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Feldspar Deposits of the Bryson City District, North Carolina

By

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LETTER OF TRANSMITTAL

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

SIR:

I have the honor to submit herewith manuscript for publication as Bulletin 62, "Feldspar Deposits of the Bryson City District, North Carolina." This Bulletin is another in the series being made possible by the cooperation of the United States Geological Survey.

Feldspar is one of the most important minerals being produced in North Carolina. This report is the first detailed study of a feldspar district in North Carolina. It is believed that the information contained herein will be of considerable value to those interested in feldspar and feldspar production.

Respectfully submitted,

GEORGE R. ROSS,
Director.

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FEELDSPAR DEPOSITS OF THE BRYSON CITY DISTRICT, NORTH CAROLINA

By Eugene N. Cameron

ABSTRACT

Feldspar deposits developed in the Bryson City area of western North Carolina in the late 1930's and early 1940's are estimated to have yielded between 130,000 and 150,000 tons of feldspar, worth about $500,000. With the decline of discoveries in the Spruce Pine district, the area attracted considerable interest as a source of new supplies of high-grade potash feldspar. The present investigation was undertaken to determine the size and extent of the feldspar deposits, the characteristics of the pegmatite bodies, and the relation of the pegmatites to the structure and to the other rock units of the area. A further aim was to test the applicability of the zonal concept of pegmatite structure to prospecting and development of feldspar deposits.

The geologic history of the area apparently began with deposition of a series of interbedded sandy shales, feldspathic sandstones, and minor arkosic conglomerates, generally referred to the Ocoee series. These rocks were intruded by bodies of peridotite, gabbro, and perhaps other basic rocks. The whole series was then sharply folded along northeast-trending axes and metamorphosed to schists, quartzites, metaconglomerates, metaperidotite, metagabbro, and hornblende and biotite schists and gneisses. Metamorphism was followed by a period of granitic invasion, during which a complex consisting partly of granite but largely of mixed rocks formed by soaking and granitization of the older rocks was developed. This granitic complex underlies an elliptical area about 7 miles long and 2 miles in maximum width. The internal structure of the complex suggests that it is an elongate lens, but its relation to the broader structure of the meta sedimentary rocks is not fully known. The metasedimentary rocks flank the granitic complex. The complex itself appears to have developed largely by granitization of the metagabbro, metaperidotite, and the associated hornblende and hornblende-biotite schists and gneisses.

The main period of granitic invasion was followed by intrusion of dikes and irregular bodies of quartz monzonite porphyry, leucogranite, and granite porphyry. Deformation after intrusion of quartz monzonite porphyry produced a second foliation in parts of the older granitic rocks. Minor folds in the older granitic rocks and in the metasedimentary and metabasic rocks may have been produced at this stage, or may have developed during an intermediate stage of deformation.

The final event in the development of the bedrock complex of the area was the emplacement of tabular, lenticular, pipelike, and irregular pegmatite bodies ranging up to more than 400 feet in length and more than 100 feet in maximum width. These bodies are found within the granitic complex and in the metasedimentary rocks adjacent to the complex. Bodies in granitic rocks were emplaced along fractures; bodies in the metasedimentary rocks entered partly along fractures and partly along foliation surfaces. Most of the larger and more productive bodies occur along the northwest margin of the complex in a belt of border gneiss that extends from Deep Creek nearly to the Tuckasegee River. In part, the larger pegmatites appear to be related to fractures that extend obliquely across the belt of border gneiss at places where the gneiss and the enclosing rocks are asymmetrically flexed. The intersections of fractures with the border gneiss appear to control the westward to southwestward plunges indicated for some of the pegmatite bodies.

The pegmatites consist essentially of plagioclase, perthite, and quartz, with minor muscovite or biotite or both, accessory magnetite and garnet, and traces of tourmaline, allanite, and other minerals. Beryl is a prominent accessory mineral in part of one pegmatite. The pegmatites range from sensibly homogeneous to strikingly zoned. Most of them show two to six mappable zones, distinguished primarily on the basis of textural features and on proportions of quartz and feldspars. A definite sequence of mineral assemblages is recognizable in the pegmatites of the district, and this sequence is in essential agreement with sequences observed in other districts. Knowledge of this sequence has direct applications to problems of prospecting and development of feldspar deposits in the district.

Both potash feldspar (perthite) and soda feldspar (probably albite to oligoclase) have been produced from the district. Feldspar of No. 1 grade comes from inner intermediate zones consisting of coarse to very coarse perthite and quartz, or of perthite, plagioclase, and quartz. No. 2 feldspar has been produced in

general from middle intermediate zones containing large proportions of feldspars in graphic intergrowth with quartz. The middle and inner intermediate zones lie in the interior parts of the pegmatites but are generally nearer the hanging wall than the footwall. In the two largest and most productive mines, perthite-quartz zones have been followed more than 360 feet down the plunge.

Investigation of the district indicates that knowledge of the internal structure of the pegmatites, and of the relationship of the occurrence of commercial feldspar to zonal structure, can be effectively applied in prospecting and mining. Much time and effort have been spent in the district exploring parts of pegmatites unlikely to contain feldspar, and promising parts of pegmatites at some deposits have been overlooked. Recommendations for prospecting procedures are made.

Muscovite mica in books large enough to yield sheet mica has been found in a few pegmatites in the area, and small tonnages of mica appear to have been produced from time to time. Mica concentrations in the pegmatites, however, appear to be small, and most of the books are so marred by structural defects that they are salable only as scrap mica.

Descriptions of 29 pegmatite mines and prospects are given. The more important mines are discussed in detail, and detailed maps and other diagrams of the pegmatites exposed in them are presented.

INTRODUCTION

GENERAL STATEMENT

Pegmatite deposits discovered in the early 1930's in the Bryson City district of western North Carolina have yielded appreciable quantities of high-grade potash feldspar, and in the middle 1940's the district attained second rank among the producing areas of the State. With the decline of discoveries in the Spruce Pine district, one hundred miles to the northeast, the Bryson City district aroused considerable interest as a possible source of new supplies of potash feldspar.

In 1943, Charles E. Hunter,[1] assisted by W. T. McDaniels, Jr., examined the district to ascertain the mode of occurrence of the feldspar deposits. A reconnaissance geologic map of the granitic complex of Bryson City and its vicinity was made. The study indicated that the productive pegmatites occur mostly in a narrow belt along the western side of the granitic complex. In 1944 and 1945, Mr. Hunter discussed his findings with Dr. J. L. Stuckey, State Geologist, and with various members of the U. S. Geological Survey, and pointed out that more detailed study of the district was advisable. The present cooperative investigation is an outgrowth of these discussions. Its purpose was twofold—to make a thorough study of the geology and pegmatite deposits of the district, and to appraise the usefulness of the zonal concept of pegmatite structure in prospecting, developing, and mining feldspar deposits. Full results of the investigation are to be given later in a comprehensive report. The present report summarizes the more salient features of the geology and mineral deposits of the area.

PREVIOUS INVESTIGATIONS

The geological literature dealing directly with the Bryson City area is extremely scanty. Brief references to the region are found in the reports of the Geological Survey of North Carolina published in 1875[2] and 1885.[3] On the geological map accompanying the second report, the rocks of the area are designated as Huronian in age. The Tuckasegee drainage area also is mentioned briefly by Hayes and Campbell.[4] Reports by Pratt[5] and Ries[6] contain brief references to kaolin mining in the Bryson City area and in adjacent parts of Swain County, and a corundum prospect southwest of Bryson City is mentioned by Pratt and Lewis.[7] In 1907 the geology of the Nantahala quadrangle, which adjoins the Bryson City area on the west

[1] Geologist, Regional Products Research Division, Tennessee Valley Authority.
[2] Kerr, W. C., Report of the Geological Survey of North Carolina, vol. I, Raleigh, 1875.
[3] Genth, F. A., and Kerr, W. C., Geology of North Carolina, vol. II, Raleigh, 1885.
[4] Hayes, C. W., and Campbell, M. R., Geomorphology of the southern Appalachians: Nat. Geog. Mag., vol. 6, pp. 63-126, 1894.
[5] Pratt, J. H., The mining industry in North Carolina: North Carolina Geologic and Economic Survey, Econ. Papers nos. 6 (1902), 8 (1904), 9 (1905), 11 (1907), 14 (1907), 15 (1908), 23 (1911), 34 (1914), and 49 (1919).
[6] Ries, H., The clays of the United States east of the Mississippi River: U. S. Geol. Survey Prof. Paper 11, 298 pp., 1903.
[7] Pratt, J. H., and Lewis, J. V., Corundum and the peridotites of western North Carolina: North Carolina Geol. Survey, vol. 1, p. 47, p. 252, 1905.

and southwest, was described by Arthur Keith.[8] As the Bryson City area lies on strike with the northeastern part of the Nantahala quadrangle, Keith's findings are of much interest. The geology of the Cowee quadrangle, which includes the Bryson City area, also was mapped by Keith, and copies of his unpublished map have been available to the writer.

In 1913, A. S. Watts[9] discussed the mining of kaolin and feldspar in western North Carolina, described three deposits in the Bryson City area, and gave test data for clays and "semikaolinized feldspar." In 1922 and 1925, W. S. Bayley[10] described several of the kaolin deposits and discussed the kaolin industry of the time.

Discussions of the broader features of the Appalachian region bear on certain problems of the Bryson City district. Of particular interest is a series of papers on the geomorphology of the southern Appalachians by Frank J. Wright.[11] Discussions of the stratigraphy and structure have been given by G. W. Stose and A. J. Stose.[12]

NATURE AND EXTENT OF INVESTIGATION

Field work of the investigation occupied approximately six months of the period September 1946 through April 1947. The principal pegmatite mines and prospects were studied and mapped in detail, and numerous smaller bodies were examined. An area at Bryson City of approximately 18 square miles underlain by the Bryson City granitic complex and enclosing rocks was then mapped on a scale of 1,000 feet to 1 inch. The base map used was an enlargement of the topographic map of the Bryson quadrangle, scale 1:24,000. Mapping consisted of systematic traverses at intervals of 500 to 1,000 feet, together with supplementary traverses to walk out contacts and other significant features. The principal pegmatite deposits were surveyed largely by plane table and telescopic alidade; this was supplemented at the Deep Creek No. 1 mine by transit survey. Surface exploration by means of postholes, pits, and trenches was done at several deposits. Mr. Alfred A. Bush assisted in the detailed mapping, supervised part of the exploratory work, and mapped and studied the South McCracken and Cox No. 2 deposits.

ACKNOWLEDGMENTS

The Bryson City area was studied in cooperation with the North Carolina Department of Conservation and Development, under an arrangement made with Dr. Jasper L. Stuckey, State Geologist. Information and assistance also were given freely by the Tennessee Valley Authority. The writer is particularly indebted to Mr. Charles E. Hunter, geologist for TVA, and Mr. H. S. Rankin, Director of the Regional Products Research Division. The results of the reconnaissance study made in 1943 by Hunter and W. T. McDaniels, Jr., were made available to the writer and have been most helpful. Laborers and equipment provided by TVA made possible the exploratory work described below. Mr. R. H. Jahns has supplied the writer with a plane-table map of the surface workings of the Swain mine, made in June 1945. Mine owners and operators in the district have furnished much information and have extended full cooperation. The writer wishes to express his appreciation especially to Mr. W. J. Alexander and Mr. Oscar Pittman for information and for many courtesies.

The classification and nomenclature of pegmatite units employed in this report follow the usage developed by geologists of the U. S. Geological Survey during World War II, as elsewhere described.[13]

[8] Keith, Arthur, U. S. Geol. Survey Atlas, Nantahala folio (no. 143), 1907.

[9] Watts, A. S., Mining and treatment of feldspar and kaolin in the southern Appalachian region: U. S. Bur. Mines Bull. 53, 170 pp., 1913.

[10] Ries, H., Bayley, W. S., and others, High-grade clays of the eastern United States: U. S. Geol. Survey Bull. 708, 314 pp., 1922.
Bayley, W. S., The kaolins of North Carolina: North Carolina Geol. Survey Bull. 29, 132 pp., 1925.

[11] Wright, F. J., The Blue Ridge of southern Virginia and western North Carolina: Denison univ., Sci. Lab., Jour., vol. 22, pp. 116-132, 1927.
————, The erosional history of the Blue Ridge: Denison Univ., Sci. Lab., Jour., vol. 23, pp. 321-344, 1928.
————, The older Appalachians of the South: Denison Univ., Sci. Lab., Jour., vol. 26, pp. 143-250, 1931.
————, The newer Appalachians of the South, part 2, South of the New River: Denison Univ., Sci. Lab., Jour., vol. 31, pp. 93-142, 1936.
————, Erosional history of the southern Appalachians: Jour. Geomorphology, vol. 5, no. 2, pp. 151-161, 1942.

[12] Stose, G. W., and Stose, A. J., The Chilhowee group and Ocoee series of the southern Appalachians: Amer. Jour. Sci., vol. 242, pp. 367-390, 401-416, 1944.
————, Ocoee, series of the southern Appalachians: Geol. Soc. America Bull., vol. 60, pp. 267-320, 1949.

[13] Cameron, E. N., Jahns, R. H., McNair, A. H., Page, L. R., The internal structure of granitic pegmatites: Econ. Geology, Mon. 2, 113 pp., 1949.

The writer wishes to thank Mr. Carl E. Dutton for a critical reading of the manuscript and Mr. John B. Hanley for his careful editing. Mr. James J. Page and Mr. Preston E. Holtz have contributed helpful criticisms.

HISTORY OF MINING

Records of mining activity in the Bryson City area are scanty, and the mining history must be pieced together from fragmentary data from a number of sources. Judging from local reports, mining activity in the district began probably in the last century with production of small amounts of gold from the gravels of local streams such as Bryson Branch. In 1901[14] the first kaolin mines in Swain County (presumably north of Bryson City) were opened, and a small plant for cleaning and preparing the kaolin for market was erected. Pratt's reports for succeeding years[15] contain brief references to kaolin mining, together with some production data. Several companies were active at various times in the district during this period, but the operations of the Harris Clay Co. appear to have been the most productive. According to Mr. W. C. Queen and Mr. S. W. Enloe, the company began operations in 1907, or possibly a little earlier, and continued until 1912 or 1913. During this period about 16,000 tons of processed kaolin was shipped from mines of the company, and an additional 2,000 tons probably was received by the company from mines of other operators in the Bryson City district. The principal mine of the company was the Randall mine (pl. 1, no. 7). Clay dug from this mine was flumed down to a washing plant in the valley north of the Swain mine, thence to a drying and pressing plant on Deep Creek. The processed kaolin brought $13.50 per ton delivered to East Liverpool, Ohio. Freight was $4.37 per ton. Mr. Enloe estimates the total production of the Bryson City district at about 25,000 tons. Sporadic operations at other mines appear to have continued until the early 1920's, but none of the mines appears to have yielded large amounts of clay.

Accounts of kaolin mining and processing methods as practiced in western North Carolina around the turn of the century are given by H. Ries,[16] and the operations of a later period are described by A. S. Watts.[17] Watts gives an analysis of finished clay from the Randall mine and of "semikaolinized feldspar." He noted the occurrence of fresh feldspar at the mine and suggested that "semikaolinized feldspar" (weathered perthite) should be usable for pottery purposes.

Nearly thirty years passed before the value of Watts' suggestion was demonstrated. According to local report, the first prospecting for feldspar in the Bryson City district was in 1934 by two brothers named Brooks. A few thousand tons of feldspar probably was produced, mostly from the Deep Creek No. 1 deposit, but sizable bodies of high-grade feldspar were not discovered. In 1939, W. J. Alexander leased the DeHart and Deep Creek No. 1 deposits. Production from the DeHart mine was small, though the product was No. 1 feldspar of high quality. Prospecting at the Deep Creek No. 1 deposit, however, was shortly rewarded by the discovery of the shoot of feldspar which has proved to be the most important deposit of the district. Subsequent exploration of the pegmatite at the Swain mine led, in 1940, to discovery of another large shoot of high-grade feldspar. These discoveries attracted other operators to the district, and development of other deposits was the result. These efforts were not all crowned with success, but in early 1947 four mines were in operation and several other deposits were being prospected actively.

Figures for total production of feldspar from the district are not available. The writer estimates that to the end of 1946 between 130,000 and 150,000 tons of crude feldspar, the major portion No. 1 potash feldspar, was produced. The value of the output, at the mines, is estimated roughly at $500,000.

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[14] Pratt, J. H., The mining industry in North Carolina: North Carolina Geol. and Econ. Survey, Econ Paper No. 6, p. 86, 1902.
[15] Pratt, J. H., The mining industry in North Carolina: North Carolina Geol. and Econ. Survey, Econ. Paper No. 8 (1904), No. 9 (1905), No. 11 (1907), No. 14 (1907), No. 15 (1908), No. 23 (1911), No. 49 (1919).
[16] Ries, H., Clay deposits and clay industry in North Carolina: North Carolina Geol. Survey Bull. 13, 1897.
——————, The clays of the United States east of the Mississippi River: U. S. Geol. Survey Prof. Paper 11, 298 pp., 1903.
[17] Watts, A. S., Mining and preparation of feldspar and kaolin in the southern Appalachian region: U. S. Bur. Mines Bull. 53, 170 pp., 1913.

GENERAL DESCRIPTION OF THE BRYSON CITY DISTRICT

LOCATION AND GENERAL INFORMATION

The Bryson City district lies at the southern edge of the Great Smoky Mountains, 51 miles west-southwest of Asheville and about 42 miles northeast of Murphy (fig. 1). The Tuckasegee River flows through Bryson City and, on its westward course to junction with the Little Tennessee, nearly bisects the area. The area is served by the Murphy Branch of the Southern Railway. Paved roads connect it with Dillsboro and Waynesville to the east, and with Murphy, Franklin, and other communities to the south and southwest. Gravel and dirt roads give access to much of the surrounding territory.

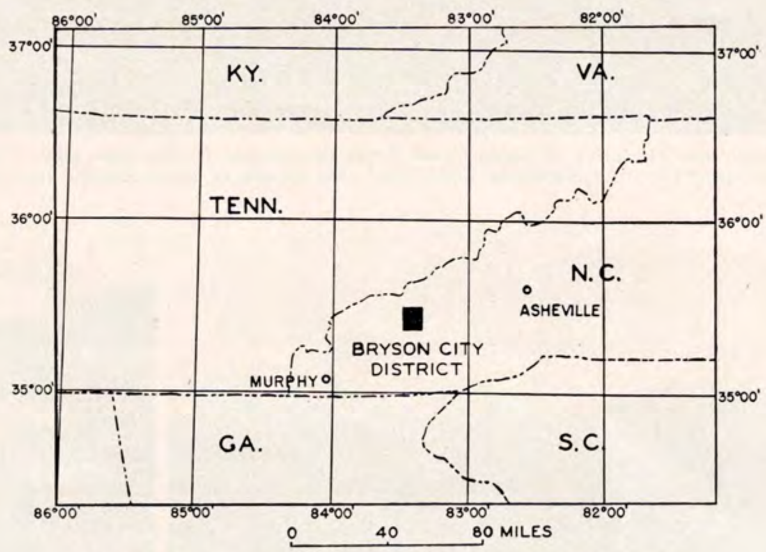


FIGURE 1. INDEX MAP OF BRYSON CITY AREA

Bryson City, a town of about 1,700 people, is the county seat of Swain County and the supply and community center for the surrounding area. The inhabitants depend for their livelihood chiefly on small industries, together with farming and lumbering carried on in the vicinity. The area is at the head of Fontana Reservoir, and lying as it does in a setting of great beauty on the south edge of the Great Smoky Mountains National Park, it is becoming a center of a flourishing tourist trade. A small percentage of the residents have found employment in the feldspar mines.

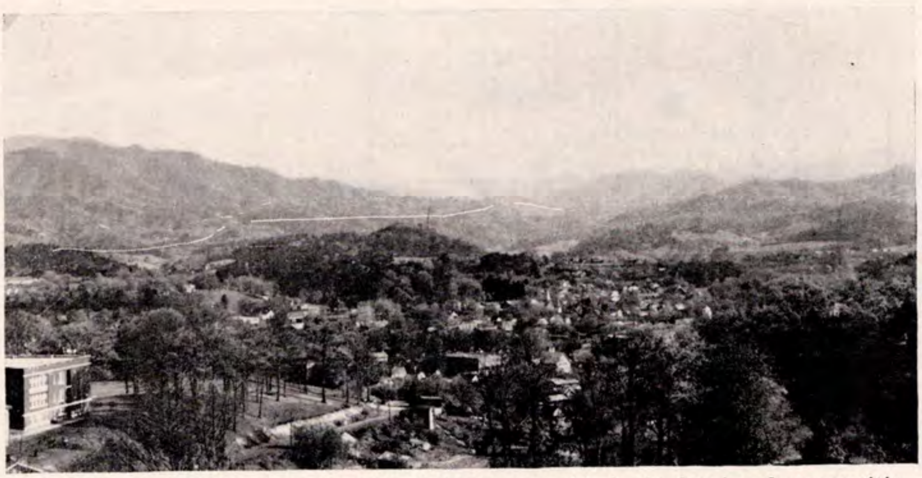
TOPOGRAPHY AND PHYSIOGRAPHY

The area included in the Bryson quadrangle is mountainous. Elevations range from about 1,630 feet at the point where the Tuckasegee River leaves the quadrangle to more than 4,000 feet on the high ridges of the northern and southeastern parts of the quadrangle. The town of Bryson City lies near the midpoint of a topographic basin developed on a granitic complex (pl. 1 and pl. 2, B). The basin is hilly but is markedly lower than the encircling ridges and appears subdued in contrast. Its basin-like character is best exhibited north of the Tuckasegee River, where Deep Creek, a brawling mountain torrent, and smaller streams to the west have cut deeply. The lower courses of these streams are marked by valleys in early to full maturity, with straths of various widths. The broadest and most continuous strath is along Deep Creek.

The contrast between surrounding ridges and granite lowland was developed at a considerably earlier period, partly by the Tuckasegee River, partly by the tributary streams. An erosion surface was developed widely at this time on the granitic rocks north of the Tuckasegee River. The surface has since been maturely dissected, sediments mantling it have been eroded away, and probably the actual surface is nowhere preserved. Its former extent and approximate position, however, appear to be indicated by the summits of

PLATE 2.

A. View looking northeast across the valley of Deep Creek from the terrace on the west side. The prominent terrace (center and right middle ground) is at approximately elevation 1,840 feet. The mouth of Betts Branch is at the extreme right.



B. View northward along the axis of the topographic basin developed on granitic rocks, from the 2,000-foot terrace immediately south of Bryson City (in fore and middle ground).

C. Deep Creek No. 1 mine from the southeast.

the divides of the present drainage, which lie at elevations close to 2,000 feet. Allowing for later dissection, these summits define a surface extending from the Tuckasegee River opposite benchmark 1749 (on the railroad), nearly due north to the confluence of Juney Whank Branch and Deep Creek. The margin of the surface can be traced from this point southwestward to the upper part of Bryson Branch, east of Sherrill Gap, whence it passes irregularly southeastward to Bryson City. The arcuate ridge extending eastward and southeastward from a point just south of Franklin Grove Church, and forming the rim of the valley of Bryson Branch just above its junction with the Tuckasegee River, appears to have stood above the surface and may have formed the north wall of a meander of the ancient valley of the Tuckasegee River.

This erosion surface is poorly preserved north of the Tuckasegee River in the area west of Bryson Branch; it probably did not extend far from the river. South of the river the surface was apparently not extensive, but it is clearly indicated in the area of Arlington Church and the Bryson City reservoir, and is probably represented by the tops of the dissected ridges west of lower Buckner Branch and between lower Buckner Branch and Cochran Branch.

The erosion surface is probably to be correlated with the surface described by Willis[18] and by Hayes and Campbell[19] from the Asheville region and later correlated by Wright[20] with the Harrisburg peneplain

[18] Willis, B., Round about Asheville, North Carolina: Nat. Geog. Mag., vol. 1, pp. 291-300, 1889.
[19] Hayes, C. W., and Campbell, M. R., Geomorphology of the southern Appalachians: Nat. Geog. Mag., vol. 6, pp. 63-126, 1894.
[20] Wright, F. J., The older Appalachians of the South: Denison Univ., Sci. Lab., Jour., vol. 26, p. 165, 1931.

of the Appalachian Valley to the west. The valleys developed during this stage of erosion appear to be preserved, not greatly modified, along the upper parts of some of the smaller tributary streams, such as the upper end of Toot Hollow Branch, and the middle and upper portions of Durham, Juney Whank, and Tom Branches. For the first three streams named, the contact of the granitic complex with surrounding rocks is a fall line marked by small steep gorges. Above them the valleys open out into the "hollows" that figure so prominently in Carolina mountain legend and are one of the delightful features of the region. During the long history of successive degradations of the mountains, hollows have repeatedly developed above belts of resistant rocks that have impeded successive entrenchments of the streams.

Certain long spurs that extend, with slightly undulating summits, outward from the higher ridges suggest remnants of still higher and older local erosion surfaces. The ragged mass of ridges with crestlines at elevations in the neighborhood of 2,200 feet, lying between Betts Branch and Johnson Branch, is a conspicuous example. Dissection at higher levels is far advanced; the outlines of these ancient surfaces are obscure.

Below the 2,000-foot level, terraces and benches are found at various elevations down to the floors of the present valleys (pl. 2, A). Cappings of poorly sorted gravels and sands are preserved on many of them, and the locations of the more prominent deposits are roughly shown on plate 1. The outlines of the terraces are commonly not clearcut. Along their outer margins, there has been much slumping of the adjacent valley walls, so that the terraces merge into the valley slopes. At their streamward margins they pass similarly into terraces at lower levels, into deposits mantling the present valley floors, or into material washed downward and forming a heavy mantle over the valley sides. No attempt has been made, in the present investigation, to outline these deposits precisely or to distinguish between deposits at various levels.

The features of the Tuckasegee drainage basin are mirrored, though indistinctly, in those of the drainage of Alarka Creek, where terraces or remnants of erosion surfaces at several elevations are more or less clearly indicated.

In general, the area is at present one of steep slopes and active erosion. In places the rocks are deeply weathered for 100 feet or more downward from the surface, but the soil mantle is thin. Decomposed but undisturbed bedrock lies no more than 3 to 6 feet below the surfaces of many of the slopes. This condition is important to prospectors, for it means that in large parts of the area the character and extent of bedrock units beneath the soil can be determined rapidly and cheaply by means of postholes, pits, and shallow trenches.

Denudation in the area is accomplished chiefly by fluvial erosion, but creep and small-scale landsliding play an important role in feeding the branches of the streams. Almost every excavation or mine opening that penetrates the overburden and the decomposed bedrock shows one or more surfaces along which landslip has taken place, and some of the mine workings show these surfaces in bewildering profusion. With brief experience, one soon realizes from surface features that slips have occurred at innumerable places in the area. Inevitably, slips are more conspicuous around mine openings and are particularly prominent on steep slopes, where removal of support by excavation has led to new slips or to renewed movement on old surfaces. Such slips are a common source of difficulty in shallow openings, and larger slips led to the closing of one of the district's three most productive mines.

The author is convinced that mass movements of soil and weathered bedrock are a major factor in the degradation of the region. Movements[21] are mostly creep, slump, and earthflow, but debris-avalanching may occur, especially adjacent to artificial or natural excavations.

BEDROCK UNITS

GENERAL STATEMENT

The rocks of the Bryson City area (pl. 1) are a varied assemblage, the cumulative result of a long and complex history of sedimentation, intrusion, granitization, and successive deformations. Part of this history is plainly shown; part is obscure and is likely to remain so until the geology of the older Appalachians as a whole has been much more intensively studied than at present. The present paper is essentially a

[21] Sharpe, C. F. S., Landslides and related phenomena, Columbia University Press, 137 pp., 1938.

progress report covering the results of field investigations to date. More thorough analysis of the structural and petrologic problems of the district must await laboratory studies and a subsequent review of critical features in the field.

The rocks of the area comprise schists, metagraywackes and quartzites, and metaconglomerates derived from sediments; hornblende, hornblende-biotite, and biotite schists and gneisses; metaperidotite and granite gneisses; and later granites, porphyritic quartz monzonite, pegmatites, and quartz veins. The ages of these rocks are unknown. They have been variously assigned to the pre-Cambrian, to the Paleozoic, or to both, but the different attempts to correlate them with formations of known age serves chiefly to demonstrate deficiencies in current knowledge of the region.

METASEDIMENTARY ROCKS

Surrounding the granitic complex is a monotonous succession of interbedded schists, feldspathic micaceous quartzites, and feldspathic metaconglomerates that are evidently derived from a thick series of clastic sediments. Schists and quartzites are the predominant members; the metaconglomerates are a minor component. The thickness of these rocks is unknown. They form part of the group of rocks known as the Ocoee series.

The schists are fine-grained to coarse-grained evenly bedded quartz-mica schists and feldspathic schists that occur in beds ranging from a knife-edge to many feet in thickness. The predominant types are fine- to medium-grained rocks consisting of quartz and muscovite, subordinate to minor biotite, accessory garnet, and minor amounts of feldspar. Variants are biotite-quartz schist, kyanite-bearing schists, and rare staurolite-bearing schists. West of the area mapped, along the road leading past Rock Creek Church, graphitic schists and phyllites rich in kyanite are exposed. As noted by Ross,[22] in the roadcut on the south side of the Tuckasegee River east of Milksick Cove, sulfides are widely disseminated in small amounts though the schists as well as associated quartzites and metaconglomerate. Weathering of the sulfides has resulted in marked yellow and brownish discoloration of the rock.

The quartzites are evenly bedded, gray to dark gray, fine- to medium-grained rocks consisting of quartz and feldspar with various amounts of biotite or muscovite, or both, accessory garnet, and locally kyanite. Beds range from a fraction of an inch to 6 feet or more in thickness; most are less than 1 foot thick. Lenses of pseudo-diorite[23] are present locally in the quartzites, particularly west of the granitic complex. They range from a few inches to more than 6 feet in length and from an inch to a foot in thickness.

The metaconglomerates are gray to dark-gray rocks consisting of prominent white pebbles of feldspar 1/16 inch to 3/8 inch in diameter set in a matrix consisting of flattened and crushed quartz pebbles originally of comparable size. More or less sandy material is invariably present, and with increase in the ratio of sandy material to pebbles these rocks grade into quartzites, with which they are interbedded. In the few exposures of metaglomerates found, crossbedding is not commonly discernible, but it is probably a common feature of the quartzite-conglomerate assemblages.

In places along the margins of the granitic complex, these metasedimentary rocks have been injected and impregnated with coarse granitic and pegmatitic material. The effects are particularly prominent along the east side of the granitic complex and around the south end, and are well exposed in the highway cuts on Highway 19 eastward from the mouth of Kirkland Creek to the bridge over the Tuckasegee River. These injected rocks were mapped as "Carolina gneiss" by Keith,[24] but apart from the introduced material, they differ in no essential respect from the metasedimentary rocks. Metaconglomerates and lenses of pseudodiorite are included in the series. It seems evident that the "Carolina gneiss" as recognized by Keith in the Bryson City area is a lithologic facies, not a stratigraphic unit. Similar conclusions were reached by Kesler[25] for the rocks of the Gaffney-Kings Mountain area. The remainder of the metasedimentary rocks is shown

[22] Ross, C. S., Origin of copper deposits of the Ducktown type in the southern Appalachian region: U. S. Geol. Survey Prof. Paper 179, pp. 102-103, 1935.

[23] Emmons, W. H., and Laney, F. B., Geology and ore deposits of the Ducktown mining district, Tennessee: U. S. Geol. Survey Prof. Paper 139, pp. 15, 20-21, 1926.
Ross, C. S., *op. cit.*, pp. 2-22.

[24] Keith, Arthur, Cowee quadrangle, unpublished map in files of U. S. Geological Survey.

[25] Kesler, T. A., The tin-spodumene belt of the Carolinas: U. S. Geol. Survey Bull. 936-J, p. 252, 1942.
________, Correlation of some metamorphic rocks in the central Carolina piedmont: Geol. Soc. America Bull., vol. 55, pp. 755-782, 1944.

on Keith's map largely as part of the Great Smoky conglomerate. Just west of the granitic complex, synclinal belts of the Nantahala slate, considered by Keith to overlie the Great Smoky conglomerate, are shown on his map, and one of these belts falls within the area mapped during the present investigation. Presumbaly, this designation was applied to prominent schist members of the metasedimentary series. The writer has discovered no basis either for the synclinal structure indicated by Keith or for the distinction of a Nantahala slate within the mapped area. Attempts to define such a unit and to trace it along the strike met with no success.

METAPERIDOTITE

Metaperidotite is exposed in two narrow belts, both lying within the granitic complex near its contact with metasedimentary rocks. The longer belt extends along the western margin of the complex. From a point half a mile northwest of the highway bridge over Alarka Creek it can be traced almost without interruption for 9,000 feet north-northeastward. Scattered outcrops are found northward of this point as far as the Deep Creek No. 1 mine at the head of Toot Hollow, but its continuity over this distance is uncertain, owing to lack of exposures. The second belt lies just west of the westernmost tongue of metasedimentary rocks that projects northward into the south end of the granitic complex.

Dunite composed largely of olivine with a little enstatite was reported by Pratt and Lewis[26] from a locality 3 miles a little south of west of Bryson City, with the statement that corundum is said to have been found there. Unaltered dunite has not been found by the writer. Outcrops commonly show massive to schistose, medium-grained to extremely coarse-grained rock consisting essentially of tremolite, anthophyllite, and chlorite. This rock grades through intermediate facies into hornblende schist, hornblende-biotite schist, and biotite schist. The changes appear related partly or entirely to the development of the granitic complex. The biotite schists are commonly interlayered with feldspathic schists, and in several places, by increase of feldspar, the biotite schists pass into biotite granite gneiss. Stages in the conversion of metaperidotite to biotite granite gneiss are particularly well shown in the cut bank along the new gravel road at the Oscar Martin prospect (pl. 1, No. 36).

The peridotite has been profoundly modified since its intrusion, and its original extent and relationships to adjacent rocks are much obscured. These matters are discussed briefly in a subsequent section.

HORNBLENDE AND BIOTITE SCHISTS AND GNEISSES

Fine-grained to coarse-grained, dark-green to black rocks characterized by hornblende or biotite, or both, occur throughout the granitic complex. They form layers, lenses, and streaks ranging from less than one inch to tens of feet in thickness and from a foot to 100 feet or more in length. The outlines of the larger bodies cannot be traced satisfactorily in the field, hence no attempt has been made to distinguish them on the areal map. They show a wide range of composition, having various amounts of quartz, epidote, plagioclase and potash feldspars, and accessory garnet, sphene, apatite, and black iron oxides. Clinopyroxene is present in at least one sample collected.

These rocks are of the lithologic types described from various quadrangles of the older Appalachians and the Piedmont by Keith as the Roan gneiss, but no unit, of this name is distinguished in the Bryson City area on Keith's unpublished map of the Cowee quadrangle. In the Bryson City area, two groups of these rocks have been roughly discriminated by the writer, according to their occurrence and associations. One group is derived by metamorphism and granitization of peridotite. A series consisting of metaperidotite, hornblende schist, biotite schist, biotite-rich gneiss, and biotite granite gneiss is clearly indicated by exposures in mine workings along the main peridotite belt and in roadcuts at the Oscar Martin prospect that intersect the shorter peridotite belt on the north side of Alarka Creek. The other group consists of hornblende, hornblende-biotite, and biotite schists and gneisses that are found elsewhere in the area and are not associated with metaperidotite. Like the first group, they were extensively modified during development of the granitic complex, and transitions to biotite granite gneiss are found in numerous places.

Lithologically the two groups are much alike; whether the distinction made in the field is a valid one is questionable. Keith[27] states that in the Nantahala quadrangle altered dunites and peridotites break

[26] Pratt, J. H., and Lewis, J. V., Corundum and the peridotites of western North Carolina: North Carolina Geol. Survey, vol. 1, p. 47, 1905.

through and across the structure of the Roan gneiss, and more recently J. B. Hadley[28] has stated that the peridotite at Buck Creek, N. C., is injected into the Roan gneiss. Furthermore, Keith's mapping indicates that most of the ultramafic bodies in the Nantahala quadrangle are intrusive into Roan gneiss. It seems entirely possible that hornblende and biotitic rocks of both derivations are represented in the Bryson City area.

The Roan gneiss was considered by Keith[29] to be a series of metamorphosed igneous rocks, probably ranging in composition from diorite to gabbro. In the Bryson City area, the presence of metagabbro that appears to grade into hornblende and biotite schists and gneisses lends support to Keith's conclusion. The metagabbro, however, has not been seen in contact with other rocks in the Bryson City area; its original mode of occurrence is obscure.

METAGABBRO

An area about 1,000 feet long and probably 350 feet in maximum width, straddling the divide west of the lower end of Bryson Branch, is underlain by rocks ranging from massive biotite-hornblende metagabbro through biotite-hornblende gneiss to biotite schist and gneiss. The core of the mass is apparently composed of metagabbro, the margins of biotite-hornblende and biotite schist and gneisses. The metagabbro is a medium-grained, massive, black and white mottled rock consisting essentially of plagioclase and clinopyroxene partly replaced by hornblende, biotite, and microcline. Pyroxene is lacking in the schistose and gneissic facies. The float indicates that the mass is cut by thin stringers of pegmatite, and pegmatitic solutions may be responsible for part of the alteration.

Contacts of the metagabbro body are concealed. Presumably its emplacement preceded the development of the granitic complex.

GRANITIC ROCKS

General statement.—The rock complex of the central part of the area mapped shows a range of lithologic types which is altogether extraordinary, the more so because preliminary microscopic examination indicates that the predominant types fall within the rather narrow mineralogical range between granite and granodiorite. In part this complexity is due to the presence of intrusives of different ages, in part it is due to granitization of metaperidotite, hornblende and biotite schist and gneiss, and metasedimentary rocks of the Great Smoky formation, and in part it is due to later deformation and metamorphism of some of the rocks of the complex. Some of the facies of the granitic gneisses form bodies large enough to be mapped as separate units, but pending petrographic studies, the entire complex, apart from a border gneiss forming the margin of part of the complex, is shown on plate 1 as a single unit.

Granitic gneisses.—The predominant rocks are fine- to coarse-grained, equigranular to markedly inequigranular, leucocratic and mesocratic gneisses ranging in composition from granitic to granodioritic. Both foliated and linear gneisses are present; foliation and lineation range from indistinctly to strongly developed in various facies. Essential minerals are microcline and microperthite, plagioclase (probably ranging from albite-oligoclase to andesine), and quartz ,with subordinate or accessory biotite, muscovite, hornblende, and epidote. The proportions of these minerals vary within a wide range. Sphene, apatite, zircon, magnetite, and garnet are common accessory minerals. Foliation is due to knife-edge elongate or irregular laminae of biotite as much as 3 inches by 6 inches in length; to parallel arrangement of augen composed of microcline or of microcline, plagioclase, and quartz; to alternating layers of quartz-rich, feldspar-rich, biotite-rich, hornblende-rich, or epidote-rich rock, ranging in thickness from a knife-edge to a half inch or more; to elongate streaks of parallel-oriented biotite flakes; to discontinuous folia of mica flakes intergrown with feldspars and quartz; and to parallel disseminated flakes of biotite or muscovite, or both. Linear structures and combinations of platy and linear structures are widely developed. Elongate patches and flat thin lenses of biotite, parallel-oriented augen, and pencil structures developed by rotational shear are the principal types. In a few places, such as the roadcuts on Highway 19 southwest of the Bryson City limit and the cuts on the north bank of the Tuckasegee River 600 feet east of the 1,721-foot benchmark, massive or virtually massive biotite granite is present.

[27] Keith, Arthur, U. S. Geol. Survey Geol. Atlas, Nantahala folio (no. 143), p. 3, 1907.
[28] Hadley, J. B., Preliminary report on corundum deposits in the Buck Creek peridotite area, Clay County, North Carolina: U. S. Geol. Survey Bull. 948-E, p. 103, 1949.
[29] Keith, Arthur, op. cit., p. 3, 1907.

In addition to small-scale foliation, larger-scale layering is visible in the majority of outcrops. This structure is due to alternation of layers of contrasting texture or composition, or both. The layers range from an inch to tens of feet in thickness. Some layers, perhaps the majority, are thin flat lenses, but within the limits of the average exposure the apparent structure is that of a layered pile of rocks.

Mixed rocks.—Most large outcrops of the granitic gneisses show layers or lenses of material rich in biotite or, less commonly, hornblende. These layers range from biotite-rich granitic gneiss to the biotite or biotite-hornblende schists discussed above. Gradations between the two extremes are exposed at a large number of places. Both simple concordant or discordant injection and diffuse feldspathization and attendant changes are involved (fig. 3, E, Ms. p. 52). The endless repetition of such features observed in the course of mapping the complex indicates clearly that mixed rocks formed from the biotite and hornblende schists and gneisses are an important component of the complex. Discrimination between the mixed rocks and granitic rocks intrusive in the generally accepted sense is one of the major problems of the area.

Though mixed rocks constitute the predominant types, normal intrusive contacts between hornblende and biotite schists and gneisses and granitic rocks have been observed at a number of places. Certain bodies of schist and gneiss appear to occur as angular inclusions in granitic gneiss, which is in sharp discordant contact with them and is apparently chilled against them (fig. 3, C, Ms. p. 52).

Border gneiss.—Mapping of the granitic complex has shown that it can be divided into facies, each of which is characterized by some predominant type or types of rocks. In plate 1, however, only one facies the border gneiss, is shown as a separate unit. In typical exposures the rock is a medium-gray, markedly foliated gneiss consisting of microcline or composite quartz-feldspar porphyroblasts and augen set in a medium- to coarse-grained matrix that consists essentially of biotite, quartz, and feldspar. The augen and porphyroblasts range from 1/8 inch to 1½ inches in length. Most exposures show foliation due to parallel orientation of porphyroblasts or augen, to alternation of augen-rich and augen-poor or augen-free bands, to alternating biotite-rich and biotite-free thin lenses, or combinations of these features. All gradations between unaffected porphyroblasts and augen are found; the augen are due to granulation, flattening, and elongation by shearing parallel to foliation.

The border gneiss is shown on plate 1 as a unit separating the metasedimentary rocks from the granitic complex. From the vicinity of the Ball No. 1 mine it extends northward around the end of the granitic complex and thence southward along the eastern margin as far as Betts Branch. South of Betts Branch along the eastern margin, and south of the Tuckasegee River along the western margin, border gneiss does not form a mappable unit, though rocks of similiar lithologic character are indicated by float or exposures in a number of places.

The thickness of rocks mapped as border gneiss ranges from 50 to more than 200 feet. The rock is not a homogeneous or sharply defined unit, however, even apart from the lithologic variations described above, for it appears to be interlayered everywhere with granite gneiss and biotite schist and in places with hornblende-biotite schist, actinolite schist, and actinolite-chlorite schist. These rocks form concordant layers an inch to 10 feet or more thick. The contact of the unit with metasedimentary rocks is commonly marked by a 1- to 10-foot zone of feldspathized mica schists and micaceous quartzite, and adjacent to border gneiss the quartzites in places likewise show small augen. No true transition, however, between metasedimentary rocks and border gneiss has been found. Inward toward the granitic complex, interlayered granitic gneiss becomes more abundant. The inner boundary of the border gneiss has been located from float over most of the area; it is only a rough approximation. Exposures along the western margin of the complex, particularly between the Branton and Deep Creek No. 1 mines, suggest that the border gneiss has been produced by granitization of biotite and biotite-hornblende schists. In part these schists appear to have been developed by metamorphism of peridotite.

Other granitic rocks.—The granitic gneisses are cut by small bodies of granitic rocks of several different types. Leucocratic granite and fine-grained granite form small dikes and stringers cutting granitic gneisses in road and railroad cuts along the north side of the valley of Alarka Creek, in roadcuts along the north side of the Tuckasegee River west of Bryson City, and elsewhere. Dikes of medium-gray granite porphyry are exposed, or indicated by float, at a number of places in the southeastern part of the area. They consist of sparsely distributed, tiny (1 to 2 mm) phenocrysts of sodic plagioclase set in a microcrystalline ground-mass of quartz, plagioclase, orthoclase, and biotite in faint parallel arrangement (flow structure). The best exposed is a series of roughly parallel dikes 1 to 20 inches thick, cutting the granitic gneisses in the long railroad cut between Frisbee Branch and Robinson Gap Branch. The dikes strike about N. 40° E. and dip about 35° W. Their contacts with gneiss are sharp and uneven.

In plate 1, a trail is shown joining the Jenkins Branch road about 2,775 feet S. 34½° E. of Arlington Church. Beginning a short distance north of the junction, light-colored bodies of decomposed leucogranite gneiss are exposed in the roadcut at intervals for a distance of nearly 500 feet. The longest body is exposed for nearly 250 feet. It cuts irregularly across interbedded mica schists and feldspathic mica quartzites, the foliation and bedding of which have an apparent dip of 60° to 70° S. The foliation of the leucogranite gneiss is in the same direction, though in general a few degrees less steep in dip, and in general is markedly discordant to the contacts of the body. The foliation of the leucogranite gneiss is evidently due to metamorphism after emplacement. Bodies of similar granite gneiss are exposed at intervals in the metasedimentary rocks along the eastern margin of the granitic complex as far south as the southern slope of the northwest shoulder of Barnes Mountain, where two bodies of the gneiss are indicated on the map. Contacts of these two bodies are nowhere exposed, and outlines of the bodies as shown on the map are probably rough approximations. None of the other bodies could be traced out. In all known occurrences the leucogranite gneiss appears to have foliation essentially the same in attitude as that of the enclosing metasedimentary rocks. Comparable rock within the granite complex has not been certainly identified.

In the lower part of the valley of Cochran Branch, the granitic complex is cut by a series of irregular dikelike bodies of a porphyritic quartz monzonite. This rock is characterized by phenocrysts of microcline ⅛ inch to 2 inches long set in a medium-grained pepper-and-salt matrix. The rock consists essentially of microcline, plagioclase, quartz, and biotite. One irregular dike at least 25 or 30 feet thick, with northwesterly strike and a probable moderate southwesterly dip, is exposed in the first railroad cut west of Cochran Branch. Another dike, about 18 feet thick, is exposed along Highway 19, about 400 feet S. 55° W. of the intersection of the highway with the Bryson City limit. It is nearly vertical, trends roughly east, and cuts unevenly across granite gneiss, the foliation of which strikes N. 34° E. and dips 72°-77° SE. Both bodies contain inclusions of granitic gneiss and show distinct fluidal arrangement of thick tabular microcline phenocrysts parallel to the dike margins.

Another dikelike body of similar rock is exposed in the highway cut straddling the Bryson City limit, at the sign marking the limit. It is about 15 feet thick at the base of the cut but broadens upward. Its walls are uneven; its strike is probably about N. 5° W. and its dip steep east. It differs from the dikes described above in that it has a strong foliation striking N. 65° E. and dipping 66° SE. parellel to, and passing without interruption into, the foliation of the enclosing granite gneiss. The gneiss here is a thinly platy augen gneiss; it has been produced by deformation and metamorphism of the less distinctly foliated granite gneiss that forms the wall rock of the dikes of porphyritic quartz monzonite described above. Southward the trend of the zone of intense shearing, of which this exposure is a part, swings to N. 25° E. and passes eastward of the undeformed dike exposed in the roadcut to the south. A second deformed, highly irregular, foliated body of porphyritic quartz monzonite is exposed in the first roadcut north of the city limit.

North of the Tuckasegee River a body of unmetamorphosed porphyritic quartz monzonite 800 feet S. 35° E. of the McCracken mine appears to be indicated by float, and a second, too deeply weathered to be identified with certainty, may be represented in a roadcut 1,050 feet N. 32° W. of Franklin Grove Church.

STRUCTURE

GENERAL STATEMENT

The structure of the rocks of the Bryson City area is complex. The area lies in the belt of folded rocks forming the older Appalachian Mountains, and its rocks bear witness to profound deformation, punctuated by various stages of development of the granitic complex and followed by the emplacement of bodies of pegmatite. The keys to this history, so far as they are available, lie in the structural characteristics of the metasedimentary rocks flanking the complex, in the internal structures of the granitic complex, and in the relationships of the granitic rocks to the metasedimentary rocks.

STRUCTURE OF THE METASEDIMENTARY ROCKS

General features.—The series of sedimentary rocks originally present in the area has been strongly folded and metamorphosed to schists and quartzites of middle rank. Dips of foliation and bedding range from gentle to vertical but are steep over most of the area. From Alarka Creek northward along the west side of the granitic complex to Ogle Knob, the bedding and foliation at most places dip steeply east. North of Ogle Knob, dips of bedding and foliation are prevailingly steep northwest or west along the western side of the area, although steep easterly dips are found in some places. In general, strike and dip of bedding and strike of foliation in the metasedimentary rocks appear to be parallel to the contact of metasedimentary rocks and border gneiss along this side of the granitic complex. The bedding of the metasedimentary rocks nearest the contact with border gneiss swings around the north end of the granitic complex and apparently conforms in general to the boundary of the complex. Foliation in both border gneiss and granite gneiss appears to show a conformable swing in trend. Taken alone, the pattern of foliation and bedding suggests that the north end of the granitic complex is a blunt arch that plunges northward beneath the metasedimentary rocks.

Along the east side of the granitic complex, foliation and bedding almost everywhere dip northeast, east, or southeast, but vertical or steep westerly dips are found locally. The strike and dip of bedding and the strike of foliation are in general parallel to the trend of the easterly margin of the granitic complex. Outcrops are sparse and poor around the south end of the granitic complex, except around the westernmost of the three prongs in which the granitic complex terminates. This prong appears to be wedge-shaped, with a gentle or moderate southward plunge, hence its structure is in marked contrast to the apparent domical form of the north end of the complex. This structural anomaly is one of the principal problems of the area. The available keys to the problem are in the smaller structural features of the metasedimentary rocks and the granitic rocks. The characteristics of the minor folds are particularly important.

