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AN INVESTIGATION OF THE THORIUM OCCURRENCES WEST OF WAUSAU, WISCONSIN

by

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AN INVESTIGATION of the THORIUM OCCURRENCES NEAR WAUSAU, WISCONSIN.

12 pm.

Edward Hess, March 13, 1957.

Introduction:

During the summer of 1956, I was given the opportunity to investigate the thorium occurrences in the north central part of Wisconsin under the joint sponsorship of WARF and the Wisconsin Geological Survey. All available field evidence was collected during that time, with further laboratory investigation to be continued during the fall semester.

The thorium deposits to be discussed in this paper are located in Stettin township, approximately 7 miles west of Wausau. Thorium vein deposits have been found over an area of 10 sq. mi., while thorium occurrences in pegmatites comprise several additional sq. mi..

Although much surface exploration has been done in the area, no competent drill core has yet been available for study, and most of the trenches are in the regolith or residual soil zone. Hence much of the material obtained for study is badly weathered, or is just present as thorium-bearing nodules in the soil.

Purpose:

The purpose of my thesis is to show the mode of occurrence of these deposits and their genetic relationships to the area and to each other. Also the inability to identify these metamict thorium minerals has presented a rather perplexing problem which I have incorporated into my thesis.

Previous Work:

Weidman (5) and Emmons & Snyder (1) have worked out the general geology of the area; Geisse (2) described a detailed study of syenite, nepheline syenite, and related rocks of a small area; Turner (3) wrote on radioactive zircons found in pegmatites in the syenite-aplite region. The latest paper—and the one of most interest concerning thorium— was that of Vickers (4). Emmons(1a) also discussed syenite, etc. origin.

General Geology:

The rocks are considered pre-Cambrian in age, lying within the Wisconsin Pre-Cambrian shield. The general sequence of the rocks in the Wausau area is thought to be as follows:

	Thorium veins (youngest?)
	Syenite & Nepheline syenite pegmatites
	Syenite
	Aplite
	Granite
Pre-Cambrian	Greenstone
	Quartzite
	Argillite
	Rhyolite (oldest)

Mineral Deposits:

There are two modes of occurrence of the thorium minerals in syenite pegmatites, and in veins. All the radioactive deposits have been found by geiger counter or scintillometer; mainly because of the scarcity of outcrops, and secondly because very few people can identify thorium minerals in the field.

The pegmatites, which are confined to the syenite-aplite complex, are predominantly non-zoned. Thorium found in these pegmatites occurs as large irregular reddish-brown, vitreous "blebs", up to a couple inches in diameter, but sparsely scattered. Almost invariably some quartz is associated with the thorium "blebs".

Another pegmatite, quite different from the others, has very high radioactivity associated with a much finer-grained (hydrothermally altered?) portion of the pegmatite. Vickers (4, p.38-40) gives some surface information and analyses of this material.

Still another occurrence with a fine-textured core but pegmatitic boundaries has abundant pyrite and fluorite associated with it. The host rock for this last occurrence is a gray syenite; it is not the pink syenite as in the preceding cases.

The vein deposits are structurally controlled, and have a general east-west to northwest-southeast strike with a north dip, except for one area where the veins are striking north-south and dipping east. The veins vary from ½" to 1" where seen, and reportedly 42 to 5" thick at the Titan pit. From 15% to 30% thorium has been reported as assay values. One float specimen of sheared quartz and thorium mineral suggested a minimum width of one vein to be 14" wide, although the thorium content was probably only a couple of percent. These veins have been found in both greenstone and granite-- never in the syenite area.

The mineralogy of these veins varies from those of essentially pure thorium-bearing mineral to those thorium minerals present in sheared quartz veins. Very minor chalcopyrite is also associated with these quartz-thorium veins. Fluorite is present in the wall rock near some of the "solid thorium-mineral veins".

Wall rock alteration near the thorium-bearing veins consists predominantly of hematite-stained walls (especially evident in the granite host rock) and some silicification.

Genetic Relationships:

Field evidence, X-ray powder patterns, and X-ray spectrographic results of thorium minerals suggest a genetic relationship between the veins and the syenite-aplite complex-- presumably during or shortly after the formation of the syenite pegmatites.

Laboratory Problems & Procedures which have been, or are now being, attempted to solve them:

I. Problem: Location of thorium-bearing minerals in the rock samples-- Since most of the specimens are weathered to a great extent, and iron stains are quite prevalent along with other secondary products, it is rather difficult at times to distinguish which mineral(s) may be thorium-bearing. Also,

because of their isotropic appearance under a petrographic microscope due to their metamict condition, they cannot be distinguished from other isotropic non-radioactive minerals (if present). There is always the possibility that not all the thorium minerals present are isotropic (or metamict).

Procedures:— Autoradiograph methods have been tried lately. After much experimenting with nuclear track plates (donated by J. Guilbert) but without much success because of lack of proper developing fluid available, professor Bailey's X-ray photo film was found to serve the purpose of showing the location of radioactive material in a sample.

II. Problem: Determination of what mineral(s) with replacement type features within the "solid thorium-vein" is radioactive.

Procedures:— A very thorough examination of all the hand-specimens with a binocular microscope having 3 to 27 power magnification (rarely 96X) revealed many interesting and unusual features which could not be distinguished macroscopically nor could it be noticed in thin-section. The vein is not solidly uniform thorium-mineral as previously believed, but is quite complex in character. Autoradiographic methods should reveal further information concerning this problem.

III. Problem: Identification of thorium-bearing minerals.

Procedure:— No optical data could be determined under a petrographic microscopic (except the refractive index) due to their metamict condition which makes them appear to be isotropic.

X-ray powder patterns are also useless unless the mineral is heated to a high temperature to restore its (original??) internal atomic structure. X-ray patterns obtained after heating the vein thorium mineral for six hours over a Bunsen burner, and for three hours at 1000°C, resulted in completely different patterns. Nothing could be found anywhere in the ASTM index, Bailey's private file or metamict mineral powder patterns, nor in any of the literature. Upon heating both a sample of unaltered greenish-black vein material and a sample of reddish-brown thorium mineral from a syenite pegmatite to 1000°C, identical X-ray patterns were extracted from both. At lower temperatures, the pegmatitic thorium gave a much more diffuse pattern than that of the unaltered vein thorium.

