Airborne and Ground Reconnaissance of Part of the Syenite Complex Near Wausau, Wisconsin

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AIRBORNE AND GROUND RECONNAISSANCE OF PART OF THE SYENITE COMPLEX NEAR WAUSAU, WISCONSIN

By R. C. Vickers

ABSTRACT

Twelve radioactive mineral localities were found as a result of airborne and ground reconnaissance for radioactive minerals in part of the syenite complex near Wausau, Marathon County, Wis. The rocks in the area are of Precambrian age and consist of syenite and nepheline syenite, which have intruded older granite, greenstone, quartzite, and argillite. Outcrops are few, and much of the rock is deeply weathered and covered by residual soil.

Thorium-bearing zircon pegmatite float was found within the area of syenite and nepheline syenite at 4 localities. Reddish-brown euhedral to subhedral crystals of well-zoned zircon (variety cyrtolite) comprise more than 40 percent of some specimens. The radioactive mineral at 4 localities outside the area of syenites was identified as thorogummite, which occurs as nodular masses in residual soil. Alinement of the thorogummite float and associated radioactivity suggests that the thorogummite has resulted from weathering of narrow veins or pegmatites containing thorium-bearing minerals. Unidentified thorium-bearing minerals were found at 3 localities, and a specimen of allanite weighing about 2 pounds was found at 1 locality.

Shallow trenches at two of the largest radioactivity anomalies showed that the radioactive material extends down into weathered bedrock. The occurrences might warrant additional exploration should there be a sufficient demand for thorium.

INTRODUCTION

As zirconium, thorium, and certain rare earths are among the elements that are notably enriched in many alkalic and nepheline syenites (Rankama and Sahama, 1950, p. 179–180, 518–528, 564–567, 570–572), the literature concerning the syenites near Wausau, Marathon County, Wis., was reviewed. Radioactive zircon and several minerals that contain rare earths had been reported. The area of syenites, therefore, was examined to study the reported occurrences, to test methods of prospecting for radioactive minerals where outcrops are few, and to use these methods in the search for additional occurrences. This work was done by the U. S. Geological Survey on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

ACKNOWLEDGMENTS

X-ray equipment at the University of Wisconsin was used to identify some of the minerals, and the use of these facilities is greatly appreciated. The author also wishes to express his appreciation to Ernest F. Bean, formerly State geologist of Wisconsin, for providing specimens of zircon-bearing rock from the Wausau area. George F. Hanson, State geologist of Wisconsin, was especially helpful in allowing the writer access to unpublished information. Appreciation is also expressed to Elaine Geisse and Daniel S. Turner, who permitted publication of thesis material, and to Loren C. Hurd, of Rohm & Haas Co., for permission to use unpublished geologic data.

LOCATION, ACCESSIBILITY, AND SURFACE FEATURES

Figure 2 shows the location of the area investigated and the boundary of the syenite complex. The investigation was conducted in secs. 9, 10, 11, 14, 15, 16, 21, 22, 23, 26, 27, and 28, T. 29 N., R. 6 E., Marathon County, Wis. The area is about 7 miles west of Wausau, Wis., and is accessible by many secondary roads.

The area consists of low, rolling hills having a maximum relief of about 200 feet. It is part of the Driftless Area of Wisconsin, from which weathering products have not been extensively removed; consequently, residual soil covers most of the area, and outcrops are very scarce.

Because of the fertility of the residual soil, more than 75 percent of the area is under cultivation; the remainder is wooded. The relatively high value of the land for agriculture has caused a lack of interest in exploration for valuable minerals.

PREVIOUS GEOLOGIC WORK

Weidman (1907) did the first comprehensive geologic work in the Wausau area and first reported the occurrence of nepheline syenite. Emmons and Snyder [1] studied the geologic structure of the Wausau area to determine the probable conditions under which the nepheline syenite was formed and to appraise the nepheline reserves. A possible origin for the syenite and nepheline syenite has been proposed by Emmons (1953).

Several workers have described unusual mineral occurrences in the area. Weidman (1907, p. 312–315) noted abundant zircon in quartz-feldspar pegmatites associated with nepheline syenite in the NW¼ sec. 22, T. 29 N., R. 6 E. Marignacite, a variety of pyroclore, containing about 18 percent rare earths and 0.20 percent thoria, was originally described from the same area (Weidman, 1907, p. 308–312).

[1] Emmons, R. C., and Snyder, F. G., 1944, A structural study of the Wausau area: Wis. Geol. Survey file report, Madison, Wis.

