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DEPARTMENT OF MINES AND TECHNICAL SURVEYS
MINES BRANCH

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by

F. E. Senftle, C. McMahon, and G. G. Eichholz .
RADIOACTIVITY DIVISION

Price 50 cents

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ABSTRACT

Simple apparatus for the radiometric assaying of radioactive ores in the field and in mill assay offices is described. The use of portable and line-operated ratemeters is illustrated and the choice of suitable Geiger tubes and equipment discussed. Practical procedure for beta and gamma assaying is outlined and factors determining the sensitivity of the unit are explained.

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DETERMINATION OF URANIUM IN ORES BY FIELD ANALYSIS

PART I

by

F. E. Senftle and C. McMahon

INTRODUCTION

The usual laboratory methods of uranium analysis are either tedious, time-consuming chemical procedures or elaborate physical methods requiring sensitive equipment. There is thus an urgent need for a method of estimating by approximate analysis the uranium content of ore samples in the field. A rough field analysis is eminently practicable to the mining engineer who must make on-the-spot ore assays. When a new property is being developed it is desirable to know the uranium content of channel samples in order to guide the diamond drilling and digging operations. Prospectors, too, require approximate analyses of their hand specimens to evaluate their discoveries.

To satisfy the demand for these types of analyses, several field procedures have been tried. Two general plans can be followed. One is fast but will yield only a rough estimate. The other is slightly longer but will give an assay probably within 10 per cent of the true value if done carefully.

For field operation it is necessary to strip the more accurate laboratory methods of analysis of all refinements because of the limited equipment and skilled techniques involved. Most of the

corrections normally used, with the exception of that for equilibrium, will not alter the gross analysis to any extent.

When uranium atoms in a mineral disintegrate, they break down into other radioactive elements and eventually the number of elements being formed is equal to the number breaking up. The ore is then said to be in equilibrium. Certain geological processes, however, such as natural leaching, sometimes remove some of these elements selectively and hence reduce the radioactivity of the ore sample. The ore is then said to be out of equilibrium. The field analysis may then be in error by as much as 50 per cent since the apparatus is calibrated with standards that are in equilibrium. However such a large error due to loss of equilibrium is the exception, and in most cases uncorrected field types of analysis are justified.

The field counter reacts to thorium as well as uranium, and the total activity of the sample may be due to both elements. However, the analyses given in the following methods are in terms of per cent U_3O_8 equivalent, that is, that amount of U_3O_8 which would account for the total radioactivity of the sample if possible thorium contributions are disregarded.

EQUIPMENT

The equipment required is simple. For field work it is assumed that there is no source of electric power, and accordingly

only portable counters are considered. To measure the activity of a wide range of samples, the counter should be of a sensitive design and be constructed with a ratemeter. The more simple, earphone type of counter, although better for prospecting, is too limited in its usefulness for field assay, and is not recommended.

The ratemeter type counter used in tests of the field extimate and field assay methods is shown in Fig. 1. It is a commercial type designed after the National Research Council type GP-19. It contains three Geiger tubes and the ratemeter is sufficiently stable to make reasonably accurate analyses. Any good commercial type with similar characteristics can be used with equal success. *

As shown in Fig. 2, the carrying case is removed and the counter unit (A) is mounted on a box (B) fitted with a removable shelf (C). The top of the box has been cut away so that the bottom of the counter is exposed to the inside. The shelf rests on two runners and can be placed either two inches or five inches from the bottom of the counter case. This enables one to handle very high-grade samples without overloading the counter.

Other equipment consists of a suitable set of standards, standard ore trays (D), an iron mortar (E), pestle (F), a simple scale (G), a screen (H) (about 35 mesh), and a rock sledge hammer.

*Note added on revision: The instrument shown is now obsolete. For a list of currently available instruments refer to Report TR-126/55 obtainable from the Geological Survey of Canada or from the Mines Branch, Ottawa. Considerations governing the choice of a suitable instrument are discussed in Part II of this publication.