Qualitative analyses by X-ray spectrograph methods of both vein thorium and pegmatitic thorium showed the same elements present in the same proportions in the two different specimens.

Careful examination of all the rock samples under a binocular microscope as mentioned under Problem II also revealed some unidentified crystals which may be a thorium mineral in known radioactive samples. Autoradiographs and X-ray powder patterns may bear this out.

Since identification of these thorium minerals does not seem possible at the moment, I shall only attempt to correlate the X-ray powder patterns, X-ray spectrograph results, and any optical data of the various thorium occurrences with each other in an effort to relate the deposits and to see how many different results will be obtained.

Although these are my three major problems, a fourth very important problem is one of obtaining fresh, unweathered material in order to determine true wall rock alteration and primary mineralization. Binocular observation has suggested that ten or twelve thin-sections from select specimens of the presently available material will help form a more complete picture of the radioactive occurrences in the Stettin township district.

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CONDENSED DESCRIPTIONS OF SELECTED DEPOSITS
DISCUSSED IN THE M.S. THESIS ENTITLED, "AN INVESTIGATION OF
THORIUM OCCURRENCES WEST OF WAUSAU, WISCONSIN"
By Ed. Hare

Locality #2:

The deposit at Locality #2 is located in a road ditch that forms the south boundary of SW¼, sec.10. Pink syenite and coarse pink syenite-pegmatites are exposed here. The radioactive mineral is in a quartz-bearing, coarse pink syenite pegmatite having a northerly trend. The dip of the pegmatite cannot be determined from present exposures. Insufficient outcrops also prevent the determination of the length and width of the pegmatite. There is not enough thorium mineral present in the pegmatite or concentrated in the overlying soil to allow one to trace the pegmatite on the surface of the ground with the aid of a scintillation counter.

The thorium mineral has a deep red, resinous to irridescent luster. Associated with the shapeless bleb of the thorium mineral are euhedral crystals of red-brown zircon. These were both enclosed in a small pocket of quartz, about 3 inches in diameter, found within the pegmatite. This quartz pocket was found at an apparent distance of four feet from the contact of the pegmatite with the pink syenite host rock.

X-ray powder patterns reveal the zircon to be partly metamict, but the deep red thorium mineral is completely metamict. Upon heating of the red thorium mineral for 6 hours over a Bunsen burner flame, a faint powder pattern was obtained. Further heating of the specimen to 1000°C for 3½ hours

gave results identical to that of an unaltered thorium-bearing mineral from a narrow zonal deposit in greenstone host rock at Locality #10 which was heated to an equal temperature. An attempt was made to correlate the powder patterns obtained from the thorium mineral at this locality with that of any of the radioactive minerals that have X-ray powder pattern data published in the literature through 1956. The search failed to reveal a similar powder pattern. A semi-quantitative X-ray spedtrographic analysis showed that the red thorium mineral contains the same elements in approximately the same proportions as an analysis of the unaltered thorium mineral from Locality #10. The elements recorded were: Fe**, Th**, Y, As, Ce, Hf, Gd, Sm, Mn, Nd. The specimens were analyzed under ordinary atmospheric conditions; hence, no elements could be detected that had an atomic number of less than 22. The X-ray data from the deposits of Locality #2 and Locality #10 are so identical to one another that this characteristic is one ofthe features used in the author's conclusions to show that a genetic relationship exists between the deposits found in the syenite-aplite complex and those found in the nearty granite and greenstone area.

Locality #3:

The deposits at Locality #3 are in the E½ of NE¼, NW¼, sec.16, and the W½ of NW¼, NE¼, sec. 16. Float rock suggests that a series of long, tabular quartz-feldspar pegmatites is present. The anomalies of the two eastern bodies trend N65W, and the anomalies of the two western bodies trend N80E. Peg-

matite A has been exposed in a shallow exploration trench and strikes N80E, dipping 25-35° in a southerly direction. This particular anomaly overlying Pegmatite A reportedly can be traced for approximately ¼ mile. A count of 40 to 60 times background was obtained from the pegmatite exposed in the trench. The count is from two to four times background along the anomaly where the pegmatite is not exposed at the surface. The pegmatite is at least 18 inches thick, and the upper contact of the pegmatite is not exposed. The hanging wall and footwall of the pegmatite body is greenstone. The footwall has the appearance of a stratified tuff, and is bleached from a dark green to a grey color near the pegmatite. No attempt was made to determine if the bleaching had caused any mineralogical changes in the wall rock. The true relationships of the hanging wall cannot be seen in the trench.

The quartz-feldspar pegmatite exposed in the trench becomes aplitic in texture near the base and the top of the body. Tight fractures that are rather evenly spaced parallel to the plane of the pegmatite, but lying within the pegmatite, are noticeably like those fractures seen in the thorium-bearing quartz veins at Locality #25. The deposits at this locality were not investigated until just recently; hence the mineralogical study, especially of the opaque minerals, is not complete. A macroscopic determination of the minerals present in Pegmatite A is as follows:

Quartz ---------- 40-70%, the greater concentration being in the lower part of the pegmatite.

Feldspar ---------- 20%, becoming as high as 50% near the top of the pegmatite.
Dark minerals ---------- 10%

Many solution cavities formed by weathering of a previous mineral are now partly filled with limonite and goethite. A thin-section taken 16 to 18 inches above the base of Pegmatite A shows the following analysis:

Quartz ---------- 45%
Oligoclase ---------- 40-45%, with 25% being present as small euhedral crystal laths.
Zircon (altered) -------- 5%
Magnetite and chocolate-brown opaque grains thought to be altered mostly to goethite -------- 10%. Much yellow-brown limonite stain is present throughout the thin-section.

Anomaly B trends N65W. Float samples show a very fine-grained, pinkish-gray to light tan colored aplite. Greater radioactivity is associated with the pinkish-gray sample.