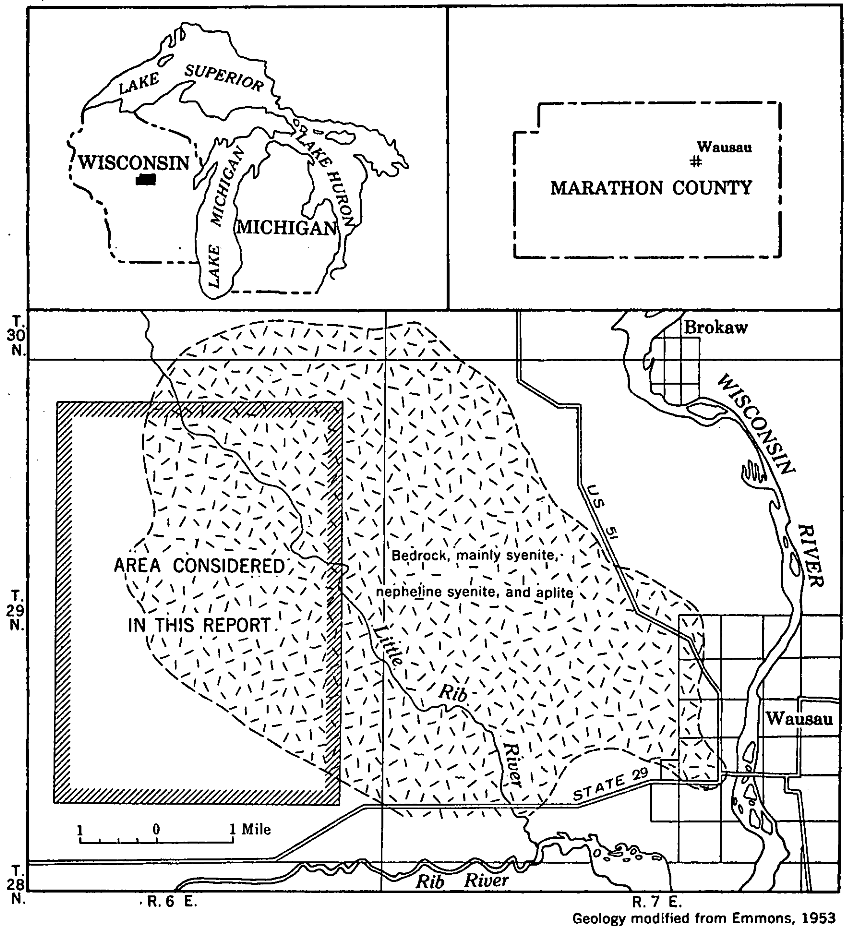

FIGURE 2.—Index maps showing the location of area of investigation near Wausau, Marathon County, Wis.

In addition, Weidman (1907, p. 252–253, 217–218) suggested that lavenite (silicate containing zirconium) and mosandrite (silicate containing zirconium and rare earths) possibly occur in the NE¼ sec. 27, T. 29 N., R. 6 E., and that allanite or piedmontite may occur at the rapids in the Wisconsin River at Wausau. Geisse[2] described eucolite, a variety of eudialyte containing rare earths, from near the NE¼ sec. 27, T. 29 N., R. 6 E.

The radioactivity of the igneous rocks in the Wausau area was first investigated by Turner.[3] He found that the gamma activity of the various rocks was directly proportional to the frequency of occurrence

[2] Geisse, Elaine, 1951, The petrography of the syenites, nepheline syenites, and related rocks west of Wausau, Wis. [Unpublished Master of Science thesis in files of Smith College Library, Northampton, Mass.]

[3] Turner, D. S., 1948, Heavy accessory mineral and radioactivity studies of the igneous rocks in the Wausau area, 107 p. [Unpublished Doctor of Philosophy thesis in files of Univ. Wis. Library, Madison, Wis.]

of zircon, the zircon-bearing pegmatites being the most radioactive, then the aplites and syenite pegmatites. His gamma-ray measurements were done with a laboratory Geiger-Müller counter, and no attempt was made to measure the radioactivity of the rocks in the field.

PREVIOUS EXPLORATION

Many attempts have been made to exploit the zircon-bearing pegmatites reported in the NW¼ sec. 22, T. 29 N., R. 6 E. About 3,100 pounds of float containing about 25 percent zircon was obtained from rock piles during the 1920's. During World War II interest was revived somewhat when some of the favorable ground was leased to Mr. H. L. Geisse who mined about 7 tons of zircon-bearing rock from shallow open pits and shipped it to the Rohm & Haas Co. of Philadelphia, Pa, for beneficiation tests and chemical analyses.

During 1946 a magnetic and resistivity study, together with diamond drilling, trenching, and soil sampling, was conducted by the U. S. Bureau of Mines in the area of zircon-bearing pegmatites in the NW¼ sec. 22. No zircon-bearing rock of a grade comparable to that present as float in the area was found.

GENERAL GEOLOGY

Because outcrops are scarce, only the general features of the bedrock geology are known. Syenites of various kinds have intruded an older igneous and metamorphic series consisting of granite, greenstone, quartzite, and argillite. Within the area of younger igneous rocks shown in figure 3, the bedrock is mainly medium- to coarse-grained syenite, which contains numerous dikes of syenite pegmatite, and locally nepheline syenite and quartz-feldspar pegmatite. Most of the dikes are restricted to the area of syenite. The size and shape of the intrusive rocks are not well known, but there is general agreement among the several workers in the area [4] (Weidman, 1907) regarding the time relations of the various rock types.

A generalized geologic column is given below.

Precambrian	Younger intrusive rocks	Syenite and nepheline syenite pegmatite Syenite Aplite
	Older igneous and metamorphic rocks	Granite Greenstone Quartzite Argillite

A single age determination by the Larsen method of zircon from a syenite pegmatite has recently been completed by H. W. Jaffe, of the U. S. Geological Survey. The results indicate an age of about 560

[4] Emmons, R. C., and Snyder, F. G., 1944, op. cit.

