NORTH CAROLINA

DEPARTMENT OF CONSERVATION AND DEVELOPMENT

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INFORMATION CIRCULAR 20

FELDSPAR RESOURCES OF NORTH CAROLINA

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RALEIGH

1969

Table of Contents

Illustrations

Figures

Tables

The Feldspar Resources of North Carolina

by

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Introduction

Purpose and Scope

This is one of a series of information circulars published by the North Carolina Division of Mineral Resources dealing with the mineral industries and resources of North Carolina. The purpose of this report is to acquaint interested persons with the general chemical and physical properties, the history, development, geology and methods of the milling of feldspar, as well as to give an appraisal of the present feldspar industry. This report has also been written in an attempt to condense into one publication the voluminous amount of material which has been written in connection with the mining, milling and marketing of feldspar in North Carolina.

Acknowledgments

The preparation and publication of this report were carried out under the direction of Mr. Stephen G. Conrad, State Geologist.

The writers wish to acknowledge the valuable assistance rendered by members of the staff of the North Carolina State University

Minerals Research Laboratory.

The cooperation of the state's feldspar producers is also gratefully acknowledged.

During the preparation of this report, publications of the Division of Mineral Resources, United States Geological Survey, United States Bureau of Mines and numerous other technical publications were freely utilized and are listed among the references cited.

Feldspar

General Mineralogy

Feldspar, the most abundant and widespread mineral, includes two distinct aluminum silicate subgroups, the potassium and barium feldspars and the plagioclase feldspars which comprise the isomorphous series sodium-calcium feldspar. The potassium feldspars, which have the chemical formula $KAlSi_3O_8$ include the minerals sanidine, orthoclase, microcline and adularia. The plagioclase feldspars consist of six members of a solid solution series grading from high soda, or albite feldspar, to high calcium, or anorthite feldspar. The chemical composition of the intermediate members of the series are normally denoted by the percentage of albite or anorthite molecule contained, i.e. andesine (Ab70-An30). The theoretical compositions of the most important feldspar species are shown in Table 1 (Kyonka and Cook, 1954).

Naturally occurring feldspars never have the ideal compositions shown in Table 1 inasmuch as there is always a small amount of mixing of soda ion and potash ion within the two groups. It is also common for potash feldspar crystals to contain minute intergrowths of plagioclase arranged in a laminar structure throughout the crystal. These laminated crystals, known as perthite, occur in all commercially mined feldspar.

The physical properties of both feldspar groups are quite similar. They have a vitreous to pearly luster and range in color from white to red brown. Hardness ranges from 6 to 6.5 and specific gravity from 2.5 to 2.9.

Plagioclase crystallizes in the triclinic system whereas potash feldspars, with the exception of microcline which is triclinic, crystallize in the monoclinic system.

Table 1. Theoretical Composition of Pure Feldspars

	K_2O	Na_2O	CaO	Al_2O_3	SiO_2
Orthoclase and microcline	16.9			18.3	68.8
Albite		11.8		19.4	68.8
Anorthite			20.2	36.6	43.2

Mode of Occurrence

Even though feldspar is amply distributed in the earth's crustal rocks, the primary commercial sources are found in pegmatites and coarse-grained granitic rocks known commercially as alaskite.

Pegmatites are formed during the last stages of crystallization of a granitic magma as a result of injection of residual magmatic solutions into the surrounding terrane. The resulting pegmatite dikes, quite irregular in both grain size and composition, are composed essentially of quartz, alkali feldspar and various mica minerals, as well as accessory beryl, tourmaline, garnet, topaz and spodumene. Frequently, rather exotic minerals such as thulite, torbernite, hyalite, columbite and samarksite also occur.

"Alaskite," which occurs in the Spruce Pine district of North Carolina, is an extremely important source of feldspar. In the strictest sense, this rock is not a true alaskite, inasmuch as the plagioclase is normally oligoclase rather than albite. Alaskite is an intrusive igneous rock of generally uniform texture and grain size, consisting of oligoclase, quartz, microcline and muscovite. Ferromagnesian minerals are rare, but minor amounts of garnet and biotite do occur.

A third commercial source of feldspar is to be found in certain river and beach sands. The feldspar in these instances is detrital material derived from the weathering of pre-existing acid igneous rocks. In the beach sands of California's Monterey Peninsula, the occurrence of feldspar is of sufficient concentration to be mined commercially.

Acid igneous rocks such as granite and many metamorphic gneisses, contain large quantities of feldspar. Generally, the presence of finely disseminated iron minerals and the difficulty of milling normally preclude the extraction of feldspar from these rocks. However, the production of feldspar from a quartz monzonite contact zone in the Shelby district of North Carolina and Georgia Marble Company's recovery of feldspar from a granite gneiss are notable exceptions.

	Crude Feldspar Produced		Ground Feldspar Sold by Mills	
Year	Long Tons	Value $	Short Tons	Value $
1945	148,493	863,740	142,208	1,665,634
1946	230,367	1,002,638	207,252	2,192,254
1947	220,997	1,081,514	217,109	2,360,352
1948	201,774	1,116,825	219,720	2,377,030
1949	160,916	973,431	159,768	2,203,604
1950	183,027	1,107,061	200,373	2,526,268
1951	166,361	1,230,404	197,704	2,886,655
1952	240,364	2,416,031	270,775	3,714,084
1953	268,042	3,290,495	272,059	3,891,684
1954	230,744	2,220,707	210,804	3,123,096
1955	242,724	2,184,793	249,855	3,850,265
1956	255,637	3,191,559	261,430	4,044,653
1957	233,439	2,728,153	237,655	3,406,055
1958	224,647	2,519,713	232,625	3,120,619
1959	292,114	2,934,552	279,448	3,251,522
1960	271,000	2,781,000	275,000	3,100,000
1961	252,000	2,477,000	267,336	2,768,610
1962	245,000	2,373,000	233,431	2,647,222
1963	268,000	2,821,000	297,401	3,611,309
1964	281,000	2,343,000	361,414	3,882,214
1965	279,000	3,153,000	303,298	3,408,000
1966	302,000	3,157,000	336,789	3,662,818

Table 2. North Carolina Feldspar Production, 1945-1966

Domestic Sources

The United States produces and consumes more feldspar than any other nation. The alaskite deposits of North Carolina's Spruce Pine district account for a large share of this production. In addition, large tonnages of feldspar are produced in the pegmatite districts of New Hampshire, Connecticut, South Dakota, Colorado, Minnesota, Arizona, Nevada, New Mexico, Texas, Virginia, South Carolina and Georgia (Figure 1). Feldspar extracted from the dune sands of the Monterey Peninsula and from granite gneisses in Georgia and South Carolina constitute the remaining domestic sources of feldspar. Minerals which may be substituted for feldspar are mined from the aplite deposits in Virginia and the nepheline syenite deposits in Canada.

Uses

Feldspar is used principally in the glass and ceramic industries, which consume more than 98 percent of all ground feldspar produced. Welding rod coatings, abrasives and filler products account for the remaining production.

Virtually all fired clay products utilize feldspar as a basic raw material. The body of ceramic products may contain 10 to 35 percent feldspar and the glaze from 30 to 50 percent.

The purpose of feldspar in whiteware bodies is to take part in physico-chemical reactions with other crystalline phases. This fluxing action is due to a deep inter-diffusion of phases rather than a simple bonding of the phases. In addition, the low diffusion point of

No.	Designation	Percent								
		SiO_2	Na_2O	K_2O	CaO	MgO	BaO	PbO	B_2O_3	Al_2O_3
1	Silica glass (fused silica)	99.5+								
2	96% silica glass	96.3	0.2	0.2					2.9	0.4
3	Soda Lime ---window sheet	71-73	12-15		8-10	1.5-3.5				0.5-1.5
4	Soda lime ---plate glass	71-73	12-14		10-12	1-4				0.5-1.5
5	Soda lime ---containers	70-74		13-16		10-13	0-0.5			1.5-2.5
6	Soda lime---electric lamp bulbs	73.6	16	0.6	5.2	3.6				1.0
7	Lead-alkali silicate-electrical	63	7.6	6	0.3	0.2		21	0.2	0.6
8	Lead-alkali silicate-high lead	35		7.2				58		
9	Aluminoborosilicate(apparatus)	74.7	6.4	0.5	0.9		2.2		9.6	5.6
10	Borosilicate--low expansion	80.5	3.8	0.4				Li_2O	12.9	2.2
11	Borosilicate-low electrical loss	70.0		0.5				1.2	28.0	1.1
12	Borosilicate-tungsten sealing	67.3	4.6	1.0		0.2			24.6	1.7
13	Aluminosilicate	57	1.0		5.5	12			4	20.5

Table 3. Approximate Compositions of Commercial Glasses

feldspar permits it to act as a cement between certain crystalline phases of ceramic bodies (Kyonka and Cook, 1954).

The glass industry today consumes 56 percent of the total production of ground feldspar. Widespread utilization of feldspar in the glass container industry began about 1935. It was learned prior to this time that the addition of alumina to batch glass increased the products resistance to impact breakage, scratching, breaking due to bending, chemical corrosion and furthermore retarded devitrification.

The Fourcault process for drawing glass in a continuous sheet compelled the flat glass industry to find a constituent which would lower the devitrification point below the drawing temperature without reducing the viscosity of the melt. With the addition of feldspar, these requirements were met and chemical stability and better workability resulted.

Minor uses of feldspar include abrasives, electric welding rod coatings, fillers, roofing granules and poultry grit.

High potash feldspar, that is feldspar with a potassium-soda ratio of approximately 12:1 containing about 13 percent potassium feldspar, has become important in the production of color television picture tubes.

