University of Wisconsin-Extension

GEOLOGICAL AND NATURAL HISTORY SURVEY
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SYENITES AND NEPHELINE SYENITES OF THE WAUSAU AREA

by

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Open-File Report 45-2
31 p. + 1 plate

1945

WISCONSIN GEOLOGICAL SURVEY

A STUDY OF THE SYENITES AND NEPHELINE SYENITES OF THE WAUSAU AREA

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The area of this study includes parts of Townships 29 and 30 North, Ranges 6 and 7 East, located in Marathon County, Wisconsin. The area lies immediately west of the city of Wausau. Specifically, it is comprised of Sections 1 - 4, 9 - 16, 21 - 28, and 33 - 36, Township 29 North, Range 6 East; Sections 3 - 10, 15-22, and 27 - 34, Township 29 North, Range 7 East; Sections 33 - 36, Township 30 North, Range 6 East; and Sections 31 - 34, Township 30 North, Range 7 East.

The area is easily accessible to both railroad and highway transportation. Wausau, a city of about 28,000 population, is served by the Chicago, Milwaukee, St. Paul, and Pacific and the Chicago and Northwestern Railways, with the latter crossing the southern part of the area of this study. U.S. highway 51 and state trunk highways 29 and 52 pass through Wausau. U.S. highway 51 crosses the eastern part of the area of this study and state trunk highway 29 crosses the southern part of the area. County highways and good quality aecondary roads cross the region at frequent intervals so that no part of the area is more than one half mile from a road.

Agriculture is the chief industry of the region, but the city of Wausau contains several manufacturing and processing establishments. Quarrying of granite, argillite, and quartzite is an important industry with quarries now operating to the northeast, east, and south of the area of this study. Exploitation of nepheline and zircon deposits of the area has been attempted in the past with zircon mined on a small scale comparatively recently.

This study has been conducted with the view:

1). Of mapping the syenite and nepheline syenite occurrences.

2) Of delimiting the areas of white nepheline syenite.

3) Of determining the areas in which zircon may occur in quantity.

4) Of determining something of the composite nature of the syenite and nepheline syenite dikes.

5) Of investigating the factors which control the iron content, and therefore the economic value, of the nepheline.

Throughout the survey the field work was accomplished by compass and pace traverse. Detailed study of critical areas and outcrops was made as the situation required it.

The Wisconsin Geological Survey field party of 1944 studied and reported on the structural factors controlling the origin and distribution of the syenites and nepheline syenites of the area. The reader is referred to the earlier report* for details of structure and lithology of the region surrounding the area of this study.

The writer has profited by work done in this area in the past. This includes that of Weidman, published as Bulletin 16, Geological Survey of Wisconsin, 1907; that of the field parties of the early 1920's in the form of township geologic plats; and that of the field party of 1944. The writer has drawn heavily from these sources as acknowledged in the following text and the accompanying map, although interpretations, particularly of the earlier work, have been modified. The writer is also indebted to Professor R. C. Emmons for ideas and suggestions pertaining to the structure and petrogeny of the area of this study.

* Emmons and Snyder, "A Structural Study of the Wausau Area", Wisconsin Geological Survey, 1944

In the report of 1944 (Emmons and Snyder) the section was given as rhyolite, greenstone and possibly later rhyolite, and quartzite; intruded by granite, with the aplite, syenites, and nepheline syenites being differentiates of the granite parent. As this study is concerned chiefly with the syenite and nepheline syenite dikes penetrating the aplite the older formations received little attention with the exception of the greenstone where it is intruded by the granite differentiates. For detailed description of the rhyolites, the greenstone and associated rock types, the granite with its hybrid phases, and the aplite the reader is referred to the earlier report.

THE APLITE

The area studied lies almost entirely within the large aplite area of Townships 29 and 30 North, Ranges 6 and 7 East with traverses over the greenstone only in so far as necessary to map the aplite - greenstone contact and to trace occasional nepheline syenite bodies into the greenstone.

The aplite was adequately described in the report of 1944 and at this time demands only brief treatment. Many varieties of aplite are seen and include a reddish-brown variety, a gray variety similar in composition to the gray syenite, and near the greenstone contact a hybrid type bearing the characteristics of both the aplite and the greenstone.

The "normal" red aplite is composed of an estimated 90-95% orthoclase feldspar and 5-10% black amphibole. Compositional variations appear frequently with the aplite bearing a minor amount of plagioclase, up to 10% quartz, and up to 20% mafic minerals - amphibole, biotite, or chlorite. In general, near the center of the aplite area quartz is absent or makes up less than 5% of the rock.

Variations in texture occur even more frequently than variations in composition. The aplite is usually sugary-textured;in places bears trachitic

texture, and is often seen with fine-granitic texture showing clean-cut mineral boundaries. Occasional areas of porphyroblastic red aplite - composed almost entirely of ortholase feldspar - are seen.

Near the aplite-greenstone contact the aplite frequently occurs in hybrid form. In the SE¼ of Section 7, T.29N.,R.7E, the aplite-greenstone hybrid appears in float in large boulders and in considerable quantity. The hybrid rock is sheared, brecciated, and contains greenstone in various stages of digestion in the aplite host. Areas of aplite up to one-fourth inch wide between greenstone "ghosts" are light pink to white in color.

In the NW¼ of Section 19, T.29N.,R.7E. the erosion surface coincides with the aplite-greenstone contact. Here the aplite shows a well-developed gneissic texture and carries greenstone inclusions. The inclusions are in all states of assimilation by the host. One such specimen carries, in addition to the greenstone, augen of quartz enclosed by mafic aplite. The banded texture of the aplite shows small overturned folds. To the southward of this occurrence the rock changes from a hybrid aplite to a hybrid greenstone consisting of 70% greenstone and 30% aplite. The rock is often banded, frequently bears aplite apophyses, but shows no brecciation.

In the NW¼ of Section 15, T.29N.,R.6E., the change from unaltered greenstone to normal aplite is easily traced. At this occurrence the hybrid ranges from a brown aplite, high in mafics and bearing greenstone inclusions, to one in which the greenstone has more or less completely changed in character. In many places hornblende porphyroblasts are all that remain to mark the greenstone inclusions. Well developed hornblende crystals range up to one-half inch in size; incompletely altered greenstone masses are frequently larger in size and enclose masses of aplite. To the southeast of this occurrence the aplite changes rapidly in character to the normal red type seen over most of the area.

