular masses, some being 2 feet across, (2) as interpenetration growths with feldspar, forming a cuneiform texture, and (3) rarely as well-developed crystals. It varies from colorless to smoky, with light-smoky shades predominating. Some of it is intergrown with, or fills the interstices between tabular crystals of tourmaline.

Muscovite occurs as flakes disseminated uniformly through the pegmatite, commonly with parallel orientation, and as books of varying sizes scattered irregularly through it. The disseminated muscovite is commonly light-green, and shows a faint pleochroism.

Some of the largest dikes and many of the smaller ones are characterized by this kind of muscovite. The deposits characterized by this fine-grained, disseminated mica are rarely of value. Some of the muscovite books are 18 by 20 by 20 inches and weigh 40 to 50 pounds. A book weighing 700 pounds has been reported from the Ridgeway mine. The average book will yield a sheet that cuts 6 by 8 inches, but some of the larger books yield sheets that cut 12 by 20 inches. The color varies from light-brown to greenish-brown, with various shades of amber predominating. Most of the crystals are clear and free from undesirable structures, but some have the "A" structure strongly developed and others are ruled, thus yielding long, narrow strips only a few inches wide. Some of the crystals are warped and others are spotted with iron oxide. Biotite was found in a few places in small flakes uniformly distributed through plagioclase.

Garnet, commonly almandite, was found in numerous specimens. Some crystals are 1 inch in diameter, although they are generally much smaller. The garnet occurs as isolated grains and nests in the feldspar and along cleavage planes of some of the feldspar where it represents a later crystallization. It occurs also as isolated crystals of variable size, slightly flattened and penetrating cleavage flakes of muscovite.

Tourmaline occurs in jet-black columnar crystals up to several inches long. It forms radiating masses of prismatic crystals, with quartz filling the interstices. It is at or near the contact, either in the pegmatite or in the wall rock. In some places, parallel growths of tourmaline and muscovite, several inches wide, occur along the contact.

Kaolin occurs in deposits of considerable thickness but is commonly intermixed with quartz, muscovite, and ferruginous clay.

PRINCIPAL MINES AND PROSPECTS

General features.—The pegmatite dikes of the Ridgeway area have been worked almost wholly for muscovite, but small amounts of feldspar have been marketed from time to time. As indicated by a detailed field study, the area contains considerable undeveloped muscovite and feldspar and minor amounts of kaolin.

The first mining was done about 1906. From 1906 to 1915, operations were confined to the Ridgeway mine near Ridgeway Station, and to several prospects in this area. From 1915 to 1920, mines were opened in all parts of the area, many of them yielding large amounts of marketable mica. At the time of greatest activity, there were about a dozen producing mines and several small prospects. Since 1920 very little work has been done. In the summer of 1928, slight operations were in progress at the Phillips mine. (See Pl. 2, No. 12.)

Ridgeway mine.—This mine is about one-quarter of a mile west of Ridgeway on the Norfolk and Western Railway. (See Pl. 2, No. 19.) It was first operated by the Pittsburgh Mica Company, later by the Ridgeway Mica Company, and still later by the Chestnut Mountain Mica Company. The mine consists of open cuts, shafts, and stopes along the strike for 160 feet and to a depth of 120 feet. The dike is 30 feet wide at the surface and 5 feet wide in the lowest workings. It strikes N.25°E. and dips 75°NW., in conformity with the schistosity of the enclosing metagabbro gneiss. In places the dike shows a series of bulges to the west. The pegmatite consists of a granular mixture of white feldspar (albite and microcline), light-smoky quartz and amber-colored muscovite. (Pl. 13, A.)

Muscovite occurs in books, some of which are 2 feet in diameter. One book is reported to have weighed 776 pounds. Some of the largest cut sheets measured 18 by 20 inches. A part of the dike 22 feet wide and 15 feet long is reported to have yielded 58,000 pounds of mica to the depth of working.

Several carloads of feldspar have been shipped from this mine.

About 100 yards east of this mine, road cuts expose a parallel dike 30 feet wide which strikes N.30°E. It swells and pinches and in places almost disappears. The texture varies from coarse-grained and massive to fine-grained and granulated, suggesting mashing.

Garrett property.—This tract is 2 miles S.30°W. of Ridgeway. It contains three mines apparently on a single dike along the contact of hornblende metagabbro gneiss and the Wissahickon schist. (See Fig. 8.) These are the Grindstaff mine, the Garrett spar mine, and the Garrett-Penn mine. There are several prospects to the southwest on parallel dikes, the largest of which is the Garrett prospect.

The pegmatites on the Garrett property are largely feldspathic and offer some of the best possibilities for commercial feldspar in the Ridgeway area. The feldspar, as a rule of the potash variety (microcline), is commonly in large cleavable masses 1 foot or more in diameter. The muscovite, however, is of poorer grade than that obtained from the Ridgeway mine.

Grindstaff mine.—This mine (Pl. 2, No. 8) consists of shafts and tunnels to a depth of 25 feet on a dike of pinkish-white feldspar (chiefly microcline), quartz, and muscovite. The mica yields sheets that cut 4 by 6 inches. Much mica and several carloads of feldspar were shipped from here.

Garrett spar mine.—This mine (Pl. 2, No. 9), one-eighth of a mile northeast of the Grindstaff mine, reveals the widest part of

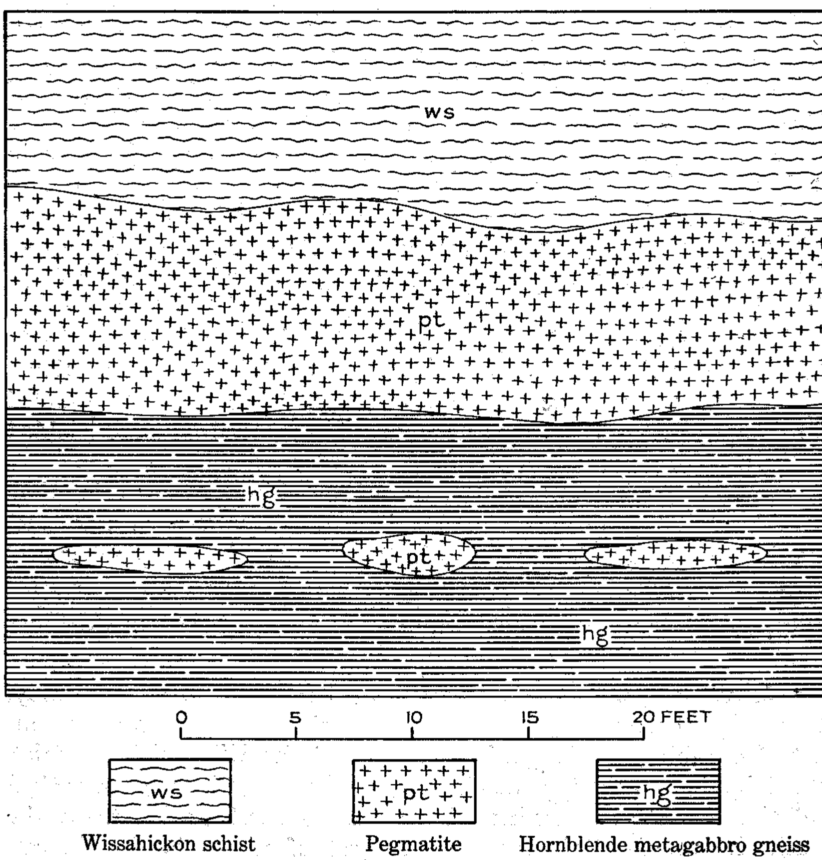


Figure 8.—Relation of the pegmatite to the Wissahickon schist and hornblende metagabbro gneiss, Garrett mines, 2 miles southwest of Ridgeway, Henry County.

the dike, which is here 30 feet wide. The feldspar is strongly kaolinized to a depth of 20 feet. Some of it has been marketed. A small amount of mica has been recovered from the kaolin.

Garrett-Penn mine.—This mine (Pl. 2, No. 13) is three-fourths of a mile northeast of the Garrett spar mine. It has been worked for feldspar and mica.

Oliver property.—This property (Pl. 2, No. 10) lies south of the Garrett tract, on the bank of Matrimony Creek. Much prospecting has been done here, but no extensive mining has been done. The pegmatite dikes are similar in size, strike, dip, and composition to those on the Garrett property. Some openings show a fairly good grade of muscovite.

Phillips mine.—This mine is on the State line, 2½ miles south of Ridgeway. (See Pl. 2, No. 12.) It consists of an open cut and a tunnel which extend 450 feet N.70°E. The southwest end was worked in the summer of 1928. The dike is 50 feet wide in the middle and narrows to 20 feet at the exposed ends. It is composed of kaolinized feldspar intermixed with quartz and muscovite. The muscovite, which is of scrap grade only, is easily mined because of the disintegration of the pegmatite. Several carloads have been produced.

Lovelace mine.—The dikes containing the Lovelace and Pace mines are characterized by the predominance of plagioclase (albite-oligoclase). They are relatively fine-grained and are schistose and banded.

The Lovelace mine, 1½ miles west of Ridgeway (Pl. 2, No. 16), was worked first in 1916, and again in 1923. It consists of an open cut 50 feet long on the southeast side of the dike. The dike exposed here is 20 feet wide, strikes N.40°E., and dips 60°NW. Muscovite occurs in books and pockets irregularly distributed through the pegmatite. It yielded some sheets that cut 4 by 6 inches, but was mostly of scrap grade. Shovel and pick were used to loosen the material; the mica was drawn out by a windlass, put in bags, and hauled to Ridgeway where it was sorted and cut into sheets.

Pace mine.—This mine is half a mile N.60°E. of the Lovelace mine on a parallel dike. (See Pl. 2, No. 17.) The mine was worked by an open cut for 70 feet along a dike 40 feet wide, which strikes N.40°E. This dike is similar in appearance and mineral composition to the Lovelace dike. It is partly porphyritic and contains some biotite. Sheet and scrap mica were produced here.

OTHER MINES

Mining and prospecting have been carried on in a small area in North Carolina and Virginia, about 1 to 3 miles west of Price, North Carolina.

Tom Smith mine.—The Tom Smith mine (Pl. 2, No. 1), 3 miles S.70°W. of Price, was the most productive. It was opened in 1918 by the Chestnut Mountain Mica Company, and was worked at various points by open cuts, shafts, and stopes. The dike is 20 feet wide and strikes N.50°W. It is composed of partly altered feldspar, chiefly orthoclase, quartz, and muscovite. The mica yielded sheets that cut 8 by 10 inches. About 150 tons of mica was mined here.

Clifton mine.—This mine is 1 mile west of Price. (See Pl. 2, No. 4.) A dike 10 feet wide can be traced for 500 feet along a strike of N.50°E. It consists of feldspar, chiefly microcline, quartz, muscovite, and rarely garnet that is 1 inch and less in diameter. Several thousand dollars worth of mica and several tons of feldspar are reported to have been sold from here.

AXTON AREA

LOCATION AND ACCESSIBILITY

The Axton area, named from Axton, on the Danville and Western Railway, occupies the northwestern part of the Draper quadrangle, partly in Henry County and partly in Pittsylvania County. It is shown on the index map (Fig. 1) and a geologic map. (See Pl. 3.)

The mapped area is rectangular, being 10½ miles long east and west and 8 miles wide. The Danville and Western Railway and the Martinsville-Danville highway cross the southwestern part of the area. Good sand-clay roads traverse all parts of the area.

TOPOGRAPHY AND DRAINAGE

The topography is more subdued in this area than it is in the Ridgeway area, although the western portion is somewhat rugged. The elevation ranges from less than 600 feet along Sandy River in the southeastern part to more than 1,000 feet on some of the divides.

Sandy River and its tributaries drain the eastern three-fourths of the area toward the southeast, and Leatherwood Creek and its tributaries drain the remainder of the area toward the west.

ROCK TYPES

The Leatherwood granite crops out in the northern part of the area. It fingers into the Wissahickon schist, which underlies the southern three-fourths of the area. A dike of hornblende metagabbro crops out in the southwestern part. Hornblende chlorite metapyroxenite dikes occur sparingly in the vicinity of Soapstone school in the central portion, and some diabase dikes are present.

The Leatherwood granite is so thoroughly decomposed in this area that an exact boundary between it and the schist could not be established.

The Wissahickon schist has the three facies, mica schist, hornblende schist, and biotite gneiss, well developed in this area. Mica schist predominates and is commonly garnetiferous. The biotite gneiss is best exposed along the streams in bands folded in the mica schist. Some of the bands are 500 feet thick. Hornblende schist is least abundant. The three facies are so intimately related that they appear to represent original beds in a sedimentary deposit, although the biotite gneiss may represent a metamorphosed igneous intrusion.

Small amounts of kyanite were found near Greens Store, and narrow veins of amphibole asbestos were observed in the central part of the area, near the county line.

PEGMATITES

General features.—Most of the pegmatite deposits in this area are grouped around a point 1½ miles N.70°E. of Axton, apparently around the border of an unexposed granite boss. The deposits are relatively less abundant and smaller than those in the Ridgeway area.

Occurrence.—The pegmatites occur most commonly as dikes ranging from less than a foot to 40 feet wide. Most of them are so thoroughly decomposed that they could not be traced far along their strike. The direction of strike differs for nearly every dike. The dip varies from 30° to 90°. As a rule the dikes follow, though locally they cut across, the schistosity.

Lenticular bodies are common. Most of them seem to be parts of a dike that has been pinched off. Figure 2 shows the relations between the dike and "eyes" of pegmatite at the Vicama mica mine (Pl. 3, No. 12).

Texture.—The prevailing texture is coarsely granular, with some of the largest masses being several feet in diameter. Graphic and porphyritic textures occur. Microscopic textures, as perthitic and pegmatitic intergrowths, are seen in some thin sections. Extensive weathering of most of the dikes has obscured many of the textural features.

Nature of contacts.—Observed contacts were generally sharp. No evidence of pegmatitic soaking was seen, although the development of narrow contact zones was seen in many places.

Mineral composition.—The pegmatites in this area are composed essentially, in order of abundance, of feldspar, quartz, and mica, with minor amounts of tourmaline, garnet, and biotite. Impure kaolin is very abundant.

Feldspar occurs commonly as granular intergrowths with quartz and, to some extent, with muscovite, and, in a few places, as jointed blocks, several feet in diameter, free from quartz. It is chiefly microcline, but there is some albite. The albite occurs generally as perthitic intergrowths with microcline, but there are some grains of the pure mineral. The feldspars are as a rule partly or wholly kaolinized in the zone of weathering, and are therefore chalky-white and friable.

Quartz is present as (1) stringers, varying from several inches to several feet wide, distributed irregularly through the pegmatite, (2) irregular grains intergrown with the other minerals, (3) a medial band, and (4) pure quartz veins. It is colorless to smoky-amber.

Muscovite is found occasionally as cleavable masses, the largest of which weigh 75 pounds. It occurs generally in flakes or scales and small tabular crystals intermixed with feldspar and quartz. It is commonly amber-colored, though not uncommonly it is light-green. It is spotted locally with limonite. Objectionable structures are fairly common, but sheets that trim 8 by 10 inches are obtained from some of the larger books.

Tourmaline is sparingly developed as prismatic, striated, jet-black crystals. It forms radiating tufts and parallel growths in the wall rock along the contact. Garnet is generally found as nests, but there are some isolated crystals, mainly in the feldspar. The largest crystals are 1 inch in diameter, but most of them are much smaller.

PRINCIPAL MINES AND PROSPECTS

General statement.—This area was extensively prospected during 1922 to 1924, but only one mine, the Vicama Mica Company mine, has been intensively worked. The deposits, shown by numerous prospects, are small. On the other hand, the decayed condition of the feldspar has made the removal of mica an inexpensive process.

Vicama Mica Company mines.—One of the mines of the Vicama Mica Company is 4 miles slightly south of east of Axton, in Pittsylvania County. (See Pl. 3, No. 12.) Mining was begun in 1922 by H. C. Fields of Martinsville, who later sold the property to the Vicama Mica Company. The workings have been confined to a distance of 500 feet along the strike of the dike, and most of them to 200 feet. They consist of several shafts 50 feet deep and tunnels from these shafts along the dike. Most of the work has been done on the southeast end of the dike, on the west bank of Georgia Branch. A dike 40 feet wide crops out at intervals for half a mile along a strike of N.40°W. It lies along the foliation of a thinly schistose biotite gneiss.

During 1924, the mine was being worked and was reported to have produced 20 carloads of scrap mica, 15 tons of punch and sheet mica, and 3 carloads of feldspar. It was abandoned soon after, but the deposit, consisting chiefly of feldspar with some quartz and muscovite, is by no means exhausted.

Prospects along the northwest extension of the dike were not deep enough to find commercial grades of mica and feldspar.

Martin mine.—This mine (Pl. 3, No. 11) is about half a mile southwest of the mine described above. It was operated by the Vicama Mica Company in 1922. It is reported that 25 tons of mica was taken from an open cut 20 feet long and 25 feet deep. The dike is about 10 feet wide and strikes N.50°W. It consists of a medial band of quartz 3 feet wide, flanked by kaolin intermixed with quartz and mica. Mica commonly occurs next to the quartz.

Dalton property.—Prospecting on this property, which is located 2 miles southeast of Axton (Pl. 3, Nos. 13 and 14), was done by the Vicama Mica Company, but little mica was found. A dike 25 feet wide, composed chiefly of microcline, is on this property. It offers possibilities for mining of feldspar.

Tyler mine.—This mine formerly worked by the Vicama Mica Company, is 7½ miles east of Axton, on the east bank of Sandy River. (See Pl. 3, No. 16.) The workings consist of a shaft 60 feet deep, from which a tunnel was made along the strike of the dike, which is N.70°W. The dike is 3 feet wide at the southeast end of the tunnel. The pegmatite is thoroughly decomposed. It is reported to have yielded 3 carloads of mica, most of which was scrap.

OTHER MINES AND PROSPECTS

Other mines and prospects north and east of Axton, were mostly developed by Messrs. Fields and Felman. They are on dikes, rarely more than 15 feet wide, composed of kaolinized feldspar, considerable quartz, and variable amounts of mica, commonly of scrap grade.

The Hairston mine 2½ miles north of Axton (Pl. 3, No. 1), is interesting because a contact zone 2 feet wide in the country rock is composed largely of tourmaline which occurs as isolated crystals 1 inch long and one-fourth of an inch in diameter, and in radiating tufts 6 inches in diameter. The dike is only 5 feet wide and narrows to 2 feet in a distance of 20 feet.