History

According to Watts (1913), pegmatite mining in North Carolina apparently began with the production of kaolin by the Cherokee Indians, presumably for shipment to England. As early as 1744 an English patent was issued for the production of procelain from an earthy mixture produced by the Cherokee nation in America, consisting probably of kaolin, feldspar and quartz (Stuckey, J.L., 1965).

FIGURE 1. MAJOR FELDSPAR PRODUCING DISTRICTS IN THE UNITED STATES

The North Carolina Mining and Manufacturing Company mined the first feldspar in the state from their kaolin mine near Sylva, Jackson County. This presumably occurred prior to 1897, however, exact dates are lacking (Stuckey, J.L., 1965). Feldspar mining, previous to and subsequent to this time, could be at best described as sporadic and haphazard. Because of improper removal of impurities and the mixing of ore of varying quality from different mines, much of the feldspar product during this period was unsuitable for use. The shipment of a carload of feldspar from the Deer Park mine in 1911 marked the beginning of feldspar mining in the Spruce Pine district. Because of the long haul to the grinding mills located in New Jersey and Ohio, it was not until 1914, when a grinding mill was built at Erwin, Tennessee, that North Carolina became a steady producer of feldspar.

In the 1920's, large mining interests began to absorb many of the smaller producers. As a result, quality control techniques were instituted, grinding mills were built in or near the town of Spruce Pine, and larger more productive pegmatites were discovered and exploited. In addition to the production from the Spruce Pine district, Buncombe, Jackson, Transylvania and Swain counties produced appreciable tonnages of feldspar. The number of feldspar producers continued to decline until by 1929 there were but 32 producers in the State.

During the late 1930's and early 1940's, Hess and Hunter (1940), while investigating the residual kaolin deposits in the Spruce Pine area found that extensive feldspar reserves were present in the underlying fine-grained pegmatite, later named alaskite by Hess. Concurrent with this was the development of the "H.F. Amine" flotation process by R.G. O'Meara of the U.S. Bureau of Mines (O'Meara, R.G., Norman, J.E., and Hammond, Walter E., 1939). As an outgrowth of this research, in 1946, the Carolina Mineral Company, later acquired by the International Mineral and Chemical Corporation and renamed the Consolidated Feldspar Department of International Minerals and Chemical Corporation, began operation at Kona, North Carolina, of the first plant to recover feldspar by froth flotation. In 1945, the Minerals Research Laboratory located in Asheville was created through the joint efforts of the Tennessee Valley Authority, North Carolina State College, and the North Carolina Department of Conservation and Development. Based upon the laboratory's research pertaining to feldspar flotation, the Feldspar Flotation Corporation began operation of a plant in Spruce Pine. Lawson United Feldspar and Mineral Corporation, the third of the large North Carolina producers began operations in 1957.

Primarily because of the advent of forth flotation, the annual production of crude feldspar in North Carolina during the period 1946-1953 increased 123 percent in volume and 188 percent in value over the previous ten years (Broadhurst, 1955). During the period 1954-1959, the North Carolina production of crude feldspar increased 17.9 percent in tonnage and 72.2 percent in value over the preceeding ten year period (Stuckey and Conrad, 1961). Table 2 shows the North Carolina feldspar production over the past twenty years.

Since the introduction of forth flotation, the feldspar industry in North Carolina has continued to grow. At present, approximately 90 percent of the feldspar produced in the State is obtained by flotation. North Carolina is recognized as a producer of high quality feldspar primarily due to rigid quality controls made possible by blending and uniform grinding.

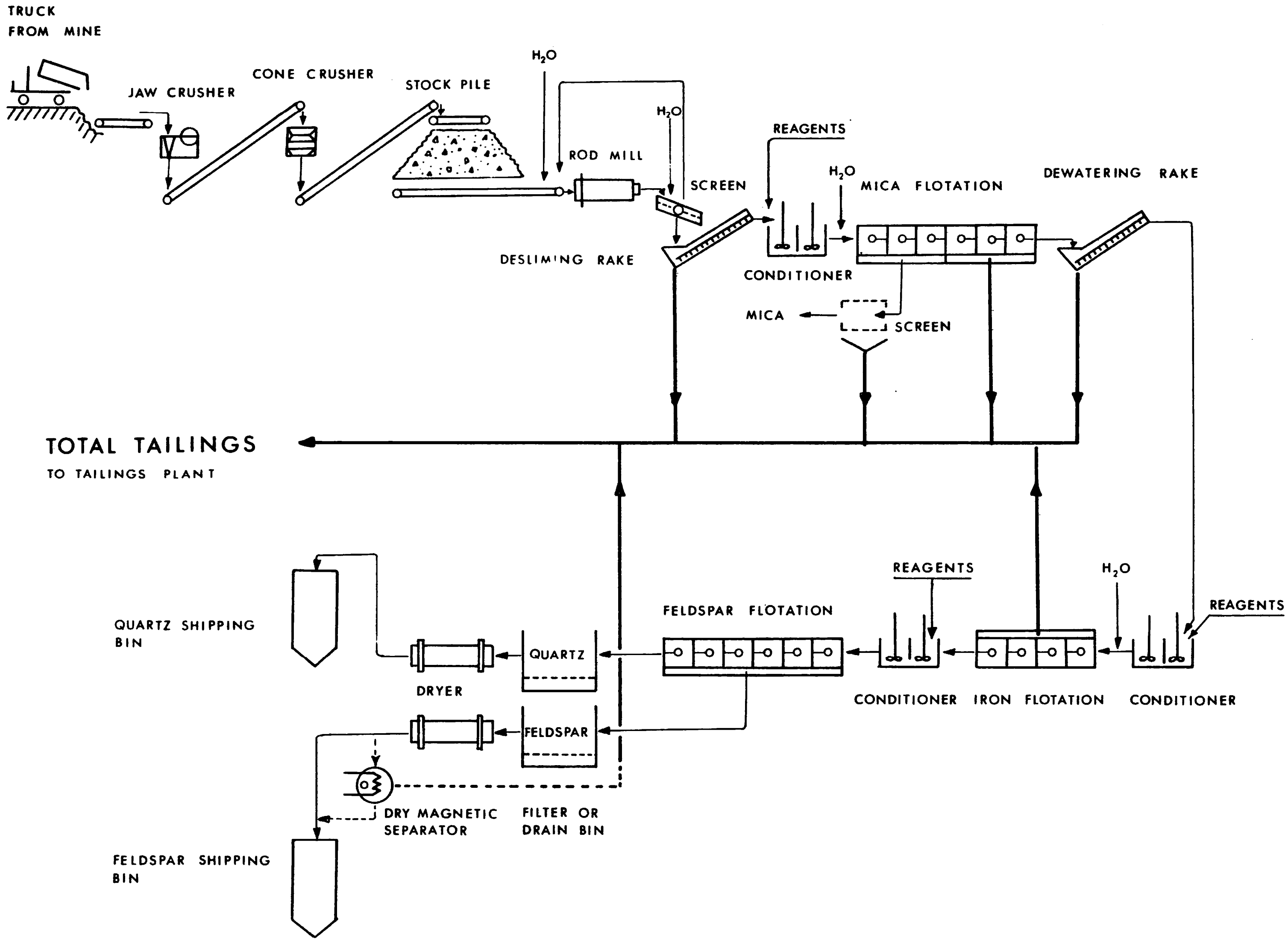

FIGURE 2. FLOWSHEET OF SPRUCE PINE FELDSPAR PLANTS

Present Industry

Fifty percent of the feldspar produced in the United States comes from mines and mills located in North Carolina. The three leading feldspar companies, International Minerals and Chemical Corporation, the Feldspar Corporation and Lawson-United Feldspar and Minerals Company, produce 65 percent of the feldspar marketed in the United States.

The world import-export trade is extremely small, due in part to the extensive world-wide distribution of feldspar deposits and to the low cost per ton of crude feldspar. This country does, however, import a small quantity of feldspar from Canada. In 1964, this total was approximately 3,000 tons (Reeves, 1966).

Three methods of processing feldspar are employed by the feldspar industry. These are: froth flotation, electrostatic separation and hand cobbing. Of these processes, froth flotation is by far the most productive, accounting for almost 70 percent of all feldspar concentrate produced in the United States. The application of froth flotation techniques to the recovery of feldspar in the 1940's made possible the mining of the extensive North Carolina alaskite deposits, which previous to this, were unused because of the difficulty of hand extraction of feldspar. The larger North Carolina producers all use flotation for the concentration of feldspar. A typical flowsheet for the recovery of feldspar and the mica by-product by froth flotation is shown in Figure 2.

The ore is normally quarried from an open pit (Figure 3) and taken to the mill by truck (Figure 4). The raw ore is ground to minus 4 inches in jaw crushers and reduced to 5/8 inch in cone crushers.