THE SYENITES

The syenites occure in great variety and abundance in comparatively narrow dikes. They appear to be the most resistant rocks of the central part of the area and are usually expressed topographically as bold hills with the intruded aplite marking the depressions. They occur in a complex array of varieties which are ascribed to two basic types - the gray and the red. The most common sub-types include a fine-grained, grayish-brown syenite and a reddish brown, coarse-grained variety. The first of these is the contact phase where the gray intrudes the red aplite; the second is the contact phase of the gray where it is intruded by the red syenite. Both the gray and the red syenite occure as pegmatite; the gray usually in narrow dikes seldom more than two feet in width, the red in dikes whose width compares with that of the normal phase.

The Gray Syenite: The gray syenite offers the best outcrops of the area and is frequently seen as flat or gently-rounded, ground level exposures, 20 to 100 feet in extent. It is most abundant in Section 14, T.29N.,R.6E. Composition of the gray syenite, wherever it is exposed, is quite consistently an estimated 85% orthoclase feldspar and 15% amphibole and biotite. Occurring with and in the gray syenite are irregular inclusions of aplite, dark mafic syenite- shonkinite, aplite and pegmatite dikes, and, at least one occurrence, lamprophyre.

The lamprophyre - seen only in quarry fragments - occurs at the large quarry in the SE¼ of Section 14, T.29N.,R.6E. The extreme eastern part of the quarry dump bears large broken blocks, some of which contain lamprophyre dikes. Blocks in which the contact of the lamprophyre with the gray syenite is seen show dikes varying in width from one-half inch to six inches. One block of the lamprohyre, about 15 inches in diameter and showing no contact with the syenite, indicates that the rock occurs in larger dikes. The most common width is three to four inches. Pegmatite dikes are seen cutting the gray syenite but none is seen in contact with or intersecting the lamprophyre. The contact of the lamprophyre

with the gray syenite is very sharp. In breaking the rock it frequently breaks free of the syenite directly along the contact.

Much of the lamprophyre is too-fine-grained for hand lens resolution. Feldspar can be seen in subhedral to anhedral grains about one-tenth millimeter in size. Plagioclase laths are abundant.

The gray syenite is frequently seen - in outcrop - in contact with the gray aplite, but very rarely seen with the red aplite. In the SE¼, NE¼ of Section 14, T.29N.,R.6E. the gray syenite and gray aplite are seen in a long narrow outcrop in the roadside ditch. Here the contact of the gray syenite and the gray aplite is not marked by any change in appearance or character of the rock on the weathered surface. In spite of the difference in grain size, one is not aware of the lithologic change except by observing the fresh rock surface. The contact, as seen in the unweathered rock, is not sharp but shows a gradual increase in grain size from the aplite to the syenite. Syenite observed one foot from the contact is "normal" gray syenite, except for development of trachitoid feldspars up to one inch in length. The feldspars show good alignment. Mafic content (amphibole and biotite) is about 15%.

At the contact there is a gradual change in grain size from one rock to the other. The composition of the aplite is much like that of the syenite - and estimated 85% orthoclase feldspar and 15% amphibole and biotite. The aplite shows some development of trachitic feldspar, but the feldspars show little alignment. The mafics are in grains from one-tenth to five-tenths millimeter; the feldspars in five-tenths millimeter grains but with tabular feldspars occasionally up to three millimeters. Texture is neither good granitic nor good trachitic.

The contact of the gray syenite with the red aplite is rarely seen in outcrop, but it is revealed in the change in float as one passes from the gray syenite onto the red aplite. Near the areas of normal gray syenite a fine-grained syenite

is frequently seen which passes into normal red aplite as one goes away from the gray syenite. In the SE¼, NW¼ of Section 14, T.29N.,R.6E. the fine-grained syenite, near the gray syenite, is composed of orthoclase feldspar (85%) and amphibole (15%). The feldspar is grayish-brown in color, almost entirely tabular and subhedral, and shows good alignment. The amphibole is in one millimeter crystals and aggregates up to three millimeters. However, because of the color of the rock and the distribution of the amphibole, texture is best described as granitic. Sufficient feldspar is unoriented to mask the trachitic nature of the rock except under close observation. This rock is neither the gray syenite nor the red.

At another occurrence in the NE¼, SE¼ of Section 15, T.29N.,R.6E. gray syenite of the normal type is seen in outcrop and a few paces distant float includes fine-grained brown syenite and normal aplite. The syenite is composed of orthoclase feldspar (85+%), biotite and amphibole (15%). Grain size of the feldspar is one to two millimeters for equant, subhedral crystals, and up to eight millimeters by one millimeter for tabular crystals. At least 50% of the feldspar is the tabular type. The feldspars show some alignment, but not particularly strong. The amphibole is in anhedral crystals of one to two millimeters size. Texture is granitic. Other float from this occurrence shows strong development of tabular feldspar with good alignment to give trachitoid texture. Feldspar crystals range in size from three millimeters equant crystals to ten millimeters by two millimeters tabular crystals. The aplite bears 10% mafic minerals and shows a few feldspar porphyroblasts of four millimeters size. Grain size of the aplite is five-tenths millimeter.

The gray syenite, because of the exeellent exposures it offers, presents the best opportunity for study of the lateral and vertical changes within the dikes. In the SE¼, NE¼ of Section 16, T.29N.,R.6E. the gray syenite is continuously exposed over a width of about 125 feet. The outcrop was studied across the

exposure to see if any change in texture or composition could be noted. The rock appears to be consistent in composition so far as can be estimated with the hand lens. The syenite is composed of orthoclase feldspar (85%), amphibole and biotite (15%). A slight variation in texture can be seen. The feldspar is in tabulor, subhedral crystals up to five-eighths inches in length and one to two millimeters in width. At the margins of the exposure and for some distance toward the center the feldspars show marked alignment giving the rock a trachitoid texture. This is easily seen both on the weathered and on the fresh surface. Near the center of the exposure the feldspar is still tabular in shape, but the alignment is poor. Tabular crystals are frequently seen at right angles to the general trend. It is also thought that twinning, of the carlsbad type, is more frequently seen near the center of the exposure than near the margins. This conclusion must be regarded as tentative only; it's confirmation would necessitate detailed microscopic study.

Other dikes of the gray syenite do not offer a sufficient width of continuous exposure to give reliable information concerning lithologic changes accross the dike.

An indication of the vertical change within the gray syenite cannot be gained from study of a single dike, but a general trend is seen when several dikes are compared. In the SE¼ of Section 14, T.29N., R.6E. gray syenite from the large quarry is composed of an estimated 85% orthoclase feldspar and 15% amphibole. The rock is massive and granitic in texture. Grain size is four to six millimeters. This is well within the aplite area - that is, where the roof rocks have been removed so the exposed aplite is uncontaminated and normal in type. The quarry rock is undoubtedly the deepest penetration of the gray syenite within the area. To the northwest of the quarry - in the same section - the gray syenite is still granitic in texture but contains some biotite, though the mafic content still is about 15% of the rock.