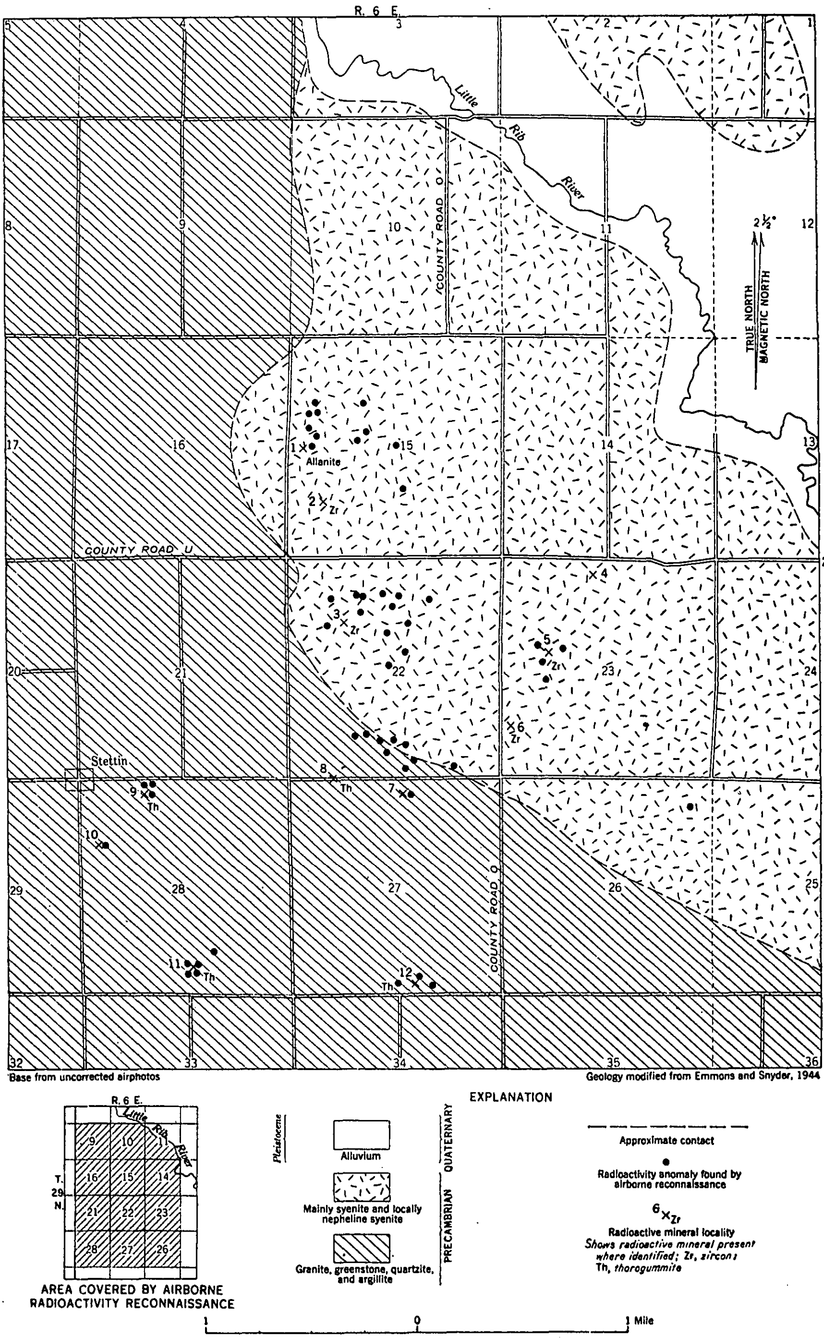

FIGURE 3. Geologic map of part of the syenite complex near Wausau, Marathon County, Wis.

million years which would correspond to Upper Precambrian (Keweenawan). This age, although preliminary, is in agreement with the geology.

RADIOACTIVITY RECONNAISSANCE METHODS

Preliminary work in the Wausau area during May 1953 showed that zircon-bearing rock could be easily detected with a Geiger counter. Several specimens of float containing abundant zircon were found near the center of the NW¼ sec. 22 (reported occurrence of zircon-bearing pegmatite), and a general reconnaissance was made to find additional zircon occurrences or other radioactive mineral localities. To obtain as much coverage as possible in the shortest time, all roads shown in figure 3 were traversed with carborne equipment consisting of a survey meter and two 2- by 48-inch Geiger-Müller tubes mounted on the roof of a half-ton truck. Reconnaissance of the interroad areas was then conducted with a scintillation survey meter. Because of the small size of the known anomalies and reported zircon occurrences, traverses were made about 200 feet apart. However, as each square mile required about 25 miles of walking, only the areas considered as the most favorable were covered, that is, almost all of sec. 22 and the W½ sec. 23.

The anomalies gave relatively high readings (from 0.5 to more than 5.0 mr/hr, background 0.03 mr/hr), so it was proposed to learn whether they could be detected with the scintillation survey meter in a light airplane while flying at a low level. To test this method of prospecting a scintillation survey meter in a light aircraft was flown over two known anomalies which were found during the ground reconnaissance. One of the anomalies (locality 5) was easily detected from the air at an elevation of about 30 feet above ground. Another radioactivity anomaly (locality 8) could not be detected because of transmission lines and trees that prevented flying less than about 50 feet above ground. From this work it was evident that relatively small areas of abnormal radioactivity could be detected from the air if the elevation of the airplane could be kept within 20 or 30 feet above ground.

Reconnaissance of about 12 sections (shown in fig. 3) was then completed with the equipment mentioned above. The flight lines were spaced about 200 feet apart and were flown at elevations ranging from 10 to 80 feet, depending upon obstructions such as transmission lines and trees. The ground speed varied between 40 and 65 miles per hour. With a background count of about 0.03 mr/hr all readings greater than 0.05 mr/hr were recorded. The position of the anomalies was indicated on airphotos. The scintillation counter was watched continuously, as most of the anomalies represented only a very momentary full-scale deflection of 0.05 mr/hr. Some of the most significant anomalies were reflown to check them and mark their position more accurately on the airphoto.

Because of the abnormal radioactivity of the syenites and related rocks, many of the radioactivity anomalies recorded over these rock types were due to the mass effect of large areas of slightly radioactive rocks. However, in the areas flown outside the syenite complex, ground checking indicated that all but one of the anomalies were related to concentrations of radioactive minerals in float and residual soil.

All the anomalies found outside the area mapped as syenite and related rocks were detected while flying less than about 20 feet above the ground. Coverage was not at all complete because many obstructions prevented flying lower than 40 to 80 feet above ground over perhaps 50 percent of the area, and because the flight lines were spaced farther apart (about 200 feet) than the width of the known anomalies.

RADIOACTIVE MINERAL OCCURRENCES

Twelve radioactive mineral occurrences were found as a result of the ground and airborne reconnaissance. Thorogummite (a variant of thorite containing hydroxyl) was identified from localities 8, 9, 11, and 12 (fig. 3); thorium-bearing zircon was found at localities 2, 3, 5, and 6; allanite was found at locality 1; and unidentified thorium-bearing minerals occurred at localities 4, 7, and 10.

Except at locality 4, there are no outcrops in the immediate vicinity of the radioactivity anomalies, and the radioactivity is due mainly to residual accumulations of radioactive minerals in the soil or radioactive minerals in float. Shallow trenching at two of the largest anomalies showed that the radioactive material extends down into weathered bedrock. The source of the radioactive float at three localities was not determined.

MINERALOGY

Three minerals that contain thorium and rare earths have been identified from the radioactive localities. These are thorogummite, zircon (variety cyrtolite), and allanite. Detailed mineralogic work would probably show the presence of other minerals containing thorium and rare earths.

