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REPORT ON THE NEPHELINE SYENITE OF MARATHON COUNTY, WISCONSIN

by

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REPORT ON THE NEPHELINE SYENITE OF MARATHON COUNTY, WIS.

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General

The area investigated is located in Marathon County, Wisconsin, roughly 7 miles northwest of Wausau, Wisconsin, in T29N-R6E and T29N-R7E of the 4th principal meridian. So far as is known, it is the only locality in the middle west where nepheline syenite occurs. Geologists have for a number of years been interested in the origin of the alkaline rock group, of which nepheline syenite is a member. Consequently, each occurrence of these rocks has been studied in more or less detail and recorded in the geologic literature. A list of all known localities where alkaline rocks are to be found is appended to this report, and it is thought to be complete as far as the present state of knowledge is concerned. From a study of this list, it will readily be seen that there is no area in the world which can successfully supply nepheline syenite to the glass and ceramic industries of the Cleveland area in competition with the Wausau district, all factors considered. There is of course the possibility that further work in the pre-Cambrian areas of the Lake Superior district of northern Michigan, Wisconsin, and Minnesota will discover new occurrences of the alkaline rocks, but this contingency is thought to be exceedingly remote. The recommendations in this report are based upon the reasonable assumption that the Wausau district can supply the Cleveland area markets for nepheline syenite without fear of competition within the United States.

Nature of the Area

The Wausau district is geologically a part of the area of pre-Cambrian igneous and metamorphic rocks which form the core of the Wisconsin Arch. The pre-Cambrian sequence has been studied at various times by the Wisconsin

Geological Survey, and Aldrich gives the following geologic column for the region:

Pleistocene  
    Glacial drift  
Pre-Cambrian  
    Igneous  
        Diabase dikes  
        Nepheline syenite  
        Pegmatite dikes  
        Syenite  
        Aplite  
        Granite  
        Greenstone  
    Sedimentary  
        Slate  
        Quartzite

This section must, however, be regarded as tentative. It seems probable that further work would change it materially.

All of the area was glaciated during the Pleistocene, but the present cover of glacial drift is as a rule thin. Post-glacial weathering has served to disintegrate and decompose the bedrock, and the ground is now covered very generally with a soil mantle in which are admixed innumerable angular boulders of the underlying rock, mingled of course with glacial erratics in many cases.

Drainage is not well-developed in the district. Swamps are numerous, as are small streams which eventually reach the principal rivers, the Big Rib and the Wisconsin.

Topographically the area is gently rolling, and precipitous slopes are very rare. The most striking topographic features are Little Rib Hill and Big Rib Hill, composed of pre-Cambrian quartzite, which lie just south-west of the city of Wausau.

Much of the land is cultivated, but at numerous points are to be found areas of native timber, principally oak, maple, spruce, cedar, and pine. The conifers are particularly abundant in the swampy portions.

Because of the advanced disintegration of the bedrock and the gentle slopes produced by glaciation, rock outcrops are generally absent. Most of them are to be found in roadside ditches, where the relationships of the various rock types are usually difficult to decipher because of the limited area of exposure. The Wisconsin Geological Survey, in attempting to map the bedrock, evidently made use of all available bits of information, including magnetic surveys, and did much of the mapping on the basis of angular float fragments in the soil mantle. As a result, their exposure maps are likely to give an erroneous impression of the number of outcrops, inasmuch as float fragments and outcrops are not separately distinguished.

#### The Nepheline Syenite

Nepheline syenite is shown on the Wisconsin Geological Survey maps as occurring in two principal areas in T29N-R6E. One of these is located in the south half of Section 22 and in the northern part of Section 27. The other starts in the southwest corner of Section 10 and extends northeast to take in parts of Sections 11, 12, 3, 2, and 1. Another small area is indicated in the vicinity of the  $E\frac{1}{2}$  corner of Section 13, but this is evidenced on the surface only by the material in farm rockpiles. In T29N-R7E, nepheline syenite is found in portions of Sections 5, 6, 7, 8, and 17. This area is delimited by means of roadside ditch exposures and angular float fragments, as well as by lines of magnetic intensity.