Minor folds.—Minor folds in the metasedimentary rocks range from gentle flexures to isoclinal folds, and their axial planes range from upright to recumbent. Two groups of folds are indicated by the relationships of bedding to foliation. One group consists of folds of the classical type in which the foliation is parallel or subparallel to the axial planes of the folds (fig. 2, A). In this report, folds of this group are termed first-order folds, because they represent the first stage of deformation recognizable in the area. As many of the first-order folds are isoclinal or nearly so, foliation in much of the area is parallel or nearly parallel to bedding. Divergencies of 5° to 20° in strike and of a few degrees to 90° in dip of foliation and bedding are shown in some exposures (fig. 2, B.), but over considerable portions of the area divergence is lacking or is so small that it has eluded a careful search of available exposures. Relationships of bedding and foliation to first-order folds are best exposed west of Bryson City in the roadcuts on the west side of the Tuckasegee River, beginning where the river makes a great bend to the north. Here, interbedded schists and micaceous quartzites are involved in a series of first-order folds. Axial-plane schistosity is well developed in the schist layers. A few of the quartzite layers show a complementary fracture cleavage.

The second group of minor folds is due to a second stage of deformation during which the limbs of the first-order folds were flexed, apparently under the influence of forces acting essentially in the same direction as before. The character of the resulting folds, here designated second-order folds, is shown in figure 2. The structures developed in the metasedimentary rocks are a function of the relative competencies of the beds. The quartzite beds yielded by simple flexure (fig. 2, D, E, F,), and the earlier developed foliation in these beds wraps around the crests and troughs of the newly developed folds. The schist layers yielded by intense crumpling of foliation (fig. 2, B, C, D, E) along axes that in general are systematically related to the crests and troughs of the new folds but have been influenced locally by the attitude of the previously developed foliation. In such places, most of the adjustment of the beds during the second deformation appears to have been accomplished along the original foliation, and axes of crumples in schist layers commonly lie in the plane of the foliation. In second-order folds that have axes parallel to the intersections of bedding and foliation planes, the axes of crumples in schist are parallel to the axes of second-order folding of adjacent competent beds. Where fold axes and intersections diverge, the axes of crumples in schist and the axes of second-order folding in competent beds diverge. In all second-order folds, in sections perpendicular to the fold axes, the axial planes of the crumples are parallel or subparallel to the axial planes of the folds of the competent layers. The crumples are fractured along the axial planes where deformation was most intense, and locally false cleavage is strikingly developed. Recrystallization appears to have played little part in the development of this structure in the Bryson City area.

Minor folds are distinguished from crumples in the discussion above, because the contrast between folds and crumples is striking in sections that consist of alternating layers of schist and quartzite, rocks that differ markedly in competence. The distinction is actually osne of scale; every gradation between minute crumples and folds with amplitudes of 15 feet or more is exhibited in the area.

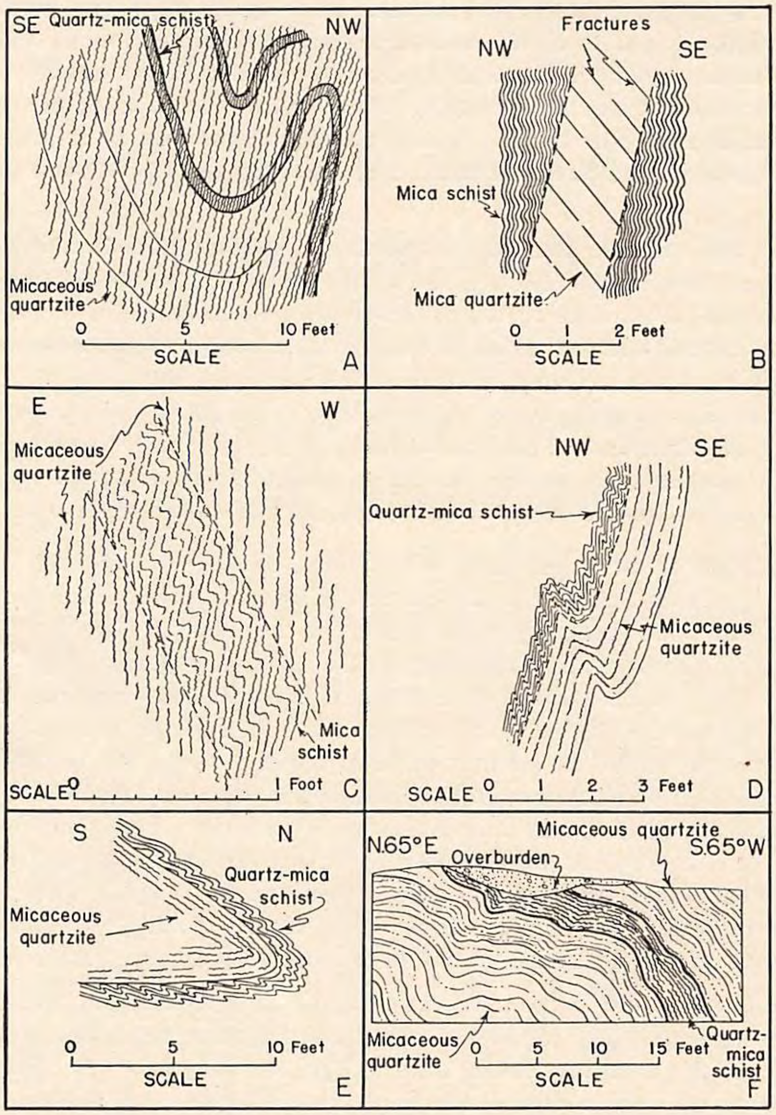


FIGURE 2. STRUCTURAL FEATURES OF METASEDIMENTARY ROCKS.

A. Axial plane foliation in interbedded quartz-mica schist (thin layers) and micaceous quartzite. South bank of the Tukasegee River, roadcut at great bend of river west of granitic complex.

B. Symmetrical crinkling in mica schist enclosing mica quartzite. Roadcut on north bank of the Tuckasegee River, west of granitic complex.

C. Asymmetrical crinkling in mica schist layer enclosed in micaceous quartzite. Same locality as for A.

D. Second order fold involving micaceous quartzite and quartz-mica schist (crumpled). Roadcut on south side of the Tuckasegee River at highway bridge, east of granitic complex.

E. Nearly recumbent fold of second order, involving micaceous quartzite (core of fold) and quartz-mica schist. Note relation of axial planes of crumples in schist to axial plane of fold. Roadcut on west side of Deep Creek, between Tom Branch and Indian Creek.

F. Second-order folds in micaceous quartzite and quartz-mica schist. Roadcut on south side of the Tuckasegee River, between highway bridge and Kirkland Creek.

Second-order folds and crumples are widely developed in the area. They are particularly well displayed in the roadcuts along Highway 19 from the eastern margin of the granitic complex to the edge of the area mapped, and beyond it to the bridge over the Tuckasegee River. Their relationships to the first-order folds are best shown, however, in the roadcuts west of Bryson City referred to above. Second-order folds range from slight monoclinal bends to isoclinal folds. Most of the second-order folds have axial planes that dip eastward or southeastward at gentle to moderately steep angles; roadcuts on Deep Creek north of the end of the granitic complex show a series of recumbent isoclinal folds.

Major folds.—The extent and character of the larger folds of the area are only partly known. The only large fold clearly recognizable is outside the area mapped; it is exposed west of the area in the roadcuts extending southward along the west bank of the Tuckasegee River from the mouth of Laurel Branch. Here the metasedimentary rocks are folded into an open, nearly upright anticline and complementary syncline, the syncline lying to the southeast. The foliation of schistose beds dips 55° to 70° E. Asymmetric crumpling is developed on the west limb of the anticline; the axial planes of the crumples dip eastward.

Stratigraphic tops and bottoms of beds as indicated by the relation of axial planes of crumples to the bedding agree with tops and bottoms of beds as indicated by the relation foliation to bedding. Except for the few places where the crests of first-order minor folds are exposed, this is the only locality in the area where the applicability of this method of analysis of folded structure to the Bryson City area can be tested. If these same relationships are applied as a general key to the structure of the metasedimentary rocks, the results are consistent in general with other data; the one apparent anomaly lies in the structure of the northern end of the granitic complex.

Along the west side of the granitic complex, the foliation in general dips eastward, whereas the bedding either dips westward, or dips eastward at a given locality at an angle that is steeper than the angle of dip of the foliation. The metasedimentary rocks therefore appear to lie on the west limb of an anticline, and this appears to be consistent with the major structure as indicated in the section along the west bank of the Tuckasegee River from Laurel Branch eastward to the great bend. Except at two places that are well west of the margin of the granitic complex, the axial planes of crumples in schist layers likewise dip east, generally at moderate angles, and this fact suggests a similar structural position for the beds. Along the east side of the granitic complex, the dip of the beds is almost everywhere easterly, and the foliation is either sensibly parallel to bedding or dips east at a smaller angle than the bedding. Similarly, the axial planes of asymmetric crumples in schist everywhere dips eastward at angles smaller than those of the dip of the bedding. These observations suggest that the metasedimentary rocks east of the complex to the limit of mapping, and beyond it along the Tuckasegee River to the highway bridge 1 mile east of the the granitic complex, lie on the overturned west limb of an anticline. If the granitic complex is essentially a concordant lens, the metasedimentary rocks both east and west of the complex are part of the same limb of a single major fold. This interpretation is consistent with the apparent wedging out of the westernmost of the three prongs in which the granitic complex terminates to the south, but it is not in harmony with the apparent domical form of the north end of the granitic complex and the immediately adjacent metasedimentary rocks.

Two features of the area limit the use of minor structures as clues to the major structure. Outcrops are poor over most of the area underlain by metasedimentary rocks. Exposures are virtually limited to railroad cuts, roadcuts, and outcrops in the beds of certain streams. The only good section across the eastern margin of the complex is given by the roadcuts and railroad cuts along the Tuckasegee River. Here bedding and foliation are almost everywhere parallel, and at most places stratigraphic tops and bottoms of beds must be inferred from the relation of bedding to axial planes of crumples and second-order folds. Crumples and minor folds are not developed in all beds, and it is possible that axes of isoclinal folds lie between points at which these features are developed. Observations of the minor structures, therefore, are not a fully satisfactory guide to the large-scale structure of the metasedimentary rocks east of the granitic complex. The lack of marker horizons in the metasedimentary rocks is an additional serious difficulty. However, the structural features of the granitic complex discussed below shed some additional light upon the problem.

Faults.—So far as indicated by mapping, faults other than landslips are not a prominent feature of the area. In the roadcut along the west bank of the Tuckasegee River, 700 feet south of Laurel Branch, a shear zone 2 to 3 feet wide with an apparent dip of 30° SE. cuts the metasedimentary rocks. The displacement is unknown. Minor faulting is indicated at a few of the pegmatite deposits, but little can be determined either of the attitudes of the fault surfaces or of the nature of displacements. It should be noted, however, that neither the character of the rocks nor the extent of exposures in the area lends itself to the detection of faulting.

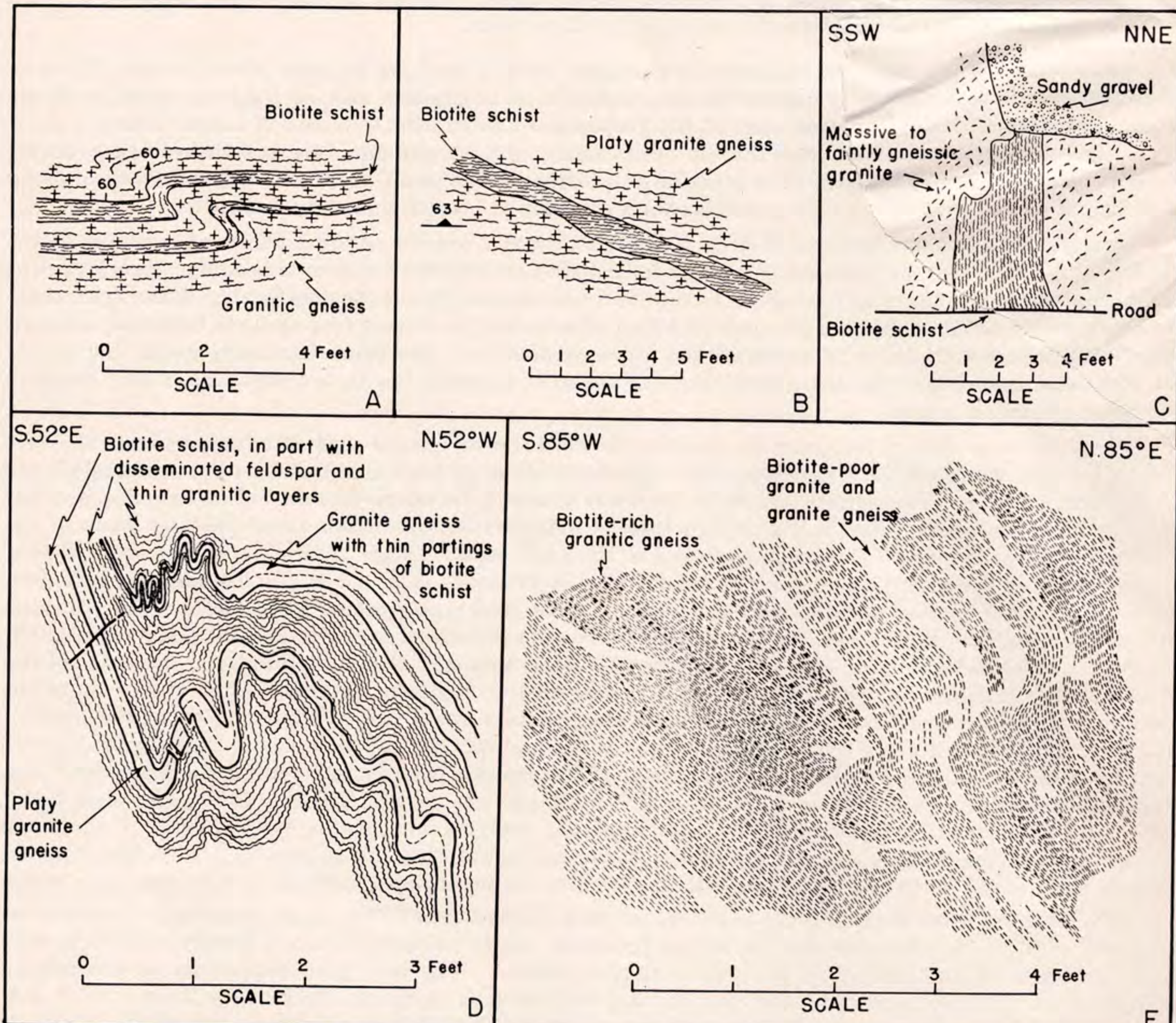


FIGURE 3. STRUCTURAL FEATURES OF GRANITIC ROCK.

A. Minor fold of interlayered biotite schist and granite gneiss. Railroad cut on west side of Buckner Branch, north of Messer Branch.

B. Discordant foliation in granite gneiss and in an inclusion of biotite schist. Exposure along cut-off portion of old Highway 19, lower Cochran Branch.

C. Discordant contact of granite with biotite schist. Roadcut on north side of the Tuckasegee River, west of Bryson Branch. All contacts of schist and granite are approximately perpendicular to the plane of the sketch.

D. Contorted layers of granite gneiss in biotite schist. Lower layer partly dismembered. Upper adit, South McCracken mine.

E. Detailed sketch of exposure on Highway 19, east of the bridge over Alarka Creek, showing an intermediate stage of granitization of biotite or biotite-hornblende schist. There are no true contacts in the exposure; all boundaries are gradational.

STRUCTURE OF THE GRANITIC COMPLEX

General features.—Like the metasedimentary rocks, the granitic complex bears evidence of a complicated history, which is recorded in a considerable range of structural features. The more important features are: (1) foliation and lineation in the complex and the relation of these features to the boundaries of the complex and to various rock types within it; (2) minor folds within the complex; (3) the heterogeneity of the complex; and (4) the form of the complex and its relationships to the metasedimentary rocks.

Foliation and lineation.—Two types of foliation are present in the rocks of the granitic complex. The first and more characteristic is expressed by layering, parallel discoid or elongate lenses, parallel folia of contrasting composition or texture, or parallel arrangement of mineral grains. This type of foliation ranges from faint to extremely marked. It is widely developed and is everywhere conformable with the foliation of the adjacent border gneiss or metasedimentary rocks, and with the boundary of the granitic complex. In places the foliation is accompanied by lineation, which is commonly expressed by elongate mineral grains or groups of grains within foliation surfaces. In most outcrops the direction of plunge of lineation is difficult to measure accurately; it is more widely developed than suggested by the data given on the map.

The second type of foliation, where recognizable, is superimposed upon the first and is produced by deformation subsequent to the development of the main body of granitic gneisses. The relationships are clearly shown in roadcuts on Highway 19, at the point where the road crosses the Bryson City limit in the valley of Cochran Branch. Four hundred feet S. 55° W. of the intersection of the highway with the city limit, granite gneiss with faint to distinct foliation striking N. 34° E. and dipping 72° to 77° SE. is cut by an unmetamorphosed dike of porphyritic quartz monzonite. The dike trends roughly east and is nearly vertical. At the city limit the granite gneiss is cut by a similar dike, but here both dike and granite gneiss have a markedly thinly platy foliation that strikes N. 65° E., and the zone of superimposed foliation swings behind (east of) the cuts showing the unfoliated dike. These exposures show that the foliation of the rocks of the granitic complex was developed in part after the intrusion of the quartzite monzonite porphyry. Figure 3 B shows discordant foliation in granite gneiss and biotite schist in the same belt as the foliated quartz monzonite porphyry. Foliation in schists and granite gneiss is normally parallel. Criteria for distinguishing earlier from later foliation throughout the complex have not been developed. However, the presence of unfoliated quartz monzonite dikes at several places in the complex suggests that the later foliation has been developed only in certain belts within the complex. The author's impression is that foliation in most of the complex is of the earlier type.

On the north side of the Tuckasegee River, muscovite granite gneiss is exposed in the railroad cut west of the northward-projecting wedge of metasedimentary rocks. In places the gneiss shows an unusual structure that appears to be a variant of the common type of foliation. The rock here consists of steeply dipping alternating layers of highly schistose and indistinctly schistore muscovite granite gneiss. The layered structure strikes N. 3°W. and dips 66° E. The foliation has the same strike but dips 57° E. The origin of this structure is uncertain; it probably represents a structure inherited from metasedimentary rocks that have been granitized.

Minor folds.—Minor folds are numerous in the granitic complex. In form they closely resemble the second-order folds in the metasedimentary rocks; they are markedly asymmetric, with their long limbs subparellel to the regional dip of foliation. The folds are strikingly developed between Messer Branch and the Tuckasegee River, in places southeast and east of Bryson City, and in places north of the Tuckasegee River and west of Deep Creek. The attitudes of these folds can be measured accurately in very few outcrops, but their general pattern has been studied in some detail. The folds are registered in flexure of the foliation. Viewed in vertical section most of the folds indicate an upward movement of the rocks on the west, relative to the rocks on the east. This fact is in agreement with the pattern of second-order folds in metasedimentary rocks to the east and west of the complex. Most of the known exceptions lie in a narrow belt extending west of Buckner Branch from Gibby Branch to the Tuckasegee River, where the relationship is reversed. However, the normal pattern is found again in the outcrops of granite gneiss nearest the western boundary of the complex. The relationships suggest a sizable second-order fold within the granitic complex between Buckner Branch and the west margin of the complex.

Exposures in the long roadcut extending eastward from the business section of Bryson City on Highway 19 indicate that there is a definite relationship between the minor folds within the granitic complex and the second-order folds in the metasedimentary rocks. The complex here includes a series of layers or enclosures of biotite schist. At a point about 900 feet from the west end of the cut, biotite schist is crumpled along axes that plunge 21°—N. 22° E. The axial planes of the crumples dip approximately 20° S.E., whereas the over-all dip of layering and foliation in the schists is 84° NW. The pattern of these crumples is the same as that of the second-order folds in sedimentary rocks east of the complex and is duplicated by the pattern of minor folds in granite gneisses in the same roadcut. It appears evident that minor folding in the granite was developed in the second stage of regional deformation. The same conclusion is suggested by relationships in several mine tunnels along the western margin of the complex, where thin layers of granite gneiss alternate with biotite schists (fig. 3, D). The emplacement of the granite gneiss has clearly been controlled by the foliation of the biotite schists, but the layers have been deformed and locally disrupted during crumpling of the biotite schists.

An exposure in the first roadcut east of the business section of Bryson City illustrates a type of linear structure that is strikingly developed in some of the granitic gneisses east and southeast of the business section. This structure consists of spindles of quartz and feldspar up to 6 inches long and half an inch in diameter, wrapped in elongate biotite folia. The linear structure thus developed plunges parallel to the axes of the crumples in the biotite schist layers, and is evidently due to the same deformation.

Heterogeneity of the granitic complex.—The origin of the heterogeneity of the granitic complex is intimately related to the origin of the foliation, and no explanation of the one is satisfactory that does not also account for the other. The key to heterogeneity appears to be largely in the character and relationships of inclusions within the complex. Inclusions of fine-grained quartz-biotite and quartz-biotite-feldspar schist, and of coarse-grained biotite schist or biotite-hornblende schist are very abundant. Many of them exposed in the area south of Franklin Grove Church and west of lower Bryson Branch, and in the lower valley of Cochran Branch, have the relationships of ordinary xenoliths in an intrusive granite. Contacts with granite in places truncate the foliation of the schists (fig. 3, C). The granite against the inclusions is relatively fine grained and massive and shows faint foliation parallel to the contacts. Other enclosures consist of layers of dark schists alternating with layers of granite gneiss; the foliation in both types of rocks is parallel to the layering. Contacts range from sharp to fading and indistinct, and some layers show gradations from schists to granite gneiss. Complex shattering, injection, and feldspathization of the dark schists is shown (fig. 3, E) in still other exposures. These effects are exhibited in hundreds of places in the complex in one stage or another. Along the eastern side of the complex, there has been extensive development of mixed rocks from metasedimentary rocks, especially in the area from Betts Branch to Jenkins Branch, and the rocks Keith mapped here as Carolina gneiss consist of metasedimentary rocks that have been partly granitized. Exposures along the margins of the belts of metaperidotite indicate that this rock likewise has been partly granitized. The development of mixed rocks is indicated at so many places that it seems clear that such rocks form the major part of the granitic complex. The uneven operation of the process of granitization offers the only reasonable explanation for the extraordinary large- and small-scale inhomogeneity exhibited by the granitic rocks, for the presence of innumerable oriented inclusions and partings of dark schists and metasedimentary rocks in the complex, and for the lack of any systematic relation of various facies of granitic rocks, the border gneiss excepted, to the borders of the complex. Furthermore, various exposures indicate that the granitic complex was formed after the development of schistosity in the metasedimentary rocks, for feldspathization of biotite schists and metasedimentary rocks was controlled by foliation. The granitic invasion took place, however, largely prior to the second stage of deformation that produced the second-order folds and crumples in metasedimentary rocks. During this stage minor folds also were widely developed in the granitic rocks (fig. 3, A). Thin layers of granite, developed in rocks marginal to the complex, were in places sharply folded and even disrupted, with local development of boudinage structure (fig. 3, D). In part, however, granitization appears to have been contemporaneous with the second stage of deformation, for lenses of massive granite similar to adjacent granite gneiss in composition and grading into it were developed locally along fractures systematically related to minor folds.

If uneven granitization is the major cause of inhomogeneity of the complex, the foliation of the granitic rocks is inherited in large measure from that of preexisting rocks. The origin of the foliation pattern within and adjacent to the complex and the origin of the pattern of minor folds within the complex must then be sought largely in the same structural history that has produced foliation and minor folds in the metasedimentary rocks. Locally, a later foliation appears to have been produced by deformation after the intrusion of porphyritic quartz monzonite, but the over-all structural pattern within the granitic complex does not seem to have been modified greatly.

Form of the granitic complex and relations to metasedimentary rocks.—In his description of the Nantahala quadrangle, Keith[30] states that the granites of the quadrangle are Archean in age and intrusive into the Carolina or Roan gneiss, and that an angular unconformity separates these older rocks from Cambrian metasedimentary rocks of the Great Smoky formation. On his manuscript maps of the Cowee quadrangle (unpublished), a belt of Carolina gneiss is shown extending northeastward from the east edge of the Nantahala quadrangle. The gneiss is shown as extending around the Bryson City granitic complex except at the north end, where granite is shown directly in contact with the Great Smoky formation. The Bryson City complex is shown correctly as separate from another comparable complex lying en échelon to the northeast. In 1944, Stose and Stose[31] published a map that includes the Bryson City area. No granite is shown in the position of the Bryson City complex, but a northeast-trending belt of intrusive granite about 20 miles long is shown southeast of Bryson City. The northwest boundary of the granite belt, as shown on their map, lies approximately at the actual southeast boundary of the Bryson City complex. They state (p. 411): "Where seen by the writers north of Whittier, North Carolina, it is a muscovite-biotite granite which intrudes, injects, and replaces rocks of the Ocoee series"(the metasedimentary rocks). They state further that the granite at Whittier is similar to Keith's Whiteside granite[32] and express their agreement with Keith's suggestion that this and other similar granites may be as late as Carboniferous in age. Stose and Stose were evidently not aware that the Bryson City and Whittier granitic complexes are separate, and were under a misapprehension as to the position of the Bryson City complex. In 1949,[33] the same authors stated that their more recent field work indicates that the granite gneiss is part of the injection complex exposed in an anticline in the Ocoee series and that the Hurricane graywacke (basal member of Ocoee series as described by them) stratigraphically overlies the granite gneiss. The "late Paleozoic granite" of the 1944 map is shown on their 1949 map as part of an "early pre-Cambrian granite and injection complex" extending from the Roan Mountain quadrangle 200 miles southwestward into Georgia. The observations leading to this revision are not recorded.

The results of the present investigation require considerable revision of the conclusions of Keith and of Stose and Stose. In the Bryson City area, the rocks mapped by Keith as Carolina gneiss are a partly granitized facies of the metasedimentary rocks. The granitic rocks of the area are younger than the metasedimentary rocks, but their relationship to the deformation of the sediments is far from simple. The cross-cutting bodies of light-colored granite gneiss in the metasedimentary rocks along the southeastern margin of the granitic complex may have been intruded prior to the development of the foliation of the metasedimentary rocks. The main body of granitic rocks was emplaced after foliation was developed in the metasedimentary rocks, in part prior to, in part contemporaneous with, the stage of deformation during which second-order folds were produced. The form of the granitic complex and its structural relationships to the metasedimentary rocks must be interpreted in terms of this history.

If the metasedimentary rocks on both flanks of the complex are on the same limb of a single major fold, the west limb of a major anticline, then the granitic complex is essentially a lens. There is a good deal of evidence to support this interpretation. The structural evidence that the sedimentary rocks lie on the limb of a single major fold has already been cited. This evidence is in agreement with lack of any arch structure in the foliation of the granitic rocks along the line of the Tuckasegee River, where the best section of the granitic complex is exposed. The structural features of the narrow wedge of metasedimentary rocks that crosses the Tuckasegee River east of Deep Creek offer further evidence. A long cut extending northeastward from the railroad gives a complete section across this wedge. The rocks exposed in the cut are interbedded mica quartzites and partly granitized coarse-grained muscovite-biotite schists. Bedding and

[30] Keith, Arthur, U. S. Geol. Survey Geol. Atlas, Nantahala folio (no. 143), 1907.

[31] Stose, G. W., and Stose, A. J., The Chilhowee group and Ocoee series of the southern Appalachians: Am. Jour. Sci., vol. 242, p. 372, 1944.

[32] Keith, Arthur, U. S. Geol. Survey Geol. Atlas, Pisgah folio (no. 147), p. 4, 1907.

[33] Stose, G. W., and Stose, A. J., Ocoee series of the southern Appalachians: Geol. Soc. America Bull., vol. 60, p. 274, 1949.

foliation are sensibly parallel, but second-order folds and crumples have developed in the rocks in the western part of the wedge. The bedding there dips steeply east; the folds are sharply asymmetric and have axial planes dipping gently east. Their relation to bedding suggests that the beds are on the overturned west limb of a major anticline, hence in the same structural position as the beds to the east and west of the complex. The contact with granite gneiss to the west is covered, but the two rocks are exposed within 10 feet of each other. In the eastern part of the wedge, bedding and foliation are sensibly parallel. It is possible that a synclinal axis passes somewhere through the middle of the cut. However, the minor structures of the metasedimentary rocks immediately east of the granite gneiss reentrant east of the wedge indicate that the metasedimentary rocks lie on the overturned west limb of a major anticline. If a synclinal axis passes through the wedge of metasedimentary rocks, an anticline and a complementary syncline are required in the reentrant of granite gneiss. There is no evidence of the existence of these two folds. Furthermore, if the wedge is synclinal, the pattern on the map requires a southward plunge, whereas the axes of minor folds in the wedge plunge N. 4° E. at an angle of about 13°. Inasmuch as exposures are poor in the reentrant of granitic gneiss east of the wedge, conclusive evidence of the structure is lacking, but the data at hand suggest that the reentrant of granite gneiss is not related to folding. It appears to be merely a projection of the main body of granitic gneiss produced largely by uneven granitization of metasedimentary rocks.

The structure of the south end of the granitic complex next requires consideration. Only the western prong merits critical discussion, because exposures of the middle and eastern of the three prongs in which the granitic complex terminates are almost wholly concealed. The western prong is bounded on the east by the wedge of schist that extends northward across Alarka Creek. A nearly complete section through this wedge is given by roadcuts and the new railroad cut north of the creek. Bedding and foliation in the metasedimentary rocks dip steeply eastward and are sensibly parallel throughout the wedge, but near the western contact of the wedge the relation of crumples to bedding suggests that the beds are overturned to the west. The west contact of the wedge cuts across the sharp bend of Highway 19 west of the bridge and intersects it near the point at which the highway climbs the valley wall. The roadcuts give a nearly continuous series of exposures from this point to the junction of the highway with the Welch Branch road. Southward the strike of the metasedimentary rocks swings from N. 35° E. to N. 56° E., and the dip decreases from 52° SE. to 27°-35° SE. in the cut on Highway 19 just east of the junction with the Welch Branch road. In the western two-thirds of this cut the rocks structurally underlying the metasedimentary rocks of the eastern part of the cut are mostly schists and gneisses characterized by numerous augen of feldspar. Cutting these rocks and interlayered with them are fine- to medium-grained leucocratic granite gneisses. Some of the augen-bearing rocks resemble the border gneiss found around the northern end of the granitic complex, but some resemble augen-bearing layers in the partly granitized sedimentary rocks east of the mouth of Welch Branch. The augen-bearing rocks and interlayered granitic gneisses extend upward and are exposed in the cuts along the Welch Branch road east of its junction with Highway 19. They are flanked and structurally overlain to the east by metasedimentary rocks, and at the junction of the two roads they are exposed conformably overlying typical interbedded schists and quartzites. Southwest of this point the strike of the foliation and bedding in metasedimentary rocks swings to east-northeast and finally to north, and the dip increases. The augen-bearing rocks do not appear in exposures along the strike south of the junction; presumably they wedge out.

Bedding and foliation are parallel in most of the exposures of metasedimentary rocks on the east side of the prong, and crumpling is lacking. Asymmetric crumpling of schists is shown, however, at the point where the Welch Branch road turns south along the branch. Bedding dips 47° SE. at this point; the axial planes of the crumples dip 18° SE. The relationship suggests again that the metasedimentary rocks on the east side of the prong are overturned to the west. The beds on the west side of the prong are well exposed in the new railroad cut from the Davis Branch road to the boundary of the granitic complex. They show the same relationship as the beds east of the prong, hence the prong appears to be wedge-shaped, not domical. As indicated on the map, however, exposures of the granitic gneiss proper at the apex of the wedge are not adequate to provide a check on the interpretation. Presumably the apex of the wedge plunges to the south.

The evidence thus far presented appears to indicate that the granitic complex is an irregular lens. Certain features of the north end of the complex, however, suggest that it has the form of a structural dome plunging northward at a moderate angle. Although the border gneiss and granitic gneisses are poorly exposed in this part of the complex, it seems clear (1) that the border gneiss forms a continuous unit that passes completely around the north end, (2) that the border gneiss in general dips outward from the complex, and (3) that the foliation of the border gneiss, so far as indicated by surface exposures, also dips outward in general from the granitic complex. If the foliation of the border gneiss and granitic gneisses is an inherited structure, as the writer has concluded, then the domical structure cannot be ascribed to thrust of an intrusive body of granitic magma. The answer to the structural pattern must therefore be sought in terms of the development of the folded structure of the district, in the first-order folding or the second-order folding, or both.

It is at once evident that the structural pattern cannot be ascribed to first-order folding, for the foliation of the border gneiss in the axial part of the domical structure is in general conformable with, not discordant to, the crest of the dome. It is therefore not of the axial-plane type characteristic of first-order folds in the district. So far as is indicated by meager exposures, the same relation holds for the foliation of the granitic gneisses. The domical structure would therefore appear to be related in some way to the second-order folds in which the preexisting foliation has been folded, and therefore wraps around the crests and troughs of the folds.

Some light on the problem is given by the structural features of the metasedimentary rocks at and near the crest of the dome, as indicated by exposures in the vicinity of Deep Creek. The most critical exposures appear to be along the creek between Tom Branch and the contact of metasedimentary rocks with border gneiss. This area has been examined with particular care. In most of the exposures bedding and foliation of the metasedimentary rocks are sensibly parallel; the beds are evidently the limbs of isoclinal folds, but crests and troughs of folds are commonly not discernible. The principal exceptions are a few exposures in roadcuts along the west side of Deep Creek. In the long cut that begins 875 feet northeast along the road from the contact, a series of recumbent folds with axes plunging approximately N. 85° W. is well exposed. The axial planes of the folds and the beds on the limbs dip northwest at moderate to gentle angles. Another set of folds in metasedimentary rocks near the contact with the border gneiss plunges northeast, parallel to the inferred crest of the granitic complex, and beds on the limbs dip in the same direction, in structural conformity with the foliation of the border gneiss. The metasedimentary rocks on the east side of Deep Creek appear homoclinal and dip northeast to east, but the outcrops are not of the kind in which gently or moderately plunging axes of isoclinal folds are likely to be detected. The data are limited, but they suggest that the apparent arch of metasedimentary rocks over the border gneiss is in reality an arch of axial planes of isoclinal and near-isoclinal second-order folds.

If this interpretation is the correct one, the pattern of foliation in the border gneiss belt remains to be explained. There appear to be two hypotheses that might fit the facts so far as known. One is that under the conditions of second-order folding, the metasedimentary rocks were structurally incompetent. They were therefore mashed against the more competent lens of granitic rocks and adjusted themselves, by means of intricate isoclinal folding, to the form of the termination of the lens. In the process, the border gneiss and the outermost part of the granitic gneisses were intensely deformed and assumed a similar pattern. This hypothesis finds some support in exposures in an adit at the Morris prospect (pl. 1) in which interlayered biotite schist and granitic gneiss are thrown into a series of intricate second-order folds. The second possibility is that at its north end the lens of granitic rocks is involved in a large, northward-plunging second-order fold, of which it is the anticlinal member. The complementary syncline should be to the east. If this is the structure, the points of emergence of the axes of both the anticline and the syncline should be found along the eastern margin of the complex. Outcrops along this side of the complex are scant. The only suggestion of emergence of fold axes is found in exposures in the bed of a small brook 2,300 feet east of Deep Creek Church, and here the structure is open to more than one interpretation owing to the difficulty of tracing out the contacts. The contacts as drawn on plate 1 are deliberately noncommittal.

In summary, the evidence appears to favor the interpretation of the granitic complex as a lens with local irregularities of the contact due both to irregular granitization and to folding of the contacts. The northern termination of the lens appears to owe its domal form to second-order folding. The precise nature of the domal structure is obscure. The apparent arch structure of the metasedimentary rocks at the north end of the dome likewise is due to second-order folding, but the lack of a traceable key horizon in these rocks makes it impossible to determine their larger structural pattern.

The problems involved may be analogous to that presented by the gneiss domes (Oliverian, Pelham, Monson, Glastonbury) that occur in a belt extending southward through western New Hampshire into eastern Massachusetts and Connecticut. These domes have been described in a series of papers by Billings and his co-workers[34] and by Balk[35]. In New Hampshire the domes are associated with the Ammonoosuc volcanics, of which amphibolites are a prominent component. The foliation of the volcanic rocks swings around the ends of the Oliverian gneiss domes, but elsewhere in the surrounding terranes, the metasedimentary rocks characteristically show axial-plane foliation. No satisfactory explanation of the development of the domes has so far been advanced.

Nature of the rocks originally occupying the area of the granitic complex.—Granitic gneisses have been developed at the expense of metasedimentary rocks in places, particularly along the eastern side of the complex; but in large part the rocks that have been granitized appear to have been hornblende and biotite schists, and to a less extent gabbro and metaperidotite. In part the hornblende and biotite schists affected are derived from gabbro and peridotite, and the question naturally arises as to whether all the hornblende and biotite schists may have this origin. No definite answer to this question can be given, but if all the hornblende and biotite schists are of this derivation, it is curious that recognizable remnants of the parent rocks should be so restricted in distribution. Furthermore, Keith[36] reports that many small bodies of peridotite are found in areas of the Roan gneiss, the characteristic rocks of which are hornblende gneisses and schists and their biotitic variants. Keith states that though the peridotites break through and cross the Roan gneiss, their association with the gneiss is both marked and close, a statement that is amply supported by his map of the Nantahala quadrangle. It seems likely, therefore, that most of the dark schists in the Bryson City area represent the Roan gneiss. It is noteworthy that according to Keith's map of the Nantahala quadrangle, the areas of Roan gneiss are typically lenticular. It is further noteworthy that of the five granite bodies appearing on the map of the Nantahala quadrangle three are partly or entirely enclosed in the Roan gneiss.

PEGMATITES

GENERAL STATEMENT

More than 150 occurrences of pegmatite within the Bryson City area have been studied by the writer. The locations of 144 of them, including all occurrences known to have been prospected or appearing to have potential economic interest, are shown on plate 1. Thirty-six of the prospects are named in the accompanying lists. Fourteen of the more important and better exposed pegmatite bodies have been mapped, chiefly by plane-table methods, and studied in as much detail as warranted by exposures. Trenches and postholes have been dug at a few of the mines to obtain additional information, and systematic surface exploration of four pegmatite bodies has been done within limits imposed by the time available. Studies of pegmatite bodies in the district are considerably hampered by the paucity of exposures, particularly by lack of exposures of fresh rock. The structure and lithology of many of the pegmatites, therefore, are not fully indicated. For many, even surface outlines cannot be fully inferred at present.

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[34] Billings, M. P., Regional metamorphism of the Littleton-Moosilauke area, New Hampshire: Geol. Soc. America Bull., vol. 48, pp. 463-566, 1937.

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DISTRIBUTION AND OCCURRENCE

Most of the pegmatites examined during the present investigation lie along or near the border of the granitic complex that extends northeast and southwest from Bryson City, and most of the pegmatite mines and prospects lie along the northwest border. Nearly two-thirds of the 144 pegmatite occurrences shown on plate 1 lie within a belt 2,000 feet wide extending from the north end of the granitic complex southward along the west border of Alarka Creek, and including the territory for 1,000 feet on each side of the middle of the belt of border gneiss that bounds the complex. The distribution shown on the map is not a wholly accurate index of the distribution of pegmatites in the area for the following reasons. (1) The belt defined above has probably been more intensively prospected than the remainder of the area; (2) large portions of the granitic complex, particularly north of the Tuckasegee River, are concealed beneath terrace and floodplain deposits; (3) the map omits some minor stringers of pegmatites and emphasizes pegmatites that have been mined or prospected. Even allowing for these factors there is a marked concentration of pegmatites in the belt defined, and large pegmatite bodies are uncommon outside this belt. The largest known pegmatite body in the central part of the granitic complex, the DeHart pegmatite (pl. 1, no. 33, and pl. 19), is only about 220 feet long and 90 feet in maximum width. The next largest, the pegmatite at the Nichols prospect (pl. 1, no. 24), is probably no more than 250 feet long and 30 feet in maximum width. The other known pegmatites, both in the central part of the granitic complex and along the eastern margin of the complex, are much smaller bodies, and many are little more than stringers.

Most of the largest bodies of pegmatite in the district, including the pegmatites from which all but a small fraction of the production of feldspar has come, lie athwart and largely enclosed in the belt of border gneiss along the western margin of the complex. Only two large bodies, the Woody No. 1 pegmatite (pl. 1, no. 2) and the Randall pegmatite (pl. 1, no. 7), are known in the metasedimentary rocks outside this belt; both lie within 1,000 feet of the northwest margin of the belt of border gneiss. Other known pegmatite bodies in the metasedimentary rocks on both sides of the complex are small, mostly less than 100 feet in length. At most places along the western side of the granitic complex no pegmatites occur more than 500 feet west of the border gneiss, but no eastern limit to the occurrence of pegmatites has been found.

SIZE, SHAPE AND ATTITUDE

The pegmatites of the district range from bodies less than 1 inch in thickness and less than 1 foot in length to bodies tens of feet in thickness and hundreds of feet in length. The largest known pegmatite of the district, the Deep Creek No. 1 pegmatite (pl. 10), is 490 feet long and 40 to 210 feet in outcrop width, but the main pegmatite at the Randall mine may be more than 550 feet long. Most of the pegmatites appear to be less than 200 feet long and less than 50 feet in thickness.

The pegmatites have various shapes. The pegmatites simplest in form are tabular bodies with parallel walls, and bodies that have the shape of flattened lenses. Some of the smaller bodies of pegmatite cutting granitic gneiss in the central part of the granitic complex exemplify this form. The larger bodies of pegmatite are commonly less simple in outline, but the shapes of the North McCracken pegmatite (pl. 15), the Harry Thomas pegmatite (pl. 8), and the Payne and Sullivan pegmatite (pl. 1, No. 35), approach a lenticular form. The outlines of most of the larger bodies are complicated by bulges of the contacts outward into the country rock, reentrants of country rock into the pegmatite bodies, or offshoots of pegmatite into the wall rocks. Branching of both the larger and smaller bodies is common. Some of the resulting forms are highly complex; for example, those shown by the north Carson pegmatite (pl. 5), Deep Creek No. 1 pegmatite (pl. 10), and DeHart pegmatite (pl. 19).

Certain of the pegmatite bodies of the district appear to be pipe-shaped. The Carson south pegmatite (pls. 5, 6) appears to be an irregular-walled pipe, plunging southwest at a gentle to moderate angle; it has numerous offshoots along fractures in the country rock. The Swain pegmatite (pl. 8) likewise appears to be an irregular pipe, plunging about S. 60° W.; and there are other bodies only partly exposed, such as the Cox No. 2 pegmatite (pl. 17), that may also have a pipelike form. In this connection it should be pointed out that the mines of the district are shallow. Deeper mining might show that the long axes of many of the pegmatites are steeply inclined. This relation has been proven for the Swain pegmatite, and allowing for erosion of the upper part of the Deep Creep No. 1 pegmatite, it is likely that the longest axis of this body also plunges at a moderate angle. The relation probably holds true for some of the other pegmatites of the district; hence their over-all dimensions are probably greater than is apparent from their surface dimensions.

Data regarding attitudes of the pegmatites of the district are limited because many of the bodies are poorly and incompletely exposed. Observed dips and strikes cover a wide range, but there appears to be a relation between attitude and geologic occurrence. Pegmatites in the border gneiss belt along the northwest side of the granitic complex in general trend north-northwest to north-northeast across the northeasterly trend of the border gneiss. Pegmatites in the metasedimentary rocks range from bodies that are markedly discordant, like the Randall pegmatite and the Woody No. 1 pegmatite (pl. 7), and of various attitudes, to concordant lenses that commonly strike northeasterly and dip west at steep angles. No generalizations can be made regarding the attitudes of pegmatite bodies in the granitic gneisses.

STRUCTURAL RELATIONSHIPS TO ENCLOSING ROCKS

The problem of the structural relations of the pegmatites to the enclosing rocks is one of the most interesting of the district and, owing to paucity of exposures, one of the most tantalizing. Fractures controlled emplacement of many of the pegmatites, and other pegmatites were emplaced along bedding and foliation of the metasedimentary rocks. The control of certain of the larger pegmatites in the border gneiss belt along the northwest margin of the granitic complex, however, is not so simple. The Branton, Cox, Deep Creek No. 1, Swain, and Carson pegmatites all are associated with asymmetric flexures of the margin of the granitic complex. In general, the flexures appear to have axes plunging at moderate to moderately steep angles to the southwest. There is a horizontal component of deformation such that the metasedimentary rocks appear to have moved northeast with respect to the granitic gneisses. Fractures related to these flexures appear to have served as an important structural control over pegmatite emplacement. Thus the Swain pegmatite (pl. 8) lies in the axial portion of a flexure and plunges S. 60° W. about 45° parallel to the calculated axis of the flexure. Faulting of a flexure is clearly involved in the localization of the prominent westward bulge of the pegmatite body at the Deep Creek No. 1 mine (pl. 10). Faulting likewise may be involved at the north Carson pegmatite. From the available data, it appears that the intersections of flexure-related fractures and the border gneiss horizon are the effective controls of emplacement of the more important feldspar-producing pegmatites of the district.

INTERNAL STRUCTURE

General statement.—The pegmatites of the Bryson City district are mixtures of quartz, microcline-perthite ("potash feldspar"), and sodic plagioclase ("soda feldspar"), subordinate to minor amounts of biotite or muscovite, or both, and traces of other minerals. Crystals of these minerals range in size from microscopic to as much as 22 feet in maximum dimension. Most crystals are between an inch and 8 feet in maximum dimension. Four textural divisions based on grain size are recognized:

Division	*Maximum dimensions of crystals*
Fine	1 inch or less
Medium	1 inch to 4 inches
Coarse	4 inches to 1 foot
Very coarse	1 foot or more

Exposed parts of some pegmatites are esentially uniform mixtures of their component minerals. Others show a more or less distinct arrangement of components into structural units of contrasting mineral composition or texture, or both. As in other districts,[37] three types of structural units within pegmatites have been recognized in the Bryson City district. These types are (1) fracture-fillings, (2) replacement bodies, and (3) zones. The units are defined as follows:

(1) *Fracture-fillings* are units that occupy fractures in previously consolidated pegmatite. They are commonly tabular.

[37] Cameron, E. N., Jahns, R. H., McNair, A. H., and Page, L. R., Internal structure of granitic pegmatites: Econ. Geology Mon. 2, 113 pp., 1949. This paper summarizes the conclusions of a group of geologists of the U. S. Geological Survey regarding the structural features of pegmatites. A review of the literature of the subject is given in the paper.

(2) *Replacement bodies* are units formed primarily by replacement of preexisting pegmatite with or without obvious structural control.

(3) *Zones* are successive shells, complete or incomplete, that reflect in various degrees the shape or structure of the pegmatite body. In ideal development, the zones of a pegmatite are successive shells concentric about an innermost zone or core.

[Th]e general relationships of the three types of units are shown diagrammatically in figure 4.