A suitable type of mortar consists of a heavy steel anvil 2 1/2" deep and 5" diameter. A 2" diameter round recess is cut 1/4" deep in the centre of the upper surface to hold a 1/8" thick steel tube 5" long. Small chips of rock can be easily pulverized by a flat-end pestle in such a mortar.

Particular care should be exercised in choosing standards. They should be analyzed by the more accurate laboratory methods, and it is recommended that from two to four standards be used covering a range up to about 6 per cent U_3O_8. Standards of about 0.1, 0.5, 1.0, and 6.0 per cent U_3O_8 are suitable. Standards should be natural, not synthetic, i.e., they should not be made by diluting an active rock with some inert pulp. In such mixtures the heavier uranium particles tend to separate out over a period of time, especially with the rough handling received in the field. A single type of ore pulp, although not entirely free from this source of error, is relatively free from serious segregation. In either case standards should be checked frequently to note any increase in activity when in an up-side-down position. The specimen to be used for the standard should be ground to pass a 35-mesh screen, analyzed by a good laboratory method, and sealed in tight metal containers to prevent loss of the pulp. The two boxes used to hold the standards in these tests measured 6" x 3" x 1 1/2" for standards up to 2.0 per cent, and 3" x 1 1/2" x 3/4" for standards from 2.0 to 10.0 per cent.

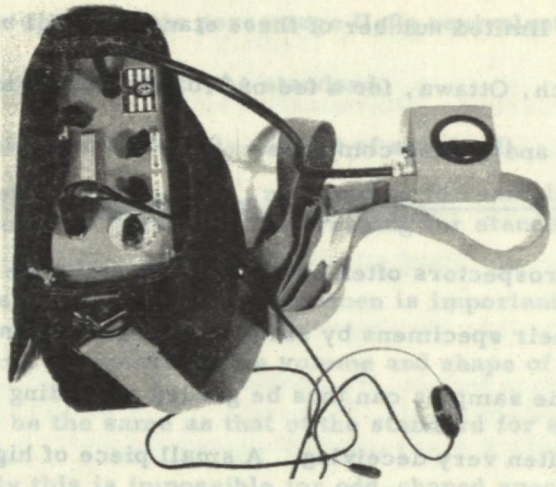

Fig. 1 - Ratemeter - type counter.

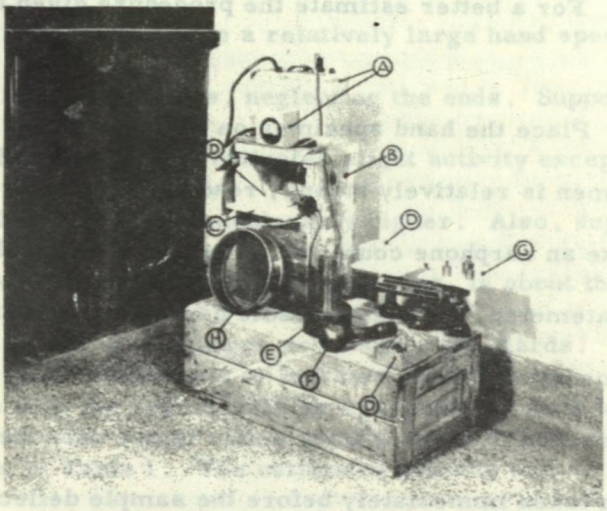

Fig. 2 - Arrangement of equipment

A - Geiger ratemeter
B - Sample box
C - Removable shelf
D - Sample and standard trays
E - Mortar
F - Pestle
G - Scale
H - Screen

A limited number of these standards will be sold by the Mines Branch, Ottawa, for a fee of $10.00 to bona fide Canadian prospectors and mining companies.