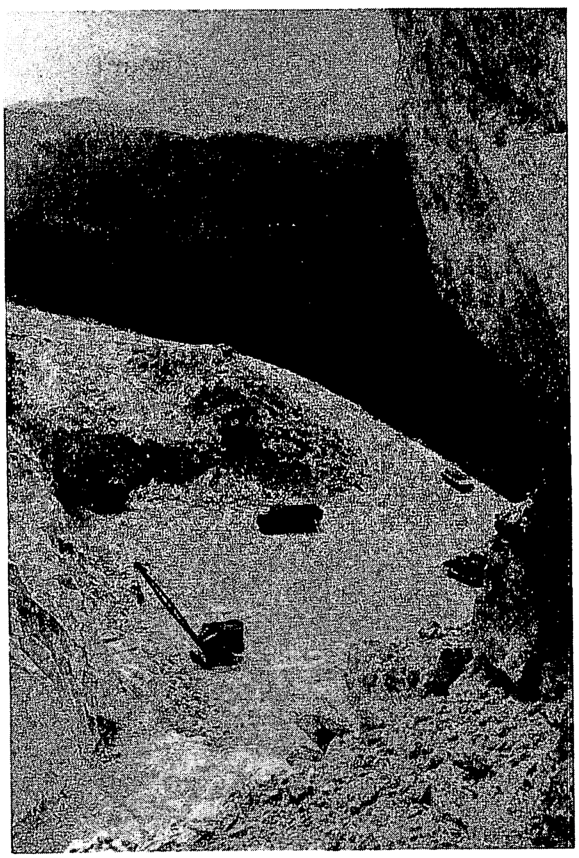

Figure 3. Chalk Mountain Mine

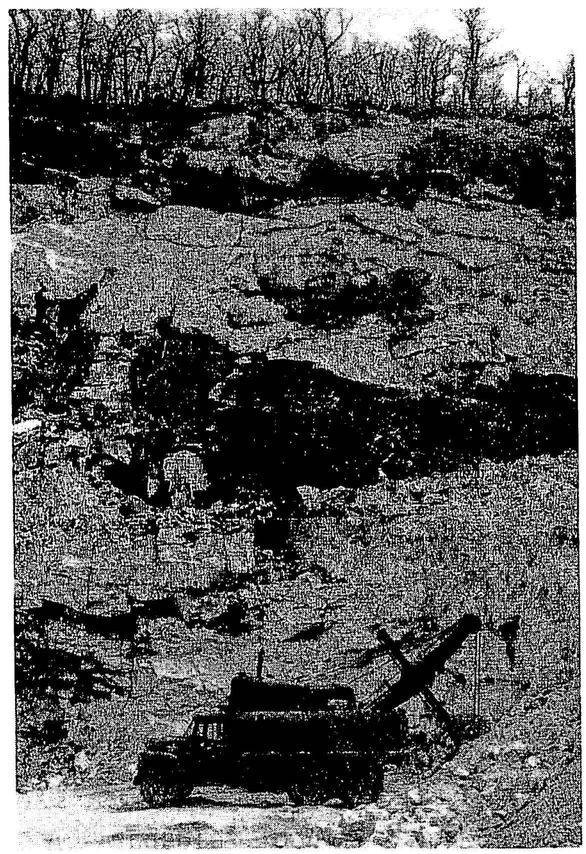

Figure 4. Loading alaskite ore at Chalk Mountain mine

Magnets are used to remove any tramp iron. The crushed ore is then stockpiled to be used later as needed (Figure 5). Next the ore is wet ground in rod mills utilizing a closed circuit with 14-16 mesh screens. Following closed-circuit grinding, the feed is deslimed and dewatered by some combination of bowl classifier, cyclone and rake, or screw classifier. From this processing, the feed enters the conditioning circuit for mica flotation. Following this step, the pulp is again conditioned and the heavy minerals and any remaining mica, especially biotite, are floated. The resulting mica-iron product is discarded (Figure 2).

The machine discharge from the mica-iron float is again froth floated in order to collect the feldspar concentrate (Figure 6). Various cleaner circuits may then be added to improve the feldspar concentrate or the quartz tailing. The feldspar concentrate is dried and classified for commercial use (Figure 2). A minus 20 mesh feldspar concentrate containing not over 0.05 percent iron oxide is sold as glass grade feldspar. If this concentrate contains 5.0 percent or more K_2O, it can be dry-ground from minus 120 to minus 325 mesh and marketed as filler or ceramic grade feldspar (Figure 7). Quartz and mica, by-products of the flotation process are also sold. On the average the typical North Carolina feldspar plant produces approximately 280 tons of feldspar concentrate per day. This concentrate as well as the by-product mica and quartz are shipped by rail to consumers (Figure 8).

Recovery of feldspar from plant wastes is accomplished by use of settling ponds (Figure 9) or filter plants (Figure 10). Potential recovery of feldspar from the 1000 tons/day waste produced by the three mills in Spruce Pine is approximately 300 tons/day.

The quality of the feldspar product is controlled by the needs of each particular customer. The grades of feldspar are normally designated by

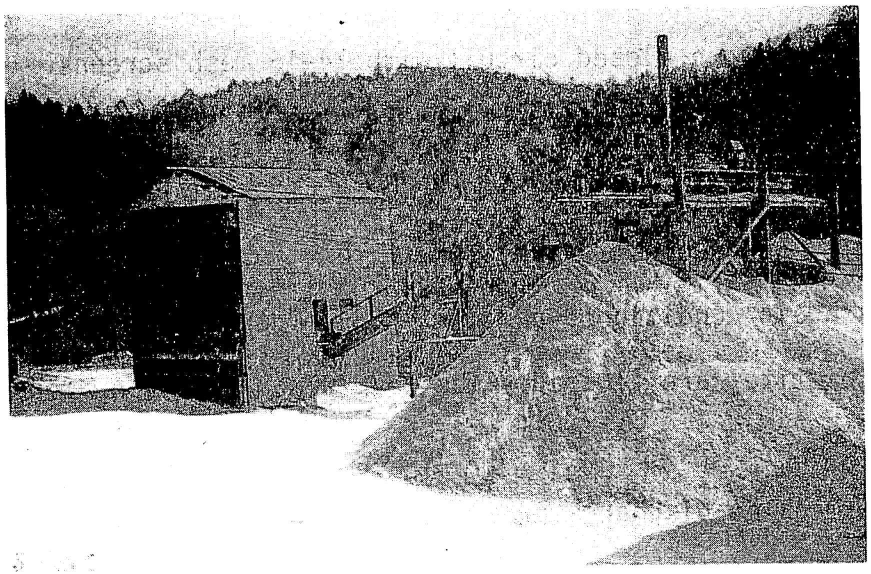

Figure 5. Crushing and stockpiling alaskite ore

Figure 6. Flotation cells

a number. Number 1 grade generally has the highest potash content and Number 2 a lower potash content. Within each grade there is a large variation in mesh size. Grades of feldspar may also be designated by the alkali content (the sum of K_2O and Na_2O), the alkali ratio (the ratio of K_2O to Na_2O), or the free quartz contained in the final product.

The glass industry commonly employs two grades of feldspar in the manufacture of glass: (1) CaO not exceeding 2 percent and containing less than 6 percent free quartz, and (2) feldspar containing not less than 17 percent alumina, alkali not under 11.5 percent and iron oxide not over 0.1 percent. This glassmaking feldspar may range from 20 to 200 mesh. Table 3 shows the compositions of various commercial glass. In the ceramic industry three grades of feldspar are used: (1) feldspar containing practically no quartz, (2) feldspar containing not over 25 percent free silica, and (3) feldspar containing not over 30 percent free silica. For vitreous enamels a somewhat coarser fraction is used, generally ranging from 20 to 30 mesh (Shand, 1958).

Normally, the selling price of feldspar product is determined by the grade or end use. According to the December 1968 issue of Engineering Mining Journal, current prices for feldspar, bulk, FOB North Carolina are: 200 mesh dry ground \$19.50 to \$21.00 per ton; 40 mesh dry ground \$19.50 to \$21.00 per ton; 200 mesh flotation \$18.50 per ton; and 20 mesh flotation \$10.00 per ton.

Description by Districts

The districts described in the following pages are presently, or have been in the past, important feldspar mining areas.

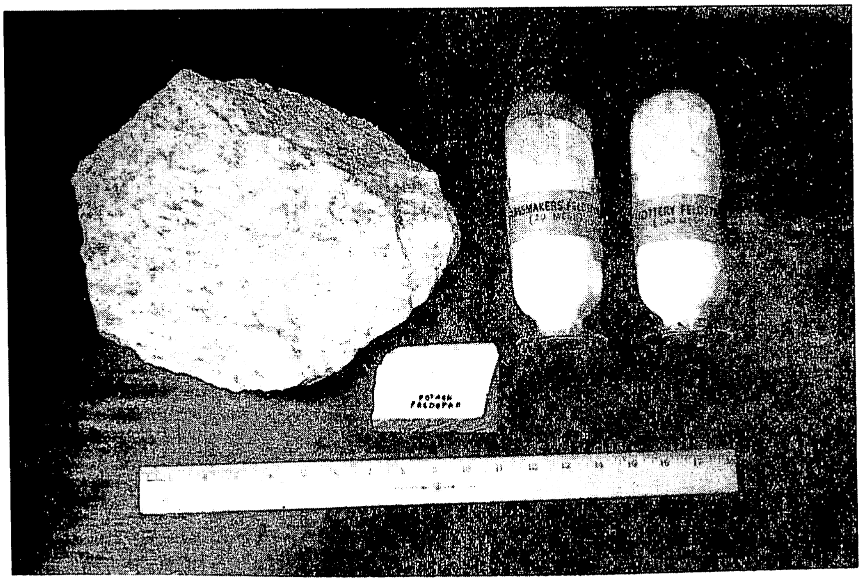

Figure 7. Alaskite ore, block feldspar, and glass and ceramic grade feldspar products

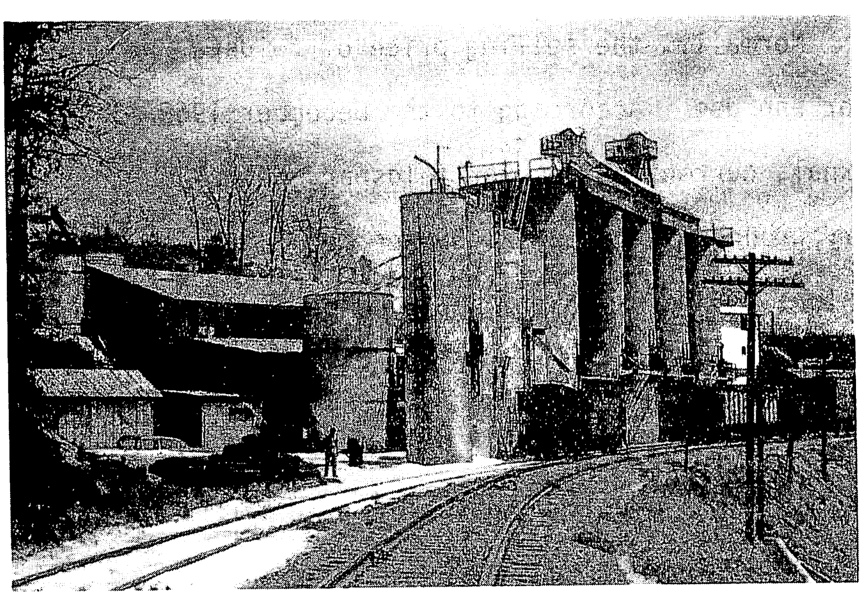

Figure 8. Storage silos and loading facilities at Feldspar Corporation's Spruce Pine plant

Today, feldspar mined in North Carolina is produced by two mining districts; the Spruce Pine district and the Shelby district. The extensive non-pegmatite deposits found in these districts have completely supplanted the pegmatite deposits of the Cashiers and Bryson City districts as the major source of feldspar in North Carolina.