In the NE¼ of section 16, T.29N.,R.6E. gray syenite is exposed (the exposure studied for lateral change) which lies much closer to the aplite-greenstone contact.

Here the syenite is still consistent in composition, but texture is no longer granitic. Feldspars are tabular in shape, up to five-eighths inches in length, and over much of the exposure show good alignment.

Occurring in abundant float at two places along the eastern side of Section 16, T.29N.,R.6E. is a mafic hybrid which is considered a phase of the gray syenite where it intrudes the aplite-greenstone hybrid. At a distance of 400 feet southwest of the exposure of gray syenite showing marked development of tabular feldspar, and about 70 feet higher in elevation, numerous boulders up to three feet in diameter include a mafic hybrid composed of orthoclase feldspar (50%), amphibole and biotite (50%). Biotite appears to be more abundant than the amphibole. The feldspar is reddish-brown in color and occurs in part (20%) in subhedral crystals up to five millimeters, and in part (30%) as fine-grained (one to two millimeters), sugary-textured, anhedral grains, making up the ground mass of the rock with the mafics. The amphibole is commonly in one-tenth millimeter grains; the biotite in flakes up to one millimeter. Texture is probably best termed porphyroblastic. Normal aplite is seen in float with the hybrid.

Several hundred feet to the south abundant float includes a mafic porphyroblastic aplite which is composed of orthoclase and plagioclase feldspar (60%), quartz (15%), and mafics (25%). The mafic minerals are amphibole and biotite. Plagioclase is minor in amount. The orthoclase is present in one-tenth millimeter grains and in five to seven millimeters porphyroblasts poikilitically enclosing biotite. The matrix is fine-grained, about one-tenth millimeter. The biotite is present in one-tenth millimeter grains and in three-tenths millimeter aggregates. A short distance southeast of this occurrence this mafic porphyroblastic hybrid is seen in great abundance in boulders up to ten feet in diameter. These latter occurrences are much closer to the one-time greenstone roof than the ones described earlier.

Summarizing the change, as seen in several dikes, the gray syenite well within the aplite is granitic in texture and biotite is absent; slightly higher in the dike system - and closer to the aplite-greenstone contact - texture is still granitic but the rock bears a small amount of biotite; still closer to the aplite-greenstone contact texture is trachitoid and feldspars are tabular in shape although the composition is little changed. Near the aplite-greenstone contact, and probably at one time penetrating the hybrid contact rock, the syenite is a mafic, porphyroblastic hybrid - variable in both composition and texture. The gray syenite is nowhere seen intruding the greenstone periphery, and it is thought that it did not penetrate the former greenstone roof.

The Red Syenite: The red syenite occurs in numerous dikes throughout the area and is more abundant than the gray syenite. It is rarely seen in outcrop, but most commonly appears in disintegrated form, either in roadside ditches or mantling the soil of cultivated fields. Texture and composition show frequent variations. Composition varies from 75% feldspar and 25% mafics to 99% feldspar. The mafic mineral commonly is black amphibole, but locally may include green amphibole and chlorite. The feldspar is usually orthoclase but in places is perthite or microcline. Quartz is commonly absent but some occurrences are noted where the syenite bears up to three or four per cent quartz and still others where quartz makes up a larger percentage of the rock but appears to be later than the syenite.

Textural variations include medium-grained syenite which may have either granitic or trachitic texture with the former the more common, and pegmatite which frequently shows spectacular crystal development.

Syenite pegmatite, syenite, and aplite are often seen in contact with each other. In the SE¼ of Section 14, T.29N.,R.6E. the three rock types occur in abundant float and frequent outcrop. Here the change from one rock type to another is rapid with contacts of two types often seen in float. At one occurrence where syenite and syenite pegmatite are in contact, the contact is gradational but

with no change in composition across the contact. Both contain about 15% black amphibole, the remainder is feldspar. At another occurrence aplite is in contact with coarse syenite. The aplite shows tabular feldspar and in places one tabular crystal is seen cutting another to form an x-shaped growth. The syenite is pink, coarse-grained (six millimeters), and contains both green (actinolitic) and black amphibole. The green amphibole is well-crystallized; the black poorly-crystallized. Feldspar crystals up to three millimeters are seen in the aplite. The contact of the aplite and the syenite is gradational but definite.

At another occurrence float includes syenite and syenite pegmatite in contact in a boulder. The rock shows medium-grained red syenite (orthoclase feldspar-90%- and amphibole-10%) in gradational contact with syenite pegmatite. The pegmatite is composed of orthoclase (85%), black amphibole (15%). The amphibole is in crystals up to one inch in length by one-fourth inch in width. The contact is marked by a mafic (25%) area of fine-grained (one millimeter) rock, one-half inch in width. The red syenite again shows tabular feldspar crystals intersecting others and in places fractured tabular crystals showing some displacement along the fracture, but with the fracture healed.

Where the red syenite intrudes the gray syenite the gray is converted to a brown sub-type. In the SE$\frac{1}{4}$ of Section 14 an exposure contains both gray and red syenite. Both are much disintegrated. The contact can be traced only in the disintegrated rock but no aplite is seen between the two types of syenite. The two syenites are in contact. The red syenite is of the type usually seen - pegmatitic in texture, low in mafics. The brown syenite - contact phase - consists of 90% pinkish-brown feldspar (orthoclase) and 10% amphibole. Grain size is four to five millimeters; texture is granitic. A very few grains of gray, comparatively fresh, feldspar are seen in the rock. The exposure permits no accurate estimate of the width of the brown syenite zone.

Another occurrence where the contact phase syenite is well exposed is along the west line of Section 14, T.29N.,R.6E. where the roadside ditch reveals red syenite

pegmatite and brown syenite outcropping continuously for about 400 feet. The pegmatite appears in narrow bodies a few feet in width at frequent intervals across the outcrop. Between the pegmatite bodies the syenite is the brown type which shows considerable variation in texture and grain size. The brown syenite appears to represent several types but hand lens study reveals basic similarities with definite trends away from the contact. At the contact grain size is variable within a given hand specimen. In places it is less than one millimeter in grain size; in other places three to four millimeters. Texture is granitic. Near the contact the amphibole is the greenish-black variety; away from the contact it is black. The mafics (amphibole) and biotite) consistently make up about 15% of the rock. The feldspar is untwinned and invariably in subhedral tabular crystals which vary in size from one to six millimeters. They appear to increase in size away from the contact - as the syenite becomes more defintely gray in character. Near the contact the feldspars show slightly more elongate form and better alignment than away from the contact. Texture is consistently granitic. Throughout the long exposure no normal gray syenite is seen but in places it is only slightly altered. Normal gray syenite is seen in outcrop a short distance - 150 feet - to the west.

