# Radioactivity Measurements on Some Rock and Water Samples from Dakshin Gangotri, Antarctica

**S.K. Verma, G.S. Mital, G.V. Rao, R. Rangarajan, K.N.S. Reddy and M. Venkatarayuda**

*National Geophysical Research Institute, Hyderbad-500007*

## ABSTRACT

The field measurements and laboratory analyses were carried out on some rock and water samples from the Dakshin Gangotri region. It was found that no significant deposits of radioactive minerals exist in the vicinity of the Priyadarshini lake. The water samples collected from the water channels in the ice-shelf and from the Priyadarshini lake were found to be free of any hazardous radioactive contaminations.

## INTRODUCTION

The gamma ray spectrometric surveys are useful in locating gamma radiation fields caused by varying concentrations of radio isotopes at different localities. The spectrometric surveys thus provide an effective tool to locate important radioactive minerals like uranium, thorium etc. in a given region. So far very few radioactive surveys have been carried out in Antarctica (Dreschoff et al., 1983) and no significant deposits in radioactive minerals have been reported in the Dronning Maud Land.

As there is very little or no pollution in Antarctica, normally the ice and water samples collected from Antarctica show the purest form of these substances. However, at places, such samples have been found to be contaminated by the fallouts resulting from the nuclear tests being carried out in various parts of the world. To determine the level of radioactive contamination, water samples were collected from the ice-shelf and from the Schirmacher Oasis region.

## DATA COLLECTION AND LOCATION OF THE SAMPLES

### Spectrometric survey

To determine the radioactive behaviour of various rock types and to locate any possible occurrence of radioactive minerals in the vicinity of Indian station, Maitree in the Schirmacher Oasis region, the radiometric survey was done along the profile shown in Fig. 1.

The survey was done using a GAD-6 portable spectrometer which is a digital, four channel, spectral-stabilized gamma-ray analyser manufactured by the Scintrex Co., USA. This spectrometer automatically displays the Compton-stripped values when the stripping factors are dialed in digitally. The stripped or unstripped outputs can be selected with the help of a switch provided in the front panel of the instrument. For a given radioactive source, the output displayed for the uranium channel is proportional to the equivalent uranium value if the Compton-stripping of the output is done. The displayed values for various channels can be automatically normalized to counts per second by selecting the proper switch. In the present survey, the values of thorium, uranium, potassium and total counts were recorded at each station. These measurements recorded along the profile are shown in Fig. 2.

A number of rock samples were collected from different geological units along the profile for subsequent study in the laboratory.

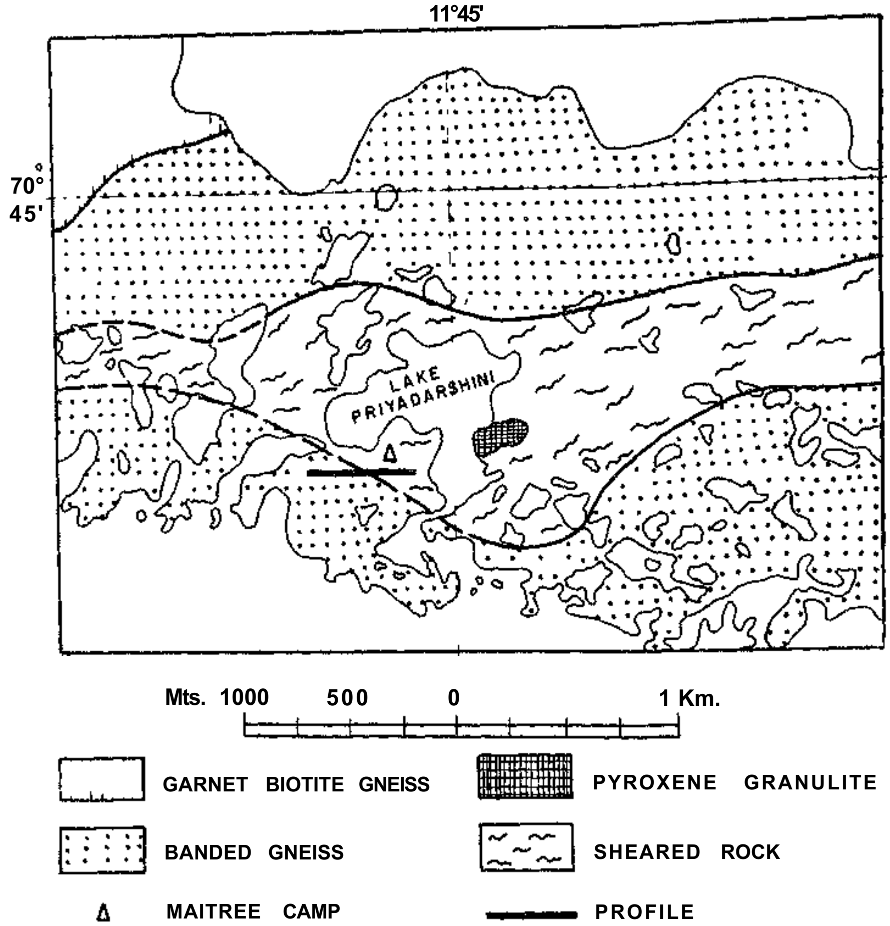


*Fig. 1.* Map showing the region of Schirmacher Oasis where radiometric survey was done.

