UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

PRELIMINARY REPORT ON RADIOACTIVITY OF SOME NORTH CAROLINA PEGMATITES

by

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Trace Elements Program

Radioactivity of some North Carolina Pegmatites

Preliminary Report

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A Geological Survey party consisting of A. L. Slaughter and S. E. Clabaugh spent one week during July 1944 in western North Carolina testing some of the Pegmatites and one Kyanite mine of that region for radioactive minerals. A more extensive reconnaissance to determine the radioactivity of black shales in the Eastern states was also undertaken during the summer of 1944, and the results are described in a separate preliminary report. Principal interest was in uranium and to a lesser extent in thorium. The work was done as part of the "Trace Elements" program under the direction of W. W. Rubey.

Richard H. Jahns of the Geological Survey and members of field parties engaged in studies of mica-bearing pegmatites under his supervision were very helpful in guiding to pegmatites known to contain radioactive minerals and to other pegmatites of possible interest. Mines and prospects examined during the course of the present investigation are shown on the index map, figure 1.

A few pegmatite mines in the Spruce Pine district are well known for occurrences of radioactive minerals, but these occurrences have never been of commercial importance. The present investigation was prompted by the possibility that large pegmatite bodies might contain disseminated radioactive materials in such quantities that uranium or thorium could be produced from them. Mines and prospects in the Spruce Pine and Franklin districts are numbered in the hundreds, and it was impossible to visit more than a few.

Field methods

A Geiger-Müller counter, which measures the gamma ray emission of radioactive substances, was used to test the pegmatites. The general technique was similar to the method of testing radioactive black shales, which is described in the preliminary report on a reconnaissance of black shales of the Eastern states. Brief preliminary counts were made with the counter tube placed at intervals along the walls of open cuts and underground workings and on dumps. These readings gave a crude relative measure of the radioactivity, and they were used as a guide in selecting the most promising rock for sampling. These preliminary counts on many dumps and in many mine workings were so low that sampling and more accurate determinations seemed unnecessary.

Samples from the more promising occurrences were crushed to about 4-mesh size, and about 500 grams of each sample was placed in a brass sample container and tested as follows: Two or three five-minute counts were made with the counter tube surrounded by the sample. Counts thus obtained are a combination of "clicks" or electrical discharges caused by gamma rays from the sample and of discharges caused by an ever-present but varying "back-ground" of cosmic rays. Before and after each sample count, a five-minute background count was made with the tube removed from the influence of the sample. A true count is then obtained by subtracting the average background count from the average sample count. The true count is calibrated approximately by readings on material of known uranium content. The true count of an unknown sample can thus be converted into an equivalent uranium content (the amount of uranium in equilibrium with its disintegration products that would yield the same gamma-ray activity).

The following is given as an example of field determinations:

Sample No.	Bg. count	Samp. count	Bg. count	Samp. count	Bg. count	Avg. Bg.	Avg. Samp.	True count	Equivalent Uranium(%)
B106-141	9	20	10	15	11	10	17.5	7.5	.0075

Counting interval is five minutes.
The factor for converting true five-minute count to percent equivalent uranium was found to be approximately .001.

Accuracy of field methods

Part of the activity of some of the samples is probably attributable to thorium and its disintegration products and to radioactive potassium, with the result that the amount of uranium in a sample may be considerably less than is indicated by the "equivalent uranium" content. On the other hand, the assumption of radioactive equilibrium probably tends to underestimate the amount of uranium in some samples, because more soluble radioactive products may have been removed from the rocks by circulating ground waters and because some radon gas may escape from the samples when they are crushed for testing.

Several sample and background counts are desirable in order to reduce the effect of random variations in the intensity of cosmic ray bombardment and of gamma ray emission from radioactive material. The true counts, or the differences between background counts and sample counts, vary according to statistical laws, and the reliability of the average difference between these counts can thus be stated in terms of the probable error of the mean of a series of observations:

$$\text{Probable error} = 0.6745 \sqrt{\frac{X_1^2 + X_2^2 + \ldots\ldots X_n^2}{n(n-1)}}$$

where X_1, X_2, and X_n are the differences between individual determinations and the average of a group of n determinations.