The mines and prospects in the Axton area may be briefly summarized as follows: Although there are 16 different workings, only one (mine 12) has proved to be a commercial possibility. In most of the others, prospecting has been limited to a few test pits, rarely over 20 feet deep, which have yielded a negligible amount of mica. The feldspar is generally thoroughly decomposed. The kaolin is rather impure, being mixed with quartz and ferruginous clay.

ALTAVISTA AREA

LOCATION AND ACCESSIBILITY

This area, as shown on the index map (Fig. 1) and a geologic map (Pl. 4), contains about 30 square miles. The Southern Railway and the Richmond-Danville highway traverse most of the eastern portion.

TOPOGRAPHY AND DRAINAGE

The topography is rather rugged, with elevations ranging from about 550 feet along Roanoke (Staunton) River to 1,100 feet on Jasper and Wheeler mountains.

Roanoke River and its tributaries, of which the chief is Old Woman's Creek, drain the area. The general direction of drainage is to the north.

ROCK TYPES

The rocks associated with the pegmatites in this area were mapped by Watson[63] as undifferentiated Cambrian with lenses of limestone. On the new geologic map of Virginia (1928), Anna I. Jonas has placed these rocks in the pre-Cambrian, mapping them as Wissahickon schist with lenses of Cockeysville marble.

The pegmatites were seen by the writer to occur in a conglomeratic biotite gneiss whose composition varies from granite

[63] Watson, T. L., Geologic map of Virginia: Virginia Geol. Survey, 1911. (Revised 1916.)

to quartz monzonite. It is a dark-gray gneiss, medium- to coarse-grained, with a porphyritic texture. The phenocrysts of feldspar and quartz range from a small fraction of an inch to several inches in diameter. Some of the larger ones resemble rounded pebbles. Most of them are elongated parallel to the schistosity.

The microscope shows the principal minerals of the wall rock to be quartz and feldspar, either of which may predominate. The feldspar is orthoclase and albite-oligoclase in about equal amounts, with a few scattered grains of microcline. Subordinate minerals are biotite and muscovite. The chief accessory minerals are magnetite, ilmenite, titanite, garnet, epidote, chlorite, kaolinite, and sericite.

Field relations, texture, and mineral composition suggest that the rock is a metamorphosed sediment, probably originally an arkosic conglomeratic sandstone. The sands may have been derived from a granite or a quartz monzonite.

Some diabase dikes were found. The limestones in this area were not studied, as they are not near commercial pegmatite deposits.

PEGMATITES

General features.—Pegmatite deposits are sparingly developed in this area and are largely confined to a belt 1 mile wide, which extends for 5 miles from the Jackson mine on the Virginian Railway, 1¾ miles west of Altavista, to the Motley prospect, 1 mile south of Motley Station on the Southern Railway. The Broomfield prospects are in the southwestern part of the area.

Occurrence.—The pegmatites are dikes, up to 40 feet wide, which strike N.35°-80°W. and dip 45° to 90°.

Mineral composition.—The chief minerals are feldspar and its decomposition product, kaolin. Quartz is the next most abundant mineral. Muscovite is found only sparingly. Garnet is indicated locally by limonite pebbles in kaolin. Tourmaline occurs in a few places along the contact in the wall rock.

MINES AND PROSPECTS

There are 6 mines and prospects in the Altavista area, 3 being in kaolin, 1 in feldspar, and 2 in feldspar and muscovite.

KAOLIN MINES AND PROSPECTS

Jackson mine.—This mine (Pl. 4, No. 1), on a bluff overlooking the Virginian Railway, consists in the main of a large opening, to a depth of 10 feet below the surface, at the intersection of two tunnels each 30 feet long, 8 feet deep, and 5 feet wide. The dike strikes N.35°E. and dips 40°-45°NW. It is lens-shaped, with a maximum width of 40 feet and a length of 300 to 500 feet.

The pegmatite is composed of kaolinized feldspar with quartz intergrowths. Quartz occurs also as stringers about 1 foot wide. The feldspar contains nests of partly decomposed garnet. Muscovite occurs in scaly bands and flakes intermixed with kaolin.

This clay has been described by Ries and Somers[64] as follows:

"The material (Lab. No. 2187) is coarse-grained and contains an abundance of quartz and coarse muscovite." . . . . .

"A sample was ground to pass through a ten-mesh sieve, and molded into bricklets. These had an air shrinkage of zero, and burned creamy white. They showed a moderate absorption and became steel hard at Cone 9. The details of these tests are as below:

Cone	Fire shrinkage Per cent	Absorption Per cent
03	1.0	18.5
1	1.6	16.8
9	3.3	13.7

"The material in its crude form could probably be used for common fire brick, if there is enough of it."

Motley prospect.—This clay deposit is exposed by a cut on the Southern Railway, 1 mile south of Motley. (See Pl. 4, No. 5.) It strikes N.50°E. and dips 45°SE. It is 45 to 50 feet wide, pinching out towards both ends.

The pegmatite is composed of kaolin intermixed with quartz and mica. The kaolin is stained by iron and manganese hydroxides. A few veins of almost fresh feldspar, from 8 to 12 inches wide, cut across the face of the deposit.

The wall rock, which is very schistose at this point, strikes N.60°W. and dips 60°NE. It contains small "eyes" of pegmatitic material near the contact. The pegmatite is also slightly schistose near the contact.

Ries and Somers[65] stated that the material here might make boiler-setting brick.

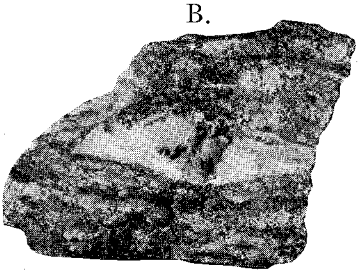
Broomfield prospects.—These prospects are half a mile south of Brights, in the extreme southwest part of the area. (See Pl. 4, No. 6.) There are 7 prospects in a quarter of a mile in a belt

[64] Ries, H., and Somers, R. E., The clays of the Piedmont province, Virginia: Virginia Geol. Survey Bull. 13, pp. 75-76 and Pl. XV-B, 1917.
[65] Op. cit., p. 75.

A.

C.

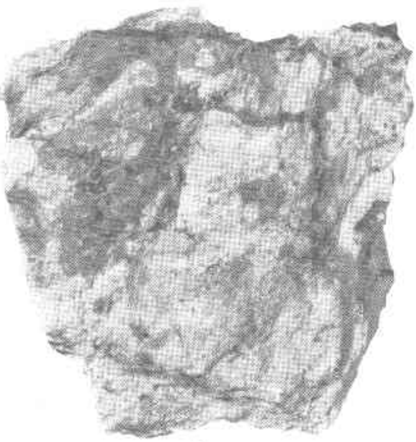
B.



A. Coarse-grained pegmatite showing feldspar (white) and quartz (gray), from the Ridgeway mine, one-fourth mile west of Ridgeway, Henry County. X ¾.

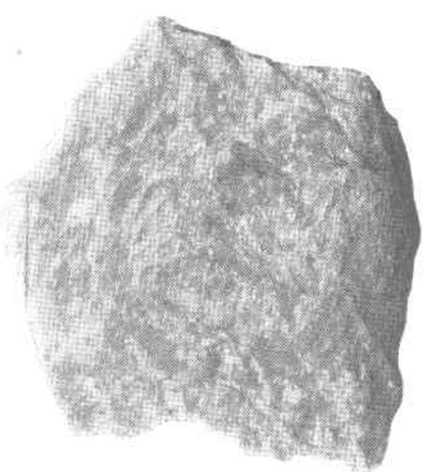
B. A lenticle of pegmatite in the biotite gneiss facies of the Wissahickon schist from the Ridgeway area. X ¾.

C. Fine-grained schistose pegmatite from the Pace mine, 2 miles west of Ridgeway, Henry County. X ¾.



A.

C.



B.

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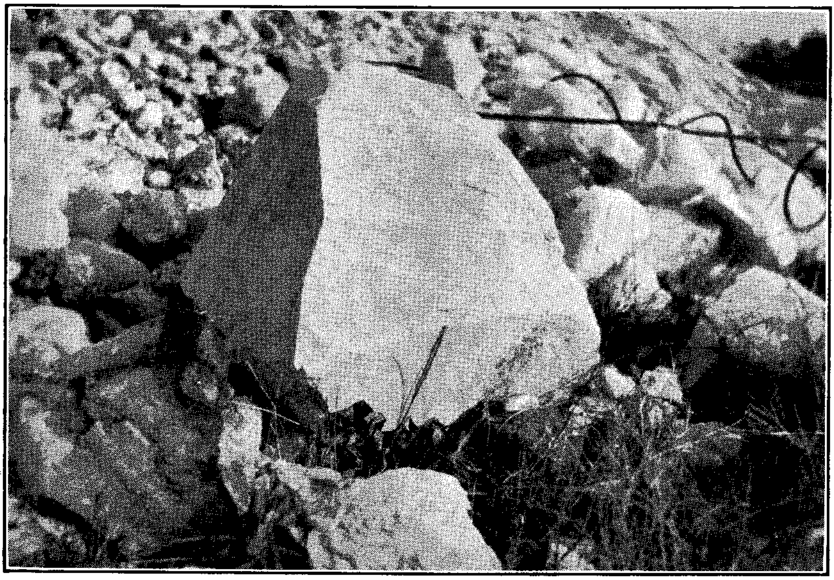
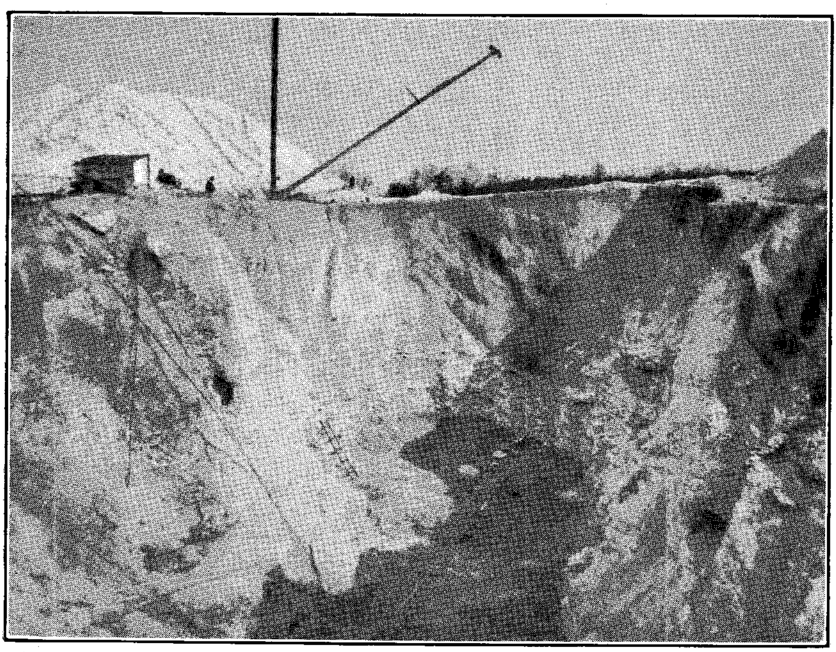
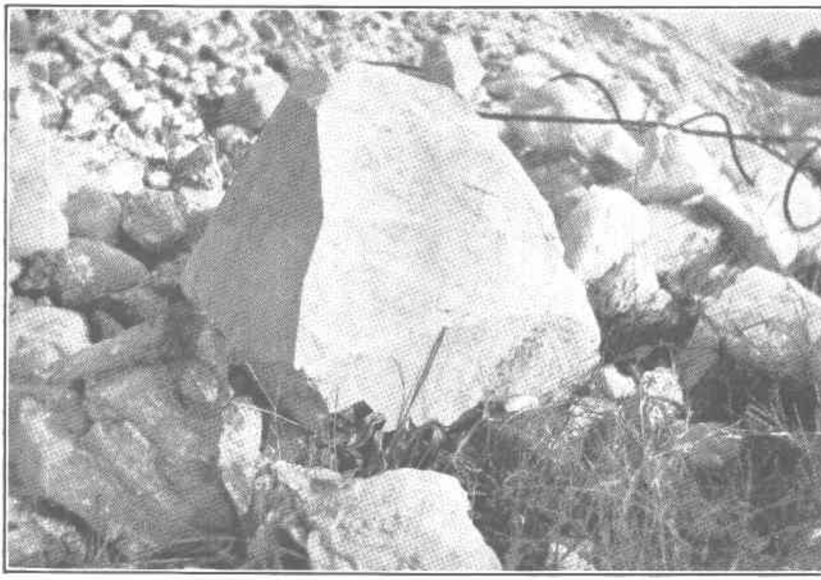


A. A crystal of feldspar from the Wheatly mine, 1 mile southeast of Moneta, Bedford County.



B. Open cut at the Wheatly mine, as it appeared in November, 1931.



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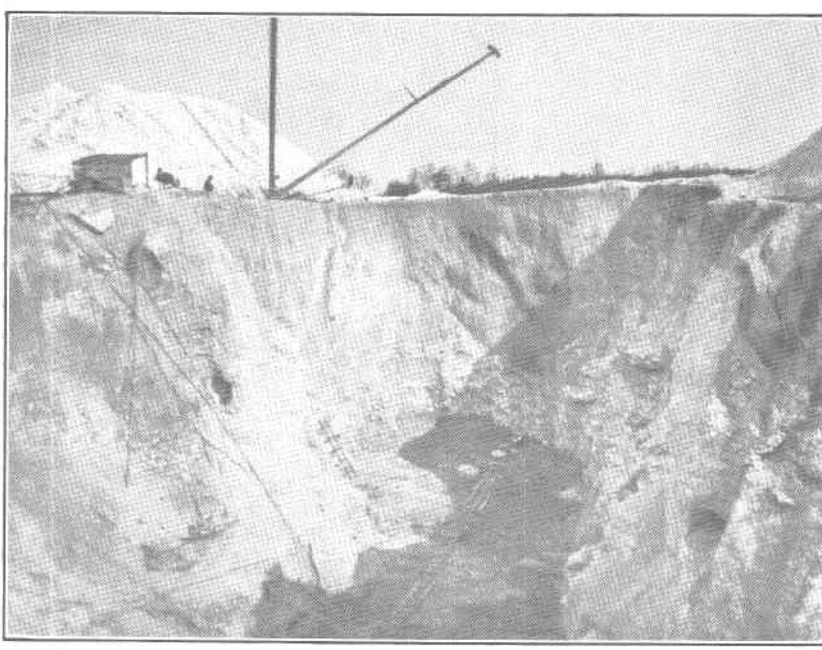
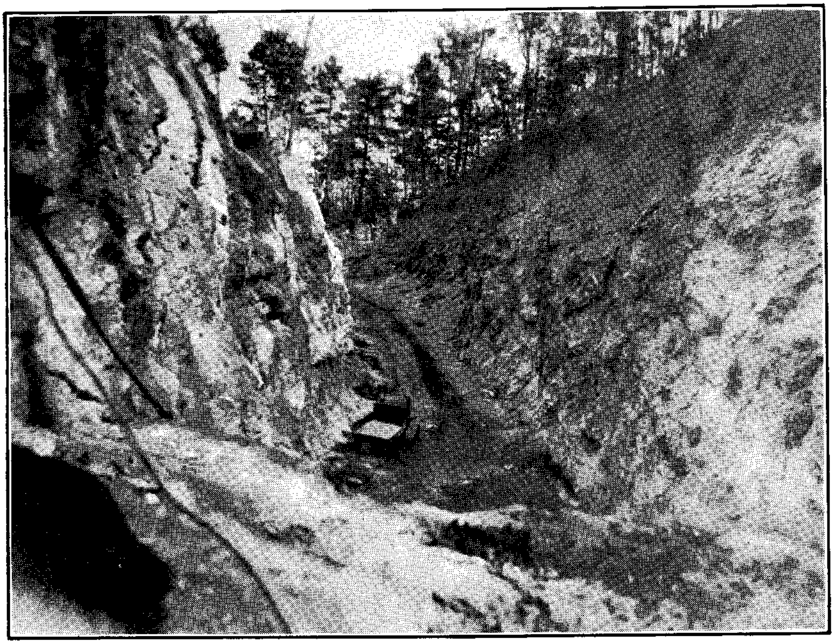
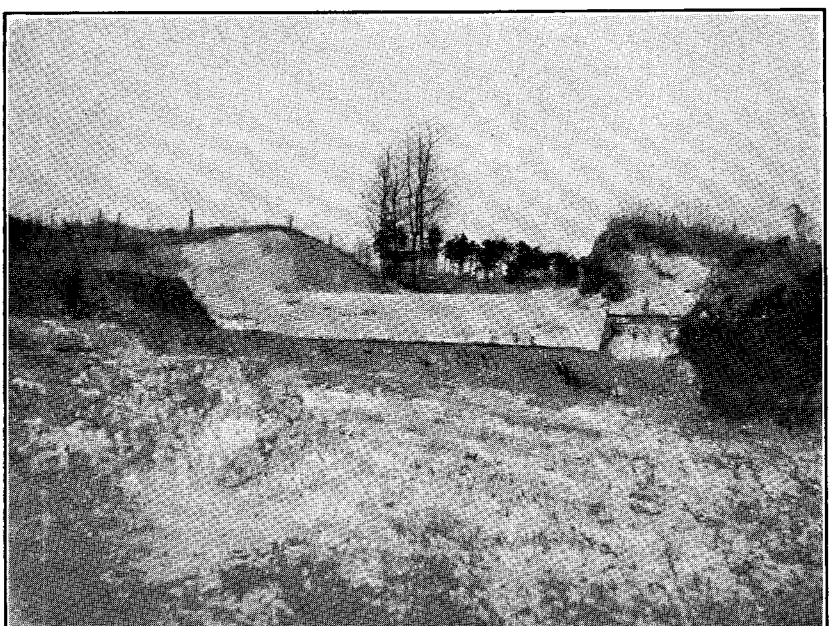


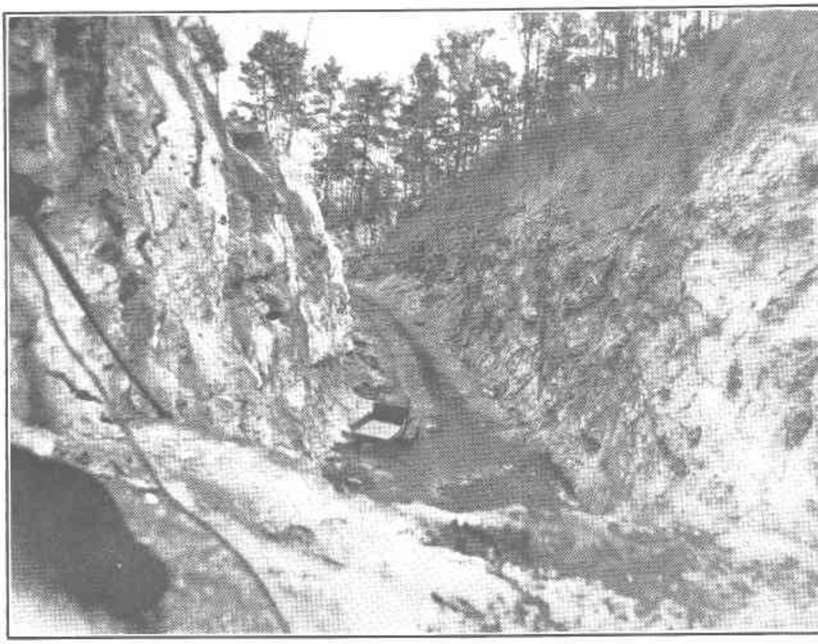
B. Open cut at the Wheatly mine, as it appeared in November, 1931.



