Geophysical Research Abstracts
Vol. 13, EGU2011-3354, 2011
EGU General Assembly 2011

Radon Background Fluctuations and Radiometric Determination of Uranium, Thorium and Potassium

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Gamma ray spectrometric surveys are based on the radiometric measurements of U, Th, K and form the basis of uranium exploration programme. The terrestrial distribution of the naturally occurring primordial radio elements (U, Th, and K) is studied in the surveyed areas with systematic sampling procedures. These samples are then analysed for determination of U, Th, and K employing radiometric standards by comparative methods in the laboratories with proper grinding to a reasonable mess size. The procedure for determination, instrumentation, experimental set-up, acquisition of radio elemental windows data and Multichannel Analyser data (8K), reduction of this data finally to concentrations of radio elements, calibration of the system is described.
The most important advancement in Uranium Exploration Programme over the earlier total radioactivity measurements is the advent of gamma-ray spectrometric technique for measurement of U, Th and K radio-elements present in earth's crust. Ground and airborne gamma ray spectrometry is employed for this exploration. The complex gamma-ray spectrum emitted from a rock sample is analysed using a scintillation detector-NaI(Tl) for determination of U, Th and K with the characteristic gamma-ray energies of 1.76 MeV from 214 Bi (daughter product of 238U), 2.62 MeV from 208Tl (daughter product of 232Th) and 1.46MeV from 40K. The characteristic energy resolution of NaI(Tl) for these energies is used to select the windows or region of interest (ROI) from gamma-ray energy spectrum obtained with a multichannel analyser (MCA) and the net photo-peak-counts are computed after background and Compton scattering and other corrections. The most nagging problem faced in these corrections is mainly due to Radon effect and this problem is mainly is focussed in this paper. The concentrations of U, Th and K are computed using the window sensitivities. Preparation of the powdered sample in -200 mesh-size and packing of the sample to the required density is of paramount importance in the laboratory analysis while a special measurement is carried out for airborne radon in airborne gamma ray surveys. In the radiometric measurements, the net counts for a sample are obtained by the subtraction of background counts from gross counts. Both of these measurements are subjected to statistical errors. Optimum division of time available for sample and background count measurement is also discussed with associated errors. The detection limit of any radiometric measurement is a function of the fluctuation of background counts, which ultimately determines the lowest threshold value. This aspect is also discussed for various radiometric techniques for measurements of U, Th and K.

The total gamma-ray activity of any rock sample containing U, Th and K shall be the sum of the individual radio-elemental activity i.e. all Ni.λi's where Ni, is the ith disintegrating nuclide and λi is its disintegration constant which may belong to U or Th or K or all. One will not know, therefore, whether this total radioactivity measured is due to U or Th or K or U+Th+K or other than them. Also it is not known whether radio-element is in radioactive equilibrium. Th is almost in equilibrium with its daughters due to very short half-lives of its daughters. It would not be correct to attribute this total radio-activity to Uranium alone. To distinguish the results of such measurements, it is designated as %eU3O8 and not as % U3O8 which will be same provided U-series in equilibrium with its daughter products. For determination % U3O8, beta-gamma method is used. In this method total beta particle counts from Uranium series and total gamma ray counts from radium group of uranium series are simultaneously observed by using an end-window beta-tube and NaI(Tl) scintillation detector.
The most important and significant cause of background in uranium region of the gamma ray spectrum therefore is that due to 222Rn while contribution due to Cosmic and instrumental set-up remain almost stable. IAEA (1991) recommended Energy window scheme for radiometric determination of U, Th and K as follows
Element
Analysed Isotope Used Gamma-ray Energy Measured
(MeV) Energy window
(MeV)

238U 214Bi 1.76 1.66-1.86
232Th 208Tl 2.62 2.42-2.82
40K 40K 1.46 1.76-1.56

The measuring equipment for determination of %eU3O8 comprises of NaI(Tl) detector surrounded by lead shield, a HV supply for detector, a counter-timer for registering the counts or a PC based multichannel analyser (MCA), for acquiring the complete gamma-ray energy spectrum are described in this paper.
Radon gas occurs naturally in the environment with variable distribution, concentrating sufficiently in the built environment in some areas to pose health risks to the radiometric personnel. Radon levels can successfully be reduced in the laboratory buildings. For this purpose in AMD a low background and semi underground room (LBG) was constructed with quartz material walls. It is a major remediation step for controlling Radon and the Health Hazard subsequently. This LBG room if not properly cleaned and evacuated then it can be assumed partially like low lying terrains, a valley, cave, closed mine, archaeological places, abandoned dwelling and to some extent a simulation of these situations can be done . We present some results from LBG room which was monitored for the closed room condition of Saturday, Sunday and then evacuated on hourly basis over extended period before a minimum background is achieved for radiometric measurements. Numerous data on natural Gamma ray spectra have been acquired on two MCA Systems in LBG on various dates, months. In these spectra at times we clearly observe pronounced peaks of 1.76, 1.12, and 0.609 MeV peaks indicating accumulation of mobile 214Bi. Various field samples (received from different uranium exploration areas) analysed in a week in this LBG room are varying in Uranium concentrations definitely affect the ambient atmosphere of the room and the decay of radon, 222Rn (3.82d, alpha decay) in this atmosphere of LBG room produces decay products that condense on existing aerosol particles. These decay products include 218Po (3.0 min, alpha decay), 214Pb (26.8 min, beta decay) and 214Bi (19.9m, beta decay), 214Po (alpha decay), 210Pb (22.3y).
This paper describes the sampling and measurement procedure, the range of radioactive aerosols, measuring instrumental assemblies, results of variation of background in LBG room, variation of background over water bodies and at 600m above ground studies over various parts of India and will discuss about Radon as the main driving force for such variations with an application to both radio elemental determination and possible health Hazards.