For the example given on the preceding page, the probable error in the true count is as follows:

Sample No.	True count	Probable error	Percentage probable error
S106-141	7.5	±0.8	11

The percentage probable error in the true count for many samples is greater than for the example given. The equivalent uranium content determined by field counts for samples S106-141, S106-143, S107-145, S107-150, and S107-151 may be expected to show larger errors, for each is based on one five-minute sample count. The probable error can be reduced by increasing the time of counting, but the procedure adopted for the present field investigation is considered sufficiently accurate for the detection of any sizeable body of radioactive rock.

In the table that follows chemical analyses and gamma ray measurements made in the Washington laboratories of the Geological Survey are tabulated for comparison with the field counts on crushed samples. Methods and accuracy of the uranium analyses are discussed in a report now being prepared in the Section of Chemistry and Physics of the Geological Survey. In all samples the uranium content determined by chemical methods is lower than the equivalent uranium content estimated from Geiger counts, and in several samples, it is so much lower that the presence of other radioactive elements such as thorium seems clearly indicated.

Samples analyzed for uranium

Sample No.	Uranium determined by chemical analysis In percent	Equivalent uranium determined by gamma ray counts of crushed sample In percent	
		Laboratory counts	Field counts
S106-139	----	.506	----
-140	.003	.010	.012
-141	.003	.010	.008
-142	.003	.007	----
-143	----	.003	.003
-144	----	.005	.010
S107-145	----	.004	----
-146	.005	.032	.042
-147	.006	.028	.048
-148	.003	.012	.052
-149	.004	.030	.036
-150	.002	.029	.023
-151	.003	.009	.014
-152	----	.007	.002

Mines examined

Six pegmatite mines in the Spruce Pine district and five in the Franklin district were examined briefly. Another, the Jones zircon pegmatite mine, is in Henderson County, east of the Franklin district. The Yancey Cyanite mine is in a body of metamorphic rock on the west margin of the Spruce Pine district. The locations of these mines are shown on the index map (fig. 1).

Pegmatites of the Spruce Pine district have been described by Kesler and Olson[1], and by these and other workers in more recent unpublished reports

[1] Kesler, T. L. and Olson, J. C., Muscovite in the Spruce Pine district, North Carolina: U. S. Geol. Survey, Bull. 936-A, 1942.

of the Geological Survey. Mines tested for radioactive material are discussed briefly in the paragraphs that follow. The first six are in the Spruce Pine district.

Flat Rock mine.--The Flat Rock mine, which is a well known locality for the occurrence of several uranium minerals, is not now in operation. A number of preliminary readings made on the dumps and along the walls of the mine workings there gave counts of 2 to 3 per minute, indicating that little or no radioactive material is present. High counts were obtained at one point along the wall, and a small crystal of uraninite was found about two inches below the surface. The rock adjacent to this crystal was stained with yellow alteration products from the uraninite. Laboratory counts of a sample (S106-139) from the stained enclosing rock indicate that it contains .606 percent equivalent uranium. This relatively high uranium content is of no significance as the quantity involved is exceedingly small.

Fannie Gouge mine.--The mine is inactive and the workings are filled with water. A few small pieces of uraninite and autunite were found on the dump. The dump contains about 2500 tons of rock, and preliminary counts at scattered points over the dump ranged from 3 to 17 per minute. Sample S106-140 is a grab sample from the dump at the point where the count of 17 per minute was recorded. Both this sample and another grab sample from the dump (S106-141) contain .003 percent uranium by chemical analysis.

McKinney mine.--The McKinney mine produces feldspar and scrap mica, and the open-cut workings are extensive. Miners had recently sorted out a boxful of samarskite, but no radioactive minerals were observed in place. Preliminary counts made along walls of the pits averaged about 7 per minute. A grab sample of broken feldspar (S106-142) contains .003 percent uranium by chemical analysis, and a grab sample from a pile of scrap mica (S106-143) contains .003 percent equivalent uranium as determined by laboratory counts.

Tantrough mine.--The Tantrough mine is a small, operating mica mine. Preliminary counts on the dump were low, 2 to 4 per minute, and no samples were taken.

Wiseman and Pink mines.--The Wiseman and Pink mines are two inactive feldspar mines in the same area. On dumps and in underground workings of these mines preliminary counts ranged from 2 to 6 per minute. No samples were taken.

Mines in the Franklin district.--In the Franklin district the following mica mines were examined briefly:

Big Terrapin mine

Ridge mine

New Wolfe mine

John Long No. 2 mine

Berry mine

Preliminary counts on dumps and along walls of workings at these mines were at no places greater than 8 per minute, and the average was less than 5 per minute, indicating a very low content of radioactive elements. No samples were taken.

