ECONOMIC GEOLOGY OF
SOME PEGMATITES
in Topsham, Maine

BY

V. E. SHAININ

U. S. Geological Survey

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Director, U. S. Geological Survey

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Maine Geological Survey
Joseph M. Trefethen, State Geologist
Maine Development Commission
Augusta, Maine
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INTRODUCTION

For nearly a century feldspar has been produced from pegmatites in a belt eight miles long and slightly more than a mile wide, extending from the Androscoggin River at the village of Topsham (Fig. 1), north-northeast to the village of Bowdoinham. Brief descriptions of the feldspar mines have appeared, and unusual minerals occurring in them have been studied, but no detailed investigation of the geology of the belt nor of the pegmatites and their feldspar deposits has been made. The present investigation was undertaken by the State and Federal Geological Surveys to provide information on the composition and mode of occurrence of the feldspar deposits; on the form, character and distribution of the productive pegmatites; and on the relationships of the productive pegmatites to the other rocks of the belt. This report presents the results of the field study, which is to be supplemented later by laboratory investigations.

The pegmatite belt is in an area of low relief; most of it is heavily wooded and some is swampy. It is drained by tributaries of the Androscoggin and Kennebec Rivers, the most important of which, the Cathance River, traverses the belt about three miles from its southern end. Over considerable parts of the belt, glacial drift covers the bedrock, but exposures are numerous in places on the broad ridge extending through Mount Ararat (Fig. 2) parallel to the belt and on a lower parallel ridge along the east side of the belt. The area is readily accessible by means of passable dirt and gravel roads leading into it from paved highways east and west of the belt. The main line of the Maine Central railroad passes through Brunswick, immediately south of the area, and a branch line runs north-northeast from Brunswick along the east side of the area.

FIELD WORK AND ACKNOWLEDGMENTS

The investigation was a cooperative project of the Maine Geological Survey and the U. S. Geological Survey. Approximately three months was spent in the field. An area of one and a half square miles in the southern part of the pegmatite belt was mapped by pace and compass methods on a base map (scale 1,320 feet to 1 inch) compiled from aerial photographs and from the U. S. Geological Survey topographic

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FIGURE 1, INDEX MAP SHOWING LOCATION OF TOPSHAM AREA AND OF THE THREE QUARRIES MAPPED IN DETAIL
map of the Bath quadrangle. Traverses were closely spaced, and intervening areas were systematically examined. All pegmatite bodies of sufficient size to be shown on the scale employed were mapped, and all others exposed were studied. Parts of three pegmatite mines were mapped by plane table and telescopic alidade on scales of 20 and 40 feet to 1 inch, and the pegmatites mined were studied in detail.

Field work was in charge of the author, of the U. S. Geological Survey, and was done under the general supervision of Mr. E. N. Cameron, who made many valuable suggestions in the field and during preparation of the report. Mr. Harry Perry, of the Maine Geological Survey, served as field assistant. The author wishes to express his appreciation of the wholehearted cooperation given by Dr. Joseph M. Trefethen, State Geologist of Maine. Messrs. Winthrop Staples and Joseph Brannigan, of Consolidated Feldspar Company, Inc., gave freely of their own time to assist the author’s inquiries into the history and technique of mining and milling in the district.

PREVIOUS WORK

Bastin\(^1\) described some of the pegmatite quarries in the Topsham area in 1911, and soon afterward Katz\(^2\) studied the stratigraphy of an area in southwestern Maine that extends nearly to the Topsham district. Burbank\(^3\), Palache\(^4\), and Gonyer\(^5\) have described minerals from a cavity in a pegmatite located in the Topsham district immediately north of the area mapped in the course of the present study. Gonyer\(^6\) and Kroupa\(^7\) have analysed samarskite and monazite, respectively, from pegmatites in Topsham and the age-determinations made from these analyses are discussed in this bulletin under “Geologic History.” Minerals occurring in a pegmatite on Standpipe Hill have been described by Yedlin\(^8\). Fisher\(^9\)’s studies of the structure and metamorphism of the Lewiston region, which includes the Topsham area, have thrown light on the broader geologic relations and have provided a background for the present study.

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EXPLANATION

Pegmatite showing dip (Letter "G" indicates localities in which bodies of granite occur in pegmatite)

Aplite
Showing strike of foliation

Pejepscot gneiss
(Biotite- and hornblende-gneiss, granitized biotite-gneiss, and small bodies of granite-gneiss)

Contact, inferred

Strike and dip of foliation

Pitch of lineation

Strike and dip of foliation with pitch of lineation

Pitch of minor folds (straight arrow), and dip of axial plane of overturned minor folds

Pitch of crest of pegmatite

Feldspar mine or prospect

SECTION A-A' SHOWING INFERRED STRUCTURE

FIGURE 2, GEOLOGIC MAP OF PART OF THE TOWN OF TOPSHAM, MAINE

Geology by V.E.Sh
HISTORY OF MINING

The Topsham area has been prominent among the pioneer feldspar-producing districts of New England. Two conditions were responsible: nearness to the coast, and ease of transportation to ceramic plants near the Atlantic seaboard, chiefly at Trenton, New Jersey. Transportation of feldspar from Maine to Trenton by water was both easy and cheap, and the Topsham district and other districts located on tidewater held a distinct advantage over districts farther inland.

The first feldspar mining in Maine was done between 1852 and 1860 by a Mr. Jordan, who worked the property of John W. Fisher in Topsham. In the late 1860's a Mr. Carr of Grafton, West Virginia, worked one season at the quarry Jordan had begun, then sold it to Golding Brothers of Trenton, New Jersey. In the meantime, W. D. Willes was operating quarries on the Fisher property, and about 20 years later he purchased the original Jordan quarry. In 1872 the Trenton Flint and Spar Company built the first feldspar mill in Maine on the Cathance River in Topsham. For many years it was the only feldspar mill in Maine and it was being operated in 1945 by the Topsham Feldspar Company. From 1860 to the early 1880's, all feldspar produced in the district was packed in barrels, shipped by scow to Bath, Maine, and transferred there to sea-going vessels for shipment to Trenton, New Jersey. Since the early 1880's shipment has been chiefly by rail.

From 1902 to 1929 the Maine Feldspar Company, Topsham, bought most of the feldspar produced in the district. In 1929 the company consolidated with the Golding Company, Trenton, and other companies, to form the Consolidated Feldspar Company, Inc., which now has a mill in the village of Topsham. Records of production are fragmentary. The output of the district is said to have been small (probably 1,000 to 2,000 tons per year) immediately after World War I, but production increased from the early 1920's until 1929. Production in the late 1920's is reported to have been approximately 12,000 tons yearly. Production was small during the depression of the early 1930's but gradually increased to about 5,000 tons per year in the late 1930's. In the early 1940's the output was approximately 7,000 tons per year, and the annual output was approximately 10,000 tons in the late 1940's.

