222Rn and 220Rn emanations from powdered samples of samarskite as a function of annealing temperature

DARIUSZ MALCZEWSKI1,* AND MARIA DZIUROWICZ1

1Faculty of Earth Sciences, University of Silesia, Bedzinska 60, 41-200 Sosnowiec, Poland

ABSTRACT

Emanation coefficients for radon (222Rn) and thoron (220Rn) were measured from fully metamict samarskite collected from Centennial Cone after 1 h and 24 h annealing in argon from 473 to 1373 K. For the 1 h annealing run, 222Rn emanation coefficients ranged from 5 × 10^-6 to 2.1 × 10^-5 %, while 220Rn coefficients varied from 6.3 × 10^-3 to 2 × 10^-2 %. For the 24 h annealing run, 222Rn coefficients ranged from 5.8 × 10^-6 to 2.3 × 10^-5 %, while 220Rn coefficients varied from 4.1 × 10^-3 to 1.5 × 10^-2 %. The 222Rn and 220Rn emanation coefficients vs. annealing temperature data can be described by an exponentially decreasing sinusoidal function. Both 222Rn and 220Rn emanation coefficient values after annealing considerably exceeded those measured from an unheated powder reference sample and from the original samarskite sample.

Keywords: Samarskite, radon emanations, thoron emanations, recrystallization, Centennial Cone, 222Rn, 220Rn

INTRODUCTION

Samarskite is a complex Nb-Ta-Ti-REE + Y-Ca-U-Th multiple oxide containing uranium, thorium, iron, and other elements and has always been found to be completely metamict (Sugitani et al. 1985). Due to its chemical complexity and metamictization, samarskite’s chemical formula and crystal structure have not been unambiguously characterized. The proposed structural formulas are AB2O6, A3B5O16, and ABO4 where A = REE, U, Th, Ca, Fe, and Ti and B = Nb, Ta, and Ti (Kommov 1965; Graham and Thorner 1974; Ewing 1975; Lumpkin et al. 1988). The recently suggested ABO4 formula is based on microprobe analysis of 19 samarskite samples after annealing at 800°C under hydrogen and on analysis of samarskite-(Yb) from the Little Patsy pegmatite annealed under a weakly reducing atmosphere at temperatures up to 1100 °C (Warner and Ewing 1993; Simmons et al. 2006). As seen in Table 1, the uranium and thorium concentrations correspond to a calculated total absorbed dose, DT, of 6.5 × 1017 α-dose mg^-1. The α-doses from the 238U and 235U series comprise the dominant contribution to the total α-dose of samarskite from Centennial Cone. The ratio of α-doses from D_{238U} + D_{235U} to D_{232Th} is about 27.

The aim of the study is to determine the relationship between 222Rn and 220Rn emanations and annealing temperature for powdered samples of samarskite. Additionally, this work aims to show that 222Rn and 220Rn emanations can be correlated with the thermally induced transition from the low- to high-temperature phase of samarskite. Results obtained are compared with emanation values from a fragment of the original sample, the unannealed powdered reference sample, and with values from powdered monazite, thorite, uraninite, and zircon samples crushed to comparable small grain size as reported from literature sources (Table 2).