Yancey Cyanite mine. --The Yancey Cyanite mine, which ceased operation in the winter of 1943-1944, produced kyanite, garnet, and scrap mica from large reserves of kyanite-bearing metamorphic rock in which pegmatite stringers are rare and unimportant. When operating, the company handles between 300 and 400 tons of crude ore per day. The mine is described in considerable detail in an unpublished report by M. R. Chute of the Geological Survey.

Samples collected by a Geological Survey party in 1943 from the Yancey Cyanite mine and mill in a search for a number of rare and uncommon metals were later tested for radioactivity. Laboratory Geiger counts indicated the following:

Sample 1, Kyanite concentrate, not radioactive.

Sample 2, coarse garnet concentrate, not radioactive.

Sample 3, fine garnet concentrate, .023 percent equivalent uranium.

Sample 4, flotation tails, .002 percent equivalent uranium

Sample 5, magnetic separator rejects, .004 percent equivalent uranium.

Sample 6, crude ore, .003 percent equivalent uranium.

The fine garnet concentrate (sample 3) probably contains fine sulfides and some chromite. A sample of impure fine garnet concentrate (B106-144) collected from the mill in July 1944 contained only .006 percent equivalent uranium by laboratory Geiger count.

Preliminary counts made along the walls of open cuts and underground workings ranged from 4 to 9 per minute, indicating a very low and rather uniform content of radioactive materials. These radioactive materials are concentrated in the fine garnet fraction (sample 3) during milling. Therefore it is possible that a uranium-or thorium-bearing concentrate may be obtained as a by-product of any future kyanite production from this deposit.

Jones zircon pegmatite mine. --The Jones zircon pegmatite is located east of the Franklin district and south of the Spruce Pine district, near Hendersonville, North Carolina (fig. 1). The mine is one mile south of Zirconia and 0.4 miles east of U. S. Highway 25 in Henderson County.

The mine is now being operated for feldspar, but zircon was mined from weathered parts of the pegmatite in former years.

The pegmatite consists of a prominent central zone of light colored minerals, from which feldspar is mined. This central zone is surrounded by ill-defined zones in which smaller stringers and masses of pegmatite penetrate darker layers of vermiculite-rich rock. The pegmatite consists mostly of pink microcline which is thoroughly kaolinized near the surface. Zircon is present in small crystals, and much of the dark vermiculite-rich rock contains an abundance of yellow titanium oxides which have replaced sphene crystals. Polycrase, monazite, and a number of other minerals have been reported from the pegmatite.

The accompanying sketch map (fig. 2) shows the location of samples taken at the Jones mine. Also shown are preliminary counts made with the Geiger counter at numerous points in the pegmatite area. Chemical analyses are given in the table on page 5, and the samples are described briefly as follows:

S107-145, .004 percent equivalent uranium by laboratory count; channel sample taken horizontally 20 inches along face of cut. The sample consists largely of feldspar.

S107-146, .005 percent uranium by chemical analysis; grab sample from small dump.

S107-147, .006 percent uranium by chemical analysis; chip sample from light colored layers of rock in old adit. The sample consists largely of feldspar with some vermiculite and titanium oxides.

S107-148, .003 percent uranium by chemical analysis; chip sample from dark colored layers of rock in old adit. The sample consists largely of vermiculite with some feldspar and titanium oxides.

S107-149, .004 percent uranium by chemical analysis; sample chipped across dark and light bands of rock (7 foot channel sample) in old adit.

S107-150, .002 percent uranium by chemical analysis; vertical channel sample from 1.4 feet of dark reddish-brown rock in face of new cut. The sample contains abundant vermiculite and yellow titanium oxides.

S107-151, .003 percent uranium by chemical analysis; vertical channel sample from 4.5 feet directly below S107-150. The sample consists largely of feldspar with some vermiculite and titanium oxides.

S107-152, .007 percent equivalent uranium by laboratory count; grab sample from small dump.

The radioactivity of samples S107-146,-147,-149, and -150 measured in the laboratory and expressed as equivalent uranium is about 4 to 14 times greater than the uranium content found by chemical analysis. It is almost certain that other radioactive elements, probably thorium and its disintegration products, contribute most of the effect. Work is now in progress in the chemical laboratory of the Geological Survey to determine the quantity of thorium present.