MILLING TECHNIQUES

The methods used in the old mill of the Trenton Flint and Spar Company in the latter part of the 19th century are typical of the early techniques employed in New England. The equipment consisted of a jaw crusher, three wet grinding pans, three settling tanks at different elevations and a large flat-topped kiln of brick where the settlings were dried.

The mine-run feldspar was first run through the jaw crushe. A little more than a ton of the crushed material was then placed in a grinding pan with a few inches of water and was ground for about twelve hours. The sides of the grinding pan were built of matched wooden staves set vertically in the form of a circle and about two and one half feet high. The floor of the pan was made of smooth French flint blocks. The pan itself was about ten or twelve feet in diameter. In the center a vertical shaft driven by a crown gear carried heavy timber cross-arms which revolved just clear of the pan floor. In each of the four compartments formed by the cross-arms, several of the large flint blocks were placed. These blocks were dragged on the floor and did the grinding. After the grinding was finished, a plug in the side of the pan was removed and the contents allowed to flow to the settling tanks. After sufficient settling and thickening, the material was shoveled to the top of the wood-fired kiln for final drying, after which it was barreled and shipped.

The technique employed in 1945 at the mill of the Consolidated Feldspar Company, is typical of present day treatment. Mine-run feldspar is run through a jaw crushe that reduces the blocks to 3/4-inch stock. The crushed rock is then transported on a bucket elevator to a stack drier where it is thoroughly dried by a coke fire, then dumped into a 40-ton storage tank from which it is fed to an 8-mesh hummer screen. The rock that passes the screen is carried on a conveyor belt to an Exolon magnetic separator, where some of the iron-bearing minerals are removed by a strong electromagnet. The minerals removed constitute an average of four per cent of the mine-run product. The iron-free material passes from the magnetic separator to a 20-ton bin, from which it is fed to a cone mill lined with Norwegian flint bricks and equipped with 2-inch Calais flint pebbles. Here the rock is reduced to 200-mesh, then carried to a 14-foot Gayco air separator where it is further reduced to the final 325-mesh product. The powdered feldspar contains approximately seventy-three per cent silica, fifteen per cent alumina, nine per cent potash, and three per cent soda.

The finished product is carried to the stock house on a conveyor belt. The house has a capacity of 400 tons, and two adjoining storage bins have capacities of 100 and 75 tons each. The spar is bagged at the stock house and shipped by rail. About 75% of the mill's output is used for abrasive binders and the remainder in tile and pottery.
GEOLOGY

General Statement

The Topsham area is underlain by gneiss and by a variety of granitic intrusives which may all have been injected in Carboniferous time. The gneiss lies in a zone of high-grade metamorphism and is variable in texture and composition. In some places it has been impregnated with granitic material; in others it has been injected along the foliation planes by gneissic granite. Large and small bodies of quartz-plagioclase aplite and numerous bodies of pegmatite have been intruded into the gneiss. Small bodies of biotite granite are enclosed in some of the pegmatites. The pegmatites cut gneiss, gneissic granite, and aplite, hence are younger than all these rocks. Basic dikes, probably of Triassic age, are the youngest rocks of the area.

The area lies on the eastern flank of a broad anticline. The regional strike of the foliation of the gneisses is northeast, and the dip of the foliation is gentle or moderate to the southeast.

Pejepscot gneiss

The Pejepscot gneiss varies markedly in the Topsham area. The most common variety is a dark-gray, medium to coarse-grained biotite-gneiss which contains minor amounts of hornblende. The amount of hornblende in the gneiss, however, varies from place to place, and some lenses or layers of the formation consist of dark-green, medium- to coarse-grained hornblende-gneiss. In the northwestern corner of the area mapped, layers of lime-silicate gneiss alternate with those of biotite gneiss. In some places, especially in the highest ridge in the eastern part of the area, the biotite gneiss has been impregnated with granitic material. The resulting rock is a granitic gneiss that has more feldspar and quartz and less hornblende than the typical gneiss. One specimen of light-colored granitic gneiss contains a large plagioclase crystal, which, because it cuts folia of the rock, appears to be a meta­cryst, formed by replacement of the gneiss. Mixed rocks consisting of gneiss injected along its foliation planes by aplite or pegmatite are common.

A chemical analysis and calculated mineral compositions of Pejepscot gneiss are given by Fisher. According to him (p. 113) quartz makes up about 40 per cent of most specimens. Feldspar is polysynthetically twinned andesine (An 40), generally unaltered. Biotite ranges from nearly colorless through pale yellow to moderate yellowish-brown. Alteration is to chlorite. Plates are usually oriented parallel to the foliation. The lime-silicate gneiss of the northwestern part of the mapped area is composed of quartz, andesine, and diopside, with accessory hornblende, sphene, and epidote.

Gneissic Granite

Gneissic biotite-granite occurs throughout the area in layers of various thicknesses that have been injected into the Pejepscot gneiss and are conformable in general to the foliation of the gneiss. The layers range from three inches to at least twenty feet in thickness; one layer was traced 450 feet along the strike. The gneissic granite is typically light gray, medium-grained, and composed of quartz, microcline, and albite or albite-oligoclase, with accessory biotite and traces of apatite, magnetite, and zircon. Hornblende is present in small amounts locally, and in places magnetite is an abundant accessory mineral. A body of pinkish granite exposed in the bed of the Cathance River at N. 11510, E. 8500 is otherwise similar in composition and texture to the more typical light-gray rock. In places the gneissic granite has a distinct foliation which consists of a parallelism of biotite flakes. This foliation consistently has the same attitude as the regional foliation.

Aplite

Aplite forms an irregular body 4,000 feet long and at least 2,500 feet wide, near the center of the area mapped, and three small bodies of aplite, none more than 200 feet across, which crop out near the large one. The contacts between aplite and gneiss are everywhere concealed, although aplite occurs interlaminated with gneiss at the northern end of the large aplite body.

Two lithologic varieties of aplite are present. One is a sugary, granular grayish-pink rock, mostly poor in biotite; the other is a faintly foliated, more compact, grayish-white rock, commonly containing disseminated flakes of biotite as well as parallel biotite-bearing layers 1 to 25 mm. thick. The two varieties are similar in composition except in biotite content; they consist of quartz, microcline, and plagioclase, with accessory biotite, magnetite, and garnet. Octahedra and irregularly shaped masses of magnetite 1 to 20 mm. in diameter are common in both kinds.

