A facility at the National Nuclear Research Centre, Pelindaba, for the calibration of gamma survey meters used in uranium-prospecting operations

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SYNOPSIS

Ground radiometric surveys in uranium prospecting have in the past suffered from two serious shortcomings. Owing to varying instrument sensitivity and the often arbitrary height at which readings are taken, it has been impossible to compare results obtained in different surveys and, moreover, to relate such readings to actual U_3O_8 concentrations. A set of calibration sources designed to overcome these problems has recently been constructed on the site of the National Nuclear Research Centre, Pelindaba. A discussion of the standards applied and the instrument calibration procedure is presented.

SAMEVATTING

Grondradiometriese opnames in uraanprospektering was tot dusver aan twee ernstige gebreke onderworpe, nl. die wisselende gevoeligheid van die instrumente en die dikwels arbitrêre hoogtes waarop lesings geneem word. Hierdie gebreke maak dit onmoontlik om die resultate van verskillende ondersoeke te vergelyk en om sulke lesings met werklike U_3O_8-konsentrasies in verband te bring. 'n Stel kalibreerbronne met behulp waarvan hierdie probleme oorkom kan word, is onlangs op die terrein van die Nasionale Kernnavorsingsentrum te Pelindaba voltooi. 'n Bespreking van die standaarde en die prosedure wat vir die kalibrering van instrumente gevolg word, word aangebied.

INTRODUCTION

Ground radiometric surveys are usually carried out on a purely empirical basis, and the results are recorded in terms of total counts per second or in terms of the standard deviation from the background count. As instruments of varying sensitivity are used, and as readings are often taken at arbitrary heights above the ground, it is usually impossible to compare readings obtained from various instruments.

In order to overcome this problem to some extent, a series of four standards of known mass and uranium content was constructed at Pelindaba. The correlation between the gamma count rate at a specific height above the sources and the equivalent U_3O_8 concentration of a large mass containing disseminated uranium can now be achieved for various instruments.

CONSTRUCTION OF THE STANDARDS

The standards are composed of Bird Reef, which was hand-picked off the reef belt at West Rand Consolidated Mines, and sorted, with the aid of a scintillation counter, into four concentration categories of 2 tons each.

The ore was crushed on the mine to 90 per cent minus 2 cm, and then packed in drums prior to being transported to Pelindaba.

Each standard contained 968 kg of crushed ore of known uranium content and 97 kg of cement. After thorough blending of the dry ore and the cement, the dry mix was treated in four batches in a concrete mixer. Three samples were taken from each batch, making a total of twelve samples per standard. The samples were allowed to equilibrate for two months prior to being assayed by two laboratories, radiometrically and chemically, for U_3O_8. The results were averaged to give a mean for each standard.

Each standard was poured into a prepared ring of sheet metal 2 m in diameter and recessed to groundlevel. The rings each accommodate a standard 0,3 m thick and are 30 m apart.

Analyses of the 48 samples taken during the preparation of the sources yielded the mean concentrations given in Table I.

TABLE I
MEAN U_3O_8 CONCENTRATIONS

Source No.	U_3O_8 concentration (kg/t)
1	4,14
2	2,45
3	1,48
4	0,54

COUNT RATE OF STANDARDS RELATIVE TO THOSE OF LARGE ORE BODIES

A computerized procedure, PELSHIE[1], developed by G. P. de Beer, was utilized in the calculation of the relative gamma count rate 0,5 m above a source of unit U_3O_8 concentration and of the same dimensions as those of the calibration sources, as well as the count rate expected at 0,5 m above an infinite plane source with the same U_3O_8 content. A comparison of these results indicates that the count rates above the calibration sources are 51 per cent of the count rates expected from infinite plane sources of the same U_3O_8 concentrations. This implies that the gamma count rate

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0,5 m above the calibration sources should be correlated with simulated concentrations of infinite plane sources equal to 51 per cent of the true concentrations mentioned previously. This manipulation yields the results shown in Table II.

TABLE II
SIMULATED U_3O_8 CONCENTRATIONS

Source No.	Simulated U_3O_8 concentration (kg/t)
1	2,1
2	1,25
3	0,76
4	0,28

CALIBRATION OF INSTRUMENTS

The procedure involves the determination of the gamma count rate 0,5 m above each of the four calibration sources. These readings are then plotted against the simulated U_3O_8 concentrations given in Table II, and the regression line through the four points is calculated. This line is drawn on a graph and is used to determine corresponding U_3O_8-equivalent concentrations of readings taken in the field. The use of this graph requires that all readings should be taken with the same high-voltage, discriminator, and gain settings on the instrument, and at the correct height, and that the radio-active equilibrium of ^{238}U and its daughter products should not be disturbed.

The use of this calibration also requires that the orebody should have sufficiently large dimensions. If such an assumption is unreasonable, the calibration curve will give the lower limit of the U_3O_8 concentration.