THOROGUMMITE

Reddish thorogummite ($Th(SiO_4)_{1-x}(OH)_{4x}$) occurs as nodules commonly from one-half to 1 inch in diameter in residual soil and weathered bedrock. X-ray powder photographs of the material show that the mineral is crystalline (not metamict) and is associated with various amounts of hematite. Although thorogummite and thorite give almost identical X-ray powder photographs, thorogummite is believed to be formed by the alteration of primary thorium minerals, including thorite, to occur as fine-grained aggregates that are not metamict but crystalline, and to contain essential water (Frondel, 1953, p. 1007–1017). Because crystalline aggregates of thoritelike material occur in residual soil and appear altered, the material is probably thorogummite. A semiquantitative spectrographic analysis of an impure sample of the thorogummite by G. W. Boyes, of the U. S. Geological Survey, follows.

Element	*Percent* [1]
Th	XX.
Fe	X.+
Si	X.
Al, Ca, Mg, Y	X.−
Ti	.X+
Mn, Na, Ce, Dy, Er, Gd, La, Sm	.X
Nd, Yb	.X−
Cu, Nb, Pb, V	.0X+
Ba, Co, Sc	.0X−
Be	.00X

[1] Spectrographic notations, in percent, are: XX=greater than 10; X^+=5–10; X=2–5; X^-=1–2.

The sample contained 2.5 percent equivalent uranium and 0.001 percent chemical uranium.

ZIRCON (VARIETY CYRTOLITE)

Zircon occurs in quartz-feldspar pegmatite float as reddish-brown euhedral to subhedral crystals that range in length from 1 mm to about 10 mm. Thin sections of the zircon-bearing rock show that the zircons are well zoned, altered, iron stained, and in part metamict.

A chemical analysis of altered zircon concentrates from sec. 22 done by the Rohm & Haas Co. as reported by Turner [5] is given below.

Constituent	*Percent*
ZrO_2 and HfO_2	49.6
SiO_2	30.1
Rare earths as Y_2O_3	2.6
Cb_2O_5 and Ta_2O_5	0.9
U_2O_3	<.05
ThO_2	<.05
Al_2O_3	5.1
Fe_2O_3	3.5
TiO_2	2.6
MnO_2	1.8
CaO	<.05

[5] Turner, D. S., 1948, Heavy accessory mineral and radioactivity studies of the igneous rocks in the Wausau area, 107 p. [Unpublished Doctor of Philosophy thesis in files of Univ. Wis. Library, Madison, Wis.]

Constituent	*Percent*
MgO	<. 05
Pb	<. 05
Zn	<. 05
S	<. 05
Ignition loss at 1000° C.	3. 5
	100. 25

Spectrographic analysis of impure zircon concentrates from sec. 22 by G. W. Boyes, of the Survey, follows.

Element	*Percent*
Si	XX.
Zr	X.+
Fe	X.
Al, Ce, Th	.X+
Ti, Hf, La, Y	.X
Nd	.X−
Mn, Ca, Dy, Er, Gd, Nb, Yb	.0X+
Mg, Ba, Pb	.0X−
Cr, Cu, Sc	.00X+
Be	.00X−

ALLANITE

The allanite reported as float from locality 1 occurs as a single massive specimen weighing about 2 pounds. The specimen has been altered to a yellowish to brownish color on the exterior but appears black and fresh in the interior. The specific gravity of fresh-appearing material from the center of the specimen is 3.92. The specimen contains 0.57 percent equivalent uranium and 0.001 percent chemical uranium. A spectrographic analysis of the material by R. C. Havens, of the Survey follows.

Element	*Percent*
Ce, La	XX.
Si, Fe, Ca, K, Nd, Th	X.+
Al	X.
Gd, Sm, Y	X.−
Dy	.X+
Ti, Mg, Er	.X
Mn, Sc	.X−
Pb, Yb	.0X+
Ba, Sr, V	.0X
B	.0X−
Zr, Sn	.00X+
Be, Ga	.00X
Co, Cu, Ni	.00X−

X-ray powder photographs of the material show a very diffuse pattern, indicating that the material is probably metamict. The mineral gelatinizes with HCl.

Based on the above data, the material is tentatively identified as allanite.

DISTRIBUTION OF RARE EARTHS

Rare-earth elements (lanthanides) are associated with all the radioactive mineral occurrences, but the relative proportions vary. The thorium-bearing zircon occurrences contain cerium as the dominant rare-earth element whereas the thorogummite specimens are characterized by greater abundance of gadolinium and erbium. The relative abundances of rare-earth elements in specimens of thorogummite and zircon (cyrtolite) are shown in figure 4.

DISTRIBUTION OF THORIUM AND URANIUM

The results of analyses of samples collected in the area show that thorium is the principal radioactive element present, is generally associated with small quantities of uranium, but the ratio of these two elements is not constant. The highest uranium contents were found in samples of zircon concentrates that contained as much as 0.054 percent uranium and about 0.8 percent thorium. The highest thorium contents were found in specimens of thorogummite which contained as much as an estimated 15 to 20 percent thorium but only about 0.001 percent uranium.

Hematite is closely associated with thorogummite, a secondary mineral, and thus the hematite may also be of secondary origin. The low uranium content of hematite-bearing samples may have resulted from the leaching of uranium during weathering. Analyses of samples of radioactive hematite-bearing rocks and samples of zircon by S. P. Furman, R. F. Dufour, J. S. Wahlberg, G. W. Boyes, J. W. T. Meadows, Wayne Mountjoy, and P. J. Dunton, of the Survey, are listed below in order to compare their uranium and thorium contents.

Locality	*Sample*	*Equivalent uranium (percent)*	*Chemical uranium (percent)*	*Thorium (percent)*[1]
8	Thorogummite and hematite	4.2	.001	XX.
8	----do	2.5	.001	XX.
5	Hematite (radioactive)	3.0	.001	X.+
6	Zircon and quartz	.12	.008	.X+
3	----do	.10	.034	.X
6	Zircon concentrates	.21	.054	.X+

[1] Spectrographic determination.

Inasmuch as most of the samples in this report have been taken near the surface, differential leaching has probably decreased the original uranium/thorium ratios because of the greater mobility of uranium during weathering. Larger amounts of uranium may be expected in unweathered samples taken at depth, but the grade of material that may be present is believed to be too low to be of commercial value.