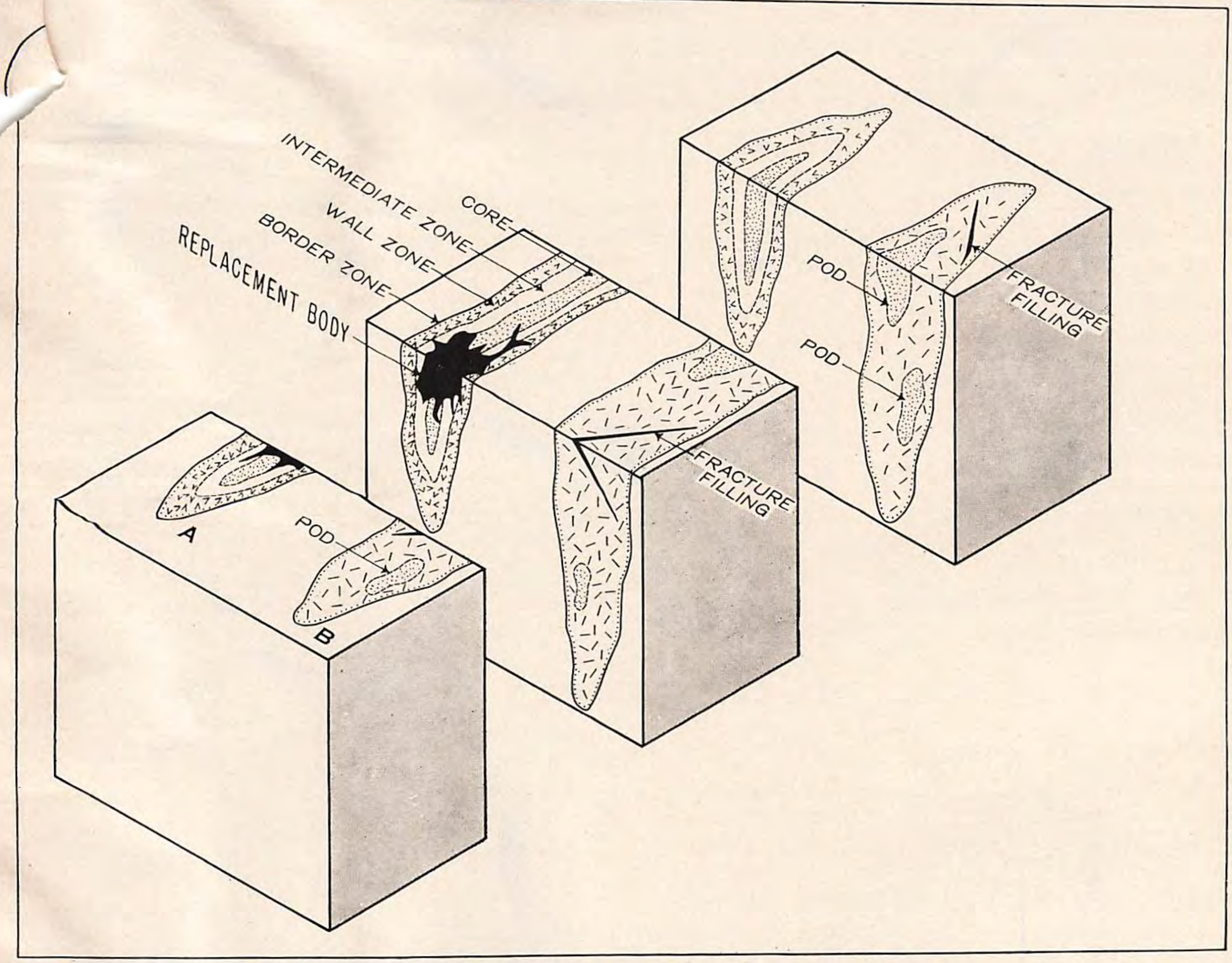

Figure 4. Idealized Diagram to Show Types of Pegmatite Units

Pegmatite units in the Bryson City district range from tiny veinlike fracture-fillings to bodies hundreds of feet in length and tens of feet in width. Some units differ markedly from adjacent units in composition or texture, or both. Others have gradational boundaries and can be distinguished only by close study and comparison. In a few instances, one unit grades imperceptibly into another and only the contrast between typical parts of the units can be recognized. Two different investigators would agree in recognizing the units but would not agree, within close limits, on the positions of boundaries between units. This difficulty is particularly serious in the Bryson City district owing to the simple mineralogy of the pegmatites. Tourmaline, beryl, and other striking accessory minerals, which in some districts assist in delineating boundaries between structural units, are virtually lacking in the Bryson City district. In most of the units the essential minerals are feldspars and quartz. The units differ chiefly in texture and in proportions of these minerals,

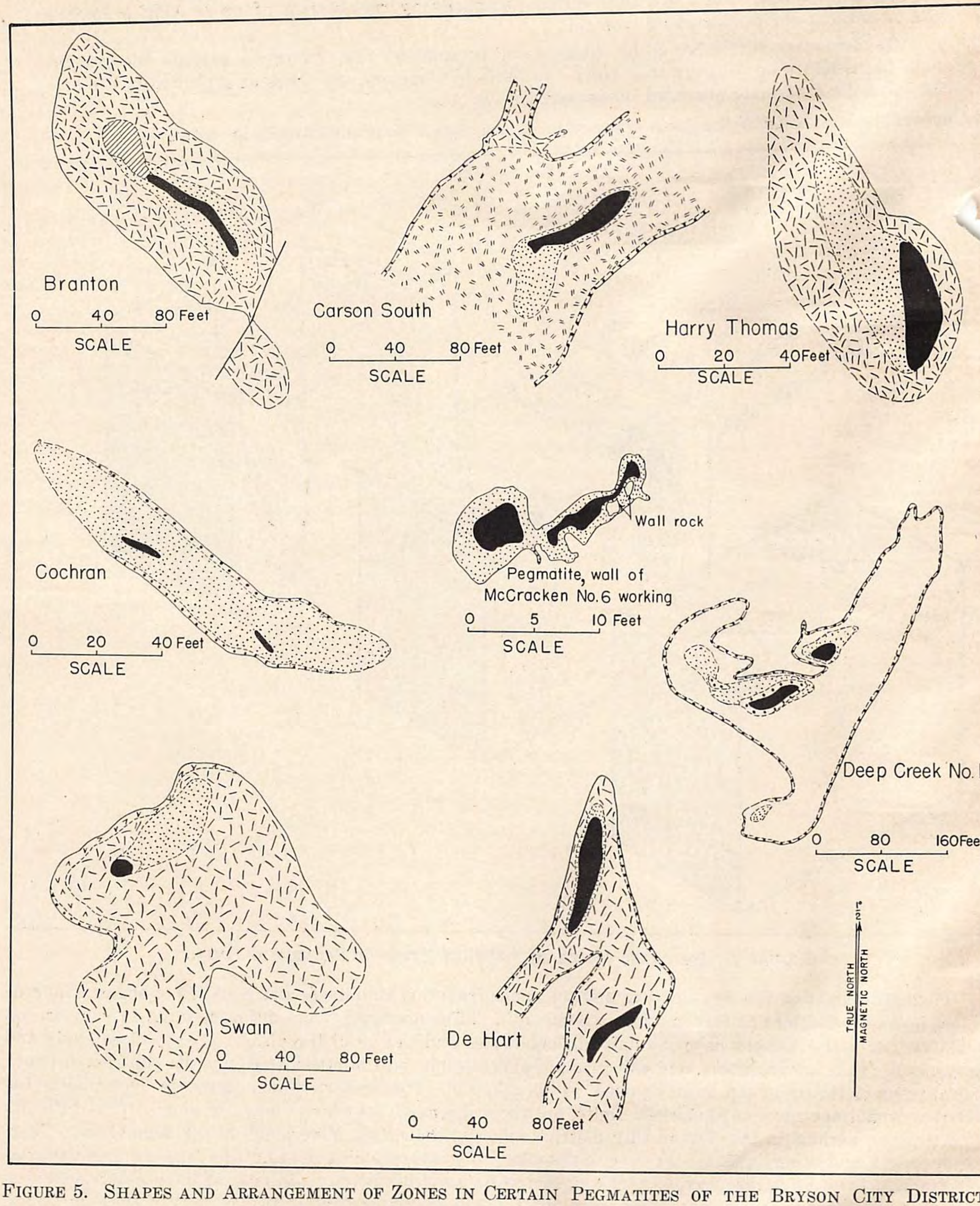

FIGURE 5. SHAPES AND ARRANGEMENT OF ZONES IN CERTAIN PEGMATITES OF THE BRYSON CITY DISTRICT.

and in general the contrasts between units are not marked. Structural units can be recognized in some of the pegmatites only on the basis of detailed mapping and structural analysis.

Zones are quantitatively and economically by far the most important structural units in the pegmatites of the Bryson City district. Certainly more than 99 percent of the feldspar and kaolin output of the district has come from zones. Fracture-fillings are conspicuous in the Deep Creek No. 1 pegmatite, in the north Carson pegmatite, and in the Swain pegmatite, and may have yielded a tiny fraction of the total output of kaolin and feldspar. Replacement bodies are minor features of a few of the pegmatites of the district.

Zones.—The outstanding feature of zones is their concentric arrangement within pegmatite bodies. The zones reflect more or less accurately the configuration of the pegmatite walls. Ideally, zones are successive complete shells concentric about the innermost zone or core. In many pegmatites, however, one or more zones are incomplete or discontinuous, forming pods, layers, lenses, or pipelike bodies (figs. 4 and 5). There are all gradations between complete zones of nearly uniform thickness and those that are developed along one side or at one end of a pegmatite body. The zonal character of partly or asymmetrically developed units, however, is ordinarily readily recognized from their systematic relationship to the walls of the pegmatite body and to other zones of the pegmatite. Figure 5 shows variations in shapes and arrangement of zones in certain pegmatites of the district.

Observations in the district indicate clearly that there is no relation between the size of a pegmatite body and the degree of development of zonal structure. Well-developed zonal structure of the kind found in the Deep Creek No. 1 pegmatite is shown likewise in certain smaller pegmatites (fig. 6). On the other hand, a few of the larger pegmatites of the district are only indistinctly zoned.

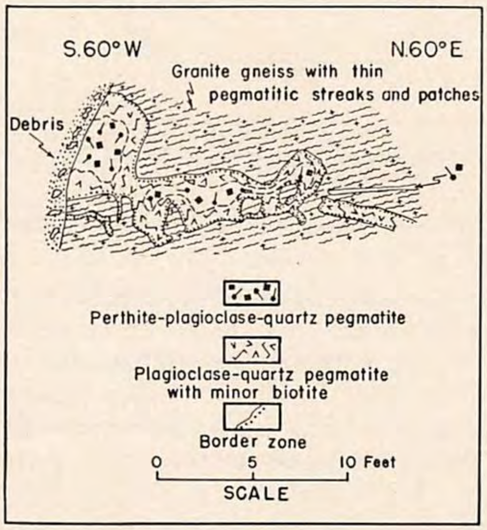

FIGURE 6. SKETCH OF SMALL PEGMATITE BODY, MCCRACKEN NO. 6 WORKING.

According to their positions within pegmatites, zones have been classified[38] into four types: border zones, wall zones, intermediate zones, and cores, and this classification is followed in the present report. The use of this classification is shown in figure 4. The border zone, the outermost zone of a pegmatite, is commonly a fine-grained selvage less than two inches thick. The wall zone, next inside the border zone, is generally much coarser and ranges from 6 inches to several feet thick. The core, or innermost zone, is generally an elongate lens, a podlike body, or a pipelike body, located at or near the midportion of the pegmatite. In some pegmatites the core is discontinuous, composed of a series of disconnected pods or lenses (fig. 7).
Any zone between the core and the wall zone is an intermediate zone. Many pegmatites have two or more intermediate zones which are distinguished by the use of such terms as outer, middle, and inner intermediate zones. The term "core-margin zone" is sometimes useful as a designation for the innermost intermediate zone. Zones, as well as other pegmatite units, are designated also by names that express their mineral com-

[38] Cameron, E. N., Jahns, R. H., McNair, A. H., and Page, L. R., The internal structure of granitic pegmatites: Econ. Geology, Mon. 2, 113 pp., 1949.

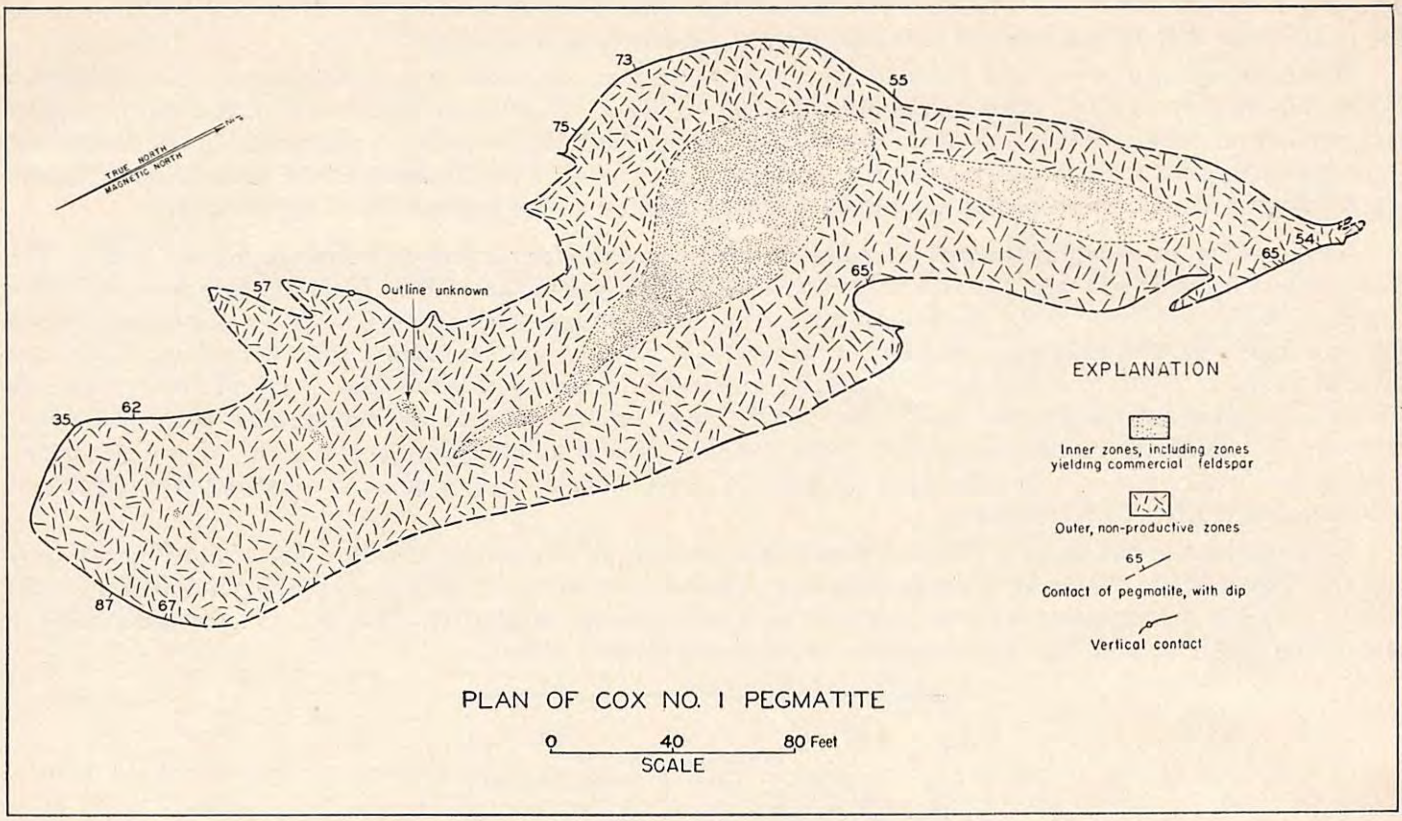

FIGURE 7. PLAN OF THE PEGMATITE BODY AT THE COX NO. 1 MINE. GEOLOGY PARTLY RESTORED.

position in terms of the most abundant minerals, thus: plagioclase-quartz-perthite pegmatite, perthite-quartz pegmatite. The order of the minerals in such a name is the estimated order of decreasing abundance.

It has been frequently noted that the outer zones of a pegmatite are commonly more regular and more continuous than the inner zones, and this generalization, so far as it can be checked in limited exposures, holds true for the pegmatites of the Bryson City district. Intermediate zones, particularly the inner ones, are commonly lenticular and are so uneven in thickness or so incompletely developed that the internal structure of a pegmatite may be markedly asymmetric. Inner zones in the Bryson City district are commonly located nearer the hanging wall than the footwall and are commonly best developed, as in other districts, in the thicker parts of a pegmatite body. The inner zones of the Deep Creek No. 1 pegmatite (fig. 8) are a noteworthy illustration. This generalization is important to the prospector, because the inner zones of the pegmatites of this district are the productive ones.

The relative continuity of the wall and border zones is particularly well illustrated where there are septa or reentrants of wall rock extending into a pegmatite. The wall and border zones commonly follow in detail the wandering of the contact of pegmatite and wall rock. Inclusions of wall rock in a pegmatite (fig. 9), even if enclosed in an intermediate zone, are separated from the material of this zone by wall and border zones.

Because asymmetry of internal structure is so common in pegmatites, limited exposures are seldom a reliable guide to the over-all structure of a pegmatite body. Zonal structure is a three-dimensional problem. An apparent core at one level may prove to be an intermediate zone at another level (fig. 10), or a zone that is apparently a complete shell at the surface may be found to be discontinuous in depth.

The border or outermost zone in pegmatites of the Bryson City district is commonly a fine-grained mixture of plagioclase and quartz with various amounts of perthite. Biotite, magnetite, and garnet are common, perhaps characteristic, accessory minerals, but in the exposed parts of some pegmatites these minerals, if ever present, have been destroyed by weathering and are represented by brown to black spots composed of

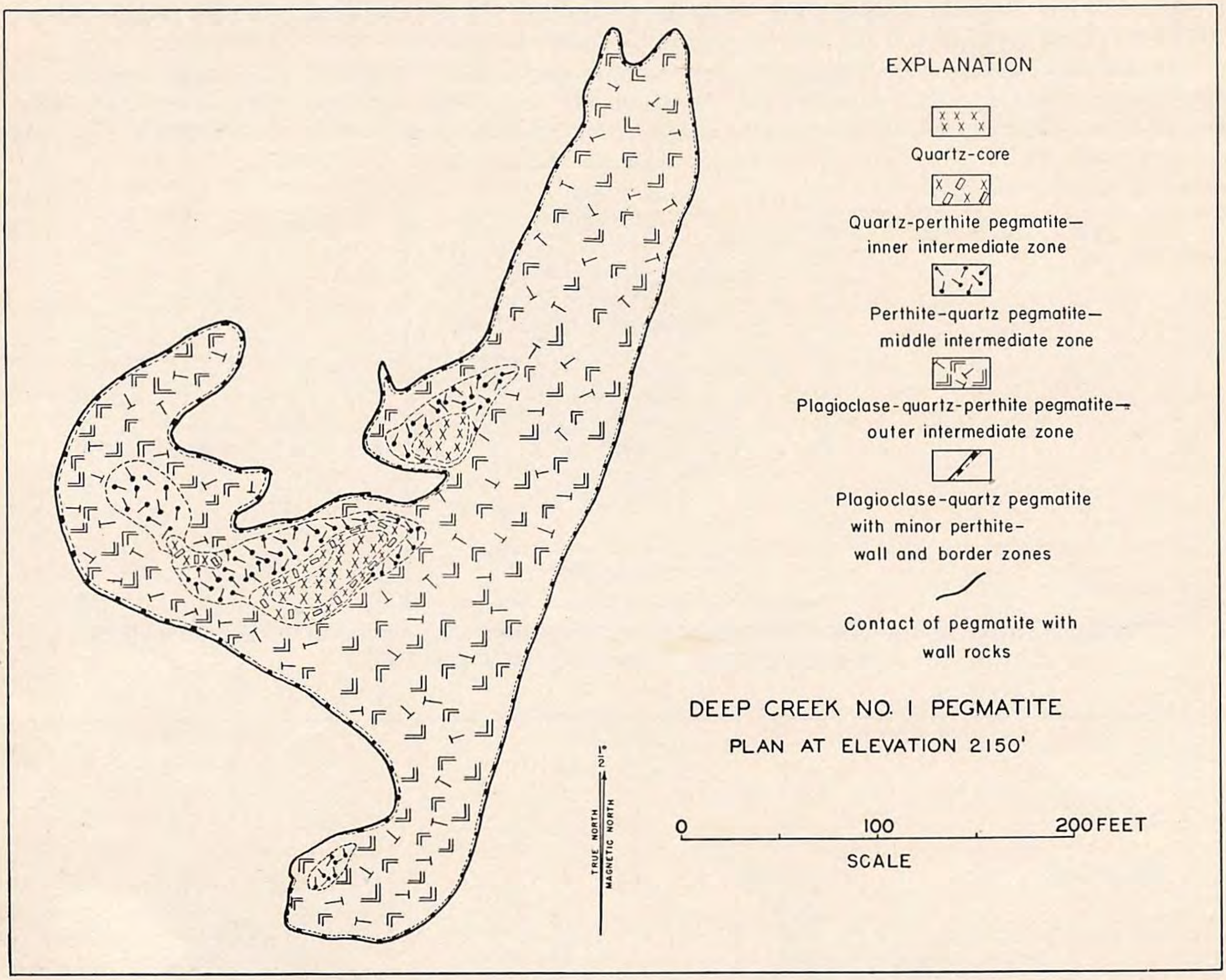

Figure 8. Plan of Deep Creek No. 1 Pegmatite at Elevation 2,150 Feet.

limonite or manganese oxides or both. Biotite occurs in many of the zones as flakes up to 1 inch broad oriented roughly perpendicular to the contact of the pegmatite. The border zone, so far as determinable, is a continuous envelope enclosing the remainder of the pegmatite. Border zones commonly range from ¼ to 1 inch in thickness, but locally are as much as 6 inches thick. They grade abruptly into adjacent wall zones by increase in grain size. The border zone is of no economic importance, but is useful in structural analysis. Its preservation along a contact is a strong indication that there has been no significant displacement; conversely, its absence is a reliable criterion for the detection of fault contacts.

The wall zones of the pegmatites are commonly medium- to coarse-grained mixtures of plagioclase and quartz with various amounts of perthite, and accessory to scarce biotite, muscovite, garnet, and magnetite. In general, they range from 6 inches to 3 feet in thickness. Outward they pass abruptly, by decrease of grain size, into the border zones; inward they pass gradually, by increase in grain size and commonly by change in mineral proportions, into intermediate zones. The most distinct wall zones, such as the wall zone of the Cox pegmatite, are rich in blocky plagioclase free of intergrown quartz. With increase in perthite and in amount of quartz in irregular or graphic intergrowth, they become progressively more difficult to distinguish from pegmatite of the outermost intermediate zone. This variation can be found within a single pegmatite. The wall zone in the Deep Creek No. 1 pegmatite (pl. 10), for example, is much more distinct in the vicinity of the main working than in the north working. Wall zones appear to have been prospected for kaolin in the early days of the district but are too thin to be important sources of feldspar.

Intermediate zones of the pegmatites are coarse to very coarse mixtures of plagioclase, perthite, and quartz, with accessory biotite or muscovite, or both, garnet, magnetite, and more rarely beryl, tourmaline, and allanite. Crystals of feldspar range in general from 1 foot to as much as 15 feet in length. The com-

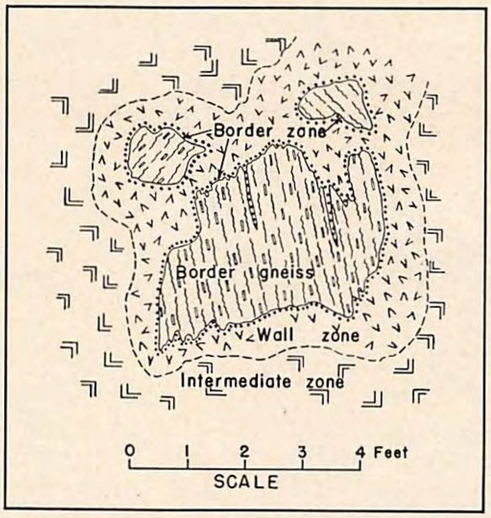

FIGURE 9. SKETCH SHOWING DEVELOPMENT OF ZONES AROUND INCLUSIONS IN THE MIDDLE INTERMEDIATE ZONE, CARSON SOUTH PEGMATITE.

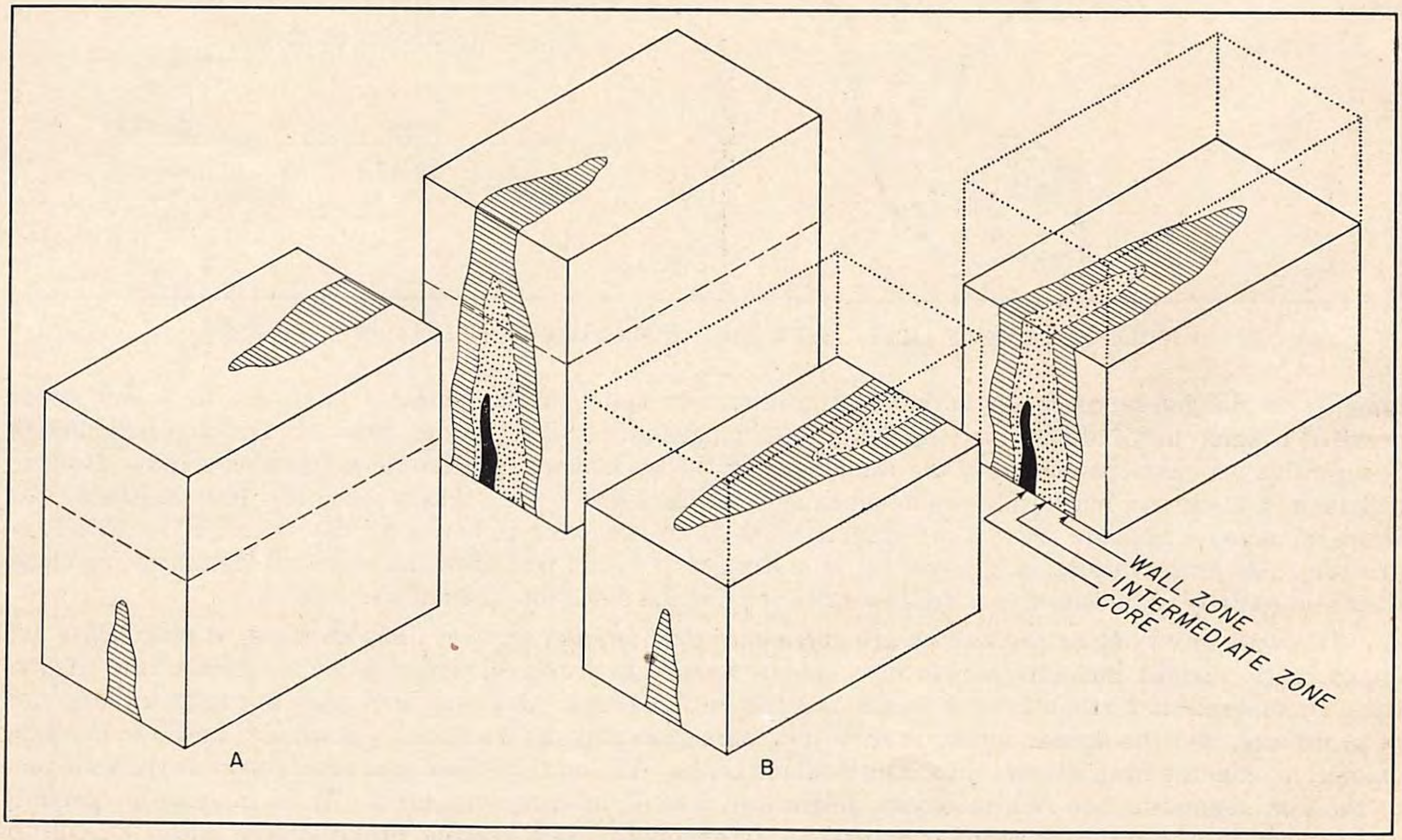

FIGURE 10. TWO STAGES IN THE EXPOSURE OF A PEGMATITE BY EROSION. IN THE FIRST STAGE THE INTERMEDIATE ZONE APPEARS TO BE THE CORE.

PLATE 3.

A. Steeply dipping quartz fracture fillings (to left of opening) cutting pegmatite at mouth of chamber, Carson mine, No. 3 working. The most prominent fracture filling is about 4 inches in maximum thickness.

B. Cox No. 1 mine. Upper part of main working at left, beneath derrick boom.

monest type of intermediate zone is one consisting of plagioclase, quartz, and perthite. The perthite occurs in part as coarse to very coarse crystals partly or entirely in irregular to graphic intergrowth with quartz. This type of material is ordinarily not workable for feldspar. In some pegmatites this zone passes inward into a zone composed largely or almost entirely of coarse to very coarse plagioclase and perthite in graphic intergrowth with quartz. The second intermediate zone of the Carson south pegmatite is a particularly striking example. The inner intermediate zone of the north McCracken pegmatite is a variant of this zone, consisting largely of graphic intergrowths of perthite and quartz, with subordinate perthite free of intergrown quartz. In the Deep Creek No. 1, Swain, and other pegmatites, the innermost intermediate zone, or pair of zones, consists essentially of very large crystals of perthite (up to 22 feet in maximum dimension at the Deep Creek No. 1 mine) and massive quartz forming the matrix of the perthite crystals. These inner intermediate zones are the source of the bulk of the commercial feldspar of the district.

The cores of the well-zoned pegmatites commonly consist of massive quartz or of massive quartz with scattered crystals of massive perthite or plagioclase, or both. Such cores are exemplified by that of the Deep Creek No. 1 pegmatite (now largely removed), the cores of the Woody No. 1 pegmatite, the Woody No. 4 pegmatite (pl. 4), the Carson south pegmatite, and others. It seems probable that quartz cores are characteristic of distinctly zoned pegmatites of the district. Some pegmatites have apparent cores composed of other material, but the true cores may have been removed by erosion or may be concealed beneath the surface. The chances of removal or concealment are the greater because in most of the pegmatites known to have quartz cores, the core forms only a small fraction of the total bulk of the pegmatite. Cores of some of the pegmatites are discontinuous, consisting of disconnected segments occurring at intervals along the strike or dip. Cores of this type occur in the Cox No. 1 pegmatite (fig. 7), in the Deep Creek No. 1 pegmatite (fig. 8, fig. 11), and in several smaller pegmatites in the district. Most of them are situated,

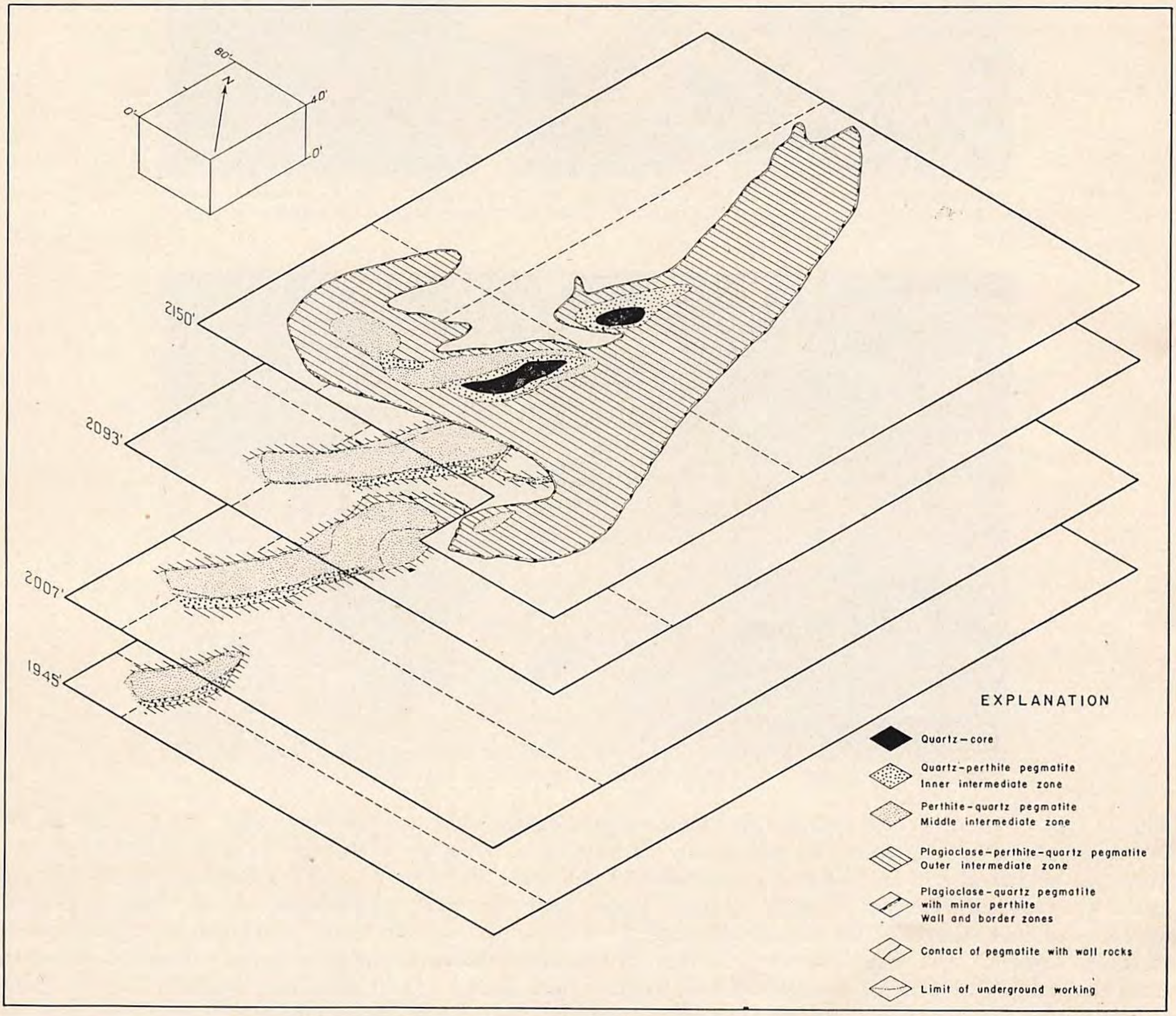

FIGURE 11. ISOMETRIC PLATE DIAGRAM SHOWING ARRANGEMENT OF ZONES IN THE DEEP CREEK NO. 1 PEGMATITE.

together with the other inner zones, in the broader parts of the pegmatites, and are nearer the hanging wall than the footwall.

Sequence of mineral assemblages in the zoned pegmatites.—In the course of wartime studies of pegmatites by the U. S. Geological Survey it was noted that the pegmatites within a given district have similar zonal structures and also similar sequence of assemblages of essential minerals in the zones inward from the walls. For any district, it is possible to draw up a general sequence of mineral assemblages. Few pegmatites in a district contain zones corresponding to all the members of the sequence. Members are lacking in some pegmatites, in others a single zone, contains minerals belonging to two or more adjacent members of the sequence. In any given pegmatite, the mineral assemblages present occur in an order from the walls inward that corresponds to the general sequence. Comparison of pegmatite bodies of various districts studied during the war led to a recognition of a general sequence of mineral assemblages that holds for all but a very few of the many hundreds of pegmatites examined.[39] The general sequence recognized, from the walls of the pegmatites inward, is as follows:

PLATE 4.

Quartz core of Woody No. 4 pegmatite.

1. Plagioclase-quartz-muscovite.
2. Plagioclase-quartz.
3. Plagioclase-quartz-perthite, with or without muscovite, with or without biotite.
4. Perthite-quartz or quartz-perthite.

[39] Cameron, E. N., Jahns, R. H., McNair, A. H., and Page, L. R., The internal structure of granitic pegmatites: Econ. Geology, Mon. 2, 113 pp., 1949.

5. Perthite-quartz-plagioclase-amblygonite-spodumene.
6. Plagioclase-quartz-spodumene.
7. Quartz-spodumene.
8. Lepidolite-plagioclase-quartz.
9. Quartz-microcline.
10. Microcline-plagioclase-lithia mica-quartz.
11. Quartz.

In some pegmatite districts only a few members of the general sequence have been found in the pegmatites thus far studied; those members found, however, occur in an order from the walls inward corresponding to the sequence above.

A clearly defined sequence of mineral assemblages likewise is found in the pegmatites of the Bryson City district. The general sequence for the district is given in table 1, together with the sequences of mineral assemblages for 26 pegmatites of the area. For each pegmatite, the order in which the mineral assemblages present are read from left to right is the order in which zones corresponding composition are found from the walls of the pegmatite inward to the core. No exceptions to this order have been found. However, one anomaly is shown in the table. The third member of the general sequence is perthite-quartz pegmatite. This member typically consists of very large massive perthite crystals with interstitial coarse massive quartz. In many of the pegmatites, however, such as the Carson north pegmatite, the zone having the sequential position of the perthite-quartz assemblage contains plagioclase crystals similar in size and habit to the perthite. Blocky plagioclase is present in equal, perhaps greater, amounts than perthite in the Carson south pegmatite, and blocky plagioclase is present to the exclusion of perthite in the Woody No. 4 pegmatite. With increase in plagioclase, the assemblage becomes similar in mineral composition successively to the second and first members of the general sequence, but it invariably resembles the perthite-quartz member closely in texture and is in striking and consistent contrast to the other two members of the sequence.

TABLE 1. SEQUENCE OF MINERAL ASSEMBLAGES IN 26 PEGMATITES OF THE BRYSON CITY DISTRICT

PEGMATITE	Mineral Assemblages						
	I Plagioclase-quartz-muscovite	II Plagioclase-quartz, with minor to subordinate perthite	III Plagioclase-quartz-perthite	IV Perthite quartz	V Perthite-plagioclase-quartz	VI Quartz-perthite	VII Quartz
Woody No. 1		X	X		X	X	X
Woody No. 2		X	X				
Woody No. 4					X		X
Carson north		X	X	X		X	X
Carson south		X	[2]X		X		X
Randall		X	X				
No 8 prospect			X	[1]X			[1]X
Swain		X	[2]X	X	X		X
H. Thomas			X		X	[3]X	
Deep Creek No. 1		X	X	X		X	X
N. McCracken		X	X	X		[1]X	[1]X
McCracken, west cut		X	X		X		
S. McCracken		X	X		X		
Cox No. 1		X	[2]X	X			X
Cox No. 2		X	[2]X	X			
Hyatt No. 2 prospect		X		X			
Branton No. 1			[2]X		[4]X	X	
Cochran			[2]X		[1]X		[1]X
Nichols prospect		X	X	X		X	
Ball No. 1			X				
Ashe Thomas	X			X			X
DeHart No. 1		X	X		X	X	
Simon DeHart	X		X	X			
D. Thomas No. 1		X			X		X
Hans No. 1		X			X		
Payne and Sullivan		X	X		X	X	

[1] In pods.
[2] Two zones differing in texture.
[3] Perthite content higher than normal. Transitional between members IV and VI.
[4] Position of unit in sequence uncertain.

It is therefore regarded as a variant of the perthite-quartz assemblage. Plagioclase occurring in this unit may, in part at least, have formed by replacement of preexisting perthite. Laboratory studies will be required to test this possibility; field observations have left the matter unsettled.

Of the 11 members of the general sequence recognized by comparison of sequences for various districts, only members 1, 2, 3, 4, and 11 are represented in the pegmatites of the Bryson City district, a generalization that serves to emphasize their mineralogical simplicity. Member I of the Bryson City sequence corresponds to member 1 of the general sequence, member II is transitional between members 2 and 3, member III is equivalent to member 3, members IV and VI are subtypes of member 4, and member VII corresponds to member 11 of the general sequence. Member V is anomalous with respect to the general sequence.

Owing to this anomaly, a consistent sequence of assemblages cannot be recognized at present on the basis of mineralogy alone, but a consistent sequence is evident if both mineralogy and texture are taken into account. Member I of the sequence consists essentially of medium- to coarse-grained plagioclase all or nearly all free of intergrown quartz, subordinate interstitial quartz, and muscovite. Member II is similar but lacks muscovite and in some pegmatites contains subordinate to minor perthite. Graphic intergrowths of feldspars and quartz are rare in these two members. Member III of the sequence consists of coarse to very coarse plagioclase-quartz-perthite pegmatite with numerous graphic to irregular intergrowths of feldspars and quartz. Inward toward the core this member becomes rich in graphic intergrowths and the inner part may consist almost entirely of graphic intergrowths. The two facies are mappable as separate zones in the Carson south pegmatite and in the Cox No. 1 pegmatite. Member IV of the sequence consists essentially of perthite and quartz, the quartz occurring as coarse masses interstitial to large, quartz-free crystals of perthite. The inner intermediate zone of the McCracken pegmatite, which contains much perthite in graphic intergrowth with quartz, is clearly a type transitional between members III and IV of the sequence. Member IV, just described, and member V are not found in the same pegmatite, although various pegmatites show every gradation between the two. Member VI of the sequence consists of large crystals of perthite scattered through quartz, and member VII consists entirely of massive quartz.

It is essential that a clear distinction be made between mineral assemblages and zones. A single mineral assemblage may be represented in a pegmatite by two or more zones differing in textural fabric or in the presence or absence of an accessory mineral. Thus the wall zone and outer intermediate zone of the Branton pegmatite are both composed of material corresponding to the second member of the general sequence. The wall zone, however, contains both biotite and muscovite, whereas biotite is lacking in the intermediate zone. In the McCracken pegmatite, on the other hand, members IV, VI, and VII of the sequence are represented only by pods consisting of lenses of quartz with large perthite crystals along the margins. The sequence therefore serves as a basis for predicting where a given mineral assemblage, if present, will be found within a pegmatite. Whether a distinct zone corresponding to the mineral assemblage is present can be determined only by investigating the appropriate part of the pegmatite.

It should further be noted that the terms "border zone," "wall zone," etc., are used without reference to composition. In pegmatites in which the plagioclase-quartz assemblage is present, this assemblage forms the border and wall zones. In pegmatites in which this assemblage is lacking, plagioclase-quartz-perthite pegmatite commonly forms the border and wall zones.

Fracture-fillings.—Fracture-fillings are found in many of the pegmatites of the district. They range from bodies less than an inch thick and a few inches long to tabular bodies 3 feet thick and 50 feet or more in length along strike and dip. The simplest are the tabular bodies, which occupy parallel fractures. Fracture-fillings of this kind are a conspicuous feature in the main working and south working at the Deep Creek No. 1 mine, and are found in the Carson north pegmatite (pl. 3, A), the Swain pegmatite, and other pegmatites of the district. The fillings cut across the middle and outer zones of the pegmatites, and some extend out into the wall rocks. In places fillings of similar nature occupy networks of fractures. Complex networks of veins cut the outer zones of the Deep Creek No. 1 pegmatite in the main working (pl. 10), and similar networks appear to be represented in the north wall of the No. 1 working at the Carson mine.

Fracture-fillings in the Bryson City district are simple in mineralogy; they commonly consist of quartz with subordinate to minor amounts of perthite or plagioclase, or both. Many of the fillings, such as those in the Deep Creek No. 1 pegmatite, are zoned; feldspars form an irregular, discontinuous selvage along each wall and project inward into the quartz which forms the medial portion of each filling. The feldspar crystals are invariably euhedral against the quartz. The boundaries of fracture-fillings in weathered feldspathic pegmatite are commonly obscure, because the feldspar selvages are difficult to distinguish from the pegmatite of the walls. At first sight the boundaries may appear to be at the margins of the medial quartz "rib."

The fracture-fillings consisting predominantly of quartz or of quartz and feldspar are closely analogous in composition and textural fabric to the quartz and quartz-perthite zones found in the central parts of such bodies as the Carson south pegmatite, Deep Creek No. 1 pegmatite, and Swain pegmatite. One fracture-filling observed by R. H. Jahns (pl. 8, plan of workings at elevation 2,122 feet) at the Swain mine in 1945 was a direct offshoot of the quartz core. Most of those exposed in the north wall of the main working of the Deep Creek mine are probably related to the quartz core of the pegmatite in the same way, but the part of the pegmatite in which junctions of fillings and core would be expected has been removed in mining.

Smaller fracture-fillings, widespread in the district, consist of single books or groups of slablike books of biotite or muscovite, or both, along fractures or networks of fractures cutting quartz and feldspars, especially in the inner zones of the pegmatites. In some pegmatites there are parallel striplike crystals of biotite that appear to be at least partly fracture controlled. Veinlets of pyrite cutting feldspars in the Deep Creek No. 1 pegmatite, veinlets of thulite(?) cutting feldspar in the Carson south pegmatite, and veinlets of quartz and muscovite in the inner zones of the Carson south pegmatite are rarer types of fracture-fillings observed. Fracture-fillings of quartz with minor feldspar are of interest because they appear to form a link between the more normal pegmatites and pegmatitic quartz veins scattered through the district. The latter are similar in composition to the fracture-fillings. Some, however, differ in that the quartz is gray to blue-gray and almost chalcedonic in appearance. Commonly they contain, in addition to quartz, only sparsely scattered crystals of perthite. Numerous small quartz veins or lenses with minor amounts of feldspars and muscovite are present in the metasedimentary rocks along the eastern margin of the granitic complex. They have been prospected at several places for mica or for feldspar. Various occurrences appear to show every gradation between the "veins" and more normal pegmatites.

Lenses of coarse quartz are common in the metasedimentary rocks, especially west of the granitic complex, and presumably are the source of the small amounts of gold said to have been panned from the gravels of Bryson Branch and other streams of the area. The relation of these lenses to the pegmatites is not known.

Replacement bodies.—Replacement bodies, a conspicuous feature of certain pegmatites in various districts,[40] are small and of minor importance in the Bryson City district. In places in the Deep Creek No. 1, Carson north, Swain, and other pegmatites, perthite has been partly replaced by albite(?) and greenish, fine-grained muscovite. The total amount of perthite involved is apparently very small.

WALL ROCK ALTERATION

Alteration of wall rocks adjacent to the pegmatites is not a prominent feature of the Bryson City district. Most contacts of pegmatites with wall rocks are sharp and well defined, although locally border gneiss an inch to a foot from pegmatite contacts has been converted to biotite aplite. Wall-rock alteration, where present, is commonly restricted to increase in the feldspar content of enclosing rocks. The most striking alteration is at the McCracken mine. Granite gneiss in the walls of the main working has been extensively "soaked" with pegmatite material, to the extent that in many places contacts between pegmatite and gneiss are gradational. Probably no great chemical change is involved; the chief effects appear to be coarsening of texture and obliteration of gneissic structure. A different type of alteration related to pegmatite development may be represented in the metasedimentary rocks along the eastern side of the granitic complex. In places there are abundant coarse lenses and streaks of quartz and feldspar along the foliation of the metasedimentary rocks; muscovitization of quartzite and marked coarsening of the texture of muscovite schists are other effects observed. In places, a coarse mixture of quartz and muscovite, similar to the burr rock of the Spruce Pine and other southern mica districts, has been developed. The limited nature of exposures and the weathered condition of the metasedimentary rocks have prevented detailed analysis of alteration effects in this part of the area.

[40] Jahns, R. H., Mica deposits of the Petaca district, Rio Arriba County, New Mexico: New Mexico Bur. Mines and Min. Resources Bull. 25, pp. 48-51, 1946.

MINERALOGY

General statement.—The pegmatites of the Bryson City district are extremely simple in mineralogy, consisting almost entirely of quartz and feldspars, with minor amounts of biotite or muscovite, or both. The commonest accessory minerals are magnetite and garnet. Tourmaline, allanite, beryl, fluorite, pyrite, thulite(?), and galena(?) are scarce minerals in the district.

Feldspars.—The name feldspar is applied to a group of alkali-bearing aluminum silicates; the group is commonly divided into potash feldspars and the soda-lime feldspars. The potash feldspars are orthoclase and microcline ($KAlSi_3O_8$); the soda-lime feldspars comprise a series ranging from albite ($NaAlSi_3O_8$) to anorthite ($CaAl_2Si_2O_8$). The feldspars of the pegmatites of the Bryson City district are perthite (microcline with subordinate albite in oriented, intergrown thin lamellae), and sodic plagioclase probably ranging from albite to oligoclase (90-70 percent albite, 10-30 percent anorthite).

Perthite forms crystals ranging in maximum dimension from fractions of an inch to as much as 22 feet. Most of the crystals are between an inch and 10 feet in length. In general the smaller crystals are found in the outer zones of the pegmatites, the larger crystals in inner zones. In most pegmatites of the district perthite (if present) is found in every zone except the quartz core, but it is most abundant in the inner intermediate zones. Certain of these zones, such as the middle intermediate zone of the Deep Creek No. 1 pegmatite (pl. 11), contain a high proportion of coarse perthite. In parts of a pegmatite in which the feldspar content is high, perthite generally occurs as poorly formed crystals. In general, perthite exhibits crystal form against massive quartz of the inner zones, and crystals of perthite surrounded by quartz are almost invariably euhedral. In degree and type of its intergrowth with quartz, perthite shows a systematic variation inward from the walls of multi-zoned pegmatites. In the wall zone and outer intermediate zones, much of the perthite is intimately intergrown with quartz. The intergrowths are mostly irregular, but in part are of the graphic type. In middle intermediate zones the proportion of perthite forming graphic intergrowths with quartz is high, some perthite free of quartz is found, and irregular intergrowths are uncommon. In inner intermediate zones, such as the perthite-quartz zone and quartz-perthite zones of the Swain and Deep Creek No. 1 pegmatites and the perthite-plagioclase-quartz zone of the Carson south pegmatite, most or all of the perthite is free of intergrown quartz. Perthite in fracture-fillings and feldspar-bearing quartz veins likewise is free of intergrown quartz.

Fresh perthite from the various pegmatites has a glassy luster and ranges from white through cream to buff, light greenish-buff, pink or flesh-colored, or reddish brown. White feldspar irregularly splotched with light gray is found in a few pegmatites but is decidedly uncommon. The microcline component of perthite is resistant to weathering, and parts of pegmatites in which plagioclase is completely altered may contain hard perthite differing from unweathered material only in being dull in luster and stained red to brown by iron oxides along cleavages and fractures. More severe weathering causes alteration of the thin plates of intergrown albite, and disintegration of the microcline to a crumbly mass or even to fine "sand."

Plagioclase forms crystals similar in size range to those of perthite, except that crystals of plagioclase more than 8 feet in length are uncommon. In crystal habit there is a close similarity between perthite and plagioclase, and the plagioclase shows a comparable variation from zone to zone in habit and in degree and kind of intergrowth with quartz. In the majority of the pegmatites, however, plagioclase is not an abundant constituent of the innermost zones, which apart from quartz cores are predominantly perthite-rich. As noted previously, however, plagioclase is as abundant or even more abundant than perthite in the inner zones of certain pegmatites. The genetic relationship of plagioclase to perthite in these zones is one of the most interesting problems of the district. Field study was without conclusive results, and no generalizations appear warranted pending laboratory study. The abundance of plagioclase in graphic intergrowth with quartz is particularly noteworthy. Graphic intergrowths of perthite and quartz are a common feature of pegmatites in many districts, but the writer knows of no other district in which graphic intergrowths of plagioclase and quartz are a characteristic feature of the pegmatites. These intergrowths are present in profusion in every well-exposed and distinctly zoned pegmatite in the Bryson City district. In the Carson south pegmatite, the middle intermediate zone consists almost entirely of graphic intergrowths of quartz and perthite or plagioclase, intergrowths with plagioclase predominating.

Plagioclase is white to pale gray except where stained brown by limonite or black by manganese oxides. All or nearly all crystals show multiple twinning, indicated in fresh material by fine parallel lines that appear when light is reflected from the proper cleavage surface. This and its common pure white color usually serve to distinguish plagioclase from perthite, but distinction between the two feldspars is extremely difficult in the core-margin zone of the Carson south pegmatite, which contains white perthite as well as plagioclase. Plagioclase in weathered portions of pegmatites is converted to white, compact kaolin, some of high purity, and this is readily distinguished from hard, relatively unaltered perthite and from the gritty products of perthite disintegration.

Quartz.—Quartz occurs in every type of structural unit found in the pegmatites of the district. It forms minute grains, spindles, and elongate plates in graphic intergrowth with both plagioclase and perthite, irregular intergrowths of varied texture with feldspars, coarse-grained masses interstitial to feldspars, and larger bodies that constitute the cores of some of the pegmatites. It is invariably anhedral against the feldspars. Quartz crystals lining cavities rarely occur in the district.

Quartz ranges in color from clear and colorless to white or milky, to gray, or to faintly smoky. Most quartz in the larger bodies appears to be coarse-grained and has a glassy luster, but some in the feldspathic quartz veins and fracture-fillings is dull, dense, and apparently fine-grained. In some pegmatites, notably in the quartz-perthite zone of the Carson north pegmatite exposed in the No. 1 working, shearing has caused the development of several sets of fractures and granulations of the quartz.