Locality #10:

Mr. John E. Jones, Jr., of the Aesir Mining Company, has sunk an exploratory shaft about 40 feet deep on NW¼, NE¼, sec.21. Unfortunately, the shaft was partially filled with water at the time of investigation, thereby obscuring the radioactive mineral zone. The narrow zone was estimated to be striking N80E and dipping 70 to 80° to the north. The radioactivity anomaly can be traced for 200 feet before fading out to the east and disappearing beneath a swamp to the west. Mr. Jones reports that the zone has a maximum width of four inches near the bottom of the shaft. Several other radioactivity anomalies and localized "hot spots" have also been found in the immediate vicinity, and have approximately an

east-west trend. Chemical analyses of select samples from the thorium mineral deposit have run as high as 28.8% ThO_2 and 3.9% rare earth oxides. The host rock is greenstone, cut by numerous small pink syenite dikelets. The greenstone is occasionally cut by white feldspathic veinlets containing abundant pyrrhotite and minor chalcopyrite. Some fresh thorium-bearing "vein" material in contact with greenstone host rock was found in the waste pile. These samples will be the basis of the discussion of this radioactive deposit.

All hand specimens containing both partially altered and unaltered thorium mineral were thoroughly examined to determine the exact nature of occurrence of the thorium mineral in the "vein" or zone. The zone containing the thorium mineral is delineated by the presence of very minute hair-like veinlets of montmorillonite cutting the matrix which resembles very closely that of the adjacent greenstone (amphibolite) host rock. The veinlets do not cut the radioactive mineral. The hair-like veinlets, when examined more closely under a microscope, are actually pairs of veinlets, each veinlet being composed of a different mineral. The green, fibrous veinlets are montmorillonite, and the adjacent veinlets of a green-black, vitreous mineral are an amphibole. The thorium mineral occurs in patches, and is replacing part of the matrix within the zone. Short, minute veinlets and grains of chalcopyrite are sometimes present in and near the zone. Minor purple fluorite is present in the zone, but is more concentrated in the bleached band between the thorium-bearing zone and an outer, iron-stained "front". There is a gradual destruc-

tion of the mafic mineral outlines as the thorium mineral-bearing zone is approached; yet the zonal matrix is approximately the same color as the host rock. Excluding color, one can observe under crossed nicols that the grain boundaries and the optical properties of the amphiboles of the greenstone become almost completely obliterated in the thorium mineral zone, leaving only occasional remnants to attest to the original mineral. Wherever syenite dikelets cross the thorium-bearing zone, thin stringers of fibrous montmorillonite transgress the dikelet and connect the thorium mineral zone on either side; yet the stringers of montmorillonite narrow quite abruptly upon entering the thorium-bearing zone enclosed in amphibolite, but do not pinch out. No other mineral present in the thorium-bearing zone where enclosed by amphibolite transgresses the syenite dikelet.

Optical properties of the unaltered thorium mineral are few. Color in thin-section is a light orange-brown to grayish-white. The isotropic condition is probably due to the metamict state of the mineral. Refractive index is around 1.655, increasing upon heat treatment. Specific gravity is at least 3.72. The mineral has a high vitreous to resinous luster and a light brownish-gray streak.

Radioactive, red-brown nodules found in the same radioactivity anomaly just west of the shaft, give a thorogummite X-ray powder pattern. Despite identification of the secondary thorium mineral, X-ray methods failed to show any close correlation of the unaltered thorium mineral from the shaft with any known X-ray powder pattern data in the literature.

After both specimens had been heated to 1000°C, the unaltered, amber-colored thorium mineral from Jones' shaft produced a pattern identical to the pattern obtained from the bright red thorium-bearing mineral found enclosed in a quartz pocket in a pegmatite at Locality #2. The patterns are completely dissimilar when heated at lower temperatures. As mentioned earlier in the description ofthe deposit at Locality #2, semi-quantitative X-ray spectrographic analyses were made of the same two thorium mineral specimens discussed above. The analyses revealed the same elements were present in almost identical proportions in both specimens. It was also mentioned earlier that no known powder data for radioactive minerals published through 1956 could be correlated with any of the powder patterns mentioned above, although the U.S. Bureau of Mines analyzed and named a sample of thorium mineral from this deposit as thorite. Chemical analyses by others of select samples from this deposit have run as high as 25% to 30% ThO_2 and close to 4% rare earth oxides.

The author has stated in both the conclusions and under the general description of this group of deposits that there appears to be a definite genetic relationship between the deposits found in the greenstone and granite and those deposits of the syenite-aplite complex.

Locality #15:

The Glen Bergen prospect pit is at Locality #15 in in SW¼, NW¼, sec.23. The deposit has been discussed earlier by Vickers (U.S.G.S. Bull. 1042-B, p.38-40, 1956.). With the aid of

a scintillation counter, he found "anomalous radioactivity in an oval-shaped area that measures about 90 by 40 feet." The radioactivity anomaly has a north-south trend. Insufficient exposures prevent the dip of the body from being determined. The radioactivity is restricted to a much finer-grained, hydrothermally altered portion of a very coarse pink syenite host rock. The pegmatite consists primarily of perthite, hornblende, and some quartz. Hornblende crystals attain a length of nearly one foot in the coarse pegmatite, whereas the largest grains (feldspar) in the radioactive, finer-grained phase of the pegmatite are uniformly 1/20 inch in diameter. Microcline is the most abundant type of feldspar found in the hydrothermally altered phase. Interstitial to the microcline grains are smaller grains or crystals of quartz, acmite, and partly metamict zircon (cyrtolite). The zircon occupies up to 10% of the radioactive mineral deposit. R.C. Vickers says that the hydrothermal alteration of the hornblende to pyroxene (acmite) "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 fractures." Vickers also states that the primary source of the thorium in the hematite may be zircon, and that the hematite is probably a product of weathering.

Thin-sections were made of two specimens of the radioactive, hydrothermally altered portion of the pegmatite;

The minerals present are as follows:

23-G-1 (surface float with much of the hematite removed).

Microcline	65%
Microperthite	5%
Quartz	2-4%
Aegerine-augite	12%
Zircon	11%
Hematite (and magnetite)	5%

23-G-2 (specimen with a heavy hematite coating, taken from the Bergen pit).