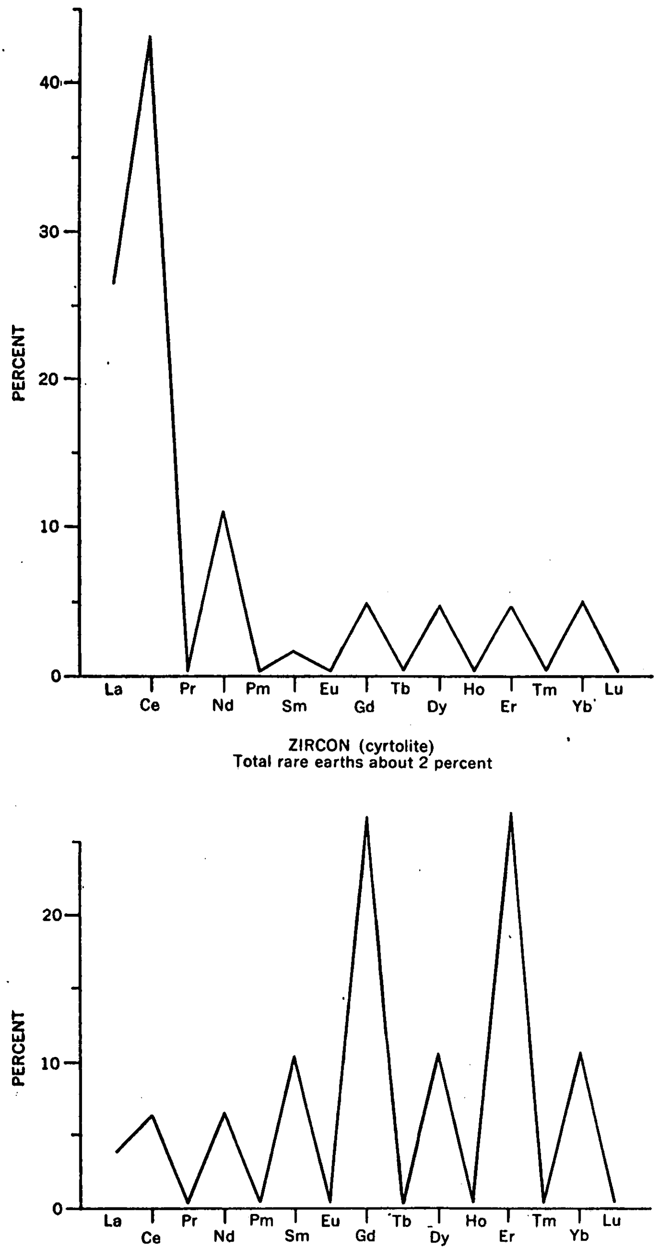

FIGURE 4.—Graphs showing relative abundances of the rare-earth elements in specimens of thorogummite and zircon from the Wausau area, Marathon County, Wis. Compiled from spectrographic analyses by G. W. Boyes, U. S. Geological Survey.

STRUCTURE

The structural patterns of the various syenites in the area are very incompletely known because of the lack of outcrops. Emmons and Snyder [6] have interpreted the syenites as being narrow dikes that trend northwestward. They further suggest that the zircon-bearing pegmatites may well occur along northwestward-trending faults. The zircon-bearing pegmatite float from sec. 22 (locality 3) originally was reported [7] to have a northwesterly trend, but later exploration of the pegmatite revealed a northerly trend. Detailed reconnaissance with a scintillation counter at locality 5 showed a northerly trend of the radioactivity anomaly and presumably the zircon-bearing rock. The radioactive fine-grained phase of syenite at locality 4 has a strike of N. 45° E. Outside the area mapped as syenite and nepheline syenite, all the radioactive anomalies in the vicinity of the thorogummite occurrences have a westerly trend. The radioactive anomaly at locality 8 trends N. 70° W.; anomalies at localities 9, 10, and 12 trend almost due west. This alinement of the anomalies and their narrow width (2 to 20 feet) as compared to their length (120 to 200 feet) suggest that the primary radioactive mineral (possibly thorite) has been localized along westward-trending faults or fractures in the roof rocks. It would thus appear that structures of various trends have localized the radioactive minerals.

The shape and attitude of the intrusive syenites in the area can be inferred from the results of ground reconnaissance with a scintillation counter. Some of the rock types, namely coarse syenite and nepheline syenite and their residual soils, were found to be abnormally radioactive (as much as 0.2 mr/hr, background 0.03 mr/hr), and thus the type of bedrock below residual soil could be determined by traversing. Although no attempt was made to determine the exact shape and extent of such anomalies, the radioactivity of the residual soil indicated that much of the coarse syenite was not restricted to narrow dikes but occurred in large irregular shaped bodies underlying several tens of acres. Northwesterly trends of radioactivity were not apparent in the area of syenites examined, except in the SW¼ sec. 22 at the contact between coarse syenite and the older rocks. Although the geologic map of part of the Wausau area (Emmons, 1953) shows a northwesterly trend for all the syenite and nepheline syenite dikes, the author was unable to find evidence which would support this interpretation.

DESCRIPTIONS OF RADIOACTIVE LOCALITIES

LOCALITY 1

Ground reconnaissance in the S½NW¼ sec. 15 in the vicinity of the anomalies detected from the air showed slightly abnormal radio-

[6] Emmons, R. C., and Snyder, F. G., 1944, A structural study of the Wausau area: Wis. Geol. Survey file report, Madison, Wis.
[7] Wisconsin Geological Survey Township report, T. 29 N., R. 6 E. [Unpublished.]

activity (0.1 mr/hr, background 0.03 mr/hr) over a large area. Moreover, two abnormally radioactive specimens were found among rocks piled along a fence row. The first specimen, weighing about 2 pounds, is composed mainly of allanite with minor amounts of fluorite and quartz. A description and an analysis of this specimen are given on page 33. The specimen contains 0.57 percent equivalent uranium and 0.001 percent uranium. A second specimen, weighing about 10 pounds, is composed mainly of pyroxene (50 percent), quartz (5 percent), and feldspar (40 percent), with small amounts of allanite(?) and fluorite. It contains 0.065 percent equivalent uranium.

