Preface

Radon is the heaviest of all naturally occurring noble gases and it has a total of 36 isotopes, all of which are radioactive (ranging from ^{193}Rn to ^{228}Rn). Only three of these isotopes occur naturally and are constantly produced at a known rate in the ^{238}U-(^{222}Rn, radon), ^{235}U-(^{219}Rn, also known as actinon), and ^{232}Th-(^{220}Rn, also known as thoron) series. Radon has received the most attention among all the noble gases over the last four decades, largely due to the fact that it is the single major contributor to the ionizing radiation dose received by the general population. Radon is the second most frequent cause of lung cancer after smoking, and is classified as a human carcinogen. While the noble gas applications extend from cosmochemistry to different branches of geoscience, applications of radon are generally confined to near-surface Earth processes, due to its short mean life (5.53 days). Note that the presence of mantle ^{3}He in the oceans is indicative of diffusion of helium from much deeper sources inside the Earth, but sources of radon to Earth systems is much more confined to shallower depths. Most review articles and books such as *Noble Gases* by Minoru Ozima and Frank Podosek and the articles in the edited volume *Noble Gases in Geochemistry and Cosmochemistry* by Don Porcelli, Chris Ballentine and R. Wieler in Reviews in Mineralogy and Geochemistry serve as key reference works for the researchers working in noble gas geochemistry, but most of these publications have discounted the utility of radon as a tool to investigate several Earth surface processes. The sensitivity of radon measurement is the highest among all noble gases. In terms of molar concentration, 1 pico Curie (pCi) can be easily measured (1pCi of ^{222}Rn activity contains 1.76×10^{4} atoms which corresponds to 2.9×10^{-20} mole of radon). While there are a large number of scientific reports from national and international agencies (e.g., US Environmental Protection Agency, US National Academy of Science, World Health Organization) that describe findings on indoor radon in peer-reviewed journal articles, and many scientific reports pertaining to indoor radon as a health hazard, there is no single book on the applications of radon as a tracer in Earth systems. This book is designed to address that deficiency.

This volume is structured to examine the current body of knowledge in regard to all major aspects of the applications of radon as an environmental tracer. Each chapter is written as a review article, providing a critical synthesis with sufficient details for those who are technically trained but not necessarily working in this or similar area of research. This book is divided into 11 chapters. Chapter 1 is concerned with the physical, chemical, and nuclear properties of radon and the relationship between radon and its progeny. Chapter 2 gives an in-depth review of existing instrumentation for the measurements of radon and its progeny in environmental samples (water, air, and soil gas). The mechanisms of radon emanation and the factors that control the variations of the radon emanation coefficient are presented in Chap. 3. Radon has a simple emanation function from the Earth's surface, and the gradient in radon concentrations in the atmosphere as a function of latitude and longitude serves as a valuable tool to quantify factors and processes in the atmosphere that redistribute the radon released from the Earth's surface (Chap. 4). Progeny of radon, in particular ^{210}Po and ^{210}Pb, have been widely utilized as tracers to quantify a number of atmospheric processes that include source tracking and transport time scale of air masses, residence time and removal rate constant of aerosols and flux to and exchange between environmental systems of other gas species such as CH_4 and Hg^0 (Chap. 5). Radon concentration gradients at key interfaces such as sediment–water and air–water in aqueous systems (oceans, rivers, and lakes) have been utilized to determine exchange rates of gases across these interfaces (Chap. 6). The most widely used chronometer among the U-Th-series radionuclides is ^{210}Pb, which is a progeny of radon, with over 2,300 published articles over the past four decades. Its utility as a tracer and chronometer is presented in Chap. 7. Radon has a high solubility in organic liquids, similar to other noble gases, and hence its usefulness as a tracer for investigating the partitioning of radon between organic solvents and groundwater along with its application in quantifying infiltration of meteoric water and as a dating tool (in conjunction with ^{4}He) are given in Chap. 8. Radon as a tracer in geochemical exploration studies are presented in Chap. 9. In earthquake studies, radon is widely used as a precursor to predict earthquakes and several case studies are presented in Chap. 10. Finally, in Chap. 11, a summary of factors that affect radon entry indoor and potential techniques for radon entry prevention and mitigation are summarized. At the end of each chapter, future research direction is also included.

This book will prove to be a valuable resource for researchers in atmospheric science, marine and environmental sciences, earthquake studies, geochemical exploration studies (including uranium and hydrocarbon), organic pollutant studies in groundwater, noble gas geochemistry, and radon as a health hazard. Sections of the book are expected to be useful as a supplementary text to a number of graduate courses that include Environmental Isotope Geochemistry, Geochronology and Tracer Studies in Groundwater, Atmosphere and Ocean system.

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