The Cashiers and Bryson City districts are necessarily included in this description because of the long history of mining in the areas and their feldspar potential.

Spruce Pine District

Location

The Spruce Pine district, the principal feldspar producing area in North America, includes parts of Avery, Mitchell and Yancey Counties (Figure 11). It comprises a 300 square mile area twelve miles wide and 25 miles long. The area is mountainous with altitudes ranging from 2,100 feet above sea level at Green Mountain to 6,684 feet above sea level at Mt. Mitchell. The North Toe and South Toe Rivers provide drainage for the area and join at Micaville to form the northeasterly flowing Toe River. The district is served by U.S. Highway 19E and by State Highways 226, 80, 261 and 194; and by the Carolina, Clinchfield and Ohio Railroad and the Yancey Railroad.

General Geology

The Spruce Pine district is underlain by a complex series of interlayered metasediments which have been recrystallized into mica and hornblende gneisses and schists and subsequently intruded by diverse igneous rocks including alaskite, pegmatites, dunites and diabase dikes. The rocks in the

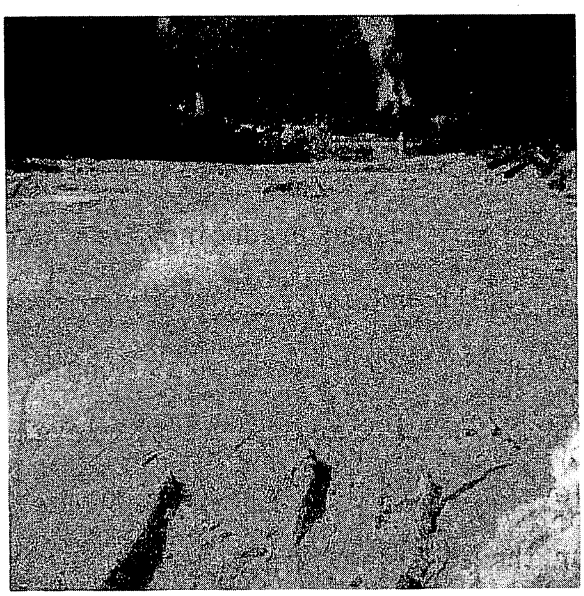

Figure 9. Tailings pond of Lawson-United Feldspar and Mineral Company.

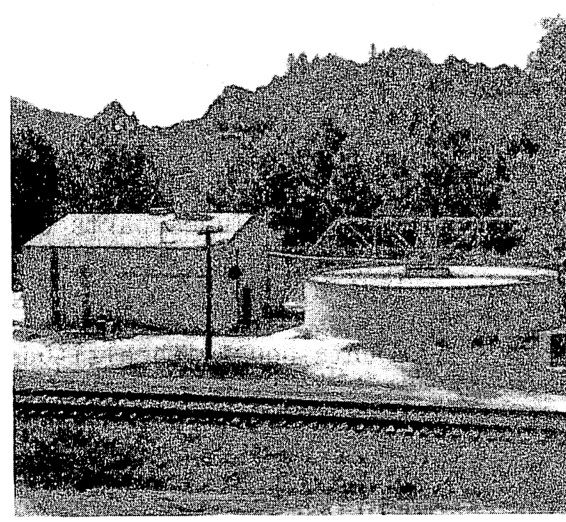

Figure 10. Filter plant of International Minerals and Chemical Corporation.

district have undergone extensive deformation, resulting in a southwesterly plunging assymetrical synclinorium about 20 miles wide. The central portion of the synclinorium is occupied by the mica gneisses and schists and younger intrusives, with the Cranberry and Henderson gneisses forming the boundaries to the northwest and southeast respectively.

Mica gneiss, the most abundant rock type in the area, is predominantly a fine grained even-textured gneiss composed of oligoclase or sodic andesine, quartz and biotite. Garnet, epidote, staurolite, kyanite and orthoclase are common accessory minerals. Mica may be dominant locally giving the rock a schistose character. With an increase in the quartz content, the mica gneiss grades into quartzite.

Narrow bands of mica schist occur locally in the district and are interlayered with the gneisses. The schist is normally a coarse textured muscovite schist composed of oligoclase, quartz, muscovite and biotite. Garnet, epidote, tourmaline, kyanite and staurolite may be present in minor amounts.

Extensive areas of migmatite or injection gneiss surround many of the larger alaskite bodies. Injection is more noticeable along the weaker foliation planes of the schist units. The injection gneiss is characterized by lenses and streaks of oligoclase or andesine, quartz, muscovite and biotite with minor amounts of apatite, garnet, sphene, magnetite, zircon, ilmenite, staurolite, allanite, clinozoisite, chlorite and pyrite.

Thick sequences of hornblendic rocks are common throughout the district, but occur primarily in northeastern Avery County. These rocks are present as interlayered hornblende gneisses and schists and amphibolites, and are commonly interbedded with the mica gneiss and schist. The hornblendic rocks are black to dark green, medium to coarse-grained mixtures of hornblende,

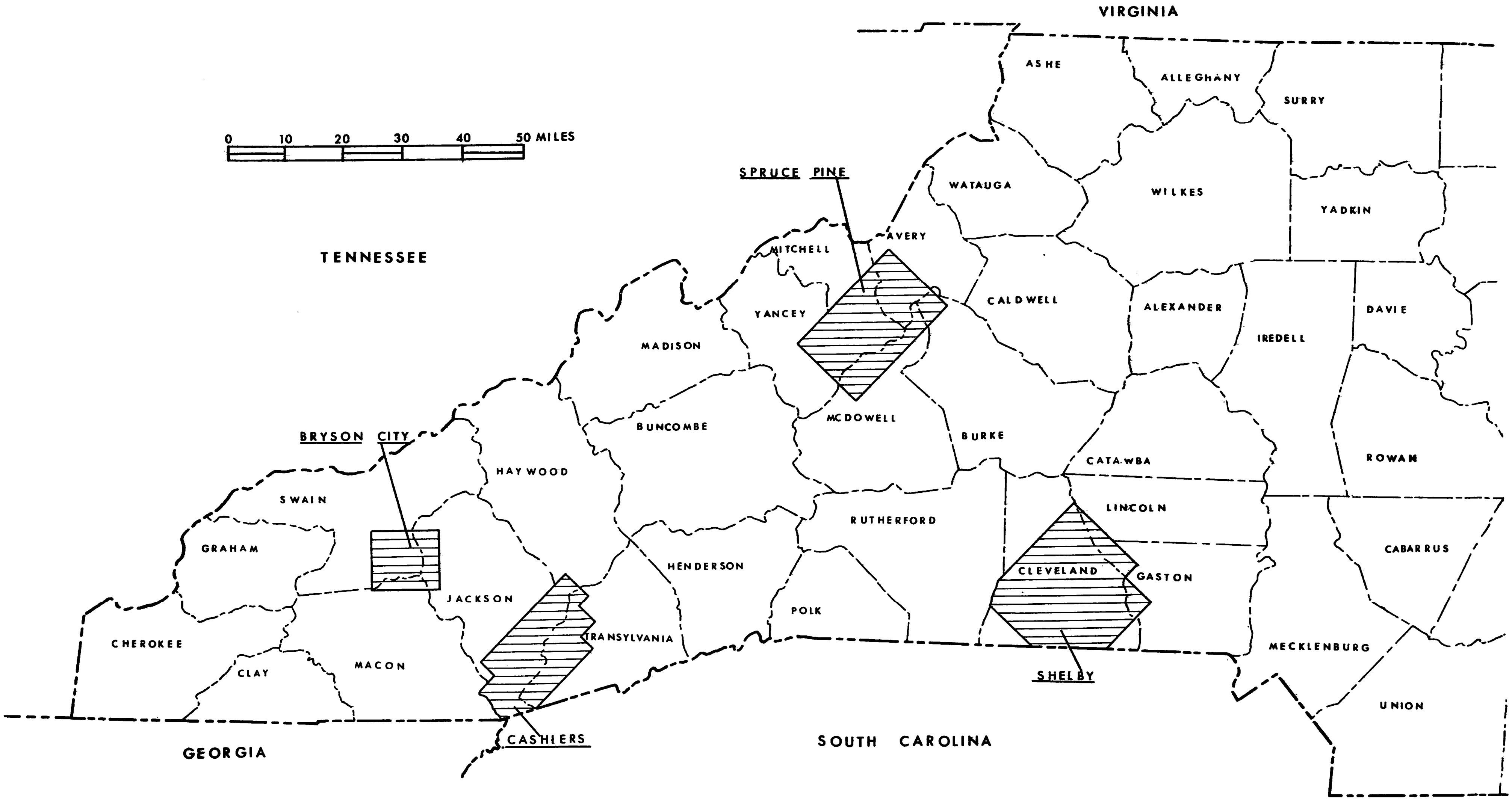

FIGURE 11. INDEX MAP OF THE CASHIERS, SPRUCE PINE, BRYSON CITY, AND SHELBY DISTRICTS.

oligoclase or andesine, and quartz with varying amounts of garnet, epidote, biotite, chlorite, magnetite, ilmenite, pyrite, chalcopyrite, sphene, rutile and apatite. The origin of these hornblendic rocks is not certain. It has been suggested that they may be of sedimentary origin, possibly derived from impure dolomitic limestone; or, more likely, a metamorphosed mafic volcanic extrusive (Parker, 1952).