Microcline	60%
Andesine	10%
Acmite	5%
Zircon	4%
Hematite	20%

By comparing the minerals identified in the two thin sections of the same body of rock, one can see that the minerals which were present interstitially to the feldspar grains are partly or completely obscured by the heavy hematite coating. There is some question as to whether the mineral identified as andesine may be just a different orientation of the microcline grains.

Locality #17:

The deposit at Locality #17 is situated on a "bridge" of solid rock flanked on either side by water-filled, abandoned quarries in NE¼, NE₄, sec.23. A radioactive, teardrop-shaped body is enclosed in a host rock of gray syenite. The lens strikes N.50E. It is 18 feet long, and from zero to 3 feet wide, with the narrowest part of the lens at its northern extremity. The lens can be separated into two zones--a non-radioactive, pegmatitic outer zone from ½ inch to 2 inches wide, similar in mineral composition to the adjacent

gray syenite, and an inner radioactive zone of aplite, deficient in mafics and richer in quartz than the syenite. Radioactivity seems to be directly related to the color of the aplite body. The gray, more bulbous southern part of the lens averages approximately ten times background, grading into the dark brownish-red, more constricted northern part of the lens which averages 18 to 20 times background. Abundant purple fluorite and pyrite are present throughout the lens. A small pocket, or core, about 6 inches in diameter, consists of massive quartz with minor carbonate. This core is found in the most bulbous part of the southern extremity of the lens.

Examination of a thin-section of the gray syenite host rock disclosed the following minerals:

Microperthite	75%
Oligoclase-andesine	10%
Biotite	5%
Arfvedsonite	5%
Magnetite	1-2%
Fluorite	less than 1%
Zircon	less than 1%

In the radioactive, red-brown aplitic phase, minor quartz is present. The red-brown color is attributed to finely-divided hematite that is especially concentrated along grain boundaries. The following minerals were seen in a thin-section of the red-brown, aplitic body.

Feldspars (microcline predominant)	90%
Quartz	2-3%
Fluorite	3%
Zircon	minor
Thorogummite?	4-5%
Pyrite	1-2%

The material identified as thorogummite, mentioned in the

thin-section identification above, is based on its similar optical properties to other thorogummite specimens which have definitely identified as such. The thorogummite? mineral grains present here are too small to separate and identify by X-ray methods.

Whereas the adjacent gray syenite host rock has about 20% mafics, the radioactivity-bearing aplite phase has very little, if any, mafic minerals. Both the pyrite and the purple fluorite are, with few exceptions, restricted to the aplite lens, and the red coloration so prevalent in the fine-grained phase fades out quickly-- though not abruptly-- as the coarser-grained gray syenite is encountered.

Locality #24:

A series of parallel, elongated radioactivity anomalies are present at Locality #24 in NW corner, NE¼, sec.29. Four trenches have been dug: two across the largest anomaly, and one each across two smaller, parallel anomalies. Trench A, which is the narrowest of the two trenches crossing the largest anomaly, is the only trench that shows the true vein relationships, but even this exposure is highly weathered.

The largest anomaly at Locality #24 trends N12W, but the strike exposed in Trench A is north-south, although this may be only a local irregularity in the general strike of the vein. The anomaly becomes more northwesterly when it is traced northward into section 20. The length of the anomaly is over 500 feet in section 29 and can be traced for an additional 160 feet into section 20. This gives an overall

length of approximately 700 feet for the anomaly with radioactivity readings of at least two times background. The tabular vein exposed in Trench A strikes north-south and dips 37° to the east. Much radioactivity is associated with a highly weathered, deep red, clayey zone 16 inches thick. This zone comprises a mixture of deep red clay and fragments of quartz that have small pockets and stringers of red clayey material. Below the zone of radioactivity is a one inch band of orange-yellow clay. A one-half inch band of red-orange clay overlies the radioactive zone. The red-orange clay is in turn overlain by an 18 inch band of essentially barren jasperoidal quartz, dark red near its footwall and becoming a translucent white in color near the upper contact. The wall rock is extremely altered. Originally an argillaceous greenstone, the hanging wall has been bleached and sericitized, with a finely-divided hematite powder giving the rock a reddish-pink color. The footwall is limonitized and very low in quartz. Mr. C.W. Little, Jr., of Marathon Thorium Enterprises, has stated that recent core drilling of this vein revealed a dark green, massive rock at the footwall of the vein. Therefore, weathering is probably the principle cause of alteration of the footwall greenstone to a limonitic mass of rock.

Several thin-sections of the altered host rock and the "jasperoid" zone from Trench A, and float samples from the thorium-bearing quartz veins intersected by Trenches C and D, were studied to determine what minerals and textures were present. The pink altered greenstone of the hanging wall is

a quartz-graywacke, criss-crossed by many small fissures and veinlets of a sericitic mineral. The whole rock, excepting the sericite veinlets, is permeated with microscopic hematite particles. Examination under a petrographic microscope of the so-called "jasperoid", a term used in the field, has revealed that this is in reality an intensely sheared mass of quartz. Minor sericite, a trace of thorogummite, and a clouded, light-brown mineral present in grains which are too small to permit determination of its optical properties, are also found. Secondary quartz veinlets run parallel to the shearing. A specimen of thorium-bearing vein quartz material from the deep red, clayey zone consisted of 80% crushed and sheared quartz. Deep red thorogummite material and hematite was introduced interstitially to the granulated quartz fragments. A few small sheaf-like clusters of a chloritic mineral are consistently associated with the red-brown opaque masses of thorogummite. There is also minor magnetite and traces of chalcopyrite.