LOCALITY 2

Specimens of zircon-bearing pegmatite were found along a fence row in the SW¼SW¼ sec. 15, T. 29 N., R. 6 E. The zircon, estimated to make up about 20 percent of the rock, occurs as yellowish to reddish-brown euhedral to subhedral grains that are commonly about 4 mm in diameter. The source of the zircon-bearing rock was not found during a scintillation counter survey of the adjacent fields.

LOCALITY 3

The reported site where several tons of zircon-bearing pegmatite were removed during the 1940's is about 100 feet southeast of the center of the NW¼ sec. 22, T. 29 N., R. 6 E. The former open pits have been filled, and the area now is under cultivation. Abnormal radioactivity was detected in a few small areas, and several specimens of zircon-bearing pegmatite were found on or very near the surface. A description of the zircon-bearing rock is given on page 32–33.

According to Fiedler [8] the zircon occurred as thin but continuous bands in highly sheared feldspar and quartz and also in rich lenses in quartz. He reported that three zircon bands, each about 6 inches wide, were followed continuously for about 40 feet along the strike of the shear zone in the main pit, and a rich lens of zircon surrounded by barren and fractured quartz-rich pegmatite was found about 100 feet south of the main pit along the strike of the zircon-rich bands.

LOCALITY 4

Abnormal radioactivity is associated with a fine-grained phase of gray syenite exposed in an abandoned quarry in the NE¼NW¼ sec. 23, T. 29 N., R. 6 E. The radioactive syenite is about 8 feet long and from 6 inches to 1 foot thick. Thin sections show that the rock is mainly orthoclase with abundant fluorite and some quartz. No radioactive minerals were identified in thin section. Analyses show that the

[8] Personal communication from W. M. Fiedler to Rohm & Haas Co., Philadelphia, Pa., 1942.

rock contains 0.23 percent equivalent thorium and 0.004 percent uranium. Spectrographic analyses show that thorium is the most abundant rare element present.

LOCALITY 5

Abnormal radioactivity was first detected in the SW¼NW¼ sec. 23, T.29 N., R. 6 E., in the specimens found along a fence row. These specimens, composed of acmite, microcline, and zircon contain fracture coatings of highly radioactive hematite. A scintillation counter traverse of adjacent cultivated fields shows anomalous radioactivity in an oval-shaped area that measures about 90 by 40 feet. An isorad map of the anomaly, made by tracing out each of the contours of equal radioactivity on a gridded surface, is shown in figure 5.

The thorium content of channel samples taken in several shallow trenches, which were dug in the area of anomalous radioactivity, is also shown in figure 5. Bedrock was penetrated in all the trenches except in the east end of trench no. 5. In general the highest thorium contents in the bedrock were found in the area of highest radioactivity on the surface. However, the isorad map shows mainly the radioactivity of the residual soil before trenching and therefore may show little or no relationship to the presence of radioactive minerals at depth.

The results of analyses by S. P. Furman, H. E. Bivens, J. N. Rosholt, Jr., and G. W. Boyes, of the Survey, of channel samples taken in the trenches are tabulated below.

Trench no.	Length (feet)	Equivalent uranium	Chemical uranium	Th [1]	Ce [2]	Zr [2]
1	1	0.004	--------	nil	--------	--------
2	2	.055	--------	0.15	--------	--------
	2	.041	0.018	[3] .12	0.X−	0.X+
3	3	.021	.006	[3] .06	.X−	.X+
4	3	.057	.012	.17	.X	.X+
	1	.075	--------	.22	--------	--------
5	2	.073	.003	.22	.X−	.X+
	2	.064	--------	.20	--------	--------
	4	.026	--------	[3] .08	.0X+	.X
6	2	.021	--------	[3] .06	--------	--------
	2	.014	.001	[3] .04	.X−	.X−
7	1	.006	--------	nil	--------	--------

[1] Radiochemical analysis. Thorium content is computed by determining the amount of a particular daughter product present (in this case Bi^{212}) by alpha particle count after chemical separation. If the sample is in equilibrium, the amount of Bi^{212} is proportional to the amount of thorium in the sample.

[2] Spectrographic analysis.

[3] Based on eU/Th ratios of other samples.