The nepheline syenite is easily recognized in weathered fragments by the pitting or honeycomb appearance produced by solution of the nepheline, which is more readily removed by decomposition than are the other constituents of the rock. Probably because of the relative rapidity of weathering of this rock as compared to the other igneous rock types of the area, the nepheline syenite is as a general rule found in low or swampy ground, with some important exceptions.

In hand specimens, the rock possesses different textures in different parts of the area. These will be mentioned in that part of this report dealing with quarry locations. Briefly, they are; the gray medium-grained type, the pink medium-grained type, the dark gray gneissic type, and the pegmatitic type. Mineralogically the rock is relatively constant, consisting of nepheline, orthoclase, acid plagioclase, hornblende, and minor amounts of biotite and magnetite, probably resulting from alteration of the hornblende. Weidman divides the nepheline syenite into three types from microscopic studies. He calls these the hedenbergite fayalite nepheline syenite, or the Marathon type, (consisting of anorthoclase, nepheline, sodalite, hedenbergite, barkevikite, fayalite, and magnetite), the aegirine sodalite nepheline syenite, (consisting of anorthoclase, microperthite, microcline, albite, orthoclase, nepheline, sodalite, aegirine, arfvedsonite, lepidomelane, magnetite, cancrinite, fluorite, apatite, and zircon), and finally intermediate phases of the nepheline syenite which partake of the character of both the preceding.

#### Quarry Locations

During the course of the field work, each of the areas indicated by the Wisconsin Geological Survey as containing nepheline syenite was visited with a view to establishing possible quarry locations. Most of these could be eliminated immediately as possible sites for quarrying, because of their obvious physical handicaps. Two, however, have potentialities, and these are given full consideration here. The first of these may be called the Section 2 Location, and the second the Geppert-Kiepke location, from the names of the landowners.

#### The Section 2 Location

This prospective nepheline syenite quarry location is situated in the  $W\frac{1}{2}$  of the  $SW\frac{1}{4}$  of the  $SE\frac{1}{4}$ , and in the  $SW\frac{1}{4}$  of the  $NW\frac{1}{4}$  of the  $SE\frac{1}{4}$  of Section 2, T29N-R6E. The nepheline syenite here occurs in a prominent ridge, trending west of north in these forties. The conditions are



## SECTION 2 LOCATION

### LEGEND

- ==== Town Road
- ==== Farm Road
- - - - Fence line
- Farm building
- 10- Contour line (Datum base of ridge)
- |||| N Sy. Nepheline syenite outcrop
- |||| Sy. Syenite outcrop

illustrated in the sketch map attached to this report.

The west slope of the ridge is steep, and on this side the ridge rises out of a low, level, somewhat swampy, timbered area. The east slope is relatively gentle; on it is located a group of farm buildings. The land north of the ridge is generally level and cultivated, and at the south boundary of the location is a town road.

The surface of the ridge bears abundant angular float of nepheline syenite; no other type of rock can be seen in the float except at the south end near the point marked C on the sketch map, where syenite outcrops and forms much of the float material.

Two prominences occur on the crest of the northern part of the ridge, near the points marked A and B on the sketch map. At and near each of these prominences nepheline syenite outcrops. The exposure marked A consists of medium-grained nepheline syenite, consisting macroscopically of orthoclase, nepheline, amphibole, and biotite. There also seems to be some magnetite. Locally it is a flow gneiss, with abundant femic material, and in this type are small bands or segregations of almost pure nepheline.

The exposures marked B are entirely medium-grained nepheline syenite, with composition identical with that of the rock exposed at A. The outcrops are thoroughly jointed, and break readily into small polygonal blocks.

The rock at C appears to be a well-weathered syenite, consisting dominantly of orthoclase and amphibole, with no nepheline observed. In the float at the crest of the ridge were seen a few fragments of pegmatitic nepheline syenite, with coarse crystals of nepheline and feldspar, and minor quantities of femic minerals. A type was also observed in one case which consisted almost entirely of white feldspar with small amounts of nepheline, and femic minerals almost absent.



Samples were taken from the exposures at B and also from the flow gneiss at A.