1 This and other locations are in terms of the coordinates given on Figure 2.
The bodies of aplite appear to be cross-cutting, but the foliation of the large body is parallel to the regional foliation of the Pejepscot gneiss. As aplite has been found interlaminated with gneiss, it seems that foliation in the gneiss was well developed prior to the injection of the aplite. The foliation of the aplite may, therefore, be an inherited structure, the aplite having formed presumably by replacement of the gneiss. It is also possible that the foliation is a primary structure.

**Biotite Granite**

Small irregular masses of biotite granite occur within several bodies of pegmatite (see Fig. 2). The contacts between pegmatite and granite are wavy and irregular and range from sharp to gradational. In some places, irregular veins of pegmatite have been formed by replacement of granite. The veins are 6 inches to 2 feet long and have walls that do not match. No evidence of brecciation of the granite has been observed, so the veins cannot be related clearly to fractures.

The granite is a light-gray rock composed of quartz, microcline, plagioclase, biotite, and hornblende, with traces of garnet. In various blocks within a given pegmatite the grain size ranges from one mm. to eight mm., and one block shows a transition from fine-grained to coarse-grained granite. In two of the pegmatites, coarse crystals of biotite, perthite, and plagioclase are present within enclosed granite masses. The biotite forms subhedral books one inch wide, eight inches long, and one-quarter to two inches thick. The perthite occurs as subhedral to euhedral crystals one to six inches long; some are graphically intergrown with quartz. Plagioclase crystals are of the same size but are commonly of irregular form.

In the area mapped, granite was observed only within pegmatite or in contact with it. Whether the blocks are due to recrystallization of aplite inclusions or were derived from an unexposed granite body is unknown.

**Pegmatites**

*Distribution and structural characteristics.* Pegmatites are common in all the other rock units in the area mapped. Contacts with wall rock, in the few places where they are exposed, are commonly irregular, and some are gradational. Most of the pegmatites appear to be roughly tabular lenses that range from 6 inches to 1,900 feet in length and from 1 inch to at least 80 feet in thickness. Only the larger bodies are shown in Figure 2. The pegmatites along the eastern side of the area mapped are thin sheets that dip eastward, roughly parallel to the
Fig. 3. Diagrams illustrating emplacement of pegmatites by replacement.

A. Plan showing replacement of gneiss along gradational and sharp concordant contacts of pegmatites.

B. Section showing three, sub-parallel, closely folded biotite layers in pegmatite. The minerals of the pegmatite are not noticeably deformed and foliation in the biotite-gneiss wallrock is not folded. This suggests simultaneous replacement and forceful injection.

C. Section showing replacement of gneiss by pegmatite along discordant contact.
local slope of the topographic surface. They are therefore exposed for considerable distances in the direction of dip and occupy areas on the map that are greatly disproportionate to their thicknesses. Most of the pegmatities strike N. 5°-20° W.; of the remainder the majority strike between N. 5°W. and N. 30°E. Most of the pegmatites in the eastern part of the area strike northeastward, whereas most of those in the western part strike northward or northwestward. In general, the eastern pegmatites are thinner and more nearly concordant with foliation than those in the western part. It is noteworthy that none of the eastern pegmatites has been mined for feldspar.

The great majority of the pegmatites dip between 30 and 50 degrees eastward. The opposite walls of some of the bodies, mostly those too small to be shown on the map, have dips indicating downward convergence or divergence of the walls. This divergence is undoubtedly due in some places to irregularities of the walls, but in others it probably indicates tapering of the lenses upward or downward. The crest of one pegmatite plunges 48°, N. 50° E. and the keel of another plunges 5°, N. 25° E. A few other crests and keels are exposed, but their attitudes could not be determined.

**Mode of emplacement.** The pegmatites appear to have been formed both by injection and by replacement of wall rock. Some of them appear to have entered by forcing aside the gneiss, for along their margins secondary foliation parallel to the contacts but markedly divergent from the regional foliation has been developed in the gneiss. The contacts of certain other pegmatites that likewise appear to have been injected are markedly discordant and seem to indicate stoping.

Many pegmatites in the area contain biotite in thin layers or "streaks" that are commonly parallel to the regional foliation of the gneiss and appear to be inherited from replaced wall rock. In at least one pegmatite, at point N. 11400-E. 8650 in Fig. 2, the biotite layers are folded as though the original gneiss had been contorted during injection and replacement (see also Fig. 3B). In some places, biotite-rich layers in the wall rock can be traced into pegmatite several inches beyond the contacts, which are wavy, irregular, and discordant (Fig. 3A and C). These features indicate that some of the pegmatites were formed, in part at least, by replacement of the gneiss. The relative importance of injection and replacement in the area as a whole, however, requires further study.

**Internal structure and composition.** The pegmatites are broadly similar in internal structure and composition. Bastin¹ found little indica-

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¹Bastin, E. S., op. cit., pp. 109-117
tion of systematic arrangement of mineral constituents in them, but the present more detailed studies indicate that some, in general those that have been most deeply exposed by erosion or mining, exhibit zonal structure. A zoned pegmatite is one in which the minerals are grouped into lithologic units of contrasting composition or texture that have a systematic arrangement with respect to the walls of the pegmatite. The component lithologic units are termed "zones" and have the shape of successive shells concentric about an innermost zone or core (see Fig. 4). Usually, zonal arrangement appears to have resulted from development of the pegmatite in successive stages inward from its walls. Five types of zones have been recognized in the pegmatite bodies at Topsham (Fig. 5). These are, in the order of their occurrence, from the pegmatite walls inward: border zone, graphic granite-quartz-plagioclase-perthite wall zone, quartz-muscovite intermediate zone, perthite intermediate zone, and quartz-perthite or quartz zone. The fifth zone appears to form the cores of the pegmatites. In addition to zones, fracture-controlled replacement bodies cutting the zones are found in one pegmatite. The relationships of bodies of this kind to zones are shown diagrammatically in Figures 4 and 5.

The border zone ranges from one inch to one foot in thickness, and is present in pegmatites that have sharp contacts with wall rock. This zone is fine-grained and consists of quartz, plagioclase, perthite, biotite and small amounts of garnet and muscovite. It is of no economic importance.