The anomaly which is partially exposed in Trench C strikes N11W to N17W. Another anomaly southwest of Trench C strikes N5W. Both of these anomalies can be traced over 150 feet with a scintillation counter. A weak anomaly suggesting a possible fourth vein also trends N5W. This anomaly is about 30 feet west of that intersected in Trench D. A thin-section of a quartz vein sample found in the residual soil at Trench C revealed the quartz as having a clear, mosaic texture. Only one corner of the thin-section showed quartz

with undulatory extinction. There are parallel, closely-spaced fractures cutting quartz grains but not displacing them. The salmon-pink replacement veinlets of partly metamict zircons in the quartz vein are also parted by the fractures. Thorogummite grains are not affected by these fractures. This can probably be explained by the fact that the thorogummite is a secondary product of alteration. Trench D showed float of vein material similar to that found in Trench C. One specimen showed that the vein was at least two inches wide at the location of the trench. Evidence of faulting is shown by a heavily sheared and mylonitized siliceous greenstone found in the diggings from Trench D. The rich brown grains in the vein quartz were identified by the X-ray powder method as thorogummite. Also the pink mineral occurring as stringers in the quartz vein was identified as partly metamict zircon. The powder patterns of thorite and thorogummite in the literature are very similar. Dr. S.W. Bailey states that the substitution of thorium for zirconium in the zircon crystal lattice causes a shift in the powder lines so that they fall intermediate to those ordinarily obtained from X-ray powder patterns of zircon and thorogummite or thorite. A chemical analysis by A. Kaiser of a brick red mineral from a float sample obtained from the largest anomaly at this locality showed the presence of 20% thorium and rare earths.

Locality #25:

A series of narrow, tabular-shaped, granitic pegmatites are present at Locality #25 in the southern part of the

Stettin district. The six narrow tabular pegmatite bodies are exposed in a roadcut of solid rock along Co. Hwy "O" in the SW corner of section 35. All the pegmatites strike N65-70W and dip 51-61° northeast. The strike and dip of Pegmatite #6 was not determined because of its irregular shape. The pegmatites were controlled by fissures. Some of the pegmatites terminate below the top of the outcrop, which is 15 feet high. The thicknesses of the pegmatites near the base of the outcrop range from 2 inches to 5 inches wide. Overburden prevents the lengths of the narrow bodies from being known. The mineralogy is very similar for all six pegmatites; hence, only Pegmatite #1 need be described. A macroscopic determination of the minerals present in Pegmatite #1 is as follows:

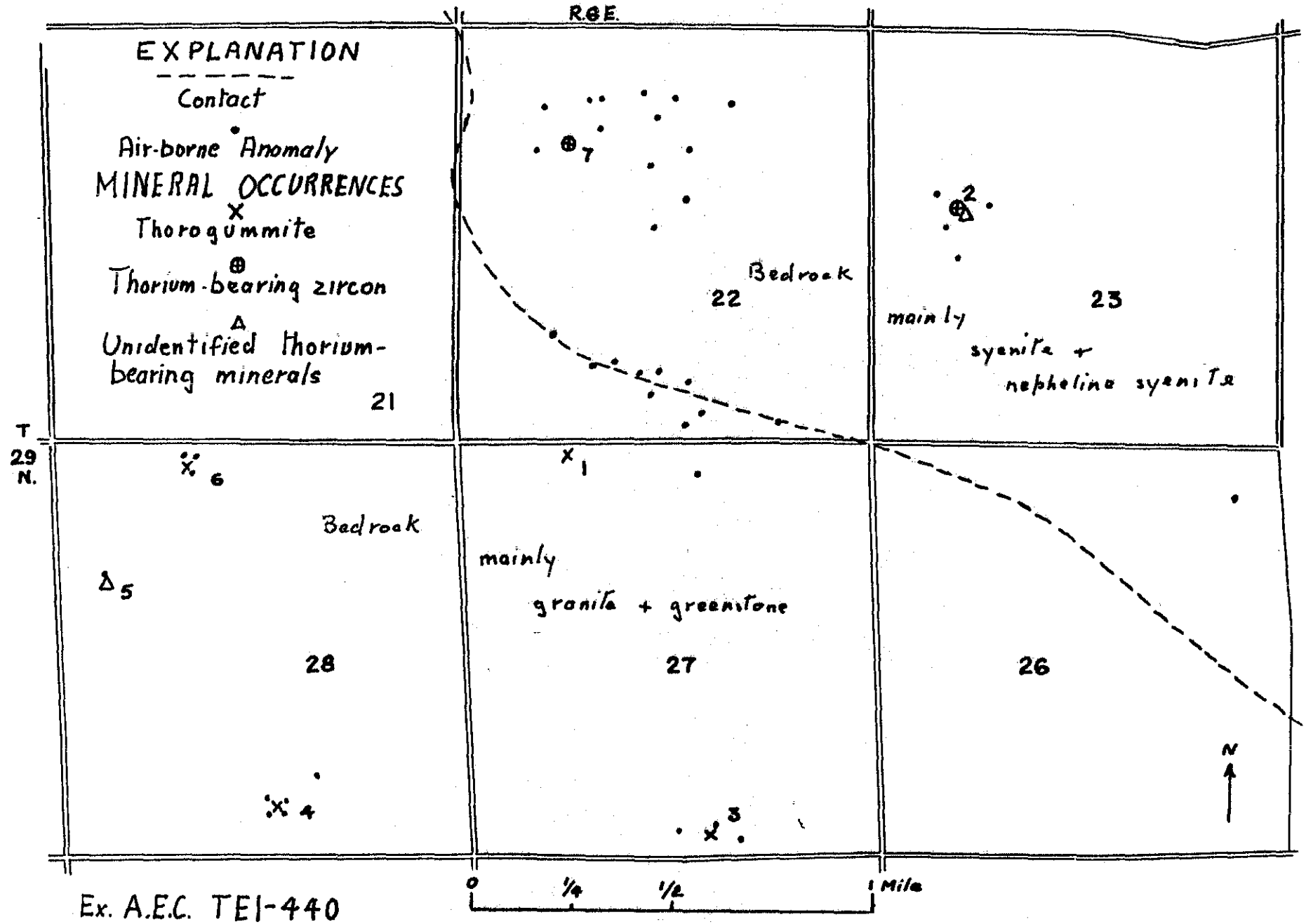
Potash feldspar	70%
Quartz	20%
Muscovite/minor Biotite	5%
Zircon (radioactive)	1-5%
Magnetite	1-10%

The feldspar content decreases slightly toward the hanging wall of the pegmatite. The amount of zircon becomes almost nil, whereas magnetite greatly increases as the aplitic-textured hanging wall of the pegmatite is approached. Minor purple fluorite is found in the host rock adjacent to the footwall of the pegmatite.