Weidman gives the following chemical analysis of the rock in this location:

SiO <sub>2</sub>	54.76%
Al <sub>2</sub> O <sub>3</sub>	24.72
Fe <sub>2</sub> O <sub>3</sub>	2.73
FeO	2.35
MgO	0.10
CaO	1.67
Na <sub>2</sub> O	10.38
K <sub>2</sub> O	2.37
H <sub>2</sub> O	0.53
	<u>99.63</u>

*Quill 16 B-245*

certain

It seems that practically all the iron oxide and lime and magnesia, with small amounts of the soda and potash, can be removed from this rock by a magnetic separation.

The farm buildings are unoccupied, and the barns are apparently used only for storage.

It is recommended that a quarry face be opened on the west side of below the exposures marked B, and at the base of the ridge. the ridge. This procedure would involve some clearing of timber, and removal of nepheline syenite talus blocks which have slumped to the base of the hill and are covered with soil. Much of this talus, if not too badly weathered, can probably be used. If the quarry is so opened, a maximum working face of 80 feet can be quickly and economically obtained. By bottle-necking into the ridge in this manner, operations could be extended north and south parallel to the trend of the ridge without the necessity of removing useless rubble from the entire west slope.

The level area at the base of the ridge on the west side provides an excellent place for the machinery set-up, providing it is cleared of the timber. It is used at present only for pasture, as is the ridge itself.

Stripping does not in general appear to be excessive. It is sufficiently heavy to support a fairly good growth of timber, but tree size is not invariably an accurate criterion of thickness of stripping.



According to local report, the well at the farm house is 60 feet deep. At the north end of the ridge a ground water seep occurs. It is thought that no difficulties with ground water would be experienced unless operations were extended downward below the present base of the hill.

It is estimated as a probable maximum that the ridge can be quarried for 450 yards along its length, with an average working face of 40 feet, and with an average width of 150 yards. This would make available about 877,500 cubic yards of stone, or, at 160 pounds per cubic foot, about 1,895,400 tons of nepheline syenite. This could be indefinitely extended, of course, by development to some depth, accompanied by mounting costs. It is thought that the possibility of exhaustion of the nepheline syenite with depth is very remote.

On this basis, and allowing for a 40% swell on breaking, about 1,228,500 cubic yards of stone would be shipped from this location.

It would be advisable to delimit the nepheline syenite by trenching and test-pitting before quarrying extensively. It is bounded, of course, in the south part of the hill by the syenite, but the abundance of this is problematical at present.

This location is owned by Richard Kniess, R. F. D. 1, Wausau, Wisconsin.

The property adjoining this location on the west is owned by Arthur Prechel, R. F. D. 1, Wausau, Wisconsin. It is recommended that sufficient of his property be purchased along the N-S  $\frac{1}{4}$  line of Section 2 to provide room for a road to the quarry, and for the quarry set-up. The road would be approximately 350 yards in length, and would connect with the town road bounding the location on the south.

The total haul from this location south to the nearest point on the Chicago and Northwestern Railroad accessible by road is 8.1 miles. The haul would follow the red line indicated on the accompanying blue-printed

township map, and would be over rolling, unsurfaced town and county roads 4.5 miles south to S. T. H. 29, which is concrete-surfaced. S. T. H. 29 must be followed east for a distance of 2.2 miles to the road turning south to the Mount View Sanatorium. The sanatorium road is crossed by the C. & N. W. R. R. 0.4 miles south of S. T. H. 29, and at this point is a freight siding used to unload coal for the sanatorium. It is probable that portions of the town roads on this haul will be impassable during wet weather and thaw seasons.

The haul east on S. T. H. 29 is necessitated by the fact that no bridge exists across the Big Rib River between S. T. H. 29 and the railroad, on the town road leading due south. Further, this town road is impassable even in dry weather. If it were possible to put this road into good condition, and to have a bridge constructed across the Big Rib River, the haul would be reduced to 6.0 miles.