### Collection of water samples

The samples of water were collected from the water channels occurring on the ice-shelf about 35 km south from the coast and from the Priyadarshini lake, shown in Fig. 1. The samples were collected in sterilized bottles and were sealed subsequently.

## DATA ANALYSIS AND INTERPRETATION

### Spectrometric analysis

Three major sources causing gamma radiations in rocks are potassium (K), uranium (U) and thorium (Th). The three characteristic gamma-ray energies associated with these elements for the purpose of spectrometric surveys or assaying are 1.461 MeV for potassium, 1.764 MeV for uranium and 2.615 MeV for thorium. The response recorded in the channels for K, U and Th are normally compared against an ambient radiation level caused mainly due to sources like cosmic rays, radioactive nuclides produced in nuclear explosions, natural radioactive nuclei in the earth's atmosphere and some trace amounts of radioactive elements in most rocks and soils. A precise determination of the background radiation level is a must for targets with low concentrations of radioactive elements. However, for ore-deposits rich in radioactive elements, the measurement of the background level is

**not so important. As the objective of the survey was to locate the presence of radioactive minerals, if any, in the Schirmacher Oasis region, background levels were recorded near the Indian Station on the ice-shelf. The background count rates found to be 7(K), 1.75 (U), 1.5(Th) and 400 (Tc) where Tc is the total count rate.**

**An examination of the count rates measured along the profile shown in Fig. 2 with respect to the background level mentioned above reveals that no rock in the region covered by the survey possesses any extraordinary concentration of radioactive minerals. Only at stations six and thirty two (at respective distances of 60 m and 320 m) a slight increase in the count rates was observed. The samples collected from these two locations belonged to the leucocratic gneiss rocks. Along the profile, three other samples were also collected—two of them belonging to the banded gneiss rocks while the fifth sample was a pyroxene granulite rock. These samples were subsequently analysed in the laboratory.**

**The above mentioned five rock samples were analysed for U, Th and K concentrations using a laboratory gamma-ray spectrometer. The spectrometer system comprises of a 5" dia, 6' high nal(TI) crystal detector (installed in a 7" thick lead shield) and a 1024 channel pulse height analyser. About 400 gm of rock sample grounded to -60 mesh was filled in cylindrical plastic container and count-rates were obtained placing it over the detector. The count rates used for computation were approximately over 200 keV—wide segments of the gamma-spectra centred over the 2.62 MeV, 1.76 MeV**