FIELD ESTIMATE METHOD

Prospectors often obtain a rough estimate of the radioactivity content of their specimens by simply holding them under the Geiger counter. The samples can thus be graded according to their activity, but this is often very deceiving. A small piece of high-grade pitchblende on a corner of the specimen may show more activity than a lower grade of ore, although the latter may actually contain more uranium. For a better estimate the procedure given below is recommended.

Place the hand specimen on the shelf under the counter. If the specimen is relatively strong, read the ratemeter deflection; if weak, take an earphone count over a period of several minutes. When using a ratemeter, the meter needle does not return to the background level immediately on the removal of a specimen from under the counter. For this reason it is sometimes better to use only the background deflection taken immediately before the sample deflection or to wait several minutes for the meter needle to return to the true background level, (See method used in Table 1). After subtracting the background readings, record the deflection or counts per minute for each of the several sides of the specimen. Average the net readings and weigh

the sample. The approximate percentage U_3O_8 equivalent may then be obtained by comparison with the standard.

Thus % U_3O_8 equivalent = (% U_3O_8 content of standard) x

$$\frac{\text{weight of standard}}{\text{weight of sample}} \times \frac{\text{net reading for sample}}{\text{net reading for standard}}$$

Choice of the size of the specimen is important for the best results. Strictly speaking, the volume and shape of the unknown specimen should be the same as that of the standard for an accurate assay. Obviously this is impossible for odd-shaped specimens, but the specimen can be chipped down with a hammer to approximate the size and shape of the standard.

Consider for example a relatively large hand specimen having roughly four large sides, neglecting the ends. Suppose that a quick check under the counter indicates slight activity except at one corner where the activity is considerably higher. Also, suppose that the specimen, with a slight amount of trimming, is about the same size and shape as one of the larger and weaker standards. Readings should be taken with the appropriate backgrounds for each of the four sides, as shown in Table I. The estimated activity will be that of the specimen as a whole. To get the U_3O_8 equivalent content of the active corner, the specimen should be broken down to the size of one of the smaller and more active standards, and a separate estimate should be made on the active portion. It is apparent that the procedure to be followed will depend upon the specimen and can be altered somewhat

(Cont'd on page 9)

TABLE I

Example of Uranium Determination by the Field Estimate Method

Steps		
1.	Sample - Hand specimen having roughly 4 sides	
	Preliminary Data	
2.	Sample weight, W_x grams	248
3.	Standard weight, W_s grams	503
4.	Standard grade, C_s % U_3O_8 equiv.	1.37
	Experimental Determinations*	
5.	Background activity	7.5
6.	Standard activity (total)	27.0
7.	Background activity	6.0
8.	Net Standard activity, (6 minus average of 5 and 7)	20.3
9.	Side #1 of unknown specimen	11.0
10.	Side #2 of unknown specimen	12.5
11.	Background activity**	5.5
12.	Side #3 of unknown specimen	11.0
13.	Side #4 of unknown specimen	9.5
14.	Background activity**	5.5
15.	Standard activity (total)	27.5
16.	Background activity**	6.0
17.	Net Standard activity, (15 minus av. of 14 and 16)	21.8
18.	Average of 8 and 17, N_s	21.0
19.	Net specimen activity, N_x, (av. of 9, 10, 12, 13 minus av. of 7, 11, 14)	5.3
	Calculation	
20.	% U_3O_8 equiv., $C_x = \frac{C_s \cdot W_s \cdot N_x}{W_x \cdot N_s} = \frac{1.37 \times 503 \times 5.3}{248 \times 21.0}$ =	0.70
	Accuracy	
21.	Laboratory assay, % U_3O_8 equivalent	0.56
22.	Deviation, per cent	25

*Activity in divisions on the ratemeter at distance of 2"

**Reading taken several minutes after previous one in order to allow the ratemeter to adjust itself to true background.

to fit the circumstances.

As this method is only approximate much care should be taken when comparison is made with the standard and in positioning the specimen similarly to the standard. Since the specimen is not crushed, this method is used mostly with screening samples and drill cores where only the order of the magnitude of the U_3O_8 content is necessary.