An alternative haul, and the one recommended, for this location would be to follow the yellow line indicated on the accompanying township maps due east for  $4\frac{1}{2}$  miles to S. T. H. 51, and then south on S. T. H. 51, which is surfaced with concrete, approximately  $3\frac{1}{2}$  miles to the Wausau city limits, a total distance of 8 miles. This haul is over much better roads than the one just outlined.

The total acreage recommended for purchase is the  $W\frac{1}{2}$  of the  $SW\frac{1}{4}$  of the  $SE\frac{1}{4}$ , and the  $SW\frac{1}{4}$  of the  $NW\frac{1}{4}$  of the  $SE\frac{1}{4}$  of Section 2, or thirty acres in all, plus whatever is needed from the Prèchel property for the quarry road and set-up. This could probably be extended if developments show the nepheline syenite to have a greater lateral extent than it is considered advisable to estimate in this report.

#### Geppert-Kiepke Location

This location is situated in the  $S\frac{1}{2}$  of the  $SE\frac{1}{4}$  of the  $SW\frac{1}{4}$  of Section 22, in the  $S\frac{1}{2}$  of the  $SW\frac{1}{4}$  of the  $SE\frac{1}{4}$  of Section 22, in the  $S\frac{1}{2}$  of the  $SE\frac{1}{4}$  of the  $SE\frac{1}{4}$  of Section 22, and in the  $N\frac{1}{2}$  of the  $NW\frac{1}{4}$  of the  $NE\frac{1}{4}$  of Section 27,

T29N-R6E. No outcrops are exposed, but abundant angular nepheline syenite float occurs in the area.

Topographically the location is made on the south slope of a flat-bottomed, swampy valley trending N of W. A small stream flows through this valley, and the valley floor bears a good growth of maples, scrub oaks, and conifers. The valley floor proper is about 1/8 mile wide, and the gentle north slope bears a hillside swamp over most of its length.

The south slope of the valley, on which the location is made, provides no good point for economical development of a quarry face. The slopes are gentle and are pastured. They rise to a ridge south of the east-west town road which marks the south line of Section 22.

A sand pit worked as a source of surfacing for town roads is located in the SE $\frac{1}{4}$  of the SW $\frac{1}{4}$  of the SE $\frac{1}{4}$  of Section 22.

The nepheline syenite in the float on the south slope of the valley ranges, north to south, from medium-grained nepheline syenite, exhibiting fluxion structures with small black schist inclusions, to fine-grained nepheline syenite amphibolitic fluxion schists, to crenulated basic schists with stringers of nepheline syenite, to fine-grained basic diorite. Most of the float is high in femic minerals. Locally the fragments of the schistose material contain pegmatitic bands consisting of about 90% nepheline and 10% orthoclase. These do not exceed 8" in width and 2' in length as observed. In one of these pegmatitic stringers a fractured crystal of nepheline 8" long and 4" wide was seen. These pegmatitic portions seem to be localized along flow lines in the schistose material, and evidently are the result of mineralizing juices penetrating the rock along these flow lines.

Evidently the contact of the nepheline syenite and the basic diorite is situated just south and southwest of this location, and the ridge to the south of the east-west town road is very probably underlain by the diorite. Accordingly, it would be expected that as quarrying operations

extend to the southern portion of that location the quality of the nepheline syenite would become progressively poorer until this rock would give way entirely to diorite. The presence in one place of red pegmatitic float, consisting of orthoclase, quartz, and amphibole, suggests that the nepheline syenite is intersected locally by quartzose pegmatite dikes.

Weidman gives the following chemical analysis of the nepheline syenite from this location:

SiO <sub>2</sub>	57.82%
Al <sub>2</sub> O <sub>3</sub>	24.23
Fe <sub>2</sub> O <sub>3</sub>	1.56
FeO	1.03
MnO	Trace
MgO	0.28
CaO	1.04
Na <sub>2</sub> O	9.20
K <sub>2</sub> O	3.03
H <sub>2</sub> O total	0.73
TiO <sub>2</sub>	0.30
ZrO <sub>2</sub>	0.28
Cl	0.15
S	Trace
P <sub>2</sub> O <sub>5</sub>	Trace
	<u>99.65 plus</u>

*Bull 16  
P 253*

This analysis can at best be regarded only as an approximation, inasmuch as the character of the rock is variable. An average would doubtless be much higher in feric minerals than this analysis suggests.