A. Open cut in the Hottinger mine, 7 miles east of Bedford, Bedford County, as it appeared in November, 1931.

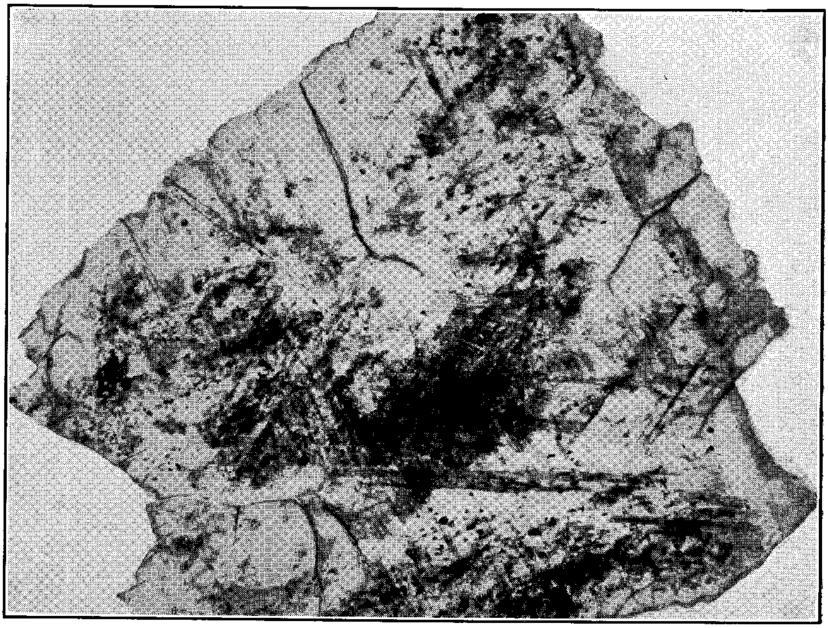


B. The Patterson prospect, 7 miles east of Bedford, Bedford County, as it appeared in November, 1931.

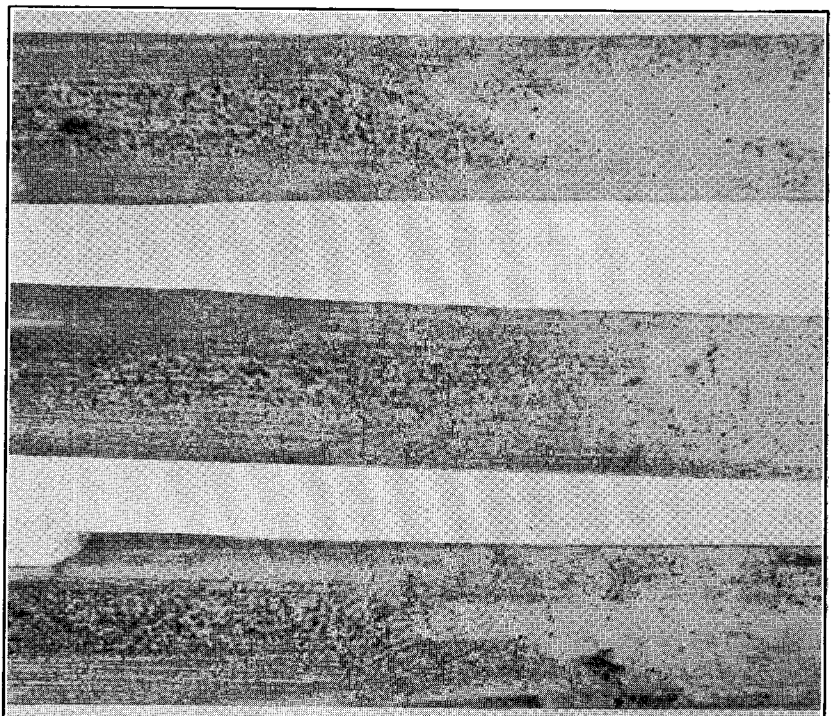


A. Open cut in the Hottinger mine, 7 miles east of Bedford, Bedford County, as it appeared in November, 1931.

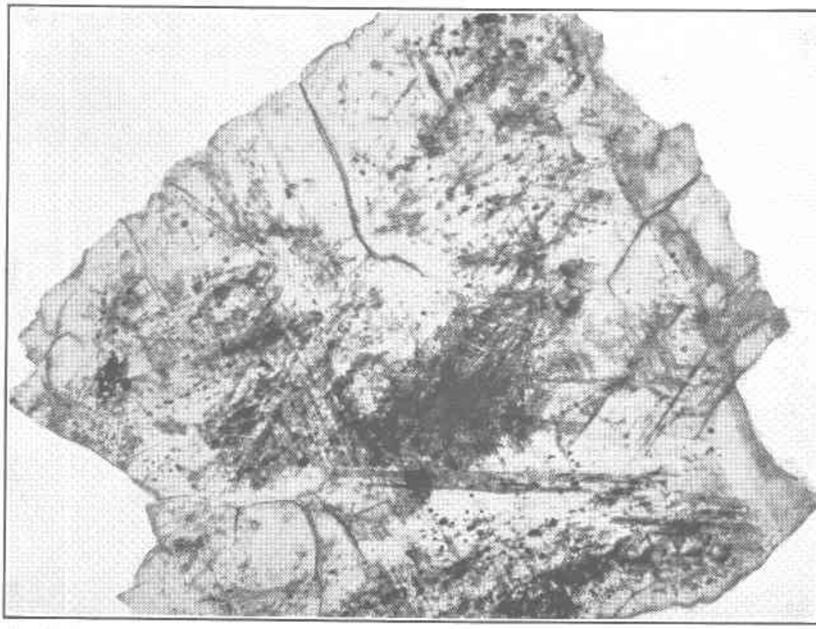
B. The Patterson prospect, 7 miles east of Bedford, Bedford County, as it appeared in November, 1931.



A. Mica from the Chestnut Mountain area, showing inclusions of manganese and hydrous iron oxides. X ¾.



B. Ribbon mica from the Bland mine, 2½ miles northeast of Amelia, Amelia County. X ¾.



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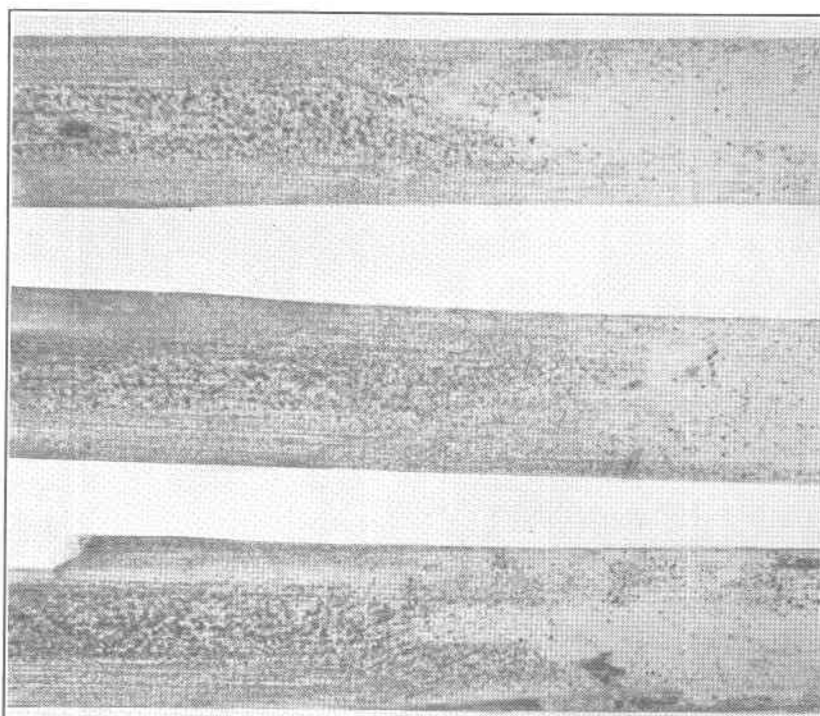


B. Ribbon mica from the Bland mine, 2½ miles northeast of Amelia, Amelia County. X ¾.

trending N.80°W. They consist of pits that are from 5 to 25 feet deep and from 5 to 10 feet wide. By each pit there was, in 1928, a mound of snow-white to reddish-white kaolin and a pile of mica that would weigh between 150 and 300 pounds. The kaolin appears to be of moderately good grade. The mica is of scrap grade, with the blocks averaging about 3 inches in diameter.

Float and soil indicate that the dike is 150 feet or more wide and one-fourth of a mile long. This may be a belt of several parallel dikes, but this could be determined only by prospecting.

FELDSPAR AND MICA MINES AND PROSPECTS

Farmer prospect.—This prospect is 1 mile north of Motley and 300 yards west of the Richmond-Danville highway. (See Pl. 4, No. 4.) The dike exposed here is 40 feet wide, and it is traceable for 300 yards along the strike of N.60°E. It is composed chiefly of feldspar, with some quartz and less muscovite.

The feldspar is light-gray to buff, and is in coarse crystals, the largest being 1 foot or more in diameter. Thin sections show it to be microcline with perthitic intergrowths of albite. An analysis of a specimen from this dike is given on page 38. The potash content of 9.52 per cent and the soda content of 2.59 per cent indicate that about one-fourth of the feldspar is albite.

The dike has been prospected at several points, at one place to a depth of 40 feet. Two carloads of feldspar were shipped for use in scouring soap.

Smith mine.—This mine is 2 miles southwest of the Jackson kaolin mine, on the east bank of a small stream. (See Pl. 4, No. 2.) It has caved in. The pegmatite here is 40 feet wide, strikes N.70°E., and dips 60°SE. It is chiefly buff microcline intergrown with quartz, in masses up to 6 inches in diameter. Quartz bands several feet wide are distributed irregularly through the dike. Muscovite occurs sparingly and irregularly. It is of a light-brown color and is frequently spotted. The pegmatite shows evidences of metamorphism, "eyes" of feldspar being surrounded by a granulated mixture of quartz, feldspar, and mica.

MONETA-BELLS DISTRICT

LOCATION AND ACCESSIBILITY

This district is mostly in Bedford County, the northeastern part being in Campbell County. (See Fig. 1.) It is a rectangular area 35 miles long and from 2½ to 5 miles wide. (See Pl. 4.) It is bounded on the southwest by Roanoke River and on the northeast by James River. The Virginian Railway crosses the southern part, and the Norfolk and Western Railway the northern part of the area. Moneta is in the southwestern part of the area, and Bells is in the west-central part.

TOPOGRAPHY AND DRAINAGE

The relief of the area is moderate, with elevations ranging from 500 feet along James River to 1,150 feet on Stone Mountain.

The southwestern three-fourths of the area is drained by Roanoke River and its tributaries, chiefly Goose Creek, Big Otter River, and Little Otter River. The general direction of drainage is to the southeast. The northeast quarter is drained by James River and its tributaries, mainly Ivy and Dreaming creeks.

ROCK TYPES

The prevailing rock type in this region is the Moneta gneiss, which consists of two distinct but closely associated facies, namely, (1) a hornblende diorite gneiss, and (2) a biotite-quartz monzonite gneiss. The intimate relationship existing between these two facies is shown in Figure 9.

PEGMATITES

General features.—The pegmatite deposits in the Moneta-Bells district present some striking contrasts to those of the other districts. The dikes are generally wider and more persistent along their strike. They can be traced farther, because the terrane is more rugged and the residual soil is not so deep as in the eastern Piedmont. They are more feldspathic, and muscovite occurs only in minor amounts. Hence the usual procedure is reversed, in that feldspar is mined primarily with muscovite as a by-product.

Occurrence.—The general mode of occurrence here is in dikes, although the tendency towards a lenticular form is very pronounced. This is shown at the Young mine (Pl. 4, No. 9), where the deposit is 300 feet wide but narrows to 30 feet one-eighth of a mile northeast of the mine. The dike exposed by the Wheatly mine has a maximum width of 125 feet which, 500 yards southwest of the mine, narrows to 50 feet.

The dikes are very persistent along their strike, for example, the one through the Young and Wheatly mines can be traced intermittently for 9 miles from Roanoke River on the southwest to Goose Creek on the northeast. Several dikes possibly dovetail into each other here. Some of the dikes seem to be very deep;

the Wheatly mine has been worked to a depth of from 75 to 100 feet, yet the pegmatite persists. The strike of the dikes is N.50°-65°E., and the dip ranges from 65°SW. to almost vertical, conforming as a rule with the strike and dip of the foliation of the enclosing rocks.

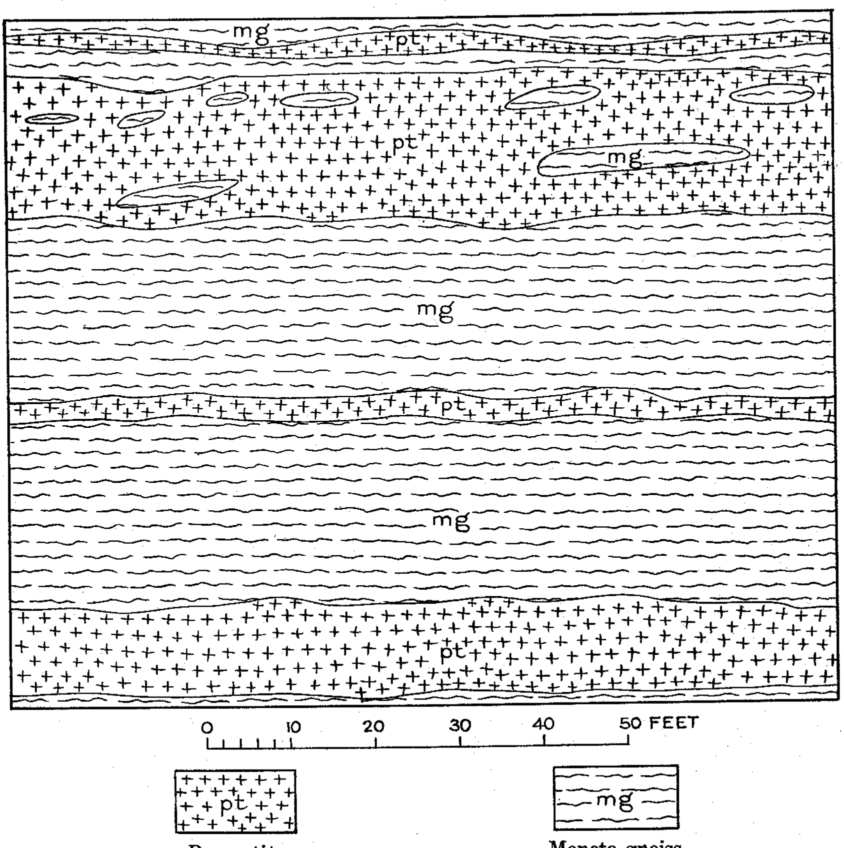


Figure 9.—Relation of pegmatite dikes and Moneta gneiss, near Bells, Bedford County.

Some of the deposits are elongated, interfingering, lenticular bodies. Lit par lit structure occurs locally, especially in the hornblende facies of the Moneta gneiss.

Texture.—The prevailing texture is coarsely granular, but in places it is coarsely graphic and locally it is medium-grained. A slightly schistose texture is developed locally along the contacts. The coarsely granular texture results chiefly from an intergrowth of feldspar and quartz with some muscovite. Some of the larger masses measure several feet across. In places the pegmatite is coarse-grained in the center and relatively finer grained towards the sides. Lenses of finer grained pegmatite are in places irregularly distributed through the coarse-grained material. A coarsely granular graphic texture, in which the masses are several inches thick and 6 inches square, is rather common. Not uncommonly the faces of the intergrown quartz and feldspar show distinct grooving along their contact.

Nature of contacts.—The contact, as shown by Figure 9, is generally sharp. The wall rock, in a few places, shows evidence of pegmatitic soaking. Inclusions of the wall rock in the pegmatite, varying from lenticular bodies 1 to 5 feet long to bands 4 feet wide and 10 feet long, are common. Some of them are partly absorbed, but generally they are only slightly affected. The wall rock also projects into the pegmatite at several places.

Mineral composition.—The pegmatites in the Moneta-Bells district are largely composed of feldspar and quartz, with feldspar dominant. Other minerals are muscovite, biotite, tourmaline, garnet, pyrite, and rutile.

Feldspar, composing 50 to 60 per cent of the mass, occurs commonly coarsely crystallized with quartz. The size of the masses, which average 1 foot in diameter, permits an easy separation from the quartz. One crystal (See Pl. 14, A) measured 18 inches in diameter. The feldspar is chiefly microcline, but orthoclase and albite are not uncommon. A series of 30 thin sections of specimens from the area shows microcline, or orthoclase reverting to microcline, almost invariably with perthitic intergrowths of a plagioclase feldspar (albite or albite-oligoclase). (See Pl. 8, A, B.) The plagioclase occurs as grains ranging from less than 0.1 to 0.5 millimeter, and as spindles distributed irregularly through the potash feldspars. Chemical analyses (p. 38) of two specimens from this area indicate that the potash feldspar contains from 20 to 25 per cent of the soda feldspar. Albite occurs also as irregular grains and masses ranging from one-tenth of an inch to several inches in diameter. The albite is commonly snow-white, but some is buff and cream-colored. The feldspar is generally strongly kaolinized to depths of from 15 to 20 feet, but is fresh below this depth.

Quartz occurs as irregular masses, ranging from a few inches to more than 12 inches in diameter, intergrown with feldspar and, to some extent, with muscovite. In some places it forms bands up to 12 feet wide. It is, as a rule, massive and jointed. Much of it has a waxy, translucent appearance not unlike paraffin.