In the NE¼ of Section 14, T.29N.,R.6E. a 250 feet long exposure of red syenite pegmatite along the Little Rib River together with several nearby exposures of gray syenite reveal contact phases of the syenite pegmatite with both the gray syenite and the aplite. For the most part the long exposure is good red syenite pegmatite. In places it bears a little quartz; in places it shows aplitic areas, irregular in shape and showing no structural trend; and in places it is hybridized by contact with the aplite and the gray syenite. At one place the hybrid is gray aplite composed of quartz (10%), orthoclase feldspar (75%), and amphibole (15%). The feldspar is in one-tenth to four-tenths millimeter subhedral to anhedral crystals. The amphibole is in well-oriented needles up to eight millimeters long and not over one-tenth

millimeter wide. Showing a gradational contact with the aplite is coarse, red quartz syenite. Composition is quartz (5%) orthoclase feldspar (85%), and amphibole (10%). The feldspar is in four to six millimeters subhedral crystals; the amphibole in intersecting one inch long and two millimeters wide crystals. Texture is granitic. Normal red syenite pegmatite outcrops a few feet from the hybrid. The hybrid area at this occurrence extends in places up to 10 or 12 feet with areas of good pegmatite within the hybrid.

Fifty paces to the west, in the same outcrop the hybrid is again exposed with normal syenite pegmatite. The hybrid bears 15% amphibole and biotite, the remainder is feldspar. Near this exposure are small masses of a dark rock - in sharp, angular contact with the pegmatite - which appear to be remnants of a lamprophyr dike. Most of the dike rock has been removed by erosion and its position is now marked only by a sharp, straight pegmatite boundary striking N.15° W. The lamprophyre is too fine-grained for hand lens indentification of its constituent minerals. A few plagioclase laths can be seen.

A short distance east of the dike aplite and contact phase gray syenite are seen in a not-too-good exposure. The contact is gradational over several feet with no normal gray syenite seen in the exposure. Both the aplite and the gray syenite are cut by syenite pegmatite.

In general, the red syenite lies well within the aplite; but in a few instances it, unlike the gray syenite, intrudes the greenstone. Such intrusions of the greenstone by the red syenite are not common. Evidence will be cited in a later section showing that the greenstone capping is very shallow and that it is intruded by the syenite for only a short distance, perhaps not over 50 feet.

Near to and in the greenstone the red syenite shows frequent textural and compositional variations. It usually has a marked hybrid appearance. In the SW¼ of section 35, T.30N.,R.6E. red syenite is seen in abundant float near the greenstone contact, but still within the aplite. The rock shows porphyroblastic texture with

feldspar porphyroblasts up to one-half inch set in a fine-grained, sugary-textured ground mass. The fine-grained matrix bears 10% mafic minerals and a little quartz. The rock has more the appearance of a refused and recrystallized aplite than a distinct intrusion by the red syenite.

Hybridization of the red syenite is frequently characterized by the development of green, actinolitic amphibole, whereas, the normal red syenite - both medium-grained and pegmatitic phases - bears black amphibole. In few instances is the red syenite a distinct hybrid contact phase. One such contact phase is seen (in float) in the NW¼ of Section 26, T.29N., R.6E. where the red syenite penetrates the greenstone. The rock has a distinctly hybrid appearance. Composition and texture vary throughout a single specimen. Part of the rock bears pegmatitic texture with orthoclase feldspar crystals up to one inch in diameter; part is aplitic-textured feldspar carrying one-half inch amphibole crystals; and part is high-mafic aplite. Both green and black amphibole are present; the black bears poikilitic feldspar, the green does not. There is no regular distribution of the two types of amphibole; both appear intimately inter-mixed in one to two millimeter aggregates and both occur as large well-developed crystals. Much of the aplitic area is in grains below one-tenth millimeter in size - too fine for hand lens resolution, while some of the aplitic area resolves into one to two millimeter subhedral feldspar (untwinned) crystals. Quartz is irregularly distributed throughout the aplite.

Other occurrences can be cited showing that the red syenite, as it penetrates the greenstone, loses its characteristics and is hybridized; often becoming an irregular-textured, porphyroblastic aplite, rather that a true syenite.

The Quartz Syenite: Still another distinct phase of the syenite - not widespread in its occurrence, but abundant where it does occur - is the quartz syenite. A short distance north of the center of Section 20, T.29N.,R.7E. it is revealed in abundant outcrop and float. Composition is orthoclase feldspar (75%), quartz (5%), hornblende (20%). Texture is equi-granular, but with the feldspars showing a

tendency to have trachitoid texture. In some parts of the exposure the trachitoid texture is pronounced, in other parts quite indefinite. There is a trace of gneissosity which gives a reading of strike N. 55°E., dip 70°S. Grain size of the minerals is two to four millimeters.

Rounded masses of rock 15 feet long and 10 feet high (above ground) and low masses (at ground level) 50 to 60 feet long, as well as abundant smaller float make up the exposure.

In places the syenite reveals greenstone inclusions up to three inches long and one inch wide. The greenstone inclusions appear flattened in outline. Many are partly digested.

The quartz syenite is seen in abundance at only one other occurrence - in the SE¼ of Section 29, T.29N.,R.7E.

The above descriptions indicate the nature of the variations of the syenites and their contact phases. Structural relations of the syenites, petrogenesis, and the composite nature of the dikes will be discussed in a later section.

THE NEPHELINE SYENITES

The nepheline syenites, like the normal syenites, occur in narrow dikes. They, too, show wide variation in color, in texture, and in composition. On the basis of nature of occurrence, texture, and color they are grouped into three types: the gray, the nepheline syenite hybrids, and the white. In a general way textural variations are related to the color variety, and both are closely associated with the nature of the occurrence of the nepheline bearing rocks.

Because of the composite nature of the dikes which is even more marked in the nepheline syenites than in the syenites - no fixed composition can be given for a particular type.

The Gray Nepheline Syenite: The gray nepheline syenite is well exposed in both outcrop and abundant float in the SE¼ of section 2 and the NW¼ of Section 12, T.29N.,R.6E. Both exposures are expressed topographically as prominent hills,

covered with abundant float and revealing several good outcrops.

The term "gray" as used here implies more than merely a color designation. It includes nepheline syenites ranging in color through various shades of gray, pink and brownish gray. In occurrence the type includes those nepheline syenites which occur in the aplite, but not far below the former greenstone roof. Still a further factor important in the classification used here is the nature of the crystallization and the distribution of the mafic constituents of the rock. The mafic constituent is predominatly black amphibole. In the "gray" nepheline syenite the amphibole most commonly occurs in crystalline aggregates or in discreet, but poorly developed, crystal units.