On the hill slope in the N $\frac{1}{2}$  of the NW $\frac{1}{4}$  of the NE $\frac{1}{4}$  of Section 27, just south of the east-west town road, is a small pond, indicating emergence of ground water at this point, which lies topographically above those parts of the location situated just north of this point.

Conditions here are decidedly unfavorable for the opening of a quarry. The objections are as follows:

1. The valley slopes are too gentle to allow rapid and economical development of a working face.
2. Stripping could be expected to be heavy.
3. The character of the nepheline syenite is variable.

Locally it contains abundant nepheline, but generally it is high in feric

constituents. Likewise, it is evidently locally intruded by quartzose pegmatite dikes.

4. Ground water conditions are likely to be unfavorable, although this cannot be stated with certainty.

5. Three farm houses in good condition with accompanying buildings are located just south of the east-west town road, adjacent to and within the location. This would probably make acquisition of the land for quarrying purposes costly.

The total tonnage of material which could be obtained from this location cannot be estimated, inasmuch as sufficient information is not available, but it would undoubtedly be very large.

In view of the objections raised, it is recommended that this property be acquired as a reserve and to eliminate competition. It is more favorably situated as to haul than the Section 2 location, but cannot compete with the Section 2 location as regards quarrying conditions and quality of rock. It is believed to be essential, however, that it be purchased to safeguard against the possibility of quarrying by another company in competition with the Section 2 location. Further, it will provide a reserve of relatively high-cost nepheline syenite which could be put into operation with the exhaustion of the Section 2 location.

Operations on this location would be along the order of open-cut mining, rather than quarrying along a vertical face. Pumping, lifting charges, and inferior quality of the rock would combine to raise the cost of operation to such a point that it is reasonably thought the gain the shorter haul over that of the Section 2 location would provide would be more or less nullified.

Taxes and carrying charges on this property would probably not be in any way excessive, inasmuch as it is of very doubtful value.

The haul would be straight south on the county road to S. T. H. 29 for a distance of 2 miles, then east on S. T. H. 29 to the Mount View Sanatorium road, a distance of 2.9 miles, then south on the Mount View Sanatorium road 0.4 mile to the freight siding, a total distance of 4.6 miles. If the C. & N. W. R. R. could be reached by a bridge across the Big Rib River along the north-south town road mentioned in the discussion of the Section 2 location, this haul would be reduced to 2.5 miles.

An alternative haul to Wausau along S. T. H. 29 could not be selected in preference to this, because of the considerable greater distance involved.

The  $S\frac{1}{2}$  of the  $SE\frac{1}{4}$  of the  $SW\frac{1}{4}$ , the  $S\frac{1}{2}$  of the  $SW\frac{1}{4}$  of the  $SE\frac{1}{4}$  of Section 22, and the  $N\frac{1}{2}$  of the  $NW\frac{1}{4}$  of the  $NE\frac{1}{4}$  of Section 27 are believed to be owned by Martin Geppert, R. F. D. 1, Wausau, Wisconsin. The  $S\frac{1}{2}$  of the  $SE\frac{1}{4}$  of the  $SE\frac{1}{4}$  of Section 22 is owned by Henry Kiepke, R. F. D. 1, Wausau, Wisconsin.

A maximum total of 80 acres would be involved in this purchase. This could probably be cut down by exploration of the property. It is doubtful whether it would be necessary to acquire the  $N\frac{1}{2}$  of the  $NW\frac{1}{4}$  of the  $NE\frac{1}{4}$  of Section 27, in view of the physical handicaps to development in the way of ground water conditions and lack of steep slopes. Likewise, the sand pit makes it doubtful whether it would be advisable to acquire the  $S\frac{1}{2}$  of the  $SE\frac{1}{4}$  of the  $SE\frac{1}{4}$  of Section 22. If these two twenties could be eliminated, the purchase would be reduced to 40 acres.