Numerous discordant, round to elliptical shaped dunite bodies are present throughout the district. The dunites are medium to coarse-grained rocks consisting primarily of olivine (forsterite) with minor serpentine, enstatite, talc and chromite. Although the outer edges of the dunites are generally sheared and altered, the cores are normally undeformed.

Minor rock types in the area include the Bandana Dolomite, a white crystalline dolomitic marble located 1.3 miles northwest of Bandana, Mitchell County. This dolomitic marble is 50 feet thick and approximately 2,000 feet long. Numerous diabase and basalt dikes crosscut the area and are particularly abundant in the northeast part of the district. It has been suggested that they are possibly related to the Triassic volcanic rocks in the central Piedmont of the State.

Alaskite

Distribution: The occurrence of large bodies of alaskite may be noted in four areas of the Spruce Pine district: The Brushy Creek-Gusher Knob area, Avery County; the Spruce Pine area, Mitchell County; the Kona area, Mitchell and Yancey Counties; and the South Toe River Valley, Yancey County. Smaller bodies may be found throughout the district but are most common in the southeastern portion. These smaller outcroppings of alaskite are probably apophyses of a large unexposed intrusive mass.

Mineralogy and Structure: The alaskite is a medium-grained mixture of 40 percent oligoclase, 25 percent quartz, 20 percent microcline and 15 percent muscovite. Biotite, garnet, apatite, allanite, epidote, thulite, pyrite and pyrrhotite are common accessory minerals. The average grain size is 0.5 inch, becoming finer towards the margins of the bodies. The margins of the larger bodies often show some foliation due to parallelism of mica flakes or mineral streaks. The contact of the alaskite with the country rock is commonly irregular due to alaskite injection, crosscutting relations of the alaskite, and the various inclusions within the alaskite (Olson, 1944).

Pegmatites

Distribution: The pegmatites are distributed in the northern and western sections of the district in a northeasterly trending area 25 miles long by 10 miles wide. They are common both in the alaskite and in the metamorphic units. However, they are larger and more abundant near the margins of the large alaskite bodies. This is suggested by textural irregularities due to coarsening of the grain size along the alaskite margins (Olson, 1944). The pegmatites range in length from a few inches to over 2,000 feet and in width from a few inches to more than a hundred feet.

Mineralogy and Structure: The composition of the pegmatites is variable but commonly is quartz, microcline, oligoclase, albite and muscovite. Biotite, garnet, apatite, allanite, epidote, thulite, zoisite, calcite, beryl and columbite are common accessory minerals. Microcline is more abundant in the central portion of the pegmatites and in those pegmatites high in sodic plagioclase. These microcline crystals occasionally reach lengths of six feet.

Zoning is present in many of the Spruce Pine pegmatites, but is not as prominent a feature as in the pegmatites of the Bryson City or Cashiers district. Few of the pegmatites have more than three zones. The border zones are usually fine-grained plagioclase-quartz-muscovite; the wall zones are composed of a coarser material of the same composition; and the cores are commonly massive quartz or coarse perthitic microcline and quartz.

Within the alaskite, the pegmatites which tend to be tabular in shape and have sharp contacts with the alaskite indicate post-alaskite emplacement and crystallization while those with gradational contacts and irregular shapes tend to indicate pre-alaskite emplacement and crystallization.

Selected Mines

Pine Mountain Mine - The Pine Mountain mine, 1 mile north of Minpro, is presently operated by the Lawson United Feldspar and Mineral Company. The original mine was located in several pegmatites near the margin of a large alaskite body. Mica schist, mica gneiss and migmatite form the contact along the western side of the alaskite and are also present as inclusions within the body. Most of the mining was from an open pit cut in a pegmatite body striking N.10° E. and dipping 75° SE. Garnet, allanite, gahnite, autunite and torbernite occur as accessory minerals.

Present day mining operations are conducted in the massive alaskite body, with the numerous pegmatites encountered within the body mined selectively to upgrade the quality of the product.

Chalk Mountain Mine - The Chalk Mountain mine, operated by the Feldspar Corporation, is located approximately 1.75 miles southwest of Spruce Pine and

0.5 mile south of U.S. Highway 19E. The mine was originally worked for mica in the early and middle 1900's. Both the northwestern and eastern sides of the mountain are being quarried for alaskite. On the northwestern face, the mine is worked in a series of 30 to 40 foot benches. Currently only the lower bench of the northwestern face and the eastern face are being mined. The northwestern quarry face is approximately 400 feet long and about 200 feet high.

The alaskite body is dome shaped and exhibits exfoliation as well as a pronounced set of northwest trending vertical joints. Numerous pegmatites averaging approximately one foot in width cut the alaskite. Biotite schist inclusions are common throughout the body, but are more abundant and larger at the southern end of the quarry (Figure 4). These inclusions contain both crosscutting alaskite and pegmatite dikes and concordant lenses and augen-shaped bodies of alaskite. The biotite schist inclusions are parallel to the foliation of the country rock.

Grain size in the alaskite varies from medium to coarse. Coarser grained alaskite tends to occur along contacts with pegmatites and toward the northern end of the quarry. Feldspar crystals up to one foot in length are relatively common in this portion of the pit. Slight to moderate foliation due to parallelism of mica flakes and elongation of feldspar and quartz is present. Biotite and garnet are the common accessory minerals. Hyalite, a relatively rare fluorescent form of opal, and autunite, a uranium phosphate mineral, are also found.

Hootowl Mine - The Hootowl mine is located 3.25 miles S. 50° W. of the Liberty Hill Church and 0.5 mile N. 15° E. of Crabtree Mountain in Mitchell County. This mine at one time supplied a large quantity of feldspar and flat green-stained mica.

The original mining was of a large irregular pegmatite body approximately 500 feet long, 250 feet wide, and 150 feet deep. This body, striking northeast and dipping westward, forms an anticlinal fold in the overlying hornblende and mica gneiss. Microcline, the primary feldspar in the mine, occurs as large crystals and as graphic intergrowths with quartz.

Deer Park Mines - The Deer Park mines are located on the North Toe River approximately 0.5 mile N. 64° E. of Penland. These mines were the source for the first feldspar shipped from the Spruce Pine district in 1911. Prior to 1911, the mines had been worked for many years for sheet mica.

The most productive pegmatites are located in an anticlinal fold in the upper part of the alaskite body. The largest of these, at the No. 5 mine, strikes N. 50° E. and dips 65° SE. The maximum exposed thickness is 120 feet and mining had advanced down pitch for 600 feet. Contacts with the wall rock are gradational and inclusions of mica schist, migmatite and hornblende gneiss are often encountered. The central part of this pegmatite is a coarse-grained microcline-perthite, grading outward into a medium-grained zone of plagioclase-microcline. Outward from this zone the amount of plagioclase increases as the grain size decreases.

The No. 2 pegmatite is much smaller than the No. 5. Feldspar in this dike-like body was obtained from a zone of microcline 10 to 25 feet thick. The other pegmatites on the property yielded limited quantities of feldspar.

Chestnut Flat Mine - The Chestnut Flat mine located 0.75 mile east of Bear Creek Post Office, was one of the largest feldspar mines in the United States. The pegmatite at this mine is a tongue-shaped body 25-80 feet thick. Most of the mining was adjacent to a large quartz body near the center of the pegmatite. Parts of this quartz core were used in the manufacture of the mirror for the 200-inch telescope at the Mt. Palomar observatory in California.

Feldspar was mined along an inclined stope 190 feet wide and 750 feet long. Westward from the west wall of the stope the pegmatite splits into several thin branches which resulted in only limited mining activity in this area. Eastward from the stope the pegmatite thins quite rapidly. Several smaller pegmatites occur parallel to the Chestnut Flat mine, but none were as extensively mined as the Chestnut Flat.

Reserves

Brobst (1962) in describing the feldspar reserves of the Spruce Pine district states, "In the Spruce Pine district the reserves of feldspar in the part of the alaskite within 50 feet of the surface recoverable by flotation exceed 200 million tons." This figure indicates reserves adequate for several hundred years of continuous production.

Bryson City District

Location

The Bryson City district is located in Swain County midway between Asheville and Murphy, near the southern edge of the Great Smokey Mountains (Figure 11). The district is accessible by U.S. Highways 19 and 19A, State Highway 28 and the Murphy Branch of the Southern Railway. The area is mountainous with elevations ranging from about 1,630 feet above sea level to over 4,000 feet above sea level. The higher peaks enclose the city of Bryson City, located in a topographic basin formed by the westward flowing Tuckaseigee River.