FIELD ASSAY METHOD

The sample to be analyzed should be roughly crushed with a field hammer and then further reduced to 35-mesh or smaller in the mortar. If the sample is known by its effect on the Geiger counter to be relatively weak, sufficient should be pulverized to fill a large tray. Smaller amounts of the more active samples may be used with smaller trays. In all cases the sample trays should be covered with a flat piece of sheet metal of the same gauge as that in the trays to reproduce similar absorption conditions as are present in the sealed standard trays.

The unknown sample must be placed in trays of the same shape and volume as that holding the standard with which it is compared. With a little experience an operator can quickly estimate the size of tray necessary for an analysis by holding the uncrushed specimen under the counter for a brief period. It is advantageous to choose a standard, and hence the corresponding tray, that will give the same

order of deflection or counts as that of the unknown sample. Thus, for the greatest accuracy, a sample of 650 grams giving a deflection of 10 divisions should not be compared with a 150-gram standard giving a deflection of 50 divisions, but rather with say, a 500-gram standard that will give the same order of deflection or count.

The measuring procedure to be followed should be similar to the field estimate method described above, but more care should be taken to insure that all readings are taken in a similar manner. It is important that the instrument be at least 50 feet from any ore bag or other active material. If possible, the Geiger counter should be shielded with 2" thick lead bricks (not shown in the picture), although this is essential only for very weak samples. Lead shielding will reduce the background count and increase the relative sensitivity of the the instrument.

One serious difficulty with portable instruments of this type is the change in sensitivity with time. To obviate this difficulty it is absolutely necessary to standardize the instrument before and after each sample determination. The sequence of the determinations should be in this order -- background, standard, background, unknown sample, background, standard, and background. Since the ratemeter action depends upon the charging and discharging of a condenser, sufficient time should elapse after the standard and sample determination to insure a true background reading. Some counters are supplied

(Cont'd on page 12)

TABLE II

Example of Uranium Determination by the Field Assay Method

Steps		Deflection Method		Count Method
		A	B	C
1.	Sample number	2	4	4
	Preliminary Data			
2.	Sample weight, W_x grams	150.0	533.0	533.0
3.	Standard weight, W_s grams	108.7	503.3	503.3
4.	Standard strength, C_s $\%U_3O_8$ equiv.	5.96	1.37	1.37
	Experimental Determinations*			
5.	Background activity	5.0	10.3	23.0
6.	Standard activity	14.3	33.3	88.0
7.	Background activity	4.0	11.0	21.5
8.	Net standard activity, (6 minus av. of 5 and 7)	9.8	22.7	65.8
9.	Unknown sample	28.5	15.4	34.5
10.	Background activity	4.3	11.0	20.5
11.	Net sample activity, N_x, (9 minus av. of 7 and 10)	24.3	4.4	13.5
12.	Standard activity	15.3	31.8	76.5
13.	Background activity	5.3	11.0	18.5
14.	Net standard activity, (12 minus av. of 10 and 13)	10.5	20.8	57.0
15.	Average of #8 and #14, N_s	10.1	21.7	61.4
	Calculation			
16.	$\%\ U_3O_8$ equiv., $C_x = \frac{C_s \cdot W_s \cdot N_x}{W_x \cdot N_s}$ =	10.4	0.26	0.28
	Accuracy			
17.	Laboratory assay, $\%\ U_3O_8$ equiv.	10.3	0.30	0.30
18.	Deviation, per cent	1	13	6.7

*Columns A and B in ratemeter divisions; column C in counts per minute.
Column A: Standard and sample, 5 inches from counter
Columns B and C: Standard and sample, 2 inches from counter.

with a shorting key to discharge the condenser and thus bring the meter back to zero. This key should not be used when the greatest possible accuracy is desired.