#### Water Supply

Water may be secured from small streams near the locations. The Little Rib River may be reached  $\frac{1}{2}$  mile west of the Section 2 location. The small stream in the valley north of and adjacent to the Geppert-Kiepke location might be utilized as a minor source of water, although it may be intermittent.

### Contract Quarrying and Hauling

Contract quarrying and hauling is being done for the Minnesota Mining and Manufacturing Co., with its plant in Wausau. This company quarries the Rib Hill quartzite, but I do not know the name of the company which does their quarrying and hauling by contract. According to Mr. E. F. Bean, state geologist, the M. M. M. Co. quarrying is done for \$1.00 per ton, and haulage charges are 5¢ per mile per ton. It is thought that similar rates could be secured for the Section 2 location.

### Freight Rates

Freight rates on the C. & N. W. R. R. are 4.7¢ per 100 pounds, or 94¢ per ton, for crushed stone, from Wausau to Green Bay. Apparently they would class either the untreated or the processed rock as crushed stone.

### Plant Set-up

The question exists in my mind as to whether it might not be advisable to locate the concentrating plant in Wausau, rather than on the docks at Lorain, Ohio. By removal of the feric minerals magnetically at Wausau, the freight costs to the Cleveland area could be measurably reduced for the processed material over the untreated rock. Abandoned plant sites and railroad facilities are available in Wausau, and the sites could probably be rented at a low figure. Labor may be readily obtained, and probably at a lower price than at Lorain. Unless there is a market for the ferromagnesian materials, it seems to me that the economical procedure would be to locate the concentrator at Wausau.



Negative Notes

T29N-R6E

- SW $\frac{1}{4}$  of SW $\frac{1}{4}$  of Section 10  
Nepheline syenite float and roadside ditch exposures.  
Nothing to warrant exploration.
- SW $\frac{1}{4}$  of NE $\frac{1}{4}$  of Section 10  
Nepheline syenite float in cut-over swamp. No quarry possibilities.
- NW $\frac{1}{4}$  of SE $\frac{1}{4}$  of Section 10  
Nepheline syenite float on gentle hillside slope; pastured. No quarry possibilities.
- SW $\frac{1}{4}$  of NW $\frac{1}{4}$  of Section 11  
Nepheline syenite float in swamp. No quarry possibilities.
- NW $\frac{1}{4}$  of NW $\frac{1}{4}$  of Section 1  
Nepheline syenite float in swamp. No quarry possibilities.
- NW $\frac{1}{4}$  of NW $\frac{1}{4}$  of Section 12.  
Nepheline syenite float on gentle wooded slope. Dead-fall shows heavy stripping. Also nepheline syenite float in farm rockpiles. Intruded greenstone in roadside ditch. No quarry possibilities.
- E $\frac{1}{4}$  corner of Section 12.  
Nepheline syenite float in farm rockpiles. No exposures. No quarry possibilities.

T29N-R7E

- Occurrences along N-S town road on N-S line between Sections 7 and 8.  
Nepheline syenite float. Small, fragmental, weathered exposures in roadside ditches. No quarry possibilities.
- Occurrences on town road along E-W line between Sections 8 and 17.  
Abundance of greenstone outcrop in roadside ditches. Float of nepheline syenite. Proximity of contact suggested.
- Exposures along S $\frac{1}{2}$  of N-S line between Sections 5 and 6. No outcrops.  
Only nepheline syenite float and farm rockpiles seen. NW $\frac{1}{4}$  of SW $\frac{1}{4}$  of Section 5 and NE $\frac{1}{4}$  of SE $\frac{1}{4}$  of Section 6 mostly in swamp or timbered low ground. No quarry possibilities.
- Pit in NW $\frac{1}{4}$  of SW $\frac{1}{4}$  of Section 5  
Large pit just SE of farmhouse--used for road material. Stuff exposed is thoroughly disintegrated syenite, cut by small pegmatites and basic dikes. No nepheline syenite observed. Syenite shows abundant schistose shear zones. All of the rock is disintegrated and fragmental. Some fragments of coarse-grained diorite also seen.
- Exposures diagonally NW-SE across Section 8  
Only nepheline syenite float and farm rockpiles seen, in tilled, gently rolling fields. No quarry possibilities.