General Geology

The geology of the district is quite complex as a result of the long history of sedimentation, intrusion, granitization and deformation. The central portion of the district is underlain by a granitic complex composed of fine to coarse-grained, leucocratic and mesocratic gneisses, ranging in composition from granitic to granodioritic. The primary mineral constituents in the gneisses are microcline and perthite, plagioclase and quartz with minor amounts of biotite, muscovite, hornblende and epidote. Foliation, when present, is usually due to the elongation of biotite grains, parallelism of feldspar and quartz augen, or alternation of layers of contrasting composition. The northern half of the granitic complex is enclosed by a border gneiss consisting of a medium gray foliated gneiss. It is composed of microcline and quartz porphyroblasts and augen in a medium to coarse-grained biotite, quartz and feldspar matrix. Around the southern half of the complex, a similar border gneiss is thought to occur.

The border gneiss separates the granite complex from the surrounding Ocoee Group of metasedimentary rocks. This metasedimentary group consists predominantly of interbedded schists and feldspathic micaceous quartzites, with minor feldspathic metaconglomerates. The bedding and foliation in these metasediments is generally parallel to the contact with the border gneiss.

Although the metasedimentary rocks and the granite complex comprise the bulk of the rocks, other rock types are not uncommon. Near the contact of and lying within the granite complex, metaperidotite is exposed in two narrow belts. This rock is highly altered, varying in texture from massive to schistose and is composed of tremolite, anthophyllite and chlorite. The metaperidotite grades into hornblende schist and biotite schist. Within the complex, it is common to find hornblende and biotite schist and gneiss layers, lenses and streaks.

Pegmatites

Distribution - The greatest concentration of pegmatites in the district occurs along the western border of the granitic complex, extending from near Deep Creek Church southwestward to Mt. Carmel Church. The largest and most productive of the pegmatite bodies are enclosed by a belt of border gneiss along the western edge of the complex (Cameron, 1951).

Mineralogy and Structure - The pegmatites occur in a variety of shapes and sizes ranging from small stringers to massive bodies 500 feet in length. The average pegmatite is about 200 feet long and about 50 feet thick. The larger bodies tend to be irregular in shape with the outer contacts often intruding the country rock. The emplacement of the pegmatites in the enclosing rocks is commonly controlled by fractures, bedding and foliation.

The composition of the pegmatites is quartz, microcline-perthite and sodic plagioclase with small amounts of biotite and muscovite. Grain size varies between one inch and eight feet in maximum dimension. Zoning is the most important structural feature within the pegmatites. Ideally, the zones are concentric shells reflecting the shape or structure of the pegmatite. These zones are arranged around a core with each zone, in ideal situations, possessing a characteristic mineral assemblage. The zones are classified according to their position within the pegmatite as follows: (1) Border Zone - The outermost zone, normally only a few inches thick, is composed of a mixture of fine-grained plagioclase and quartz with varying amounts of perthite and accessory minerals. (2) Wall Zone - The thickeness of this zone may range from six inches to several feet, it is commonly a mixture of medium to coarse-grained plagioclase and quartz with varying amounts of perthite and accessory minerals. (3) Intermediate zone - There may be several intermediate zones within a pegmatite inasmuch as any zone between the wall zone and the core is considered as intermediate. These zones are mixtures of coarse to very coarse-grained plagioclase, perthite and quartz with accessory biotite or muscovite. Crystals of feldspar range from one foot to fifteen feet in length. (4) Core - The innermost zone of the pegmatite is a massive quartz or quartz with perthite and plagioclase core. This zone may be discontinuous, consisting of disconnected segments along the strike or dip (Cameron, 1951).

Selected Mines

Carson Mines - The Carson mines are located approximately 0.5 mile N. 85° E. of Deep Creek Church and 0.8 mile S. 35° E. of the crest of Sharptop Mountain, Swain County. This property was originally worked by the Harris Clay Company for kaolin around 1910. Production of feldspar began in 1941. The mines include four openings in two large pegmatites, the largest of which is 400 feet long and 200 feet wide. This pegmatite, known as the north pegmatite, is distinctly zoned in some portions, but the only potentially productive zone appears to be the perthite-quartz wall zone, (Cameron, 1951). The south pegmatite has yielded the largest quantities of feldspar, mostly from the middle and inner intermediate zones.

Woody No. 1 Mine - The Woody No. 1 mine is 0.7 miles N. 84° W. of Deep Creek Church near a tributary of Deep Creek, Swain County. It was worked in 1941 with some potash feldspar produced. The pegmatite, consisting of 5 zones, is emplaced in interbedded quartz-mica schists and is quite irregular in shape. The largest quantity of feldspar was produced from the perthite-quartz-plagioclase zone. Most of the high grade feldspar has been mined, but it is likely that considerable amounts of lower grade feldspar still exists (Cameron, 1951).

Swain Mine - The Swain mine located 0.5 mile N. 57° W. of Randall Cemetery, was the second largest producer in the district. It was first worked in 1940 with operations continuing for six years. The pegmatite is pipe-like, consisting of seven zones of which the perthite-quartz zone has been the most productive. Unusually rich in large crystals of perthite, this zone contains very little plagioclase or quartz. Much of the original shoot still exists and it is probable that sizable quantities of feldspar remain (Cameron, 1951). The limits of the original mining were restricted due to instability of the extremely weathered pegmatite and country rock.

Deep Creek No. 1 Mine - The Deep Creek No. 1 mine is located 0.6 mile N. 83° W. of Randall Cemetery, Swain County. The mine was originally worked for kaolin in the early 1900's and began producing feldspar in 1935. It was the largest producer of high potash feldspar in the district.

The mine is an open cut, 180 feet long, 140 feet wide and 95 feet deep, in a large, irregular lens-shaped pegmatite, 490 feet long and 40 to 210 feet wide. The pegmatite strikes N. 17° E. and dips to the west. The contact of the pegmatite and the enclosing border and granite gneiss is generally sharp, indicating probable emplacement along a fracture.

The pegmatite is made up of six zones of which the perthite-quartz intermediate zone has been the most productive. The border zone, 2 to 6 inches thick, is composed of fine-grained plagioclase, quartz and perthite with small amounts of biotite, magnetite and garnet. The wall zone is from 1.5 to 7 feet thick and is composed of plagioclase and quartz with accessory perthite, biotite, magnetite, garnet and pyrite. The wall zone grades into the outer intermediate zone with an increase in grain size and perthite content. The outer intermediate zone consists of a mixture of coarse to very coarse-grained plagioclase and perthite, with graphic intergrowths of quartz. The middle intermediate zone consists primarily of perthite and subordinate amounts of quartz and plagioclase. The inner intermediate zone is composed of quartz with scattered crystals of perthite. Tourmaline, biotite and allanite occur as accessory minerals. The core of the pegmatite is massive gray to milky quartz.

The middle intermediate zone, the inner intermediate zone and the core are asymmetric and discontinuous, usually occurring as small pods with the outer intermediate zone. They form well-developed bodies only in the westward bulges of the pegmatite where the perthite-quartz zone has been extensively mined.

Reserves

The prospect of marketing large quantities of feldspar from the Bryson City district is not favorable. The primary handicaps are the competition from the Spruce Pine district where an abundance of alaskite is found, the long distance to the mills and the lack of additional large bodies of pegmatite.

The Cashiers District

Location

The Cashiers district comprises an area of about 265 square miles in southeastern Jackson and southwestern Transylvania Counties (Figure 11). The northern tip of the district lies in the southern most part of Haywood County while the southern tip of the district extends into Macon County.

The district lies entirely within the Blue Ridge physiographic province.

General Geology

The metamorphic rocks underlying the Cashiers district are chiefly mica gneisses and schists of a complex and varied composition and of probable metasedimentary origin. This series was originally designated as Carolina Gneiss by Keith. However, because of the complexity and variability of the composition, the formation name is no longer accepted. In addition, hornblende gneisses and schists with interlayered mica gneiss and schist underlie extensive areas of the district. This unit, designated Roan Gneiss by Keith, also has a composition so varied and complex as to make a formation name inappropriate.

The regional strike of these metamorphic rocks is northeast and the dip southeast, with local variations.

A widespread area of this district is underlain by extensive bodies of moderately to well foliated, medium to coarse-grained, locally porphyritic metamorphosed granite, composed of potash feldspar, plagioclase, quartz, muscovite and biotite with minor amounts of magnetite, pyrite, ilmenite and garnet. This metamorphosed granite, mapped as Whiteside Granite by Keith, is of probable Late Paleozoic (?) age and occurs as lacolithic bodies and sills which dip slightly to the southwest.

In addition to the metagranite complex, smaller bodies of ultramafic rocks, such as dunite, soapstone, etc., are present in the Cashiers district.

Numerous pegmatites are associated with, and probably derived from, the Whiteside Granite. These pegmatites are sill-like bodies having a moderate dip and composed of quartz, perthite, plagioclase, muscovite and garnet with accessory beryl, tourmaline, samarksite and uraninite.

Locally, the mica schists and gneisses have been injected by granitic and pegmatitic material forming extensive migmatite zones. In addition, numerous small non-foliated granite dikes cut the Whiteside Granite, the pegmatites and the migmatite. According to Keith, these granite dikes are more abundant near the bodies of Whiteside Granite and are of similar composition; thus they were probably derived from the same source as the Whiteside Granite (Olson, 1952).

Pegmatites

Distribution, Size and Shape: The bulk of the productive pegmatites are found within the mica gneiss and schist complex which occupies the south central and northern portions of the district. In the south-central part of the district, the mica gneiss and schist units are surrounded by two large bodies of Whiteside Granite and it is within this area that the highest concentration of pegmatites are found. The pegmatites vary in thickness from one to seventy-five feet. The most productive ones are found among those pegmatites which range in size from twenty-five to seventy-five feet. Although the overall length and depth of these pegmatites is unknown, it is reasonable to assume that these dimensions are many times the known thickness.