The gneissose host rock is transitional between granite and greenstone. The rock has small, elongated red feldspar and quartz augen in a matrix of finer grained mafic minerals.

Radioactivity of the pegmatites is not very high. Even

with the scintillometer directly in contact with the bodies of pegmatite, radioactivity counts only averaged about two times background. Radioactivity in Vein #1 gave readings of over four times background. The red-brown, radioactive zircons found in the pegmatites at this locality have an unusual crystal habit of first order pyramids with second order prisms. The crystals were first thought to be garnets until X-ray identification proved otherwise.



Ex. A.E.C. TEI-440

416½ A SW
Miami, Oklahoma
August 15, 1957

Mr. George F. Hanson
State Geologist
Wisconsin Geological Survey
Madison,6, Wisconsin

Dear Mr. Hanson,

Enclosed is a typewritten description of the various thorium mineral deposits that I investigated in the Wausau area during the summer of 1956. I have not included the deposits mentioned in my thesis, but I will type them up and have them sent to you by Monday or Tuesday, August 19th or 20th. It has been so unbearably hot that a person perspires profusely even if he is not doing anything. I have been typing part of the report almost every night, but the weather prevents me from typing for very long at a time. Just yesterday the temperature was around 103°, and our(a fellow geologist and I) apartment has has no fans or air-conditioners.

Until I turn in the rest of the descriptions of the thorium deposits next week, I am---

Sincerely yours,

Edward Hare

DESCRIPTION OF DEPOSITS NOT MENTIONED IN THE MASTER'S THESIS ON THE RADIOACTIVE MINERAL DEPOSITS IN THE WAUSAU AREA

Locality #1:

The deposit at Locality #1 is at the west side of a field in SW¼, SW¼, sec.4. This "hot" zone could only be traced by use of a scintillation counter, due to the complete lack of outcrops. The elongated radioactivity anomaly, which locally reached three times background, had a N65W trend at its eastern end, becoming N55W farther west. Although the radioactivity count was rather variable along its length, the anomaly could be traced for at least 400 feet east of the north-south ½ mile fence, and several dozen feet west of the fence before fading out as it is traced into a swampy valley. No samples were recovered because of heavy soil cover.

Locality #4:

A series of "hot" spots have been found at Locality #4 in SE¼,SW¼, sec.16. The anomalies have approximately east-west trends. One anomaly can be traced for about 200 feet. The vein causing the radioactivity anomaly may be much longer if a somewhat parallel anomaly located a couple of hundred feet west of the previously mentioned anomaly comes from the same vein. Surface counts of radioactivity of the various anomalies average 2½ times background, locally reaching a factor of six, and rarely ten. Heavy soil cover prevents any further knowledge of the nature of the deposits. Hence, no samples could be obtained.

Locality #5:

The property containing the radioactivity anomaly at Locality #5 is at the east side of NE¼, SE¼, sec.17. The general trend of the anomaly is N80-85W, and it can be traced for 250 feet with a scintillation counter. Average surface counts are two tb three times background. Counts up to ten times background are obtained in the road ditch. The width of the radioactivity anomaly is relatively narrow, averaging between five to ten feet. No samples cound be obtained at this locality because of heavy soil cover.

Locality #6:

The deposit at Locality #6 is in the SW corner of SW¼, SE¼, sec.20. The radioactivity anomaly is a continuation of the vein exposed in Pearson's trenches A and B in the NW corner of NW¼, NE¼, sec.29, but here the anomaly has a more northwesterly trend. The anomaly can be traced northward for 160 feet from the south boundary of sec.20 before becoming indiscernable. Two rock piles located a couple of hundred feet north and west of this anomaly contained large pieces of vein quartz with scattered red-brown, altered, radioactive grains averaging ¼ inch in diameter. One piece of low-grade float showed that the vein is at least nine inches wide somewhere within the radioactive deposit.

Locality #7:

A small radioactivity occurrence is present at Locality #7 in the NE corner of SE¼, SE¼, sec.20. Scintillation counter readings showed an elongated anomaly about 200 feet long, but

with a narrow width of abnormal radioactivity. The trend of the anomaly is N85W. Counts average around two times background. In the road ditch a count of over 30 times background was observed. No specimens could be obtained because of soil cover.

Locality #8:

The deposits at Locality #8 consist of two small veinlets exposed on a road shoulder at the north boundary of NW¼, NW¼, sec.21. Heavy soil cover prevents the small tabular veins from being traced beyond the road bank. Both veins are very thin-- less than ¼ inch. They consist almost entirely of thorogummite and minor quartz. The western veinlet has a three to four inch red jasperoidal zone, while the more easterly vein has only an altered, hematite-stained zone one to two inches wide. These veinlets are enclosed in a chloritic, schistose to granulitic host rock that has fracture cleavage striking N65E to N75E with an almost vertical dip. The western veinlet strikes N57W and has an indeterminable dip. The eastern veinlet strikes N55W and dips 45°NE.

Locality #9:

The major part of the anomaly at Locality #9 is located in the N½ of NE¼, NW¼, sec.21. The elongated radioactivity zone trend s N35W, varying perhaps 5°, and can be traced for at least 650 feet in sec.21. An additional 120 feet of the same anomaly is present across the section road in sec.16. The greatest amount of radioactivity is in section 21, where

the average count is from three to six times background. Counts as high as ten times background are detected locally. Near the central portion of the length of the anomaly in section 21, one can detect two separate anomalies that seem to broaden and merge as they are followed eastward. In two of the broader parts of the anomaly, the surface width of radioactivity having a minimum count of three to four times background was 20 feet and 40 feet wide respectively. A radioactive mineral-bearing rock specimen 1½ inches wide was found in the soil zone overlying the anomaly. It consisted largely of clear, massive quartz (60-70%), with the remainder of the rock composed of finer grained constituents mentioned below. Float rock found on either side of the anomaly was greenstone. Thin section studies of the quartz-feldspar pegmatite showed the following minerals:

Quartz ---------- ----------	80%
Oligoclase/andesine, with euhedral laths enclosed in quartz grains	15%
Sericite ----------	2-3%
Zircon & opaques ----------	2-3%

No attempt was made to determine the opaque minerals. The radioactivity associated with the quartz-feldspar specimen may be caused by thorium substituting in the zircon lattice.