Conclusions

None of the pegmatites examined in the Spruce Pine and Franklin districts of North Carolina showed sufficient radioactivity throughout the mine workings or dumps to encourage hope that these districts might be an important source of radioactive elements. Apparently the uranium-bearing minerals, for which the Spruce Pine district is well known, occur only in insignificant quantities.

The Yancey Cyanite mine may possibly be a source of uranium-or thorium-bearing minerals that could be recovered as a by-product in future operations aimed primarily at Kyanite production. This possibility cannot be evaluated adequately without further mineralogic studies and chemical analyses of samples from the deposit and the mill.

The Jones zircon pegmatite may be a possible source of thorium, but this possibility must be checked first by chemical determinations of thorium and then by further investigation of the size of the deposit.

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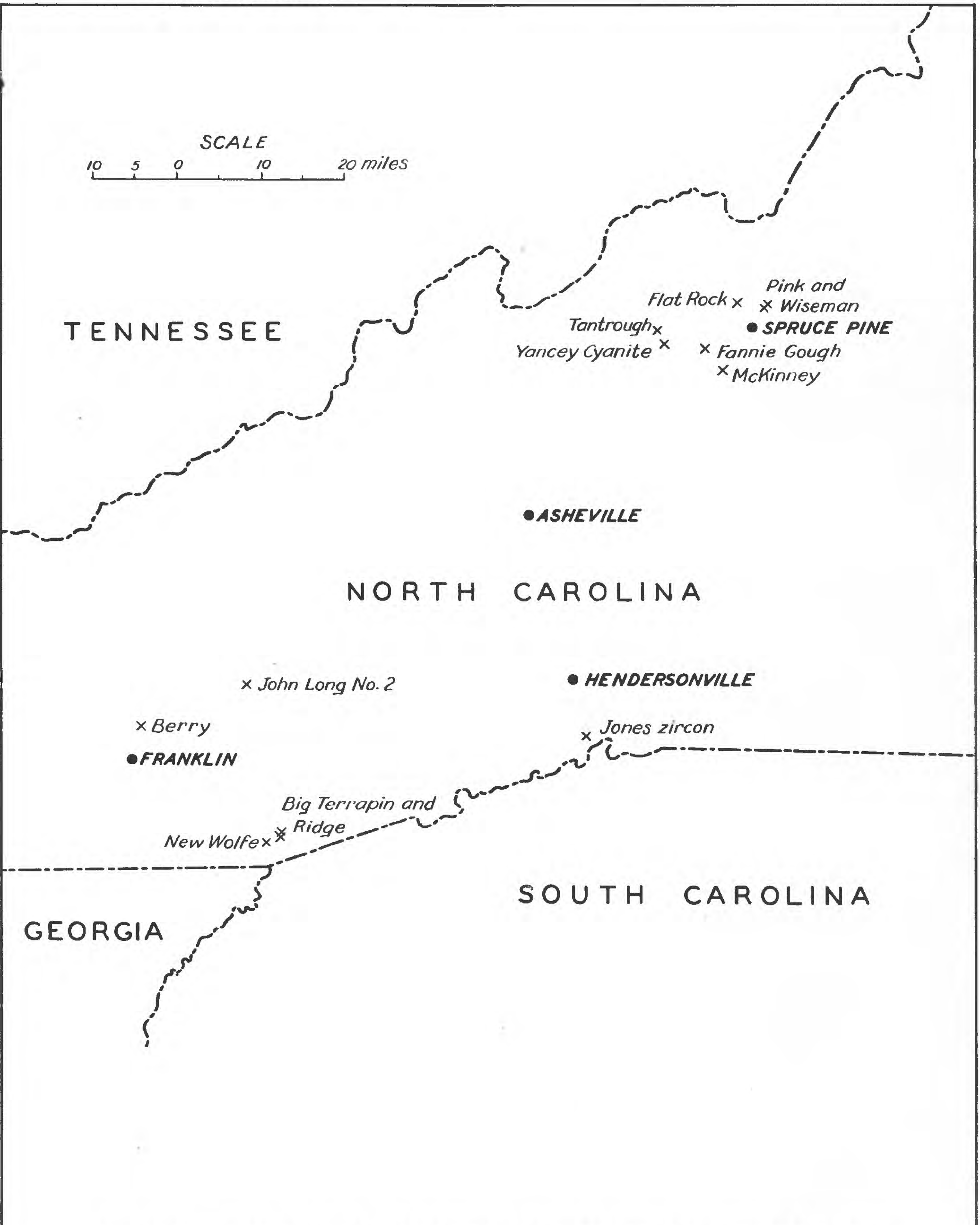