The wall zone lies immediately inside the border zone and forms the bulk of each of the pegmatites. Its thickness appears to vary directly with the size of the pegmatite, but for the most part its thickness cannot be determined accurately because of insufficient exposures. Wall zones are economically important because they have yielded large amounts of No. 2 feldspar, chiefly graphic granite. They consist of graphic granite (intergrown quartz and perthite), together with separate coarse crystals of quartz, plagioclase, perthite, and biotite, and small amounts of muscovite, garnet, and magnetite. The proportions of the essential minerals vary widely from place to place within

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Footnotes:

The terminology of pegmatite units employed in the present report was jointly developed and adopted by parties of the U. S. Geological Survey working in various pegmatite districts during World War II.

2 The term "wall zone" has been adopted for the second zone of a pegmatite body, rather than the zone immediately adjacent to the wall rock, in conformity with long-established usage in the pegmatite mining industry. The outermost zone, here called the "border zone," is thin and of no economic importance, hence has commonly been ignored.
some wall zones. In some pegmatites, only the part rich in graphic-granite is visible; in others, exposures consist chiefly of quartz and plagioclase; in still others, such as the pegmatite in the No. 2 and No. 3 quarries, long and deep exposures show several different mineral associations. If the pegmatites of the Topsham area were well enough exposed to show not only the mineralogic variations within wall zones, but also the positions of all parts of the zones with respect to the walls of the bodies, the wall-zones could perhaps be broken into two or more separate units.

Biotite is a common accessory in the wall zones and occurs mostly in "bladed" crystals a foot long, one to three inches wide, and one-eighth to one-quarter of an inch thick. Some crystals at the No. 1 and No. 2 quarries are twenty feet long, eight feet wide, and one to three inches thick; they appear to have formed along fractures in the pegmatite. Most of these fractures are of very small extent, and commonly the area of a fracture surface is no greater than the area of the biotite crystal that coats it. Three planes of parting in the biotite, roughly normal to cleavage, intersect at exactly sixty degrees, and break the crystals into a number of long blades and rhombs. The biotite on joint surfaces and small biotite blades that cut directly through quartz grains in graphic granite are clearly younger than the other minerals of the zone.

The quartz-muscovite zone is known in the Topsham area from a single occurrence. In the pegmatite at the No. 1 quarry a quartz-muscovite zone six inches thick occurs between the wall zone and the core (Fig. 4, section A-A). This zone may be comparable genetically to the late muscovite of the Trenton quarry described below. The muscovite in the quartz-muscovite zone is entirely scrap, and the zone is of no economic importance.

The perthite zone has been clearly recognized only in the pegmatite of the No. 2 quarry, where it is discontinuous and consists of bodies that lie adjacent to segments of the quartz-perthite core. It consists of crystals of perthite two to ten feet in diameter, with subordinate quartz and minor amounts of biotite, muscovite, and garnet. It grades imperceptibly into the surrounding wall zone, but its inner margin against the quartz-perthite core is sharp, being defined by the faces of perthite crystals that project into the core. It supplies pure perthite readily separable by hand sorting and may have been of more economic importance in the past than the present working faces would indicate.
The quartz-perthite core consists essentially of quartz and subordinate coarse perthite. It is commonly discontinuous, consisting of small pods or disconnected segments (Fig. 5) ranging from one and a half feet to thirty feet in length. At the Trenton quarry there seems to be a single large core with an apparent thickness of sixty to ninety feet and a length of at least two hundred and forty feet. The walls of the pegmatite body, however, are nowhere exposed, and it is possible that additional core segments are present in it. The core of the pegmatite of the No. 1 quarry appears to consist entirely of quartz, but it is poorly exposed, and parts now covered may contain perthite.

Garnet is common in some wall zones, and it appears to be associated with late muscovite in those pegmatites in which replacement bodies of muscovite have formed, such as the No. 4 pegmatite. Garnet is widespread in this pegmatite; much of it has been decomposed, and the iron released from it appears to have been largely responsible for the heavy staining of perthite and quartz in the core.

Palache described crystals of cleavelandite, lepidolite, topaz, beryl, tourmaline, cassiterite, columbite, herderite, apatite, and microlite lining the walls of a cavity in a pegmatite immediately north of the area mapped by the present writer. None of these minerals was found in the course of the present survey. Most of them are probably limited to cavities, which are uncommon in pegmatites of the Topsham area.

In the pegmatite mined in the Trenton quarry tabular, fracture-controlled replacement bodies composed of plagioclase, muscovite, quartz, and garnet cut the core and the quartz-plagioclase-perthite wall zone that surrounds the core. Aggregates of muscovite similar to muscovite of the replacement bodies occur in the core; they were probably formed at the time the replacement bodies were formed.

Basic Dikes

A fine-grained, very dark gray, olivine-bearing basic dike cuts pegmatite at N. 7950, E. 9620 (Fig. 2). The dike is five to seven feet thick and is at least one hundred feet long. It strikes N. 30° E. and appears to be vertical. This dike is probably related genetically to post-pegmatite basic dikes of the Lewiston region that have been described by Fisher as Triassic in age.


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Geologic Structure

According to Fisher, the area mapped lies on the eastern flank of a broad anticline. The foliation in the gneiss in general strikes N. 20° E. and dips 35° E., but locally the strike ranges from northwest to northeast and the dip ranges from 20° to 70° E. Overturned drag folds in the gneiss plunge N. 28° - 35° E. at angles of 12 to 20 degrees, and their axial planes dip 40° to 55° SE. Lineation in aplite due to elongation by deformation of magnetite and quartz crystals pitches N. 20° - 70° E. at angles of 20° to 25°.

Two small faults were found in the area. One of them is in the No. 4 quarry. It strikes east, and dips 75° N., and is probably a reverse fault. The displacement along it is at least 17 feet. The second, a normal fault in the north-central part of the area at N. 11070, E. 7550 (Fig. 2), strikes N. 55° E. and dips 80° NW. The displacement along it is unknown. There is great variation in the attitude of joints in the area. More than half a dozen entirely different attitudes were recorded, but time did not permit detailed study of the joint systems. One generalization that can be made, however, is that most of the joints dip much more steeply than observed contacts between pegmatite and wall rock. No set of joints parallel to pegmatite-wall rock contacts was found, and in several places conspicuous joints cut pegmatites. These observations suggest that the joints in part at least are younger than pegmatite.

Geologic History

The history of the Topsham area is complex, and only a broad summary can be given on the basis of field study. Sedimentary rocks were deposited in the area, probably in early Paleozoic time, and in later Paleozoic these were metamorphosed to form the gneiss. Parts of the gneiss were impregnated or replaced by granitic solutions, and into other parts layers of granite were injected. Biotite flakes in the granite were arranged in parallel orientation either as a result of flow-age during intrusion, or as a result of later deformation. After the intrusion of granite, aplite invaded the rocks, and formed a large, apparently irregular, and discordant mass in the western part of the area. Elsewhere aplite was injected into the gneiss and gneissic granite, and, still later, aplite stringers cut the resulting banded gneiss, or pegmatite. The gneisses were then compressed into minor folds, and pegmatite, chiefly in sheets and lenses, was injected into all of the

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other rocks. The small granite bodies that are now found within the pegmatites may have formed by recrystallization of aplite inclusions, or may be stope-blocks derived from an unexposed granite body.