Mineralogy and Structure: Generally, the pegmatites of the Cashiers district are simple in composition. Quartz, with occasional concentrations of smokey quartz, perthite, plagioclase, normally oligoclase, muscovite and garnet make up the bulk of the composition. In addition, occurrences of biotite are relatively common. Rarer minerals which have been noted by several investigators, are beryl, black as well as pink tourmaline, apatite, pyrrhotite, pyrite, epidote, uraninite, uranophane, autunite and bismutite.

Pegmatite zoning, common in pegmatites of other feldspar districts in North Carolina, is also a feature of the pegmatites of the Cashiers district. Generally speaking, the core of the typical zoned pegmatite in the Chasiers district consists of quartz with occasional perthite and muscovite. The outer wall or wall zone of the pegmatite contains plagioclase, perthite and muscovite. Thicker pegmatites contain graphic intergrowth of perthite and quartz. These intergrowths are not restricted to a particular zone, but ostensibly occur as an intermediate zone between the core and the wall zone. Thus, the minerals of economic importance, i.e., feldspar and mica, are to be found in the outer zones of these pegmatites.

Inasmuch as most of the pegmatites are concordant, it may be assumed that the emplacement of these bodies was controlled by the schistosity of the wall rock. In addition, the pegmatites have suffered deformation both contemporaneous with, and after emplacement. Evidence for this is found in the subparallel orientation of mineral grains to the wall rock and fracture filling as evidenced in the wall zone of the pegmatites.

Olson (1952, p. 8), in describing the structure of the Cashiers pegmatites states:

"Many of the textures are similar to those in the Spruce Pine district, which have been described and illustrated by Maurice (1940, pp. 59-63, 71-72) and probably originated by similar processes, such as protoclastic deformation, filter pressing, some replacement, and less commonly cataclastic deformation."

Selected Mines

The Cashiers district has never been a large producer of feldspar and, at the present time, no feldspar mining is conducted in this district. Peak production occurred during the war years, 1942-1945.

Although the Cashiers district is normally associated with the production of sheet mica, the following mines, described in detail by Olson (1952, pp. 12-17), were of prime importance in the production of feldspar.

Sheep Cliff Mine- The Sheep Cliff mine is located approximately two miles northeast of Cashiers, Jackson County, on the northeastern side of Little Sheep Cliff Mountain.

This mine is an open cut approximately 100 feet long and 70 feet wide. The pegmatite is 65 feet thick, irregular in shape, strikes northeast, dips to the northwest, and consists of three zones. The core is made up of clear to pale rose quartz and is seven feet thick. The intermediate zone contains quartz, perthite blocks up to three feet in length, and minor plagioclase, mica, beryl and samarskite. It was from this zone that by-product mica was produced. The wall zone contains graphic intergrowths of quartz and perthite, quartz, perthite, plagioclase, muscovite and garnet.

Bald Rock Mine - The Bald Rock feldspar mine is located on the eastern side of Bald Rock Mountain at the head of Bracken Creek, Transylvania County.

The mine consists of an open cut which has exposed the central portion of the pegmatite. The pegmatite has a minimum thickness of seventy-five feet, strikes N. 30° - 50° E.,and dips northwest at 45°. The body apparently thins out to the southwest and thickens to the northeast. The pegmatite is enclosed by, and is concordant with, the surrounding granite.

The composition of the pegmatite wall zone is perthite, quartz and muscovite. Graphic intergrowths of quartz and feldspar are common, and contacts between zones in the pegmatite are gradational. While the mica content is quite variable, seams of high concentrations of biotite and muscovite are frequently encountered. The inner zone is of much the same composition as the wall zone, except that graphic granite is not as abundant and quartz and muscovite are not as widely disseminated. Fracture filling by fine-grained quartz, perthite, oligoclase, garnet and locally coarse muscovite, occurs in the wall zone.

L.M. McCall Feldspar-Mica Mine - The L.M. McCall mine is located one-half mile northwest of Penhook Gap, near the Jackson-Transylvania County line. The mine consists of two open cuts, 65 X 40 feet and 140 X 40 feet. The two pits expose a concordant pegmatite body 35 feet thick, 300 feet long, striking N. 30^{o} E.,dipping 80^{o} NW, and plunging to the southwest. To the southwest, the pegmatite apparently splits into several finger-like bodies.

The pegmatite is composed of perthite, quartz, oligoclase, muscovite, biotite and pyrrhotite. There is present in the pegmatite a thin border zone of perthite-quartz, probably the initial zone of crystallization. An intermediate zone, consisting of perthite, graphic granite and quartz with minor amounts of muscovite and biotite, makes up the bulk of the pegmatite. The inner zone is composed of massive quartz with accessory pyrite and pyrrhotite. These two sulfides also occur in the border zone. Post fracture filling is evidenced by several thin oligoclase-quartz bodies.

This mine was worked for high potash feldspar and muscovite in the late 1940's.

Reserves

There are no estimates for tonnage reserves in the Cashiers district. Of the mines examined by Olson (1952), only the three described above are of sufficient size to warrant mining. In recent years high potash block feldspar has been mined from this district to upgrade feldspar from the Spruce Pine area.

The Shelby District

Location

The Shelby district is located in the south-central Piedmont of North Carolina. With an area of 750 square miles, the district includes the Shelby, Lincolnton, Kings Mountain and Gaffney quadrangles (Figure 11). It covers most of Cleveland, southwestern Lincoln and western Gaston Counties.

General Geology

The Shelby district is underlain by metamorphic gneisses and schists into which two phases of igneous rocks have been intruded. The oldest of these is the Toluca Quartz Monzonite, a foliated biotite quartz monzonite exposed in the western and northern portions of the district. The younger of the two is the Cherryville Quartz Monzonite, a massive to weakly foliated muscovite-biotite quartz monzonite occurring in the eastern section of the district.

Biotite gneisses and schists, hornblende gneiss and sillimanite schist comprise the principal metamorphic rocks of the western and southern portions of the district. The "Sillimanite Belt" (Hunter and White, 1946) passes through the northwest section of the Shelby district.

The eastern boundary of the district is delineated by a series of early Paleozoic siliceous and calcareous metasediments known collectively as the Kings Mountain Belt. The siliceous metasediments consist of quartzites, slates, volcanics, phyllites and conglomerates. Crystalline dolomites, limestones and calcareous shales make up the calcareous group which is apparently a younger sequence than the siliceous metasediments. This calcareous group grades unevenly westward into more strongly metamorphosed gneisses and schists.

Two other rock units of inferred metasedimentary origin are present in this district. Kesler has divided them into two groups, nonuniform layered and uniform layered. The former unit is considered to be that part of the geologic sequence mapped as Carolina Gneiss and Roan Gneiss and finer grained Bessemer Granite by Keith and Sterrett. The latter unit considered by Keith and Sterrett to be Bessemer Granite, is enclosed by the non-uniform layered unit and is thought to be derived from thick-bedded shales and volcanic tuffs (Kesler, 1955).

The major structure in the district is revealed by the uniform northeasterly strike and the dips which vary from flat to vertical and occasionally westerly, especially to the west of the Kings Mountain Belt. The structure is interpreted by Kesler (1955, p. 50) as, "a rather tightly compressed anticline whose core includes the siliceous metasediments of the Kings Mountain ridge belt." The limbs of the anticline contain the remaining metamorphic rocks of the area.

Intrusive Rocks

The two major intrusive igneous units within the Shelby district are the Toluca Quartz Monzonite and the Cherryville Quartz Monzonite. In addition to these, numerous Triassic diabase dikes and pegmatite dikes cut the major rock units.

Toluca Quartz Monzonite - The Toluca Quartz Monzonite, originally mapped as Whiteside Granite by Keith and more recently termed quartz monzonite by

Griffiths and Overstreet, is a medium gray, weakly to strongly foliated gneissic rock. Foliation is quite pronounced in smaller bodies and near the margins of the larger intrusive bodies. Normally the Toluca is concordant but local discordances have been noted.

Although the texture and composition of the Toluca Quartz Monzonite is quite variable, it is fundamentally composed of oligoclase, microcline, orthoclase, quartz and biotite with minor amounts of garnet and muscovite and traces of zircon, apatite, ilmenite and monazite.

Cherryville Quartz Monzonite - The Cherryville Quartz Monzonite, the second major intrusive igneous rock, and probably the most extensive of the two intrusives, crops out in a broad belt along the western side of the "Tin-Spodumene Belt." South of the town of Cherryville the quartz monzonite is essentially concordant; however, to the north it bends eastward and becomes discordant.

The mineralogy of the Cherryville permits division of the unit into two types. This division is based on the predominance of biotite or muscovite in the rock. Essentially the composition of the Cherryville is oligoclase, microcline, quartz, muscovite and/or biotite with accessory zircon, ilmenite and apatite. The texture varies from massive to slightly gneissic and grain size from the normal medium grained to very coarse grained, almost pegmatitic, along the eastern boundary of the intrusive.

Associated Pegmatites

There are two varieties of pegmatites associated with the Cherryville: the well-zoned, mica-bearing pegmatites of the northern portion of the district, and the spodumene-bearing pegmatites which are restricted to the mid-portion of the "Tin-Spodumene Belt." The mica pegmatites consist of perthite, oligoclase, quartz and muscovite, while the spodumene pegmatites contain, in addition to spodumene, microcline, albite and quartz.

The pegmatites range in size from several inches to several hundred feet in width. The depth of these pegmatites is also quite variable, the deepest being at least 900 feet. However, the average depth of the productive pegmatite is 200-300 feet.

Basically, the pegmatites are tabular with rather erratic trends. However, the general trend is northeast with dips varying from vertical to 20 degrees.

