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PROGRESS REPORT AND CONTINUATION APPLICATION

"Transport of Radon and Thoron at the Earth's Surface"

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1. Introduction

This report covers progress under the current funding period 1 Jan 91 to 1 Jan 92 and presents the continuation proposal for 1 Jan 92 to 1 Jan 93. The previous progress report was submitted in May 1990, so activities during the last half of 1990 will also be included.

Major activities over the last year have centered on the study of disequilibrium of radon progeny near the earth's surface and the sources of thoron in indoor air. In addition, we have carried out supplemental measurements of radon sorption coefficients in porous materials focusing on the physical mechanism of sorption.

For the upcoming project period we anticipate continuing to concentrate on studies of radon progeny disequilibrium and the sources of indoor thoron. We now have a significant amount of data from both projects. We are ready for some initial analysis after which a decision will be made whether more data are needed or whether to concentrate on modeling. A new post-doc, Dr. Piotr Wasiolek, will join our group in July and some flexibility in our program objectives will be reserved to accommodate his research interests. Dr Wasiolek has spent the last year at Clarkson University working with Dr. Phil Hopke on radon and aerosols in indoor air. Prior to that he completed a dissertation on indoor radon at University College, Dublin. He is an experienced radon researcher and we feel lucky to have recruited him.

Our research planning has focused on a three-year time period and we do not expect major developments at this early stage. However, already it is clear we have obtained very important data on the sources of indoor thoron. We have used our one-of-a-kind two-filter system to measure the effect of sub-slab mitigation systems simultaneously on indoor thoron and radon, and this is proving a powerful technique for determining what fraction of the indoor thoron comes from the soil. Another significant development is the improved computer codes we are writing for calculating radon progeny disequilibrium near the earth's surface. For the first time these codes are providing theoretical insight into previously controversial experimental observations of the concentration of ^{214}Pb in outside air being higher than its parent isotope ^{218}Po.

Further details of our research activities over the last year and plans for the next year follow.

2. Disequilibrium of Radon and Radon Progeny Near the Earth's Surface

This project focuses on modeling and measurements of the disequilibrium between radon and radon progeny near the earth's surface. In addition to advancing basic environmental science knowledge of dry deposition and turbulent transport, models developed should be useful in health physics for estimating radiation dose from radon progeny at ground level under varying atmospheric conditions.

Dr. Schery spent the summer of 1990 as a visiting scholar at the Nuclear Science and Technology Organisation (ANSTO) near Sydney, Australia. He was accompanied by Ken Eack, a senior at NMIMT. In collaboration with Dr. Stewart Whittlestone, precision data for radon and attached and unattached radon progeny were obtained at several heights on the ANSTO meteorological tower. Additional data has been obtained at the Mauna Loa Observatory and on the campus of NMIMT. The Australian and Mauna Loa measurements benefitted from the extensive meteorological data available at these sites. The time-honored model of Jacobi and Andre (1963) has proven inadequate to explain our observations, especially for the top few meters above the soil. As a result, we have been developing new models. A key feature is inclusion of separate treatment for attached and unattached progeny which was not done by Jacobi and Andre (1963). A computer code RPOUT has been developed by S. D. Schery and is now in the review process at ANSTO. A more powerful version of Schery's code is under development by Rong Wang as a part of her master's degree work. Her code calculates radon, attached radon progeny, unattached radon progeny as a function of: height above soil, radon flux from soil, vertical turbulent transport, and aerosol concentration. Both codes indicate that it is possible for the concentration of ^{214}Pb to exceed that of its parent ^{218}Po under certain atmospheric conditions. Observations of this apparent decay chain "inversion" have been controversial and to our knowledge our model is the first to provide a sound theoretical explanation. Some of the initial results of this research were presented at the fall AGU meeting (Schery et al., 1990).

Our future plans for this project involve attaining additional data on the campus of NMIMT to more rigorously test our models. With the collaboration of Stewart Whittlestone, we have developed two high volume air sampling stations, each of which can measure attached and unattached progeny at outdoor levels. Flow rates are of the order of 400 lpm and data are logged into two laptop computers using a custom interface. A first year graduate student from Great Britain (Henry McCracken) will be visiting NMIMT for the summer and will help with the measurements. In addition, NMIMT senior Ken Eack, under support from the NSF's Research Experience for Undergraduates program will continue to collaborate on the project.

3. Sources of Indoor Thoron

This project focuses on studying the sources of thoron in indoor air. Much less is known about indoor thoron than about indoor radon, and in particular the relative importance of sources such as building materials, soil, and outside air is poorly understood. Although at present thoron is not a priority pollutant issue in the USA it could well become more important as more is learned about its behavior in the indoor environment. An apparent radioactive "hot spot" has been identified in Yangjiang County, China, and a new issue recently raised for the USA is that residual thoron dose might in some cases limit the effectiveness of present radon mitigation systems. Drs. Schery and Grumm recently completed a review article describing these and other issues entitled "Thoron and its Progeny in the Atmospheric Environment" which has been accepted for publication as a chapter in the Wiley Series "Advances in Environmental Science & Technology."