Later, joints and minor normal and reverse faults cutting all rocks of the area were formed and, probably in Triassic time, basic dikes were intruded.

**Age of Pegmatites**

Samarskite from Topsham, presumably collected from a pegmatite, has been analysed by Gonyer. An age determination for this specimen, based on atomic disintegration, gives approximately 232 million years, or Carboniferous. Monazite, from a pegmatite about a quarter of a mile from the samarskite locality, was analysed by Kroupa (op. cit.), and the age of this specimen has been calculated by Adolph Knopf as more than 600 million years or Proterozoic. No evidence was seen during the present investigation to suggest the presence of more than one generation of pegmatite. On the contrary, the writer was impressed with the similarity in internal structure, mineralogy and degree of deformation in the pegmatites observed. These criteria, while they suggest a similar age for the pegmatites studied, do not, however, rule out the possibility that more than one generation of pegmatite is present.

The place of the pegmatites in the history of the area, described under the preceding section "Geologic History," was inferred from relative age relations observed in the field. The Carboniferous age of Gonyer's analysis is more in harmony with these field relations than the Proterozoic age of the other analysis.

**FELDSPAR DEPOSITS**

**General Statement**

The pegmatites of the area studied have supplied large amounts of No. 2 feldspar and appear to contain large reserves of feldspar of this grade. The amount of No. 1 feldspar available appears to be small, but in the past larger amounts may have been mined than would be suggested by inspection of the present quarry faces. The bulk of the feldspar produced has come from the wall zones of large pegmatites, and the remainder has come from the intermediate perthite zones and from quartz-perthite cores.

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1Personal communications. November and December 1947

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**Wall-zone Deposits**

The wall zones are the source of the No. 2 feldspar produced in the district. Large quantities of No. 2 feldspar, chiefly graphic granite, still remain in the wall zones of some of the pegmatites. As feldspar containing up to fifty per cent quartz is often accepted by the Topsham mill of the Consolidated Feldspar Co. at $6.00 per ton, not only graphic granite but also other perthite-rich material in the zone can be mined, sorted out, and sold as No. 2 feldspar. Next to quartz, biotite is the chief impurity in wall zones and must be separated from marketable feldspar by hand. Garnet and magnetite are minor impurities that can be removed from most of the wall-zone material by magnetic separation at the Topsham mill. Decomposition of garnet has occurred in the wall zones of some pegmatites, however, and the iron released is probably the cause of heavy staining of perthite and quartz in inner zones.

**Perthite-zone Deposit**

A perthite-zone deposit has been recognized in the pegmatite of the No. 2 quarry, although it is too small to support mining operations independent of the wall-zone. The feldspar present in it is coarse, pure, and readily separated from impurities by hand. This zone is therefore a potential source of small quantities of No. 1 feldspar, which can be sold separately or mixed with the No. 2 feldspar obtained from wall-zone material so as to improve its average grade.

**Quartz-perthite Core Deposits**

Core deposits are found in a number of pegmatites of the Topsham area. As perthite occurs in them in large crystals readily separable by hand, these deposits have probably been the principal source of No. 1 feldspar produced in the district. In most of the pegmatites, however, the cores consist of centrally located, small, disconnected segments enclosed in, and therefore separated by, wall-zone material. They form only a small proportion of the parts of the pegmatites exposed, and it seems evident that selective mining of core deposits so as to obtain a high-grade product is impractical. The core mined in the Trenton quarry is the sole known exception; it has an apparent thickness of sixty to ninety feet and a length of at least two hundred and forty feet. A considerable part of this core has been removed, but the bulk of the output of the quarry appears to have been No. 2 feldspar from the wall zone. Coarse milky quartz can be recovered from the cores as a by-product of feldspar mining.
Importance of Perthite-zone and Core Deposits

Although a casual inspection of the present quarry faces suggests that the perthite and quartz-perthite zones are too small and scattered to supply much feldspar, it is noteworthy that quarrying has almost invariably been confined to the central parts of the pegmatites. Furthermore, quarrymen report that the central parts of many of the larger quarries contained core segments and associated perthite zones in greater abundance than is now apparent. It may well be that the amount of high-grade perthite obtainable from these zones was sufficiently large to improve the average grade of the mine-run feldspar appreciably. It seems equally probable, however, that except at the Trenton quarry, none of these bodies was large enough to warrant selective mining for No. 1 feldspar alone.

During World War II, mining operations were on a very small scale, conducted sporadically by crews of one to three men who mined small amounts of feldspar for sale to Consolidated Feldspar Company. Fear of increased costs prevented large-scale operations. Experience with small-scale operations indicates that in all probability the miners tended to concentrate on the better parts of a given pegmatite, moving on to another working upon exhaustion of the higher-grade material in sight. For this reason it seems likely that the present quarry faces are not representative of the average material mined in the past.

Outlook for Future Operations

If operators in the district continue to rely principally on hand sorting for procurement of marketable material, the outlook for the district depends primarily on the market for No. 2 feldspar and the cost of producing it. The principal minable material in the quarries is graphic granite, in which quartz and feldspar are so intimately intergrown that they cannot be separated by hand sorting. Addition of pure perthite from a perthite zone or a quartz-perthite core would lower the average content of free silica, but the amount of high-grade material available is probably not large enough in the average pegmatite of the Topsham area to reduce the percentage of quartz below twenty per cent.

So far as known, flotation of feldspar from graphic granite of the Topsham area has not been attempted, and whether this type of treatment would be economically feasible is difficult to predict. Graphic granite would undoubtedly yield potash feldspar of No. 1 grade, but as graphic granite itself would have to be hand-sorted from the rest of the pegmatite, the cost of the entire operation might be prohibitive. Mass milling of entire pegmatite bodies would require separation of garnet, magnetite, muscovite, biotite, and quartz in order to yield a product of No. 1 grade. Whether this product would qualify as a No. 1 potash feldspar is uncertain, for the plagioclase content of the wall zones varies from place to place, and no data are at hand to indicate the limits of variation. Reserves of material available for mass milling, however, appear to be large.