The gray nepheline syenite shows considerable range in composition but invariably the nepheline content is relatively low. The more common types occurring in the SE$\frac{1}{4}$ of section 2, T.29N.,R.6E. have an estimated composition of 65-85% feldspar, 5-25% nepheline - with the percentage usually below 20 and frequently 10 or less, and 5-20% amphibole. The feldspar appears untwinned under the hand lens. Texture of the gray nepheline syenite is usually granitic, sometimes with a trace of gneissosity. Grain size is most commonly two to four millimeters. Locally the nepheline syenite may have trachitic texture with finer grain size than is seen in the granitic type. Over some areas the nepheline syenite is extremely fine-grained (five-tenths millimeter or less) and texture is best termed aplitic. Both the feldspar and nepheline vary in color from gray to grayish-brown and commonly are the same color in a given rock.

As one crosses the dike in a northeast-southwest direction - transversely to the strike of the body - compositional and textural types vary rapidly, with areas of normal aplite and nepheline syenite aplite occurring with and between the nepheline syenite occurrences. No textural or compositional type prevails over more than a short distance before it gives way to another rock type - either another nepheline

syenite, an aplite, or a nepheline syenite aplite. Contacts of two or more types are not seen in outcrop but occasionally appear in float. One large boulder showing several types in contact is worthy of quotation from the field notes. "Approximately two feet of the boulder consists of gneissic nepheline syenite (type A), composed of orthoclase feldspar (75%), nepheline (20%), and black amphibole (5%). Both the feldspar and nepheline are grayish brown in color and the ratio is difficult to estimate. Grain size is about two millimeters.

"In contact with this (Type A) is a mafic nepheline syenite (Type B) composed of poikilitic amphibole (35%) and pinkish colored feldspar and nepheline (65%). The nepheline appears to be about 20% of the rock but this is uncertain because of the color similarity with the feldspar. The amphibole is in three to five millimeters crystalline aggregates, the feldspar in one to two millimeters crystals. This mafic rock shows a gradational contact with the gneissic nepheline syenite described above.

"Next in order and still showing a gradational contact is a six to eight inch zone of fine-granitic textured nepheline syenite (Type C). The rock is composed of orthoclase feldspar (75%), amphibole (10%), and nepheline (15%). The amphiboles are in elongate crystals up to four millimeters; the feldspars in subhedral crystals, one to two millimeters in size. In contact with this (Type C) is a three to four inch zone of mafic nepheline syenite with poikilitic amphibole like that described above (Type B). In sharp, well-defined contact with this is a five to six inch mass of the type first described (Type A).

"Cutting this last type (A) and in sharp, angular contact with it - not trending across the entire boulder, but more in the nature of an inclusion - is an irregular mass up to 12 inches thick of grayish white nepheline syenite (Type D). The rock is predominantly orthoclase feldspar (89%), with nepheline (10%), and amphibole (1%). Part of the feldspar is in one to two millimeters tabular crystals, part in a crushed-looking matrix. This rock is more nearly aplitic in texture

than any seen on the northwestern part of the dike?

Float and outcrop over the southeastern part of the dike - which is 50 to 60 feet lower in elevation than the northwestern part - differ somewhat from that seen at the higher elevation. Nepheline content is invariably lower. The northwestern part of the dike averages close to 20% nepheline; the southeastern part about 10% with types frequently containing less than 5%. Texture in the southeastern part is more commonly granitic with less rock of trachitic or gneissic texture. Grain size is slightly larger to the southeast than to the northwest.

The nepheline syenite occurring in the NW¼ of Section 12, T.29N.,R.6E. is much like that occurring in Section 2 in texture, occurrence, and degree of crystallization of the amphibole. It differs somewhat in containing more pink to brownish gray nepheline but is still classed with the "gray" type.

The Nepheline Syenite Hybrids: The nepheline syenites classed in this group include the pegmatoid types which show frequent color variations, the fine-grained mafic nepheline syenites which bear an aplitic texture, and the nepheline-greenstone injection gneiss. These types characteristically occur in the aplite-greenstone contact rocks or penetrating the greenstone. They are distinctly hybrid in character. Color of the nepheline ranges from light gray, thru dark gray, red, and brown. Invariably the nepheline content is higher than in either of the other groups and in places the nepheline syenite grades into a nephelinite.

The mafic constituent of the rock is present in two forms: in the pegmatite as iron in solution in the nepheline giving the nepheline an unusually dark color, and in the nepheline syenite aplite as fine grains - often one millimeter or less in size - intimately intermixed with the fine-grained nepheline and feldspar.

Rocks of this group show a wide range in texture, with rapid changes from one textural type to another. The pegmatoid and aplitic textures are probably the most common and often occur in a single boulder. Granitic texture is frequently seen and gneissic texture is not uncommon.

The pegmatoid type represents one of the most spectacular rocks of the area. It can be seen at many places but nowhere in such a profusion of color and textural types as in the NW¼ of Section 19, T.29N.,R.7E. Here the present erosion surface coincides with the aplite-greenstone contact, and the nepheline syenites penetrating the hybrid contact rocks are themselves hybridized. The country rock varies in a short distance from a mafic aplite bearing greenstone inclusions, through an aplite-greenstone hybrid, to a contaminated greenstone penetrated by aplite apophyses. The nepheline syenites show even greater variation than the host. Colors range from gray, through red, to dark brown and include some of the darkest nepheline of the area. Texture varies with equal rapidity and includes pegmatitic, granitic, and gneissic, with the first being the most common. In places the rock contains more than 50% brown nepheline in crystals up to three inches in size; in places the nepheline is set in a granitic-textured matrix; and in places the nepheline is dark gray in color and occurs in crystals rivaling the brown in size.

Other occurrences of the brown pegmatoid nepheline syenite include those in Sections 7 and 18, T.29N.,R.7E. and the SE¼ of Section 9 and the NW¼ of Section 10, T.29N.,R.6E.

Pegmatitic-textured sodalite nepheline syenite occurs at two places - the SW¼ of Section 8, T.29N.,R.7E. and the SE¼ of Section 35, T.30N.,R.6E. At the first-mentioned occurrence sodalite is minor in amount, making up 5-10% of the rock; at the second occurrence it is abundant, in places making up 50% of the rock.

Occurring in equal abundance with the pegmatoid variety and often closely associated with it is a fine-grained, mafic, aplitic-textured nepheline syenite. As seen in the NW¼ of Section 10, T.29N.,R.6E. the mafic minerals constitute 40% of the rock. The texture of the nepheline syenite is variable but is usually such that the mafic mineral and nepheline are intimately associated in a fine-grained (one to two millimeter or less) ground mass.