FIGURE 1. – INDEX MAP OF WESTERN NORTH CAROLINA SHOWING LOCATION OF MINES TESTED FOR RADIOACTIVE MATERIALS

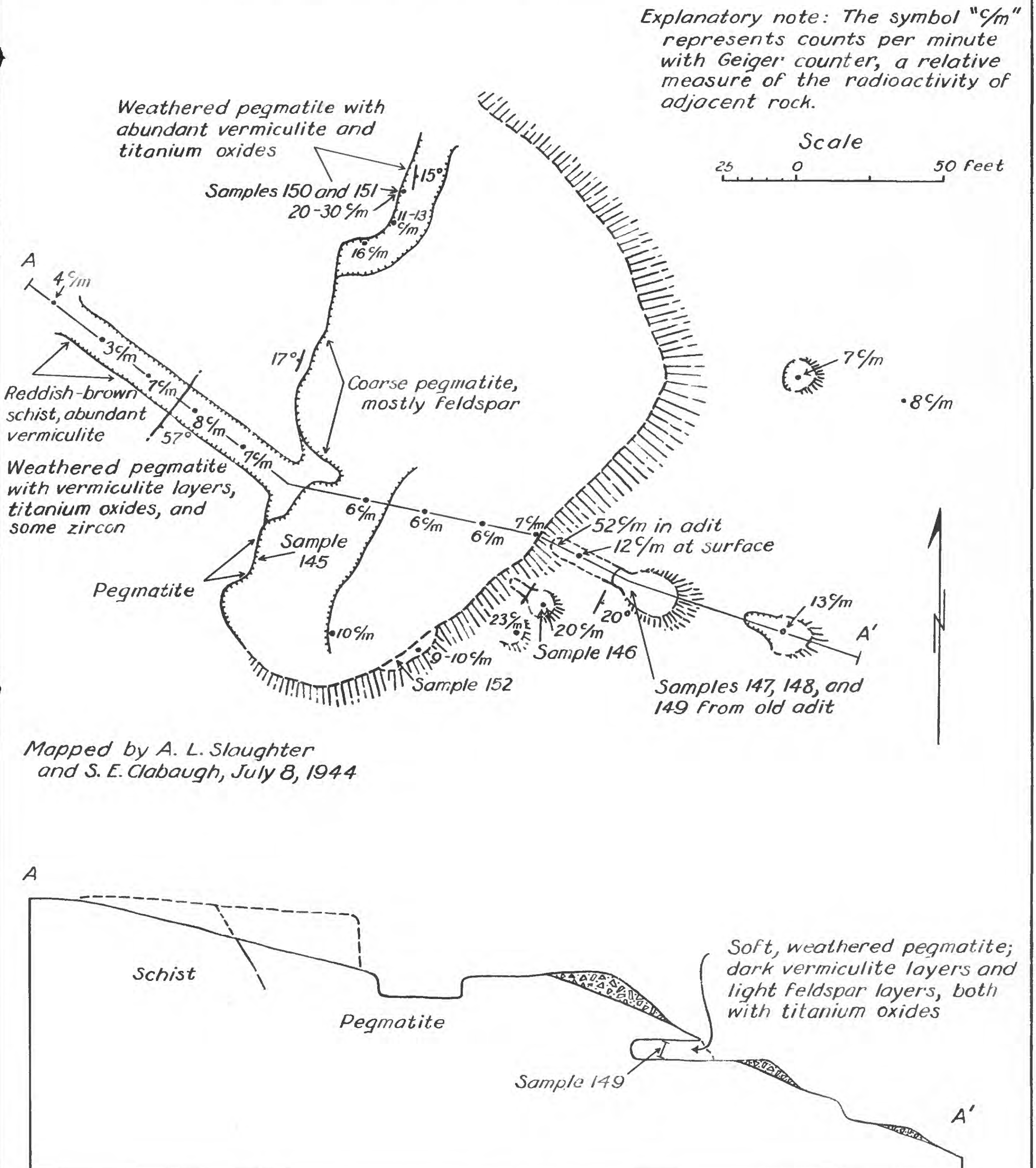

FIGURE 2.–SKETCH MAP AND GENERALIZED CROSS SECTION OF THE JONES ZIRCON PEGMATITE MINE