To show the proper procedure more clearly, the results of several samples are given in Table II . The final result is calculated from the same formula used in the field estimate method (p.7). To obtain enough counts to operate the ratemeter with weak samples it is sometimes necessary to raise the voltage on the Geiger tubes. This effect can be seen in Table II , column B, where the background deflection in about twice that in column A for a stronger sample.

It should be emphasized that unless the above methods are used with care, the analysis may involve a very large error. For ores containing over one per cent U_3O_8 equivalent an accuracy within 10 per cent of the true value can be expected provided the apparatus is properly standardized and the procedure regulated. For ores between one per cent and 0.1 per cent, an accuracy within 20 per cent of the true value should be obtained.

PART II

ROUTINE RADIOMETRIC ANALYSIS FOR URANIUM IN ORES

by

G. G. Eichholz

INTRODUCTION

The routine testing of radioactive ores in mills and assay offices requires a method of assaying that is quick and simple to perform and relatively accurate. It is thus intermediate between purely qualitative field determinations as described in Part I and the more precise radiometric determinations by the beta-gamma (equilibrium) method.[1] If it can be assumed that the ore is in equilibrium, or at least that the ratio of beta to gamma equivalents does not vary very much for the mine ore handled, then a method based on determining either the gamma or the beta equivalent only will be found satisfactory. This leads to a considerable simplication in equipment and some saving in time compared with the more precise equilibrium method. It then frequently becomes possible to obtain the uranium equivalent directly by suitable marking of a meter scale or by the use of a graph.

The methods and procedure outlined here are by no means new or original, but it is felt that a summary of them would be useful to those interested in quick and simple methods of analysis. The

methods discussed are intended primarily for small mills and for field determinations. For larger assay offices and for precise determinatio of uranium content, the beta-gamma (equilibrium) method is always recommended.

METHOD AND EQUIPMENT

The essential feature of any radiometric assay method is the placing of a known, and preferably constant, amount of the sample in a precisely reproducible position with respect to a radiation detector By interchanging the unknown sample with a known uranium standard sample of comparable weight and condition the detector can be calibrated and the uranium content estimated. Uranium and thorium both emit beta and gamma radiations of similar character and a method depending on detecting only one of the radiations cannot discriminate between the two elements. For that reason the term "uranium equivalent" is used to describe the result obtained; more detailed tests to determine possible thorium content or any dis-equilibrium of the uranium in the ore would have to be done by means of a beta-gamma (equilibrium) counter or by chemical methods. However, in a large number of cases knowledge of the beta or gamma equivalent is all that is required.

In most such cases there would be no point in aiming for the ultimate in sensitivity and hence a good Geiger tube will usually be adequate. A Geiger tube is considerably less sensitive to gamma rays

than a scintillation detector, but this drawback is balanced by the fact that equipment for setting up a Geiger tube is simpler and more compact. A scintillation counter would offer an advantage only where relatively coarse ore must be assayed. For most other applications the sample should be ground to ensure uniformity and a Geiger counter can then be used effectively.

The equipment required consists of the Geiger tube proper, a count-rate meter, and any suitable arrangement to ensure reproducible location of the samples with respect to the Geiger tube. A large range of possible configurations presents itself and only a few typical ones will be described here. The choice of actual components will largely be governed by what is on hand. Some lead shielding around the sample holder and detector, especially above it, may be used with advantage in places where the background count rate is high or very variable.

The choice of the ratemeter, the most expensive component of the system, may be considered first. The most important factor is whether or not the equipment will be used in a place where a steady source of alternating voltage is available. In the field and on new mine sites this is generally not the case and a battery-operated unit is required. Many such portable Geiger counters are listed in an annual Mines Branch report [2]. For assay purposes, a good quality counter

with a fairly large meter and preferably several ranges of count rates should be chosen. Such counters are usually sold with a Geiger tube connected; those where the Geiger tube is housed in a separate probe rather than in the box itself are more convenient for assay purposes, but either type can be used. In many cases the Geiger probe supplied can be replaced easily by a tube more suitable for assay work.