Biotite.—Biotite is the characteristic mica of the pegmatites in granitic gneisses and the border gneiss. In border zones it occurs as thin flakes or striplike crystals 1/8 inch to 1/2 inch in length. In wall zones it occurs mostly as sparsely scattered books up to 3 inches broad and 1/2 inch thick. In outer and middle intermediate zones it is found as striplike crystals ranging from 2 inches long, 1/4 inch wide, and 1/64 inch thick up to 32 inches long, 4 inches broad, and 2 inches thick, and occurs also in slabby books, many deformed, up to 2 1/2 feet broad and 6 inches thick. Some crystals in the Cox No. 1 pegmatite are partly chloritized. The striplike crystals of biotite are commonly haphazardly oriented, but the clusters consist of various crystals lying in a single plane and forming crisscross, rosette, or spray-like patterns. The crystals transect quartz and feldspars and appear to be fracture-controlled. A variant of the striplike habit is particularly well displayed at the No. 3 working of the Carson mine. Here fracture surfaces are coated with composite crystals of biotite composed of parallel strips up to 1 foot long, 1 inch wide, and 1 inch thick. Part of one such composite crystal (the remainder has been mined out) measures 5 feet long, 1 foot broad, and 1 inch thick. Another is 7 feet long and 2 inches thick; the width is not shown. The fractures cut quartz and feldspars and are plainly later. The slabby books of biotite are found in all zones but are particularly characteristic of the intermediate zones and core. They are developed along fractures of one or more sets cutting quartz and feldspars. A most striking occurrence of fracture-controlled biotite is indicated, in generalized form, on the plan of the 2,073-foot level of the Deep Creek No. 1 mine (pl. 11). Here biotite books 1 to 6 inches broad and up to 3 inches thick form an intricate network occupying closely spaced fractures. The fractures transect the outer part of the quartz-perthite zone and the inner part of the perthite-quartz zone. The master fractures strike N. 55° E. and dip 76° NW. They are connected by oblique fractures and, where the network intersects feldspar, by fractures parallel to the cleavages of feldspar. Part of this fracture-controlled body of biotite has been removed. The remaining part is 3 feet thick and is exposed for 12 feet vertically and for 8 feet along the strike. It is evident that biotite, in considerable part at least, has formed after consolidation of much or all of the pegmatite body. Biotite occurs in the Swain pegmatite as flakes along fractures cutting quartz-feldspar fracture-fillings and occurs at the Randall mine with muscovite in an irregular network of quartz veinlets cutting the outer intermediate zone.

The surfaces occupied by biotite strips are in many places coated by greenish sericite, and a selvage of plagioclase and sericite or fine-grained greenish flake muscovite is developed where they cut feldspar. The selvages range from fractions of an inch to 3 inches or more in thickness.

Biotite in parallel intergrowth with muscovite is common in the Branton, Cochran, Randall, Woody No. 1, and other pegmatites. Striplike crystals of biotite and muscovite as much as 10 feet long, 6 inches wide, and 2 inches thick are found in the Woody No. 1 pegmatite.

In weathered parts of the pegmatites, vermiculite has formed from some of the biotite books. Its bronze color may serve to distinguish it from biotite. Some of it exfoliates when heated, but various specimens show very different capacities for exfoliation.

Muscovite.—Muscovite is abundant in a few of the pegmatites within the granitic complex and is the characteristic mica of pegmatites in the metasedimentary rocks. It shows a wide range of colors—pale green, gray-green, amber, rum, and ruby. It forms crystals ranging from microscopic size (sericite) to 10 feet in maximum dimension. The maximum diameters of crystals, however, lie mostly in the range between 1/8 inch to 8 inches. The crystals range from anhedral and highly irregular to euhedral. Commonly the maximum dimensions of crystals lie in the plane of the cleavage, but the outer intermediate zone at the Branton mine contain anhedral books that are elongate parellel to the *c* axis and are as much as 4 inches in length. The books are embedded in quartz. Muscovite shows the same range in habit as biotite, occurring as flakes, slabby books, and striplike crystals. All these habits may be shown in the same pegmatite, as, for example, in the Woody No. 1 pegmatite. In the outer intermediate zone of the pegmatite at the Branton mine, muscovite crystals as much as an inch in diameter form single books, together with nests of books, as much as 8 inches by 4 inches in diameter. Books of gray-green muscovite as much as 1 foot long, 6 inches broad, and 4 inches thick are numerous along the margin of the quartz core. In the beryl-bearing unit of the pegmatite, books up to 10 inches broad and 1/2 inch thick lie at the centers of irregular bodies of "burr rock" consisting of quartz thickly intergrown with small muscovite books. In the Cochran pegmatite irregular bodies of burr rock up to 6 by 2 feet in cross section enclose tapered strips of biotite up to 18 inches long, several inches broad, and 1 1/2 inches thick. In the DeHart pegmatite, muscovite books 2 inches broad or less form striking aggregates in the outer intermediate zone.

Small flakes and books of muscovite are common in thin quartz fracture-fillings in many of the pegmatites. In some pegmatites such as the Carson pegmatites, and the Swain, Deep Creek No. 1, and McCracken north pegmatite, perthite has been partly replaced by plagioclase, now kaolinized, containing disseminated small crystals of greenish muscovite.

Distribution of biotite and muscovite.—Comparison of the distribution of biotite and muscovite in the pegmatites of the district as a whole indicates that there is a broad relationship between the relative abundance of the two micas and the type of country rock. In pegmatites in granitic gneisses and in border gneiss, biotite is the characteristic mica and is normally far more abundant than muscovite. Whatever muscovite is present is largely in fracture-fillings with quartz, as coatings on small fracture surfaces, or associated with plagioclase in aggregates formed by replacement of perthite. Muscovite in general predominates over biotite in pegmatites in metasedimentary rocks and appears to be the only mica present in many of these pegmatites, particularly the small bodies scattered through the metasedimentary rocks along the eastern margin of the granitic complex. This relationship appears to be shown within the limits of a single body in the Carson north pegmatite. Muscovite is the characteristic mica of the part of the body exposed in the No. 1 working where the wall rocks of the pegmatite, at least on one side, are metasedimentary rocks. Biotite is abundant in the No. 3 working where border gneiss forms the wall rock, whereas muscovite is present only in late-stage material and in minor amounts. Inasmuch as muscovite is abundant in the metasedimentary rocks and commonly lacking or only a minor component in the rocks of the granitic complex, the distribution of the mica suggests that reaction of pegmatitic fluids with the enclosing wall rocks has influenced the type of mica formed.

Although a broad relationship of type of mica to type of wall rock is evident, there are numerous exceptions. Muscovite and biotite are both abundant in the Woody No. 1 deposit, and biotite appears to be the predominant mica in the Woody No. 2 prospect. Biotite is moderately abundant in the Randall pegmatite, though less so than muscovite. All three of these pegmatites are in metasedimentary rocks. In the DeHart pegmatite, in granitic gneiss, muscovite is moderately abundant though subordinate to biotite. In the Branton pegmatite, which is almost entirely in border gneiss and granitic gneiss, and in the Cochran pegmatite, which is mostly in border gneiss, muscovite is more abundant than biotite. Biotite appears to have developed earlier than muscovite where the two micas are intergrown or in close physical association, but no over-all difference in time of deposition has been recognized. The crystallization of biotite in pegmatites in border gneiss appears to have begun earlier than that of muscovite, for only biotite is found in the border and wall zones (apart from muscovite-bearing fracture-fillings) ; but deposition of both evidently continued into the final stages of pegmatite development, for both minerals occur in large part as fracture-fillings.

Other minerals.—Garnet occurs in many of the pegmatites of the district as scattered red trapezohedral crystals generally 1/16 to 1/4 inch in diameter. As garnet is readily destroyed by weathering, it is probably considerably more widespread than is evident from the exposures available. It is present in every pegmatite in which unweathered material is exposed. Garnet is commonly a minor accessory, but closely spaced garnet crystals form striking aggregates up to a foot in diameter in the core-margin zone of the Carson south pegmatite. Crystals as much as an inch in diameter are found in some pegmatites, and in the DeHart mine 3-inch crystals are present. Garnet is not confined to any one zone of a pegmatite, but in general it is more common and coarser in inner zones than in outer zones.

One extraordinary occurrence of garnet indicates that in part it has developed relatively late in the period of pegmatite formation. In the south working of the DeHart mine closely spaced garnet crystals 1/16 to 1/4 inch in diameter occur along planar to sinuous surfaces cutting the outer intermediate zone at high angles. Thickly disseminated garnet crystals occur also in feldspathic pegmatite adjacent to a fracture-filling of quartz about 14 inches long and 1 inch thick.

Magnetite forms scattered crystals in many of the pegmatites and like garnet may be much more widespread than is indicated by the prevailing weathered exposures. It is found chiefly in border, wall, and outer intermediate zones, as unevenly scattered crystals or groups of crystals 1/16 inch to 1 inch in diameter. It appears to be most abundant in border zones where adjacent border gneiss has been aplitized. Crystals are octahedral in habit, range from euhedral to anhedral, and have prominent octahedral parting.

Tourmaline and *allanite* have been found only in the Deep Creek No. 1 pegmatite where they occur along the gradational boundary between the perthite-quartz and quartz-perthite zones. Tourmaline forms rod-shaped aggregates of elongate, flattened, striated black parallel prisms as much as 4 inches by 1 inch in cross section and 1 foot or more in length. The aggregates reach a maximum length of 5 feet and are as much as 6 inches by 1 foot in cross section. The crystals are embedded in quartz and perthite and extend across the boundaries of the two minerals. Most of the tourmaline prisms are slightly bent, fractured, and faulted normal to their long axes. Quartz heals the cross-fractures. The quartz surrounding one such aggregate in the drainage tunnel of the main working shows a remarkable system of radial fractures extending outward from the aggregate as much as 2 feet.

In some of the aggregates tourmaline is partly embedded in black lustrous allanite which forms rounded to irregular coarse-grained masses that have been fractured and veined by late feldspar and quartz. Feldspar adjacent to allanite shows the characteristic reddish discoloration resulting from radioactivity.

The occurrence of allanite and tourmaline from top to bottom of the Deep Creek No. 1 mine, and only in the gradation between the perthite-quartz and quartz-perthite zones, is noteworthy. As the boundary between the zones is gradational, there is no true contact surface which might serve as a structural control for tourmaline and allanite deposited after consolidation of the zones. Furthermore, the adjacent quartz and feldspar vein the allanite and tourmaline, and are evidently later, though probably only slightly later. It seems evident that tourmaline and allanite were formed during the period when the deposition of the material of the perthite-quartz zone was giving way to deposition of the quartz-perthite pegmatite.

Beryl occurs only in the Branton pegmatite where it is found in sparsely scattered, yellowish-green, partly kaolinized crystals and columnar groups of parallel crystals at least 7 by 5 by 4 inches in maximum size. The crystals are restricted to a unit which is probably the inner intermediate zone of the pegmatite.

Pyrite, fluorite, and *galena* are late minerals, occurring along fractures cutting other minerals. Pyrite has been observed in several pegmatites, purple fluorite only as traces in the Cox No. 1 pegmatite, and galena only as traces in the Cox No. 1 and Carson south pegmatites.

Weathering products of the pegmatite minerals include kaolin, limonite, and manganese oxides, in addition to the vermiculite previously described. Kaolin formed from plagioclase is ubiquitous in the upper, weathered portions of the pegmatites, where it forms compact masses that are white except where stained by limonite or manganese oxides. In general the water table is the downward limit of effective kaolinization in the district, but kaolin is reported at depths 100 feet or more below water level at the Swain mine. Limonite is widespread as a coating along fracture surfaces of feldspars or as a pulverulent product of the weathering of biotite, garnet, magnetite, or pyrite. Manganese oxides are spottily distributed. Spots of manganese oxides in most places problaly record the former presence of garnet.

ORIGIN OF THE PEGMATITES

General statement.—For a recent review of the voluminous literature on the origin of pegmatites the reader is referred to the report by the author and others.[41] The present report is essentially a summary of field observations, and only such comments are offered as seem justified at the current stage of the investigation.

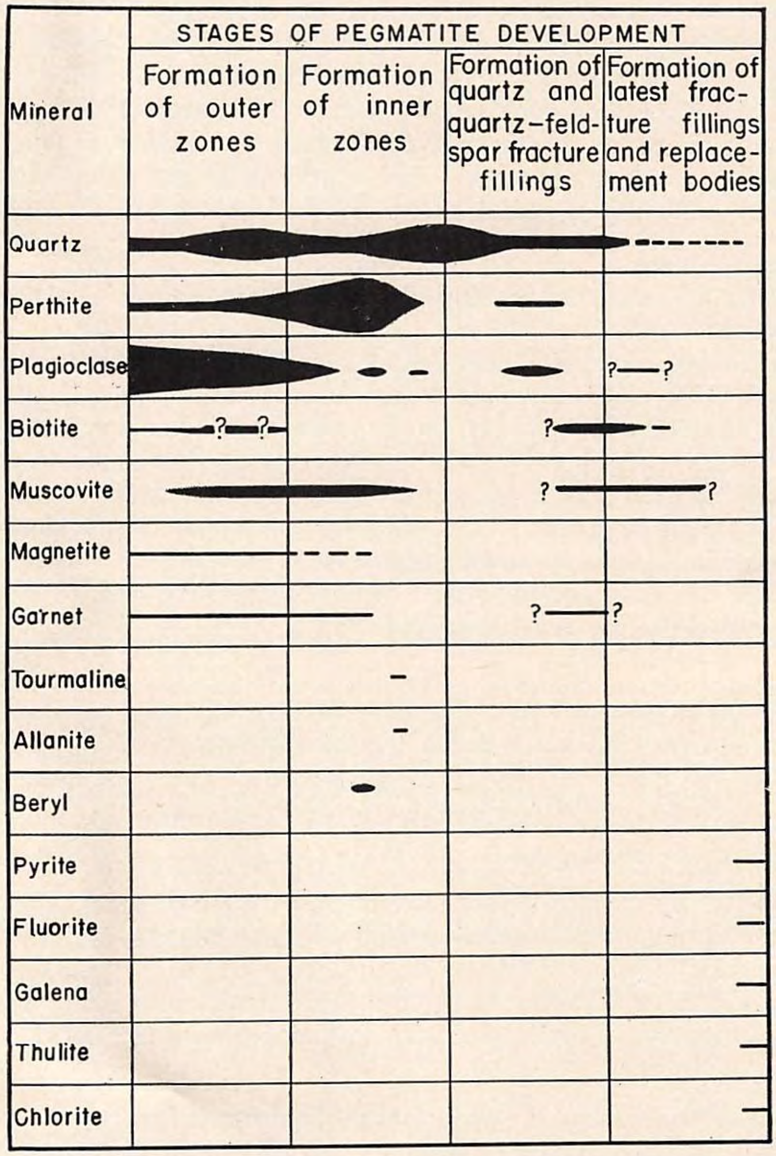

FIGURE 12. SEQUENCE OF MINERAL DEVELOPMENT IN PEGMATITES OF THE BRYSON CITY DISTRICT.

Mode of emplacement.—Most of the pegmatites of the Bryson City district appear to be fillings of fractures caused by deformation of the region after the development of the granitic complex. There is little indication of forceful injection of the pegmatitic fluids; permissive injection consequent upon dilation ap-

[41] Cameron, E. N., Jahns, R. H., McNair, A. H., and Page, L. R., The internal structure of granitic pegmatites: Econ. Geology, Mon. 2, 113 pp., 1949.

pears adequate to account for the relationships observed. Fractures, faults in part, that are related to southwesterly plunging asymmetric folds appear to have controlled the emplacement of some of the larger pegmatites of the border gneiss belt along the western margin of the granitic complex. Pegmatitic material has been produced in small part by soaking, recrystallization, and partial digestion of wall rocks, but there is no reason to believe that these processes account for the presence of the larger bodies, for too many of the pegmatite bodies of the district occupy sharply defined chambers obviously produced by fracturing.

Although it is possible that the pegmatite bodies represent a late stage in a long-continued sequence of events leading to the development of the granitic complex, there is little evidence, beyond geographical association, that the relationship is one of parent to offspring. A complicated sequence of events separates the development of the main part of the granitic complex from the development of the pegmatites. The concentration of productive pegmatites along the northwest margin of the granitic complex appears to be more a matter of structural control by a favorable horizon than a strict genetic relation. Pegmatites occur widely over the region southeast of the Bryson City area; and from the data at hand it seems dubious that the complex at Bryson City is the true focus of a pegmatite swarm. Northwest of the complex, pegmatites apparently die out within a short distance, and their disappearance appears to coincide with a decline in the metamorphic rank of the metasedimentary rocks. The relationships are an intriguing problem, but there seems little to be gained by indulging in speculation until more is known of the regional geology.

Sequence of mineral formation.—Tentative conclusions as to the sequence of mineral formation in the pegmatites are summarized in figure 12. In determining relative ages of the minerals three criteria have been used: peseudomorphs, vein relationships, and position in the zonal sequence. The first two criteria need no comment. They have been widely applied and their reliability, provided proper precautions are observed, is not seriously questioned. The third criterion requires comment and, indeed, defense. Its use rests on the premise that the order in which the zones occur, from the walls of the pegmatites inward to the cores, is the chronological order of formation of the zones; that in the absence of evidence to the contrary the presence of a mineral within a zone indicates that it formed contemporaneously with the zone; and that fracture-fillings and replacement bodies have developed in general after the zones. The evidence for the development of zones from the walls inward to the core in zoned pegmatites in general[42] is reviewed only briefly here with comments on the portion of the evidence applicable to the Bryson City area.

The main features of zoned pegmatites in general that point to development of zones from the walls inward are as follows:

1. The material composing an inner zone may transect an outer zone or replace any part of the outer zone. The reverse is not true. In the Bryson City district, at least one fracture-filling is known to be an offshoot of the core of a pegmatite. Other fracture-fillings cutting outer zones have the composition of inner zones. Fracture-fillings cutting inner zones and comparable in composition to outer zones have not been found.

2. Zoned pegmatites show definite sequences of mineral assemblages from the walls inward to the cores, and the general sequence of dominant mineral assemblages is the same for a number of districts. It seems unlikely that so consistent a sequence would be found if zones are formed from a body of liquid in any other way than by successive deposition of contrasting layers inward from the walls. This general sequence is applicable, with the minor exception noted above, to the pegmatites of the Bryson City district.

3. In some pegmatites, systematic variations in the compositions of certain minerals from zone to zone inward toward the core have been observed. In plagioclase the anorthite content decreases inward, in beryl the alkali content increases, in micas the lithia content increases. On the assumption that pegmatite development proceeds with falling temperature, these variations suggest that the zones developed inward from the walls. The reverse variation has not been found. The validity of this generalization cannot be verified for the Bryson City district pending laboratory studies, but no contrary evidence has been noted.

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[42] Cameron, E. N., Jahns, R. H., McNair, A. H., and Page, L. R., op cit., (Mon. 2).

4. Minerals of inner zones may replace minerals of outer zones, but the reverse has not been found. This generalization likewise needs laboratory study before it can be applied to the Bryson City district.

Inasmuch as the validity of these arguments for the pegmatites of the district can only be partly verified, the paragenetic sequence given in the table is tentative and subject to revision. Their use actually rests on basic similarities between the pegmatites of the Bryson City district and those that have been more fully studied in other districts. Study of the mutual relationships of quartz and the feldspars, including the mode of development of the graphic intergrowths, is particularly needed. Much work remains to be done before the picture of the development of pegmatite zones in the area can be considered complete.

The fracture-fillings occupy structures that transect zonal structure and are clearly products of a late stage of development. In part they are contemporaneous with the cores of the pegmatites, in part they formed after the cores or at least after the core segments exposed at the present itme. Replacement bodies, albite and muscovite, were formed at some stage after the development of quartz-perthite zones, for a small fraction of the perthite in these zones have been replaced. The time of the replacement relative to the time of development of the quartz cores is not definitely known.

In summary, available evidence indicates that the pegmatites of the Bryson City district were formed in two main stages: an earlier stage during which the zonal structure was developed, and a later slightly overlapping stage during which fracture-fillings and replacement bodies were formed. The first stage is quantitatively much the more important of the two, as in most districts in this country in which pegmaties have been mapped and studied in detail.

MINERAL DEPOSITS

FELDSPAR DEPOSITS

General statement.—Feldspar deposits are scattered widely over the Bryson City area, but most of them are small and offer little encouragement to prospecting and development. Prospecting has been focussed primarily on pegmatites located during the earlier period of kaolin mining. The principal known deposits, including the five that have yielded the bulk of the feldspar produced, lie along the northwest margin of the granitic complex between Deep Creek and Sherrill Gap.

Kinds of feldspar.—In common with most granitic pegmatites, those of the Bryson City area contain two groups of feldspars: perthite (potash-soda feldspar) and plagioclase (soda-lime feldspar). Table 2 gives the theoretical compositions of important feldspars of the two groups.

TABLE 2. THEORETICAL COMPOSITIONS OF FELDSPAR MINERALS

Name	Formula	Composition, in percent				
		SiO^2	$A1^2O^3$	K^2O	Na^2O	CaO
Microcline	$KA1Si^3O^8$	64.7	18.4	16.9		
Albite*	$NaA1Si^3O^8$	68.7	19.5		11.8	
Anorthite*	$CaA1^2Si^2O^8$	43.2	36.7			20.1

* Natural plagioclase feldspars form a series ranging in composition from pure albite to pure anorthite.

Perthite is an intergrowth of microcline feldspar with albite. Albite is the subordinate component, occurring as thin parallel to subparallel lenses and lamellae in the microcline. In some specimens the lamellae are of microscopic dimensions, in others lamellae an inch or longer and 1/20 inch thick are found. The lamellae in most specimens are large enough to be visible under a hand lens or even to the unaided eye.

The presence of a fine, cross-hatched pattern of lines, visible between the albite lamellae on cleavage surfaces of many samples, assists in distinguishing perthite from plagioclase. Perthite is commonly white, cream-colored, or light buff, but greenish, red-brown, or pink tints are shown by specimens from some of the pegmatites. Fresh, unweathered feldspar is hard and has a glossy luster. Weathered specimens are dull and softer, and specimens in an advanced stage of weathering may crumble easily under light pressure. Such specimens are actually mechanical mixtures of relatively unaltered microcline with kaolin derived from the plagioclase. Watts' term[43] "semikaolinized feldspar" apparently refers to this weathered perthite. Watts comments (p. 59) that "semikaolinized feldspar is peculiar in that in 16 such deposits sampled, no semikaolinized soda feldspar was found, every deposit being potash feldspar with a maximum soda content of 1.11 percent." He concluded that the material is higher in potash and alumina than associated fully kaolinized bands. Watts seems not to have recognized the derivation of "semikaolinized feldspar" from perthite.

Brown limonite stain along cleavages and fractures is a common feature of perthite from weathered parts of pegmatites. Feldspar from some pegmatites is pink on outer surfaces but shows the common white to light-buff color on freshly broken surfaces.

The plagioclase group of feldspars is commonly represented in granitic pegmatites either by albite or by oligoclase (90-70 percent albite, 10-30 per cent anorthite), though andesine (70-50 percent albite, 30-50 percent anorthite) is found in a few districts. Preliminary optical tests on samples of plagioclase from the Bryson City district suggest that the prevailing species are albite and albite-oligoclase; hence the feldspar is high in soda content and low in lime content. The plagioclase is commonly white; rarely, specimens are greenish due to minute inclusions of pyrite or gray due to disseminated minute black inclusions of unknown identity. Plagioclase in the weathered parts of pegmatites is entirely or almost entirely altered to clay.

Commercial grades of feldspar.—Specifications for commercial grades of feldspar depend on the uses to which the feldspar is put. There are two principal categories of commercial feldspars: potash feldspar for use in pottery and glazes, and soda feldspar used in the glass industry. Within these categories, however, commercial feldspar as sold by the mills varies within wide limits. Potash feldspar of commerce is perthite, hence always contains a small percentage (usually about 2 percent) of soda (Na_2O) in the form of albite. Soda feldspar is sodic plagioclase, commonly albite or oligoclase.

According to Metcalf,[44] the following are specifications for standard commercial grades (in percent):

For pottery bodies:	
SiO_2	65 to 73
K_2O	3.5 to 12.5
Na_2O	6.5 to 1.5
Fe_2O_3	0.10 to 0.05
For glazes:	
Na_2O	4.0 to 9.0
For glass:	
SiO_2	64.0 to 72

Within each category, grades are established as follows (in percent):

No. 1 grade:	
Free silica (quartz)	maximum 6
CaO	maximum 2
No. 2 grade:	
Al_2O_3	minimum 17
Na_2O plus K_2O	minimum 11.5
Fe_2O_3	maximum 0.1

Feldspar for pottery and glazes must be ground to 99 percent minus 200-mesh. Feldspar for glass making must be ground to minus 20 mesh, and 42 to 85 percent must be plus 200-mesh.

Feldspar for pottery is mixed with clay because it serves as a bonding and fluxing agent. High-potash feldspar has generally been preferred, but soda feldspar has been used to some extent. In glass making, feldspar is added to the melt chiefly as a source of alumina, which increases the resistance of the glass to

[43] Watts, A. S., Mining and treatment of feldspar and kaolin in the southern Appalachian region: U. S. Bur. Mines Bull. 53, pp. 58 ff., 1913.
[44] Metcalf, R. W., Marketing feldspar: U. S. Bur. Mines Inf. Circ. 7184, 13 pp., 1941.

thermal and physical shock. Soda feldspars are preferred for glass making because they give a lower fusion temperature, lower viscosity of the melt, and longer firing range.

A special application of feldspar is its use as the abrasive ingredient in scouring soaps and powders. Feldspar for this purpose must be free of quartz and must grind to a pure white color. Either soda or potash feldspar is suitable, but as few pegmatites yield sizable amounts of quartz-free soda feldspar separable by hand, most feldspar for cleansers is potash feldspar.

Mining and preparation for market.—Pegmatite mining in the past traditionally has consisted of a number of scattered, small operations employing simple methods. In the Bryson City district the rock is drilled for blasting by use of pneumatic drills, and the broken rock is handsorted into waste and various grades of commercial feldspar on the floor of the working. Every effort is made in handsorting, within limits imposed by cost, to reduce the content of free quartz and deleterious impurities. The latter consist essentially of micas, garnet, and magnetite, all of which carry iron and are undesirable in other ways. Pieces containing excess intergrown quartz are discarded. Graphic intergrowths of quartz and feldspar are saved, however, provided the mine has a market for No. 2 feldspar, as the intergrowths fall within the limits set by the commercial standards for free quartz in feldspar of this grade.

At the mines supplying ceramic feldspar no attempt is made to maintain a chemical control over the product. Separation into grades is made on the basis of experience, checked by analyses of shipments reported from the mills. The crude feldspar is crushed at the mills, analyses of batches are made, and batches from various storage bins are blended to obtain the products specified by the consumer.

Feldspar and waste rock are hoisted from the mines by aerial tramway and skip or by derrick hoist. At the Swain mine both a derrick hoist and an inclined rail haulageway were used at different stages of operation. Most of the feldspar recovered has been shipped to mills at Spruce Pine, N. C., chiefly by rail but partly by trucks. The cost of trucking from the mine to the railroad at Bryson City was reported in 1946 to be about $.60 per ton, the freight rate to Spruce Pine $2.03 per ton, and the cost of trucking from railroad to mill at Spruce Pine another $.60 per ton, or a total shipping charge of $3.23 per ton. Prices paid by various mills for feldspar delivered at Spruce Pine are reported to range from $7.00 to $8.00 per long ton. Because of the high shipping costs, most feldspar shipped from the Bryson City district until 1946 for ceramic use was of No. 1 grade, because No. 2 feldspar could not be sold at a profit in the open market in competition with feldspar produced in the Spruce Pine district. In 1946, the Interstate Feldspar Corp. established a mill at Dillsboro, and in 1947 this mill was grinding No. 2 feldspar for the glass trade. In January 1949, No. 1 potash feldspar ground to 200 mesh was quoted in Engineering and Mining Journal at $18.50 per ton. Glass feldspar, white, 20-mesh, No. 1 grade, was quoted at $11.75 to $12.50 per ton.

Types of feldspar deposits.—Feldspar mined in the Bryson City area has come almost entirely from three of the mineral assemblages listed in table 1 (ms. p. 90) : plagioclase-quartz-perthite pegmatite, perthite-quartz pegmatite, and perthite-plagioclase-quartz pegmatite. Plagioclase-quartz-perthite pegmatite forms the bulk of many pegmatites and, because wall zones composed of plagioclase-quartz pegmatite are thin, may extend nearly to the pegmatite walls. Most of the material of this assemblage is too heavily intergrown with quartz to yield feldspar even of No. 2 grade. In a few pegmatites, however, this assemblage is represented by two zones, an outer zone of worthless material, an inner zone composed largely of graphic intergrowths of feldspars and quartz with subordinate to minor perthite and plagioclase free of quartz. Zones of this type occur in the Deep Creek No. 1 pegmatite (not mapped separately), in the Cox No. 1 pegmatite, and in the Carson south pegmatite. Material from these zones has been recovered for glass feldspar.

Perthite-quartz pegmatite is represented by two types of zones, both occurring as inner intermediate zones. One type is exemplified by the perthite-quartz zone of the north McCracken pegmatite in which a large proportion of the perthite occurs as graphic intergrowths with quartz. This material would yield a superior No. 2 feldspar. The second type, represented in the Cox No. 1, the Deep Creek No. 1, the Swain, and other pegmatites, consists of large quartz-free perthite crystals with interstitial massive quartz. The feldspar is easily separated by hand from quartz, and this type of zone has yielded all but a very small percentage of the feldspar of No. 1 grade produced in the district, including all the feldspar suitable for use in cleansers. As the ratio of perthite to quartz in these zones is high, the yield per ton of rock mined also is high.

Perthite-plagioclase-quartz zones, where present, occupy the same position in the pegmatite as that normally occupied by perthite-quartz zones and likewise yield feldspar of No. 1 grade. The only zone of this kind that has been productive is the core-margin zone of the Carson south pegmatite. Feldspar produced from this zone by the Blue Ridge Mining Co. was sold for ceramic purposes, but that produced by the Whitehall Co. has been used for cleansers.

All three types of mineral assemblages from which commercial feldspar has been produced form inner zones of the pegmatites. In pegmatites or parts of pegmatites in which a quartz core, a quartz-perthite zone, or both, are present, any productive zones will be between the core and the outer zones. In pegmatites or parts of pegmatites in which a quartz core and quartz-perthite zone are lacking, the productive zones are the innermost zones. In tabular pegmatites these zones will be at or very near the midportion of the pegmatite. In large, irregular bodies, the innermost zones commonly lie between the hanging wall and the geometric center of the pegmatite.

The fact that minable feldspar is restricted to inner zones is an important consideration in locating feldspar, for experience in this and other pegmatite districts indicates that inner zones are commonly thickest and best developed in the thickets part or parts of a pegmatite. This relationship is clearly shown in plans of the Cox No. 1 and Deep Creek No. 1 pegmatites (figs. 7 and 8). In the Cox No. 1 pegmatite, for example, the inner zones are discontinuous, reaching maximum development in the broad irregular bulge near the center of the pegmatite. In the Deep Creek No. 1 pegmatite there are three westward bulges of the hanging wall (west wall) of the pegmatite; the inner zones are confined to these bulges. In the Swain pegmatite (pl. 8) the productive perthite-quartz zone is confined to the bulbous northerly portion of the pegmatite.

Recommendations for feldspar prospecting.—The present study indicates that prospecting for feldspar in the Bryson City district is a fourfold problem. First, a pegmatite large enough to contain sizable inner zones must be located; second, the shape of the pegmatite, particularly the positions of the thick portions, must be found; third, the inner zones must be located within the thick portions; and fourth, the dip, strike, and plunge of the pegmatite and of the potentially productive inner zones must be determined.

Ordinarily, the size and shape of a pegmatite can be determined together. In the Bryson City district, the limits of the pegmatite at the surface are seldom indicated by outcrops or by float, but the limits can be found rapidly and cheaply, where overburden is not too heavy, by bulldozing or by postholes, pits, and trenches. Such methods are particularly effective because decomposed bedrock lies essentially undisturbed within a few feet of the surface in many parts of the area. When the thicker portions of the pegmatite have been discovered, trenches inward from the contacts with country rock can be used to determine the nature of the inner zones exposed at the present erosion level and can be used to outline the workable zones, if such are found. The first few pits and trenches should yield at least partial information as to the sequence of zones within a pegmatite, and later trenches can therefore be limited to the vicinities of the productive zones, except as further information regarding the shape and attitude of the walls is required. Plate 15 shows how trenches and postholes were used to outline the limits of the McCracken north pegmatite and the limits of the potentially productive perthite-quartz zone within it.

Surface exploration yields valuable information regarding the potentialities of a pegmatite, but as pegmatites are a three-dimensional problem, such exploration is only a beginning. Productive zones are limited in extent in depth; they have bottoms and tops as well as ends. In a given pegmatite, erosion may not yet have exposed the top of the productive zone; in another, it may have reached nearly to the bottom of the zone or even below the bottom. Here, however, the empirical principle that inner zones are likely to be confined to the thicker portions of a pegmatite can assist in the search for feldspar. The contacts with wall rock will be exposed in determining the limits of a pegmatite. If the dips of the contacts along the sides of a pegmatite body are consistently toward the center of the body, the pegmatite is probably narrowing in depth and the bottom of the shoot is likely to be relatively near the surface. If dips are consistently away from the center, the pegmatite is probably thicker at depth, and there is a good chance that the surface exposures are either near the top of the productive zone or at least well above its bottom.

Conclusions with regard to downward pinching or swelling in depth, however, should be made only if the pegmatite walls are exposed at a number of points, for mapping indicates that the walls of the pegmatites within the district are irregular, that local reversals of dip are not uncommon, and that the walls of some pegmatites vary markedly in strike and dip within short distances. The plunge of rolls of pegmatite walls and minor structural features of the wall rocks can be used in some pegmatite districts as a guide to the position of the pegmatite and its productive zones at depth. However, knowledge of these features in the Bryson City district is not yet adequate to indicate their reliability. The larger pegmatites in the border gneiss belt along the northwestern margin of the granitic complex appear to have developed along westward-dipping fractures or groups of fractures trending obliquely across the belt. Observations of the few pegmatites that have been mined underground suggest that the plunge of a pegmatite can be roughly calculated as the intersection between a plane including the two longer dimensions of the pegmatite (if it approaches lenticular form) and the plane of the foliation of the border gneiss at the locality. The plunge of the pegmatite at the Swain mine appears to be related to the plunge of the axis of an asymmetric flexure of the country rocks.

In exploring for productive inner zones care must be taken to distinguish between cores and thick quartz-feldspar fracture-fillings. The outline of a core reflects the shape of the pegmatite body. Any tabular body oblique to the walls or to the general zonal structure of a pegmatite is suspect as a probable fracture-filling.

If surface exploration is done with reference to the internal structure of the pegmatites of the area, a saving of much time and effort spent in exploring unproductive parts of pegmatites should result. The district shows much evidence of haphazard prospecting, some of it underground work that has been relatively slow and expensive. Surface exploration is rapid and cheap. It does not furnish all the information required by the prospector, but it should enable him to narrow the targets of exploration and also to be sure that no potentially productive portion of a pegmatite at the surface has been overlooked. There are too many pegmatites in the district that have been tested only by one or two pits or adits, with no attempt to outline the pegmatites or to locate the parts most likely to contain commercial feldspar.

The same structural characteristics used to guide surface prospecting can be used to guide subsurface exploration by adits, or drifts, or drilling. Diamond drilling has been successfully applied in other districts to exploration of pegmatite deposits, both of feldspar and of other minerals, and with proper care might prove useful in the Bryson City district. No general statement, however, can be made as to the feasibility of drilling feldspar pegmatites. Each deposit must be considered separately. Detailed knowledge of the structure of the exposed parts of the deposit, and of the texture and mineralogy of each zone is essential. Much will depend on whether the potentially productive zones pass abruptly or gradually into adjacent zones.

As indicated in figure 10, the lack of inner zones in surface exposures does not necessarily mean that these zones are lacking in a pegmatite. Erosion may not have bitten deeply enough to expose the inner zones of the body. Detection of shoots hidden in these zones is a difficult problem because the cost of subsurface exploration must be kept as low as possible; the average feldspar deposit cannot support heavy exploration costs. The problem is essentially one of locating a hidden zone, if the zone is present, with a very limited amount of exploration. The writer has no panacea for this problem. It seems evident, however, that a search for hidden shoots should not be made unless study of a pegmatite gives some definite reason, such as indications of marked downward increase in the thickness of the pegmatite, for suspecting the presence of a potentially productive zone. Perusal of the maps and diagrams accompanying this report will indicate clearly that the odds are heavily against the prospector who conducts subsurface exploration solely out of hope that better rock lies below. The large number of unsuccessful prospect workings in the district is sufficient evidence of the truth of this statement. Systematic prospecting with reference to internal structure, however, should materially reduce the odds, although it is not likely to reverse them.

MICA DEPOSITS

General statement.—There are a number of mica prospects in the Bryson City area, mostly on the southeastern margin of the complex. Records of operations at these prospects are scanty, and no appreciable production appears to have been made; hence only a brief description of the economic features of the deposits is warranted.

The micas are a complex group of aluminum silicates characterized by a basal cleavage along which they can be split into thin, flexible, elastic sheets and flakes. Only two species of true mica are found in pegmatites of the Bryson City district: biotite, the black iron-magnesia-potash mica, and muscovite, the lighter-colored potash mica. Biotite has no uses in industry at the present time; muscovite is the principal mica of commerce.

Characteristics of muscovite.—Muscovite is found in pegmatites in "books" or crystals that reach maximum thicknesses of several inches or more and maximum breadths of a foot or more parallel to the cleavage. Most books have irregular outlines, but some books show part or all of the nearly hexagonal outline which is the characteristic crystal form of the mineral. Thin sheets of muscovite are nearly colorless, but thicker sheets and books generally have distinct color. Most books are more or less marred by various structural defects of which the following are the most common:

Cross-fractures—cracks interrupting the sheets.

Tanglesheet—due to intergrowth of adjacent laminae, so that the books do not split along a single cleavage plane without tearing.

Reeving—sets of closely spaced parallel minute corrugations of the cleavage. Generally two sets of reeves are present, intersecting at angles of 60° ("A" mica) or 120° (herringbone or fishtail mica).

Ruling—sets of sharp, parallel parting planes, at angles of approximately 60° to one another and at an angle of approximately 67° to the cleavage plane.

Wedge structure—wedge-like books, due to interlayering of sheets of different size, some extending only part way across the book, so that one side of the book is thicker than the other.

Waviness—undulations of the laminae.

For a more complete description of the structural defects of mica, the reader should refer to the discussion by Sterrett.[45] Structural defects mar most mica books to greater or less extent, but flawless sheets can be obtained from parts of some books.

In addition to structural defects, mica books from some deposits contain minute inclusions of minerals such as iron oxides, tourmaline, and garnet. If large, these inclusions interrupt the continuity of the cleavage laminae, spoiling the sheets. If small, the mica is said to show *mineral stain*. Mica from the weathered portions of deposits may show *clay stain* or *vegetable stain* due to infiltration of matter carried by ground waters.

Preparation of muscovite for market.—Mica books as they come from the mine are rifted into thin slabs. Slabs too marred by structural defects to yield sheet mica are set aside as scrap mica. The others are split into thinner sheets from which the defective parts (bench scrap) are partly trimmed (half-trim, three-quarter trim) or entirely trimmed (full trim). The final product is trimmed sheet mica. The sheets are graded according to size of the flawless area; standard sizes range from 1 by 1 inch and 1¼ by 1¼ inches (punch mica) to 6 by 8 inches.[46] Within the various grades sheet mica is further classified according to quality, determined by flatness and degree of staining, as clear, slightly stained, fair stained, good stained, stained, and heavy stained. Qualification of mica was done by eye for many years, but in recent years there has been a trend toward basing qualifications, at least partly, on electrical qualities as indicated by special testing devices.

Prices paid for mica depend on size and quality, increasing with both. In January 1949, prices quoted ranged from 12 to 22 cents per pound for punch mica to $6.00 per pound for sheets 6 by 8 inches. Scrap mica was quoted at $25.00 or more per ton.

Uses of Mica.—Sheet muscovite has a unique combination of luster, elasticity, tensile strength, low thermal conductivity, low electrical conductivity, resistance to high temperatures, and ease of fabricating due to its softness and ease of splitting.[47] These properties make it useful for a large variety of electrical, radio, and radar purposes. Chiefly it serves as an insulating medium. Ground scrap mica likewise finds many uses;

[45] Sterrett, D. B., Mica deposits of the United States: U. S. Geol. Survey Bull. 740, pp. 11-19, 1923.

[46] For detailed specifications for grading and classification of mica, see Standard methods of test for grading and classification of natural mica: Am. Soc. for Testing Materials, A. S. T. M. designation D351-38 (1938). Also Amer. Soc. for Testing Materials, Tentative specifications for natural block mica and mica films suitable for use in fixed mica-dielectric capacitors, A. S. T. M. Designation: D748-45T, 1947.

for example, as a filler in paint and rubber, in roofing materials, and as a lubricant. For further information on use, discussions by Wierum and others, by Albertson and others, and by Gwinn,[48] may be consulted.

Mica from deposits of the Bryson City district.—Muscovite from deposits of the Bryson City district is nearly colorless, greenish, amber, rum, or light ruby in color. The books seen at most prospects are badly marred by cracks, mineral inclusions, tanglesheet, reeving, ruling, and other defects. Little sheet mica can be found in the dumps and the small workings. Experience has shown, however, that the quality, grades, and average sheet content of mica present in a pegmatite can seldom be judged from abandoned workings. Mr. Oscar Martin states that small amounts of sheet mica have been obtained from a few deposits on the southeastern side of the granitic complex. Scrap mica, probably less than 50 tons in all, also have been produced.

Occurrence of muscovite.—Exposures of book mica-bearing pegmatites in the district are very poor, and little information has been obtained as to the occurrence of sheet-bearing mica. Observations indicate however, that the occurrence is comparable to that in the Franklin-Sylva and certain other districts.[49] In some pegmatites mica books apparently occur disseminated through the full widths of the bodies. In zoned pegmatites mica books large enough to yield sheet mica are concentrated in one or more zones and are lacking or nearly lacking in others. In the Simon DeHart prospect (pl. 1, no. 34) wedge-A muscovite in books up to 10 by 8 by 3 inches apparently occurs in a discontinuous wall zone. In the Ashe Thomas deposit (pl. 1, no. 32) book muscovite occurs partly in the wall zone, partly along the margin of the quartz core. A small pegmatite body (pl. 1, no. 31) southeast of Bryson City consists of a quartz core 3 to 9 inches thick flanked by a book muscovite-bearing wall zone ranging from 2 to 4 inches in thickness. In the Branton pegmatite (pl. 1, no. 21) muscovite books are concentrated along the contact of the outer intermediate zone and the core.

Some of the small prospects scattered along the southeast margin of the granitic complex from the latitude of Arlington Church northward to the Tuckasegee River appear to have tested tabular or lenticular bodies of quartz, with minor amounts of plagioclase and books of muscovite. None of these deposits appear to be of any consequence. The small prospects on the northeast side of Welch Branch apparently were in similar deposits.

In pegmatites in which the distribution of book mica is related to zonal structure, exploration should be governed by the same principles as those discussed in connection with feldspar deposits. In mica-bearing pegmatites, however, attention must be paid both to wall zones and to inner zones. Wall-zone deposits of mica are known from a number of pegmatite districts, and in some have been richly productive. Though commonly more continuous and more uniform in width than inner zones, wall zones in some pegmatites are discontinuous or vary markedly in mica content along strike or dip. No single exposure of such a zone, therefore, is an adequate guide to its content of book mica.

KAOLIN DEPOSITS

General statement.—Kaolin mining in the Bryson City district is apparently an industry of the past, owing to the discovery and development of deposits of high-grade kaolin in the Spruce Pine district and elsewhere that are much larger and lend themselves far better than pegmatite deposits to low-cost mining. The kaolin industry of the first twenty years of the present century is described or mentioned by J. H. Pratt,[50] H.

[47] Germany is reported to have been successful in laboratory synthesis of sheet phlogopite mica during World War II, but the process was not developed to the commercial stage. See Tyler, P. M., Synthetic mica research, Office of Military Government of Germany (U. S.), FIAT. Final Rept. (April 1946).

[48] Wierum, H. F., and others, The mica industry: U. S. Tariff Comm. Rept. 130, 2d ser., p. 155, 1938.
Albertson, J. M., and others, Mica: U. S. Tariff Comm., War Changes in Industry Series, Rept. no. 21, 89 pp., 1947.
Gwinn, G. R., Strategic mica: U. S. Bur. Mines Inf. Circ. 7258, p. 18, 1943.

[49] Olson, J. C., and others, Mica deposits of the Franklin-Sylva district, North Carolina: North Carolina Dept. Cons. and Devel. Bull. No. 49, pp. 10-13, 1946.
Cameron, E. N., Larrabee, D. M., McNair, A. H., Page, J. J., Stewart, G. W., and Shainin, V. E., Structural and economic characteristics of New England mica deposits: Econ. Geology, vol. 40, pp. 369-393, 1945.

[50] Pratt, J. H., The mining industry in North Carolina: North Carolina Geol. and Econ. Survey, Econ. Papers Nos. 6 (1902), 8 (1904), 9 (1905), 11 (1907), 14 (1907), 15 (1908), 23 (1911) and 49 (1919).

Ries,[51] W. S. Bayley,[52] and A. S. Watts.[53] The most comprehensive discussions are those by Watts and Bayley; the reports by Pratt are chiefly brief summaries of mining activity and production. The reader is referred to the publications listed for a detailed account of kaolin operations. The following discussion is restricted to new information on the occurrence of kaolin and its bearing on prospecting for feldspar.

Occurrence of kaolin.—Most of the kaolin output was obtained from zoned pegmatites, and the internal structure of the pegmatites as described in previous sections of this report is therefore reflected in the occurrence and distribution of the kaolin. Kaolin was formed chiefly from plagioclase; hence the plagioclase-rich zones undoubtedly yielded the highest proportion of kaolin per cubic yard of material moved. The zonal structure of the pegmatites was not generally recognized, but the occurrence of high-grade kaolin in "bands or streaks" within certain pegmatites was well known, and some of the kaolin workings offer clear evidence of selective mining of kaolin-rich parts.

Two members of the sequence of mineral assemblages listed in table 1 (ms. p. 90) contain kaolin-rich material where weathered. One is the plagioclase-quartz assemblage, No. II of the sequence, which forms the wall zones of many of the zoned pegmatites. This was mined from the southern part of the Cox No. 1 pegmatite, from the Deep Creek No. 1 pegmatite, and possibly from the Swain pegmatite. The other assemblage is the perthite-plagioclase-quartz assemblage, the abnormal variant of member No. IV of the sequence. Weathering of plagioclase-rich portions of inner zones composed of this material has resulted in bodies rich in massive pure kaolin. Bodies of this type were worked at the Branton mine, but operations were not confined to these two zones. At the Randall, Carson, Swain, Cox, Deep Creek No. 1, and other deposits, kaolinized plagioclase-quartz-perthite pegmatite of intermediate zones was worked, although the content of quartz and perthite in this material is high. Zones rich in perthite ("hardtack"), quartz and perthite, or quartz, were not mined; knowledge of this has been used as an aid in feldspar prospecting.

Experience in the district indicates that the size of an old clay working is not necessarily proportional to the size of the pegmatite explored. Labor was cheap at the time of kaolin mining, and by lavish use of it, supplemented by horse-powered dragline and scraper devices, large amounts of weathered country rock were moved at some mines in order to gain access to relatively small pegmatite bodies. The Woody No. 4, Carson No. 2, Hans, and upper Ogle workings are noteworthy examples.

OUTLOOK FOR THE FUTURE

The future of mining in the Bryson City area appears to depend on success in discovering additional deposits of No. 1 potash feldspar. With the development of processes for recovering feldspar from granites, syenites, and other rocks by flotation, the importance of pegmatite mines as sources of feldspar seems likely to decline. The Bryson City area, moreover, is under a heavy handicap of adverse freight rates to major milling and consuming centers.

Prospecting for feldspar in the district thus far has been concentrated along the northwestern side of the granitic complex, but some work has been done at other places scattered over the granitic complex and along the southeastern margin. Thus far, large pegmatite bodies have been discovered almost exclusively along the northwestern side of the complex north of the Tuckasegee River. In an area in which pegmatite bodies in general are poorly exposed, an appraisal of the chances of finding additional large bodies must be made with caution. The writer is not greatly optimistic, but it should be pointed out that a number of pegmatite occurrences already known are incompletely explored, and their outlines are only partly known. Bodies such as the Lackey pegmatite and the Harrison T. Crisp pegmatite may be somewhat larger than would appear from present exposures. A few other bodies, such as the McCracken north pegmatite and Carson north pegmatite, would appear to warrant further systematic exploration to determine whether economic concentrations of feldspar are present.

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[51] Ries, H., The clays of the United States east of the Mississippi River: U. S. Geol. Survey Prof. Paper 11, 298 pp., 1903. Bayley, W. S., in Ries, H., Bayley, W. S., and others, High-grade clays of the eastern United States: U. S. Geol. Survey Bull. 708, 314 pp., 1922.

[52] Bayley, W. S., The kaolins of North Carolina: North Carolina Geol. and Econ. Survey Bull. 29, 132 pp., 1925.

[53] Watts, A. S., Mining and treatment of feldspar and kaolin in the southern Appalachians: U. S. Bur. Mines Bull. 53, 170 pp., 1913.

DESCRIPTIONS OF MINES AND PROSPECTS

MORRIS PROSPECT

The Morris prospect (pl. 1, no. 1) lies 1,700 feet N. 80° W. of Deep Creek Church, a few hundred feet inside the boundary of the Great Smoky Mountains National Park. Mr. S. W. Enloe of the Harris Clay Co., Spruce Pine, N. C., states that the property was prospected for clay presumably between 1910 and 1915, but results were disappointing.

Workings consist of a large number of pits on the crest and west side of a low spur, and an adit that extends 45 feet N. 71° W. into the east side of the spur. No pegmatite is exposed in the adit. The walls of the pits are so slumped that little can be seen in them, and no pegmatite can be seen in place. One line of pits trending N. 24° W. for 105 feet along the crest of the spur apparently explored a veinlike body of quartz with subordinate to minor kaolinized plagioclase. Another group of excavations about 100 feet west of the crest of the spur consists of 6 pits spaced over a length of 150 feet, roughly along a line trending N. 10° W.

There is no indication that any sizable body of pegmatite was discovered during prospecting. For this reason, and because perthite appears to be virtually lacking in the waste piles, the prospect offers little promise as a source of commercial feldspar.

CARSON MINES

General information.—The Carson mines lie 2,900 feet N. 85° W. of Deep Creek Church (pl. 1, no. 3). They straddle a spur that separates two branches of a small tributary of Deep Creek, and they extend across the valley of the small branch south of the spur. In 1946 the mines were accessible from the road along the west side of Deep Creek by a side road leading up the tributary. The mines are on land owned by a Mr. Carson of Bryson City. Mineral rights are owned by the Harris Clay Co., Spruce Pine, N. C.