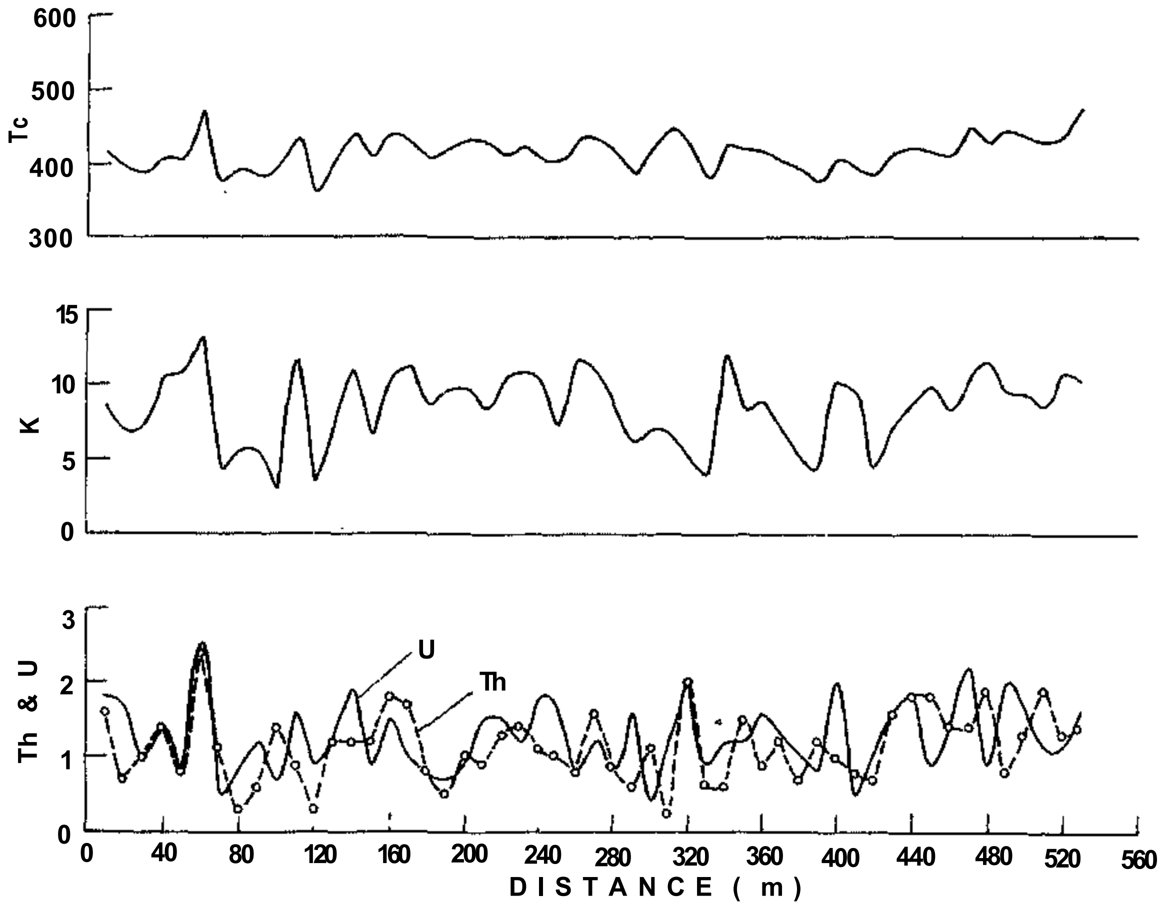


*Fig. 2.* **Records of thorium, uranium, potassium and total counts from the rocks of Schirmacher Oasis.**

and 1.46 MeV peaks of $T1^{208}$, $Bi^{214}$ and $K^{40}$ respectively. Least-square fitting of count rates of the *standard* samples and with those of rock samples was employed for obtaining the elemental concentrations. The standard samples were made from a set of accurately analysed uranium ore samples obtained from U.S. Atomic Energy Commission's New Brunswick Laboratory. Spectroscopic grade of KE1 was used as 'Potassium Standard'. The results are shoen in Table I.

TABLE I

*Laboratory analysis results for U, Th and K Concentrations in the five rock Samples collected from Schirmacher Oasis.*

| S.No. | Rock type | Th(ppm) | U(ppm) | K(%) |
|---|---|---|---|---|
| 1. | Banded gneiss | 1.7 | 0.4 | 1.1 |
| 2. | Banded gneiss | 0.8 | 0.2 | 2.2 |
| 3. | Pyroxene granulite | 0.1 | -- | 0.5 |
| 4. | Leucocratic gneiss | 2.0 | 0.5 | 1.3 |
| 5. | Leucocratic gneiss | 3.0 | 0.3 | 5.6 |

Again it was found that the laboratory analysis did not show any high concentration of radioactive minerals in the rock samples.

Radioactive measurements on water samples

Radioactivity (low energy) of water samples collected from Antarctica was measured by LKB-Wallac Rack Beta Liquid Scintillation Counter System (Fig. 3). This is an automatic microcomputer-controlled four channel Scintillation Counter intended for counting beta emissions over the energy range of 1 keV to 2800 keV. It is possible to measure accurately very small amounts of low energy radioactive materials with the help of this instrument.

The energy range of the instrument (1-2800 keV) is covered by 256 logarithmically arranged energy level numbers.

Some of the radio-isotopes which can be measured by this counter and then approximate count windows for unquenched samples are shown below:

| | *Radio isotope* | *Approx count window(V)* | *Max. energy (keV)* |
|---|---|---|---|
| 1. | $^{3}H$ | 8-110 | 18 |
| 2. | $^{14}C$ | 50-165 | 159 |
| 3. | $^{32}P$ | 110-212 | 1740 |
| 4. | $^{131}I$ | 120-190 | 610 |
| 5. | $^{35}S$ | 50-165 | 167 |
| 6. | $^{45}Ca$ | 50-175 | 254 |

*Principle*

The energy from the emitted radiation is absorbed by a fluorescent material (scintillator) and re-emitted as light photons. These are detected by a photomultiplier tube and counted to electrical pulses for analysis.