Muscovite is rather scarce in the vicinity of Moneta, but is slightly more abundant in the dikes near Bells. It occurs as scales, flakes, and in books weighing not more than 10 pounds. It has the typical light-amber color. Biotite generally occurs near or at the contacts and locally along minor joint planes. Garnet occurs locally as isolated crystals, commonly in quartz, and as nests. Individual crystals range from one-tenth of an inch to 1 inch in diameter. Tourmaline is much rarer here than in the other deposits. A few crystals of rutile and pyrite were found at the Young mine.

Kaolin is abundant as a weathering product of feldspar. The upper 10 to 20 feet of many of the larger dikes and all of some of the smaller ones, at least to the depth of mining, consists of kaolin. The upper 2 to 3 feet is iron-stained, but below this depth the kaolin is snow-white. It contains considerable quartz, feldspar, and muscovite. Almost no effort has been made to market this kaolin, except near Forest.

MINES AND PROSPECTS

GENERAL FEATURES

The earliest prospecting in this area was in the neighborhood of Forest, Bedford County, then in the vicinity of Bells, but in recent years operations have been largely confined to the region around Moneta and Bells. The nature of the material mined has also varied, kaolin and mica being mined first, whereas feldspar has been almost the only mineral mined in the last few years. The present operations were begun in the spring of 1923 by the Moneta Mining and Mineral Company. This company has been succeeded by the Clinchfield Sand and Feldspar Company. At present the Moneta-Bells district is the main source of feldspar in the State. Two large quarries are being operated near Moneta and one 7 miles east of Bedford, and extensive prospecting has been done in the vicinity of Bells.

MONETA AREA

Wheatly mine.—This mine is 1 mile S.45°E. of Moneta. (See Pl. 4, No. 11.) It was first operated about 1924 by the Moneta Mining and Milling Company. Later it was bought by Wesley Hicks, of Bedford, and leased to the Seaboard Feldspar Company which is now operating it. The workings in November, 1931, consisted of an open cut 300 feet long, 150 feet wide, and 100 feet deep. The material is loosened by blasting and by pick and shovel, and is raised by a derrick and crane. It is then hauled by trucks to the Virginian Railway, whence it is shipped to the grinding mill at Brookneal.

The dike, so far as could be determined, is about 900 yards long and 125 feet wide at a maximum. It narrows in both directions until it apparently pinches out. (Pl. 14, B.) This pinching is shown on the northeast wall of the open cut. The dike strikes N.63°E. and dips almost vertically. The pegmatite is composed chiefly of a white feldspar, with a very light-green tinge, in masses that average about 1 foot in diameter. The most recent work has revealed some rather fine crystals, one on the dumps measuring 18 inches in diameter. (Pl. 14, A.) The next most abundant mineral is quartz, which is often translucent and has a paraffin-like appearance. It is intergrown with feldspar and, in one place, forms a band 12 feet wide near the middle of the dike. Muscovite occurs sparingly and biotite is occasionally developed along fracture planes. Garnets are also found.

The feldspar is almost wholly of the potash variety, with perthitic intergrowths of albite. Three analyses made by the owners gave the potash content as 11.92, 12.80, and 13.90 per cent, and an analysis made by J. H. Yoe, Chemist of the Virginia Geological Survey, showed 12.23 per cent potash and 3.51 per cent soda.

Young mine.—This mine is 1 mile south of Moneta and three-fourths of a mile southwest of the Wheatly mine. (See Pl. 4, No. 9.) It was first worked about 1923 by Mr. Young, but is now operated by the Seaboard Feldspar Company. In November, 1931, there were three open cuts about 150 feet apart, on the southwest side of a small stream. The middle cut appears to have been made on the main dike and was the first one opened. The open cut is approximately 150 feet long, 25 feet wide, and 35 feet deep. The material was formerly loosened by blasting and by pick and shovel, and hauled to the top by small cars operated by an engine and cable. The mine is now abandoned. The dike revealed here is about 50 feet wide, but 300 yards northeast of the opening, it narrows to 25 feet, and 500 yards northeast of the opening, to 10 feet. It strikes N.55°E. and has a steep southeast dip.

The opening on the northwest side of this dike shows three separate dikes, each 15 feet wide, that appear to be offshoots of the main dike. The opening on the northwest side is the most recent one and was being operated in November, 1931. The workings at that time consisted of an open cut 50 feet deep, 35 feet wide, and 75 feet long. The dike here is apparently an offshoot of the main dike, being nearly as wide but having a more easterly strike.

The composition of the pegmatite here is similar to that in the Wheatly mine. In addition, small quantities of pyrite and rutile were observed.

The Young and Wheatly mines have not exhausted the supply of feldspar in this area.

Hales Ford prospects.—These prospects (Pl. 4, No. 7) mark the southeastern end of the Moneta deposits, although small deposits along this same general strike occur in Franklin County. The dike crops out in Roanoke River a short distance east of Hales Ford bridge. It is exposed also in the road, where it consists of three members, 10, 50, and 60 feet wide. The pegmatite consists largely of quartz, with some feldspar and less muscovite. Garnet is rather abundant. The feldspar on the surface is not of commercial grade.

Nance and Woolridge prospects.—These prospects (Pl. 4, Nos. 12, 13, and 14) are near the northeastern end of the dike, or series of dikes, extending from Roanoke River to Goose Creek. The dike here is 30 feet wide and strikes N.60°E. It is very similar in composition to the dike to the southwest. The feldspar is microcline which, in places, is perthitic. No outcrops of this dike were found northeast of Goose Creek.

Nichols prospect.—This prospect is 2 miles south of Moneta on the W. C. and H. W. Nichols property. (See Pl. 4, No. 8.) The dike widens from 15 to 30 feet in a distance of 100 feet. It is composed of feldspar (chiefly microcline), quartz, and considerable muscovite. The feldspar on the surface is not of commercial grade, and the muscovite could be sold only for scrap. Both minerals may improve in quality, with depth.

BELLS AREA

Bells prospects.—These prospects are from three-fourths of a mile to 1 mile south of Bells on the east bank of Big Otter River, Bedford County (See Pl. 4, No. 19.) Prospecting was begun here about 15 years ago and shipments of feldspar were made from time to time. Extensive prospecting had been done in 1928 by the Clinchfield Sand and Feldspar Company, and had revealed 5 dikes. (See Fig. 9.) A small dike, which crops out at the river, is 5 to 15 feet wide. It is composed chiefly of coarse-grained feldspar, some quartz, and minor amounts of muscovite and biotite. The wall rock projects into the dike in a series of bulges. Twenty feet to the southeast a dike 100 feet wide crops out. It can be traced for half a mile northeast of the river. Along the southwest contact it contains inclusions (horses) of the wall rock, some of which are several feet in diameter. It is similar in composition to the first-mentioned dike. Another dike 150 feet to the southeast is 15 feet wide. About 150 feet farther southeast, a dike 40 feet wide contains more muscovite than the other dikes. Some of the blocks are 1 foot in diameter. Two carloads of mica had been mined in the summer of 1928. This dike has been prospected half a mile southwest of this point on the Truxtall property. The fifth dike, 100 feet southeast of the fourth, is 25 feet wide. It is finer grained than the other dikes.

These dikes, as a rule, strike N.50°E. and dip about 60°SE. The feldspar, as shown in thin sections, is chiefly microline with perthitic intergrowths of albite. A chemical analysis made by John H. Yoe, shows 12.07 per cent of potash and 1.80 per cent of soda, indicating a high grade of feldspar. Feldspar from the second dike mentioned above is of the best grade. The first dike mentioned above contains considerable soda feldspar free from potash feldspar.

Apparently a large quantity of feldspar, which is of as good grade as that being mined near Moneta, was available here in 1928.

This area was revisited in November, 1931, when it was found that work had been resumed in September, 1931, on the dike nearest the river. Two shafts about 25 feet apart had been dug along the strike of the dike, into the steep river bank. Several carloads of feldspar were reported to have been shipped. About one-fourth of a mile southeast of this prospect, considerable work had been done also on a dike apparently parallel to the five dikes described above. This dike is 50 feet wide, strikes N.50°E., and dips steeply to the southeast. This deposit was worked for about two years by the Seaboard Feldspar Company, during which time a pit 150 feet long, 25 feet wide, and 50 feet deep was excavated. The work was discontinued several weeks previous to this visit, because the deposit had been practically exhausted. The minerals in the dump were similar to those already described, except that garnet was rather abundant. Some of the largest crystals were 6 inches in diameter. The feldspar from this mine was hauled by trucks to Goode, a station on the Norfolk and Western Railway. It was then shipped to the grinding mill at Brookneal. It is reported that a large amount of a good grade of feldspar was mined here.

Hottinger mine.—This mine is in Bedford County about 7 miles east of Bedford and 2 miles north of Otter Hill, and several hundred yards southwest of Little Otter River. (See Pl. 4, No. 25.) It is on John Mitchell's property and is operated by the Seaboard Feldspar Company. At the time of the writer's visit in November, 1931, it had been in operation about two years. The workings consist of an open cut along the strike of the dike, several hundred feet long, 23 feet wide, and 50 feet deep. (Pl. 15, A.) Its location on the side of a hill makes it possible to drive trucks into the open cut, for loading.

The dike strikes N.27°E., dips nearly vertically, and has a maximum width of about 50 feet. It narrows, within 300 yards, to 35 feet.

The pegmatite is composed chiefly of a white feldspar, having a very light-greenish tint, and translucent quartz that has a light-smoky tint. Muscovite occurs in small amounts and biotite is developed along fracture planes. Garnet and pyrite are also present. Some of the largest feldspar masses are 3 feet in diameter, although diameters of 6 inches are more common. The material is hauled by trucks to Bedford.

Patterson prospect.—This prospect is a few hundred yards northwest of the Hottinger mine, on the opposite side of a small stream. The work done here has been of an exploratory nature. (Pl. 15, B.) The dike appears to be 125 feet wide, with a strike nearly parallel to the dike which contains the Hottinger mine. The composition of this pegmatite is similar to that of the pegmatite just across the stream.

Otter Hill prospects.—These prospects are 3 miles southwest of Bells (Pl. 4, No. 18), west of Big Otter River, on the northwest bank of Falling Creek. They are apparently the ones described by Sterrett[66] as follows: "The deposit was worked by an open cut 40 feet long, and 20 feet in greatest depth, and a shaft, now filled with water, reported to be 30 feet deep, in the end of the cut. The open cut was driven northwestward into a hillside about 30 feet above a creek. A hoist was arranged over the shaft, and a tram extends from it to the shop and storehouse, about 40 feet to the northwest." He suggested that the mine could have been worked to better advantage from a lower level on the hillside about 75 feet to the southwest. Apparently acting on this advice, 5 pits were dug along the southwest extension of the dike.

The dike is 25 to 30 feet wide, strikes N.30°E., and dips nearly vertically. It is composed chiefly of kaolinized feldspar and disintegrated quartz, with muscovite scattered through it in books,

[66] Sterrett, D. B., Mica deposits of the United States: U. S. Geol. Survey Bull. 740, p. 318, 1923.

rarely more than 1 foot in diameter, and in tablets. The muscovite is chiefly of scrap grade. A mass of garnet crystals, reported from this mine, and shown to the writer, weighed 20 pounds and contained some crystals 6 inches in diameter.

Harris prospects.—These prospects (Pl. 4, Nos. 20 and 21) are 4 miles southwest of Forest. They are three-fourths of a mile apart, apparently on different dikes. The eastern one is on a dike about 75 feet wide, and the western one is on a dike 25 feet wide. These dikes consist chiefly of feldspar and quartz in coarse grains, becoming finer grained at the contact. Thin sections show the feldspar to be a perthitic microcline, similar to that found near Moneta.

Feldspar deposits are exposed northeast and southwest of these prospects, probably being a part of the pegmatization which reaches its maximum slightly south of Bells.

FOREST AREA

The dikes in the area near Forest, Bedford County, have been worked chiefly for kaolin, and to some extent for mica. None of the mines are deep enough to reach fresh feldspar.

Everett prospect.—This prospect is 2 miles southwest of Forest on the strike of one of the dikes exposed on the Harris property. (See Pl. 4, No. 22.) It is an open cut 150 feet long, 30 feet wide, and 60 feet deep. Several carloads of kaolin were shipped from here for making pottery. The dike is at least 15 feet wide and strikes N.36°E., but the strike changes to N.85°E. at the northeastern end of the cut. The deposit is chiefly kaolinized feldspar, mixed with quartz fragments and clay, and with some mica and garnet.

Radford prospect.—This prospect is 2 miles northeast of Forest. (See Pl. 4, No. 23.) The dike is 10 feet wide and strikes N.50°E. It is similar in composition to the dike exposed at the Everett prospect.

Ivy prospect.—This deposit is 3 miles north of Forest. (See Pl. 4, No. 24.) Some of the earliest work in the area was done here. Prospects have been made on two parallel dikes 200 feet apart, which strike N.60°E. The northwestern dike is 15 feet wide and the southeastern dike is 25 feet wide. These dikes are similar to others exposed in the area. They have been worked for kaolin and muscovite, neither of which is of good grade.

CHESTNUT MOUNTAIN AREA

LOCATION AND ACCESSIBILITY

This area is in Franklin County, on the southeastern slope of Chestnut Mountain, 11 miles southeast of Rocky Mount. (See Fig. 10.) The area mapped comprises less than 1 square mile which is crossed by a secondary road.

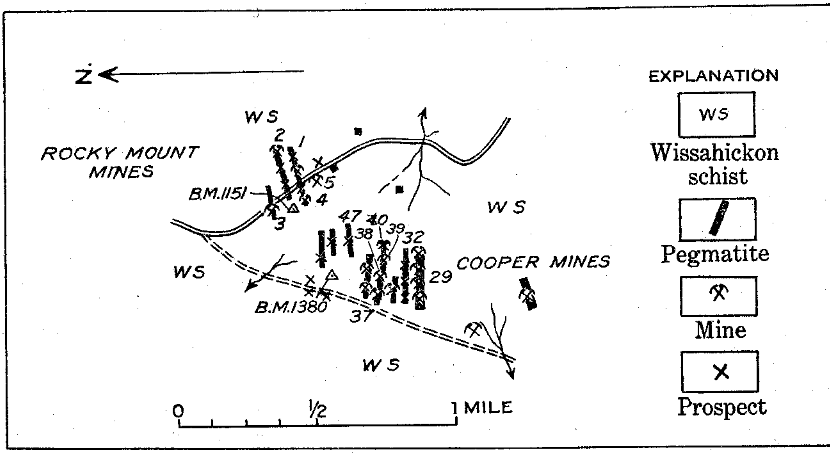


Figure 10.—Sketch map of mines and prospects on Chestnut Mountain, Franklin County.

TOPOGRAPHY AND DRAINAGE

This area has rugged topography, with elevations ranging from less than 1,000 feet along the foot of the mountain to more than 1,500 feet along the crest. It is drained by small streams that flow into Toms Creek and Keaton Branch, tributaries of Snow Creek.

ROCK TYPES

The only rock associated with the pegmatites in this area is a weathered, iron-stained quartz-mica schist belonging to the Wissahickon formation. This schist is a brown to red-brown, mottled rock. It is composed chiefly of iron-stained muscovite and quartz, with minor amounts of epidote, garnet, tourmaline, magnetite, chlorite, and limonite.

PEGMATITES

General features.—The pegmatites of the Chestnut Mountain area are thoroughly decomposed, and the weathered residue is so intermixed with clay that the deposits are largely obscured on the surface. On the other hand, this disintegration of the pegmatites has made the removal of mica very easy, so that these deposits have been thoroughly exploited, at least to water level.

Occurrence.—Wherever observed, the pegmatites have a dikelike form, but there are some lenticular bodies. The workable dikes range from 10 to 30 feet wide, and are traceable in some places for 600 feet. The strike is variable, although it is most commonly northwest. Most of the dikes cut across the schistosity of the enclosing rocks, which strikes northeast.

Texture.—The original texture is obscured by the thorough weathering of the pegmatites. The prevailing type appears to have been coarsely granular.

Nature of contacts.—The contacts of these pegmatites are commonly marked by a distinct zone several feet wide, composed of a granular, friable mixture of sugary quartz, medium-grained scaly muscovite, and columnar tourmaline. This relatively finer grained material is in places sharply separated from the coarser grained pegmatite.

Mineral composition.—The chief constituents of these deposits are kaolinized feldspar, quartz, and muscovite, with variable but minor amounts of garnet and tourmaline.

Kaolin occurs as a powdery, white to reddish-white material mixed with red clay, quartz, muscovite, and partly decomposed feldspar. The feldspar, wherever it can be identified, is mostly orthoclase and microcline, rarely albite. The kaolin is too impure to be of commercial value.

Quartz is abundant, as intergrowths with partly decomposed feldspar, muscovite, and tourmaline. It is found also in stringers, some 10 feet wide, irregularly distributed through the pegmatite. It is colorless to smoky-gray.

Muscovite occurs as books, some of which are more than 1 foot in diameter, and as scaly masses. It is commonly light-amber in color. Not uncommonly this mica is marked by brown to black frayed lines that cross each other at diverse angles, and by irregular mosslike spots. (See Pl. 16.)

Garnet, in the form of limonitic pellets, is found in the weathered feldspar and in the contact zone. Tourmaline is abundantly developed in the contact zone, where it occurs in a matrix of muscovite and quartz, as jet-black crystals half an inch to 1 inch in diameter and 6 inches long. It occurs also in the pegmatite as reticulated masses, with quartz in the interstices.

MINES AND PROSPECTS

General features.—Although the Chestnut Mountain area is small, much mica, chiefly of scrap grade, has been mined here. One dike is reported to have yielded more than 400 tons. Considerable sheet mica, the largest pieces measuring 6 by 6 inches, has been cut. The peculiar markings described above have been detrimental.

The operations, which were most extensive from 1917 to 1920, were largely confined to an area about three-fourths of a mile northwest of Beekers Church (at B. M. 1151 and point 1380, Rocky Mount sheet). More than 50 mines and prospects were in this area. The deposits seem to be exhausted. The abundance of mica in these pegmatites may indicate that other deposits exist in this area, although they will be difficult to find because of the deep weathering of the bedrock.

Deposits along the Rocky Mount road.—The workings along the Rocky Mount-Martinsville highway (Fig. 10, Nos 1-5), consist of trenches, shafts, and tunnels. The largest trench is 60 feet long, 12 feet wide, and 20 feet deep. It is reported that 100,000 pounds of mica was taken from it, some of which yielded sheets that cut 6 by 6 inches. The dike exposed here strikes N.65°W., and is 15 to 20 feet wide. It consists of kaolinized feldspar, quartz, and muscovite.