The property was formerly known as the Hill property and was originally worked for kaolin by the Harris Clay Co., probably around 1910. The clay was washed in a plant located on the spur below the No. 2 working, and the product was flumed down to the drying and pressing plant on Deep Creek. Production data are not available. In 1941 and 1942 the property was prospected and operated for feldspar by W. J. Alexander and Oscar Pittman. In 1943 the Whitehall Co. leased the mine, worked it for 4 months, then subleased to Oscar Pittman, who operated the mine in the latter part of 1943 and part of 1944. Production records of these earlier operations are not available. During part of 1944, United Feldspar and Mineral Corp., Spruce Pine, N. C., is said to have worked the mine on Pittman's sublease. In late 1945 and early 1946, the Blue Ridge Mining Co., Spruce Pine, N. C., worked the property on sublease from the Whitehall Co.; production was about 700 tons of No. 2 feldspar and a small tonnage of No. 1 feldspar. The Whitehall Co. took over the mine in July 1946 and operated until early 1949, producing 2,079 tons of No. 1 feldspar and 602 tons of No. 2 feldspar. Almost all mining and prospecting for feldspar has been done at the No. 3 and No. 4 workings, and production has come mainly from the No. 4 working.

The principal workings at the mines are 4 open cuts (pl. 5). The No. 1 working is an open cut about 100 feet long, 40 to 60 feet wide, and 5 to 30 feet deep. The cut trends about S. 75° W. Its walls have caved in places, and the full depth of the working is uncertain, but at the west end of the cut the depth may have been as much as 50 feet at the time operations were abandoned. The No. 2 working is a heart-shaped open cut about 140 feet from north to south, 120 feet in maximum width from east to west, and 10 to perhaps 50 feet in depth. The maximum depth is uncertain because the headwall has slumped. A short crosscut trench gives access to the east side of the open cut. Both the No. 1 and No. 2 workings are reported to have been made by Harris Clay Co. A shaft, now partly filled by debris, was sunk in the decomposed interbedded quartz-mica schists and feldspathic mica-quartzites on the spur separating the two workings. The depth of the shaft is 21 feet to the top of the fill.

The No. 3 working is an open cut 90 feet long, 18 to 45 feet wide, and 5 to 40 feet deep, trending nearly due north. From the north end a small chamber extends from the floor to the open cut. A steep shaft sunk a few feet north of the headwall presumably connected downward with the chamber, but timbering concealed the actual connection at the time of examination. In early 1947, after the mine had been mapped, a glory hole was sunk to a depth of more than 20 feet in the floor of the open cut at the north end. No workable body of feldspar was discovered.

The No. 4 working is an open cut 100 feet long, 53 feet wide, and 75 feet in maximum depth, in the bottom of the branch leading past the Woody No. 1 mine. This working has been the source of most of the feldspar recovered from the Carson property and was the only property in actual operation during 1946 and early 1947. A derrick located at the rim of the open cut northwest of the hoist house was used to hoist feldspar and muck from the floor of the working. Feldspar was loaded on trucks and hauled to the railroad at Bryson City. No. 1 feldspar, together with No. 2 feldspar for the glass trade, has been produced from the mine, but the principal product at the time of investigation was No. 1 feldspar from use in scouring preparations.

General description of the pegmatite bodies.—Two pegmatite bodies, designated in this report as the north and south pegmatites, are exposed on the Carson property. They may be connected at depth or at the surface in the area northeast of the No. 4 working, but the bedrock in this area is completely concealed by mining debris and soil. Both pegmatites are discordant bodies having complex outlines determined largely by fracturing of the wall rocks. Taken together, the two bodies extend across the full width of the belt of border gneiss. In large part the north pegmatite lies along the contact of metasedimentary rocks and border gneiss. The southwest end of the pegmatite is entirely in border gneiss. The south pegmatite lies in augen gneiss, near the boundary with granitic gneiss; a narrow body of pegmatite along the contact of border gneiss with granitic gneiss, adjacent to the hoist house, is probably an offshoot of the south pegmatite.

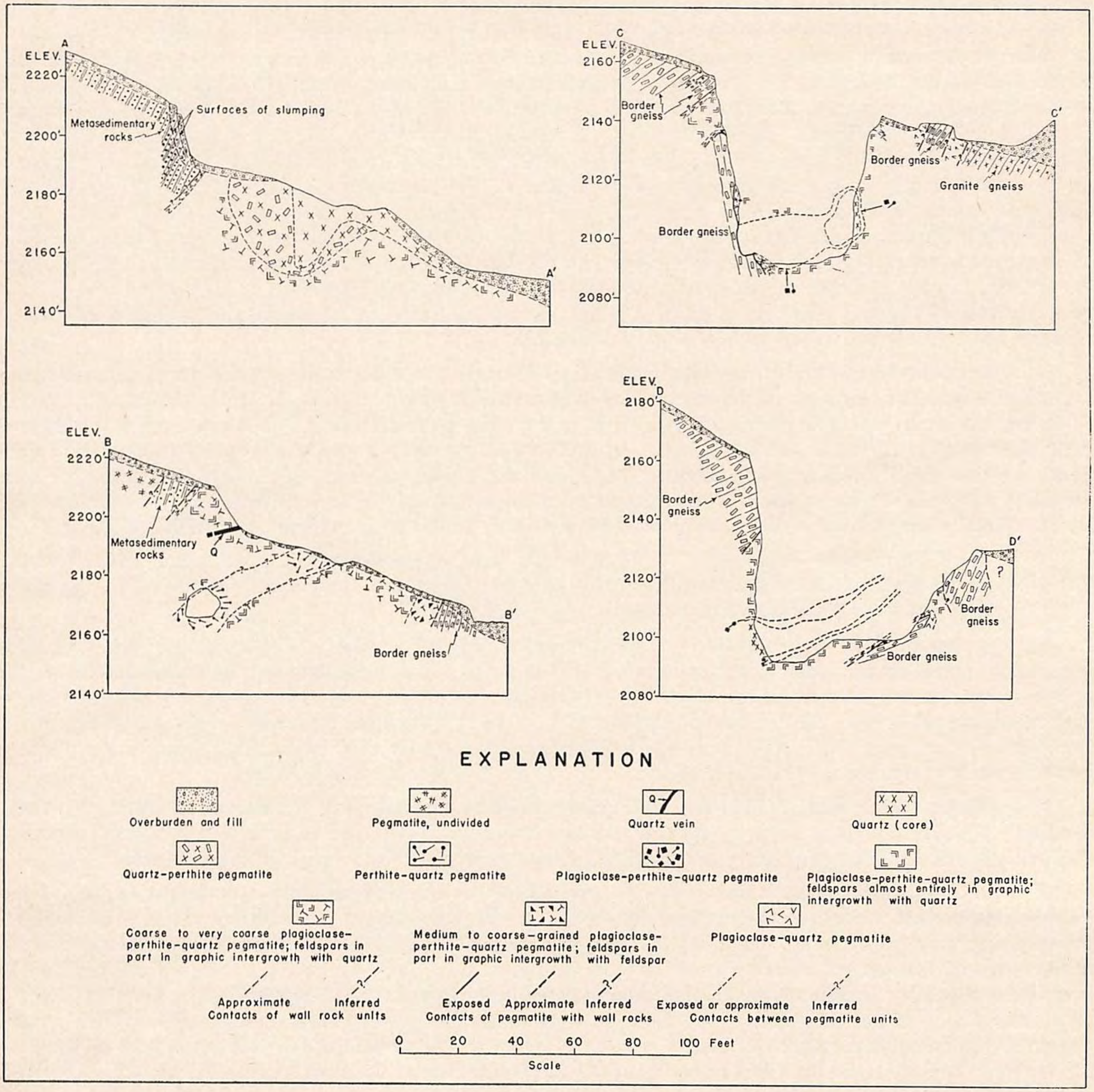
Like the Deep Creek No. 1 and No. 2 pegmatites, the Carson pegmatites lie in a sharp flexure (possibly faulted) of the contact of border gneiss with metasedimentary rocks. The structure involved cannot be determined fully from present exposures.

North pegmatite.—The north pegmatite is an extremely irregular branching body exposed over an area approximately 400 feet long and 200 feet wide. It is roughly oval in plan, but there are a number of wedge-like projections of the wall rocks into the body. Exposures do not indicate the relationships of the pegmatite to the wall rock clearly, but in general it is markedly discordant to wall-rock structure. It appears to occupy a series of interconnected fractures, chiefly in border gneiss, that are related to a sharp asymmetric flexure of the contact between border gneiss and overlying interbedded quartz-mica schists and feldspathic mica-quartzites. Large parts of the pegmatite are concealed beneath dump material, material slumped from the walls, and original overburden. A series of postholes and trenches dug during the present investigation has clarified the structure of part of the body, but information is still incomplete. The contacts vary markedly in strike and dip within short distances; dips in general are moderately steep to steep.

The northernmost exposures of the pegmatite are in the No. 1 working, made during clay mining operations. In the south wall of the working the lower part of one segment of the core of the pegmatite, consisting of fractured, glassy to sugary quartz stained by limonite along fractures, is exposed. The core has three prominent sets of joints, one striking N. 25° E. and dipping 15° E., a second striking N. 33° E. and dipping about 80° NW., and a third striking N. 35° W. and dipping about 75° SW. The keel of the core is apparently double; its two parts are separated by an upward bulge of the margin of the core. Part of the southeastern keel has been removed by erosion. Beneath the northwestern part of the keel and along its northwest side, there is a prominent zone consisting of 1- to 5-foot euhedral crystals of perthite embedded in a matrix of massive quartz. The two minerals are present in approximately equal amounts. Books of amber muscovite up to 3 inches broad and 4 inches thick are sparsely scattered through the quartz-perthite zone and are particularly numerous along its margin against the quartz core. Scattered crystals of kaolinized plagioclase are present in the zone. Much of the perthite is crumbly due to weathering. The quartz-perthite zone evidently extended across the cut, for similar material lies directly against the border zone of the pegmatite in the north wall of the open cut directly opposite. Where pegmatite is present on the north wall, it forms a skin not more than a few feet thick. Evidently this wall is the approximate northern end of the pegmatite. The attitude of the contact and the internal structure of the pegmatite suggest that the pegmatite plunges southward at a moderate angle.

Outside the quartz-perthite zone in the No. 1 working, except along the central part of the north wall, there is a thick zone of plagioclase-quartz-perthite pegmatite with numerous graphic intergrowths of quartz and feldspar. Plagioclase is wholly kaolinized. In the western part of the working this zone is separated from the wall by a border zone ½ to 1 inch thick and a wall zone 1 foot thick, both composed of kaolinized plagioclase and subordinate quartz. Manganese oxides and limonite stain the kaolin; probably they record the former presence of accessory garnet.

PLATE 6.



CARSON MINES
Swain County, North Carolina
CROSS SECTIONS

In the No. 2 working the wall zone is apparently continuous along the west wall. Other exposures in postholes and trenches dug during the present investigation show chiefly plagioclase-quartz-perthite pegmatite. Contacts of pegmatite with border gneiss were uncovered at three places, and the wall zone, 1 to 2 feet thick, is present at least at two. An isolated exposure in the northern part of the working (pl. 5) show very coarse kaolinized plagioclase in contact with massive quartz. The outline and internal structure of the pegmatite in the area of the working could not be determined fully, because the floor is concealed beneath thick debris. The pegmatite, if a single body, is evidently interrupted by a series of partings or reentrants of border gneiss. No indication of a sizable body of feldspar of commercial grade was found.

The No. 3 working, or upper feldspar mine, is near the northwest end of the north pegmatite. The pegmatite here is distinctly zoned. The plagioclase-quartz wall zone found in the No. 1 and No. 2 workings is lacking along the footwall (south wall) but is present in places along the north or hanging wall and ranges from 1 to 2 feet in thickness. Inside the border zone along the footwall (pl. 5, and pl. 6, section B-B′), there is a zone of medium- to coarse-grained plagioclase-perthite-quartz pegmatite about 9 feet thick in which the feldspars are largely in graphic intergrowth with quartz. This zone grades into a thick zone of pegmatite similar in composition but extremely coarse-grained, with feldspar crystals as much as 7 feet by 5 feet. Scattered bodies of quartz up to 6 feet by 2 feet occur in the zone, and perthite against them is euhedral and free of intergrown quartz. Single books and composite crystals of biotite occur along fractures cutting feldspar and quartz. In the chamber at the head of the cut, a fracture surface 5 feet by 1 foot is coated with a composite crystal of biotite consisting of parallel strips up to a foot long, an inch wide, and an inch thick. Such crystals occur elsewhere along several sets of fractures.

A zone composed of very coarse blocky perthite (crystals up to 6 feet in length) and plagioclase and subordinate quartz is enclosed in the coarse plagioclase-perthite-quartz zone. This perthite-quartz unit is evidently the innermost intermediate zone of this part of the pegmatite body. In the east wall of the cut it ranges from 8 to 12 feet in thickness, but in the west wall it consists of two parts, each 1 to 2 feet in thickness, on either side of a quartz core segment 3 to 5 feet wide. Perthite is the dominant feldspar in this unit. Sparsely scattered masses of kaolin containing numerous small flakes of muscovite are derived probably by hydrothermal alteration of perthite to albite and muscovite, followed by alteration of albite to kaolin.

A series of quartz veins 2 inches to 3 feet thick cuts into all zones except the zone next to the footwall. The veins trend north to northeast and dip steeply west or northwest. Quartz also veins shattered perthite along cleavage cracks and along cross-fractures.

Prospecting thus far has failed to discover a minable body of feldspar. The inner part of the coarse plagioclase-quartz-perthite zone contains considerable amounts of No. 2 feldspar, partly soda feldspar, partly potash-soda feldspar, but plagioclase above the level of the floor of the cut is kaolinized, and yield per ton of rock moved would be low. The bottom of kaolinization is said to have been reached in the glory hole made subsequent to mapping, but as the present operators are interested primarily in No. 1 feldspar, no attempt has been made to determine whether the yield of No. 2 feldspar would repay mining.

The only potential source of feldspar of No. 1 grade is the perthite-quartz zone exposed in the walls and heading. This zone strikes about N. 45° E. and dips about 45° NW. The glory hole was flooded when inspected in April 1947 but must have passed through the underside of the zone at shallow depth.

The perthite-quartz zone is thickest in the east wall of the working and in the northeast branch of the chamber, apparently thinning westward along the strike. It is not known whether the unit is anywhere sufficiently thick to repay mining, but it would seem worthwhile to strip the remaining overburden from the surface east of the quarry, so as to trace the perthite-quartz unit along the strike in this direction, and to extend the northeast branch of the chamber along the strike of the zone. The possibilities for development of a sizable body of perthite-quartz pegmatite at depth could be more accurately evaluated if more were known of the downward extent of the two wedges of country rock that nearly separate the part of the pegmatite body worked in the open cut from the part lying to the north. If these wedges bottom within a short distance of the surface, there would be a marked swelling of the pegmatite downward, and the chances of finding a large body of feldspar at depth would be greater than if the wedges of country rock persist or expand at depth. The same question of structure is involved at the west corner of the No. 2 working. The strip of schist separating the part of the pegmatite indicated by postholes west of the No. 2 working is narrow, and dips of the contacts on either side of the strip, where observed, suggest that the strip wedges out at no great depth. Exploratory work would be required, however, to solve these problems. In view of the pronounced irregularity of the walls of the pegmatite, surface observations are a dubious guide to conditions at depth. At present the north pegmatite must be regarded as of doubtful promise as a commercial source of feldspar.

South pegmatite.—The No. 4 or south pegmatite, like the others, is only partly exposed. The part of it revealed by feldspar mining appears to be an extremely irregular pipe, with offshoots extending into the border gneiss along several sets of intersecting fractures. The principal fractures trend northeasterly to east-northeasterly and dip steep northwest to southeast. The pipe plunges west-southwest or southwest at an angle, estimated roughly as 20°. The irregular underside of the pipe appears to have been intersected by the east end of the cut at the 2,105-foot level (pl. 6) and along the west half of the north wall at the same elevation. At the latter place the underside is characterized by irregular rolls that plunge about 35°, S. 48° W. The crest of the pegmatite apparently plunges beneath a border gneiss wedge that splits the pegmatite in the upper part of the wall of the cut.

Contacts of the pegmatite with wall rock are commonly sharp, but border gneiss septa separating parallel branches of the pegmatite along the east rim have been converted to fine-grained aplite, with wisps of partly aplitized gneiss, for distances of 1 to 4 inches from the contacts. Slickensided, sericite-coated surfaces indicate slippage along contacts at several places, but displacements are apparently negligible. The pegmatite has numerous joints. The most prominent set strikes N. 79°-85° E. and dips 82° S. to vertical (pl. 5, plan at elevation 2,115 feet). On the north side of the cut (pl. 5, plan at elevation 2,115 feet), an oblique-slip reverse fault striking N. 5° E. and dipping 32° W. intersects the contact of pegmatite and border gneiss. The apparent maximum displacement parallel to the dip is 1 foot.

The pegmatite consists of 6 asymmetrically developed zones and a series of small fracture-fillings. The border zone is ¼ to ½ inch thick. It is a fine-grained (1/16-1/4 inch) mixture of plagioclase and quartz, with minor to subordinate perthite, scattered flakes of biotite oriented subperpendicular to the contacts, and scattered crystals of magnetite up to ½ inch in diameter. The border zone is the only continuous zone of the pegmatite; it envelops the main body and extends along the walls of all offshoots. Inward from the walls of the pegmatite the border zone grades at most places into a wall zone (plagioclase-quartz pegmatite of pl. 5) 6 inches to 2½ feet thick. The wall zone is composed essentially of coarse blocky plagioclase with subordinate quartz and various amounts of perthite. Scattered, haphazardly oriented books of biotite (chloritized in part) up to 3 inches long, 1½ inches broad, and ¼ inch thick, and sparsely distributed crystals of magnetite 1/16 to ½ inch in diameter also are present. Quartz occurs in graphic intergrowth with a few plagioclase crystals in the wall zone of the offshoot of the main body shown in the plan at elevation 2,115 feet.

The wall zone is absent in the northwestern part of the working, in the vicinity of elevation 2,105 feet (see plan), and a unit composed of plagioclase-quartz-perthite pegmatite lies directly against the border zone. This unit is a coarse- to giant-grained mixture of plagioclase, quartz, and perthite, with minor biotite and accessory small red garnet crystals. Quartz is irregularly intergrown with some of the feldspar crystals, but graphic intergrowths are rare. This unit forms the apparent core of the northwest offshoot of the main body shown on the plan at elevation 2,115 feet. Here the unit is separated from the border zone by the wall zone. The unit is a zone ranging from 1½ to at least 7 feet in thickness. Its known and inferred relations to other zones are indicated in the plans. The zone is probably the outer intermediate zone of the pegmatite.

Where present, the wall zone in the remainder of the workings is directly in contact with the middle intermediate zone, a lithologic type without parallel in the writer's experience. This unit consists almost entirely of true graphic intergrowths of quartz with white plagioclase and pink perthite. Proportions of the two feldspars vary from place to place, but in general plagioclase is the more abundant. The feldspar crystals range from a few inches to 4 feet in maximum dimension. Much of the graphic intergrowth is on a minute scale. Scattered through this peculiar "graphic granite" are strips of biotite 2 to 12 inches long, ¼ to 1 inch broad, and 1/64 to 1/8 inch thick. Some of the strips are arranged in crisscross, rosette, or spray-like patterns. The crystals occupy sericite-coated fracture surfaces of small extent. Plagioclase adjacent to the strips is greenish because of the development of sericite and muscovite flakes up to 1/16 inch in diameter. The alteration extends up to 3 inches from the strips. The relationship of the two feldspars in this zone is an intriguing problem to be given further study.

The middle intermediate zone is separated from the border zone in some of the workings by either the wall zone or the outer intermediate zone. Both these zones are absent along part of the west side of the working in the lower levels, and the middle intermediate zone lies directly against the border zone.

The inner intermediate zone consists of coarse to very coarse crystals of massive plagioclase and perthite, with subordinate interstitial quartz. As shown in plates 5 and 6, this zone is asymmetric and varies markedly in thickness. The maximum thickness (measured vertically, north of the quartz zone) is probably about 18 feet, but the average thickness is much less. Plagioclase occurs mostly as stout crystals 4 inches to 1 foot in diameter; perthite crystals range up to several feet in length. Much of the perthite is white and resembles plagioclase so closely that the proportions of the two minerals are in doubt. Biotite forms scattered curving books and clusters of books, up to 6 inches broad and 1 inch thick, along fractures transecting feldspar and quartz. Red garnet forms scattered crystals 1/16 to 1/4 inch in diameter; in a few places it forms clusters up to a foot in diameter. Minute crytals of pyrite and coatings of thulite(?) occur along fractures in plagioclase in a few places.

The inner intermediate zone in general is thickest along the north side and the crest of the quartz core described below. It was discovered first near the east end of the open cut and has since been followed downplunge to the west-southwest. The angle of plunge cannot be determined accurately but appears to average about 17°.

The core of the pegmatite is an irregular, perhaps discontinuous, body of quartz which plunges with the inner intermediate zone. Most of the core has been removed, and the outlines as restored in the cross sections (pl. 6) involve considerable inference. Scattered crystals of plagioclase are present in the core in places. Quartz of the core extends outward as narrow veinlets into the inner and middle intermediate zones. Biotite occurs along fractures cutting quartz of the core.

At the time of mapping, two types of fracture-fillings were exposed cutting the middle intermediate zone in the bottom of the workings. Both are veinlets ¼ inch or less in thickness and 5 to 7 feet in exposed length; they occur along fractures that have uneven walls. The older set, striking N. 40° W. and dipping 80° NE., consists of veinlets of quartz with minor microcline (perthite?) and scarce magnetite. The younger set, transecting the first, consists of veinlets of quartz and greenish muscovite that strike N. 70°-80° E. and dip 70°-80° S.

Commercial feldspar has been produced from both the middle and inner intermediate zones, the former yielding No. 2 feldspar, the latter mixed soda-potash feldspar of No. 1 grade. Both feldspars are fresh and unweathered. The graphic granite of the middle intermediate zone is satisfactory for the glass trade, but some difficulty was reported in obtaining material free of biotite. The last operators were interested primarily in obtaining quartz-free feldspar for use in scouring powder, hence operations were restricted so far as possible to the inner intermediate zone of perthite-plagioclase-quartz pegmatite.

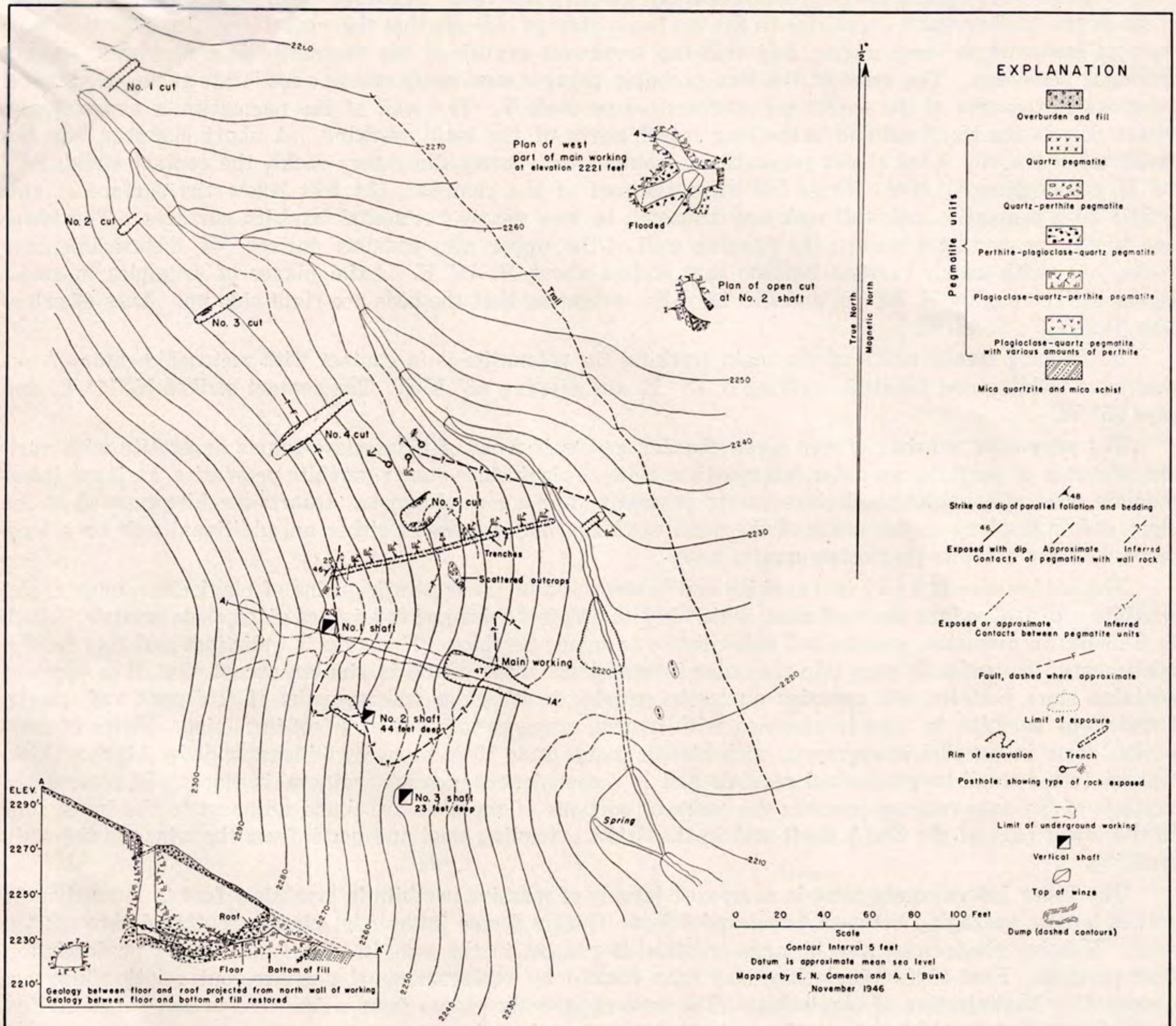
Reserves of commercial feldspar remaining in the pegmatite depend largely on the downplunge extent of the two zones thus far productive. No exploratory data are available, and in view of the extremely irregular form of the pegmatite no estimate of reserves is feasible at the present time. For the same reasons, potentialities of the various offshoots of the pegmatite cannot be assessed. It seems unlikely that any large amount of pegmatite will be found at the surface south or west of the present open cut. Extensions of the body northeastward from the cut are concealed beneath debris.

WOODY NO. 1 MINE

Description.—The Woody No. 1 mine is located 3,650 feet N. 84° W. of Deep Creek Church (pl. 1, no. 2), in the valley of the brook that flows through the lower Carson mine. In the winter of 1946-1947, the mine was accessible by road to the Carson mine, thence by 800 feet of foot-trail. An old road connecting the two mines by way of the valley was impassable. The mine is on land owned by Mr. Samuel C. Woody of Bryson City. Mineral rights are held by the Harris Clay Co., Spruce Pine, N. C. The Woody pegmatite was prospected by Mr. W. L. Alexander in 1941. Later in the same year the Whitehall Co. worked the deposit under lease and produced 171 tons of No. 1 potash feldspar. No further work had been done at the time of mapping.

Openings at the mine consist of 8 small open cuts and 3 vertical shafts (pl. 7). The main working consists of the No. 1 shaft, an open cut 55 feet S. 74° E. of the shaft, and appended underground workings. A partly filled irregular chamber that may extend as much as 20 feet south from the bottom of the shaft (approximately at elevation 2,220 feet) is connected with the open cut by a tunnel trending N. 80° W. A drift extends from the base of the shaft 50 feet S. 70° W. At 26 feet from the shaft, a cross-drift has been run 9 feet into the southeast wall of the main drift, and another on a curving course has been run 22 feet into the northwest wall. At the intersection of the main drift and the crosscuts there is a vertical winze about

PLATE 7.



WOODY NO. I MINE
Swain County, North Carolina
GEOLOGIC MAP, PLANS, AND CROSS SECTION

17 feet deep, nearly filled with water at the time of visit. The No. 2 shaft, with collar at 2,258 feet, is 44 feet deep; water level is at 40 feet. At 39 feet below the collar an alcove, 6½ feet high and of shaft width, extends 6 feet N. 30° W. The No. 3 shaft, 23 feet deep (by sounding) and dry, appears to be entirely in wall rock. Several postholes and approximately 100 feet of trench were dug during the present investigation in an attempt to obtain further information on the structure and composition of the pegmatite body worked on the property, but systematic surface prospecting was not attempted.

Despite the considerable number of workings on the property, the pegmatite is poorly exposed and its form and structural relationships are poorly indicated. It is extremely irregular in plan but has roughly the shape of a Y. The stem of the Y extends approximately N. 30° W. The pegmatite is enclosed in interbedded quartz-mica schists and feldspathic mica quartzites which, wherever exposed, are in an advanced stage of decomposition due to weathering. Contacts are sharp, consistently discordant, and notably irregular in detail, varying markedly in strike and dip within a few feet. Scattered observations and the relationships of the underground exposures to the surface outcrops indicate that the west wall of the pegmatite dips west at moderate to steep angles, and that the southwest branch of the pegmatite is a westward dipping irregular semi-lens. The crest of the lens probably plunges west-southwest at a moderate angle. Structural relations in the area of the shafts are summarized on plate 7. The wall of the pegmatite is exposed elsewhere only in the No. 3 cut and in the long trench north of the main working. A short chamber into the headwall of the No. 3 cut shows pegmatite in contact with metasedimentary rocks, the contact striking N. 36° E. and dipping 83° NW. Three feet below the roof of the chamber (14 feet below the surface at this point) both pegmatite and wall rock are truncated by two nearly horizontal landslip surfaces. The lower one offsets the contact 4 inches; the hanging wall of the upper slip consists entirely of metasedimentary rocks, here with nearly vertical bedding that strikes about N. 45° E. Axial planes of crumples in schist layers strike roughly N. 69° E. and dip 23° SE., indicating that the beds are right side up. Axes of crumples plunge 9°, S. 48°W.

In the long trench north of the main working the pegmatite is in contact with metasedimentary rocks that have bedding and foliation striking N. 37° E. and dipping 46° NW. The contact strikes N. 11° E. and dips 25° W.

The pegmatite consists of five zones: border and wall zones of plagioclase-quartz pegmatite with various amounts of perthite, an outer intermediate zone of plagioclase-quartz-perthite pegmatite, an inner intermediate zone of perthite-plagioclase-quartz pegmatite, and a core of quartz. Quartz-perthite exposed on the slope and in the long trench north of the main workings may represent either an additional unit or a local variant of the perthite-plagioclase-quartz zone.

The border zone is 1 to 2 inches thick and is composed of ¼- to 1-inch grains of plagioclase, quartz, and perthite. It grades into the wall zone, which is 1 to 1½ feet thick and consists of plagioclase crystals ½ inch to 6 inches in diameter, quartz, and subordinate to minor perthite. This zone is indistinct and may be discontinuous. It grades in turn into the outer intermediate zone, which is similar except that it is coarser, contains more perthite, and contains numerous graphic to irregular intergrowths of feldspars and quartz. Crystals of perthite, in part intergrown with quartz, range up to 8 feet by 4 feet in section. Strips of muscovite, some in parallel intergrowth with biotite, range up to 10 feet long by 6 inches wide by 2 inches thick. Garnet forms small trapezohedral crystals and is a conspicuous accessory mineral in places. In general, the crystals of the zone coarsen inward; the coarsest portions of the zone are found adjacent to the inner zone in the lower part of the No. 1 shaft and in the drifts extending west and north from the winze in the main working.

The inner intermediate zone is composed largely of massive perthite in crystals 1 foot to more than 14 feet in length, averaging between 4 feet and 8 feet. Quartz forms interstitial masses scattered through the zone. Massive plagioclase, also in large crystals, is present in the zone in places and locally predominates over perthite. Part of the plagioclase may have formed by replacement of perthite, but relationships are obscured by kaolinization of plagioclase. The zone apparently ranges from a few feet to more than 16 feet in thickness, but its thickness can be estimated at only a few places.

The core of the pegmatite is formed by massive quartz, against which the perthite and plagioclase of the inner intermediate zone are euhedral. The core is well exposed in the No. 1 working, but its extent outside this working is uncertain. Massive quartz exposed in the No. 5 cut and in the trench just south of it contains scattered large crystals of perthite. This unit is bordered on the west by pegmatite which resembles the outer intermediate zone, but the material on the east is abnormally rich in very coarse perthite and plagioclase, partly in graphic intergrowth with quartz. The relationships involved are not fully understood.

The internal structure of the pegmatite, particularly the structure of the inner intermediate zone and core of the pegmatite, is only partly indicated. In the bottom of the No. 2 shaft, and in the heading driven 6 feet N. 30° W. from the shaft, massive quartz is exposed in contact with a layer of perthite-plagioclase-quartz pegmatite 2 to 3 feet thick. The quartz forms the entire floor of the heading. The contact with perthite-plagioclase-quartz pegmatite is irregular but has an average strike of N. 25° E. and a dip of 45° SE. The perthite-plagioclase-quartz pegmatite is overlain by pegmatite of the outer intermediate zone. The relationships of the units shown here to those exposed in the main workings are not known. The massive quartz bodies exposed in the two workings may be parts of a continuous core. Data at hand suggest that the inner intermediate zone is thickest on the hanging-wall side of the quartz core exposed in the main working, and that the thickest parts of both units plunge southwestward.

As shown in cross section A-A′ on plate 7, the pegmatite in the main adit is displaced along a series of minor faults that strike north to N. 57° E. and in general dip 18° to 27° E. or SE. One fault shown on plate 5, however, is a markedly curved surface. It dips 21° E. at the shaft, becomes horizontal near the middle of the adit, and dips gently west near the adit mouth. Some of the faults are simple, others are fault zones up to 4 feet wide, consisting of closely spaced parallel slip surfaces. Limonitic clayey gouge with fragments of pegmatite marks most of the fault surfaces, and some of the surfaces are rudely fluted. Apparent displacements along the faults range up to 3½ feet. The faults, at least in part, are landslips that appear to be governed by sheet fractures roughly parallel to the topographic surface. In the drifts leading from the winze the pegmatite is cut by a series of uneven, gouge-filled fractures striking in general about N. 10° E. and dipping 15°-20° E. Apparent displacements along these fractures are no greater than an inch or two. The displacements may represent landslip along preexisting sheet-fractures developed parallel to the topographic surface during erosional unloading. In the bottom of the No. 2 shaft, a fault of unknown displacement striking N. 68° E. and dipping 42° NW. is offset by another fault striking N. 77° E. and dipping 25° SE. Striations on the two surfaces suggest a strong horizontal component of motion in each case.

In the adit at the main working, the quartz core is intersected by several sets of joints, the most prominent of which strike N. 19° W. and dip 88° E. to 83° W.

Feldspar.—Feldspar in the Woody No. 1 pegmatite includes both potash and soda feldspars ranging from pure and massive to heavily intergrown with quartz. It seems evident that only potash feldspar has thus far been recovered, because all plagioclase exposed in the workings is either completely altered to kaolin or in a moderately advanced stage of kaolinization. The potash feldspar is cream to light buff where fresh, but fractures and cleavage surfaces are stained by limonite in many places, especially near major joints, shear surfaces, and faults. Most of the stain, however, is of a kind that should be lost in grinding, and the quality of a properly sorted product should be high.

Plagioclase feldspar is kaolinized in all the workings that were accessible, but kaolinization is less complete in the drifts extending from the winze, which lie deeper than the other workings. This fact suggests that unweathered plagioclase would be found not far below this level.

Up to the time of mapping (1946), two factors had prevented further development of the Woody No. 1 pegmatite. One was the failure of the workings to disclose any sizable body of No. 1 feldspar. Most of the production came from the perthite-quartz-plagioclase zone along the hanging-wall side of the quartz core, which has been followed for a distance of about 40 feet. The winze was sunk in an attempt to find the downward continuation of this zone. According to local report, work at the mine stopped when the bottom of the shoot was penetrated.

The limited data at hand suggest that the core of the pegmatite at the level of the floor of the winze strikes about N. 70° E. and plunges westward at a low to moderate angle. The end of the core may be represented in the south drift from the winze. If this is so, the extension of the perthite-plagioclase-quartz zone would be downplunge to the west. There is, however, no indication whether the shoot expands or contracts in thickness at depth.

The second factor retarding development is the poor condition of the ground because of the faults and joints described above. The main adit has partly caved and is in dangerous condition, and considerable work would be necessary to ensure safe access to the area around the winze.

Mining to date has aimed at recovery of No. 1 potash feldspar. Considerable amounts of feldspar of No. 2 grade may be present in the pegmatite, particularly below the zone of weathering. The inner part of the outer intermediate zone is rich in No. 2 potash feldspar and kaolinized No. 2 soda feldspar. It also contains some No. 1 feldspar, and a width of 28 feet of this material was found east of the quartz-perthite unit in the trench north of the main working. Below the limit of weathering this material should yield a high proportion of No. 2 feldspar of better than average quality.

There is an additional possibility that feldspar of commercial grade might be found in the part of the pegmatite east of the creek, especially in the vicinity of the quartz body that is exposed at two places. However, Mr. W. J. Alexander reports that pits sunk along the margins of this body failed to disclose appreciable amounts of feldspar.

Further development should begin with stripping or trenching to disclose the full outlines of the pegmatites at the surface and the configuration of the various zones. This information is needed as a guide to further underground work.

WOODY NO. 2 PROSPECT

The Woody No. 2 prospect (pl. 1, no. 6) lies 2,970 feet N. 49° W. of Randall cemetery, on land owned by Mr. Samuel C. Woody of Bryson City. Mineral rights are owned by the Harris Clay Co., Spruce Pine, N. C. The prospect probably was developed during the search for kaolin deposits in the period 1910-1915. The only workings are an open cut 64 feet in length, 25 to 50 feet in width, and 37 feet in maximum depth, and a small pit nearby. The cut trends N. 12° E.

Metasedimentary rocks with bedding and foliation striking N. 55° E. and dipping 84° SE. form the headwall and west side of the open cut. Decomposed pegmatite is exposed in the east wall in tight contact with the metasedimentary rocks. The contact strikes N. 80° E. and dips 81° SE. The pegmatite shows a ⅛- to ¼-inch border zone, an indistinct wall zone 2 feet thick composed mainly of coarse kaolinized plagioclase and quartz, and an apparent core of plagioclase-quartz-perthite pegmatite. The apparent core contains numerous graphic intergrowths of feldspar and quartz, accessory biotite in small books and in striplike crystals, and accessory muscovite in small flakes. The materials described above were exposed by cleaning off the east wall of the cut. The southern part of the pegmatite and the south contact with the wall rocks were not exposed. The pegmatite is concealed outside the working.

WOODY NO. 3 MINE

The Woody No. 3 mine (pl. 1, no. 4), 3,000 feet N. 46½° W. of Randall cemetery, straddles the ridge south of the Woody No. 1 mine. The property is owned by Mr. Samuel C. Woody of Bryson City; mineral rights are owned by the Harris Clay Co., Spruce Pine, N. C. The mine was probably operated between 1910 and 1915 by the Harris Clay Co. Workings consist of an open cut about 200 feet long, 65 to 130 feet wide, and about 65 feet in maximum depth. The working trends roughly N. 20° E. There has been much slumping of the walls of the cut, and relationships are poorly shown.

The working appears to have explored a series of westward-dipping lenses of pegmatite enclosed in interbedded quartz-mica schists and mica quartzite. All the rocks are in an advanced stage of weathering. One pegmatite lens about 12 feet thick is exposed for 20 feet along strike in a large slumped block on the west side of the open cut near the south end. It is a medium- to coarse-grained mixture of plagioclase, quartz, and perthite with minor biotite. In part the plagioclase is in graphic intergrowth with quartz. The contact of the pegmatite with the metasedimentary rocks is irregular and discordant in detail, but the lens is probably broadly concordant.

A second pegmatite body on the east side of the working near the south end was partly exposed in two trenches excavated during the present investigation. The pegmatite is at least 75 feet long and trends approximately N. 30° E. It is 18 feet wide in a trench near the north end of the pegmatite. The southeast contact strikes N. 20° E. and dips 78° NW.; the northwest contact strikes N. 53° E. and dips 79° SE. The attitudes of the contacts in this trench suggest that the pegmatite has a southwestward-plunging keep, but exposures are too limited to give proof. In a second trench 40 feet SSW., the contact strikes N. 3° W. and dips 28° W. The contacts are discordant; bedding and foliation of the metasedimentary rocks adjacent to the pegmatite strike N. 49° E. and dip 80° NW.

The pegmatite has a border zone ¼ inch thick enclosing a coarse-grained wall zone of kaolinized plagioclase with a subordinate quartz minor perthite, and accessory biotite and muscovite. The wall zone is 6 inches to 2½ feet thick. The remainder of the pegmatite exposed consists of coarse to very coarse plagioclase-quartz-perthite pegmatite, in which the feldspars in part form graphic to irregular intergrowths with quartz.

In the west wall of the working, near the north end, decomposed pegmatite appears in slumped material. The pegmatite body from which this material came is probably now largely removed above the level of the floor of the working. It may have been either a separate pegmatite or the northern extension of the pegmatite exposed in the same wall near the south end of the working.

The mine does not appear promising as a source of commercial feldspar. No large body of pegmatite appears to be present, nor is there any indication of a body of feldspar sufficiently free of intergrown quartz to yield commercial feldspar by handsorting.

WOODY NO. 4 MINE

The Woody No. 4 mine (pl. 1, no. 5) lies 2,730 feet N. 39° W. of Randall cemetery, straddling the crest of the ridge that lies south of the Woody No. 1 and Carson mines. The mine is on land owned by Mr. Samuel C. Woody of Bryson City; mineral rights are held by the Harris Clay Co., Spruce Pine, N. C. The main working is an open cut roughly 150 feet long, 100 feet wide, and 55 feet in maximum depth, trending S. 25° W. from the crest of the ridge. A smaller open cut just over the crest on the north side of the ridge is about 25 feet long, 18 feet wide, and 12 feet deep. It trends N. 35° E. The two cuts are connected by a shallow excavation. The mine was worked for kaolin in the early part of the century.

The workings are in a tabular or flat-lenticular pegmatite body near the contact of the metasedimentary rocks with border gneiss. Structural relations of pegmatite to wall rocks are obscured by slumping of the walls of the cut. The pegmatite strikes between N. 3° E. and N. 12° E. and dips about 50°-55° W. The footwall of the pegmatite is border gneiss. Metasedimentary rocks form the first exposures west of the pegmatite at most places, but part of the contact of border gneiss and metasedimentary rocks is exposed at one point in the west wall of the cut. It seems probable that the pegmatite is largely in border gneiss, but it trends obliquely across the strike, so that its north end intersects the contact of border gneiss and metasedimentary rocks. Three shallow trenches made during the present investigation exposed the footwall side of the pegmatite and the underlying border gneiss. The foliation of the border gneiss strikes N. 22° E. and dips 52° NW. In two small exposures in the trenches, the footwall of the pegmatite strikes N. 7°-23° E. and dips 52°-70° NW.

At the contact with border gneiss there is a fine-grained ⅛-inch border zone of plagioclase and quartz. This is overlain by 2½ feet of very coarse, kaolinized blocky plagioclase, forming the wall zone, and this in turn is overlain by a core of massive quartz 4 to perhaps 6 feet thick (pl. 4). The part of the pegmatite above the quartz core has been removed by mining and erosion. The quartz core forms a prominent ledge with a westward-sloping upper surface nearly parallel to the dip of the pegmatite body. The core is exposed for 50 feet along the strike and for about 25 feet down the dip. Exposures in a third trench dug at the north end of the ledge of quartz suggest that the ledge is faulted off, but relations are obscure.

The pegmatite is an interesting one, and it is unfortunate that exposures are too poor to permit satisfactory study. It appears to be too small to yield significant amounts of feldspar.

RANDALL MINE

The Randall mine (pl. 1, no. 7), also known as the Sharptop mine, lies 3,500 feet N. 46° W. of Randall cemetery, at the head of the branch that flows immediately north of the Swain mine. The mine is partly on land owned by Mr. Samuel C. Woody of Bryson City and partly on land owned by Mr. Harry Thomas, also of Bryson City. Mineral rights are owned by the Harris Clay Co., Spruce Pine, N. C. The mine was worked for kaolin by the Harris Clay Co. for several years, beginning about 1907, and is reported to have been the most productive kaolin mine of the Bryson City district. The clay was flumed to a washing plant down the valley leading southeast from the mine, and thence was flumed to the drying and processing plant of the company on Deep Creek.

An open cut approximately 550 feet long, 35 to 150 feet wide, and 35 to 65 feet deep was excavated. A series of shafts was sunk in the floor to depths reportedly as much as 75 feet. In 1940 and 1941, Messrs. W. J. Alexander and Oscar Pittman sank 2 shafts, each about 35 feet deep, in the floor of the cut near the north end. Both shafts bottomed in fill of the old clay shafts. An adit was driven 20 feet N. 61° W. into the west wall of the open cut near the north end, and a drift was run N. 25° E. for 5 feet from a point inside the mouth of the adit. A winze at the end of the drift leads to another drift that lies 6 feet below. The drift runs 6 feet N. 48° W. from the winze and 7 feet S. 48° E. This work disclosed no minable body of feldspar. In 1946 Mr. Pittman sank two shafts farther south in the pit, but again no feldspar of commercial grade was found. One shaft is 23 feet deep, the other about 15 feet deep. In the course of the present investigation the walls of the open cut at the north end and northeast corner were cleaned off so far as possible, and the accessible workings were briefly examined. Large blocks have slumped from the west wall of the cut, and most of the rest of the cut is heavily overgrown and covered with debris. The pegmatite as a whole was found to be too poorly exposed to warrant detailed study. The following is a description of the more salient features exposed.

The pegmatite appears to be either a large lenticular body or a series of lenses trending parallel to the open cut (N. 15° to 20° E.) and dipping at a moderately steep angle to the west. It is enclosed in interbedded quartz-mica schists and micaceous feldspathic schists. Above the level of the floor of the open cut these rocks are in an advanced stage of weathering. The average strike of the foliation of the metasedimentary rocks in the west wall of the open cut is about N. 25° E., and the average dip is about 55° NW. Schist layers are crumpled on a small scale; axes of crumples plunge 2°, N. 25° E. The west contact of the pegmatite with wall rock is uneven; it has an average dip of about 50° W. The east contact of the pegmatite is exposed about 70 feet south of the north end of the open cuts. It strikes N. 43° E. and dips 80° SE., cutting across the foliation of the metasedimentary rocks, which here strikes N. 41° E. and dips 46° SE. Two parallel pegmatite stringers just southeast of the contact may be connected with the main body along dip or along strike.

In the drift the pegmatite shows a thin border zone, an indistinct wall zone 1½ to 3 feet thick, and a third zone that forms the remainder of the pegmatite exposed. The wall zone is composed of medium- to coarse-grained plagioclase-quartz pegmatite with minor to subordinate perthite and accessory muscovite and biotite. The border zone is similar but fine-grained. The third zone, probably an intermediate zone, consists of coarse-grained to very coarse-grained plagioclase-quartz-perthite pegmatite with strip muscovite and biotite. In part the two micas occur in parallel intergrowth. Some of the feldspar crystals are free of intergrown quartz, some are partly or entirely irregular or graphic intergrowths with quartz. This material is exposed in the north end of the cut and in at least one of the shafts. Except that it is notably richer in muscovite, the material strongly resembles that of the intermediate zones of the Cox, McCracken, Deep Creek No. 1, and other pegmatites of the district.

No other zones can be recognized in the pegmatite at present, but from its general similarity to other pegmatites of the district, one would expect to find other zones within it, including one or more zones of the types that are productive at the feldspar mines. Furthermore, the size of the pegmatite, as indicated by the dimensions of the open cut and by fragmentary data regarding kaolin operations, indicates that such zones might contain considerable tonnages of material. The failure to find the zones suggests that either they have been removed by erosion or they have not yet been reached by prospecting. The outlook for further exploration, however, is not good. The extent of the kaolin workings, with their deep fill, is not accurately known, and there has been much slumping of the walls of the open cut. Further prospecting might entail heavy expense without yielding commensurate information regarding the over-all form of the pegmatite and its internal structure. It seems likely that the deposit will remain an enigma.

NO. 8 PROSPECT

The No. 8 prospect (pl. 1, no. 8) lies 2,850 feet N. 51° W. of Randall cemetery. Ownership was not investigated, and nothing is known of the history of operations. The prospect consists of an adit extending 44 feet N. 7° W. into the side of the ridge on which the Woody No. 2, No. 3, and No. 4 mines are located. From a point 22 feet from the portal a drift runs N. 77° E. for 20 feet and a second drift extends N. 80° W. for 28 feet.

The working exposes an extremely irregular pegmatite body, apparently a series of connected irregular lenses having a general northeast trend. The wall rocks are weathered metasedimentary rocks. A section along the line of the main adit would show a pegmatite with irregular pendants and upward-projecting re-entrants of interbedded quartzite and mica schist and numerous apparent inclusions of wall rocks. The wall rocks are locally injected and feldspathized. Bedding and foliation appear to have exerted the major structural control, but contacts are sharply discordant in places. The entire pegmatite body appears to be plunging to the southwest.

The pegmatite is a medium-grained to very coarse-grained mixture of plagioclase, perthite, and quartz, with minor biotite in striplike crystals. Apart from a half-inch border zone, and the presence of scattered pods of massive quartz 1 foot to at least 5 feet in maximum dimension, there is little indication of zonal structure. Against massive quartz, perthite crystals are euhedral and lack the graphic intergrowths that are common in both perthite and plagioclase away from the quartz bodies. All plagioclase in the pegmatite has been altered to kaolin.

The prospect appears unpromising as a source of commercial feldspar. The pegmatite seems to be small, and much of the feldspar is heavily intergrown with quartz.