In places where a regulated line voltage is available, any line-operated ratemeter with a built-in high-voltage supply can be used. Besides those made by Measurement Engineering Ltd., Arnprior, Ontario, and by Electronic Associates Ltd., Willowdale, Ontario, a wide range of British and U. S. made ratemeters is available commercially. Such instruments are generally more expensive than the portable ones, but they are more dependable and usually have a larger meter, so that readings can be more accurate and calibration simpler.

The choice of Geiger tube is a little more complex. The main decision is whether to obtain the beta equivalent or the gamma equivalent of the sample. As pointed out before, Geiger tubes are relatively insensitive to gamma rays. On the other hand to obtain a consistent beta assay the detector must view directly a uniform, reproducible smooth surface of the sample. This is probably feasible only in a fairly well established location such as a mill or a small commercial assay office. It is recommended that a gamma assembly be

used in the field and wherever coarser samples only are available, and a beta detector in more permanent locations where the Geiger tube can be mounted safely in a fixed position.

All portable counters whose Geiger tubes are enclosed in the instrument case, e.g. that shown in Fig. 1, are essentially gamma detectors. Many of those with a separate probe have an arrangement whereby the beta sensitivity of the tube can be employed by the use of a protective slide. In many cases it is thus easiest to work with the Geiger tube that was supplied with the counter. Where this Geiger tube is found too small or insensitive, a bigger one can be obtained from most dealers[2]. A useful and relatively cheap all-round Geiger tube is the Victoreen 1B85 "Thyrode", which can be fitted into most portable counters.*

For beta assaying, an end-window tube is preferable because of the higher sensitivity obtainable; however, such tubes are rather delicate and many prefer thin-walled Geiger tubes mounted over long, rectangular, sample containers. In fixed laboratories, where prolonged, reliable operation is more important than ruggedness, the use of halogen-quenched end-window tubes is strongly recommended (Appendix 1). Such tubes retain their operating characteristics over very long periods of time and have an excellent shelf life.

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* Care must be taken to handle any such thin-wall tubes by their bases only, as the walls collapse easily under the slightest pressure. The same applies to mica-window tubes.

SET-UP AND OPERATION

To obtain as many counts as possible from a given sample, it is essential that the detector be placed as near to the sample as possible. Also, for good comparison with the standard samples, the assembly should be strong and stable and as far away from sources of electrical interference and vibration (welding and threading machines, pneumatic drills, etc.) as possible. The more permanent the set-up, the fewer calibrations and standardizations are necessary. In the field a re-calibration is required every time the equipment is set up (page 10), whereas in a permanent office one check a day will frequently be adequate. Figs. 3 and 4 show two typical assemblies. In Fig. 3, a portable Geiger counter (Electronic Associates, type 135P) is shown with its associated Geiger probe placed below the sample holder as a gamma detector. In Fig. 4, a line-operated ratemeter (Measurement Engineering Ltd. type 1903) is shown with an alcohol-quenched end-window Geiger tube (Tracerlab type TGC1) used as a beta detector above the sample. As pointed out before, many other components may be used equally well.

For proper operation it is essential to fix the positions of the Geiger tube and sample container as firmly as possible, otherwise inconsistent results will be obtained. The choice of sample container is governed largely by convenience. The larger the sample, the more counts above background will be obtained for a given grade,