It remains important to check counter efficiency and stability from time to time; this is commonly done by measuring the count rate of a sealed source containing a few micrograms of radium at a specific distance.

CONCLUSION

Different gamma survey meters have been calibrated in this manner: some of the calibration curves obtained are shown in Fig. 1. The large variation in sensitivity illustrated in the figure is due mainly to the dimensions of the various detector crystals but is also dependent on high-voltage, discriminator, and gain settings on the various instruments.

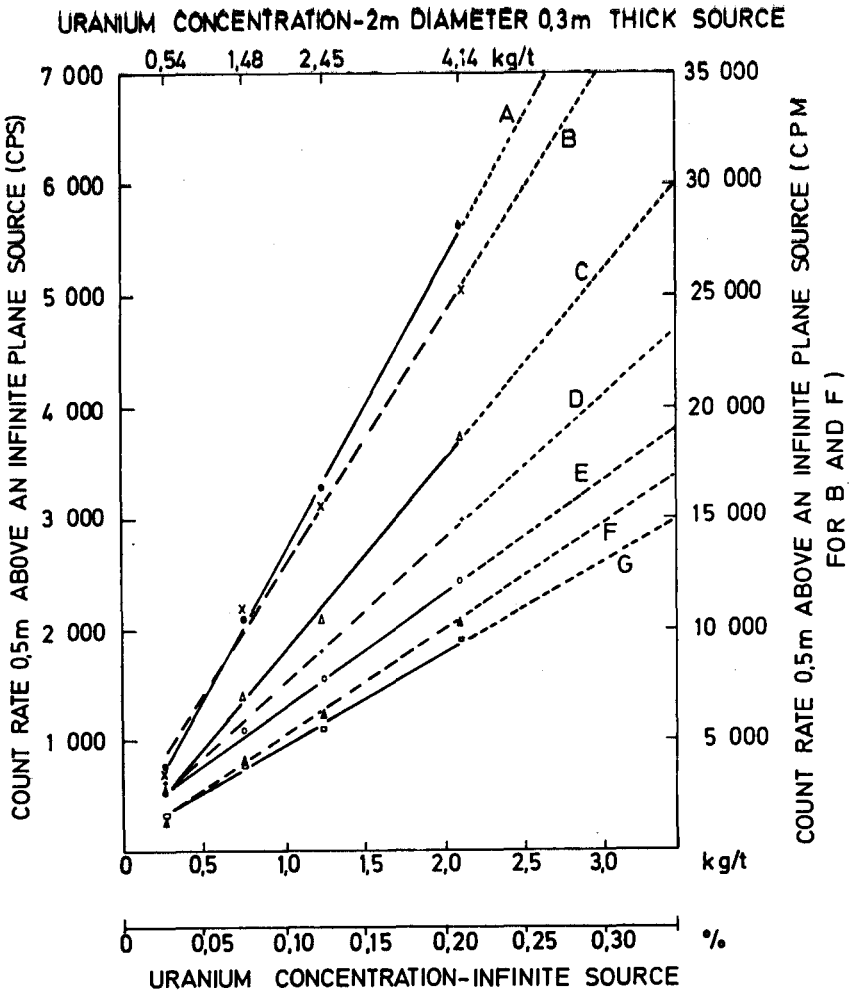

Fig.1—Calibration curves obtained for different gamma survey meters

The calibration curves have been put to the test in the field in areas of known uranium concentration and have been found to be accurate enough to give the field geologist a semi-quantitative yardstick to assist him in evaluating the potential of an area while in the field.

Concern is often expressed about the possible interference of high potassium concentrations with the gross gamma count rate. (Natural potassium contains 0,118 per cent ^{40}K, a gamma-emitting radionuclide.) The low yield of gamma radiation from potassium (216 gamma emissions per minute per gram of potassium), compared with 10^6 gamma emissions per minute per gram of ^{238}U in equilibrium with its daughter products, and the lower counting efficiency of scintillation detectors for the high-energy ^{40}K gamma rays, result in a very much lower contribution by potassium than by uranium to the gross gamma count. In a count taken over a suitably wide energy range, a 5 per cent potassium content would yield the equivalent of only 0,001 per cent U_3O_8. On the other hand, ^{232}Th and its daughter products have an energy distribution rather similar to that of the ^{238}U series and, detected with roughly the same counting efficiency, would have practically the same concentration-count rate relationship. To distinguish between ^{238}U and ^{232}Th, an instrument with an energy discrimination facility should be used.

ACKNOWLEDGEMENT

The assistance received from West Rand Consolidated Mines, who provided the ore, and from the General Mining and Rio Tinto Laboratories, who analysed the samples, is gratefully acknowledged.

REFERENCE

1. De Beer, G. P. PELSHIE—A general purpose shielding program for point and extended gamma-ray sources. Atomic Energy Board, *Report PEL-213*. 1971.