Recommendations for Prospecting

The pegmatites in the district are poorly exposed, for most of those that have been quarried in the past are either flooded or backfilled, and those that have not been worked extensively are commonly concealed to a large extent by overburden or vegetation. These local conditions greatly complicate the problem of prospecting. In general, chances of developing a productive deposit appear to be best in the larger pegmatite bodies of the district that show indications of perthite zones or quartz-perthite cores. Examination of the quarries suggests that the central parts of these pegmatites are in general richer than others in coarse graphic granite and in addition their inner zones contain at least small tonnages of readily separable No. 1 potash feldspar.

Zonal structure has been found in 12 of the 145 pegmatites large enough to be shown in Figure 2. The coordinates of these bodies (see Fig. 2) are as follows:

<table>
<thead>
<tr>
<th>No.</th>
<th>Coordinates for location on figure 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N. 5800, E. 5500 (No. 1 Quarry)</td>
</tr>
<tr>
<td>2</td>
<td>N. 8300, E. 7500 (No. 2 Quarry)</td>
</tr>
<tr>
<td>3</td>
<td>N. 10580, E. 9400</td>
</tr>
<tr>
<td>4</td>
<td>N. 11200, E. 7520</td>
</tr>
<tr>
<td>5</td>
<td>N. 9100, E. 8400</td>
</tr>
<tr>
<td>6</td>
<td>N. 8900, E. 8400</td>
</tr>
<tr>
<td>7</td>
<td>N. 9600, E. 8300</td>
</tr>
<tr>
<td>8</td>
<td>N. 4500, E. 6180</td>
</tr>
<tr>
<td>9</td>
<td>N. 10000, E. 6880</td>
</tr>
<tr>
<td>10</td>
<td>N. 8400, E. 7020</td>
</tr>
<tr>
<td>11</td>
<td>N. 5700, E. 5160</td>
</tr>
<tr>
<td>12</td>
<td>N. 7300, E. 6200</td>
</tr>
</tbody>
</table>

Nos. 1 and 2 are the pegmatites of the No. 1 and No. 2 Quarries described below. Inasmuch as many of the pegmatites are poorly
exposed, others besides those listed may well have zonal structure. Because of the extensive cover of overburden and vegetation it was not possible, in the time available, to measure accurately the dimensions of the zoned pegmatites listed above.

BERYL

Beryl is an uncommon mineral in the pegmatites. Crystals up to ten inches in diameter were reported by Bastin1 to be moderately abundant in the William Willes feldspar quarry, one and a half miles northwest of Cathance Station (north of the area mapped), and some gem beryl was reported found with green gem tourmaline in cavities at the Trenton (G. D. Willes) quarry. During the present investigation scattered crystals were found in the core of the pegmatite body in the No. 2 quarry, and a few small crystals were found on the clump of the Trenton quarry. Although crystals of beryl may be recovered occasionally during feldspar mining, it seems evident that only trifling amounts of the mineral are present in the area.

MICA

Bastin2 described the occurrence of mica in several of the mines in the Topsham district. Most of the muscovite was wedged, hence usable only as scrap mica, and the amount available was small. During the present investigation no deposit of muscovite capable of yielding more than a fraction of one per cent of sheet mica was found. The pegmatite in the Trenton quarry contains more scrap mica, in the replacement bodies, than any of the other pegmatites studied, but even at this quarry the amounts available are insufficient to support an operation for mica alone.

DESCRIPTIONS OF FELDSPAR MINES

No. 1 Quarry

General information. The No. 1 quarry (Fig. 6) lies .25 mile N. 27° E. of Mount Ararat. To reach the quarry from the Walker Homestead, in Topsham, travel .95 mile northward on route U. S. 201, turn right and proceed .15 mile to a spring on the right hand side of the road; travel 100 feet northeastward from the spring to a fork in the road; follow the right fork for .38 mile to a road leading eastward; proceed 230 feet on this road to the quarry.

1Bastin, E. S., op. cit. p. 114.

The quarry is on land owned by the Consolidated Feldspar Company, Inc., but is said to have been operated by the Maine Feldspar Company prior to 1929. A vertical diamond-drill hole was sunk in the pegmatite in the southeastern part of the quarry by the company, but no record of the core recovered could be obtained. The present quarry is an open pit one hundred and sixty-five feet long, forty feet wide, and fifteen feet deep.

Geological Relations. The pegmatite is approximately fifteen hundred feet long, and the average outcrop-width of the body is one hundred and twenty feet. Its attitude is unknown.

Several irregular bodies of wall rock are exposed in the cut. Some of these may be projections of the true walls of the pegmatite, but some appear to be inclusions. Contacts between wall rock and pegmatite are commonly gradational. The wall rocks are of three types: 1) light-colored medium- to coarse-grained biotite gneiss; 2) injection gneiss composed of alternating layers of very dark coarse-grained biotite gneiss and light-colored, medium-grained biotite granite; and 3) light-colored medium-grained gneissic granite in which biotite occurs either in thin bands or in parallel disseminated flakes. The layers of biotite gneiss in the injection gneiss are one-quarter inch to one and a half inches thick; the layers of biotite granite are one to five inches thick. The three types of wall rock are intimately mixed. Angular bodies of fine-grained (one to three mm.) alaskitic rock occur in the pegmatite. Contacts between them and typical pegmatite are commonly gradational, and they are believed to be recrystallized and partly assimilated wall rock.

Internal structure and composition of the pegmatite. The pegmatite is zoned from the walls inward as follows:

1) Border zone, two inches to one foot thick, consisting of fine-grained quartz, perthite and plagioclase with minor amounts of biotite, muscovite and garnet.

2) Quartz-plagioclase-perthite wall zone, at least twenty feet thick. Consists of quartz, plagioclase, perthite and graphic granite with minor amounts of biotite, muscovite, garnet, magnetite and columbite-tantalite(?). Intergrowths of quartz, plagioclase and perthite, in quarter-inch to 1-inch grains, are widely distributed in the zone. Quartz makes up sixty to seventy per cent of the intergrowths. White to flesh-colored massive plagioclase is the principal feldspar in the intergrowths. Perthite occurs in
FIGURE 6. GEOLOGIC MAP AND SECTION OF NO. 1 QUARRY
salmon to deep-pink anhedral crystals scattered throughout the zone. The crystals have an average diameter of four inches but range up to two and a half feet long and one foot broad. Several are cut by tension fractures filled with milky quartz. Graphic granite is not abundant but is coarser-grained than in other pegmatites in the Topsham area.