In the SE¼ of Section 9, T.29N.,R.6E. the pegmatitic and aplitic nepheline syenites

occur together. Here the nepheline is in part brown in color and in crystals up to one inch, in other parts it is intimately associated with the amphibole in a fine-grained (less than one millimeter) matrix. The distribution of the minerals in the fine-grained matrix is 50-50. Less than 1% of magnetite is present in anhedral crystals up to one-tenth millimeter in size.

As described above the fine-grained amphibole is evenly distributed throughout the aplitic-textured rock. Instances are frequently seen where the amphibole is in aggregates as well as in fine-grained form, and others where all the amphibole is in aggregates.

In the SE$\frac{1}{4}$ of Section 18, T.29N.,R.7E the nepheline syenite occurs abundantly in float in boulders up to two feet in diameter. The rock appears to contain nepheline (60%), feldspar (25%), and amphibole (15%). Both the feldspar and nepheline are gray in color and the percentage ratio is difficult to estimate. Texture is granitic, with the nepheline units about five millimeters in size. The feldspar crystals are less than two millimeters with the majority in the order of three-tenths to five-tenths millimeter. Amphibole is seen in one-tenth millimeter grains but with 90% of it in two to three millimeters aggregates. At another occurrence in the same section the nepheline syenite consists of reddish-brown nepheline (65%), orthoclase felspar (20%), and amphibole (15%). Texture is pegmatoid. The nepheline units range in size up to one inch, the feldspars to eight to ten millimeters; while the amphibole consists of ten millimeters aggregates enclosing much feldspar. The amphibole aggregates consist of amphibole grains of one-tenth millimeter or less with feldspars of the same size. The feldspar in places makes up 50% of the aggregate. The amphiboles although concentrated in units in the rock are not crystal units.

The nepheline-greenstone injection gneiss occurs most abundantly along the south line of Sections 22 and 23, T.29N.,R.6E. This rock was described in detail in the field notes and report of 1944* from which the following excerpt is taken.

*Op. cit., Pages 19-20

"Pegmatite solutions from the nepheline syenite alone seem able to penetrate the greenstone (argillite) and where they do the reaction produces a very coarse, dark green, ptygmatically folded injection gneiss.....'Here (the south line of Section 22) nepheline penetrates the greenstone as a gneissic injection. The penetration increases in degree and coarseness to the section corner. The rock is a dark ptygmatically folded amphibole and chlorite gneiss consisting of a host of feldspar about 40%, mafics 30%, and quartz 5%. In this rock the pegmatite both crosses the gneissosity and follows it giving local pockets and narrow stringers. Single crystals of feldspar and nepheline measure up to 6 inches long and commonly up to 4 inches long. The feldspar is white, the nepheline is brownish.'"

The White Nepheline Syenite: The white nepheline syenite is unique among the rocks of this area in that color alone is the critical factor in its classification. It occurs in several dikes over a relatively small area, intruding aplite and at times associated with red syenite. The rock owes its whiteness to complete removal of the mafic constituant - amphibole - from the nepheline and feldspar by thorough crystallization. Laboratory study of this rock, as reported in 1944,* states it is "composed of about 20% nepheline only, the remainder being black amphibole 20%, and feldspar 60%. The feldspar is plagioclase and perthite, of good white color. The perthite is well crushed though considerably recrystallized, which gives it somewhat the appearance of nepheline in the field."

The white nepheline syenite is exposed in two narrow dikes in a disintegrated syenite pit in the NW$\frac{1}{4}$, NE$\frac{1}{4}$ of Section 1, T.29N.,R.6F. The white nepheline syenite cannot be traced beyond the pit, nor does float a short distance from the pit give any indication of it.

The exposure in the large pit in the NW$\frac{1}{4}$, SE$\frac{1}{4}$, Section 5, T.29N.,R.7E. offers the best opportunity for studying the rock. This pit covers an area about 400 feet in an east-west direction and 325 feet in a north-south direction. Detailed study

*Op. cit., Pages 20-21

across the pit reveals areas which have a faint pink tinge within areas of the white nepheline syenite. There is no mineral in the pinkish nepheline syenite (under the hand lens) which can give it this color. Presumably the color is derived from the breakdown of the amphibole along definite structural trends.- The white nepheline syenite extends for 275 feet - measured normal to N. 40°W. - with the white occupying 182 feet of this distance, the pinkish 93 feet. The white nepheline syenite on both sides of the exposure shows a gradational contact with the aplite.

The white nepheline syenite occurs in disintegrated rock and in abundant float at several places in the NE¼ and SE¼ of Section 6, T.29N.,R.7E.

In the NE¼ of Section 7, T.29N.,R.7E. an extremely light gray nepheline syenite occurs abundantly in float. This is among the lightest colored nepheline syenites seen in the area and appears quite light colored until compared directly with the white nepheline syenite from the SE¼ of Section 5, T.29N.,R.7E. Comparison brings out a brownish tinge. The rock consists of orthoclase feldspar and nepheline 80% and hornblende (20%). The feldspar -nepheline ratio appears to be nearly equal or with the feldspar perhaps slightly more abundant. Texture is coarse granitic, with the feldspars ranging in size up to eight millimeters and the hornblende up to five millimeters.

Further statements concerning the composite nature of the dikes, the distribution, and the structural relations of the nepheline syenites will be expressed in a later section.

The Granite Pegmatite and Later Intrusions

Granite pegmatite and later intrusions of quartz are common over many parts of the area. The normal granite pegmatite is composed of about 80% red feldspar - usually microcline or perthite - and 20% quartz. The feldspar is in crystals up to four inches in size.

The syenites and aplites, as well as the granite pegmatite, frequently contain stringers and masses of quartz which is apparently later than the host. Rock piles

of the area often bear numerous quartz boulders, which in some cases - as in the NW¼ of Section 14, T.29N.,R.6E. - consist of pure white quartz in masses up to two feet in diameter. The quartz is usually completely barren of the rarer minerals and gives strong support to the statement of Weidmann that the granite magma was lacking in the rarer elements.*

In the central part of the Town of Stettin (T.29N.,R.6E.) the later quartz intrusion of the granite pegmatite carries considerable zircon - in places sufficient to class the rock as a zircon pegmatite. The zircon pegmatite occurs in float in Sections 10, 15, 22, and 23, T.29N.,R.6E. In places the zircon is minor in amount, 5%, in places it comprises as much as 30% of the rock. As seen in float in the SW¼ of Section 10, the granite pegmatite consists of microcline feldspar, quartz, and zircon. In some boulders and cobbles of the pegmatite no zircon is apparent; in other boulders it makes up a considerable percentage of the rock. The zircon - bearing rock consists of feldspar and quartz as discreet units with the zircon appearing in a granular quartz matrix. The zircon in places amounts to 20-25% of the granular matrix; the amount of granular matrix varies from boulder to boulder.