***Sample preparation***

**A definite proportion of water sample from Antarctica and scintillator were mixed (Tables II and III) in 20 ml low potash glass vials and loaded in liquid scintillation counter for measurement of radioactivity (low energy emissions). Count rates for a background (BG) sample (distilled water) having no activity, except cosmic ray activity were also measured. The samples were counted for 1000 seconds and the activity was measured in count per minute (CPM).**

**The measurements show that there is no difference in count rate for normal BG. sample and the samples from Antarctica. This indicates the absence of significant radioactivity of Beta emissions energy in the range of (1-2800 keV) in the water samples.**

## CONCLUSIONS

**The field measurements over the rock samples and the laboratory measurements on the rock and water samples from the Dakshin Gangotri region reveal no anomalous radioactivity. Thus it can be concluded that there are no significant deposits of the radioactive minerals in the vicinity of the Priyadarshini lake. Also, the lake of any anomalous radioactivity in the water samples from the ice-shelf and from the Priyadarshini lake implies that these water sources do not contain any hazardous radioactive contaminations.**

**TABLE II**

***Count rates for the B.G. and the water samples collected from the water channels in the ice-shelf.***

| Sample | Proportions [Sample + scintillator (ml)] | CPM | | | |
|---|---|---|---|---|---|
| | | 8-110V | 100-200V | 120-200V | 200-240V |
| B.G. | (8+8) | 67.5 | 59.2 | 50.2 | 6.0 |
| W. sample from the water channel | (8+8) | 51.5 | 68.1 | 54.1 | 4.6 |
| „ | (8+8) | 54.8 | 64.2 | 53.5 | 4.2 |
| „ | (4+10) | 62.9 | 63.9 | 53.1 | 6.2 |
| Empty vial | | 30.1 | 3.0 | 2.1 | 0.0 |

**TABLE III**

***The measurement of B.G. and water sample from Priyadarshini Lake counted at randomly selected different window lengths.***

| Sample | Proportions [Samples + scintillator (ml)] | CPM | | | |
|---|---|---|---|---|---|
| | | 8-110V | 100-200V | 120-200V | 200-240V |
| B.G. | (8+8) | 67.4 | 58.7 | 49.9 | 6.0 |
| W. sample from Priyadarshini lake | (8+8) | 53.5 | 66.4 | 53.8 | 4.4 |
| „ | (8+8) | 56.4 | 63.7 | 53.0 | 4.0 |
| „ | (4+10) | 64.7 | 62.5 | 52.5 | 6.0 |
| Empty vial | | 29.0 | 2.9 | 1.9 | 0.0 |

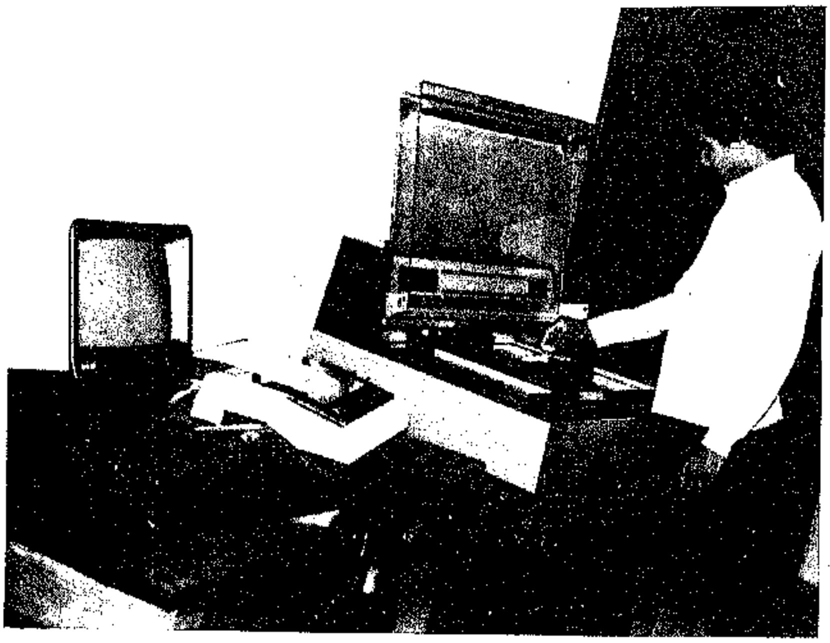

*Fig. 3.* LKB-Wallac Rack Beta Liquid Scintillation Counter System.

ACKNOWLEDGEMENTS

Thanks are due to Director, NGRI, Hyderabad for providing us opportunity to participate in the fourth Antarctic Expedition and to Dr. S.Z. Qasim, Secretary, DOD, New Delhi for providing all the support and encouragement during the expedition.

REFERENCES

Dreschoff, G.A.M., E.J. Zeller and W.R. Kropp, 1983. Radiometric survey in northern Victoria Land. In: *Antarctica Earth Science,* edited by Oliver et at., Cambridge Uni. Press, p. 429-432.