Biotite occurs mostly in blades that are one and a half feet long, two inches wide and one-eighth to one-half inch thick, and contain flattened subhedral red garnets. Biotite occurs less commonly in books one to six inches in diameter, and a quarter-inch to five inches thick. Biotite blades also cover a joint surface, ten square feet in exposed surface area, that cuts the zone in the southern wall of the quarry. The blades are actually part of a single crystal broken by three parting planes that are normal to the cleavage and intersect at angles of sixty degrees. Muscovite, in silver flakes averaging a half-inch in diameter, occurs on joint surfaces in the pegmatite, and on the cleavage surfaces of perthite crystals. It is also associated with garnet and granular milky quartz in blades oriented normal to larger biotite blades. Magnetite is uncommon in the zone but occurs in subhedral octahedra up to three-quarters of an inch in diameter.

3) Quartz-muscovite intermediate zone. This zone is six inches thick and lies adjacent to the upper margin of the core. It consists of coarse milky and smoky quartz with subordinate muscovite, feldspar and accessory garnet. The muscovite books average four inches in diameter and one inch in thickness. All have A-structure and cross-fracturing, some are slightly stained by limonite, and some contain garnet inclusions.

4) Quartz core. Only the upper part of the core is exposed, but it is at least four feet thick and twenty-two feet long. It is reported to have terminated ten feet north of its exposure in the southern wall of the quarry. The core consists solely of coarse milky to smoky quartz, the latter more common on the margin of the core than in the center. In the southern wall of the quarry a single anhedral crystal of perthite five feet by three feet is exposed adjacent to the zone.

_Feldspar._ Apart from the single large perthite crystal described above, No. 1 potash feldspar occurs in bodies more than one foot long, only in a very few places in the quartz-plagioclase-perthite zone. A large part of the pegmatite in the quartz-plagioclase-perthite zone,
however, could probably be sold as No. 2 feldspar at the Topsham mill of the Consolidated Feldspar Company. Biotite, garnet and magnetite are the harmful impurities present, and biotite is the only one of these minerals present in large enough quantities to necessitate hand-sorting.

No. 2 Quarry

General information. The No. 2 quarry (Figs. 7, 8) lies .75 mile N. 38° E. of Mount Ararat. To reach the quarry from the Walker Homestead in Topsham, travel 1.0 mile eastward, bearing left, to the Tedford road, which leads northward. Follow this road 1.75 miles to the quarry, which lies on the eastern side of the road. The quarry is on land owned by the heirs of Wildes Purrington, formerly of Topsham. It is said to have been worked prior to 1935 by the Consolidated Feldspar Company, Topsham, Maine. It is five hundred and fifty feet long, fifty to one hundred feet wide and at least forty feet deep, but the southern part is flooded and may be considerably deeper.

Geological relations. The pegmatite, which crops out also to the south in the No. 3 quarry, is at least 1,200 feet long and has an outcrop width of at least 120 feet. The contact between pegmatite and overlying wall rock is an irregular surface exposed only in the south-eastern corner of the quarry. It strikes north-south in general and dips 45 degrees east. No contact between pegmatite and wall rock on the west side of the body is visible, but the pegmatite is probably tabular. A number of irregular masses of wall rock are exposed in the eastern wall of the quarry. Most of these probably are inclusions, but a few may be projecting parts of the overlying wall. The wall rock is a light to dark-colored, medium- to coarse-grained biotite gneiss that strikes N. 20° E. and dips 25° SE. The contact with pegmatite is discordant. The contact is generally sharp, although it is gradational in some places.

Internal structure and composition of the pegmatite. The pegmatite can be divided into the following zones: border zone, graphic granite-quartz-plagioclase zone, perthite zone, quartz-perthite zone.

1) Border zone. This zone is three inches to one foot thick and is composed of fine-grained (one-sixteenth to one-quarter inch grain size) quartz, feldspar, and minor amounts of biotite and garnet.

2) Graphic granite-quartz-plagioclase wall zone, at least eighty feet thick. The zone consists of graphic granite, quartz, plagioclase,
perthite, biotite and small amounts of muscovite and garnet. The graphic granite is mostly fine-grained, with quartz rods averaging two-tenths of an inch in width and spaced one-eighth to one-fourth inch apart. The plagioclase is mostly in white, massive, irregular crystals up to seven inches in diameter. It also occurs in massive green anhedral two to six inches broad. Cavities one to three inches across in the zone are lined with subhedral muscovite and white plagioclase.

Biotite occurs in two ways: some is in single blades, two inches to ten feet long and one-sixteenth to four inches wide, arranged in radial groups; and some occurs on joint surfaces as crystals that are up to ten feet or more in breadth but are broken into blades by three parting planes intersecting at sixty degrees. The largest are found in the part of the pegmatite that is exposed in the No. 3 quarry. Many of the biotite blades are altered. Books of biotite having an average length of one-half inch were found to cut completely through quartz rods in graphic granite.

Muscovite occurs as colorless equant to bladed books, subhedral books in cavities, and thin, fine-grained flakes coating joints and cleavages of perthite. The equant books average four inches in diameter and one-half inch thick. They are most common in the southern part of the pegmatite, in the No. 3 Quarry, where they lie adjacent to small bodies of coarse quartz. The books are commonly limonite-stained, and contain no sheet mica, as they are wedged and have herringbone structure. The bladed books are five to twenty inches long, five to six inches wide and 1/25 to 3/25-inch thick. Some are wedged. Individual books are commonly arranged in radial groups.

3) Perthite intermediate zone, up to ten feet thick. This consists of crystals of pure perthite two to ten feet in diameter, with subordinate quartz and minor amounts of biotite, muscovite and garnet. Biotite and muscovite are mostly of the bladed variety described above. No graphic granite is found in this zone. The outer margin of the zone grades imperceptibly, into the graphic granite-quartz-plagioclase zone. The inner margin is sharp and consists of the faces of perthite crystals abutting coarse-grained quartz of the quartz-perthite zone. The perthite zone apparently is present only adjacent to pods of the quartz-perthite zone and is therefore found in several separate bodies.
FIGURE 7. GEOLOGIC MAP AND SECTIONS OF NO. 2 QUARRY

Contour interval: 10 feet.
Datum assumed.

Exposures in No. 3 quarry indicate that the pegmatite body extends about 450 feet south.

Geology and Topography by:
V. E. Shelton and H. M. Perry
Mapped: July 1945
4) Quartz-perthite zone, zero to eight feet thick. The zone consists of many pods, probably segments of a discontinuous core. The pods are made up of coarse milky quartz with subordinate perthite in subhedral crystals one to seven feet long, and green beryl in rare crystals one to six inches long and one-half inch in diameter. The pods range from one to twenty-five feet in length, and are very irregular. The largest pod is shown in Figure 8.