Locality #11:

The elongated radioactivity anomaly at Locality #11 is in N½ of SE¼, sec.21. Striking roughly in an east-westerly direction, the length of the anomaly was not determined at the time for various reasons. A float specimen containing material similar to thorogummite in vein quartz was discover-

ed upon digging a shallow hole over the anomaly. Float rock having a moderate amount of radioactivity had peculiar characteristics not found in any other deposit. The rock was composed of varying bands of grayish-pink and greenish-black material, with veinlets of the green-black amphibole often cutting the former.

A sample of quartz-feldspar pegmatite float showing a wall contact of the pegmatite was also found over the anomaly. Acicular hornblende crystals grow inward from the wall contact. A thin-section of the quartz-feldspar pegmatite revealed the following minerals present:

Quartz	43%
Andesine	35%
Microcline	17%
Microperthite	minor
Hornblende	5%
Zircon	1%

The andesine occurs as small euhedral laths enclosed within microcline grains, sometimes ending rather abruptly against quartz grains. Acicular hornblende crystals are exceptionally profuse adjacent to and perpendicular to the pegmatite wall, but become negligible away from the wall contact.

Locality #12:

The radioactivity anomaly at Locality #12 is in the SW¼ of SE¼, SW¼, sec.22. Being relatively weak at the surface, and striking almost east-west, the anomaly is traceable for less than 50 feet. A trench dug four feet deep across the anomaly, but still in the residual soil, revealed a higher concentration of thorium-bearing nodules. The radioactive

mineral is thorogummite. Some of the nodules are at least one inch in diameter. Minute stringers of fibrous montmorillonite were noticed in a less altered radioactive rock specimen. This is similar to that seen in the radioactive mineral deposit at Locality #10. The host rock is greenstone.

Locality #13:

The deposits at Locality #13 consist of several quartz-zircon pegmatites in the NW¼ of sec.22. The pegmatites have an abnormal amount of radioactivity associated with them. For a more complete report on these deposits, see Turner (7, p.50) and Vickers (8, p.28, 37).

Locality #14:

The deposit at Locality #14 is in NE¼ of sec.22. Several trenches have been dug in coarse syenitic pegmatites, and Mr. Rader reported that he found occasional thorium mineral "blebs". However, no definite radioactivity anomaly or zone could be traced at the surface of the ground with a scintillation counter.

Specimens of rock found as float piled against a nearby fence were radioactive. They come from a zircon-bearing, quartz-rich pegmatite. Mr. Rader mentioned intersecting a radioactive quartz-bearing "vein" in the northernmost pit he dug.

X-ray studies disclosed the zircon in the quartz-zircon samples to be partly metamict. The host rock for the radioactive mineral-bearing pegmatites is pink syenite.

Locality #16:

A small cut in a road bank at the north boundary of NE¼, NW¼, sec.23, has revealed a radioactivity occurrence that has some features which are similar to the deposit at Locality #17. "Hot spots" can be detected on either side of the road, and if a line were drawnconnecting them, the line would have a north-south strike. It is uncertain if this is a continuous zone of a vein because of the thickness of the road bed material. It may be that these hot spots occur as small pockets or lenses. The radioactive body on the south side of the road is at least 3 to 4 inches thick. The radioactivity is concentrated along the boundary of a pink syenite and aplite contact. The radioactivity is contained within the orange-tan aplite body, one inch from a contact against pink syenite to the east. The presence of small fractures were probably the primary controlling factor of the radioactive fluids. A deep red-lavender color characterizes this zone. A heavy concentration of purple fluorite and pyrite also helps to distinguish the radioactive zone from the adjacent aplite.

Locality #18:

The radioactive mineral deposit exposed in the Titan Pit at Locality #18 is in the NE corner of NW¼, NW¼, sec.27. This was the first prospect opened in the search for uranium or thorium in the district. The pit is one of the few trenches which extend deep enough to expose solid bedrock, even though the vein itself is still in a weathered condition. The surface anomaly is rather spotty, but it can be traced for a dis-

tance of about 400 feet (Figure #6 in 8, p.42). The vein exposed in the pit strikes N85W, with a maximum dip of 56°NE. The thorium-bearing vein itself was under water at the time of examination, but its relationships to the wall rock showed the vein to be of a tabular, pinch & swell nature. Two major swells with a reported width of 3 inches and 5 inches were delimited by pinches of the vein less than ¼ inch wide at either end of the pit and also in the central part of the exposed vein along its strike.

The vein consists essentially of red mud and thorogummite. The host rock is a hard, massive greenstone. A syenitic dike can be seen on the hanging wall, but is missing on the footwall. One specimen of vein material contained fragments of the syenitic dike. Therefore, the conclusion may be drawn that faulting occurred post-syenite emplacement but pre-thorium mineralization.

An examination of some rock specimens obtained from the dump pile revealed the following features: one rock specimen showed a portion of the vein cutting the aphanitic-textured syenite dike with inclusions ofthe latter within the radioactive mineral vein. A rock specimen which showed a vein consisting mostly of purple fluorite, cut the greenstone host rock. A ½ inch bleached contact zone has developed in the greenstone adjacent to the fluorite vein. Coarse magnetite with good octahedral parting also developed adjacent to the contact. A microscopic examination of the fluorite vein specimen shows an unidentified thorium mineral to comprise 20% of the

fluorite vein, andesine from 10-15%, and chlorite about 5% of the fluorite vein. Small veinlets of hornblende cut the greenstone. The magnetite noticed in the hand specimen appears to be restricted to the adjacent greenstone host rock. It is not known if this vein is a part of the same vein containing the abundant thorogummite. One sample of vein material donated by Don Colby of Wausau, showed the vein having somewhat of a replacement-type texture similar to that observed at Jones' shaft. The thorium mineral is an opaque, resinous, rich red-brown color, identified as thorogummite by X-ray techniques. The X-ray patterns suggest no relationship to the unaltered thorium-bearing material from Jones' shaft, although the red-brown thorogummite may be formed from alteration of the unweathered amber-colored material. Such may be the case since thorogummite is found as nodules in the soil along the radioactivity anomaly over which Jones' shaft is situated. The radioactivity anomaly continues west-northwest into adjacent section 22. Nodules of therogummite-bearing vein quartz were found in the soil horizon over the anomaly.. This suggests that the replacement-type veins should not be classified separately from thorium-bearing quartz veins as was first believed.