Cooper mines.—These mines along the mountain road are on a single dike. (See Fig. 10, Nos. 37-40.) The workings consist of 10 shafts connected by tunnels along the strike of the dike, over a distance of 600 feet. The deepest workings are 135 feet deep. More than 400 tons of mica is reported to have been taken from this dike. The dike is 30 feet wide, strikes N.75°W., and dips at one place 50°NE. It is composed of deeply kaolinized feldspar, quartz, and muscovite.

MISCELLANEOUS MINERAL DEPOSITS

GENERAL STATEMENT

The several areas described above include the most important pegmatite deposits in Virginia. In addition, several isolated deposits have been worked or prospected for various minerals. The principal ones are discussed briefly according to the chief mineral, or minerals, for which they have been worked.

OTHER FELDSPAR DEPOSITS

Location.—Some prospecting has been done in Charlotte County near the Virginian Railway. It has been confined to the formation mapped as Wissahickon schist, which contains granitoid to gabbroic intrusions.

Morton prospect.—This prospect is on the property of Dr. G. V. Morton, 2 miles south of Abilene on the Virginian Railway. The pegmatite for 300 yards strikes N.50°E. and has an average width of 15 feet. It consists essentially of equal amounts of feldspar and quartz. The feldspar is microcline with spindles of albite. Muscovite occurs sparingly.

The deposit is of doubtful value because of the high content of quartz and the small size of the dike.

Davis prospect.—This prospect is on the Davis property, 3 miles north of Cullen, on Wards Fork, a tributary to Roanoke River. The dike here is 10 feet wide, strikes N.60°E. for 500 yards, and dips 45°NW. It is similar in composition to the dike on the Morton property.

EMERY DEPOSITS

Location.—The emery deposits are in the north-central part of Pittsylvania County on the west side of the Southern Railway, 2 miles west and northwest of Whittles, and 20 miles north of Danville. They are the only known deposits of emery in the State

Associated rocks.—The rocks associated with the emery deposits include the Wissahickon schist and Leatherwood granite, intruded by dikes of hornblende gabbro and pegmatite. The Wissahickon schist is a schist-gneiss complex composed of three facies, garnetiferous mica schist, hornblende schist, and biotite gneiss. The Leatherwood granite occurs as irregular bodies in the schist, and not uncommonly as injection bands, forming a lit par lit structure. Much of this granite is porphyritic. The hornblende gabbro occurs as dikes, flanked on both sides by pegmatite dikes. The largest one is 35 feet wide. Pegmatites have been injected at several places into the schist-gneiss complex. They strike generally N.30°E., have a variable southeast dip, and are 30 feet wide. The pegmatites are medium-grained and are composed of feldspar, quartz, and greenish mica. These pegmatites are similar in appearance to many of the dikes in the Ridgeway area. Some of the smaller dikes cut the emery bodies.

Ore bodies.—According to Watson,[67] there are two types of ore bodies, namely, (1) in the schist, and (2) in the granite. The first type has furnished most of the workable deposits. Both types are near or at the pegmatite contacts. The ore bodies generally conform to the structure of the enclosing rocks, but in places they cut across the schistosity. They are rudely tabular with a steep southeast to vertical dip. The largest bodies discovered are from 6 to 8 feet wide and 130 feet long. The greatest depth reached by mining has been 40 feet. Many of the bodies show pinches and swells.

Microscopic study by Watson [68] showed the ore to be a spinel emery consisting of a fine-grained interlocking aggregate of spinel, magnetite, and corundum, with some ilmenite. About 50 per cent of the rock consists of spinel. Magnetite is next most abundant and corundum averages about 18 per cent.

According to Watson,[69] the ores represent metasomatic replacement deposits formed under conditions of high temperature and pressure, the emanations having arisen from the magma which produced the pegmatites. He states also that tests made on the Virginia emery, at the Bureau of Standards, show it to be the equal in every way to Turkish emery and superior to the Peekskill, New York, emery.

CASSITERITE DEPOSITS

These deposits are at the head of Irish Creek, on the west slope of and near the summit of the Blue Ridge in Rockbridge County. They are described by Ferguson,[70] who states that cassiterite is the tin-bearing mineral of the deposits. It is found in quartz veins that cut the hypersthene granodiorite, and in the adjacent altered granodiorite. In addition to quartz and cassiterite, the deposits contain arsenopyrite, siderite, wolframite, scheelite, muscovite, fluorite, and beryl.

ALLANITE DEPOSITS

According to Watson,[71] "Allanite is known to occur in at least 7 counties in the State. They are Amelia, Amherst, Bedford, Fauquier, Nelson, Page, and Roanoke counties." The Amherst deposits have been the main sources of this rare mineral in the United

[67] Watson, T. L., A contribution to the geology of the Virginia emery deposits: Econ. Geology, vol. 18, pp. 53-76, 1923.
[68] Op. cit., p. 76.
[69] Op. cit., p. 74.
[70] Ferguson, H. G., Tin deposits near Irish Creek, Virginia: Virginia Geol. Survey Bulletin 15-A, 1918.
[71] Watson, T. L., Weathering of allanite: Geol. Soc. America Bull., vol. 28, p. 475, 1917.

States. The other deposits are small and are of scientific interest only. There are no figures available on the production of allanite, but some of the dealers in minerals obtain their supply of allanite almost exclusively from Amherst County.

The allanite occurs at two widely separated places in Amherst County, namely, (1) on the property of Lucien Burley, 3 miles N.55°W. of Amherst, and (2) on the property of J. W. Campbell, 14 miles slightly west of north of Amherst, on the northeast slope of Friar Mountain.[72] As the mode of occurrence of allanite is very different in the two tracts, the tracts will be discussed separately.

LUCIAN BURLEY TRACT

Location.—This area is best reached by following State Highway No. 13 northwest of Amherst for about 5 miles, and then going southwest on a side road for one-fourth to half a mile. The main deposits are on Mr. Burley's property, although some allanite has been found on adjoining properties.

Occurrence.—The allanite occurs here very irregularly in pockets in hypersthene granodiorite. It was found as large irregular masses, some of which weighed 500 pounds. Numerous pits from which it had been taken have an alignment of N.30°E.

The allanite here is associated with the titanium minerals, rutile, ilmenite, and tcheffkinite.[73] It is massive, black, and has a dull to pitchy luster. Pitchy-black narrow bands are found in dull-black portions. The allanite is commonly partly altered on the surface to a brown earthy mineral. Ilmenite was found by the writer in one of the pits from which allanite had been taken, and a specimen of allanite intergrown with rutile was presented to him by Mr. Burley. A dike of nelsonite, closely associated with the allanite deposits, is 30 feet wide, and is traceable for 1 mile along a strike of N.30°E. Rutile and ilmenite are also disseminated through the associated rocks. The prevailing country rock is quartz monzonite containing injections of granite and pegmatite. Pyroxenite is found in places.

JOHN CAMPBELL TRACT

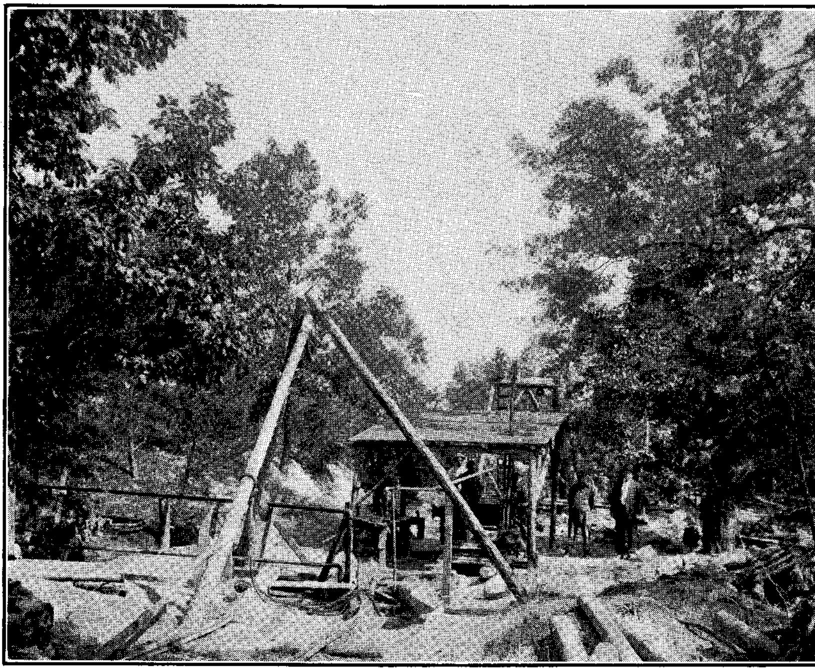
Location.—It is difficult to reach these deposits. The best plan in 1928 was to follow the road which passes through Lowesville, up

[72] See the topographic map of the Lexington quadrangle, 1894.

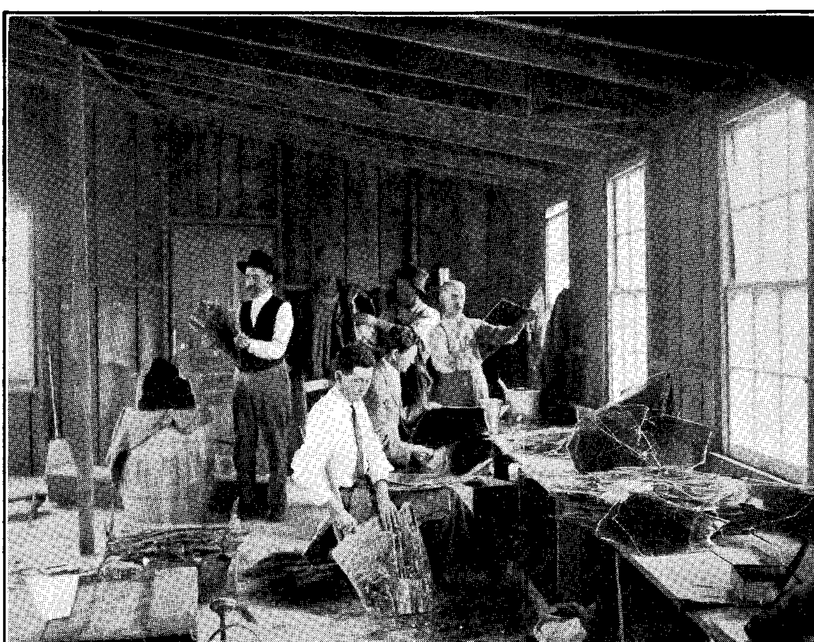
[73] Tcheffkinite was identified by H. C. Joyner, of Amherst, who made chemical analyses of allanite and associated minerals. Mr. Joyner claims that it is intergrown with allanite.

Mica from Ridgeway, Henry County, showing size of sheets and the "A" structure.

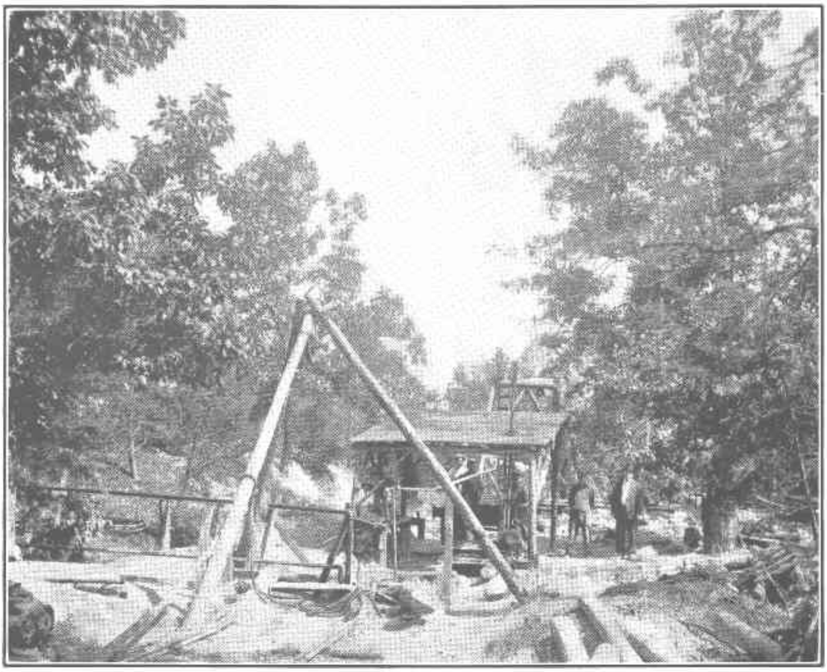
Mica from Ridgeway, Henry County, showing size of sheets and the "A" structure.



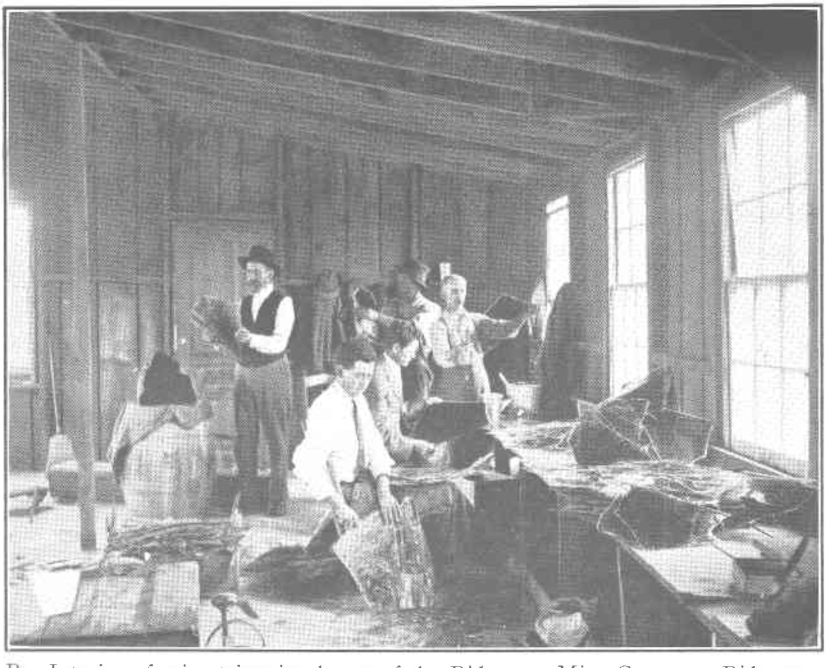
A. Surface equipment of Champion No. 2 mica mine, 2½ miles northeast of Amelia, Amelia County. (Courtesy of U. S. Geological Survey.)



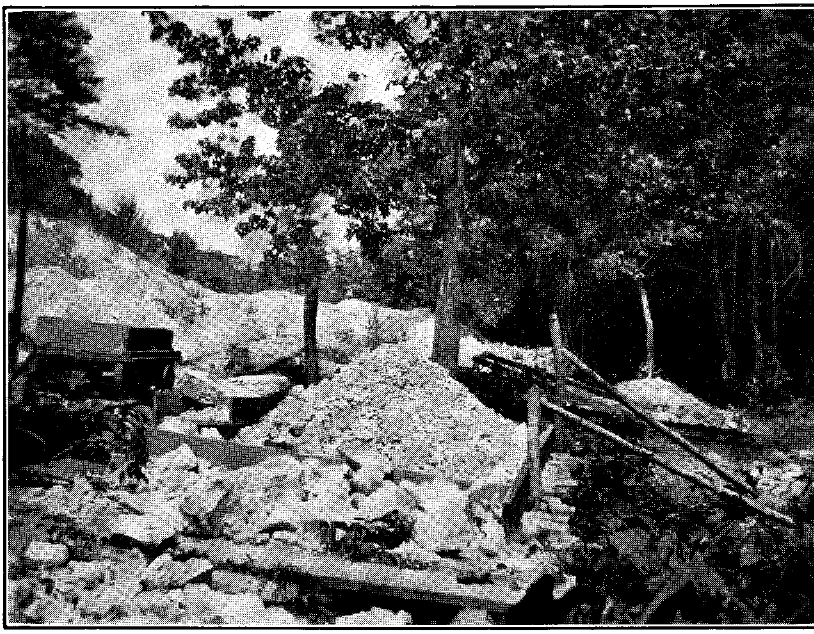
B. Interior of mica trimming house of the Ridgeway Mica Company, Ridgeway, Henry County. (Courtesy of U. S. Geological Survey.)



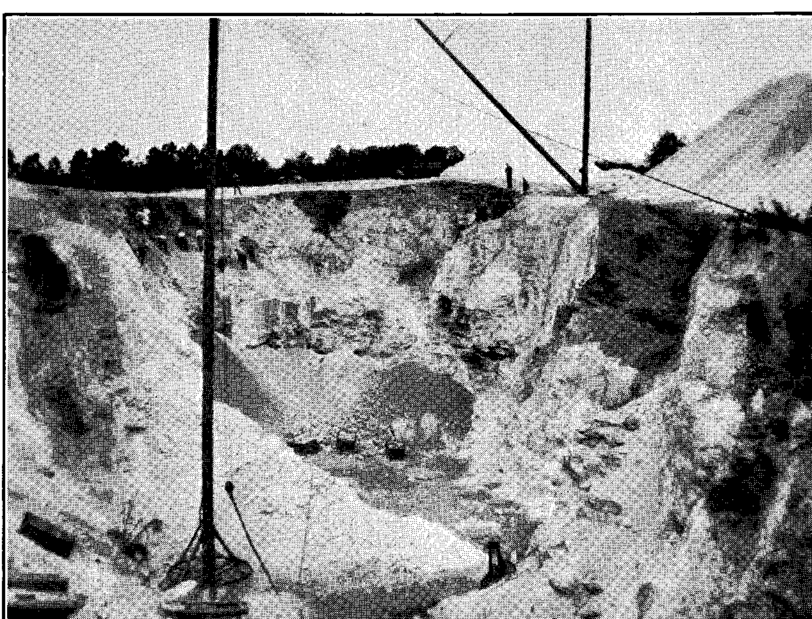
A. Surface equipment of Champion No. 2 mica mine, 2½ miles northeast of Amelia, Amelia County. (Courtesy of U. S. Geological Survey.)



B. Interior of mica trimming house of the Ridgeway Mica Company, Ridgeway, Henry County. (Courtesy of U. S. Geological Survey.)