Contact Granites

In the southeastern section of the district, the Cherryville Quartz Monzonite-biotite gneiss and schist contact zone has undergone extensive enrichment by magmatic solutions. Within this zone which is approximately one mile wide and four miles long, the quartz monzonite becomes coarse grained and muscovite enrichment is widespread. The rock is deeply weathered with large biotite and muscovite schist inclusions prominent throughout.

Most of the feldspar and all of the scrap mica produced in this district is mined from this contact zone.

Selected Mines

Feldspar obtained from the Shelby district is a by-product of the mica and lithium industries. Therefore, the mines described are primarily scrap mica or spodumene operations.

J. Bun Patterson Mine - The Patterson mine, owned by the Kings Mountain Mica Company, is situated near Potts Creek approximately 1.3 miles N. 12° W, of the intersection of U.S. Highways 29 and 74 near Kings Mountain, Cleveland County.

The mine is located in a portion of a large irregularly shaped quartz monzonite contact zone. The ore body is kaolinized to a depth of 30 to 40 feet, with a light overburden. The unweathered rock is a fine to medium-grained granitic rock composed of plagioclase, quartz and muscovite with minor amounts of potash feldspar, biotite and garnet. It is not uncommon to find mica gneiss and schist inclusions and pegmatite segregations throughout the granitic body.

Present mining is primarily for the recovery of mica by froth flotation. The feldspar is a by-product of this process.

Charlie Moss Mine - The Moss mine, also operated by the Kings Mountain Mica Company, is located approximately 2.5 miles southwest of Kings Mountain in Cleveland County. This mine, like the Patterson mine, is of primary importance as a producer of scrap mica.

The ore body is similar to the one at the Patterson mine and is located in the southern extension of the same contact zone. The deposit is quite extensive, consisting of a very irregular contact zone at least 700 feet long by 300 feet wide. The overburden is relatively thin, and the kaolinized portion of the deposit reaches a maximum depth of 40 feet.

Present mining is being carried out in open pits. As in the Patterson mine, the feldspar is a by-product of mica flotation.

Kings Mountain Mine - The Kings Mountain spodumene mine of Foote Mineral Company is located 1.6 miles S. 25^{o}.E., of Kings Mountain, south of U.S. Highway 29. This mine is within a northeasterly trending belt of lithium pegmatites located along the east side of the Cherryville Quartz Monzonite contact.

The spodumene pegmatites are composed of albite, quartz, microcline, spodumene and mica in order of abundance. A total of thirty minerals have been identified in the spodumene pegmatites. Included in this number are beryl, columbite and cassiterite (Broadhurst, 1956). The soda-potash feldspar ratio is 2:1, and combined, the two feldspars represent 41 percent by weight of the ore. The enclosing country rock consists of interlayered amphibolite and mica schist.

The mine, worked in a series of 20 foot benches, contains several large pegmatite bodies ranging from 20 to 100 feet thick (Kesler, 1961). These pegmatites are mined primarily for spodumene with feldspar and scrap mica as the chief by-products.

Reserves

As in the case of other districts in North Carolina, a complete tabulation of the reserves of the Shelby district is not available. It is probable that an adequate supply of feldspar, at the present rate of mining, is available for many years.

Outlook

Although no precise figures are available regarding the total reserves of North Carolina feldspar, it has been estimated that at the present rate of consumption the State has reserves adequate for several hundred years. The vast majority of these reserves are concentrated in the Spruce Pine district.

The feldspar industry is, of course, primarily dependent upon the glass and ceramic industries. Market fluctuations in these and allied industries directly affect the overall production of feldspar. The industry has a definite need to develop new markets for its products in order to offset any decline in the glass and ceramic industries. The feldspar producers are aware of this problem and many of the companies have undertaken research oriented in this direction.

Additional problems which confront the industry have resulted from the increased utilization of feldspar substitutes. Nepheline syenite, aplite and electric furnace slag, which is obtained from the manufacture of phosphorous, are all used as a substitute for feldspar in the manufacture of glass products. Ceramic products may contain nepheline syenite, talc, pyrophyllite or lithospar as feldspar substitutes. In addition, plastic wall tile and dinnerware as well as aluminum tile have become increasingly important replacements for ceramic tiles and dinnerware. More than half of the feldspathic material presently used in the manufacture of flint glass consists of nepheline syenite and aplite. Also the tonnage of nepheline syenite utilized in the ceramic industry in 1962 was 20 percent of the total ground feldspar shipped by eastern plants (Feitler, 1967). Crude nepheline syenite enters the United States duty free and is used in the eastern markets where freight rates do not make its use prohibitive.

Quality control, important in all industries, is of great concern to North Carolina feldspar producers. Removal of impurities, such as iron oxide

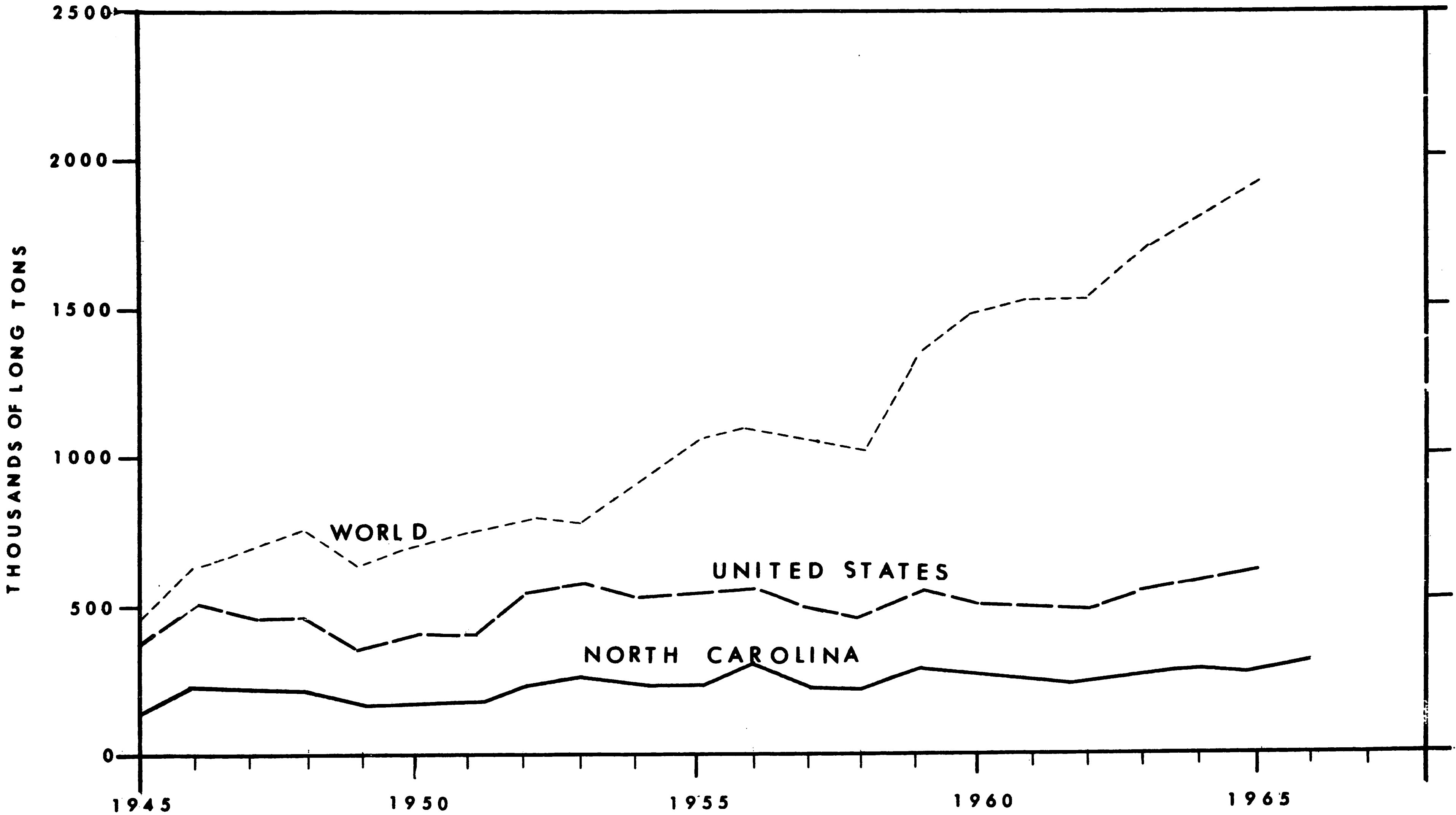

FIGURE 12. GRAPH OF WORLD, UNITED STATES, AND NORTH CAROLINA FELDSPAR PRODUCTION.

and minerals which affect the color and melting point, is of prime importance. Because marketed feldspar is always a mixture of potash and soda feldspar, an economic method of separating the potash and soda feldspar would be of considerable importance. Several methods have been proposed, i.e., Robert E. Snow, electrostatic beneficiation of feldspar (Snow, 1963), and Dewey J. Hall, flotation of potash feldspar from soda feldspar (Hall, 1963), but as yet none of these have proven economically feasible.

For the past ten years the quantity of crude feldspar produced in North Carolina has averaged approximately 267,000 tons per year. Figure 12 shows the World, U.S., and North Carolina production of feldspar for the period 1945 to 1965. It has been estimated that the United States production of feldspar will increase 43 percent by 1980 (Wells, 1965).

Feitler (1967, p. 35), in summarizing his projections for growth of the eastern ground feldspar industry states, "An increase of 22 percent by 1970 is anticipated for the production of glass feldspar. Production of ceramic feldspar projected to 1970 indicated an increase of 12 percent. Total production of eastern ground feldspar projected to 1970 is 490,000 tons which is 20 percent greater than the quantity produced in 1962 and represents an annual rate of growth of 2.3 percent." (Feitler, 1967).

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