CHAPTER I

INTRODUCTION

Radium is one of the most radiotoxic elements. There are four naturally occurring radium isotopes, two in the thorium series (5.75 year radium-228 and 3.6 day radium-224) and ore each (11.6 day radium-223 and 1620 year radium-226) in the other two natural radioactive decay series (1). The most important of these is the longest-lived radium isotope, mass number, of 226, in the uranium- radium series. As a result of its relatively long life and the high natural abundance of its ancestor, uranium 238, it is the most abundant radium isotope. The main decay chain of uranium-238, in which radium-226 occurs as a member, is given in Table 1.1 (2). Uramium-238 decays with a half-life of 4.5×10^9 years. After fourteen transformations (eight of them by α-particle emission and six by a β-particle emission) a stable end product, radium G (lead with mass of 206), is produced. This series includes radium and its decay products, radium-226 and the radon group, i.e., Rn-222, Po-218, Pb-214, Bi-214 and Po-214, which are sometimes called the radium series.

Radon isotopes are produced by the radioactive decay of alpha-emitting radium isotopes. The three naturally occurring isotopes, with mass numbers 219 (half-life 3.92 seconds), 220 (half-life 55.3 seconds) and 222 (half-life 3.8 days) are most commonly encountered. As a result of its relatively long half-life, radon-222 may migrate away from its immediate parents through porous rocks or sediments, or through water or air, causing environmental hazards. Consequently, it is subject to more intense study (1).

Radium-226 is usually quantitatively analysed by two alternative methods (1,3). In the first method, radium is separated free from other alpha emitters, usually with several milligrams of carrier, and the carrier compound transfered to a counting plate for alpha counting (1,3,4,5,6). Care must be taken to spread the solids uniformly and smoothly over the plate, so that accurate and reproducible counting rates could be obtained. A multichannel pulse height analyser is required to distinguish radium-266 from other radium-isotopes. For counting with single channel analyser, the radium isotopes could be resolved only if the measurements are made at proper times; i.e. the samples should be counted immediately after separation and at times thereafter such that the relative activity of one or two of the isotopes changes appreciably in the intervals between measurements (1,5,6). In the second alternative, radium-226 is analysed through the content of radon or its decay products since a quantitative relationship exists between members of a radioactive decay series (1,3,7). Since radon is a gas at room temperature, quantitative separation is simple. The radon-emanation method is particularly valuable for the analysis of radium-226 because the half-life of radon-222 is sufficiently long and distinguished from other radon-isotopes. No corrections for the other isotopes of radium need to be made.

Most of the methods that have been developed for the determination of radium-226 by the emanation method involved the use of special detectors for measurement of radon-222 activity, such as alpha counting with zinc sulfide scintillator (3,7,8) or by ionizing events in ionization chamber (9,10), proportional counter and Geiger muller counter (11).

The early de-emanation systems used were complex, for example, Evan (10) used a special reflux condenser for de-emanation and a cylindrical ionization chamber for radon measurement. Lucas (8) achieved an efficiency of detection of 5.4 cpm Pci^{-1} of radon at a background level of 0.06 cpm by using Lucas cell, this work was the peak of development for emanation method. Other less complex systems had lower efficiency and higher background values, for example the efficiency was 3.6 $cpmPci^{-1}$ and the background was 1 cpm according to Conlan (13)

The detectors mentioned above have some disadvantages (1,15, 17). In the counting of radon with zinc sulfide detectors, the radon gas is transferred into a counting chamber. The chamber is a glass or metal cylinder or hemisphere with an inlet tube and coated on the inner surface with zinc sulfide. The radon is transferred to the chamber with a carrier gas and the alpha activity is counted by placing the chamber on a multiplier phototube with the chamber window in contact with the cathode of the tube. To obtain good counting efficiency, the chamber must be small, about 100 cm^3, since alpha particles emitted in the gas phase must reach the zinc sulfide with sufficient energy to produce a detectable scintillation. The volume restriction is the principal disadvantage of this type of counter. In counting of radon with gas counters, a complicated system for the purification of radon-loaded carrier gas from the de-emanation system must be installed to remove any traces of oxygen, water vapor and other electron-captured gases, since these impurites reduce the size of pulses.

The liquid scintillation counter exhibits some advantages over the above mentioned counting techniques. Since the radioactive source is dissolved in the scintillator, volume of carrier gas for radon de-emanation is not limited by the size of the counting cell, larger volume for de-emanation solution can be employed. This means that no pre-concentration of radium is required (14,15,16,17).

The main objective of the present work is to develope a simple and sensitive method for the determination of radium-226 in uranium-bearing ores. The fact that a uranium-bearing ore is or is not in equilibrium with its decay products is of prime importance to the geochemists. If the uranium and its daughter products are in equilibrium (Table 1.1), the uranium content in the ore could be easily analysed by measuring the relative intensity of the beta-gamma radiations compared with a standard uranium ore under equilibrium. A quantitative mearurement of the amount of non-equilibrium, especially for radium, is essential for the formulation of a concept of the total environment of an exploration area and in predicting the likely position of mineralization (2,5,6).

Table 1.1 Main decay chain of uranium-238

Elements and isotope number in order from the parent U-238 to the stable Pb-206 showing the nature of the decay emission	half life	Relative γ activity in range 0.1-3.0 Mev	Amount in radioequillbrium with 100 g U-238 (g)
U-238	$4.5X10^{9}$ y	-	99.29
↓ α			
Th-234	24.1 d	-	$1.48X10^{-9}$
↓ β			
Pa-234	1.2 min	weak	$4.68X10^{-14}$
↓ β			
U-234	$2.47X10^{5}$ y	weak	$5.0X10^{-3}$
↓ α			
Th-230	$8.0X10^{4}$ y	weak	$1.76X10^{-3}$
↓ α			
Ra-226	1620 y	weak	$3.32X10^{-5}$
↓ α			
Rn-222	3.8 d	weak	$2.15X10^{-10}$
↓ α			
Po-218	3.0 min	-	$1.16X10^{-13}$
↓ α			
Pb-214	26.8 min	strong	$1.01X10^{-12}$
↓ β			
Bi-214	19.7 min	strong	$7.4X10^{-13}$
↓ β			
Po-214	$1.6X10^{-4}$ sec	weak	$9.1X10^{-20}$
↓ α			
Pb-210	22 y	-	$4.32X10^{-7}$
↓ β			
Bi-210 m	4.95 d	-	$2.63X10^{-10}$
↓ β			
Po-210	138.4 d	-	$7.39X10^{-9}$
↓ α			
Pb-206	stable		