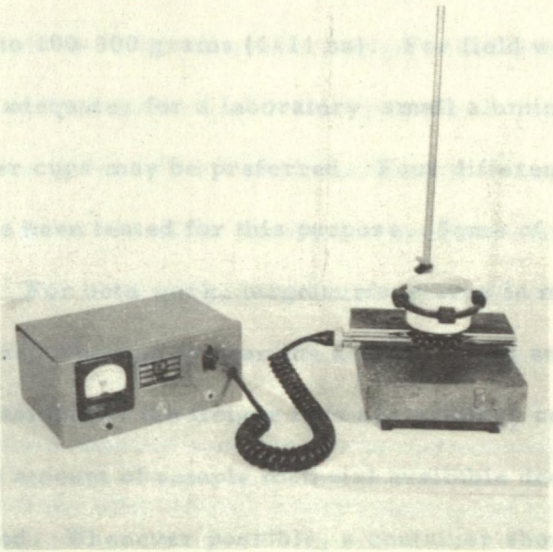

Fig. 3 - Assay assembly using portable counter and thin-walled Geiger tube.

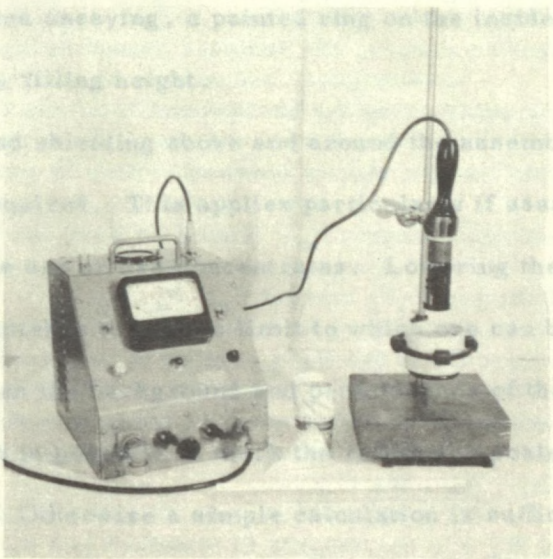

Fig. 4 - Assembly with mains-driven ratemeter and end-window Geiger tube.

but practical considerations of sampling and grinding usually limit the sample weight to 100-300 grams (4-11 oz). For field work any small tin can may be adequate; for a laboratory small aluminum dishes or disposable paper cups may be preferred. Four different types of paper cups have been tested for this purpose. Some of them can be seen in Fig. 4. For beta work, large surface area is more important than total volume, whereas for gamma assay, weight and nearness of the bulk of the sample to the Geiger tube are primary considerations. Ultimately, the amount of sample material available decides the size of container used. Whenever possible, a container should be chosen that can be filled to the rim so that a smooth reproducible surface can be obtained with a spatula. If a larger container is used, particularly in gamma assaying, a painted ring on the inside should be used to indicate filling height.

Lead shielding above and around the assembly may be added where required. This applies particularly if assaying is done near high-grade ore or ore concentrates. Lowering the background automatically extends the lower limit to which ore can be assayed.

When the background and performance of the unit are stable enough it is possible to mark the ratemeter scale directly in per cent U_3O_8. Otherwise a simple calculation is sufficient to estimate the uranium equivalent of the sample.

PROCEDURE AND CALCULATION

The following procedure should be followed:

1. Obtain reading with empty container for "background"
2. Run standard sample(s)
3. Run unknown samples (1 - 5)
4. Obtain background reading again
5. Check standard and background again (when using portable counters).

The number of sample runs between background readings depends on the consistency of the results obtained with the equipment. If the background fluctuates a lot, background and sample runs may have to alternate; if it is very steady and small compared with the average sample reading, then very few background runs are required. In the case of gamma assays, the samples should be weighed.

By subtracting the background from the sample reading the "net sample count", N_x, is obtained. This is compared directly with the net standard count, N_s. Hence we have for beta assays:

Unknown U_3O_8 content $C_x = \frac{N_x}{N_s} \cdot C_s$

where C_s is the U_3O_8 content of the standard sample.

For gamma assays the weights must be taken into account and one gets

$$C_x = \frac{N_x \cdot W_s}{N_s \cdot W_x} \cdot C_s$$

where W_s and W_x are the weights of standard and sample, respectively

The accuracy obtainable depends on the type of ore, the amount of sample, and the equipment used. For a laboratory system, 10-15% accuracy should be obtainable without too much trouble.