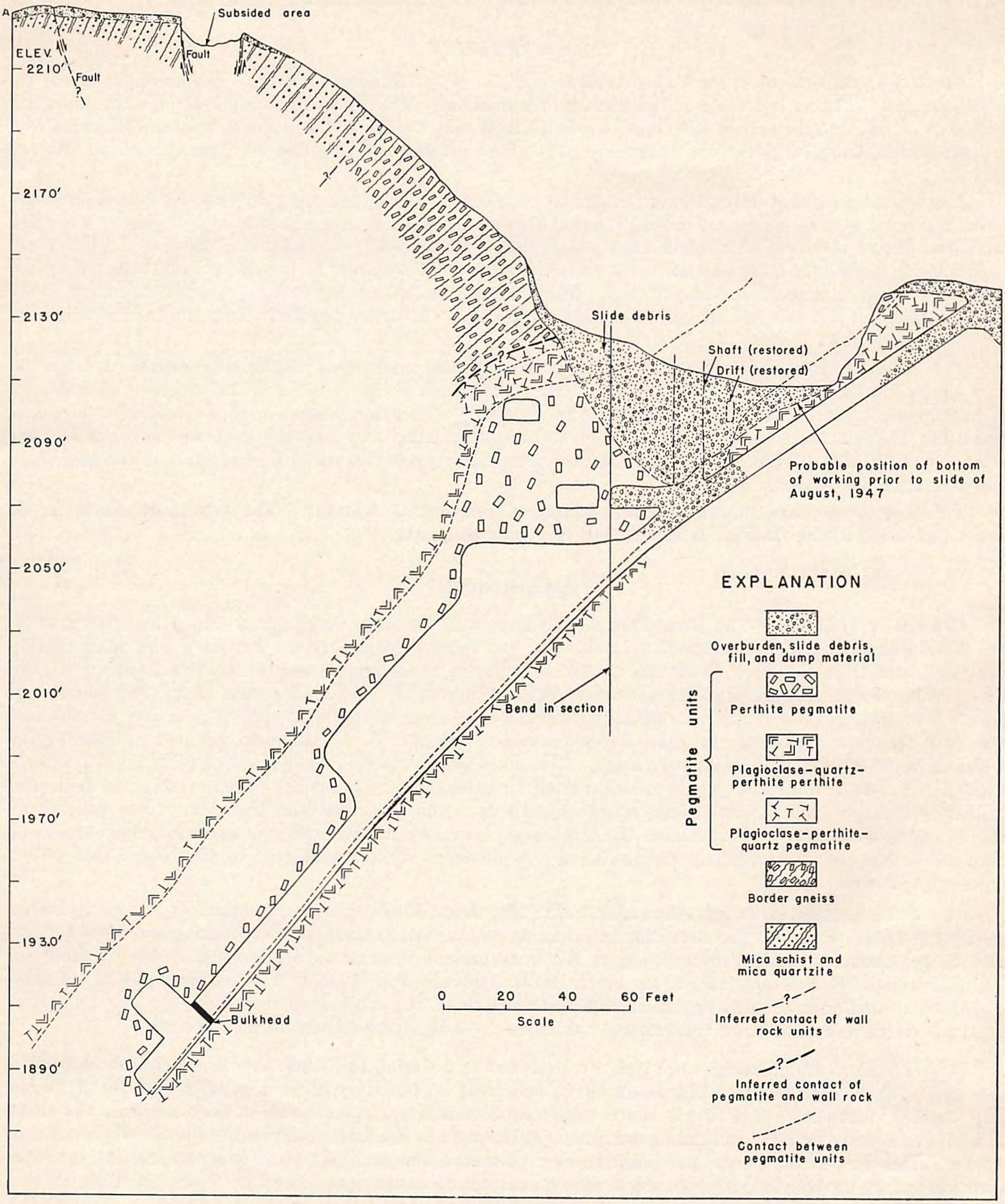
SWAIN MINE

General information.—The Swain mine, also known as the Deep Creek No. 2 mine, lies 2,100 feet N. 57° W. of Randall cemetery (pl. 1, no. 9) and is reached from Bryson City by way of a dirt road leading northeastward from the Deep Creek No. 1 mine. The mine is on land owned by Mr. Ben Lollis of Bryson City. Mineral rights to the property are owned by the Harris Clay Co., Spruce Pine, N. C. The Swain pegmatite was first mined for clay; the principal workings, a series of shafts now filled, probably lie south of the main feldspar workings. In 1940, development work by Mr. W. J. Alexander resulted in discovery of a sizable body of high-grade potash feldspar. The mine was operated by the Feldspar Producing Co., Spruce Pine, N. C., from 1940 to 1945, under sublease from Mr. Alexander. In January 1946 the mine was subleased to United Feldspar and Mineral Corp., operated until September 5, 1946, and then shut down because of caving of the headwall of the open cut. During the 6 years the mine was operated a considerable tonnage of high-grade feldspar was produced, and the mine is reported to rank second only to the Deep Creek No. 1 mine in production.

The writer is indebted to Mr. Alexander and to Mr. Oscar Pittman, superintendent of the mine during nearly the entire period of operation, for information on the methods and extent of mining and development, and to Mr. Alexander for all information on the underground workings. A plane-table map of the open pit, made for the U. S. Geological Survey by Mr. R. H. Jahns in June 1945, shows the main pit at an early stage of the final open cut mining, which followed collapse of the underground workings. The map contributed useful information on the internal structure of parts of the pegmatite then exposed.

Development.—Exploratory work (pl. 8) consisted of 2 shafts, the Muck and Marts shafts, both filled and concealed beneath debris. The Muck shaft, originally 55 feet deep, is said to be on the site of an old clay shaft 52 feet deep. The Marts shaft, originally 35 feet deep, is said to lie at the margin of the shoot of high-grade feldspar later worked in the mine. Subsequent to the sinking of the two shafts, the shoot was discovered in the vicinity of the northeastern part of the present main open cut, where the shoot, a southwestward-plunging body having the shape of a somewhat flattened pipe, intersected the bedrock surface. An adit with portal east of the open cut at elevation 2,118 feet was then driven westward to intersect the shoot, and at the same time a vertical shaft (concealed at the time of mapping beneath debris on the floor of the open cut) was sunk in line with the adit. Just short of the shaft, drifts were run northward and

PLATE 9.



SWAIN MINE

Swain County, North Carolina
SECTION ALONG LINE A-A'

southward to the limits of the feldspar shoot. A winze was sunk at the end of the north drift to elevation 2,098 feet, and drifts run at this level to the limits of the feldspar shoot were connected with the shaft. A connection of the shaft with the 2,118-foot level was then made, the shaft was sunk to elevation 2,070 feet, and from this point an inclined raise was run upward N. 64° E., to the surface. As the workings below the 2,070-foot level were developed, this raise was extended downward from the shaft as an inclined winze and became the main haulageway of the mine. Drifts on the 2,070-foot level were carried to the limits of the feldspar shoot. Subsequent mining developed workings down to elevation 1,847 feet, and the main incline was carried down approximately to elevation 1,817 feet.

Mining was done largely by drifting, for the pegmatite zone enveloping the feldspar shoot contained a high proportion of kaolin formed by weathering of plagioclase, and workings were therefore kept within the shoot. This condition persisted to the bottom of the mine. Because of the heavy pressure of the enclosing unstable material and the danger of cave-ins, only a limited amount of stoping could be done. One cave-in, in the part of the main incline between approximately elevation 1,860 feet and elevation 1,960 feet, made it necessary to sink an inclined winze from the chamber above the caved portion. From the foot of the winze, approximately at elevation 1,847 feet, a drift was run southeastward to intersect the main incline, and the caved portion was sealed off by means of a bulkhead. Subsurface operations in the mine were terminated by collapse of the lower workings. It is reported that the area of subsidence (shown on the map plate 8 and in section on plate 9) was developed at this time, so that the whole mass of rock between the surface and the lower workings was involved in the movement. On the spur above the mine there is a prominent landslip fissure (see pl. 8), and the ground between the main fissure and the headwall of the main excavation is much fissured. Movements along these fractures and the main fissure are reported to have attended the collapse of the lower part of the mine workings; but examination of the area suggests that these movements are only the latest stages of landslip involving much of the deeply weathered rock of the spur in which the mine is located.

After the collapse of the workings, a bulldozer was used to cut back the spur above the upper part of the underground workings, and open-pit mining of the upper part of the feldspar body was undertaken. In September 1946, after the pit had been deepened approximately to elevation 2,075 feet, a heavy slide of decomposed rock from the high west wall of the excavation brought mining to a close.

Geological relations.—The pegmatite is apparently a pipelike body that plunges about S. 60° W. at a moderate angle. In plan at the surface it occupies an irregular, rounded area about 180 feet in length and 170 feet in width. Outside the main working its contact is inferred partly from data obtained by postholes dug during the present investigation, partly from information supplied by Mr. Pittman and Mr. Alexander. The position of the contact south and east of the main working is only a rough approximation.

The pegmatite body extends across the belt of border gneiss. Its eastern end is enclosed in interlayered border gneiss and granitic gneiss, its main part lies in the border gneiss, and its north end is in contact with metasedimentary rocks. The huge exposure in the wall above the main pit shows that the pegmatite lies near the axis of a sharp asymmetric flexure involving metasedimentary rocks and border gneiss. Calculation from the dips of the two limbs of this flexure suggests that the axis of the flexure plunges about 45° to 50°, S. 60° W., roughly parallel to the plunge of the feldspar shoot. As it is probable that the plunge of the shoot is roughly parallel to the plunge of the pegmatite as a whole, or at least of the northern part of it, a definite relationship of the pegmatite to the fold axis is suggested. The pegmatite is sharply discordant to the wall-rock structure, and it seems probable that dilatant fracturing attending development of the fold provided the major channel along which the pegmatite was emplaced. Apart from local increase in feldspar content, the wall rocks adjacent to the pegmatite appear unaffected.

All rocks exposed in and near the workings are markedly weathered and crumble readily. Plagioclase has been entirely altered to kaolin, in the wall rocks as well as in the pegmatite. Potash feldspar is less affected. Some is crumbly due to kaolinization of albite lamellae, but much is hard and fresh except for limonite stain along fractures. Biotite ranges from nearly fresh to partly decomposed. The operators state that kaolinization of plagioclase was complete down to the lowest levels reached by mining, extending more than 100 feet below water level. The depth of weathering at this mine is in marked contrast to that of the Deep Creek No. 1 mine, where sound rock was found in general within 50 to 75 feet of the surface.

Composition and internal structure of the pegmatite.—Seven zones and a series of fracture-fillings have been recognized within the Swain pegmatite: border and wall zones composed of plagioclase-quartz pegmatite, two intermediate zones composed of plagioclase-quartz-perthite pegmatite, a third intermediate zone composed of perthite pegmatite, a core-margin zone composed of quartz-perthite pegmatite, and a core of quartz. Veins of quartz with minor feldspar cut the intermediate zones, and some of them extend across the wall and border zones and even into the wall rock. One vein exposed in June 1945 is shown on the map by R. H. Jahns as a direct offshoot of the quartz core.

The border zone, 1 to 2 inches thick, is a fine-grained mixture of plagioclase, quartz, and perthite, with accessory biotite. The wall zone, 4 to 5 feet thick, consists of coarse blocky plagioclase, now completely altered to kaolin, with subordinate quartz and sparsely scattered crystals of perthite. It is exposed only along the south wall of the main pit. It grades inward into the first intermediate zone of plagioclase-quartz-perthite pegmatite. This is a mixture of coarse-grained to very coarse grained plagioclase and perthite, with quartz and abundant accessory biotite. Plagioclase forms crystals up to 1 foot in diameter, some unevenly and irregularly intergrown with quartz. Graphic intergrowths are rare. Perthite forms stout anhedral to subhedral crystals up to 5 feet in length. Scattered masses of quartz up to 1 foot in diameter occur in the zone. Against them perthite is euhedral, but against the remainder of the quartz in the zone perthite is anhedral. Biotite occurs in books as much as 3 inches broad and 2 inches thick, in strip-shaped crystals as much as 1 foot long, 1 inch broad, and ½ inch thick, and in plates up to 1 foot long, 5 inches broad, and ½ inch thick.

Inside the first intermediate zone is the second intermediate zone, similar in mineral composition to the first but characterized by even larger crystals and by abundant graphic intergrowths of plagioclase and quartz. Graphic intergrowths of perthite and quartz also are present as well as large striplike crystals of biotite. The contact between the first and second intermediate zones is distinct in the main pit, but for practical purposes the zones can be treated as variants of a single zone, particularly as no unit comparable to the first intermediate zone can be recognized outside the main pit. Pegmatite of the type that forms the second intermediate zone is the largest single unit within the pegmatite body at the surface; it forms the walls of the main adit and is exposed in the pit, trench, and postholes south of the main pit. A trench 30 feet southeast of the south corner of the shed exposes pegmatite of this type separated from border gneiss only by the border zone.

The perthite-quartz zone is the feldspar shoot and has yielded nearly all the feldspar produced from the mine. The zone consists of crystals of perthite as much as 10 by 10 feet in cross section, sparsely scattered stout crystals of plagioclase (kaolinized) up to 2 by 2 feet, and sparsely distributed institial masses of quartz up to 1½ feet in diameter. Biotite books up to 1 foot broad and 1 inch thick are very thinly distributed through the zone, and are as much as 2½ feet broad and 4 inches thick along the margins of the zone. Taken together, plagioclase, quartz, and biotite make up only a small percentage of the zone, which is remarkably high in perthite content. The zone has the shape of a somewhat flattened pipe, the long axis of which plunges approximately S. 60° W. The angle of plunge steepens from about 40° in the upper levels to about 50° in the lower levels. The shoot ranges in width from about 40 feet to about 100 feet. It ranges from about 20 feet to about 65 feet in thickness perpendicular to the axis of plunge, averaging roughly 40 feet. In any horizontal plane passed through the shoot, the longer dimension of the shoot strikes about N. 35°-40° E. A plane including this longer dimension and the plunge axis of the shoot would strike N. 35°-45° E. and dip about 73°-79° NW.

In the upper levels the shoot consists of cream-colored perthite stained reddish to brownish by limonite along fracture surfaces. Mr. Pittman states that a quartz vein intersects the south edge of the shoot about 100 feet below the original surface. This vein persists into the lowest level reached by mining, slanting gradually across the shoot and nearly reaching the northwest edge on the lowest level. The portion of the shoot southeast of this vein is reported to consist of pinkish perthite, the portion to the northwest of white perthite.

The operators report that there was no indication that the shoot was pinching out in the lowest working; according to a rough survey of the lower workings furnished by Mr. Alexander, the length of the shoot (in horizontal plan) is near the maximum in the lowest level.

The remaining two zones, the quartz-perthite core-margin zone and the quartz core, were not observed by the writer but according to R. H. Jahns were exposed in June 1945 south of the main shaft (see pl. 8, plan of workings at elevation 2,122 feet). The core-margin zone, consisting of massive quartz with scattered large crystals of perthite, lay at one end of a small core of massive quartz.

Fracture-fillings of quartz with accessory perthite and plagioclase cut all zones and are particularly numerous in the outermost intermediate zone on the north side of the main pit. They occur along several sets of fractures. Those observed by the writer range in thickness from fractions of an inch to 2 feet, and in length from a few inches to 20 feet. A few extend across the contact into border gneiss. A vein 36 feet long is shown on Jahns' map as a direct offshoot of the quartz core. A noteworthy feature is that a few of the veins are cut by plates of biotite, formed along fractures. Evidently at least a part of the biotite in the pegmatite was formed at a very late stage.

The Swain pegmatite offers a remarkable example of a plunging pipelike feldspar shoot containing a large tonnage of feldspar. Much of the original shoot still remains in the area explored by the workings, and an additional tonnage, possibly as large as that mined or larger, is said to exist downplunge from the workings. Had the limit of weathering been reached at reasonable depth, the mine might well have become the most important source of feldspar in the Bryson City district. The unsound condition of the rock enclosing the productive shoot, and the lack of any indication that the bottom of the zone of weathering has been reached, are formidable obstacles to further mining.

The feldspar produced has thus far come from the shoot at the north end of the pegmatite. Whether other shoots are present in the southern and western lobes of the body is an intriguing problem. No indication of additional shoots has been observed by the operators, and experience with the unstable ground underlying the spur has discouraged further exploration, particularly as another shoot, if plunging parallel to the known shoot, would presumably be enclosed in similar material and subject to the same hazards.

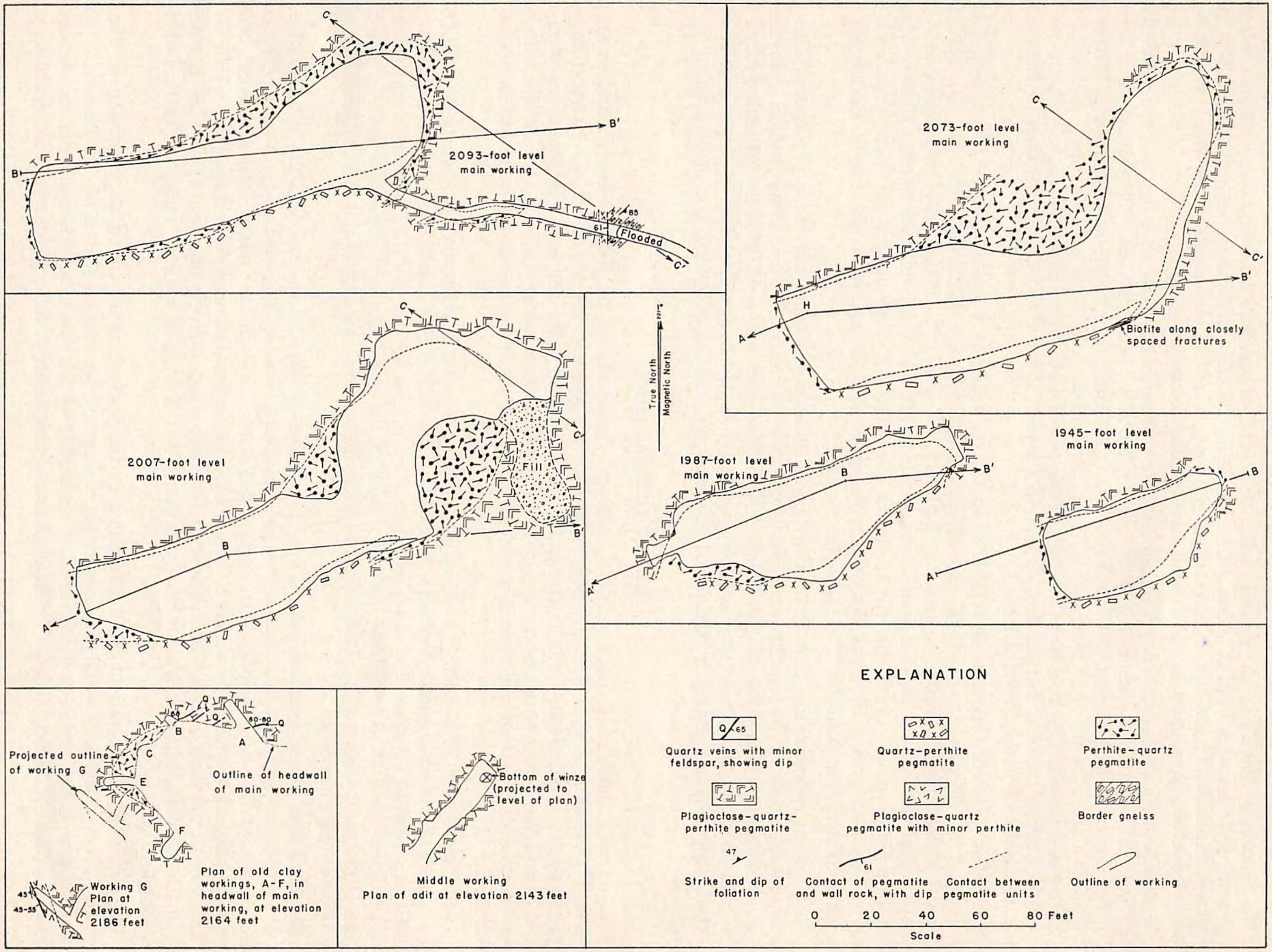
HARRY THOMAS MINE

The Harry Thomas mine (pl. 1, no. 10) lies 200 feet southwest of the Swain mine on land owned by Mr. Harry Thomas of Bryson City. Mineral rights to the property are owned by the Harris Clay Co., Spruce Pine, N. C. The deposit was opened in the 1940's by Mr. Oscar Pittman, but operations were not carried beyond the prospecting stage. Workings consist of an open cut 60 feet long, 16 to 22 feet wide, and 10 feet deep, leading to a curving adit 26 feet long. The roof of the adit near the north end has caved to the surface.

The pegmatite (pl. 8) is a lens-shaped body that cuts across the northwestern part of the belt of border gneiss to the contact with metasedimentary rocks. The lens is probably about 130 feet long and is 60 feet in maximum width of exposure, but it is probably not more than 30 feet thick. The lens strikes about N. 25° W. and dips about 80° SW. In the adit at the head of the open cut, it has been displaced by a gently dipping fault (pl. 8, section B-B′). This fault is a curved surface, and is probably a landslip with movement in an easterly direction.

The pegmatite has an apparent core of very coarse-grained perthite-quartz pegmatite with a high content of perthite in large crystals. On the west side and north end of this unit there is an asymmetrically developed zone of very coarse blocky perthite and plagioclase, with minor quartz and accessory biotite. These two zones are enveloped in coarse to very coarse plagioclase-quartz-perthite pegmatite, which forms the wall zone of the body. A thin border zone of the same composition is present. Plagioclase is entirely weathered to kaolin, and perthite is stained by limonite and is in part crumbly owing to kaolinization of albite lamellae.

The pegmatite is evidently of small dimensions at the surface and, barring an expansion in size of which there is no indication, would yield no sizable tonnage of commercial feldspar. The content of commercial feldspar in the perthite-plagioclase zone, the larger of the two units originally rich in high-grade feldspar, has been materially reduced by kaolinization of plagioclase in the upper part of the pegmatite.



DEEP CREEK NO. 1 MINE PLANS OF UNDERGROUND WORKINGS

DEEP CREEK NO. 1 MINE

General information.—The Deep Creek No. 1 mine (pl. 1, no. 11) lies 3,200 feet N. 83½° W. of Randall cemetery, on a spur near the head of Toot Hollow Branch (pl. 2, C). The mine is easily accessible from Bryson City by a gravel road up Toot Hollow to the base of the spur, thence by a graveled mine access road. The mine was originally opened for kaolin, probably in the early 1900's. In 1935, two brothers named Brooks are reported to have reopened the mine for feldspar, producing about 2,000 tons. Average recovery was low and operations were suspended in 1937. In April 1939, W. J. Alexander leased the property from the present owners, the Harris Clay Co., Spruce Pine, N. C., and Charles Thomas of Bryson City. Development work led to discovery, in 1940, of the feldspar-rich shoot that has furnished the bulk of the feldspar mined. Later in 1940, Alexander leased the mine to the Whitehall Co., New York, N. Y., who have operated the mine ever since. Total production of No. 1 feldspar from 1939 to June 1949 is reported as approximately 56,600 tons. About 2,500 tons of No. 2 feldspar also was produced in 1946-1949 from the north workings. In the winter of 1946-1947, No. 2 feldspar for the glass trade was recovered from the dump by Interstate Feldspar Corp., operating under sublease. The feldspar was trucked to the Dillsboro mill of the corporation for grinding.

Workings.—The main working (pls. 10-14, incl.) is an amphitheater-shaped open cut 180 feet in length, 140 feet in maximum width, and 95 feet in maximum depth. From the floor of the cut at elevation 2,140 feet a glory hole leads to an open stope that extends downward S. 70° W. at an average angle of about 40° (pl. 13). In October 1947, the length of this working, measured along its slope, was approximately 365 feet, and the floor was at elevation 1,940 feet. The stope is 22 to 40 feet wide and 94 to 110 feet high. Between elevations 2,090 and 2,000 feet, an irregular chamber extends northward from the glory hole as much as 80 to 90 feet. The chamber connects southwestward, around the large pillar shown in section A-A' on plate 12, with the downward extension of the main open stope. At an early stage of the operations, a drainage tunnel with a somewhat sinuous east-southeasterly course was run from the glory hole at the 2,093-foot level to the face of the hill. The mouth of this tunnel is beneath the dump, but the tunnel was still used in 1946-1947 as an outlet for water pumped from the lower levels of the mine. Until 1946, a derrick at the lip of the glory hole was used to hoist feldspar and waste from the workings. An inclined cut extending from the east side of the glory hole, at elevation 2,100 feet, to the floor of the main open cut was subsequently excavated, and an inclined cableway with skip used for hoisting. The slope of the inclined cut is 35°.

The earlier clay workings are reported to have been a pit on the south side of the present main working and appended adits and drifts. The Brooks brothers enlarged the pit and drove an adit west-northwest from the point just south of the tool shed. These earlier workings were largely removed in the excavation of the open cut, but the ends of several tunnels and appended drifts are preserved in the west and north walls of the cut. Plans of these workings are given on plate 11.

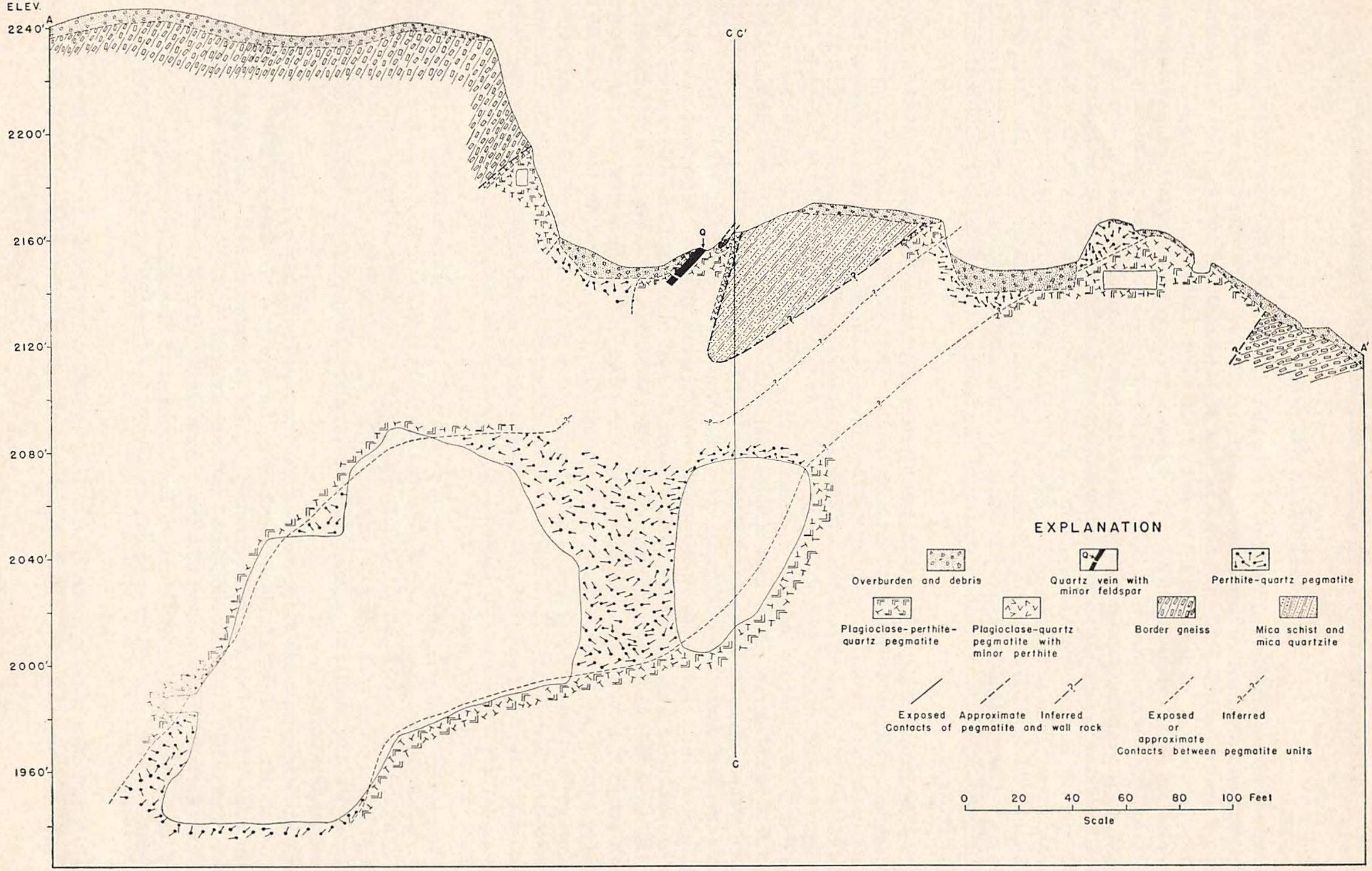
A small open cut made by Mr. Alexander south of the main working was enlarged in 1946-1947 by the Whitehall Co., and an open vertical shaft 17 feet by 19 feet was sunk in the floor to a depth of 47 feet. At 9½ feet below the collar the roof of an old drift, probably part of the clay workings, was intersected. This drift is 6 feet high and 4 feet wide, with a bearing of N. 72° W. It extended only 5½ feet to the northwest from the center of the new shaft, but extended 15½ feet southeast, apparently connecting with a filled shaft immediately beyond this point.

The middle cut, lying just north of the main cut and connected with it by a shallow crosscut trench, was made largely or entirely by Mr. Alexander in prospecting for feldspar. In October 1946 this cut, despite slumping of the walls, was 66 feet in maximum length, 52 feet in maximum width, and 40 feet in maximum depth. A drift 40 feet long, 7 to 9 feet wide, and 7 feet high extends N. 40° E. from the northeast side. A short narrow raise connects it with a short adit driven from the east face of the hill.

The north or Branch working lies about 85 feet northeast of the middle working. In October 1946 this working was a somewhat irregular open cut, roughly 85 feet long, 50 feet wide, and 43 feet deep along the west wall.

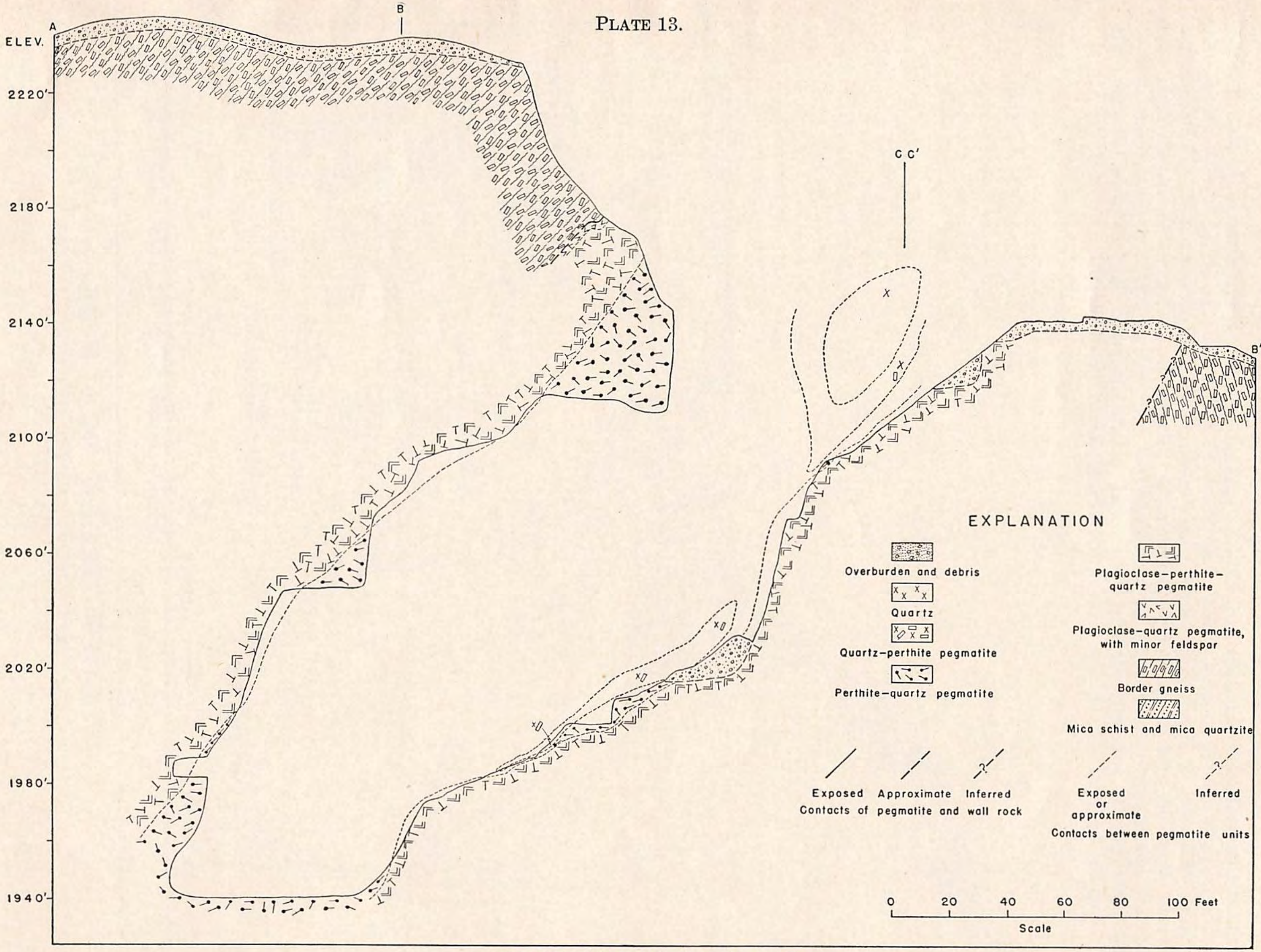
Form and relationships of the pegmatite.—The Deep Creek No. 1 pegmatite is one of the largest pegmatites in the district; it has a length of about 490 feet and an outcrop width ranging from 40 to 210 feet. It

PLATE 12.



DEEP CREEK NO. 1 MINE
Swain County, North Carolina
SECTION ALONG LINE A-A'

PLATE 13.



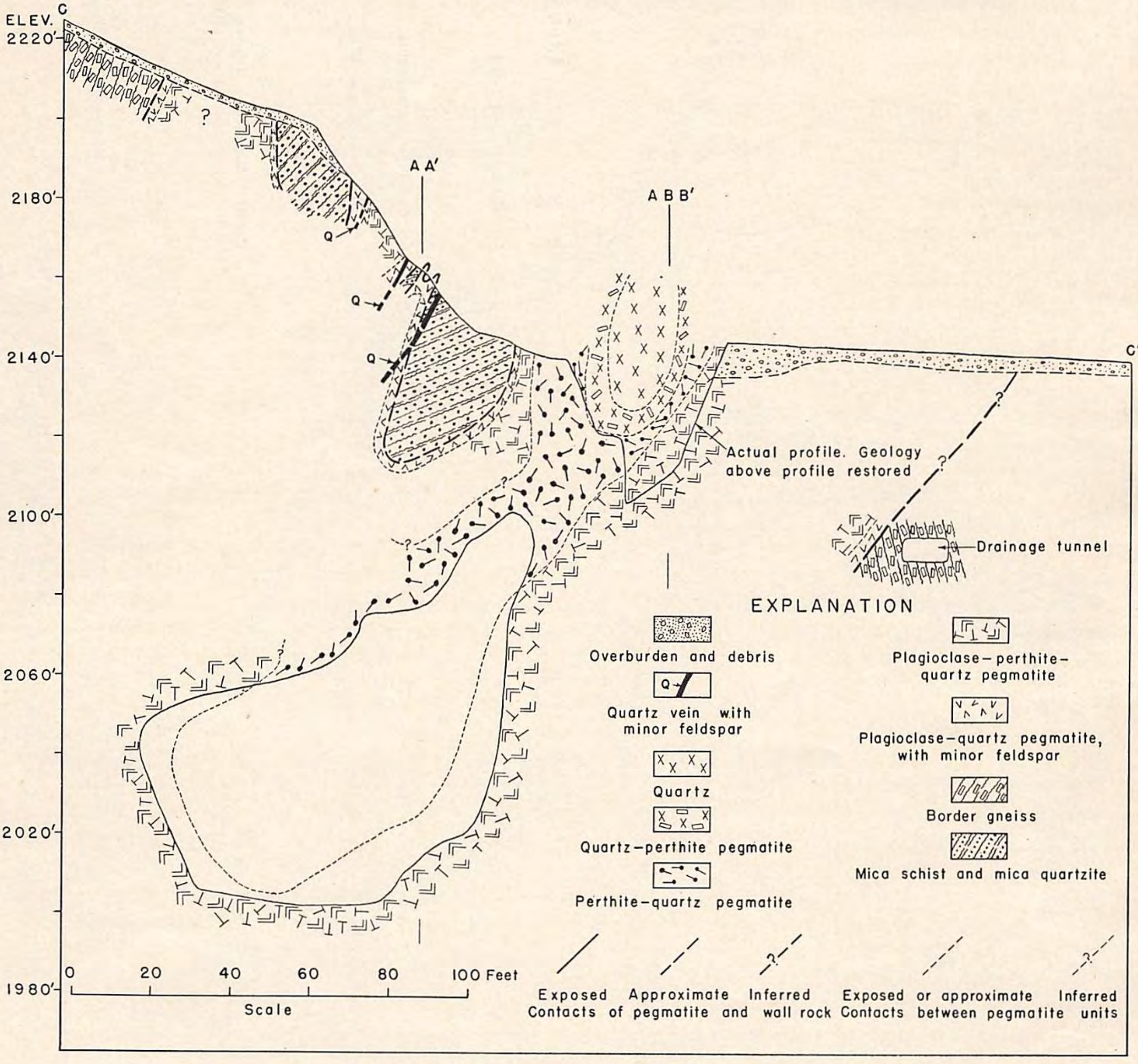
DEEP CREEK NO. I MINE

Swain County, North Carolina

SECTION ALONG LINE A-B-B'

is a markedly irregular lens, the main part of which strikes N. 17° E. and dips moderately west. The footwall is poorly exposed but is apparently uneven; it strikes N. 31° E. and dips 50° to 55° NW. in the north working, but strikes N. 1° W. and dips 61° W. where intersected by the drainage tunnel. The hanging wall is markedly irregular, with pronounced westward bulges. The middle cut explores the northernmost bulge, the southern margin of which is defined by a wedge-shaped eastward projection of the hanging wall. A dikelike offshoot of the pegmatite, striking about N. 20° W. and dipping steeply southwest, extends northward across the hanging wall from a point near the west edge of the middle cut.

PLATE 14.



DEEP CREEK NO. I MINE
Swain County, North Carolina
SECTION ALONG LINE C—C'

The main working is in the middle and largest bulge, which consists of two principal parts lying on either side of a wedge of country rock that extends southwestward part way across the bulge. The wedge is exposed along the north rim of the glory hole. The keel of this wedge apparently is less than 10 feet below the quarry rim; exposures in the underground workings show that the pegmatite extends beneath it. North of the keel the wall of the open cut shows several projections of the pegmatite into the country rock, and a northward offshoot of the pegmatite exposed in the shallow pit on the slope north of the rim. Parts of the wall, however, are inaccessible, exposures above it are poor, and details of the structure are obscure.

The internal structure of the pegmatite and the position and extent of the chamber extending northward from the glory hole strongly indicate that the bulge exposed in the middle working plunges west-southwest and connects with the main bulge beneath the northwest part of the main open cut (pl. 12).

The southernmost, smallest bulge is exposed in the south working and lies at the south end of the pegmatite body. Its northern side is defined by a prominent reentrant of the country rock of the hanging wall.

The pegmatite body trends obliquely across the belt of interlayered, northwestward-dipping border gneiss and granite gneiss, with which are associated layers of contorted biotite schist and chloritized actinolite-biotite schist. From the north end of the pegmatite to the main working the hanging wall consists of interbedded feldspathic quartzites and mica schist; the footwall consists of border gneiss. The south end of the pegmatite is in granite gneiss. The main part of the pegmatite was evidently emplaced along a fracture extending roughly N. 20° E. The main bulge, however, appears to occupy an area of complex fracturing and faulting extending northwest from the main body, for border gneiss and metasedimentary rocks lie on strike from each other on opposite sides of the bulge. The spatial relations suggest that a block of metasedimentary rocks has been dropped down along at least two faults, one extending northwest through the western part of the main working, the other partly occupied by the offshoot of the pegmatite from the northwest corner of the main working.

Contacts of pegmatite and wall rocks in general are sharp, and evidence of reaction between them is commonly inconspicuous or lacking. In the headwall of the south working, however, schists and granite gneiss along the hanging wall of the main pegmatite have been irregularly feldspathized and in places contain pegmatite layers and lenses injected along the foliation. A granite gneiss inclusion, 39 by 8 inches in size, in the south wall of the working is partly feldspathized.

Other pegmatite bodies.—Southwest of the main working a short open cut and appended short adit expose coarse-grained plagioclase-quartz-perthite pegmatite, probably part of a small pegmatite lens. The extent of this body is only roughly inferable from float. Several small stringers and narrow dikelike bodies, none apparently of any great extent, were exposed in roadcuts between this pegmatite and the main pegmatite in the fall of 1946, and a partly removed lens 3 feet long and 1 foot wide, passing downward into a stringer, is exposed west of the main pegmatite in the road that ascends the spur east and north of the middle working.

Composition and internal structure.—The pegmatite consists of 6 zones. The outermost is a fine-grained 2- to 6-inch border zone of plagioclase-quartz-perthite pegmatite with sparsely scattered flakes and thin strips of biotite 1/8 to 1/2 inch in length, and scattered crystals of magnetite up to 1/4 inch in diameter. Garnet, in trapezohedral crystals up to 1/4 inch in diameter, is a scarce accessory. Biotite strips in places are haphazardly oriented, in places subperpendicular to the contact. In small part, perthite and plagioclase form graphic intergrowths with quartz.

Inside the border zone is a medium- to coarse-grained wall zone that ranges from 1½ feet to perhaps 7 feet in thickness, averaging between 2 and 3 feet. It consists of plagioclase and quartz with minor to subordinate perthite and accessory biotite, magnetite, and garnet. In a few places pyrite crystals 1/64 to 1/4 inch in diameter line narrow fracture-controlled cavities an inch to 3 inches in length. The feldspars form crystals that are mostly an inch to a foot in diameter and range from nearly pure to heavily intergrown with quartz, in part with graphic pattern. Biotite occurs in haphazardly oriented strips up to 2 inches long and 1 inch broad, and in books up to 5 by 2 inches by half an inch. Muscovite forms small flakes and fine-grained coatings along short fracture surfaces cutting feldspar and is evidently a late mineral. The wall zone grades outward by decrease in grain size into the border zone, and passes inward by increase in grain size and ratio of perthite to other minerals into the outer intermediate zone. The unit is indistinct in places, sharply defined in others.

The outer intermediate zone is similar to the wall zone but ranges from coarse-grained to very coarse-grained and has a higher average content of perthite. Plagioclase and perthite form stout crystals ranging from a few inches up to 8 feet in length. The smaller crystals of plagioclase are commonly massive; the larger crystals are commonly graphic or irregular intergrowths with quartz. Perthite is mostly massive, but some crystals contain quartz in graphic intergrowth, irregular intergrowth, or both. Biotite forms strips up to 6 inches long, 3 inches broad, and half an inch thick, but is more common in slablike books or groups of books 2 to 6 inches broad and 1/4 to 1 inch thick. The books cut across quartz and the feldspars. Magnetite and garnet, in crystals up to half an inch in diameter, occur as rare accessories. Muscovite forms greenish flakes and flaky coatings along short fractures in feldspar.

The thickness of the outer intermediate zone is measurable at few places. It appears to range from 1 foot to at least 60 feet. Inward from the walls of the pegmatite the zone shows a gradual increase in average grain size, and the inner part in places is composed largely of 3- to 8-foot crystals of perthite, of plagioclase or perthite partly or entirely in graphic intergrowth with quartz, or both. This inner part is of some economic importance; it has furnished much of the No. 2 feldspar recovered from the north working. It forms the walls and most of the roof of the tunnel extending northward from the middle working, the walls of the upper part of the shaft in the south working, and the northern margin of the main perthite-quartz zone, next described, in the main underground working.

Three additional units form most of the remainder of the pegmatite: the perthite-quartz middle intermediate zone, the quartz-perthite inner intermediate zone, and the quartz core. These three units, distinct or telescoped, form small pods scattered through the outer intermediate zone, but their main development is in the westward bulges of the pegmatite. They are markedly asymmetric and discontinuous.

The perthite-quartz zone consists essentially of crystals of perthite, 1 foot to 21 feet in length and up to 8 feet broad, with subordinate interstitial quartz. Plagioclase in crystals up to 5 feet long is present everywhere in small amounts and in a very few places is more abundant than perthite. Biotite occurs as slablike books, in part deformed, along fractures and sets of fractures that cut the other minerals. The books range in diameter up to 2 feet and in thickness up to 6 inches. In places, the feldspars and quartz are cut by thin quartz stringers, some of which contain scattered plagioclase crystals. Flakes of muscovite, in places associated with pyrite, coat fractures that traverse feldspar and are commonly slickensided. In several places in the surface workings, perthite is partly or entirely converted to pseudomorphs of muscovite and plagioclase, now thoroughly kaolinized.

The quartz-perthite zone consists of crystals of perthite, up to 8 by 5 feet, scattered through massive, clear gray to milky quartz. Scattered books of biotite, similar in form and occurrence to those in the perthite-quartz zone, are present. Haphazardly oriented, rod-shaped aggregates of parallel tourmaline crystals transversely fractured and healed with quartz are scattered sparsely at intervals along the gradational boundary between the quartz-perthite and perthite-quartz zones. In places the tourmaline is intergrown with allanite. The aggregates range up to 8 inches by 3 inches in diameter, and from a few inches to more than 5 feet in length. Single crystals of tourmaline range up to 4 inches in diameter. They are embedded in quartz or in quartz and feldspars. Perthite adjacent to allanite shows the characteristic reddish discoloration indicative of radioactivity. The quartz core consists entirely of coarse, massive, gray to milky quartz. Its boundary against the quartz-perthite zone is drawn at the inner limit of the occurence of perthite crystals.

Plates 10 to 14, inclusive, and figure 11 show the form and relationships of the three inner zones as known and as inferred from present exposures and from information furnished by the operators. Material corresponding to one or more of these units forms scattered small pods and lenses at several places (see, for example, pl. 11, plan of 2,093-foot level), but the three units are mainly developed in the westward bulges of the pegmatite. One segment of the quartz core is exposed for 18 feet along the base of the wall of the south part of the middle working. On the north side of the core the perthite-quartz zone forms an irregular, westward-dipping body, up to 16 feet thick. An intervening quartz-perthite zone is too narrow to be mapped separately. The core evidently terminated in the cut, but the perthite-quartz zone evidently extended northeast across the cut, for it is exposed in the northwall and in the roadcut north of the working. The zone plunges approximately S. 70° W. at a moderate angle; its keel therefore passes above the roof of the tunnel extending north from the working. The point of emergence of the keel as inferred from mapping has subsequently been shown by bulldozer-stripping to be approximately correct. The crest of the body plunges southwestward beneath the outer intermeditte zone, which extends over its top in the west wall of the working.

A second segment of the core in the main working is now represented only by a small remnant of massive quartz at the southeast margin of the glory hole. According to Mr. Oscar Pittman and Mr. W. J. Alexander, the core formed a lens roughly 70 or 80 feet long and about 20 feet in maximum width. It extended S. 60° W. from a point that was roughly due north of the north corner of the hoist house and was within 10 feet south of the north rim of the cableway cut. The lens projected about 20 feet above the level of the present floor of the main working. Its bottom probably was at no point more than 20 feet below the present floor of the main open cut. This lens was apparently enclosed in a segment of the quartz-perthite zone. A second segment of this zone occurs as an isolated body extending northwest from the northwest corner of the glory hole. Two segments of the perthite-quartz zone are exposed in the main working. The main segment originally formed a hook-shaped body that was thickest along the northwest side of the core and enclosing quartz-perthite zone; it extended around the keel of the quartz-perthite zone and part way along its footwall side. It was Mr. Alexander's discovery of this segment that established the property as a potentially productive feldspar deposit.

Another segment of the perthite-quartz zone is exposed in the northwest part of the open cut. It appears related to the bulge of the pegmatite north of the projecting wedge of metasedimentary rocks. The size of this body is unknown. It may extend farther eastward than indicated on the map.

The main segment of the perthite-quartz zone expands in breadth and strike length below the floor of the main open cut. The portion of this zone lying northwest of the quartz-perthite zone has been followed downward and has been very productive. The shoot that it forms trends in general east-northeast, dips sharply north-northwest to vertical and plunges irregularly southwestward. The keel plunges at about 40° between the 2,150-foot and 2,093-foot levels, steepens markedly between the 2,093-foot level and the 2,020-foot level, flattens to about 32° between the latter level and elevation 1,970 feet, then steepens again toward the bottom of the workings. The crest of the shoot cannot be delineated fully at present, but in the lower workings it is apparently roughly parallel to the keel.

On any level the perthite-quartz zone in general extends farther northeast than the quartz-perthite zone. In places, perhaps everywhere, it extends around the keel of the quartz-perthite zone (see plan of 2,093-foot level, pl. 11) but is too narrow to repay mining where exposed. Whether the perthite-quartz zone also extends around the crest of the quartz-perthite zone is unknown. Mining has nowhere extended to the crests of the zones. Because the known perthite-quartz zones in pegmatites in the Bryson City district are best developed between the cores and the hanging walls, the prospect of discovering a workable part of the zone on the southeast side of the quartz-perthite zone does not appear bright, but the flank of the zone in the portion between keel and crest seems to offer considerable promise.

The form of the productive part of the perthite-quartz zone is complicated by a pronounced northward bulge between elevations 2,093 feet and 2,000 feet. Owing to the bulge, the keelward portion of the zone in the vicinity of elevation 2,040 feet reaches a width of nearly 100 feet. This expansion lies downplunge from the perthite-quartz zone segment exposed in the middle working. The expansion probably represents the junction of this segment with the segment followed downward from the floor of the main working. The fact that much of the roof of the underground chamber (pl. 12) is in perthite-quartz pegmatite strongly supports this inference. It is also possible that the perthite-quartz unit exposed in the northwest part of the main open cut joins the main shoot downward. If either inference is correct, a considerable tonnage of No. 1 feldspar remains above the roof of the underground chamber.