At the occurrence in the NW¼ of Section 23, T.29N.,R.6E. the zircon varies in color from a light reddish brown to a dark brown. It occurs in individual crystals up to one-fourth inch and in crystal intergrowths, composed of one millimeter crystals, that are up to one-half inch in diameter. In places zircon forms 30% of the rock. The zircon is invariably set in a quartz matrix. The zircon may at times be in contact with the feldspar, but is never contained in the feldspar.

Structure

The report of 1944** describes the region surrounding the area of this study as one of acid volcanics, overlain by argillite and quartzite, which has been intruded by granite, probably Keweenawan in age. The syenites and nepheline syenites are derived from the granite and were formed near the close of the period of intrusion.

*Weidmann, Bulletin 16, W.G.S., 1907
**Emmons and Snyder, W.G.S., 1944, Pages 21-22

The present erosion surface almost coincides with the roof of the intrusive body, with slight irregularities in the roof giving alternate areas of roof pendant and greenstone. The greenstone capping seen in Sections 7, 8, 17, and 18, T.29N., R.7E. is typical of the roof pendants. In the earlier report a figure of five degrees was given as the approximate inclination of the lower surface of the roof pendant. This study adds strong supporting evidence to this conclusion and also reveals that the lower surface of the pendant is, in places, practically horizontal and, in other cases, shows an irregular, blocky contact with the underlying intrusive. Small areas of aplite are encountered within the greenstone capping at a higher elevation than nearby greenstone float and outcrop.

At no place is the intrusive rock deeply exposed by erosion. The deepest exposure of the area of this study is the central part of the aplite area, probably that in Section 14, T.29N.,R.6E. It is significant that this is the area containing gray syenite in greatest abundance and supports the statement made earlier that the gray syenite typically occurs within the aplite, away from the greenstone contact.

Associated with the gray syenite and surrounding it on nearly all sides are numerous dikes of red syenite. The red syenite characteristically occurs in the aplite but closer to the former greenstone roof than the gray syenite. Where the red syenite penetrates the aplite-greenstone hybrid it commonly assumes a hybrid character which is expressed as a mafic, porphyroblastic rock with much aplitic-textured material. In few instances does the red syenite intrude the greenstone and when it does evidence indicates that it does not penetrate far into the basic roof rocks. In the greenstone capping of Section 18, T.29N.,R.7E. the red syenite lying fartherest within the greenstone is accompanied by nearby aplite float indicating that the roof rock is shallow and the syenite penetrates greenstone for only a few feet. In the $SE\frac{1}{4}$ of Section 9, T.29N.,R.6E. abundant red syenite float lies within the greenstone. Using the figure 5^{o}, given earlier as the inclination of the lower surface of the pendant, one arrives at a figure of 50 feet as the depth of penetration of the greenstone at this occurrence.

Associated with the red syenite but most commonly penetrating the aplite-greenstone contact hybrid and the greenstone are the nepheline syenite dikes. Penetration of the greenstone, by all except the nepheline pegmatite solutions, is probably limited to a distance comparable to that of the red syenite. However, wherever nepheline syenite is seen in greatest abundance it is in the hybrid contact rock; or, if in the aplite, the evidence indicates that the one-time basic roof lay but a short distance above. This is well shown by the occurrences of nepheline syenite in aplite in the NW$\frac{1}{4}$ of Section 12, T.29N.,R.6E and in contact hybrid in Sections 18 and 19, T.29N.,R.7E.

As indicated earlier the aplite rarely is seen in outcrop and few good structural readings are available. Enough have been obtained to indicate the elongation is approximately north-south, the greatest shortening is east-west, and the strike of the dikes- N.40°W. - represents one of the shear planes. Both shear planes find expression in the topography and stream pattern of the area. Abundant evidence of the northwest-southeast shearing is seen in the frequent occurrence of chlorite schist, white sericite schist, and greenstone breccia. In general, the faults do not reveal great movement. Later movement is expressed by the development of north-south and east-west fractures within the syenites - most commonly the gray - with the emplacement of gray syenite pegmatite and/or aplite.

Considerable evidence has been gathered concerning the composite nature of the dikes; and one area, the SE$\frac{1}{4}$ of Section 2, T.29N.,R.6E., was carefully studied for this purpose. Insufficient outcrops prevent thorough study of the many types of nepheline syenite occuring in this area and preclude accurate mapping of individual dikes. The accompanying map express this area in the form of 13 separate dikes - some of them separated by narrow aplitic areas - extending transversely to the strike of the dike for nearly 2000 feet. At no place does the nepheline syenite continue for more than 200 feet before aplite is encountered, and at no place does a given type of nepheline syenite extend for a transverse distance of more than 60-70 feet

before it gives way to another type of nepheline syenite. Some of the nepheline syenite types extend for only a few feet before they give way to another type. Red syenite occurs with the nepheline syenite. The types of nepheline syenite vary from high mafic (40%) to low mafic (5%) from high nepheline (25%) to low nepheline (5%), from granitic to fine trachitic in texture. The 13 separate dikes represent 9 or 10 distinct types of nepheline syenite and undoubtedly better outcrop or more detailed study of float would reveal several other types. As described earlier single boulders often reveal several types in contact.

The history of a dike must be regarded as one of intermittent opening and filling with two factors, nepheline syenites of different composition and slightly varying conditions of intrusion and crystallization at each stage, resulting in a wide variation of compositional and textural types.

The syenites, too, offer abundant evidence of pulsational injection. At one occurrence narrow dikes of white nepheline syenite occur within a red syenite dike. At other occurrences - such as the gray syenite - color differences are seen in the gray syenite and a given outcrop may include gray syenite, gray syenite pegmatite, gray aplite, and red syenite. Field evidence indicates that the individual dikes are quite narrow; those that appear exceptionally wide are considered to be composite dikes which cannot be differentiated because of poor exposure.

A total of 330 dikes has been mapped. Many of these are single dikes which are a part of a composite dike. Others are known to be composite dikes but the scale of the map and poor exposures prohibits their being mapped as individual dikes.

Petrogeny

The origin of the aplite, the syenites, and the nepheline syenites has been discussed in detail elsewhere by Dr. R. C. Emmons. However, certain elements stand out so clearly in the field that a brief statement is in order here.

Field observations offer strong evidence concerning the origin of the three phases of syenite - the quartz syenite, the gray syenite, and the red. The quartz

syenite and the gray syenite are regarded as distinct intrusions. Each differs quite markedly from the aplite it intrudes. The gray syenite in particular is so consistent in composition wherever it is seen that it apparently is derived from a single magmatic source. The gray and the quartz syenites could be products of the same magma with the quartz phase resulting where the magma locally was higher in silica.