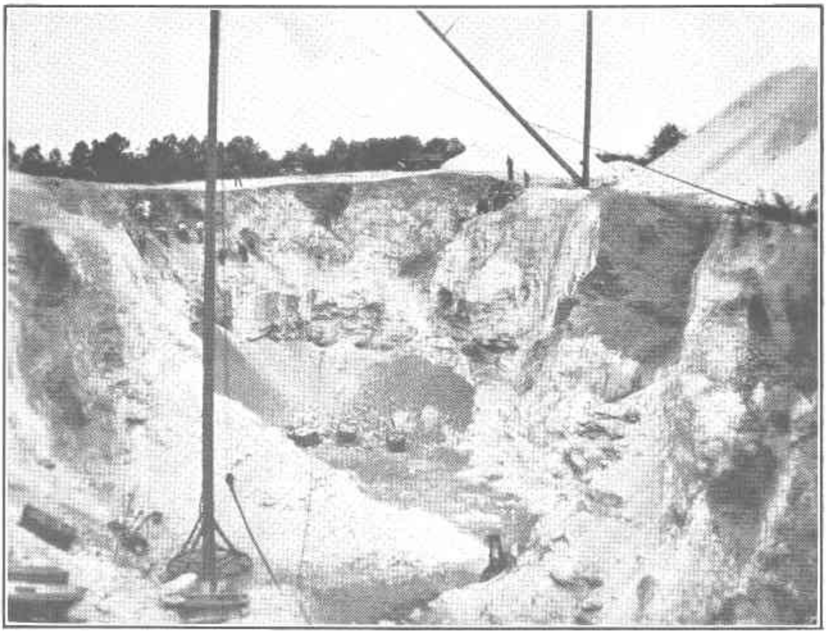


A. Dump of Rutherford mines, 1¼ miles north of Amelia, Amelia County, showing Amazon stone in background and albite in foreground.



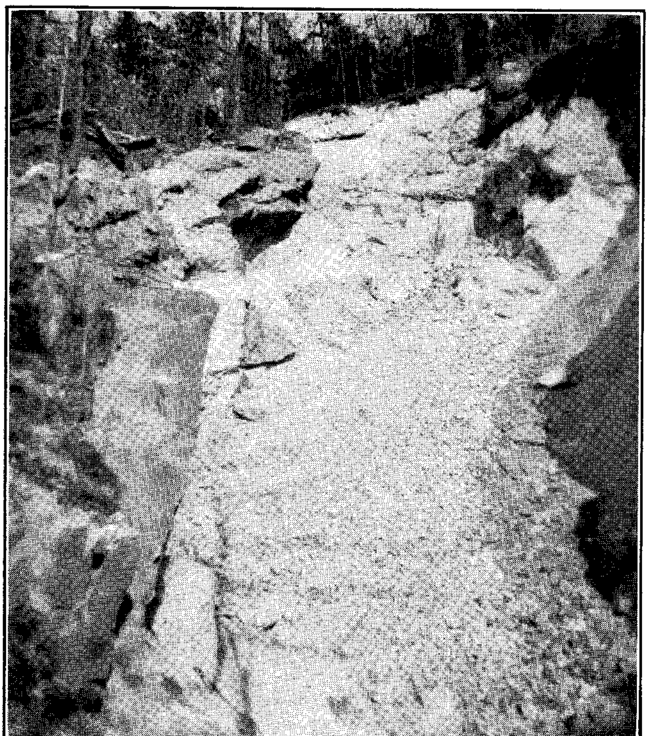
B. Open cut and mine equipment at the Wheatly mine, 1 mile southeast of Moneta, Bedford County, as it appeared in August, 1928.

A. Dump of Rutherford mines, 1¼ miles north of Amelia, Amelia County, showing Amazon stone in background and albite in foreground.

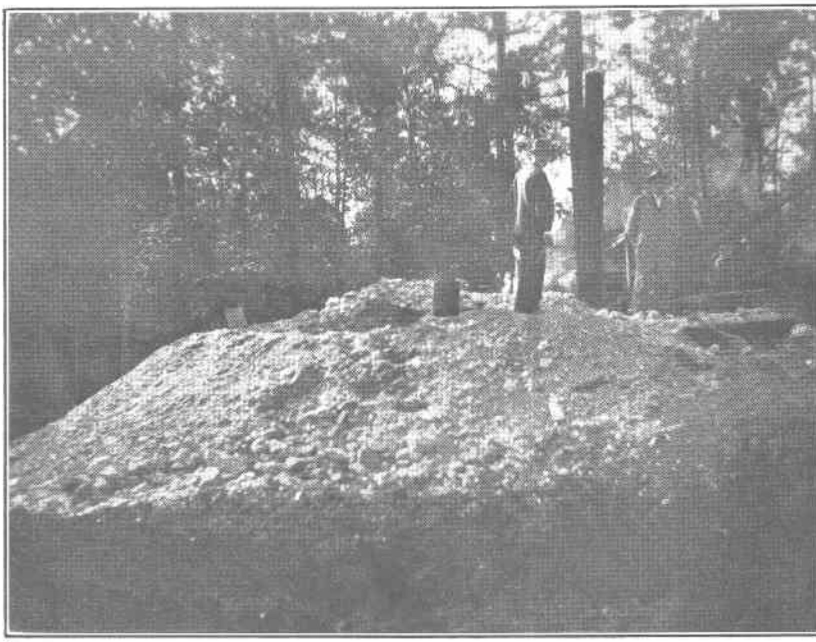


B. Open cut and mine equipment at the Wheatly mine, 1 mile southeast of Moneta, Bedford County, as it appeared in August, 1928.

A. Dump of the Morefield mine, 1½ miles southeast of Winterham, Amelia County, as it appeared in November, 1931.



B. Outcrop of pegmatite dike at the Bells prospect, 1 mile south of Bells, Bedford County.



A. Dump of the Morefield mine, 1½ miles southeast of Winterham, Amelia County, as it appeared in November, 1931.

B. Outcrop of pegmatite dike at the Bells prospect, 1 mile south of Bells, Bedford County.

Piney River to Alhambra, a distance of about 5 miles from Lowesville. The deposits are only a short distance west of Alhambra.

Occurrence.—Allanite occurs in a pegmatite dike that ranges from 10 to 20 feet wide, and that strikes N.55°W., with almost vertical dip. It is traceable for 50 yards. As shown in Figure 11, the allanite and associated minerals occupy an intermediate position in the dike, being flanked on one side by a band 2 feet wide, com-

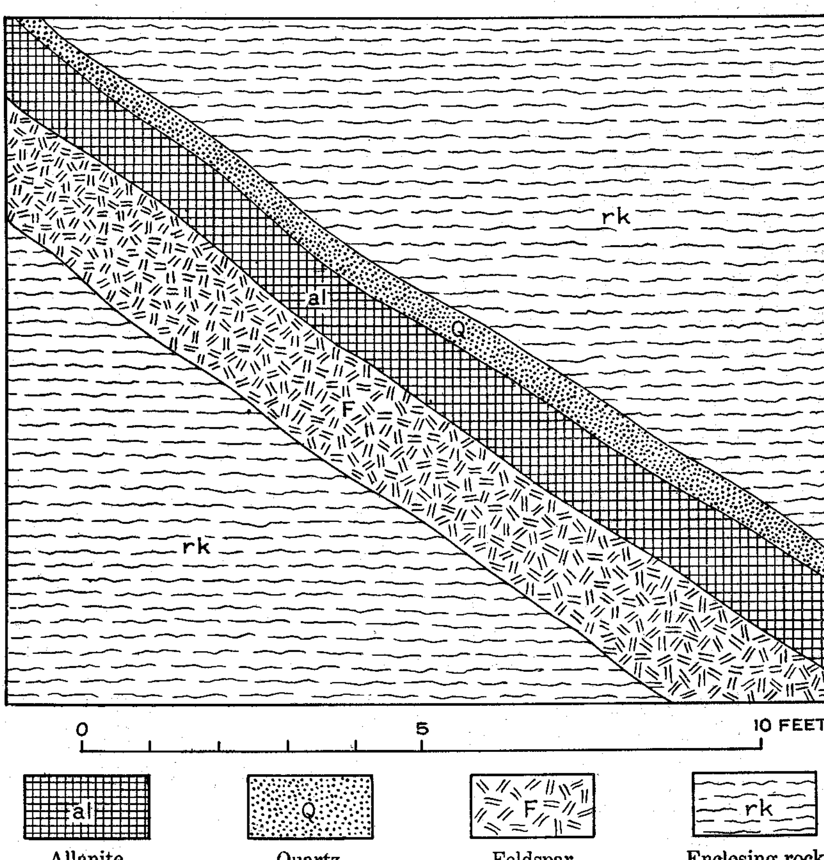


Figure 11.—Plan of relation of the minerals in the allanite deposits near Alhambra, Amherst County.

posed of quartz chiefly and some feldspar, and on the other side by a band 10 feet wide, composed of feldspar chiefly and some quartz. The allanite band varies in width from 2 to 6 feet.

Wall rock.—The wall rock is strongly impregnated with pegmatititic material, especially along the southwestern contact. It is a hypersthene granodiorite which, in hand specimens, is a black and white coarse-grained rock composed of feldspar, quartz, biotite, hornblende, and hypersthene. Thin sections show this rock to be composed essentially of feldspar (oligoclase with some orthoclase) and quartz. Subordinate minerals are euhedral brown, deeply pleochroic biotite, well-formed crystals of brown to greenish-brown strongly pleochroic hornblende, and pleochroic hypersthene. Accessory minerals are zircon, apatite, and magnetite.

Mineral composition.—Allanite, the most important mineral, is found chiefly in the middle band of the dike. It occurs also in the feldspathic band and, to a small extent, in the wall rock. It is in irregular grains and masses, ranging from a few inches to several feet in diameter, which are commonly embedded in a yellow-brown earthy material. This material is in part, at least, a secondary product of allanite.

The allanite is commonly dull-black to pitchy-black and is not uncommonly coated with, and apparently intergrown with, a yellowish-brown material, some of which has cleavage. At least some of this mineral is secondary after allanite. Allanite appears under the microscope as a brownish-yellow to greenish-yellow slightly pleochroic mineral, the color being variable even in a single crystal. It has a moderate to high index (1.70-1.75) and a double refraction that ranges from 0.032 almost to zero. A partial analysis of allanite from this locality, made in 1928 by the late J. B. Weems, Chief Chemist of the Department of Agriculture and Immigration, Richmond, is given below:

Partial analysis of allanite from Alhambra, Amherst County

(J. B. Weems, Analyst)

$FeO + Fe_2O_3$	17.24
Al_2O_3	12.44
CaO	5.58
MgO	.62
Cerium metals	6.50
Yttrium metals	6.42
SiO_2	40.00
Moisture and undetermined	11.20
	100.00

A complete analysis of a sample of allanite from Amherst County was made in 1872 by Cabul[74] as follows:

[74] Cabul, J. A., Analysis of allanite from a new Virginia locality: Chem. News, vol. 30, p. 141, 1874.

Analysis of allanite from Amherst County

(J. A. Cabul, Analyst)

SiO_2	31.23
Fe_2O_3	3.49
FeO	13.67
Al_2O_3	16.45
Ce_2O_3	11.24
$(La, Di)_2O_3$	9.90
Y_2O_3	1.65
CaO	8.69
MgO	.22
BeO	.24
H_2O	2.28
	99.06
Specific gravity	3.83

The analyses of the weathered portion of the same specimen were made by Santos[75] as follows:

Analyses of weathered allanite from Amherst County

(J. R. Santos, Analyst)

	1	2
SiO_2	8.05	21.37
Al_2O_3	16.83	20.66
Fe_2O_3	37.14	12.24
Ce_2O_3	7.13	21.90
BeO	.94	1.95
H_2O	29.55	21.37
	99.64	99.49

1. Inner crust, black-red.
2. Outer crust, white.

The allanite is associated with several minerals, the most interesting of which is sipylite, first described from the Alhambra deposits by Professor J. W. Mallet,[76] as a niobate of erbium, the cerium metals, and others. Sipylite crystallizes in the tetragonal system. The writer observed excellent crystals of the same, or a similar, mineral in a specimen presented to the Virginia Geological Survey from this locality. There are 4 crystals half an inch long and one-fourth of an inch in diameter, with a prismatic habit. One of them is terminated by a well-developed tetragonal pyramid.

[75] Santos, J. R., Examination of the products of weathering of allanite: Chem. News, vol. 38, p. 95, 1878.

[76] Mallet, J. W., On sipylite, a new niobate from Amherst County, Virginia: Am. Jour. Sci., 3d ser., vol. 14, p. 397, 1877.

The crystals are dark-brown to black. No further tests were made because of the danger of injuring the specimen.

An analysis of sipylite by W. G. Brown,[77] a student of Professor Mallet, showed the following composition:

Analysis of sipylite from Alhambra, Amherst County

(W. G. Brown, Analyst)

Nb_2O_5	48.66[a]
WO_3	.16
SnO_2	.08
ZrO_2	2.09
Er_2O_3	27.94[b]
Ce_2O_3	1.37
La_2O_3	3.92
Di_2O_3	4.06
VO	3.47
FeO	2.04
BeO	.62
MgO	.05
CaO	2.61
Na_2O	.16
K_2O	.06
H_2O	3.19
	100.48

[a] Containing about 2 per cent of Ta_2O_3.
[b] Containing about 1 per cent of Y_2O_3.

The feldspar is generally completely obscured by various alteration products, the chief one being sericite, so that the original material can hardly be recognized. Wherever it can be identified, it is microcline. The chief inclusion is zircon in prismatic crystals 0.2 millimeter in diameter. Most of the southwestern band is composed of feldspar which is also distributed in small particles through the quartz.

Quartz, confined chiefly to the northeastern band, is also found in the feldspar band. It is massive and of a bluish-gray color. Under the microscope, it shows numerous minute fractures.

Magnetite is almost invariably associated with this allanite, as quadratic to irregular grains, that range from 0.1 to 0.5 millimeter in diameter.

[77] Mallet, J. W., op. cit., p. 397.

ECONOMIC GEOLOGY OF THE MINERALS

MICA

GENERAL STATEMENT

The word "mica" is derived from the Latin word "micare," which means "to glitter" or "to shine." This term is a generic one and includes several species, biotite, muscovite, phlogopite, and others. The micas are aluminum silicates whose bases include different elements. Muscovite, the only one of commercial value in Virginia, is an orthosilicate of aluminum and potassium.

CHARACTERISTICS

Muscovite is very widespread and is present in igneous, sedimentary, and metamorphic rocks. Commercial quantities are confined to pegmatite deposits, which are of igneous origin. The muscovite occurs as blocks or books that range from less than 1 inch to several feet in diameter. The mineral crystallizes in the monoclinic system, but it exhibits a strong tendency to assume a pseudo-hexagonal form. Muscovite is colorless in thin sheets, but, when first mined, it is, as a rule, amber-yellow or dark-brown in thick blocks, although on exposure it changes rapidly to a light transparent mineral. Some mica is light-green to light-brown. Muscovite has a well-developed basal cleavage, hence it can be split into very thin sheets.

Imperfections in mica are of two kinds, (1) inclusions or infiltrations, and (2) structural. Inclusions are iron and manganese oxides which form peculiar patterns. (See Pl. 17.) Inclusions of garnet occur in some deposits. Limonite and clay infilter along cleavage planes. Structural imperfections include the "A" or chicken bone structure (Pl. 17), ribbon structure, hairlines, horsetail, and wedge. Some crystals have been twisted and warped during metamorphism.

CLASSIFICATION

Mica is classified by the United States Bureau of Mines as (1) sheet mica and (2) scrap mica.

Sheet mica of commercial grade must split easily and evenly and must be reasonably free from cracks, rulings, markings, and inclusions. It must also yield a rectangular sheet. Sheet mica is further classified into punch, circle, and sheets measuring in inches, 1½ by 2, 2 by 2, 2 by 3, 3 by 4, 3 by 5, 4 by 6, 6 by 6, 6 by 8, 8 by 10, and larger. The value of mica depends upon the size of sheet it will cut, for sheets of larger sizes bring higher prices.

Scrap mica includes that which can not be cut into sheets, because the books are too small or have serious structural defects, and that which is left after the sheets are cut. Scrap mica is ground and sold in powdered form. It must be free from foreign matter, such as limonite, clay, feldspar, and quartz.

USES

The greatest use of muscovite in sheet form is in the electrical industry, where about 90 per cent of it is utilized for insulators, condensers for magnets, for engines of various kinds, in arc lights, incandescent lamps, and X-ray apparatus. It is used also for stove doors, and in the phonograph, radio, and other industries.

Both sheet and built-up mica are used for decorative purposes as lamp shades, Christmas-tree snow, and on postcards, and for wall paper, stucco, and plasters.

Ground mica is used in great quantities for dusting automobile tires, in rolled roofing, asphalt shingles, as a filler in rubber goods, and in lubricants, paints, and in the ceramic industry.

Mica splittings, one-thousandth of an inch in thickness and irregular in shape, are used extensively for built-up mica boards in electrical insulations. Tapes, cloths, and paper faced with mica splittings are also used for insulation.

VALUE

The table given below, prepared by the United States Bureau of Mines,[78] shows the relative value of different grades of mica. It shows the great increase in value with the size of sheet, and also the relatively greater value of the sheet mica over scrap mica.

TABLE 7.—*Range of prices a pound for rough-trimmed uncut sheet mica in 1929*

SIZE	CLEAR	STAINED
Punch	$0.04–$0.15	$0.03–$0.06
1½ by 2 inches	.20– .35	....
2 by 2 inches	.35– .50	.20– .45
2 by 3 inches	.60– .95	.40– .85
3 by 3 inches	1.10– 1.60	.70– 1.45
3 by 4 inches	1.50– 2.00	1.20– 1.80
3 by 5 inches	1.65– 2.15	1.40– 2.00
4 by 6 inches	2.50– 3.00	1.60– 2.50
6 by 8 inches	3.00– 5.00	2.00– 2.75
8 by 10 inches	4.00– 7.00	2.25– 3.00

[78] Stoddard, B. H., Mica in 1929: U. S. Bur. Mines Mineral Resources, 1929, pt. 2, p. 375, 1931.

Prices of scrap mica in 1929, ranged from $10 to $30 a short ton at the mines. During 1928 and 1929, dry ground mica had an average price of $36 a ton and wet ground mica of $119 a ton.

MINING METHODS

The methods of mining mica in Virginia have been largely of the most primitive kind. The policy has been "to follow the ore." As the books of mica are very irregularly distributed through the pegmatites, and as most of the miners are ignorant of its mode of occurrence, the operations are usually of the type known as "gophering" or "ground-hogging," which consists in following the ore by small and irregular openings, with removal of very little waste. Consequently, many of the mines have been abandoned before more than a small part of the mica in the deposit has been recovered. Some of the more progressive operators mine by a system of shafts and tunnels. Drifts, cross-cuts, and stopes are also used. Where the pegmatite is thoroughly decomposed or disintegrated, the entire deposit is quarried from an open cut. In a few places the material is blasted.