The smallest of the three conspicuous bulges is exposed in the south working. The northern side of this bulge is formed by a wedge of granite gneiss and border gneiss that may extend even farther toward the footwall than inferred on the map. In October 1946, the south working was considerably smaller than shown on the map, which was revised in January 1947 to show the newer work. The headwall lay southeast of its present position, and a small open stope, 3 to 6 feet wide, extended southwest into the headwall, from a point about at the center of the southwest rim of the present shaft. This chamber was excavated by Mr.

Alexander in a lens of very coarse massive perthite and kaolinized plagioclase, with subordinate quartz and slabby books of biotite 3 to 8 inches broad and 1/4 to 1/2 inch thick. Quartz occurred in part as masses interstitial to feldspar, in part in graphic intergrowth with feldspar, particularly plagioclase. This lens was interpreted (pl. 10) as material of the perthite-quartz zone, though differing from typical perthite-quartz pegmatite in that it contained graphic intergrowths of feldspar and quartz. It strongly resembles the material forming the outer part of the productive shoot in the main working. Mr. Alexander recovered approximately 45 tons of No. 1 feldspar (perthite) from the working. The northern end of this lens was intersected by the shaft, but downward the proportion of graphic intergrowths increased, and at about 25 feet below the rim the material became noticeably poorer in perthite. It seems evident that the shaft has penetrated the bottom of the lens. Probably the lens plunges in a southwesterly direction, roughly parallel to the plunge of the productive shoot in the main working. A drift in a direction S. 70° W. from the bottom of the shaft, with crosscuts perpendicular to the drift at intervals, would appear to offer the best chance for locating the lens. It seems unlikely, however, that a shoot of large size will be found, unless there is a notable downward expansion of the pegmatite.

Small podlike bodies, mostly quartz lenses with marginal massive perthite, plagioclase, or both, are exposed in the drainage tunnel, in the roof of the north end of the tunnel in the middle working, and in the north working. One southwest-plunging pod in the northwest corner of the north working yielded a small tonnage of No. 1 feldspar.

Quartz and quartz-feldspar veins.—Veinlike fracture-fillings of quartz, most of which contain subordinate amounts of perthite and plagioclase, are exposed in all workings, and are most numerous in the main and south workings. Most of these fracture-fillings are zoned, consisting of a quartz core bordered by an irregular discontinuous selvage of perthite or of perthite and plagioclase, the crystals of which are euhedral against quartz. The fracture-fillings range from an inch to 2 feet in thickness and are exposed for lengths as great as 40 feet. None is exposed in entirety. The most prominent set is found in the north rim of the glory hole and the north wall of the main open cut. These veins strike N. 55°-78° E. and dip 60°-80° NW. They cut all zones from the perthite-quartz zone outward, and a few extend outward into the metasedimentary rocks. The material composing these fracture-fillings is not unlike that of the quartz-perthite zone, but no direct connection can be established. The part of the pegmatite which would logically be expected to show the connections has been mined out in the sinking of the glory hole.

Fracture-fillings in the south working strike N. 50° to 70° E. and dip 60° to 80° NW. Strikes of similar bodies in the middle and north working range from N. 27° W. to N. 13° E., and dips range from 59° to 67° W.

In addition to the more regular fracture-fillings, irregular bodies of similar material form lenses, veins, and networks in pegmatite of the outer zones at places along the north wall of the main working.

Feldspar.—Feldspar produced from the Deep Creek No. 1 mine has come largely from the remarkable plunging shoot followed by the main working. The part of the perthite-quartz zone forming this shoot yields, by hand sorting, a high proportion of cream, buff, or slightly greenish pure perthite. The feldspar is used in making cleansing powder, so care is taken to procure material free of quartz and other impurities that would yield particles that would be objectionable in the ground product owing to their hardness or color. A small percentage of pure plagioclase is present in the mine product. It is fully as desirable as perthite for cleansing purposes. Mining is restricted as closely as possible to the perthite-quartz zone. The percentage of feldspar in the quartz-perthite zone is too low to repay mining. The innermost part of the plagioclase-quartz-perthite zone forming the northern margin of the shoot contains considerable amounts of massive perthite, so much so that the writer had difficulty at first in distinguishing it from the shoot. The boundary is an assay wall; the northern limit of mining is set by a gradual rise in the proportion of waste to usable feldspar.

Until the establishment of a mill at Dillsboro in 1946, no attempt was made to recover or market the lower grades of feldspar, but during the present investigation recovery of No. 2 feldspar was begun, partly from the north cut, partly from the dumps.

Kaolin.—The upper part of the pegmatite, except in the north working, is deeply weathered. Plagioclase has been altered to kaolin, biotite and garnet to iron and manganese oxides. Perthite is commonly little affected, except that kaolinization of albite lamellae has caused disintegration where weathering is most pronounced, and some of the perthite near the surface is reduced to a sand. Weathering extends below the floor of the middle and main workings, but sound rock was found in the glory hole within 20 feet of the floor of the main working. In the south working plagioclase is completely kaolinized at 47 feet below the collar. The upper kaolinized part of the pegmatite was prospected, probably by the Harris Clay Co. Clay workings were primarily in the outer zones. Production is unrecorded, but was probably small.

Outlook for the future.—Future productivity of the mine depends partly on the downplunge extent of the main shoot, partly on the relationship of this shoot to the perthite-quartz bodies exposed in the middle working and in the northwest portion of the main working. Less promising possibilities are discovery of a shoot on the footwall side of the quartz-perthite zone in the main working, and of a workable perthite-quartz body downplunge from the south working.

The downplunge extent of the main shoot is unknown. In October 1946, mapping of the 1,946-foot level, the bottom level at that time, suggested a shortening of the main shoot at depth, but the working was subsequently extended northeast for at least 20 feet without reaching the keel of the shoot. The crest lies beyond the southwest end of the working on this level. According to Mr. Buchanan, foreman, mining in this direction was discontinued because the shoot narrowed.

If the present interpretation of the relationship between the main shoot and the shoot exposed in the middle working is correct, a considerable tonnage of high-grade feldspar remains between the roof of the large chamber and the floors of the present open cuts. Without more data on the configuration of the hanging wall in this part of the property, however, no estimate of reserves is possible.

Drifts across the quartz-perthite zone from the main underground working would be needed in order to determine whether a workable shoot lies southeast of it. Drilling might serve the same purpose, but the materials involved are so coarse-textured that it seems unlikely that the boundaries of the shoot could be determined except by means of closely spaced holes. Drifting likewise seems the best means of exploration from the south working.

McCRACKEN MINES

General information.—The McCracken mines (pl. 1, no. 12) lie 2,800 feet N. 55° E. of Sherrill Gap, near the headwaters of Bryson Branch. Access to the property is by improved road up the valley of Bryson Branch to the sharp bend a few hundred feet west of the ridge between Bryson Branch and Toot Hollow Branch, thence by unimproved road northward along the east side of Bryson Branch. The mines are on property owned by a Mr. J. McCracken of Bryson City. The earliest mining was for kaolin, presumably during the decade 1910 to 1920. A small amount of feldspar is reported to have been taken from the No. 3 working in the early 1940's. The property was leased by the Blue Ridge Mining Co. in 1945, and operations by the company were still in progress in early 1947. About 1,500 tons of feldspar of No. 2 grade was produced.

Workings consist of pits, open cuts, and adits, with appended drifts and chambers (pl. 15), made during operations for kaolin and feldspar. In addition, a series of trenches and postholes was dug during the present investigation to obtain information on the form and internal structure of the pegmatite. The mine workings are in a series of pegmatite bodies that extends for 480 feet nearly due north. Taken as a group, the pegmatites trend obliquely across the strike of the wall rocks. The wall rocks are granitic gneiss at the southernmost workings and border gneiss in part interlayered with granitic gneiss in the middle workings. In the No. 1 working pegmatite lies in border gneiss but is probably within 20 feet of the contact with metasedimentary rocks. Foliation in the wall rocks strikes northeasterly and dips northwest at moderate to steep angles.

Workings 1 to 4 (pl. 15) are in the northernmost and largest of the group of pegmatites, a westward-dipping lenticular body that trends a few degrees east of north but strikes roughly N. 20° W. This body apparently terminates northward in the north end of the No. 5 working. It lies in border gneiss, the foliation of which strikes northeast and dips northwest at moderate to steep angles. A second pegmatite body, apparently extending east-northeast to northeast, is exposed in the south end of the No. 5 working. It may connect with the northern pegmatite beneath the dump east of the working. The No. 6 working is in a complex assemblage of interconnected pegmatite bodies enclosed in granitic gneiss, the foliation of which strikes N. 50° to 55° E. and dips steeply southeast to northwest.

North pegmatite.—This pegmatite is a lenticular body 290 feet in exposed length and nearly 100 feet in exposed width. Structure sections suggest that its maximum thickness, which is found in the area between the No. 1 and No. 4 workings, is more than 75 feet. The hanging wall is exposed at 3 places, dipping 34° to 56° W. The footwall is exposed in the No. 3 and No. 4 workings. The contact in the adit at the No. 4 working is in part highly irregular, but at most places in the adit dips 47° SW. to 50° W. The footwall intersects the floor of the chamber of the No. 3 working (elevation 2,210 feet), and it is evident from this fact, from information supplied by the operators, and from the position of the contact at the surface as determined by postholes, that there is a pronounced downward roll of the footwall beneath the open cut of the No. 3 working (pl. 15, section A-A'). The thickness of the pegmatite down dip from this working is much less than the width of outcrop suggests. The plunge of the pegmatite is not known. A trench made to locate the northern tip of the pegmatite failed to disclose the plunge, and the plunge can be inferred only on the basis of a series of assumptions. Like the Deep Creek pegmatite, the north McCracken pegmatite appears to occupy a westward-dipping fracture developed in border gneiss. The plunge of the pegmatite should therefore be defined by the intersection of the plane of fracture with the belt of border gneiss. Taking the average strike of the border gneiss as N. 40° E., its average dip as 70° NW., the strike of the pegmatite as about N. 20° W., and its dip as 45° W., the expectable plunge of the pegmatite would be about 45°, S. 60° W.

Four zones have been recognized in the pegmatite: border zone, wall zone, intermediate zone, and apparent core. The border zone, half an inch to 2 inches thick, consists of fine-grained plagioclase-quartz-perthite pegmatite, with accessory biotite in flakes mostly oriented perpendicular to the contact. The wall zone is exposed only in the No. 1 and No. 3 workings, where it is a medium-grained mixture of blocky plagioclase, plagioclase intergrown irregularly with subordinate quartz, and accessory biotite in striplike and slablike crystals up to 4 inches in maximum dimension. The zone is absent in the No. 4 and No. 5 workings.

The bulk of the exposed pegmatite is composed of coarse to very coarse plagioclase-quartz-perthite pegmatite of the intermediate zone. This material consists of plagioclase and perthite in graphic to irregular intergrowth with quartz, blocky perthite, blocky plagioclase, and accessory biotite in large strip-shaped crystals and in slablike books up to 1 foot broad and 2 inches thick. The feldspars occur in stout crystals up to 6 feet in length.

The apparent core of the pegmatite was exposed only in the headwall of the No. 3 working at the time of mapping. It is an extremely coarse-grained mixture of quartz-free perthite and graphic intergrowths of perthite and quartz. Crystals of feldspar in this zone are as much as 8 feet in maximum dimension. This zone would yield a grade of feldspar intermediate between No. 1 and No. 2. The chamber driven into the headwall of this working was evidently intended to intersect the down-dip extension of the zone; but as the bottom of the zone is parallel to the footwall, which rolled upward at the head of the open cut, the chamber apparently passed under the shoot and is mostly in pegmatite of the intermediate zone. Trenches dug during the present investigation served to delimit the zone at the bedrock surface, but no subsurface exploration could be attempted. In order to determine whether the shoot persisted at depth in the southern part of the pegmatite, the operators in February and March 1947 drove a crosscut from the inner end of the No. 3 working. The crosscut was run 50 feet N. 84° W., without reaching the west contact of the pegmatite. At 10 to 26 feet from the adit material was intersected that was richer in perthite than usual in the intermediate zone, but higher in plagioclase than the shoot. It is not certain that this material represents the downward continuation of the shoot. Cross section A-A' on plate 15 shows that the pegmatite probably narrows abruptly downward, but it is not proven that either the pegmatite or the apparent core pinches out within a short distance of the surface. Further exploratory work is needed to determine the potentialities of the pegmatite. The logical procedure would be to extend the adit of the No. 3 working to the latitude of the No. 1 working, with cross drifts perpendicular to the strike of the pegmatite. In this way, the possibility that both pegmatite and shoot plunge west or even north-northwest would not be overlooked.

In the eastern of the two short adits into the headwall of the No. 1 working there is an irregular body of massive quartz about 5 feet long and 2½ feet in maximum width. Around this body is a mantle of blocky perthite and plagioclase in coarse crystals that project into the quartz and are euhedral against it. Plagioclase (now kaolin) appears to have developed in part at the expense of perthite. Slablike books of biotite and ruled composite crystals up to 1½ feet long, 6 inches wide, and 2 inches thick occur along fractures transecting the boundary of the quartz body. The quartz body and its mantle are both enclosed in material of the intermediate zone. A roughly tabular body of quartz margined by small kaolinized plagioclase crystals is exposed in the north branch of the chamber at the No. 3 working. It appears to be a fracture-filling that cuts the intermediate zone.

In the older workings and in all surface trenches, plagioclase is entirely kaolinized, and perthite is more or less stained brown by limonite. Plagioclase is only partly kaolinized in the western part of the crosscut in the No. 3 working, however, and this indicates that the bottom of the zone of weathering is not far below.

As at other mines in the district, landslips have offset the pegmatite in places in the surface workings. The most prominent is the one exposed in the No. 1 working; it is shown in section A-A′ on plate 15.

Middle pegmatite.—The middle pegmatite is poorly exposed in the south part of the No. 5 working. It trends northeast and appears to be about 18 feet wide. The dip of the body is not indicated. It is a coarse mixture of kaolinized plagioclase, quartz, and perthite.

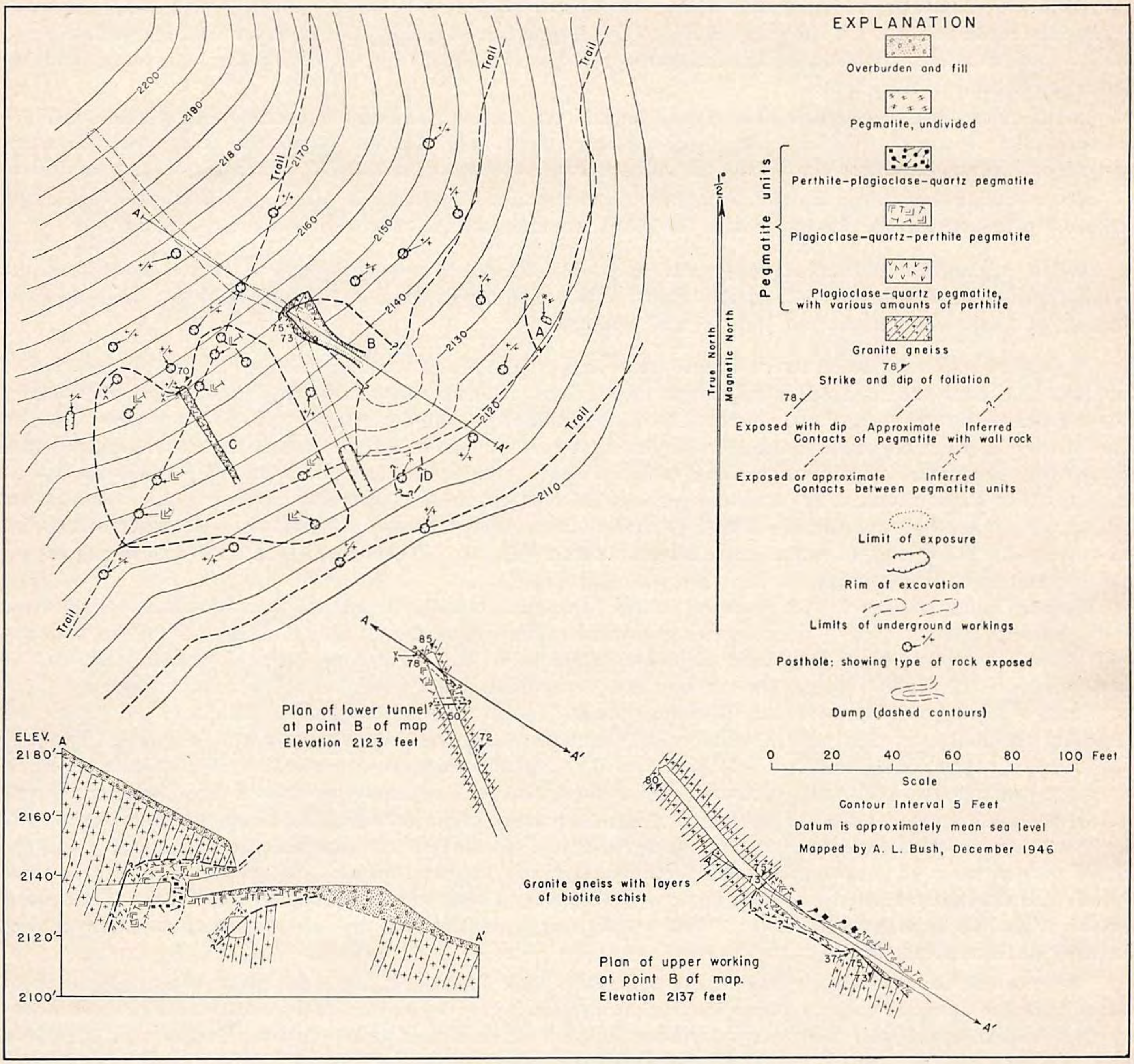
Pegmatite bodies in the No. 6 working.—The walls of the No. 6 working consist of granite gneiss that has been shattered and invaded by pegmatite in the form of lenses, streaks, stringers, and irregular bodies. Most of the bodies are small, an inch to a few feet in thickness, and a few feet to a few tens of feet in length. They form a more or less interconnected complex that could be shown only on a map at natural scale. Both crosscutting fractures and fractures along foliation have guided emplacement. Stringers along a set of fractures that strike about N. 52° E. and dip about 72° NW. are locally prominent in the eastern part of the cut. Granite gneiss separating the bodies is conspicuously feldspathized in places. Some of the small bodies are essentially homogeneous, some are distinctly zoned (fig. 6). They consist of fine- to coarse-grained plagioclase-quartz perthite pegmatite with accessory biotite.

Midway along the north wall there is a larger irregular body of pegmatite that extends from the floor of the working upward to the rim, narrowing upward. The boundaries of this body shown on the map are diagrammatic; beyond them there are numerous offshoots of the main body into the gneiss. By way of these offshoots the main body passes outward into brecciated gneiss cemented by pegmatite stringers. The main body contains numerous angular blocks of gneiss. Both walls and apparent inclusions of gneiss are markedly feldspathized, but actual contacts of pegmatite and gneiss range from sharp to fading. The pegmatite has a vague zonal structure. Adjacent to its walls and the apparent inclusions it consists of medium- to coarse-grained and plagioclase-quartz-perthite pegmatite with accessory biotite in thin books and plates up to 1 foot in diameter. Most of the books along the margin are oriented perpendicular to the contact. The pegmatite is coarser inward, and graphic intergrowths of plagioclase and perthite are prominent. The apparent core consists of large crystals of perthite (free of quartz), coarse plagioclase, minor interstitial quartz, and accessory biotite in plates up to 1½ feet long, 1 foot wide, and half an inch thick. The biotite plates cut sharply across the feldspars. For a time this pegmatite body was the source of the feldspar produced by the Blue Ridge Mining Co.

The most recent operations were in the pegmatite body exposed in the west cut, a body probably connected with the one described in the preceding paragraph. The pegmatite in the west cut has uneven but roughly parallel walls that strike east-northeast in general and have steep but varied dips. In December 1947 (see plan of West cut, pl. 15), the pegmatite body was 22 feet in maximum width at floor level. Coarse biotite schist formed the northwest wall; the contact was marked by closely spaced shear surfaces both in pegmatite and in wall rock. The southeast wall was granitic gneiss, in frozen contact with the pegmatite. The pegmatite ended against granite gneiss in the entrance to the cut; the pegmatite thus appeared to be plunging southwestward.

The pegmatite showed an asymmetrical zonal structure. A narrow border zone was succeeded inward by a wall zone 3 to 5 feet thick composed of medium- to coarse-grained plagioclase and quartz with subordinate perthite and accessory biotite. Inside this, on the southwest side of the pegmatite, there was a unit composed of coarse to very coarse blocky perthite, interstitial massive quartz, and subordinate intergrown quartz and plagioclase with striplike crystals of biotite. Between this unit and the wall zone along the northwest wall was material similar to that of the intermediate zone of the north pegmatite. The struc-

PLATE 16.



SOUTH McCRACKEN MINE
SWAIN COUNTY, NORTH CAROLINA
GEOLOGIC MAP, PLAN, AND CROSS SECTION

tural relationships of the two inner units were not indicated in the limited exposures available for inspection.

In the upper part of the open cut, the pegmatite is successively offset to the southeast and along gently dipping faults marked by red clay gouge. These faults may be landslip surfaces. There is abundant indication of landsliding in the area of the cut, and slides from the slope northwest of the mine hampered operations in the winter of 1946-1947.

Some feldspar of No. 2 grade has been recovered from this working. Further operations southwestward along the strike of the body will require the removal of large amounts of overburden.

In the east end of the No. 6 working, a 60-foot adit with two short drifts to the northwest and west has been driven northeastward. It is known as the magazine tunnel. It exposes stringers and lenses of pegmatite in feldspathized granitic gneiss and a larger, apparently lenticular body that strikes about N. 40° E. and probably dips steeply west. The lenticular body is exposed for nearly 60 feet along the strike and has a maximum width of at least 14 feet. Near its south end it is cut by a fault that strikes N. 42° E. and dips 54° NW. The pegmatite is a medium- to coarse-grained mixture of kaolinized plagioclase and quartz, with subordinate to minor perthite and abundant accessory biotite. Inclusions of granitic gneiss range from those that are little affected to those that are converted to fine-grained massive aplite. In places biotite metacrysts up to 1 inch in diameter are strikingly developed in the gneiss adjacent to the pegmatite.

The working is said to have been made many years ago during kaolin mining and is now nearly blocked in places by material caved from the roof. The pegmatite is in no respect promising as a potential source of commercial feldspar.

Summary.—Of the pegmatite bodies exposed at the McCracken mines, only the north pegmatite thus far shows indications of a sizable body of feldspar of commercial grade. Further exploration should be aimed at determining whether the apparent core of the pegmatite persists at depth.

SOUTH McCRACKEN PROSPECT

By ALFRED L. BUSH *and* E. N. CAMERON

The South McCracken prospect (pl. 1, no. 13) is approximately 300 feet southwest of the McCracken No. 6 working and about 500 feet northeast of the main working of the Cox mine. It lies at elevations of 2,115 to 2,160 feet and is located on the southwest flank of a spur that extends southeastward from the main ridge bounding the lowland area. Footpaths from the McCracken mine and the Cox mine lead to the prospect. The property is part of the leasehold of the Blue Ridge Mining Co.

The workings consist of two open cuts, each leading to an adit (pl. 16). The adit from the upper open cut extends northwest into the hillside for 118 feet. The adit from the lower open cut is 69 feet long and trends N. 22° W. The upper adit may have been driven during the early period of clay mining; it was reopened in December 1946 by the Blue Ridge Mining Co. The lower tunnel was driven in January 1947. The property was mapped by A. L. Bush. Concurrently with the mapping, surface exploration by means of postholes and a shallow trench was carried out.

Exposures in the various workings indicate that the area is underlain by three, possibly four, pegmatite bodies enclosed in granite gneiss interlayered with biotite schist. The southwestern one of the two principal bodies underlies an irregular area 72 by 74 feet in maximum dimensions. The contact of this body with granite gneiss is exposed at the northern end of the 37-foot trench west of the adits; the contact strikes N. 52° E. and dips 35° NW. The foliation of the gneiss there strikes N. 51° E. and dips 72° NW.

This pegmatite body consists of a fine-grained plagioclase-quartz-perthite border zone a fraction of an inch thick, a medium- to coarse-grained wall zone of plagioclase-quartz-perthite pegmatite 1½ feet thick (in the trench), and an inner zone (the apparent core) composed of coarse-grained to very coarse-grained plagioclase-quartz-perthite pegmatite. The apparent core has minor amounts of biotite and is characterized by graphic and irregular intergrowths of quartz and feldspar. The zonal structure is indistinct.

The pegmatite discovered by the open cuts and appended adits is a discordant, irregular-walled body; possibly it is connected with the southwestern body at depth. Information as to its structure is summarized on plate 16. The border and wall zones resemble those of the southwestern pegmatite. The wall zone is discontinuous, and in the southwest upper open cut the intermediate zone lies directly against the border zone. Strips of biotite up to 1 inch long are present in the wall zone. The intermediate zone is similar to the apparent core of the southwestern body. It is characterized by crystals of plagioclase and perthite up to 4 feet in diameter. Some of the crystals are massive, some are entirely or partly intergrown with quartz. Quartz in large masses is common, and striplike biotite crystals up to 6 inches long are present. The core of the pegmatite consists of massive perthite and massive plagioclase, in crystals 1 to 4 feet in diameter, with large interstitial masses of quartz.

Two postholes, one about 12 feet east of the entrance to the lower open cut, the other about 60 feet east of the entrance to the upper open cut, struck pegmatite. Whether these bodies are separate or are connected in some way with the two principal bodies is unknown.

The only exposed unit bearing feldspar of commercial grade is the core of the northeastern pegmatite. This core contains perthite of No. 1 grade. The plagioclase associated with it is entirely kaolinized, like the plagioclase in all the pegmatites, but there are indications that the lower limit of drastic weathering may not be far below the head of the lower adit. There is little likelihood of profitable mining, however, unless the small bodies exposed on the property are projections from a large body at depth. There is no evidence of downward expansion.

McCRACKEN SOUTHEAST PROSPECT

The McCracken southeast prospect (pl. 1, no. 16) is 2,400 feet N. 65° E. of Sherrill Gap, on land included in the leasehold of the Blue Ridge Mining Co. It lies about 200 feet southwest of Mr. McCracken's house. A bulldozer was used in 1946 by the Blue Ridge Mining Co., operators of the McCracken mine, to strip overburden at the prospect.

Three nearly parallel, dikelike bodies of pegmatite are exposed at the prospect. The west and middle pegmatites are 9 feet apart. They strike N. 37° E. and dip 70° NW. The east pegmatite and middle pegmatites are 18 feet apart where exposed. The east pegmatite strikes N. 29° E. and dips 83° W. The pegmatites range from 1 to 2½ feet in thickness and appear to be at least 150 feet in strike length. They are coarse mixtures of blocky perthite, blocky plagioclase, and quartz.

COX NO. 1 MINE

General information.—The Cox No. 1 mine (pl. 1, no. 14) lies about 1,900 feet N. 52° E. of Sherrill Gap, straddling the ravine occupied by one of the headwater tributaries of Bryson Branch. The mine is on land reported to be owned by S. D. McKinney, Little Switzerland, N. C. It was operated from 1940-1948 by the Blue Ridge Mining Co., Spruce Pine, N. C. The mine is reached by a short graveled access road that turns northward from the Sherrill Gap road near the sharp bend at the 2,040-foot contour.

The mine probably was opened about 1910; at this time the upper parts of the Cox No. 1 pegmatite were worked for kaolin. A series of open cuts, now badly slumped, was made south of the hoist house (pl. 17) over an area 140 feet long and about 120 feet wide. Other workings—open cuts, and possibly shafts—were made on the site of the present main working. No records of kaolin production are available. In the early 1940's, the Blue Ridge Mining Co. discovered a sizable body of commercial feldspar. The company's operations continued with little interruption from 1940 to 1948. From 1948 to June 1949, further mining was done by M. H. Cox.

The Blue Ridge Mining Co. produced about 30,000 tons of feldspar, mostly of No. 2 grade. Costs per ton are reported as $5.90 in 1940, but by 1948 costs had risen to $8.85 per ton. Increased labor and freight charges were largely responsible.

The main working is a roughly oval open cut 128 feet in length and 100 feet in maximum width (pl. 3, B); its floor is at 2,065 feet and its rim ranges in elevation from 2,143 feet to 2,203 feet. In the fall of 1946 a chamber with floor at elevation 2,110 feet and roof at 2,020 feet was developed in the northwest wall of the open cut. Two shallow pits and a slumped open cut 23 feet long, 15 feet wide, and 6 feet in maximum depth, also were made on the slope north of the main working.

Form and structural relations of the pegmatite.—The pegmatite is an irregular elongate lens striking nearly north and dipping irregularly but steeply west. The lens is about 450 feet long and at least 100 feet in maximum thickness. Contacts of the body are partly exposed in the workings; outside the workings a number of postholes and shallow trenches put down in the course of the present study have established the general outlines of the body. The pegmatite cuts obliquely across the belt of border gneiss; its northern tip is enclosed in metasedimentary rocks, whereas the southern end is in granite gneiss. The northern end of the pegmatite is a double wedge, with apices separated by a sharp reentrant of metasedimentary rocks. The pegmatite widens southward irregularly, and beneath the derrick site at the main working it apparently bulges abruptly southeastward across the footwall. South of this point the footwall is concealed by dumps for nearly 300 feet, and its form and precise position are uncertain. The hanging wall south of the pit is irregular; a prominent southeastward jut causes a marked constriction of the pegmatite in the vicinity of the hoist house. The relation of the form of the pegmatite to the structure of the wall rocks is not fully indicated, but the unevenness of the walls appears to be due, in part at least, to control by fractures, probably fractures subsidiary to the main fracture along which the pegmatite must have been emplaced.

The plunge of the pegmatite body is uncertain. The narrowing of the pegmatite northward, where the topographic surface is relatively high, might be taken to suggest that the body is plunging in that direction. The internal structure, however, suggests strongly that the plunge of the body is westward, and probably closer to the direction of dip of the pegmatite than to the direction of strike.

The foliation of the wall rocks in the vicinity of the pegmatite strikes N. 22°-78° E., averaging about N. 40° E.; dips range from 49° NW. to vertical. Bedding and foliation of the metasedimentary rocks are parallel so far as can be determined. Contacts with pegmatite are sharp at most places. On the west rim of the main working, border gneiss shows a biotite-rich selvage half an inch to 2 inches wide, and the foliation of the border gneiss is dragged northward for a few feet along the contact. Small apophyses of the main pegmatite extend into the walls at places. Along the contacts shown on the plans of the 2,110- and 2,120-foot levels (pl. 17), stringers, lenses, and layers of pegmatite ¼ inch to 5 inches thick and as much as 12 feet long are injected into feldspathic quartzite, chiefly along the bedding. Patches of aplitic material also are present in the quartzite.

The pegmatite is intersected in the main working by a number of shear surfaces coated by greenish sericite. The most prominent group at the time of mapping was a series of closely spaced surfaces that defined most of the wall between the floor of the open cut and the floor of the chamber. This shear zone strikes N. 88° E., dips 65°-72° S., and shows striations plunging 42°, S. 62° E. Numerous other shorter shear surfaces, of several sets ranging in strike from N. 65° W. to N. 70° E. and in dip from 50° to 80° S. to SW., are exposed. Displacements along the surfaces are negligible.

Composition and internal structure of the pegmatite.—The pegmatite consists essentially of plagioclase, perthite, and quartz, with minor amounts of biotite, accessory magnetite and garnet, and traces of pyrite and fluorite. Six zones, most of which are distinguished by textural contrasts, are recognizable within the pegmatite. The outermost zone is a fine-grained border zone ¼ inch to 6 inches in thickness. It is composed of plagioclase, quartz, subordinate to minor amounts of perthite, and accessory magnetite, biotite, and garnet. In places the zone is rich in magnetite crystals ranging up to ¾ inch in diameter. Wisps of feldspathized border gneiss derived from slabby xenoliths are exposed in two places along the hanging wall. Numerous flakes of biotite as much as ½ by ¼ by 1/16 inch are oriented subperpendicular to the contacts.

Inside the border zone is a wall zone 2 to 4 feet thick essentially similar in composition to the border zone but coarser in texture and higher in average content of massive plagioclase. The zone lacks perthite in places, particularly along the contacts in the south working, and it varies in distinctness depending on the proportion of perthite. The zone is lacking along the hanging wall in the west end of the open chamber in the main working, and inner zones are directly in contact with the border zone. The wall zone grades inward into the outer intermediate zone by increase in grain size and by decrease in the proportion of massive plagioclase.

Inside the wall zone is an outer intermediate zone composed of very coarse-grained plagioclase-quartz-perthite pegmatite with minor amounts of biotite and accessory magnetite and garnet. Perthite forms scattered anhedral to subhedral crystals up to six feet in maximum dimension, in part massive and in part in irregular or graphic intergrowth with quartz. Much of the plagioclase forms irregular intergrowths with quartz, but some forms graphic intergrowths and some occurs as massive crystals up to 6 inches in diameter. Biotite forms unevenly distributed strips up to 6 inches long, 1½ inches broad, and ⅛ inch thick and also forms slablike books along fractures cutting all the other minerals. Magnetite is locally abundant in crystals ranging from ⅛ to 1 inch in diameter and averaging ⅜ inch. The zone shows much variation in mineral proportions from place to place. On the average, plagioclase and quartz are about equal in amount and predominate over perthite. Fine-grained pyrite is found in places along fractures and is evidently a late mineral. Some biotite strips are partly altered to chlorite.

The outer intermediate zone grades into the middle intermediate zone by gradual change in texture and mineral proportions. The predominant components of this zone are graphic intergrowths of quartz with perthite and plagioclase. The feldspar crystals range from 2 to 6 feet in diameter. Massive perthite and 3-inch to 1-foot crystals of massive plagioclase also are present, and massive quartz forms small areas interstitial to the feldspars. Strips of biotite and clusters of strips up to a foot long, 4 inches broad, and 2 inches thick are present. Magnetite and garnet are minor accessories. The proportion of plagioclase to perthite in this zone varies considerably. Perthite seems to predominate over plagioclase along the hanging-wall side of the pegmatite, but plagioclase is the more abundant mineral along the footwall side. The shape of this unit is not fully known, because most of it is mined out, but the number of exposures of the unit in the walls are limited. It appears to form an irregular, incomplete envelope, 10 feet to perhaps 34 feet in thickness, around the innermost zones. It is exposed chiefly in the northern half of the open cut, but a small body of similar material in the southern wall of the open cut near the base may represent the southward extension of the zone. A second segment of the zone appears to be represented in the old clay workings south of the blacksmith house, but the material is too poorly exposed to be identified with certainty.

In the main working the two inner zones of the pegmatite, the perthite-quartz zone and the quartz core, are exposed chiefly at the north end. Here a segment of the core forms a roughly pipelike body, 3 feet to as much as 9 feet in diameter, that appears to plunge about 50°, S. 70°-75° W. At the time of mapping this body was exposed in the roof of the chamber and in the wall of the main working below the chamber floor. Its margins are most irregular; crystals of perthite project into it from the adjacent perthite-quartz zone. The core consists almost entirely of quartz but locally contains scattered crystals of perthite. Both perthite and quartz along the margins of the core are crisscrossed in places by numerous fracture-controlled plates of biotite that are fractions of an inch thick and up to 1 foot broad. One uneven biotite-coated shear surface is exposed over an area 4 by 4 feet.

The perthite-quartz zone forms an irregular envelope 4 feet to about 25 feet thick around the quartz core and appears to plunge approximately parallel to the quartz core. The zone consists essentially of massive perthite, in crystals up to 5 by 4 feet, and quartz, which occurs chiefly as interstitial masses a few inches to 8 inches in diameter. Plagioclase is subordinate but forms stout white to greenish crystals 2 inches to 1 foot in diameter. The outer portion of this unit contains some quartz in graphic intergrowth with perthite. At most places the zone is separated from the walls of the pegmatite by the middle and outer intermediate zones, but in the northwest corner of the chamber these zones are absent, and the perthite-quartz zone is separated from the wall rock only by a border zone too thin to be shown on the map.

The perthite-quartz zone and quartz core exposed in the chamber were discovered only during the most recent stages of operations. The operators state that the main working followed a small quartz core partly or perhaps entirely enclosed in a much larger segment of the perthite-quartz zone. The two units together formed a pipelike body that was mined downward from the northeastern end of the open cut to the floor. The pipe plunged steeply in a direction probably between southwest and west. The approximate eastern boundary of the perthite-quartz zone and its western contact with the quartz core were uncovered on the floor of the main working beneath debris and are shown in the plan of the 2,068-foot level. It seems probable that the pipelike body was actually the thickened portion of an elongate lens, and that in the upper part of the working the lens extended southward along the strike as far as the south wall of the open cut. The perthite-quartz pegmatite shown on the south rim of the open cut (pl. 17) may thus represent the extension of the body containing the main shoot.

The relationship between the main shoot and the segment of the perthite-quartz zone exposed in and near the chamber cannot be determined at present. It is entirely possible that the segment was connected with the main shoot, but it is also possible that either the middle intermediate zone or the outer intermediate zone, or both, extended around the segment now exposed at the north end and separated it from the core. Precisely this relationship seems to hold true in the upper part of the north wall, where the northern edge of the main shoot is separated from the perthite-quartz pegmatite and quartz core segment of the chamber.

In the open cut on the slope north of the mine, perthite-quartz pegmatite enclosing a small lens of quartz is exposed. The relationship of this material to the perthite-quartz body exposed in the chamber in the main working has an important bearing on the tonnage of commercial feldspar still remaining in the mine. The core segment and associated perthite-quartz zone in the chamber, projected upplunge, would intersect the surface in the vicinity of the small open cut, but exposures are as yet so limited that it is hardly safe to conclude that they are the downward extension of the body exposed in the cut.

Kaolin.—Much of the plagioclase present in the upper part of the pegmatite is altered to kaolin, some of which is pure white, some of which is stained by iron oxides. The bottom of the weathered zone around the main working lay not far below the original surface, but in the clay working south of the blacksmith house weathering extended to somewhat lower elevations, and part of the kaolinized upper portion of the pegmatite is preserved. In part the clay workings there seem to have followed a plagioclase-rich portion of the wall zone along the footwall of the pegmatite, but much back-fill is present in the cut, and the walls have slumped so badly that it is difficult to determine the extent and objectives of the clay workings. A ridge of material was left extending north-south, roughly through the middle of the pegmatite. Scattered exposures suggest that the ridge was not mined, because it contains a comparatively high proportion of unkaolinized potash feldspar.

Feldspar.—Feldspar produced from the mine has come largely from the pipelike body mined downward in the central portion of the main working, but production during the winter of 1946-47 came from the chamber. The pipelike body is said to have yielded considerable amounts of No. 1 feldspar as well as a good grade of No. 2 feldspar, but mining has extended outward considerably beyond the boundaries of the shoot into the outer intermediate zone. This zone and the middle intermediate zone were undoubtedly the source of much of the large proportion of No. 2 feldspar reportedly produced from the mine. The feldspar produced is reddish, light buff, or greenish perthite, and white to greenish plagioclase. Crystals sufficiently free of intergrown quartz can be separated and marketed as No. 1 feldspar. The bulk of the material recovered, both plagioclase and perthite, contains quartz in graphic or irregular intergrowth and is of No. 2 grade. Biotite, magnetite, and garnet, objectionable impurities of all zones, must be eliminated by hand sorting. Exploration has so far disclosed no shoot that appears to be comparable in size to the one mined down to the present floor level of the main working. This shoot has not yet been bottomed but is reported to be somewhat narrower than in the upper levels. Neither the extent of the smaller shoot exposed in the chamber nor its relationships to the main shoot are indicated, and no estimate of reserves of No. 1 and No. 2 feldspar can be made until further development work is done. The segment of the perthite-quartz zone exposed on the slope above the quarry offers some promise as a potential source of feldspar, and its precise extent and thickness and its relationship to the shoot exposed in the chamber should be determined. The perthite-rich material indicated by scattered exposures and postholes in the south working merits inexpensive exploration by means of pits and trenches. It seems unlikely, however, that a deposit of feldspar of commercial size is present in this part of the pegmatite unless the pegmatite expands appreciably down dip. The dips of the contact around the southern end of the pegmatite lend some support to this possibility. The dip of the footwall at the two places where it has been exposed by test pits ranges from 57° to 87° NW., whereas the dip of the hanging wall at three places exposed ranges from 35° to 62° NW. The walls of the pegmatite are known to show pronounced changes in strike and dip within very short distances, however, and too much reliance cannot be placed on the limited data available.

COX NO. 2 DEPOSIT

By ALFRED L. BUSH and E. N. CAMERON

The Cox No. 2 deposit (pl. 1, No. 15) lies approximately 180 feet west-southwest of the Cox mine main working. The deposits straddles the crest of a southeasterly trending ridge and extends to the bottom of the ravine on the southwest side of the ridge. Two foot trails connect the deposit with the Cox mine. The pegmatite probably was discovered during the early 1900's. Either then or later it was worked for clay. The mine is on land owned by a Mr. Cox and is included in the leasehold of the Blue Ridge Mining Co. of Spruce Pine, N. C. No feldspar mining has been attempted.

The principal working is an open cut 90 feet long, 80 feet wide, and 50 feet deep (pl. 17). The floor is concealed beneath fill and slumped material of unknown depth. Several shallow pits on the slope south of the mine were evidently made during the early operations. A series of postholes and shallow trenches was excavated in the course of the present investigation with the purpose of determining the extent and structure of the pegmatite body exposed in the mine.

The pegmatite appears to be a stout, blunt, irregular lens. It trends N. 42° E., dips steeply northwest, and transects the contact of border gneiss with metasedimentary rocks. It is associated with a marked flexure of the wall rocks that is registered in the pattern of the contact of the metasedimentary rocks with border gneiss. Because of this flexure the strike of the foliation of the country rocks swings from N. 32° E. west of the mine, to N. 67° E. in the open cut, and back to about N. 44° E. along the west rim of the main working of the Cox No. 1 mine. Dips range from 64° to 85° NW.

The pegmatite is exposed over a length of 170 feet and is 38 to 85 feet in outcrop width. Dips of its walls range from 48° NW. to vertical; the variation is marked and irregular within short distances, hence it is unecrtain whether the pegmatite is broadening or narrowing at depth. A roll of the contact at the northern corner of the open cut plunges 26°, N. 88° W., but there is no other suggestion of the plunge of the pegmatite. Contacts of pegmatite with wall rocks are sharp, save locally where the quartzite has been feldspathized as much as 2 inches from the contact. The wall rocks and the pegmatite (except for perthite and quartz) are thoroughly decomposed, and structural and lithologic details are not satisfactorily shown.

The pegmatite appears to consists of four zones: a border zone, a wall zone, an intermediate zone, and a core. The border zone consists of fine-grained quartz, plagioclase, and perthite, and is generally 1/8 to 1/4 inch thick. The wall zone, 4 inches to perhaps 7 feet in thickness, consists of irregularly intergrown medium- to coarse-grained kaolinized plagioclase and quartz, with minor amounts of perthite and unevenly disseminated sericite and green muscovite. The boundary between the wall zone and the intermediate zone is marked by increase in grain size and by the appearance of graphic intergrowths of quartz and feldspar. The intermediate zone, 7 to at least 20 feet thick, is characterized by coarse to very coarse crystals of kaolinized plagioclase and perthite and by scattered books of biotite up to 4 by 4 by 2 inches. Perthite and plagioclase are in part graphically or irregularly intergrown with quartz. The perthite-quartz zone, the apparent core of the pegmatite, consists of massive potash feldspar in crystals 1½ to 4 feet in diameter. Parts of the crystals show irregular or graphic intergrowth with quartz. Scattered irregular quartz masses, against which the perthite is commonly euhedral, are present.

The perthite-quartz zone is the only apparent potential source of commercial feldspar in the pegmatite. Its greatest known thickness, in the trench along the line of Section D-D′ on plate 17, is only 15 feet, and exposures in a trench excavated to explore the southwest rim of the open cut suggest that the core splits into two prongs between the two trenches. The lack of any indication of a perthite-quartz zone in the area southwest of the open cut is puzzling unless the pegmatite plunges southwest. If so, unroofing of the crest of the pegmatite by erosion has not progressed far enough to uncover the core. An adit driven about N. 10° E. from the midpoint of trench H should serve to determine this, but unless the pegmatite broadens greatly downward, discovery of a sizable body of commercial feldspar is unlikely.

PEGMATITE ON ROAD TO COX MINE

On the access road leading from the Sherrill Gap road to the Cox Mine, 1,650 feet N. 73° E. of the gap, a small pit has been made by the Blue Ridge Mining Co. in a tabular pegmatite body that strikes N. 80° E. and dips 75° S. (pl. 1, no. 18). The pegmatite cuts granite gneiss that strikes N. 53° E. and dips 64° NW. and appears to be exposed also a short distance along the strike in the cut bank of the road. The pegmatite is 6 or 7 feet thick and consists of a quartz core that is about 3 feet wide and is flanked by feldspathic zones.

A small tonnage of high-grade potash feldspar is reported to have been taken from the pit, but the pegmatite body appears much too small to support a profitable mining operation.

LACKEY MINE

A pegmatite exposed in a cut on the Sherrill Gap road, 1,300 feet N. 62° E. of the gap (pl. 1, no. 17), was prospected early in 1947, reportedly by two brothers named Lackey, of Bryson City. Some feldspar of No. 2 grade is said to have been produced and trucked to the mill of Interstate Feldspar Corp. at Dillsboro. In April 1947, an irregular inclined chamber about 20 feet deep had been opened downward to the northeast from the northwest edge of the road. Twenty feet southeast of the road there was an open cut 15 feet long leading to an adit about 18 feet long. The adit was driven by the sons of Mr. Walter Hyatt, owner of the land on the south side of the road.

The incline is just below the rounded crest of a pegmatite body; the crest appears to plunge about 53°, N. 80° W. The exposed width of the body at road level is about 30 feet. The incline is in very coarse-grained perthite and plagioclase, most of which is in graphic intergrowth with quartz. Individual crystals range up to 6 feet in length. The feldspars are cut in places by slablike crystals of biotite up to 18 inches broad. The plagioclase is partly kaolinized at the surface but is considerably harder in the bottom of the working. The adit on the Hyatt property is in similar pegmatite.

Systematic prospecting is needed to determine the shape, size, and internal structure of the pegmatite.

HYATT PROSPECT NO. 1

The Hyatt prospect No. 1 (pl. 1, no. 19) is on land owned by Mr. Walter Hyatt of Bryson City. It lies 600 feet S. 84° E. of Sherrill Gap. In December 1946 and January 1947 Mr. Hyatt excavated an open cut 27 feet in length. The cut trends N. 20° W. and follows an irregularly tabular pegmatite body cutting granitic gneiss. The pegmatite is at least 40 feet long and is 2 to 7 feet thick, but it may be thicker beyond the limits of the working. The foliation of the gneiss in the working strikes N. 51° E. and dips 89° SE.

The part of the pegmatite exposed early in 1947 is a medium- to coarse-grained mixture of plagioclase with subordinate perthite irregularly intergrown with quartz. Six feet below the original ground surface the plagioclase is hard and little kaolinized.

HYATT PROSPECT NO. 2

The Hyatt prospect No. 2 (pl. 1, no. 20) is located on the farm of Mr. Walter Hyatt of Bryson City, on the opposite side of the farm access road from the Hyatt Barn. The prospect is 1,260 feet N. 86° E. of Sherrill Gap. Excavation in the bank of the road early in 1947 exposed a tabular pegmatite body 9 feet thick cutting granitic gneiss. The pegmatite strikes about N. 70° W. Its hanging wall has an average dip of 70° SW.; its footwall dips 61° SW. It shows a border zone, a wall zone, and a core. The border zone is less than an inch thick and consists of fine-grained plagioclase-quartz-perthite pegmatite. The wall zone is 2½ to 3½ feet thick and consists of medium- to coarse-grained plagioclase-quartz pegmatite with subordinate perthite and accessory biotite. The core is composed of blocky perthite and massive interstitial quartz, with accessory biotite in slablike crystals. Test pits show that the pegmatite extends at least 125 feet northwest along the strike from the road, and that the core is present throughout this distance.

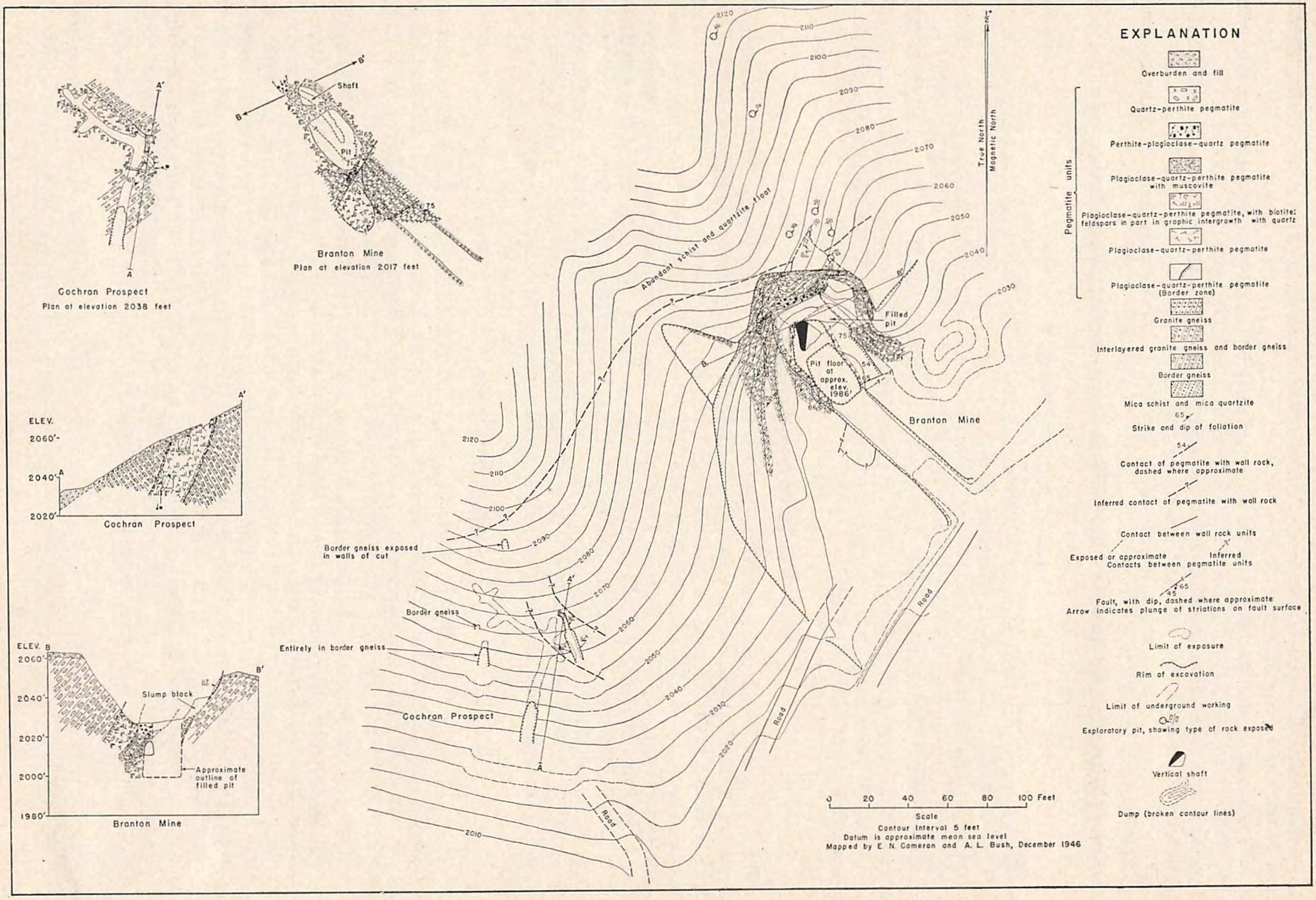
BRANTON MINE

Description.—The Branton mine (pl. 1, no. 21) lies 3,100 feet N. 22° W. of Franklin Grove Church, near the base of a spur that extends eastward from the ridge west of the Bryson City lowland. The mine is reached by way of the graveled road leading northward from Franklin Grove Church to a sharp bend 2,250 feet N. 34° W. of the church. From this point a dry-weather road leads to the mine.