The red syenite, on the other hand, offers abundant evidence that is is not a distinct intrusion but a product of refusion and recrystallization of the aplite. As seen in the SE$\frac{1}{4}$ of Section 14, T.29N.,R.6E. and elsewhere, the rapid textural changes - syenite pegmatite, syenite, and syenite aplite, the intimate association of the three, the consistency of composition across the contact, the evidence of later crystal development in the aplite and syenite all point strongly to refusion and recrystallization along closely spaced shear planes.

Of prime importance are the factors controlling the origin of the white nepheline syenite. As described earlier the nepheline syenites occur in several color and textural varieties. Nepheline of good quality exists only where the mafic constituents have been completely removed from the nepheline and feldspar. Summarizing statements made earlier, the mafic constituents are contained in the nepheline syenite as iron in solution in the nepheline crystal, coloring the nepheline red or brown; as fine-grained, anhedral amphibole crystals intimately intermixed with the nepheline and feldspar, coloring the rock a dark gray; as aggregates of amphibole crystals or discreet, poorly developed crystals, as seen in the gray nepheline syenite; or as well-crystallized amphibole, as seen in the white nepheline syenite. In the first three cases the mafic constituents are not completely removed from the nepheline and the feldspathoid is not of good quality; in the fourth case the mafic constituents are removed from the nepheline by thorough crystallization of the amphibole resulting in a white nepheline syenite.

The purity of color, then, is a result of degree of crystallization, not of the mafic content of the containing rock. The determination of the factor -- undoubtedly a

mineralizer - resulting in thorough crystallization of the amphibole is beyond the scope of this paper.

Economic Geology

Zircon: The zircon appears to offer the best possibilities for economic exploitation. As described earlier it occurs in quartz veins in the granite pegmatite. The normal granite pegmatite which occurs at many places throughout the area does not carry zircon. The zircon-bearing quartz is to be found in the central part of Stettin township (T.29N.,R.6E.) from Section 10 southward.

The specific occurrences where zircon was seen during the course of this study, together with other critical information, are as follows:

Location	Probable Sources	% Zircon(Estimated)
1) West line of Section 10 (70 paces south of northwest corner of section	Field to west of section line	5%
2) SE¼, SW¼, Section 10 (This is the Geisse-Kopplin prospect)	Center of "40"	25%
3) SW¼, SW¼, Section 15 (275 paces north, 340 paces east of southwest corner of section)	Field to east	25%
4) SE¼,NE¼, Section 22 (near east line of section, 100 paces north of east-west mid line)	Immediate field	5%
5) SE¼, NE¼, Section 22 (near east line of section, 160 paces north of east-west mid line)	Immediate field	5%
6) SE¼, NW¼, Section 23 (on east-west mid line, 50 paces east of west line of section)	Field to North	30%
7) NW¼, SW¼, Section 23 (160 paces south of above occurrence - no. 6.)	Field to North	10%

Location	Probable Sources	% Zircon (Estimated)
8) SE¼,NW¼, Section 23 (on east-west midline, 375 paces east of west line of section)	Field to North	30%

The occurrences numbered 4 and 5 are float found in the open field; all other occurrences are on rock piles. Farmers quite commonly know the approximate source of the rock on a particular rock pile. The "probable source" given is in part derived from such information.

The search for commercial quality zircon is probably best limited to the NE¼ of Section 9; the NW¼, SW¼, and SE¼ of Section 10; all of Section 15; the NE¼ of Section 22; and the NW¼ and SW¼ of Section 23. Of these localities the NW¼ of Section 23 and the SW¼ of Section 10 appear to be the most likely areas; the NE¼ of Section 9, the NW¼ of Section 10, and the SW¼ of Section 23 the least likely.

It is suggested that prospecting be guided by the search for granite pegmatite bearing an excessive amount of white quartz.

Careful prospecting undoubtedly will reveal many more occurrences than are listed above. One should expect a given occurrence to be small in extent, but possibly of high grade as is revealed by the float.

Nepheline: It is thought that this study has covered the area in sufficient detail to locate most, if not all, of the bodies of white nepheline syenite. Specifically, the areas where this rock occurs include the NE¼ of Section 1, T.29N.,R.6E.; the SW¼ and NW¼ of Section 5, T.29N.,R.7E.; and the SE¼ and NE¼ of Section 6, T.29N. R.7E. The occurrence in Section 1, T.29N.,R.6E. consists of two very narrow dikes which apparently do not extend far lineally and need receive no further attention here.

The largest exposure is at the pit in the NW¼, SW¼, Section 5, T.29N.,R.7E. This rock has been described earlier. At the pit it reveals a width of 275 feet (including 83 feet with a pinkish tinge.) This rock is completely absent both in float and outcrop immediately southeast of the pit, but apparently extends about three-eighths mile to the northwest as revealed by disintegrated rock, float, and rock piles.

The width of the dike near the northwest end cannot be determined by surface geology, nor has this study been able to confirm a fairly constant width throughout the dike. It is significant that this dike lies along one of the major fault zones of the area.

The white nepheline syenite occurs, as mapped by the writer, in five smaller dikes, all within one-half mile of the large pit described above.

The white nepheline syenite occurs in mafic aplite and its purity and color are controlled by mineralogical conditions which apparently did not exist elsewhere in the area. It is also within the realm of possibility that structural factors unknown at the present aided in the development of this rock type.

Pyrophyllite: The pyrophyllite revealed by the study of 1944 was later found to contain so much quartz that its value is questionable. It was not investigated during the course of this study.

Andalusite: Andalusite has been found occurring with nepheline in a hybrid greenstone host along the north line of Section 26, T.29N.,R.6E. Careful but unsuccessful search was made over this area. It is concluded that the andalusite is minor in amount.

Road materials: The disintegrated syenite is widely used in this area as surfacing for secondary roads. Known supplies appear to be adequate for the immediate future. When further prospecting for disintegrated rock becomes necessary it may be guided by information given on the accompanying map.

The disintegrated rock is chiefly the red syenite although the white nepheline syenite from Section 5, T.29N.,R.7E. is extensively used at present. Along the fault zones mapped during this study the disintegrated rock is frequently seen mantling the soil. Sections 10, 11, 14, 23, and 24 reveal the disintegrated red syenite at frequent intervals and often over a considerable area.

Recommendations

The zircon appears to be the most promising material of the area. It is suggested that private parties be encouraged to prospect more thoroughly the zircon bearing areas

in Sections 9, 10, 15, 22, and 23, T.29N.,R.6E. All of these area reveal considerable granite pegmatite; and zircon, often of excellent quality has been seen in all.

The white nepheline syenite occurs in several dikes, and - on the basis of surface geology - is apparently present in considerable quantity. The low nepheline content - an estimated 20% - may preclude its use, but it is suggested that parties who might be interested in such material be made aware of the nature, extent, and availability of the deposits.