The key ingredients in our present research plan for studying the sources of indoor thoron are our a one-of-a-kind two-filter system capable of unattended measurement of radon and thoron, and access to homes in New Mexico undergoing mitigation for radon. The idea is to see by how much mitigation systems effective for reducing radon transport from soil are also effective for reducing indoor thoron. This should be a powerful approach since otherwise it is quite difficult to isolate and directly measure thoron contribution from individual sources.

This thoron research is being done in cooperation with an EPA project in New Mexico whose primary purpose is to study the effectiveness of radon mitigation systems(Turk et al.,1991), otherwise the installation of the mitigation systems and accompanying meteorological monitoring would be beyond the means of the present DOE funding. We have access to eight homes that are undergoing mitigation for radon. The primary method of mitigation is subslab depressurization which presumably should be equally effective for reducing radon and thoron transport from soil. Extensive instrumentation has been installed for pressure measurements, measurement of infiltration, meteorological measurement, etc. Since the EPA project operates on a tight home-owner oriented schedule, and the priority is reduction of radon, it has placed great demands on our staff to manage the thoron part of the project in the short time available. However, we think we have obtained important data. This work is being pursued as part of Yanxia Li's dissertation project. A report describing some early results has been accepted for presentation at the June AWMA meeting (Schery et al., 91).

Future plans are first to analyze and model in depth the existing data from the eight houses. Data analysis is not expected to be quick since almost all our measurements associated with thoron and thoron progeny require use of specialized research procedures. For example, although we were able to log some

thoron progeny data with a commercial instrument (Scintrex WLM30), the manufacturer does not supply algorithms for reducing the raw data to PAEC and we have to develop them on our own. We also have to develop special protocols for calibration of our thoron instrumentation. This initial phase could take most of a year after which follow up measurements at other sites might be considered. The DOE sponsored facility at Colorado State University is one possibility. The present measurements are limited to a certain range of housing types (none of our houses have basements) and, depending on our ability to predict sources in other situations by models, measurements at a wider variety of housing might be desirable.

4.Other activities

In terms of fundamental science associated with radon transport through porous media we feel that one of our most important contributions over the last several years is study of sorption and a demonstration that in dry media typically more radon is sorbed than resides in the pore space. In dry media this means radon transport is not simple diffusion through the pore airspace as so often assumed but is strongly influenced by sorption on the surrounding grains. One of our important papers is still in press (Schery et Lopez 1991) and, for the sake of priorities, at the moment we have reduced our effort in this area over the last year. However, we have made some new time dependent measurements of desorption in an effort to elucidate the mechanism of sorption. Other things equal, if sorption is a surface process (adsorption) we would expect faster desorption than if it is a solution process (absorption). Different dependence of sorption coefficients on temperature might also be expected. We're particularly interested in comparing time dependent measurements for organic materials such as cotton or wood with inorganic substances such as concrete or clays. Dr. Vladimir Balek, Nuclear Research Institute,Czechoslovakia has been collaborating with us on this project. At this point our new data has not yet been analyzed.

Dr. Schery spent the (USA) summer of 1990 as a visiting scholar at ANSTO near Sydney, Australia. His major activities were preparation of the review chapter on thoron (see section 3) and experimental measurements of radon and radon progeny on the ANSTO meteorological tower(section 2). Although the activities of this visit were within the purview of the DOE sponsored research the vast majority of costs were covered by the ANSTO visiting scholar program.

Dr. Schery has given a number of talks on radon and thoron over the last year. Locations and dates include

Australian Radiation Lab, Melbourne, 13 Jun 90
ANSTO, Lucas Heights, Aust., 5 Jul 90
Australian Nuclear Organisation, Sydney, 28 Jun 90
ANSTO, Lucas Heights,Aust., 6 Aug 90
Space Physics Institute, Beijing, 14 Aug 90
Laboratory of Industrial Hygiene, Beijing, 13 Aug 90
Hydrology Dept., NMIMT,Socorro, 12 Nov. 1990.

Our most active collaborations remain with Dr. Stewart Whittlestone, ANSTO and Dr. Vladimir Balek, Czechoslovakian Nuclear Research Institute. Dr. Whittlestone spent most of April and May 1991 at NMIMT as a visiting scientist where he helped refine our 79-liter two-filter system for radon/thoron measurement and developed the instrumentation necessary to make measurements of unattached radon progeny. Shorter term visitors to NMIMT include Dr. Jack Kay, Drexel University, Dr. Robert Holub, Bureau of Mines, Denver, and Ivo Martinac, the Swedish Royal Institute of Technology. Dan Gaeddert, a graduate student

at NMIMT and an instructor at Georgetown College, has submitted a draft of his dissertation, "The Effect of Wind on the Exhalation of Radon-222 from a Dry, Gravelly, Sandy Loam" for review. A Ph. D. committee has been formed and his draft dissertation is being read. Professor Emeritus Marvin Wilkening completed a book (Wilkening,1990) on radon in the environment with a focus on soil and the atmosphere. Although Dr. Wilkening no longer receives direct support from our project, we provide him office space and over the years the DOE has supported much of his research on radon. His book summarizes much of what he has learned from these years of experience.

6. References

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