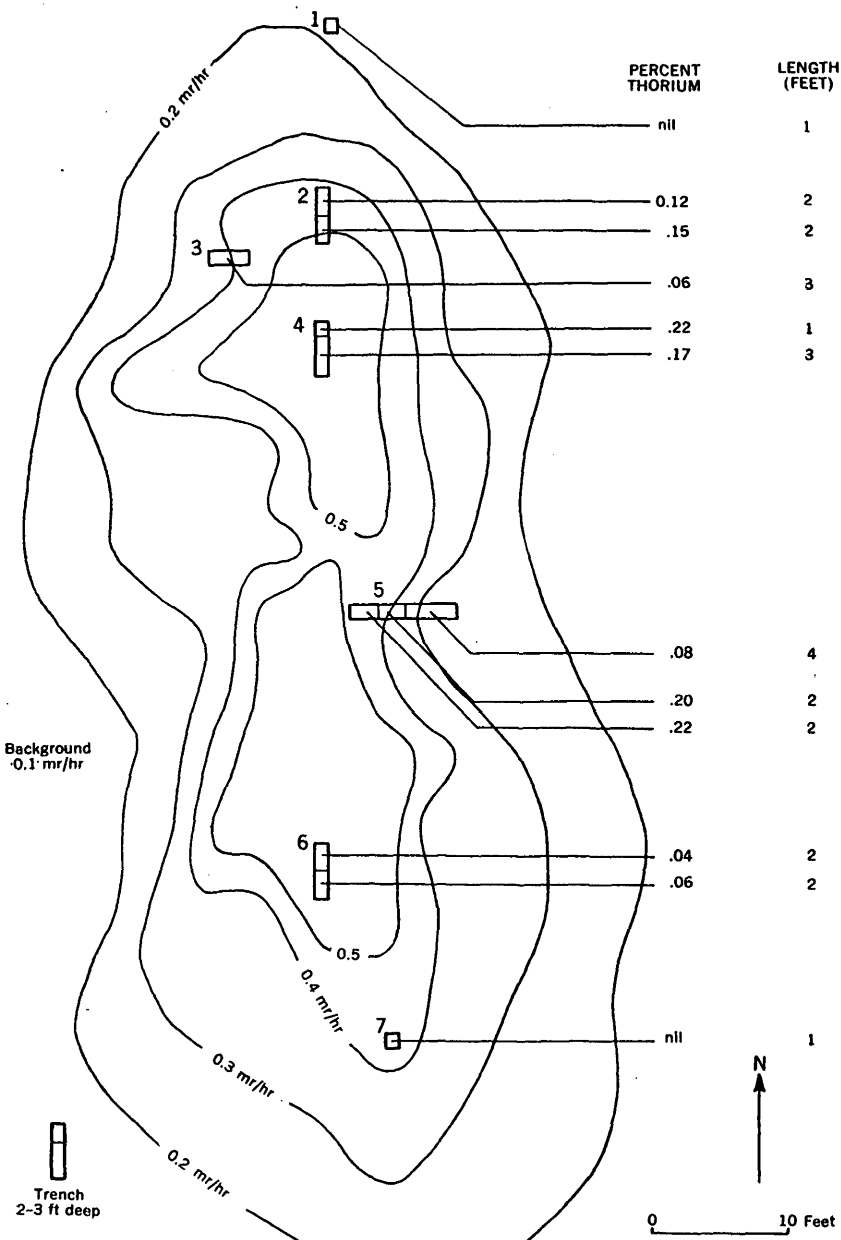

FIGURE 5.—Isorad map of radioactive anomaly at locality 5 (SW¼NW¼ sec. 23, T. 29 N., R. 6 E.) showing results of channel sampling of trenches.

Specimens taken from the trenches and pieces of float show that the wall rock is pegmatite consisting mainly of perthite, hornblende, and quartz. Some hornblende crystals are as much as 1 foot long. Abnormal radioactivity is confined mainly to areas in the pegmatite where the hornblende has been altered to pyroxene (acmite). In thin sections and in hand specimens all stages of alteration of hornblende to pyroxene can be seen. The pyroxene is much finer grained than the hornblende, the slender pyroxene crystals being 3 to 5 mm in length. Alteration of hornblende was accompanied by decrease in grain size of microcline, probably caused by brecciation, and introduction of zircon(?), which occurs as reddish altered grains about 0.6 mm in diameter. Earthy hematite that is highly radioactive coats many fracture surfaces. Spectrographic analysis of selected hematite coatings is given below.

Element	*Percent*
Th, Fe	XX.
Ca	X.
Zr	X.–
Si, Ti, Ce, Nb, Y	.X+
Nd	.X
Er, La	.X–

X-ray powder photographs of hematite coatings show a good hematite pattern with only a few, very faint additional lines. This suggests that the thorium and related elements are in either an amorphous material or a metamict mineral.

The hematite is probably a product of weathering. The primary source of the thorium in the hematite may be zircon.

LOCALITY 6

Several specimens of zircon-bearing pegmatite, similar to those at locality 3, were found in the W½SW¼ sec. 23, T. 29 N., R. 6 E. Two specimens weighing about 4 pounds each consist of quartz and about 40 percent zircon. A heavy liquid concentrate of the zircon contains 0.054 percent uranium, 0.8 percent thorium, and about 2 percent total rare earths. The specimens were found on rock piles, but no areas of abnormal radioactivity could be found in the adjacent fields.

LOCALITY 7

A radioactivity anomaly, detected during the airborne reconnaissance, in the NW¼NE¼ sec. 27, T. 29 N., R. 6 E., was checked on the ground and found to be due to a small area of nepheline syenite float. A sample of the nepheline syenite contains 0.009 percent equivalent uranium, which is about the same order of magnitude as other nepheline-bearing rocks in the area.

LOCALITY 8

Abnormal radioactivity in the N½NW¼ sec. 27, T. 29 N., R. 6 E., was found by road traverse with car-mounted Geiger counter. A maximum count of about 5 times background was detected. A scintillation counter survey of the area adjacent to the road showed anomalous radioactivity at several places. The location of the radioactivity anomalies is shown in figure 6, which also includes an isorad map of the largest anomaly and the results of channel sampling. Because part of the area is within the gravel roadbed and the adjacent ditches, some of the radioactive material probably has been moved about during road building.

At the most radioactive anomaly (plus 2.0 mr/hr) thorogummite was found in the soil within a foot from the surface. A shallow trench, 2 feet deep, was then dug. Bedrock was not penetrated in the trench, but many fragments of greenstone and decomposed syenite(?) were found. Thorogummite occurs as nodules as much as 1 inch in diameter in the decomposed rock. Results of analyses by S. P. Furman, H. E. Bivens, and R. G. Havens of the channel samples taken from the bottom of the trench (12.5 feet long and 2 feet deep) are as follows:

Field no.	Length (feet)	Equivalent uranium (percent)	Chemical uranium (percent)	Thorium [1] (percent)	Cerium [1]
WM-101-53	1	0. 007	--------	0.0X+	0.X+
WM-102-53	1	. 022	--------	--------	--------
WM-103-53	3	. 29	<0. 001	X.−	.X
WM-104-53	2	. 055	--------	--------	--------
WM-105-53	1. 5	. 009	--------	.0X	.X
WM-106-53	1	. 28	<. 001	--------	--------
WM-107-53	1. 5	. 021	--------	.0X+	.X
WM-108-53	1. 5	. 008	--------	--------	--------

[1] Spectrographic determination.

Small quantities of hematite are associated with the thorogummite, and both were identified by X-ray powder photographs. Because of the lack of outcrops in the area and the weathered condition of the bedrock, little information is known about this occurrence. The alinement of the anomalies away from the road suggests that a pegmatite or vein trending about N. 70° W. may be the source of the primary thorium minerals.

The small anomaly about 450 feet east of the largest anomaly may be due to a similar thorium-bearing body.