A very common practice has been to dig a vertical shaft in the pegmatite, remove all the mica in sight, and then sink another shaft, which may not even be in the deposit. Or, trenches are made along the dike, with trenches at right angles to the dike. Very few operators have any conception of the geologic relations of the mica. As soon as the particular book or books are removed, the deposit is abandoned and work is started on another dike. Most of the deposits have been worked to the water level only and then the mines have been abandoned. Pumps had been installed in a few mines.

The numerous deposits which have been irregularly or incompletely worked are probably the greatest potential source of mica in Virginia. Few deposits of moderate size have been exhausted. On the other hand, almost every dike of workable dimensions has been, at least, prospected.

PRODUCTION RECORDS

The earliest year for which statistics of production of mica in Virginia are available is 1886, when there was a reported production of 15,000 pounds. During 1887, there was reported a production of 3,500 pounds. From that time until 1908, mica was produced in Virginia spasmodically and in more or less variable amounts. Such records of production as are available for that period may be found in "Mineral Resources of the United States," published annually by the United States Geological Survey. The Virginia Geological Survey, from its organization in 1908 until 1923, cooperated with the United States Geological Survey and the Bureau of the Census in the annual collection of statistics of mineral production. Since 1923, the annual collection of statistics of mineral production has been made in cooperation with the United States Bureau of Mines and the Bureau of the Census. There is given in the table below statistics of mica production in Virginia, so far as the information can be disclosed, from 1908 to 1930.

TABLE 8.—*Production of mica in Virginia, 1908-1930*

YEARS	SHEET MICA		SCRAP MICA		TOTAL	
	Pounds	Value	Short Tons	Value	Short Tons	Value
1908–09........	21,260	....	121	....	142	$ 11,946
1910...........	....	....	....	....	....	....
1911-1913......	4,585	$ 4,578	47	$ 712	49	5,290
1914...........	27,672	22,358	153	2,295	167	24,653
1915...........	10,808	9,590	63	828	68	10,418
1916...........	39,978	18,251	182	2,703	202	20,954
1917...........	68,558	22,831	253	2,709	287	25,540
1918–19........	267,647	79,018	982	12,091	1,116	91,109
1920–21........	186,161	26,943	*	45,317	*	72,260
1922...........	43,449	6,577	296	9,718	318	16,295
1923–24........	98,752	10,778	649	12,302	698	23,080
1925–26........	....	....	600	15,600	600	15,600
1927–28........	31,202	11,385	93	2,405	109	13,790
1929–30........	*	*	*	*	*	17,905†

*Statistics can not be disclosed.
†Estimated.

POSSIBLE FUTURE SOURCES

As suggested above, mica mining in this State has been done in a very haphazard manner by operators who, on the whole, have been ignorant of the geologic relations of mica. The irregular distribution of muscovite makes most necessary scientific methods of exploration and mining. Before attempting to develop a deposit of mica, one should become familiar with, or seek expert advice on, the occurrence and relations of mica, so as to devise the best method of mining a particular deposit. The methods of mining and the preparation of mica for market are explained very fully by Sterrett[79] and by Myers.[80]

[79] Sterrett, D. B., Mica deposits of the United States: U. S. Geol. Survey Bull. 740, pp. 20-23, 1923.
[80] Myers, W. M., Mica: U. S. Bur. Mines Information Circular 6205, pp. 10-18, 1929.

Possible sources of mica are (1) workable deposits that have not been completely exhausted, (2) workable deposits that have been prospected only, and (3) deposits that are still untouched or undiscovered.

Deposits of the first type are to be found in all of the major producing areas. Even in the areas where operations have been most extensive, as in the Amelia area, many of the dikes have been incompletely worked. Most operators would rather develop a new deposit than try to rework an old mine. The best plan would be to prospect along the strike on either side of the old mine. This has been done in many places and new deposits have been discovered.

Deposits of the second type may or may not be potential sources, depending upon the thoroughness of prospecting. In some places, test holes show conclusively that the deposit is not a commercial one. In many other places, however, the test holes have been made in the country rock, as the operator did not understand the geology of pegmatites. In many places, insufficient prospecting has been done to determine the real value of the deposit. Moreover, much of the prospecting was done to find valuable deposits comparable to those in the Amelia and Chestnut Mountain areas. Some of these prospects show moderately profitable deposits. All of the productive areas contain such prospects.

The value of deposits which have not been prospected is very problematical. The geologic relations of pegmatites are such that the search for them may be unsuccessful. It seems that such deposits should be found in the vicinity of the Ridgeway, the Amelia, and the Chestnut Mountain productive areas. A detailed study of the whole Piedmont province in Virginia would be necessary to discover all the possible commercial deposits of mica. Mica is mined with such comparative ease in some mines in Virginia that many deposits are exhausted in a few years, and some deposits even in a few months.

SUMMARY OF PRODUCTIVE AREAS

The Amelia area has been the greatest producer and has produced also the best grade of mica. The deposits have been thoroughly exploited, but mining methods have been so irregular that many of the deposits still probably contain much muscovite of commercial grade.

The Ridgeway area has probably been the next greatest producer. Operations were discontinued here because of the decreased price of mica after the World War. These deposits have not been exhausted and large quantities of mica are no doubt still available.

The Chestnut Mountain area has been, for its size, one of the largest producers. The mica appears to be exhausted, largely because the disintegrated pegmatites have favored rapid mining. It seems probable that similar deposits may be found in this area.

The Axton area has been thoroughly prospected, but very little mining has been done here. The deposits are commonly small and the mica is of rather low grade. It seems, however, that the mica is not exhausted.

The Goochland area has never been a large producer, the deposits being for the most part small. Mica of a rather inferior grade is still obtainable here.

The Altavista and Moneta-Bells areas are essentially feldspar and kaolin areas. No large amount of mica is obtainable in either area, but a small amount may be obtained as a by-product of feldspar mining.

FELDSPAR

GENERAL STATEMENT

Feldspar is a generic term which includes several species. It is of two varieties, potash and soda-lime. Potash feldspar includes two species, orthoclase and microcline, both having the formula $KAlSi_3O_8$. The soda-lime or plagioclase feldspars include six species, ranging in composition from $NaAlSi_3O_8$ (albite) to $CaAl_2Si_2O_8$ (anorthite). The three species, orthoclase, microcline, and albite, known as the alkali feldspars, are the most important from a commercial standpoint. The alkali feldspars are distinguishable by (1) specific gravity determinations, (2) microscopic study, and (3) chemical analysis.

The feldspars are the most abundant group of minerals, as they constitute approximately 60 per cent of the earth's crust. They occur in many rocks, but masses large enough to be extracted profitably are found only in pegmatites and syenites. In commercial deposits in Virginia feldspar occurs as cleavable masses, ranging from a few inches to several feet in diameter, which are intergrown with other minerals, mainly with quartz and, to some extent, with mica.

White and various shades of gray are the prevailing colors, although buff and salmon-pink are not uncommon. The variety Amazon stone is bluish-green to pea-green.

Impurities in feldspars arise largely from mixtures with other minerals. Potash feldspar is commonly intergrown with soda-lime feldspar, and all microcline in pegmatites is perthitic. Either variety is more desirable if not mixed with the other, but potash feldspars, at least in Virginia, are rarely free from the soda feldspars, which comprise in places 25 per cent of the mass. The second most common mixture is that of feldspar with quartz. Quartz is considered objectionable if it is in excess of 20 per cent. Coarse-grained pegmatites can be broken up and a large part of the quartz removed by hand cobbing. The most objectionable impurities are the minerals containing iron, such as tourmaline, garnet, biotite, the amphiboles, and the pyroxenes. Muscovite, although a common impurity, is easily separated and forms a valuable by-product. Kaolin, commonly mixed with ferruginous clay, is a frequent impurity near the surface.

CLASSIFICATION

Feldspar is generally classified into grades as follows: Grade No. 1 includes feldspar free from iron-bearing minerals and muscovite, and containing not more than 5 per cent of quartz. Grade No. 2 includes feldspar largely free from iron-bearing minerals and containing not more than 20 per cent of quartz. Grade No. 3 is less carefully selected than the other two grades and may carry enough iron-bearing minerals to render it unfit for pottery manufacture.

Feldspar is sold either as crude or ground feldspar. The ground feldspar sold for pottery manufacture should leave not more than 6 per cent residue on a 200-mesh sieve. Feldspar entirely free from quartz is much sought after, but it is very rare.

Crude feldspar sold in 1929 for $6.46 a long ton, and ground feldspar sold for $13.73 a short ton. Ground feldspar has sold as high as $22 a ton.

USES

Feldspar is used chiefly in the ceramic industry for making pottery, enamel ware, enamel brick, vitrified sanitary ware, and electrical ware. It is used both in the body and in the glaze of porcelain, white ware, vitrified ware, and similar products. The amount of feldspar used in the body ranges from 10 to 35 per cent, and in the glaze from 30 to 50 per cent. Feldspar used for these purposes must be almost free of iron-bearing minerals. Some of the manufacturers demand No. 1 grade, although others use No. 2 grade.

Feldspar is used also as a flux or binder in the manufacture of emery and corundum wheels. Grade No. 3 is used in the manufacture of opalescent glass, the soda variety being the best. Some of the purer grades are used in the manufacture of artificial teeth. Feldspar is also used as a constituent of scouring soap, window washes, sand paper, and other abrasives. The impure varieties are sometimes ground up and used as grit for poultry. During the World War the possible use of the potash variety for fertilizer was suggested. The extraction of potash, however, has not proved commercially practicable.

The following table indicates the approximate percentage of feldspar consumed in the United States for the various uses:

TABLE 9.—*Approximate percentage of feldspar used in various industries*[81]

Ceramic and glass industries	87
Scouring soaps and abrasives	7
Binder for abrasive wheels	2
Poultry grit, roofing, stucco, and other minor uses	4

MINING METHODS

Various methods have been employed where feldspar has been mined in connection with the mining of mica. In the Moneta area, feldspar was removed from an open pit, the whole dike being worked. The material was blasted and removed with pick and shovel. In some mines the feldspar was taken out with a steam shovel and in others it was hauled to the surface in cars on an inclined track. At one time the feldspar was conveyed to the railway by a bucket line and dumped into a tipple. In 1928 this method had been abandoned and trucks were being used.

MILLING

The milling of feldspar has been described recently by Singewald,[82] as follows:

"The crude rock from the quarries may or may not be further broken up in a jaw crusher. It is then fed to chaser mills. As it comes from the chasers it is screened and the oversize returned to the chasers while the undersize goes to tube mills for final grinding. Four to six hours grinding reduces most of it to a fineness of under 200 mesh. The finished product is shipped either in bulk or in bags."

Up to 1928 there were no mills in Virginia for grinding feldspar. During that year a mill, which is still in operation, was in-

[81] Bowles, Oliver, and Middleton, Jefferson, Feldspar in 1929: U. S. Bur. Mines Mineral Resources, 1929, pt. 2, p. 84, 1930.

[82] Singewald, J. T., Jr., Notes on feldspar, quartz, chrome, and manganese in Maryland: Maryland Geol. Survey, vol. 12, pt. 2, p. 101, 1928.

stalled at Brookneal. Information on mining and milling of feldspar is given in a report by Bowles and Middleton.[83]

POSSIBLE FUTURE SOURCES

Feldspar has been mined, for several years, in mica mining, but it has been only in recent years that any serious attempt has been made to operate a mine for feldspar alone. Consequently very few, if any, of the feldspar deposits have been exhausted.

The largest deposits in the State are near Moneta and near Bells, in Bedford County. In the Amelia area, workable deposits occur at the Pinchback mine, the Schlegal mine, and the Ligon prospect. Beautiful cabinet specimens of albite can still be obtained at the Rutherford mines, where large quantities of Amazon stone are found in the dumps. (Pl. 19, A.) The deposits on the Farmer property (Pl. 4, No. 4) in the Altavista area appear to be of good grade, although little prospecting has been done here. These deposits are but a short distance from Sycamore, on the Southern Railway.

In the southern part of the State there are large quantities of feldspar at the Vicama Mica Company's mine in the Axton area (Pl. 3, No. 12), and at the Ridgeway, Garrett, Grindstaff, Lovelace, and Oliver mines in the Ridgeway area. (See Pl. 2, Nos. 8, 9, 10, 16, and 19.) The feldspar here is, for the most part, a mixture of potash and soda varieties and the percentage of quartz is high. Shipments of feldspar have been made from all of these mines, but no attempts have been made to mine it on a large scale.

Deposits of feldspar have been prospected 2 miles south of Abilene and 3 miles north of Cullen, both stations on the Virginian Railway in Charlotte County, but they are small and carry considerable quartz.

MISCELLANEOUS MINERALS

Miscellaneous minerals, as the term is used here, are other minerals found in pegmatite deposits, which have been mined from time to time. They are quartz, kaolin, emery, cassiterite, gems, and rare-earth minerals.

QUARTZ

Quartz has been mined only on a very small scale in connection with mining of mica. Many of the dikes in the principal

[83] Bowles, Oliver, and Middleton, Jefferson, Feldspar in 1928: U. S. Bur. Mines Mineral Resources, 1928, pp. 71-73, 1929; Feldspar in 1929: U. S. Bur. Mines Mineral Resources, 1929, pp. 83-93, 1930.

mica and feldspar producing areas contain quartz of high quality. In the Amelia area many of the dikes grade into pure quartz veins, some of which are 15 to 20 feet wide.

KAOLIN

Kaolinized feldspar is found in practically every dike, but the kaolin is usually not of commercial grade because of the admixture of undecomposed feldspar, quartz, mica, and ferruginous clay. Moreover, the deposits are generally too small to be of value. Kaolin deposits have been worked or prospected on R. T. Jackson's property near Altavista, on the Broomfield tract near Brights, and at various places in the Ridgeway area and near Forest in the Moneta-Bells area.

EMERY

Production of emery was reported from Pittsylvania County each year from 1917 up to and including 1929, when the Niagara Emery Mills, Inc., went out of business. At the time of the writer's visits in 1926 and 1928, the mine pits had all caved in but there was much material on the dumps. The production of emery in the past few years has apparently come from the dumps of former workings. It is probable that freight rates and competition with the Turkish emery have brought the local industry to a standstill. This area, however, is a future source, for the deposits described by Watson[84] are not exhausted.

CASSITERITE

The cassiterite deposits in Virginia were described by Ferguson[85] in 1918, and there have been no developments since then. He summarized the deposits as follows: "The existence of deposits of cassiterite in the Irish Creek district of Virginia has been known for many years, and between 1883 and 1893 attempts were made to exploit them, but as far as is known, however, very little tin was produced. . . .

"The cassiterite occurs in quartz veins, which do not appear to be continuous for long distances, and their tin content is probably very irregular. Some specimens of high-grade ore were found, however, and such early records as are available indicate that the known veins may be workable, and new veins may perhaps be discovered. Placer mining will probably not be profitable."

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[84] Watson, T. L., A contribution to the geology of the Virginia emery deposits: Econ. Geology, vol. 18, pp. 53-76, 1923.

[85] Ferguson, H. T., Tin deposits near Irish Creek, Virginia: Virginia Geol. Survey Bull. 15-A, 1918.

GEM MINERALS

The most abundant gem mineral in the Virginia pegmatites is Amazon stone, a bluish-green to pea-green microcline. It is almost entirely confined to the Rutherford mines, where several tons are still available in the dumps, and to the Morefield mine at Winterham, which was recently opened. (Pl. 20, A.) Moonstone, the translucent variety of albite, is sometimes cut for gems. It is found at the Rutherford mines. Other gem minerals that have been produced from the Rutherford mines include a hyacinth-brown spessartite, from which gems, weighing from 1 to 100 carats, have been cut, beryl, topazolite, amethyst, and microlite. Beryl of gem grade has been produced from the Morefield mine. Other gem minerals may be produced from this mine in the future.

Gem minerals have not been reported from other pegmatite deposits in Virginia.

RARE MINERALS

The largest number of rare minerals has been reported from the Rutherford deposits, where small quantities of some minerals are still available. They include columbite, allanite, fergusonite, and microlite. Manganotantalite was found by Mr. W. P. Pinchback on his property and presented by him to Dr. T. L. Watson.

Allanite has been reported from several counties, but the only commercial deposits occur in Amherst County. It is associated here with the very rare mineral sipylite. Allanite has been found at several places in the vicinity of the Lucian Burley property, 3 miles northwest of Amherst and one-fourth to half a mile south of State Highway No. 13. (See p. 96.) A single pocket has produced 1,000 to 1,500 pounds. It is probable that there are other deposits in this area.

The best known deposits are on the northeast side of Friar Mountain on the property of John Campbell, 14 miles north of Amherst and 1 mile west of Alhambra post office. (See pp. 96-100.) Mr. Campbell reports that, seven years ago, he shipped 700 pounds of allanite for specimens and that he has sold 350 pounds for research purposes. The deposit does not seem to be exhausted, and it is quite possible that other deposits will be found in this vicinity. The chief objection to the Campbell deposit is its inaccessibility.

It is probable that more detailed study will reveal other rare minerals associated with the allanite.