The sensitivity of the equipment can be expressed in terms of the uranium sample giving a net count rate equal to twice background. In the particular case illustrated in Fig. 3, a background of 60 c/min was obtained and the calibration gave 3000 c/min/% U_3O_8 with a 250 gram sample. The sensitivity, or lowest grade that can be handled with certainty, therefore, was 0.04% U_3O_8. For the case illustrated in Fig. 4, background was 60 c/min, calibration (specific activity) 5300 c/min/% U_3O_8 for the same sample weight, and hence the sensitivity was 0.02% U_3O_8. Higher sensitivities can be obtained:

1. by lead shielding to reduce the background,
2. by bringing the detector closer to the sample,
3. by increasing the amount of sample.

Whether disposable paper cups or washable metal containers are used, is obviously a matter of cost and convenience.

If a permanent calibration of the instrument is desired and feasible, this can be done with standards obtainable from the Mines Branch (Appendix 2). A unit specially designed for use in United

States assay offices using paper cups and with a permanent calibratio has been described by Mathez[3]. That unit is now available comme rcially as the Anton type 49-R Ore assayer. However, the procedur outlined above is probably more flexible.

References

1. The determination of uranium and thorium in ores by G.G. Eichholz, J.W. Hilborn, and C. McMahon. Canadian Journal of Physics vol. 31, page 631, 1954 (Mines Branch Report TR-99/52).

2. Data on portable counters available in Canada (revised May, 1955) by G. G. Eichholz, Mines Branch Report TR-126/55

3. Routine testing of samples for radioactivity in mills and assay offices in the United States by Muriel Mathez, U.S. AEC Report RME-4025, August 1953.

APPENDIX 1

Possible Sources of Supply of Some Geiger Tubes for Beta Assaying

Halogen-Quenched End-Window Tubes

Amperex types 100, 120, obtainable from Rogers Majestic Ltd., Toronto.

Anton types 201H, 210H and 1001H, obtainable from Anton Electronic Laboratories, Brooklyn 6, N.Y.

20th Century types EW4H, MB4H, obtainable from Physical Enterprises, London, Ontario.

The same firms also supply various types of halogen-quenched thin-walled counter tubes.

Alcohol-quenched end-window tubes

Tracerlab type TGC1, available from Tracerlab Inc. 130 High St., Boston 10 Mass.

Victoreen Thyrodes, obtainable from McPhar Manufacturing Company, Toronto, Ontario.

There are too many types of thin-walled counter tubes of this kind to permit a complete listing here.

APPENDIX 2

List of low-grade standard uranium samples obtainable from the Mines Branch, Radioactivity Division, 30 Lydia St., Ottawa.

	$\%U_3O_8$
T1	0.026
T7	0.10
T3	0.30
T2	0.37
T4	0.55
T8	0.65
T10	1.12
T6	1.37
T9	1.71

These samples can be supplied in 50-gram or 100-gram quantities, minus 100 or minus 200 mesh, at a price of $7.50 per 100 grams. They are available only to Canadian applicants demonstrating bona-fide requirements for standards.

APPENDIX 3

Reporting of Uranium or Thorium Determinations

Under the Atomic Energy Regulations of Canada the results of an assay or analysis of a mineral that indicates a content of more than 0.05% by weight of uranium or thorium are to be reported forthwith to the Director of the Geological Survey, Department of Mines and Technical Surveys, Ottawa, for the Atomic Energy Control Board, together with full particulars relating to the material assayed or analyzed, including the name and address of the person from whom such material was received, the purpose of the assay or analysis, and the origin of the material so far as known to the person making the report. This requirement does not apply to assays or analyses made for persons operating under orders of the Board which provide for periodical reports.

Copies of the Regulations may be obtained on application to the Secretary, Atomic Energy Control Board, Ottawa.