Locality #19:

The deposit at Locality #19 is exposed in a "T"-shaped trench, dug by the former Titan Corporation, in SW¼, SW¼, sec.27. At least three small tabular veinlets averaging less than one inch thick are present in the trench. Vein gil rives

a surface anomaly east of the trench having a trend of N80E. An irregular dip exposed in the trench varies from 18-26°NW. The vein is one inch thick on the east wall of the trench. Close jointing or fracturing runs parallel to the plane of the vein. Vein #2 locally strikes N68W, dipping 22°NE. A modified pinch and swell type of vein is present, becoming 1/2 to 3/4 inch thick until it is abruptly terminated against a greenstone inclusion. The vein cannot be detected on the opposite side of the four foot long greenstone xenolith. Close jointing or fracturing is evident parallel to the strike of the vein. Vein #3 strikes N61W with a dip of 26°NE, and has a thickness of 1/4 to 3/8 inch thick. All the veins consist essentially of red mud, massive thorogummite, with some quartz.

The host rock is a "hybrid granite" with a few greenstone inclusions averaging 2-3 feet in diameter. Red hematite staining of the wall rock is very evident adjacent to the veins. A red-brown trachytic dike cuts the host rock in the trench. The dike is composed of 80% orthoclase, 10% biotite, and 10% magnetite. It strikes N34W and dips 46°NE. Much finer, gray-green chill zones are evident on both borders of the dike.

Thin-sections were made of the granite at the footwall of Vein #2 at distances of 12 inches, 6 inches, and at the footwall contact of the vein. The following observations were made as the vein was approached:

1) Less pronounced secondary growth of feldspars.
2) Decrease in size of mafic grains as heavily hema-

tized zone is approached.
3) Change from green-colored biotite to orange-brown colored biotite.
4) Very large increase in hematite particles; especially within one inch of the vein.
5) Many small shears or fractures parallel to the vein, and some are filled with quartz.
6) Absence of sphene and apatite, although this may be just a local absence.

Locality #20:

A deposit at Locality #20 is found in the SE corner of sec.27. The radioactivity anomaly trends N85E, and is traceable for 400 feet. 225 feet of the anomaly has a radiometric count of over two times background. A shallow two-foot deep trench produced a thorogummite nodule with a minimum diameter of one inch.

Locality #21:

A small radioactivity anomaly at Locality #21 is on the west side of SW¼, NW¼, sec.27. It is located about 15 feet southwest of a rock pile, and can be traced for 60 feet. The rock pile shows the host rock to be greenstone, but no thorium-bearing rock samples were found.

Locality #22:

A series of anomalies are found at Locality #22 in SW¼, SE¼, and the SE¼, SW¼, sec.28. At least two separate anomalies are apparent. One anomaly is traceable for over 1500 feet, and is possibly much longer if an anomaly west-northwest of this occurrence is a continuation of the same vein. The anomaly, having a N75E trend, swings to N60E in the eastern portion, aligning itself just east of two elm trees at the

north fence of the SW¼ of SE¼, where another anomaly is detected. At places, the 1500 feet anomaly is 70 to 80 feet wide, but usually it is much narrower. Most of its length is at least two times background, and commonly it is over five times background. A shallow hole dug near a drill hole site, about 100 feet east of the north-south ½-mile fence, gives an extremely high radioactivity count. This would be expected upon removal of some of the residual soil. Eighty to ninety feet south of the 1500 foot anomaly is another s smaller anomaly, locally having counts of three times background. It can be traced for a couple of hundred feet, running parallel to the larger anomaly. "nother possible anomaly is about 80 feet farther south of the second anomaly. This third anomaly is also parallel in strike to the large anomaly. The vein mustoccur along a fault or shear zone. This is indicated by a badly sheared, mylonitic, gray-green rock specimen found in a shallow hole dug in the radioactivity anomaly. The host rock is a gray granite, much fresher or purer in appearance than the "hybrid granite" at Locality #20.

A large thorogummite nodule with minor intermixed quartz was found in the residual soil. The smallest diameter of the nodule was 1½ inches. Another specimen of massive vein quartz with minor thorium mineral had a minimum width of 2½ inches. A petrographic study of a thorogummite nodule revealed the following information:

Quartz ---------- 55-60%
Zircon (altered) ---------- 15-20%
Hematite and thorogummite ----- 25%
Magnetite (?) ---------- 2-3%
Talc/montmorillonite -------- trace.

The quartz grains have a mosaic pattern, with nonundulatory extinction. Fractures radiate outward from opaque thorogummite grains into the quartz grains.

Locality #23:

The radioactive mineral deposit at Locality #23 was discovered by Elmer Rader at the eastside of SE¼, NW¼, sec.28. The general strike of the elongate anomaly is N75-80E, trending more northeasterly near the eastern part of the anomaly. The anomaly can be traced at least 375 feet west of the north-south ½-mile section fence before being lost under a swamp. East of the ½-mile section fence, the anomaly extends for at least 60-70 feet. The radioactivity anomaly is not exceptionally strong. A small outcrop by a logging road 300 feet west of the fence is composed of gray granite. Samples of the radioactive rock show small, bright red, irridescent globules disseminated throughout the granite host rock. Some of the feldspar grains are heavily altered to a fine granular texture, and having a dark red color. No true vein was noted, but it was rather a zone in which the dark red globules replaced part of the granitic mineral constituents. Hand samples revealed the rock has many mylonitized planes, indicating that the rock was sheared. The radioactive globules were disclosed by X-ray powder methods to be thorogummite. The thorogummite and other radioactive minerals were probably

introduced after shearing of the granite host rock had provided channelways for the radioactive mineral-bearing solutions introduced hydrothermally.