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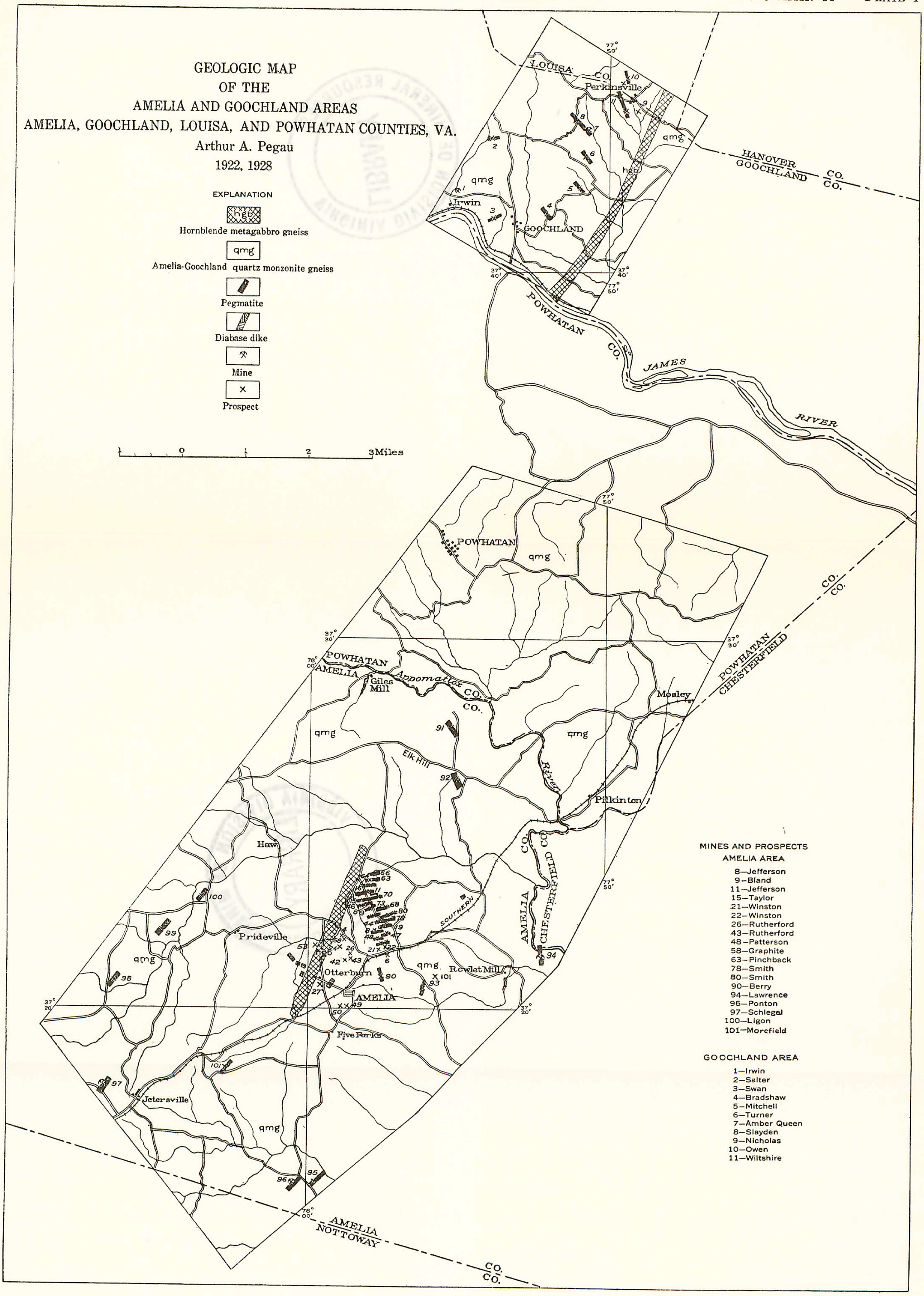
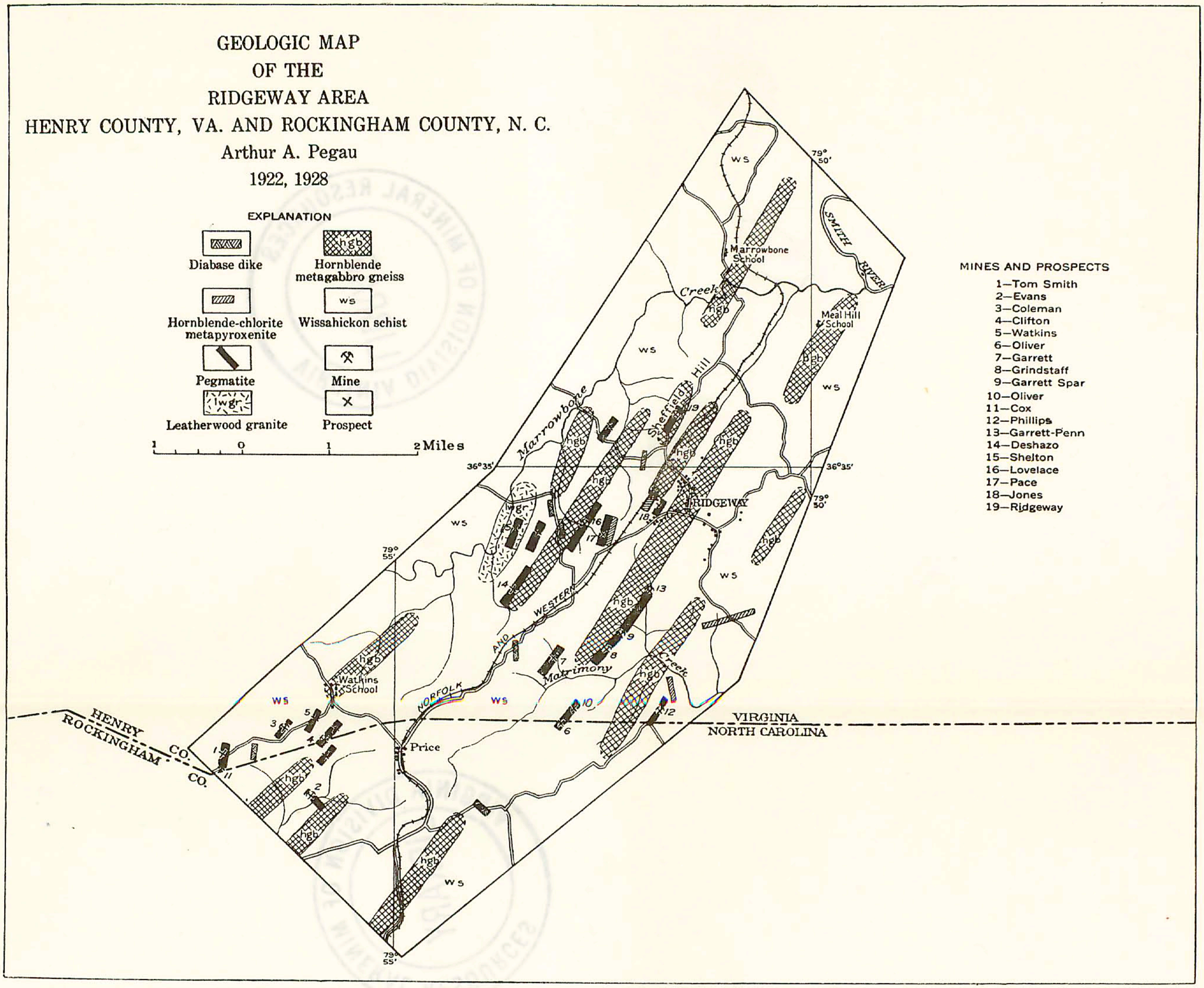
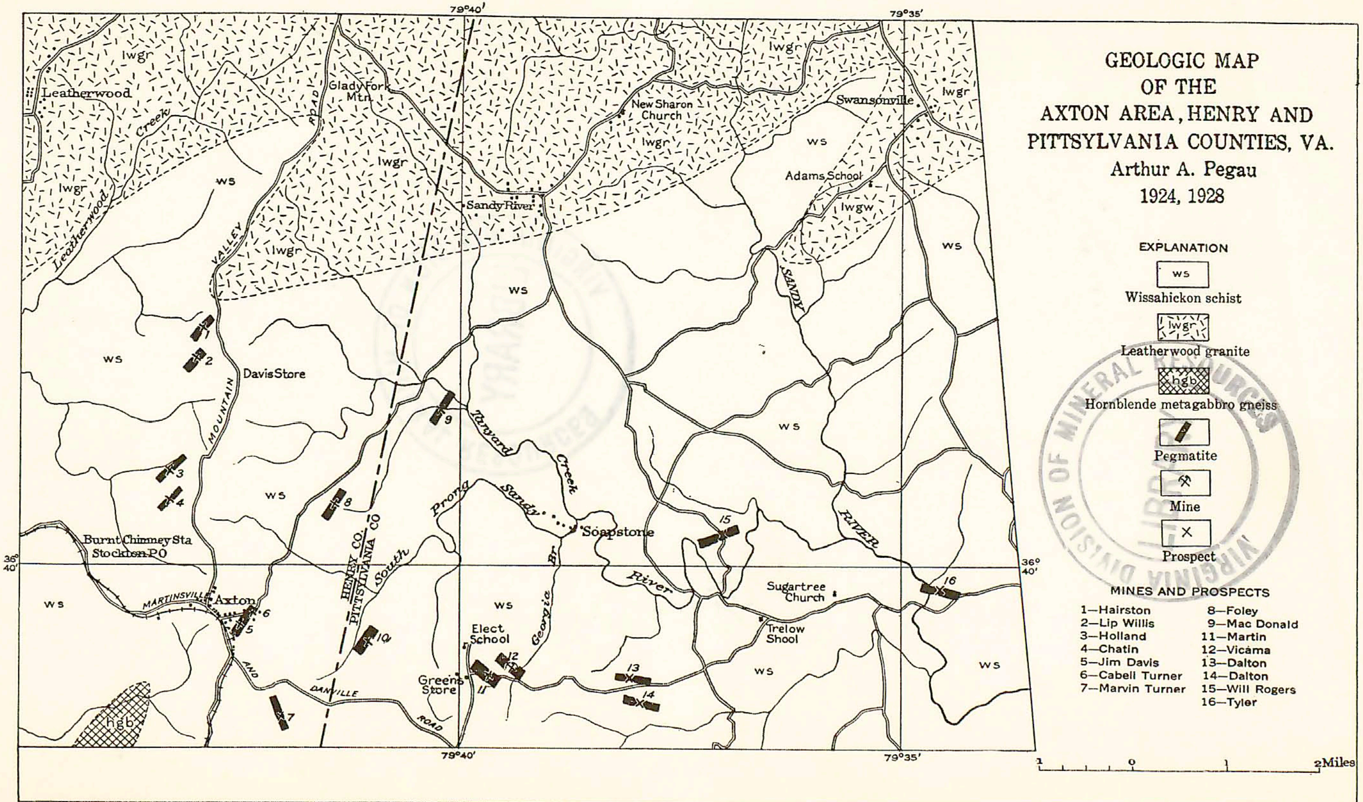
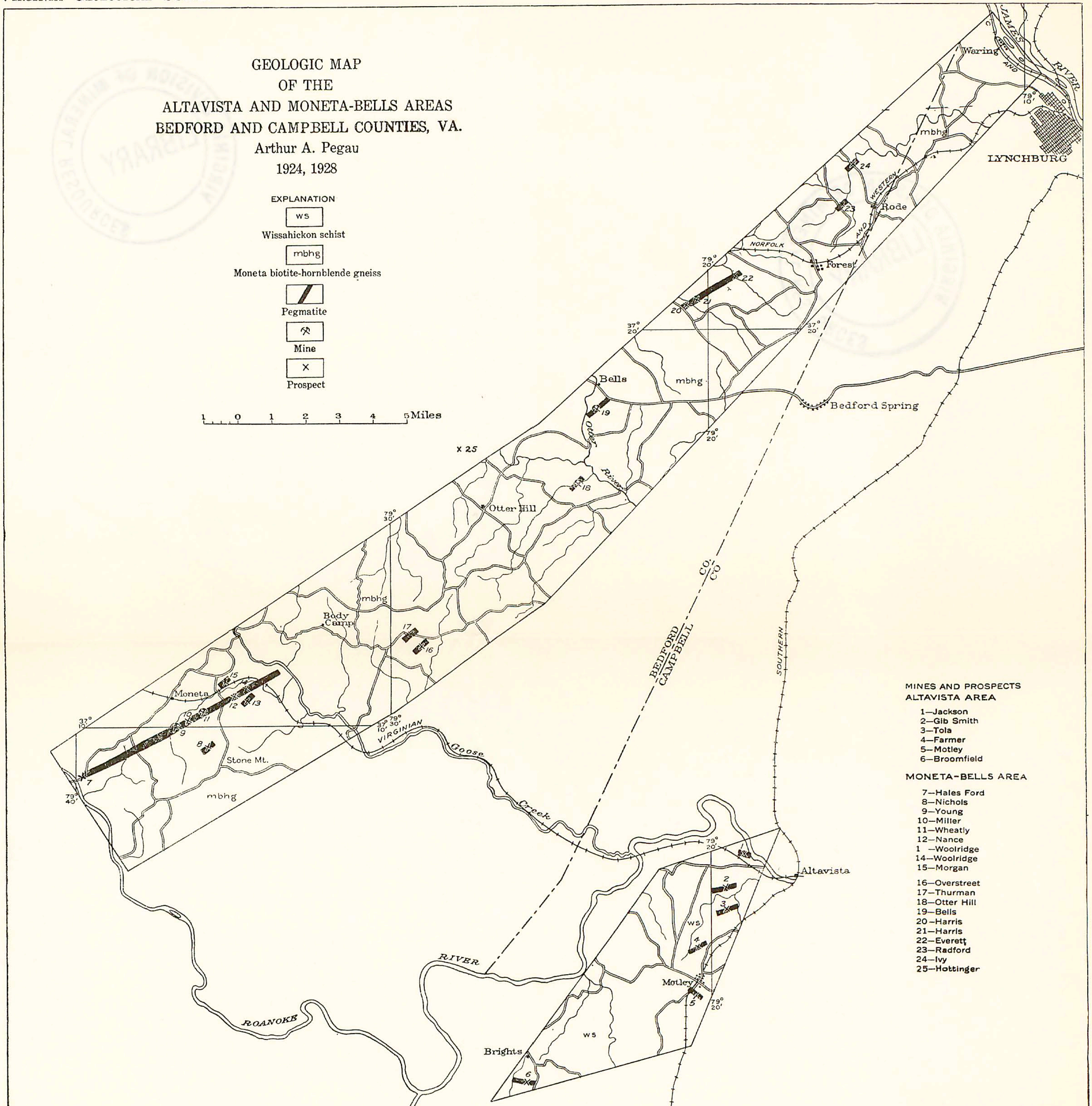

GEOLOGIC MAP
OF THE
AMELIA AND GOOCHLAND AREAS
AMELIA, GOOCHLAND, LOUISA, AND POWHATAN COUNTIES, VA.
Arthur A. Pegau
1922, 1928
EXPLANATION
hgb
Hornblende metagabbro gneiss
qmg
Amelia-Goochland quartz monzonite gneiss
Pegmatite
Diabase dike
Mine
Prospect
1 0 1 2 3Miles
LOUISA CO.
Perkinsville
HANOVER CO.
GOOCHLAND CO.
Irwin
GOOCHLAND
POWHATAN CO.
JAMES RIVER
POWHATAN
POWHATAN
AMELIA
Giles Mill
Appomattox
CO.
CO.
Elk Hill
River
Moseley
Pilkinton
POWHATAN
CHESTERFIELD
CO.
CO.
AMELIA CO.
CHESTERFIELD CO.
Haw
Prideville
Otterburn
AMELIA
Rowlet Mill
SOUTHERN
Five Forks
Jetersville
AMELIA
NOTTOWAY
CO.
CO.
MINES AND PROSPECTS
AMELIA AREA
8—Jefferson
9—Bland
11—Jefferson
15—Taylor
21—Winston
22—Winston
26—Rutherford
43—Rutherford
48—Patterson
58—Graphite
63—Pinchback
78—Smith
80—Smith
90—Berry
94—Lawrence
96—Ponton
97—Schlegel
100—Ligon
101—Morefield
GOOCHLAND AREA
1—Irwin
2—Salter
3—Swan
4—Bradshaw
5—Mitchell
6—Turner
7—Amber Queen
8—Slayden
9—Nicholas
10—Owen
11—Wiltshire


GEOLOGIC MAP
OF THE
RIDGEWAY AREA
HENRY COUNTY, VA. AND ROCKINGHAM COUNTY, N. C.
Arthur A. Pegau
1922, 1928
EXPLANATION
Diabase dike
hgb
Hornblende metagabbro gneiss
Hornblende-chlorite metapyroxenite
ws
Wissahickon schist
Pegmatite
Mine
lwgr
Leatherwood granite
Prospect
1 0 1 2 Miles
MINES AND PROSPECTS
1—Tom Smith
2—Evans
3—Coleman
4—Clifton
5—Watkins
6—Oliver
7—Garrett
8—Grindstaff
9—Garrett Spar
10—Oliver
11—Cox
12—Phillips
13—Garrett-Penn
14—Deshazo
15—Shelton
16—Lovelace
17—Pace
18—Jones
19—Ridgeway
Marrowbone School
Meal Hill School
Watkins School
SMITH RIVER
Creek
Marrowbone
Sheffield Hill
RIDGEWAY
NORFOLK AND WESTERN
Matrimony
Creek
Price
HENRY CO.
ROCKINGHAM CO.
VIRGINIA
NORTH CAROLINA
79° 50'
36°35'
79° 55'


GEOLOGIC MAP
OF THE
AXTON AREA, HENRY AND
PITTSYLVANIA COUNTIES, VA.
Arthur A. Pegau
1924, 1928
EXPLANATION
ws
Wissahickon schist
lwgr
Leatherwood granite
hgb
Hornblende metagabbro gneiss
Pegmatite
Mine
Prospect
MINES AND PROSPECTS
1—Hairston
2—Lip Willis
3—Holland
4—Chatin
5—Jim Davis
6—Cabell Turner
7—Marvin Turner
8—Foley
9—Mac Donald
11—Martin
12—Vicama
13—Dalton
14—Dalton
15—Will Rogers
16—Tyler
79°40'
79°35'
36° 40'
1 0 1 2 Miles
Leatherwood
Leatherwood Creek
Glady Fork Mtn.
New Sharon Church
Swansonville
Adams School
Sandy River
Valley Road
Mountain
Davis Store
Tanyard Creek
Prong Sandy
South
Soapstone
River
Sandy River
Burnt Chimney Sta
Stockton P.O.
Axton
Martinsville and Danville Road
Henry Co.
Pittsylvania Co.
Elect School
Georgia Br
Greens Store
Sugartree Church
Trelow Shool


GEOLOGIC MAP
OF THE
ALTAVISTA AND MONETA-BELLS AREAS
BEDFORD AND CAMPBELL COUNTIES, VA.
Arthur A. Pegau
1924, 1928
EXPLANATION
ws
Wissahickon schist
mbhg
Moneta biotite-hornblende gneiss
Pegmatite
Mine
Prospect
1 0 1 2 3 4 5 Miles
MINES AND PROSPECTS
ALTAVISTA AREA
1—Jackson
2—Gib Smith
3—Tola
4—Farmer
5—Motley
6—Broomfield
MONETA-BELLS AREA
7—Hales Ford
8—Nichols
9—Young
10—Miller
11—Wheatly
12—Nance
1 —Woolridge
14—Woolridge
15—Morgan
16—Overstreet
17—Thurman
18—Otter Hill
19—Bells
20—Harris
21—Harris
22—Everett
23—Radford
24—Ivy
25—Hottinger
LYNCHBURG
Waring
JAMES RIVER
Rode
Forest
NORFOLK AND WESTERN
Bells
Bedford Spring
Otter River
Otter Hill
Body Camp
Moneta
Stone Mt.
VIRGINIAN
Goose Creek
Altavista
Motley
Brights
ROANOKE RIVER
BEDFORD CO.
CAMPBELL CO.
SOUTHERN
x 25