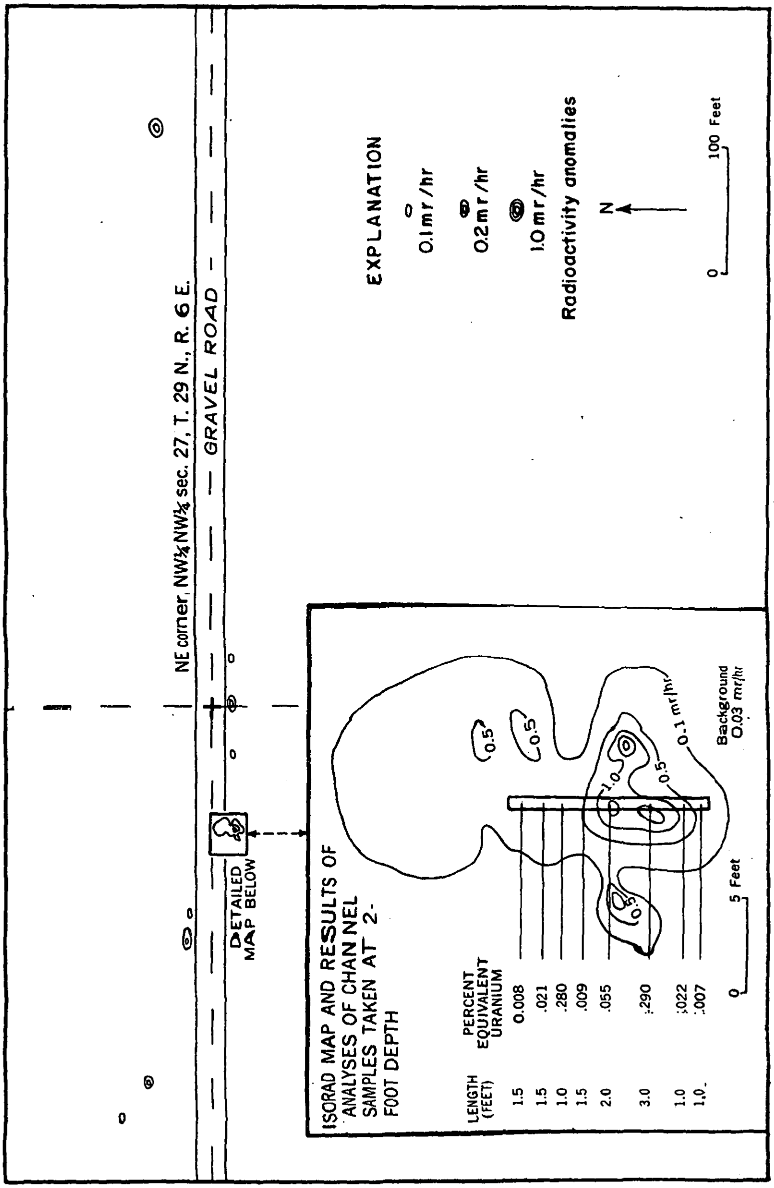

FIGURE 6.—Radioactivity anomalies at locality 8, showing analyses of channel samples.

LOCALITY 9

Anomalous radioactivity in the NE¼NW¼ sec. 28, T. 29 N., R. 6 E., was found during the airborne reconnaissance. A ground scintillation counter survey showed slight abnormal radioactivity (0.1 mr/hr, background 0.03 mr/hr) in the area and two local areas of high radioactivity caused by nodules about 1 inch in diameter composed of hematite and thorogummite. Spectrographic analyses of the nodules show XX. percent each of iron and thorium. The nodules contain 4.5 percent equivalent uranium and 0.002 percent uranium.

LOCALITY 10

An anomaly in the SW¼NW¼ sec. 28, T. 29 N., R. 6 E., which was substantiated by ground surveys, was due to abnormally radioactive fragments of syenite(?) in the soil over an area about 100 feet in diameter. Specimens of weathered syenite(?) contain 0.015 percent equivalent uranium and 0.001 percent uranium. No radioactive minerals were identified from this locality, but most of the radioactivity appears to be concentrated along fracture surfaces in the weathered syenite. A sample of the syenite contains 0.X percent zirconium and 0.0X+ percent thorium, suggesting that the radioactive mineral might be thorium-bearing zircon.

LOCALITY 11

Abnormal radioactivity at locality 11 (SW¼SE¼ sec. 28, T. 29 N., R. 6 E.) was found during the airborne reconnaissance. Ground checking indicated a westward-trending anomaly 140 feet long and 5 to 20 feet wide with a count of more than 0.2 mr/hr (background 0.03 mr/hr). Local areas of high radioactivity within the 0.2 mr/hr isorad give gamma counts of more than 5.0 mr/hr. Samples of the soil from one of the local areas of high radioactivity contain disintegrated granite(?) and a reddish radioactive mineral that was identified as a mixture of hematite and thorogummite.

LOCALITY 12

A ground scintillation counter survey of an anomaly in the SW¼SE¼ sec. 27, T. 29 N., R. 6 E., showed high counts at several places, which were caused by float composed mainly of thorogummite in residual soil. The local high counts are alined in a westerly direction for a distance of about 160 feet.

OTHER AREAS

Except for the radioactive localities described above, all the radioactivity anomalies in secs. 15 and 22 (fig. 3) recorded in the airborne reconnaissance survey are apparently related to large areas of slightly radioactive syenite and nepheline syenite. The radioactivity of the large areas of syenite and nepheline syenite would tend to mask the radioactivity from small concentrations of radioactive minerals.

CONCLUSIONS

Reconnaissance for radioactive minerals in part of the Wausau area has resulted in the discovery of six radioactive mineral localities that were found by airborne reconnaissance and six radioactive localities found by ground reconnaissance. Although there are few outcrops, the methods employed have been effective in finding bedrock occurrences of radioactive minerals by detecting abnormal radioactivity in the overlying residual soil. Zircon-bearing rocks have been found mainly within the area mapped as syenite and nepheline syenite; thorogummite has been found only outside the syenite complex. Further reconnaissance in the area of discussion and in other parts of the syenite complex would doubtless lead to discovery of additional occurrences.

The commercial value of the occurrences is not known, because several factors, such as ease of recovery of the valuable minerals from the gangue minerals, depth and lateral extent of the radioactive minerals, grade of the rock, and salability of the ore or concentrates, are not known.

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