Feldspar. Several hundred tons of No. 1 feldspar lie in exposed parts of the perthite zone, and the richest segment now visible may contain as much as 300 tons of pure perthite. The segments are separated, however, by large quantities of wall-zone pegmatite that would have to be removed in mining, or hand-sorted for recovery of No. 2 feldspar.

Very few large bodies of pure feldspar are present in the graphic granite-quartz-plagioclase wall zone. Most of the feldspar in it is either intergrown with quartz in graphic granite or irregularly mixed with quartz. Biotite and garnet are other impurities that are present in much of the feldspar in the zone. A great deal of the garnet is decomposed, and the feldspar is badly stained along cleavage surfaces and joints by iron oxides derived from the garnet. Biotite is common enough to require hand c business for separating it from marketable feldspar.

No. 4 (Trenton) Quarry

General information. The No. 4 Quarry lies 2.6 miles N. 18 E. of Mount Ararat. To reach the quarry from the Walker Homestead, Topsham, travel 2.8 miles northeastward on state route 24 to the Middlesex road. Follow this for 1.8 miles northwestward to a gravel road leading westward. Proceed on this road, bearing right, for 1.0 miles to the quarry.

The northern part of the quarry is reported to be on land owned by the Consolidated Feldspar Corporation, Topsham, and the southern part is reported to be on land owned by Russell Garland, RFD, Bowdoinham, Maine. The quarry was opened in the latter part of the nineteenth century and has been worked intermittently since. The Consolidated Feldspar Corporation quarried the northern end of the cut in 1933 and 1934 for feldspar, and David Ponziana, Topsham, worked the same part for quartz and feldspar in the spring of 1945. The quarry is approximately 1,000 feet long, 400 feet wide and 30 to 60 feet deep. The northern part was mapped in July 1945 (Fig. 9).
FIGURE 8. SKETCH OF PART OF WALL OF NO. 2 QUARRY ALONG LINE B-B' OF FIGURE 7

Approximate scale in feet

July 13, 1948

Q = Coarsely crystalline milky quartz
P = Perthite (No. 1 grade feldspar)
G = Graphitic granite (No. 2 grade feldspar)
Geological relations. The pegmatite is at least 1,000 feet long and has an outcrop of at least 150 feet in the northern part of the quarry. The contact between pegmatite and wall rock is not exposed, consequently the attitude of the pegmatite is unknown. A few inclusions of light, coarse-grained biotite-gneiss occur in the southern part of the body.

A reverse fault that strikes east and dips seventy-five degrees north cuts the pegmatite in the northern part of the quarry. Joints are common in the pegmatite and most of them strike N.-S. and dip 40°-55° W. Shearing has occurred along some of the joints, particularly those in the southern part of the quarry south of the area mapped.

Internal structure and composition of the pegmatite. Two zones are exposed in the northern part of the pegmatite: a quartz-plagioclase-perthite wall zone and a quartz-perthite core. The quartz-plagioclase-perthite zone is at least forty feet thick. It consists of fine- to medium-grained milky and smoky quartz, white and green massive plagioclase, salmon-colored perthite, graphic-granite, muscovite, biotite, and accessory garnet. The graphic granite is mostly fine-grained. Biotite and muscovite occur in bladed books one to five inches wide and two inches to four feet long. Most of the blades are altered partly or completely to chlorite (?). Small biotite blades cut completely through quartz grains in several specimens from this zone. Decomposed garnets are common in the blades, especially in biotite. Cavities ranging from one inch to one foot in diameter, found scattered in this zone, are lined with euhedral muscovite books from two mm. to three inches long. The larger books are pale ruby, wedged and possess herringbone structure. Subhedral white plagioclase also occurs in the cavities.

The quartz-perthite core has an apparent thickness of sixty to ninety feet, but its true thickness is unknown. It consists essentially of coarse milky quartz with irregular subhedral crystals of perthite one to sixteen feet long. A small amount of smoky quartz is present. One cavity six inches in diameter, lined with subhedral quartz crystals, was found in quartz of the core adjacent to a perthite crystal. Other small cavities are lined with fine-grained muscovite and plagioclase crystals. Pale green crystals of beryl two inches long and one inch in diameter, probably from the core, were found on the dump.

In the western face of the quarry the upper margin of the core appears to be displaced about seventeen feet vertically by a reverse fault (Fig. 7). The fault surface is covered with muscovite and plagioclase, which may have developed partly by replacement of the walls.
of the fault. Although only the western margin of the core appears to be exposed on the fault surface, the veneer of muscovite and plagioclase may cover part of the core. The fault cuts the eastern margin of the core in the eastern face of the quarry. Provided that the northern side of the fault is upthrown, as suggested by relations in the western face of the quarry, the eastern margin of the core probably has a steep westerly dip where it is cut by the fault.

Numerous ellipsoidal aggregates of muscovite three inches to four feet in diameter are present in quartz of the core. The core of a typical aggregate consists of diversely oriented, roughly equi-granular muscovite books one-quarter inch to two inches broad, with subordinate interstitial milky quartz. Completely enveloping this core is a rim of "spear-shaped" muscovite books, three to eight inches long, oriented with cleavages perpendicular to the surface of the aggregate. The books are pale ruby and invariably possess wedge and herringbone structures. The outer ends of the books are always thicker than the inner ends, and the apex of the "V's" formed by the herringbone reeves point toward the center of the aggregate. It is believed that the aggregates formed by replacement of the quartz, but proof is lacking.

Bodies of muscovite (in fine-grained and spear-shaped books) and plagioclase are common along joints in the core and are also found in the quartz-plagioclase-perthite zone. The bodies are four to sixty feet long, and six inches to three and a half feet thick. Some are distinctly tabular and have replaced both walls of the joints. They were formed by solutions that followed the joints in the pegmatite after development of the quartz and perthite of the core. These replacement bodies vary in size and composition but are essentially similar in their form, structure and mineralogy. Most of the joints which acted as passageways for the solutions strike north, or within a few degrees east of north, and dip at moderate angles westward or eastward. The joint surfaces in general are smooth, slightly undulating, and are covered with fine-grained muscovite.

**Feldspar.** The quartz-plagioclase-perthite wall zone contains moderate quantities of No. 2 feldspar, but very little feldspar of No. 1 grade. Biotite is abundant and would necessitate hand-sorting. Many hundreds of tons of No. 1 feldspar are present in the core at the north end of the quarry. The chief obstacles to mining it are the large amount of quartz which would have to be moved in recovering the perthite bodies and the stained condition of both perthite and quartz.