The mine is on land owned by Mr. James M. Branton. It was prospected in 1942. Feldspar Milling Corp. worked the property intermittently under lease from September 1943 until April 1944. Approximately 120 tons of No. 1 potash and soda feldspar are said to have been recovered. An open cut approximately 40 feet square and 10 to 50 feet deep was excavated in the side of the spur (pl. 18); and the northwestern of the two shafts shown on the map, now partly filled, was excavated in the floor to a depth reported to be nearly 28 feet. The property was leased to the Whitehall Co. in 1946. The open cut was enlarged in August and early September, and a large excavation was made by bulldozing. An entrance cut 19 feet wide, with a floor at an average elevation of 2,016 feet, was made, and a shaft 30 by 19 feet was sunk at the head to elevation 1,986 feet. About 40 tons of feldspar was recovered, but the yield of feldspar per ton of rock moved was so low that operations were discontinued. In April 1947, the owner began further development work at the head of the open cut.

The pegmatite body worked is an irregular lens about 120 feet long and 35 feet in maximum thickness. Its average strike is approximately N. 37° W. and its average dip is probably about 65° SW. About 20 or

PLATE 18.



BRANTON MINE AND COCHRAN PROSPECT

Swain County, North Carolina

GEOLOGIC MAP, PLANS, AND CROSS SECTIONS

25 feet from its southeast end it is offset about 18 feet to the northeast along a narrow fault zone, the principal fractures of which strike N. 24°-31° E. and dip 65° to 71° NW. Striations on one of the surfaces plunge N. 85° W. at an angle of 58°, suggesting an oblique slip that would require an upward movement of the hanging wall.

The pegmatite lies athwart the belt of border gneiss. The gneiss is narrow and much interlayered with granite gneiss, and it contains thin layers that may represent metaperidotite. Like the Cox No. 2 pegmatite, it may occupy a fracture associated with a local flexure of the wall rocks, but the precise structure is doubtful owing to the lack of exposures outside the workings. Postholes and a shallow trench put down in the course of the present investigation indicate that the northwest tip of the lens lies just within the metasedimentary rocks. The tip was exposed, though poorly, in the trench, where it plunges N. 40° W. at an angle of about 47°. The value of this reading as an indication of the over-all plunge of the pegmatite is questionable. The foliation of the wall rocks in the vicinity of the workings strikes N. 36° to 54° E. and dips 52° to 86° NW. Contacts of wall rock with pegmatite are sharp except where obscured by thorough decomposition.

The pegmatite is distinctly but irregularly zoned. Along the walls there is a fine-grained border zone composed of plagioclase-quartz-perthite pegmatite with scattered small biotite flakes. Plagioclase in part is in graphic intergrowth with quartz. Inside this zone is a coarse to very coarse wall zone. It is composed of white crystals of plagioclase ranging from 2 by 8 inches up to 2 by 2 feet, in graphic or irregular intergrowth with quartz, scattered cream to reddish-brown perthite crystals of similar dimensions, in part in graphic intergrowth with quartz, and scattered crystals of massive plagioclase. Plagioclase is entirely kaolinized in most of the working. Partly limonitized biotite, in strips up to a foot long, 2 inches broad, and ½ inch thick, occurs scattered through the plagioclase-quartz graphic intergrowths. Flakes, books, and nests of books of muscovite less than an inch in diameter occur sparsely through the zone. Fine-grained muscovite is found in places and appears to be associated with albite formed at the expense of perthite and subsequently kaolinized. At the southeast end of the southeast shaft this material appears to form the full width of the pegmatite, but at the opposite end it is separarated from the quartz-perthite core of the pegmatite by an outer intermediate zone that is 5 feet thick along the hanging wall and 3 to 8 feet thick along the footwall. This zone is similar to the wall zone, except that it is rich in irregular streaks and patches that range up to 8 by 4 inches and are composed of quartz intergrown with anhedral muscovite books ¼ to 1 inch broad. The books are commonly elongated parallel to the *c* axis and range in length up to 4 inches. Biotite is virtually lacking in most of this zone, but the zone grades outward into the wall zone. Where the outer intermediate zone is directly in contact with the core, the contact is marked by scattered books of gray-green muscovite of scrap quality. The books range from 2 inches in breadth and an inch in thickness up to 1 foot in length, 6 inches in breadth and 4 inches in thickness.

The core of the pegmatite is best exposed in the northwest shaft and in the partition separating the two shafts. It is an irregular-walled body that is 1 foot to 8 feet thick and dips about 61° SW. It consists of massive milky quartz containing scattered crystals of perthite up to 4 feet in length. Crystals of massive plagioclase and perthite up to 3 feet in length are scattered along the margins with the muscovite crystals described above.

The outer intermediate zone appears to wedge out northward along strike and also up dip in the northwest wall of the northwest shaft. In the lower part of the headwall of the open cut its position and that of the core are taken by a unit composed of massive perthite and massive plagioclase, with subordinate quartz and muscovite and accessory beryl. The composition of the zone is roughly estimated to be: 35 percent perthite, 35 percent plagioclase, 25 percent quartz and 5 percent muscovite, the last figure including a small fraction of a percent of beryl. The feldspars form stout crystals as much as 2 by 3 feet in cross section. Quartz occurs largely as masses interstitial to the feldspars but in part intergrown with the edges of the crystals. Muscovite forms numerous books ranging from ½ to 10 inches in diameter and ½ inch to 11½ inches thick. The muscovite is gray-green, ruled in 2 to 3 directions, wavy, partly tanglesheet, and cross-fractured. No sheet-bearing mica was observed. The larger books lie at the centers of irregular bodies of quartz intergrown with small anhedral muscovite books. A few muscovite books contain biotite in parallel intergrowth. The quartz-muscovite bodies range up to 5 inches by 1 foot in cross section; yellowish-green, partly kaolinized beryl occurs in sparsely scattered crystals and columnar groups of parallel crystals. The largest groups are more than 7 by 5 by 4 inches in size. The crystals appear to be more closely associated with quartz and plagioclase than with perthite.

The relationship of this zone to the core of the pegmatite could not be fully determined. It resembles the material present in the shafts along the margins of the core, and the core appears to plunge northwestward beneath it. It seems probable that it is a hood-shaped inner intermediate zone over one end of the core, of a type found in pegmatites in many districts.

Feldspar.—Feldspar produced from the pegmatite has probably been taken both from the wall zone and from the perthite-plagioclase-quartz unit. Mr. Branton reports that during operations conducted under his direction for the Blue Ridge Mining Co. the latter unit was followed downward to the southwest from the upper part of the open cut and lay about midway between the walls of the pegmatite. The Whitehall Co. shaft was sunk to explore the margins of the quartz core, but no distinct marginal zone of massive feldspar was found.

The only unit of the pegmatite that appears to contain high-grade feldspar in appreciable amounts is the perthite-plagioclase-quartz unit. This unit extends as much as 20 feet above the base of the headwall and is exposed for about 25 feet along the base; it is not large in horizontal section. There is a good possibility, however that this zone plunges in a southwesterly direction, passing downward beneath the west wall of the open cut. This possibility could be tested by cleaning out the northwest shaft and running a drift west-northwest from its bottom, but the operation might prove difficult. Plagioclase in the perthite-plagioclase-quartz unit in the lower part of the headwall is not seriously kaolinized, but the rock has been weakened by weathering, the rocks above are thoroughly decomposed, and there has been much slumping of the walls of the cut. An additional hazard is a strong flow of water reportedly encountered in the shafts.

COCHRAN PROSPECT

The Cochran prospect (pl. 1, no. 22) lies 200 feet southwest of the Branton mine, on the crest and southwest flank of a low ridge. The prospect is on land reported to be owned by Mr. Carl Cochran of Bryson City. The property was prospected by Mr. Oscar Pittman in the early 1940's. No records of production are available, but the yield of feldspar was probably no more than a few tons.

The principal working is an open cut 21 feet long leading to an adit 44 feet long. The adit runs N. 14° E. into the flank of the ridge (pl. 18). At 27 feet from the portal of the adit a drift extends 7 feet southeast, and at 34 feet a second drift with 3 appended small shallow chambers extends on a curving course to a point 46 feet N. 55° W. from the adit. Four small open cuts, one with a shallow underhand stope and another with a 4-foot adit, comprise the remainder of the workings.

The pegmatite is exposed only in the main working and in the open cut north-northeast of it. It is an uneven-walled, tabular, discordant body that strikes approximately N. 51° W., appears to dip roughly 68° W., and is about 18 feet thick in the vicinity of the main workings. It is enclosed in border gneiss, the foliation of which strikes N. 48°-59° E. and dips 65° to 72° NW. Contacts of pegmatite and border gneiss are knife-sharp; in detail they show angular irregularities apparently controlled by fractures.

The pegmatite exposed in the main working consists of a border zone, a wall zone, an intermediate zone, and a discontinuous core consisting of 3 podlike segments enclosed in the intermediate zone. The border zone is ¼ to 1 inch thick and composed of ⅛- to ½-inch grains of plagioclase, quartz, and perthite. Black spots probably represent sparsely scattered small biotite flakes. The wall zone is not well defined; it is 1 foot to 2 feet thick, medium- to coarse-grained, and composed of plagioclase-quartz-perthite pegmatite with scattered strips of biotite. Perthite occurs as highly irregular crystals intergrown with quartz along their edges and their inner ends. Plagioclase is kaolinized. The intermediate zone is a medium- to coarse-grained mixture of plagioclase, quartz, and perthite, with minor muscovite and accessory biotite and garnet. Plagioclase and perthite occur in stout, subhedral to anhedral crystals as much as 6 feet in length, in part massive, in part in irregular or graphic intergrowth with quartz. Muscovite occurs with quartz in intergrowths as much as 4 by 18 inches in cross section. Haphazardly oriented and tapered strips of biotite as much as 18 inches long, several inches broad, and 1½ inches thick, are sparsely scattered through the zone. Some of the strips are unevenly edged with intergrown quartz and muscovite. These complex masses range up to 2 by 6 feet in cross section. Black lumps of manganese oxides ⅛ to ½ inch across appear to represent weathered garnet crystals.

The pods, or core segments, are 1 foot to 3 feet thick and range from 7 to 20 feet in exposed length. They consist essentially of coarse to very coarse massive perthite and kaolinized plagioclase with interstitial massive quartz. The margins of the pods are marked by muscovite intergrown with quartz or plagioclase. The largest pod, in the northwest drift, is exposed for 20 feet along the roof and walls. It appears to dip about 47° SW. and has a moderate westerly plunge. A similar pod is exposed in the open cut and appended underhand stope north-northeast of the main working.

Feldspar.—Some feldspar of No. 1 grade is present in the pegmatite, but most of the feldspars are so heavily intergrown with quartz that recovery even of No. 2 feldspar by handsorting would be costly. In addition, the plagioclase is all kaolinized to the depths thus far reached. Feldspar in economic concentration is present only in the core segments, and none of them is large enough to warrant mining.

MASON PROSPECT

The Mason prospect (pl. 1, no. 23) lies 2,700 feet N. 55° W. of Franklin Grove Church, on land owned by Mr. Zollie Mason. The workings (fig. 13) consist of 3 open cuts leading to 3 adits driven into the steep

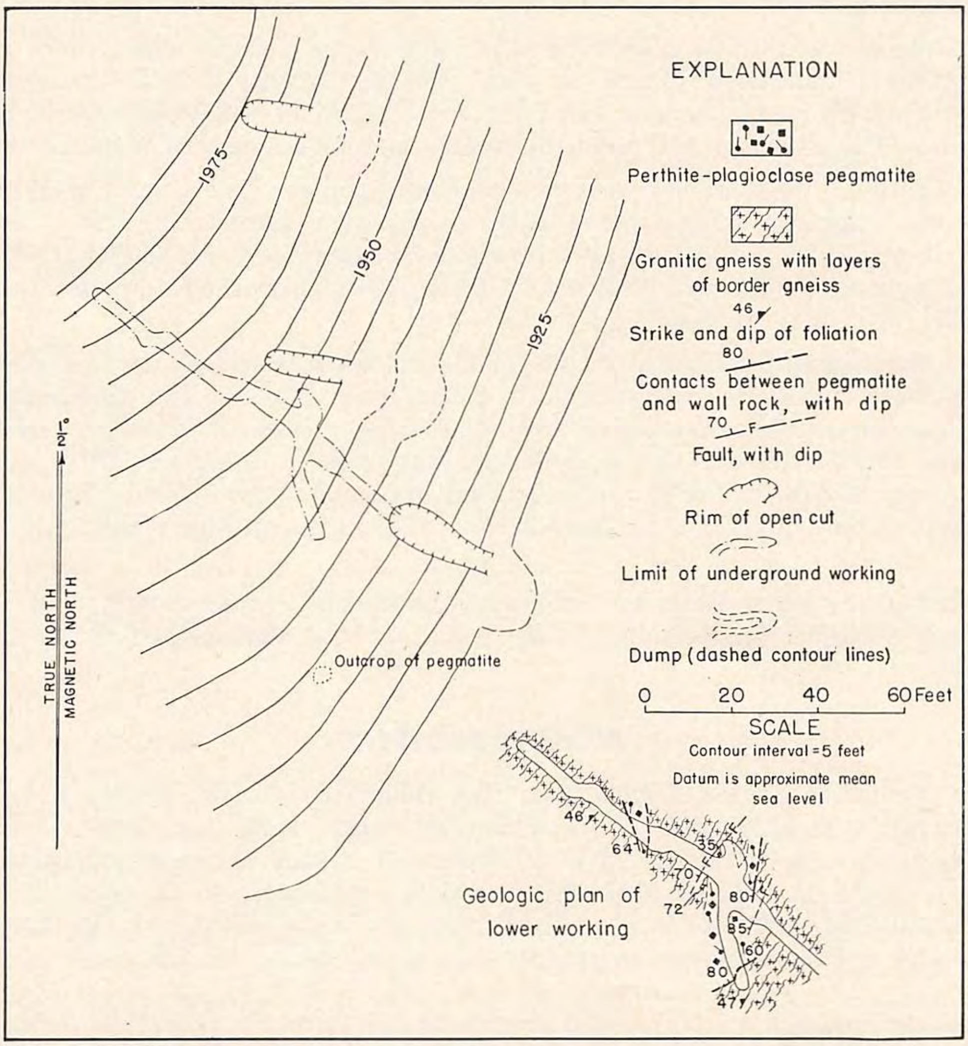


FIGURE 13. SKETCH MAP OF WORKINGS AT THE MASON PROSPECT AND GEOLOGIC PLAN OF LOWER WORKINGS.

slope of the ridge south of the owner's house. The lower of the two adits was driven by Mr. W. J. Alexander in 1941 or 1942. An open cut 26 feet long leads to the adit, which is 86 feet long. Both open cut and adit trend about N. 55° W. Twenty-six feet from the portal a drift 22 feet long extends southward from the adit, and another extends 10 feet northward. The upper two adits were made by Mr. Mason. Neither was accessible at the time the prospect was examined.

In the middle open cut, which is 20 feet long, 5 to 6 feet wide, and 6 feet in maximum depth, a tabular pegmatite body 7 feet thick is exposed. The hanging wall of the body strikes N. 14° W. and dips 66° SW. Adjacent to this is a half-inch border zone of plagioclase-quartz pegmatite with accessory biotite. This zone grades inward into a 1-foot wall zone of medium-grained plagioclase-quartz-pegmatite, which passes in turn into a 2½-foot intermediate zone of coarse plagioclase-quartz-perthite pegmatite. The core of the pegmatite consists of coarse perthite-quartz pegmatite with accessory biotite in slablike crystals. The remainder of the pegmatite to the footwall is so thoroughly decomposed that its internal structure cannot be determined. The wall rock is interlayered granitic gneiss and border gneiss.

The uppermost open cut, now badly slumped, appears as a trench 15 feet long, 7 feet wide, and 7 feet deep. The west contact of pegmatite with wall rock is exposed; it strikes N. 22° W. and has an average dip of 47° SW. Pegmatite is exposed for 5 feet below this contact, but the footwall contact is concealed. The pegmatite resembles that in the middle cut. The wall in the upper open cut consists of interlayed micaceous quartzite and quartz-mica schist.

The portal of the adit in the lower working is in interlayered granitic gneiss and border gneiss, and these rocks enclose the pegmatites shown in the plan. The geology has been sketched on the plan with a minimum of control. Both pegmatite and wall rocks are thoroughly weathered and cut by a large number of landslip surfaces. The workings are decidedly unsafe, and inspection was made as brief as possible.

As shown in figure 13, the adit intersects two pegmatite bodies. The larger, an irregular lens trending nearly north and dipping west, is exposed in the drifts for a distance of 32 feet. It has a maximum exposed width of 10 feet. The other pegmatite trends north-northwest, dips steeply west, and is 3 to 4 feet thick. The larger pegmatite body is intersected by three faults that trend north-northeast to east-northeast and dip steeply west or northwest.

In contrast to the pegmatites exposed in the middle and upper workings, the two bodies in the adit consist entirely of coarse to very coarse (crystals up to 4 feet long) perthite and plagioclase, the plagioclase completely kaolinized, the perthite little affected by weathering. Biotite and fine-grained muscovite are the only other minerals. The writer was unable to find a single grain of quartz in either pegmatite, although the dump shows pieces of quartz similar to those found in perthite-quartz zones. The feldspars have ragged boundaries against one another. It is possible that in part the original plagioclase formed by replacement of perthite.

Whether either of the pegmatite bodies intersected by the adit is connected upward with the pegmatite exposed in the other workings is uncertain. In any event, no large tonnage of feldspar appears to be present at the prospect.

NICHOLS PROSPECT

On the divide separating Bryson Branch from Toot Hollow Branch, 3,100 feet N. 62° E. of Franklin Grove Church, there is a pegmatite that was evidently prospected many years ago for kaolin (pl. 1, no. 24). The part of the pegmatite body on the land of W. C. Nichols of Bryson City was prospected for feldspar by Mr. Nichols early in 1947. In January 1947 the old workings consisted of an open cut and three cross-trenches extending 250 feet N. 75° W. from a point 75 feet east of the ridge crest. By April 1947 a bulldozer had been used to clean out the westernmost cross-trench, so that nearly the full width of the pegmatite was exposed.

The pegmatite is evidently a steeply dipping tabular body strking about N. 75° W. and cutting granitic gneiss. In the westernmost trench, the only place where the pegmatite is exposed to any extent, the north wall of the body dips 82° S., and the south wall dips 62° N. The attitudes of the contacts therefore suggest that the pegmatite pinches out downward, but only a few feet of each contact is exposed.

The exposed width of the pegmatite in the trench is about 27 feet. Along the north wall there is a 1- to 2-inch border zone of fine- to medium-grained plagioclase-quartz-perthite pegmatite. Inside this zone is a wall zone of medium- to coarse-grained blocky plagioclase with minor amounts of blocky perthite and quartz. This zone is succeeded by an intermediate zone of medium- to coarse-grained plagioclase with quartz in graphic intergrowth, accompanied by scattered crystals of perthite. Next is an inner intermediate zone (core margin zone) 7 feet thick, composed of perthite crystals up to 2 feet in diameter, with subordinate interstitial quartz. The apparent core of the pegmatite is 7 feet wide and consists of massive quartz with sparsely scattered crystal of perthite. The remainder of the pegmatite, between the core and the south wall, was covered with debris to such an extent that its internal structure could not be determined. It is about 9 feet wide and appears similar in general to the feldspathic zones north of the core, except that kaolinized plagioclase appears in the core-margin zone.

All plagioclase originally present in the pegmatite has been weathered to kaolin, and even the perthite has become friable.

Little can be seen of the pegmatite outside the trench. Scattered blocks of massive quartz are strewn over the surface for 30 feet westward along strike, and massive quartz evidently derived from the core forms an outcrop at the summit of the ridge, 150 feet eastward along the strike. The width and full length of the pegmatite body are still largely unknown. Information available does not suggest the presence of a pegmatite body large enough to yield any great tonnage of feldspar, but small-scale operations in the core-margin zone below the limit of kaolinization of plagioclase might yield a moderate tonnage of high-grade material. Before the possibility can be accurately appraised, however, systematic prospecting to determine the extent, continuity, and average thickness of the core-margin zone should be done.

BALL NO. 1 MINE

The Ball No. 1 mine (pl. 1, no. 25) lies 1,850 feet N. 70° W. of Watkins cemetery, on the slope overlooking the road that extends west of the cemetery. The land is owned by Mrs. Lura Ball of Bryson City. The Blue Ridge Mining Co. leased and operated the property in 1938 and 1939 and made two adjoining open cuts. The north cut is now about 55 feet long, 25 to 50 feet wide, and 35 feet in maximum depth. A crosscut at the northeast corner of the working gives access to the floor. Much material has slumped from the walls, and the original depth is uncertain. The south open cut trends N. 78° E. It is 65 feet long, 10 to 30 feet wide, and probably 40 feet in maximum depth.

The pegmatite is a steeply dipping body that is about 27 feet thick in the northern part of the north open cut. In this cut the east contact of the pegmatite strikes N. 13° W. and dips 85° E.; the west contact strikes N. 31° E and dips 72° to 88° E. Upward from the floor of the open cut the west contact is displaced eastward by successive gently dipping landslip surfaces. The ground north of the open cut is broken, and it is evident that much of the hill slope has been involved in landsliding.

The pegmatite shows a thin border zone of fine-grained plagioclase-quartz-perthite pegmatite. The remainder of the material exposed is a coarse to very coarse mixture of plagioclase, quartz, and perthite, with abundant accessory biotite in strip-shaped crystals and scattered books. The feldspars occur in crystals with quartz in graphic intergrowth and also in crystals partly or entirely free of intergrown quartz. Graphic intergrowths of plagioclase with quartz are abundant. The material exposed in the south open cut is similar.

The wall rock in the north open cut is border gneiss. In the south open cut the east wall of the pegmatite is granitic gneiss. The west wall is not exposed but is probably border gneiss. The foliation of the border gneiss in the north cut strikes N. 34° E. and dips 85° to 89° W. It is evident that the pegmatite is a discordant body cutting across the local trends of the belts of older rocks.

Both wall rocks and pegmatites are in an advanced stage of weathering. Plagioclase has been wholly converted to kaolin, biotite is partly oxidized to limonite and altered to clay, and the wall rocks are soft and crumbly.

According to local report, mining was discontinued owing to the failure to discover a shoot of high-grade feldspar. Much of the feldspar in the pegmatite is so heavily intergrown with quartz that even if unweathered it would not yield a satisfactory proportion of commercial feldspar.

Eighty feet S. 22° W. of the south open cut is a small pit in a narrow lens of pegmatite that strikes N. 46° W. and dips 73° NE. The pegmatite cuts across the contact of border gneiss and granitic gneiss, the contact and the foliation of the gneisses striking N. 47° E. and dipping 75° NW. The pegmatite is a coarse mixture of plagioclase, perthite, and quartz, with the coarsest material in the center of the lens.

HANS MINE

The Hans mine (pl. 1, no. 26), also known as the Thomas mine, lies 2,600 feet N. 38° W. of Mount Carmel Church, at the end of a high spur overlooking the valley of Messer Branch. According to Mr. G. L. Crisp of Bryson City, the mine was worked for kaolin by Doc* Hans from 1918 to 1920. The clay was mixed with water and flumed down Messer Branch to Buckner Branch, thence down Buckner Branch to its mouth and across the Tuckasegee River to a small plant on the north bank beside the railroad. The clay was formed into small blocks at the plant.

Workings consist of a northeasterly trending open cut roughly 240 feet long, 50 to 150 feet wide, and 15 to 50 feet deep. Three crosscuts through the east side of the open cut furnish access to the floor. There are said to be a series of shafts sunk in the floor of the cut, but they are concealed beneath debris. A short distance south of the open cut is a trench, 15 feet long and 9 feet wide, trending parallel to the cut and probably leading to a short adit.

The country rock at the mine consists of weathered interbedded mica quartzites and quartz-mica schists. At the south end of the cut the foliation of these rocks strikes N. 13° E. and dips 73° W.; in the north crosscut the foliation strikes N. 20° E. and dips 75° W. A series of lenses of pegmatite enclosed in these rocks appears to have been worked in the mine. Four lenses, each ranging in thickness from 1 foot to 12 feet, were exposed in the walls of the main cut and in the crosscuts at the time of inspection. The largest, exposed in the north and middle crosscuts, apparently ranges from 1 foot to 12 feet in thickness. In the middle crosscut it strikes N. 43° E., dips 56° to 77° NW., and is concordant in general with the foliation of the enclosing metasedimentary rocks. In addition to a thin border zone, it shows a wall zone 1 foot to 2 feet thick composed of medium-grained plagioclase-quartz pegmatite with accessory muscovite. Inside this zone is an apparent core of blocky perthite and plagioclase with subordinate quartz and accessory muscovite in ruled striplike crystals up to a foot long and an inch thick. The part of the pegmatite along the hanging wall (northwest wall) is obscured by debris, but apparently the wall zone is present there as it is along the footwall.

Whether larger bodies of pegmatite were found in the open cut during mining is not known. Present exposures in the workings offer little encouragement to the feldspar prospector.

HARRISON T. CRISP PROSPECT

The Harrison T. Crisp prospect (pl. 1, no. 28) lies 2,100 feet N. 80° W. of Mount Carmel Church on land owned by Mr. Harrison T. Crisp of Bryson City. The prospect lies on the south slope of the first valley north of the valley of Gibby Branch. Development work was done by the owner in 1946.

The main working is an adit, the portal of which is just above the bottom of the valley. The adit extends 65 feet S. 60° W. into the south wall of the valley. At 22 feet from the portal a 27-foot drift runs N. 47° W.; and at 46 feet, a 37-foot drift runs S. 32° E. A series of pits extends 300 feet S. 24° W. up the wall of the valley from the main working. One or more of these pits may be entrances to adits, now caved, that were evidently run many years ago.

The workings suggest a single pegmatite body trending obliquely across the strike of the enclosing rocks. Pegmatite is exposed in contact with metasedimentary rocks in the northwest drift in the main working. The contact is uneven but has an average strike of N. 11° E. and an average dip of 80° W. The same contact was intersected 11 feet from the southwest end of the main adit. There it strikes about N. 35° E. and has a steep northwesterly dip. Rolls of the contact plunge gently southwest. In one of the southernmost pits pegmatite is exposed in contact with granite gneiss.

The metasedimentary rocks adjacent to the contact in the main working in places are injected *lit-par-lit* by pegmatitic material. The pegmatite has only an indistinct zonal structure. A 1-inch border zone of fine-

*True name, not nickname or title.

grained pegmatite is present adjacent to the contact. This zone is succeeded inward by a vaguely defined wall zone, 1 to 2 feet thick, composed of medium- to coarse-grained plagioclase-quartz-perthite pegmatite with minor amounts of biotite, in striplike crystals and accessory small red garnet crystals. Graphic intergrowths of both soda and potash feldspars with quartz are abundant. The perthite crystals are as much as 3 feet in length. This material composes the walls of the southeast drift and the walls of the remainder of the workings except as noted above.

The thickness of pegmatite exposed in the main working is between 30 and 35 feet, and the footwall contact is not exposed. The arrangement of pits south of the main working suggests a body of comparable or greater width, but exposures are too poor to give much information on the structure of this part of the pegmatite. A series of trenches across the strike of the pegmatite would entail little effort and would at least serve to determine whether a body of feldspar of commercial grade is present at surface level. The material exposed in the main adit is not of commercial grade.

OGLE MINES

The Ogle mines are located in the upper part of the valley of Buckner Branch, on land owned by Mr. M. C. Ogle of Bryson City. The lower mine (pl. 1, no. 29) is 1,375 feet N. 4° E. of Ogle Knob, the upper mine (pl. 1, no. 30) is 1,250 feet due north of the knob. According to Mr. Ogle, the mines were worked many years ago for kaolin by a man named Frost. The mines may be the ones referred to by Bayley[54] as worked by the Carolina Clay Co. some years prior to 1918. No production data are available, but the yield was probably not great.

The lower mine consists of an open cut about 85 feet long, 60 feet wide, and 8 to 40 feet deep, trending N. 75° W. into a hill slope. The headwall of the cut is composed of weathered granitic gneiss. Pegmatite is exposed for a distance of only 8 feet at the base of the headwall. The exposure is entirely massive quartz except for a crystal of perthite, 2 by 2 feet in size, near the north end. The dumps, however, show much perthite of good quality and suggest the possibility that a perthite-rich zone is present in the pegmatite.

The floor of the pit is approximately at the level of the branch and is separated from it by only a low ridge of debris. The drainage problem presented has thus far discouraged prospecting for feldspar. An additional difficulty is the unstable condition of the ground back of the headwall of the cut. The ground surface shows a number of low landslide scarps, and it is clear that a large part of the hillside is involved.

The upper mine consists of an open cut trending S. 50° W. for 160 feet from its entrance. It is 15 to 75 feet wide, and 5 to 50 feet deep; maximum depth and width are at the southwest end. The northeast end and middle part of the cut are in granitic gneiss; the southwest end is in garnet-muscovite schist. At the contact, the schists are interlayered with muscovite granite gneiss through a thickness of 2 feet.

Aside from a few narrow stringers of pegmatite in gneiss and schist, no pegmatite is exposed in the walls of the cut. The dumps, however, show pieces of massive quartz up to 1 inch in diameter, numerous pieces of perthite an inch or less in diameter, and fragments of kaolinized plagioclase. Exposures of the wall rock indicate that whatever pegmatite was worked must have been less than 20 feet thick over a substantial part of the length of the cut.

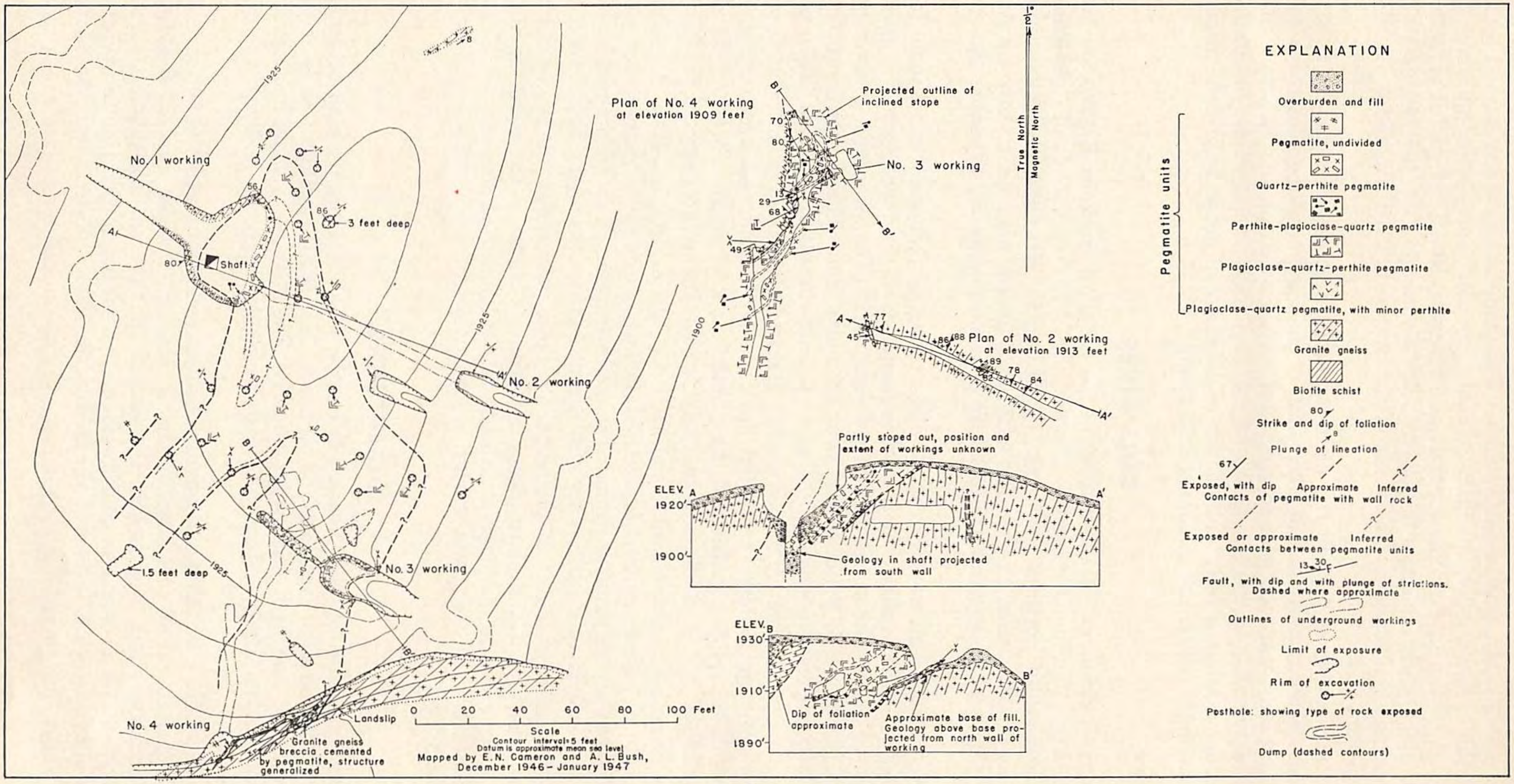
DEHART MINE

The DeHart mine (pl. 1, no. 33) lies about 350 feet N. 31° W. of the position of Jackson Line Church (now moved) as shown on the map. It is on land owned by Mr. Daniel DeHart and is accessible from U. S. Highway 19 via gravel road leading to the owner's house. The mine was opened and operated by Mr. W. J. Alexander in 1939 and part of 1940. About 300 tons of high-grade potash feldspar was produced and shipped to Spruce Pine, N. C.

The main or No. 1 working at the mine consists of an entrance cut extending 60 feet S. 60° E. to a partly filled northeast-trending open cut 44 feet long, 32 feet in maximum width, and 23 feet in maximum depth (pl. 19). A partly timbered shaft was sunk in the floor of the open cut to a depth reported as 20 feet, and from the bottom a drift 6 feet in width is said to extend in a southerly direction for a distance of about 100 feet. The shaft was filled to within 13 feet of the surface in 1946. A drift into the southeast side of the

[54] Ries, H., Bayley, W. S., and others, High-grade clays of the eastern United States: U. S. Geol. Survey Bull. 708, p. 44, 1922.

PLATE 19.



DEHART MINE
Swain County, North Carolina
GEOLOGIC MAP, PLANS, AND CROSS SECTIONS

open cut was caved and inaccessible. Ninety feet S. 65° E. of the open cut is the No. 2 working, an adit with portal at 1,914 feet. The adit extends N. 65° W. for 80 feet, at this point apparently connecting, by means of a small hole, with the caved working run from the open cut. The No. 3 working is a small open cut that leads to an incline extending downward 32 feet N. 22° W. at an angle of about 20°. A trench extends 17 feet N. 50° W. from the headwall of the open cut. The No. 4 working is an adit with portal southwest of the No. 3 working. It extends nearly north for 50 feet. At 40 feet from the portal, a sinuous, curving adit extends about 60 feet northeast and north, at which place it is blocked by fill. Six feet from the end a raise extends 14 feet upward to the east at an angle of 35°, expanding into a small chamber. At 10 feet and 20 feet south of the raise, short crosscut drifts have been run eastward from the main drift. Another small open cut west of the No. 2 working and three shallow pits complete the feldspar workings. Twenty-three postholes were put down in the course of mapping in order to outline the pegmatite and obtain additional information on its composition and internal structure.

The principal pegmatite on the property is a north-trending body about 220 feet long and 90 feet in maximum width. About half-way along its length a branch about 25 to 30 feet wide extends southwest from the main body for a distance of at least 60 feet. The No. 1 and No. 2 workings are in the northern part of the pegmatite, but the drift run southward from the shaft in the main working may lie partly in the branch. The No. 3 and No. 4 workings are in the main body south of the point at which the pegmatite divides. Just south of the division point the main body appears to be 70 feet in maximum width, but it tapers irregularly southward toward the portal of the No. 4 working.

The north part of the pegmatite is a blunt-nosed, discordant semi-lens with footwall dipping 33° to 45° W. and hanging wall dipping 56° to 68° W. The southern part of the main body is apparently much less regular in form. Both walls are highly irregular where exposed, and dips and strikes of the contacts vary widely within short distances. Although the outcrop width of the pegmatite is as much as 70 feet, the true thickness is probably nowhere more than 35 or 40 feet. At its southern end the pegmatite appears to fray out. Exposures in the cut-bank at the southern limit of the area mapped show an irregular network of pegmatite stringers, probably offshoots from the footwall of the main body. At 9 feet from the portal of the No. 4 working, the footwall intersects the adit floor. From this point to 22 feet from the portal it lies in places below the floor. At 22 feet it finally slopes downward beneath the floor, the contact there striking N. 82° W. and dipping 35° N. As shown in the plan of the working on plate 19, the hanging wall also is highly irregular. Many of the variations in the attitude of the contact are clearly fracture-controlled.

The wall rock is a medium-grained linear to platy biotite granite gneiss. In the No. 2 working the irregular lower end of a pendant of biotite schist, 5 feet in maximum thickness, is exposed. Foliations in the schist and the gneiss are parallel, even where the contact of the two is nearly perpendicular to the foliation. The foliation of the granite gneiss within the area mapped strikes north to northeast in general and dips steeply west, but in part of the No. 4 working the strike is northwest and the dip steep southwest. Both gneiss and biotite schist are in an advanced stage of decomposition throughout the workings.

A posthole 50 feet northwest of the trench at the No. 3 working disclosed a westward-dipping contact of pegmatite and granite gneiss. Nothing of the extent of this body or its relation to the main body is known. Probably it is of no great size.

The main pegmatite consists of five zones: border and wall zones of plagioclase-quartz pegmatite with minor perthite, an outer intermediate zone of plagioclase-quartz-perthite pegmatite, an inner intermediate zone of perthite-plagioclase-quartz pegmatite, and a core of quartz-perthite pegmatite. The border zone is a 1/4-inch to 1-inch layer of plagioclase-quartz-perthite pegmatite with accessory biotite. Contacts of the zone with granite gneiss are commonly sharp, but in a few places in the No. 4 working the contact is gradational over a width of 1/4 inch. The wall zone of the pegmatite is discontinuous. It is lacking entirely in the No. 1 working, but is present elsewhere and ranges from 1/2 foot to 1 1/2 feet in thickness. It is medium- to coarse-grained (grain size 1/2 inch to 5 inches) and composed essentially of massive plagioclase and quartz, with scarce crystals of perthite, scattered flakes of biotite up to 1 inch broad and 1/4 inch thick, and accessory garnet in crystals up to 1 inch in diameter. In places the zone consists almost entirely of massive plagioclase.

The outer intermediate zone is 4 to more than 15 feet thick and is composed of coarse-grained to very coarse-grained plagioclase-quartz-perthite pegmatite with accessory to minor biotite and accessory garnet.

Plagioclase forms crystals up to 3 feet in diameter, massive or in irregular to graphic intergrowth with quartz. Biotite forms striplike crystals up to 1½ feet long, 4 inches broad, and ½ inch thick. Muscovite is present in the north end of the No. 4 working in aggregates of small books, and in separate books up to 2 inches broad. It is ruled, reeved, and cross-fractured, and fit only for mica scrap.

The inner intermediate zone is composed of perthite-plagioclase-quartz pegmatite. It consists of two main segments, one forming a discontinuous envelope around the segment of the core exposed by the No. 1 working, the other a similar envelope around the core segment explored in the No. 3 and No. 4 pegmatites.

The segment of the inner intermediate zone exposed in the north workings consists of massive plagioclase and perthite crystals up to 3 feet long and 2 feet broad, with subordinate interstitial quartz. The zone has a maximum thickness of at least 6 feet; it may have been thicker in mined-out parts of the pegmatite. Only the part of the zone on the hanging-wall side of the core is exposed. The core beneath it is a mixture of stout perthite crystals 3 feet to 6 feet long embedded in massive coarse quartz, which composes areas of the face of the open cut ranging from 1 foot by 3 feet to 6 by 5 feet. Perthite and quartz are present in approximately equal proportions. Along its margins, strips, fans of strips, and slabby books of biotite 8 by 4 inches by ½ inch, up to 18 by 8 inches by 1 inch, cut quartz and feldspars along intersecting fractures. The keel of the core appears to be exposed in the shaft in the floor of the No. 1 working (section A-A', pl. 19), and calculation from this and from the data obtained in mapping would appear to indicate that the core is plunging about 40°-45° in a direction near S. 45° W. According to Mr. Alexander, the core and accompanying inner intermediate zone were followed by a tunnel southward for nearly 100 feet, at which point feldspar-rich rock pinched out. The course of this tunnel is uncertain. Material apparently belonging to the quartz-perthite zone was struck in a posthole put down 48 feet S. 18° E. of the shaft, but was found nowhere else in the vicinity. From this fact it appears that the feldspar-rich zones exposed in the No. 1 working extend southward into the southwest branch of the pegmatite. In any event, they appear to be isolated from the segments of the two innermost zones exposed in the No. 3 and No. 4 workings.

The core segment exposed in the No. 3 and No. 4 workings is an extremely irregular lens that ranges in thickness from a few inches to perhaps 8 feet, strikes north to N. 40° E., and dips 10° to nearly 55° W. to NW. It is similar in composition to the core segment of the north workings, but the ratio of quartz to perthite varies. The quartz varies from gray and glassy to light gray, milky, and banded. The banding is exposed only at one point in the No. 4 working. At this point the core dips 10° NW., whereas the banding strikes N. 40° E. and dips 25° NW. The northern edge of the core was intersected in the inclined raise and small chamber at the northern end of the working, where it appears to plunge about 55° approximately west-southwest. Twenty-four feet south of the inclined raise, the pegmatite is offset eastward by an oblique-slip reversal fault, with the downthrow on the north side. The offset part of the pegmatite appears in the walls of the drift 19 feet from the junction of drift and adit. Adit and drift appear to lie along the keel of the core, which here is nearly horizontal. In the west wall of the adit the core appears to be wedging out.

Perthite-plagioclase-quartz pegmatite similar to that in the north working forms a zone ½ to 1 foot thick along the core in the No. 4 working, but is absent in the No. 3 working. At one point, thin offshoots of the core quartz extend into fractures in the marginal feldspar crystals.

An odd feature of the pegmatite is the occurrence of a lens of quartz margined with massive plagioclase and perthite and fracture controlled biotite in the wall zone of the pegmatite in the No. 2 working (section A-A', pl. 19). The lens has a maximum length, parallel to the dip, of at least 5 feet, and a maximum thickness of 18 inches. Exposures give no explanation of this anomalous occurrence. The body does not appear to be fracture-controlled.

Aggregates of greenish, fine-grained muscovite disseminated in kaolin appear to have been formed at the expense of perthite in a few places. In the adit of the No. 4 working, there is a striking development of closely spaced garnet crystals along planar to sinuous surfaces that cut the pegmatite at high angles to the zonal structure. The principal planes strike N. 28° E. and dip about 70° NW. At one place in the adit, the garnets are thickly disseminated in feldspathic pegmatite along an inch-wide fracture-filling of quartz 1¼ feet long. Garnet also is abundant here in scattered crystals 1/16 inch to 3 inches in diameter and in aggregates of crystals up to 5 inches by 1 by ¼ inch. Garnet is evidently in large part a late mineral. Similar planar distribution of garnet is shown at several places in the drift.

Kaolin.—Except in the shaft in the No. 1 working, where plagioclase is only partly altered, all plagioclase in the exposed parts of the pegmatite is completely kaolinized, and in many places weathering of perthite is sufficiently advanced so that the feldspar crumbles readily. The amount of kaolin present in the deposit is not readily estimated, but it seems unlikely that any large tonnage is present in so small a pegmatite body. Some of the kaolin is white and apparently pure. Most is intergrown with various proportions of quartz, and some is stained by limonite or iron oxides, or both, derived from garnet and biotite.

Feldspar.—Feldspar obtained from the DeHart mine in 1939 and 1940 is said to have been of high quality. Most of the production was from the No. 1 working. As plagioclase has been entirely kaolinized in most of the workings, the feldspar must have been entirely or almost entirely perthite. Perthite in the mine ranges from cream white where nearly fresh to buff where weathered. Limonite stains many crystals along crystal boundaries, fractures, and cleavage surfaces, but it is not a serious defect, as much of this stain would be lost in crushing and washing.

Development work in the southern part of the pegmatite has failed to discover perthite-quartz-plagioclase and quartz-perthite zones of sufficient size to repay mining under current conditions. These zones are thicker in the north workings, and depending on how far they extend downplunge with the same thickness, may still contain a moderate tonnage of high-grade feldspar. At depth, moreover, as the bottom of the zone of weathering is reached and unaltered plagioclase appears, the proportion of recoverable feldspar in the perthite-plagioclase-quartz zone should rise. Some feldspar remains between the surface and the bottom of the drift run south from the shaft; this would have to be extracted by stripping and open-cut mining, but Mr. Alexander states that no stoping could be done from the drift because of the decomposed condition of the pegmatite.

The location of reserves at depth depends on the plunge of the pegmatite. If the plunge suggested by mapping is correct, the feldspar-rich zones would be found farther south on each successively deeper level.

PAYNE AND SULLIVAN MINE

The payne and Sullivan mine (pl. 1, no. 35) lies 3,700 feet N. $5\frac{1}{2}^{\circ}$ E. of Cold Spring Church, on the crest of the ridge east of Davis Branch. The mine is probably one of a group referred to by Pratt[55] as Hugh J. Sloan's mines on the property of A. J. Cunningham. Pratt reports that operation began in July 1916 and were still in progress a year later. Clay from the mines was trammed to the head of a flume 800 feet long, which carried the clay down the mountainside to a washing and pressing plant. The dried pressed kaolin was hauled by trams a mile to a siding on the Alarka Valley Railroad (on old lumber railroad). The mine here discussed as the Payne and Sullivan mine is apparently that described by Pratt as the vein first worked.

Bayley[56] visited the mines in 1918, describing them under the name of Payne and Sullivan mine. He stated that the mines had been closed down by the previous lessees (presumably Sloan) several years before his visit, after some 250 tons of washed kaolin had been recovered. Bayley's pit No. 1 is the main working described below.

The main working is an open cut 190 feet long, 20 to 50 feet wide, and about 35 feet in maximum depth. There is much debris over the floor. Bayley states that the kaolin was mined out to a maximum depth of 65 feet except at the southwest end of the excavation, where terrace-like benches were left about 40 feet above the bottom of the pit. At the time the mine was abandoned material was being removed from the terrace with the aid of two shafts. At the west end of the terrace there was a cliff 40 feet high pierced by a tunnel. Both cliff and tunnel were said to show kaolin. Slump has destroyed all evidence of tunnel and shafts. Bayley states that the southeast contact of pegmatite with the enclosing granitic gneiss was vertical so far as uncovered. The internal structure of the pegmatite, as exposed in 1947, likewise suggests a vertical body. Bayley states that the width of the deposit was 40 or 45 feet, but it is not clear whether by "deposit" he meant the whole pegmatite or merely the part worked for kaolin. The former would appear the more probable. The present exposed width, which does not include the southeast part of the pegmatite, is about 18 feet.

[55] Pratt, J. H., The mining industry in North Carolina during 1913-17, inclusive: North Carolina Geol. and Econ. Survey, Econ. Paper no. 49, pp. 147-149 (report by J. E. Smith), 1919.

[56] Ries, H., Bayley, W. S., and others, High-grade clays of the eastern United States: U. S. Geol. Survey Bull. 708, p. 44, 1922.

Along the west side of the pegmatite there is a wall zone 1 foot to 2 feet thick composed of medium-grained plagioclase and quartz with accessory biotite in books 1/4 to 1 inch broad. Inside this zone is an intermediate zone 2 to 3 feet thick composed of coarse, blocky plagioclase and perthite, plagioclase and perthite in graphic intergrowth with quartz, and accessory biotite in small striplike crystals. Inside this zone, in turn, is a core-margin zone, a few inches thick, composed of kaolinized blocky plagioclase. The core of the pegmatite, 5 to probably 12 feet thick, is composed of massive quartz containing scattered stout crystals of perthite up to 5 feet in length. The core has been left in mining, and forms a prominent rib extending 100 feet along the center of the working. The southwest end of the core is concealed.

The open cut is deepest southeast of the core, indicating that this was the kaolin-rich part of the pegmatite. Whether this part of the pegmatite is sufficiently rich in feldspar below the limit of weathering cannot be determined. Parts of the pegmatite exposed at the time of visit offer little encouragement to the feldspar prospector.