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RADON

Investigations of Radon, Thoron, and their Progeny near the Earth's surface.

Abstract

The overall objective of the proposed research is to improve our understanding of physical processes controlling the concentration of radon, thoron, and their progeny in the atmospheric environment. This information is important for understanding dose delivered to the respiratory track at the breathing level. For the proposed three-year period, emphasis will be on studies, including particle size information, of the disequilibrium between radon, thoron, and their progeny. Thoron will receive special attention because of its rising importance as an indoor pollutant and insufficient study, so far, in the DOE radon program. Indoors the mixing of thoron in rooms and the disequilibrium between it and its progeny will be measured and modeled. Outdoors the disequilibrium of both isotopes and their progeny will be studied as a function of height and meteorological conditions with particular attention to size partitions at the breathing level. Models predicting disequilibrium for both attached and unattached progeny will be tested and refined. Metrology and instrumentation development related to the preceding tasks will be explored, including improved thoron gas measurement and measurement of flux density.

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B. SCIENTIFIC AND TECHNICAL APPROACH

B.1. Objectives (Aims)

The broad objective is to improve our understanding of the physical processes controlling the concentration of radon, thoron, and their progeny in the atmospheric environment. A direct benefit to the DOE radon program should be an improved understanding of the dose delivered to the respiratory track from radon isotopes at the breathing level in a wider variety of environmental situations. Additionally, we hope our research is fundamental enough that results may be of value to related interests of the DOE such as dispersal of radioactivity pollutants and the behavior of radioactive particulates and pollutants near surfaces. Subsidiary benefits of our radon research include scholarship in the field and training of students.

Due to proposal processing constraints it is necessary to propose tasks in the middle of our present project for a three-year period starting almost two years from now. Our lab has a capability of a broad range of topics related to environmental radon. Traditionally, specific details and timetables within broader objectives have been formulated on a shorter time scale to accommodate the changing personnel (such as graduate students) and to benefit from the latest work of other research groups. One of our strengths over the years has been choosing long-range, more fundamental areas of research suitable for investigation in the less-structured academic environment. Therefore, the following more specific objectives are provided as our present best

projections of tasks, but are subject to updating. We plan to address the following questions:

1. In the outdoor environment near the breathing level what disequilibrium between radon and thoron can be expected as a function of height and what is the partition between attached and unattached states so as to enable better estimates of dose? Are there special situations where the dose from these progeny can be significant?

2. Can improved outdoor models be developed that predict disequilibrium and unattached fraction as a function of meteorological, terrain, and aerosol conditions? Are there any implications of these models for the U. S. legislative mandate to achieve indoor radon levels comparable to outdoor levels?

3. In the indoor environment how well mixed is thoron in and among rooms, and what are representative disequilibrium factors and unattached fractions? Can this information be used to make better predictions of thoron dose as fraction of total dose in U. S. housing.

4. How can instrumentation and metrology for thoron gas and thoron exhalation be improved?

B.2. Background

Radon isotopes have been an important object of research dating from Ernest Rutherford's time. Following initial study from the fundamental physics perspective, there has been a long period of interest in applications in the earth and atmospheric science. New Mexico Institute of Mining and Technology's (NMIMT) involvement in radon research started in the 1950's from the atmospheric science perspective under the leadership of Marvin Wilkening. Dr. Wilkening's early work included use of radon as a tracer of atmospheric transport and studies of the flux of radon from a variety of soils and geographical locations. Although now retired from active research, Wilkening recently completed a book on environmental radon summarizing much of his knowledge gained over the years (Wilkening, 1990).

Dr. Stephen D. Schery took over the leadership of NMIMT's atmospheric radioactivity group in 1985 and, following national trends, gave increased emphasis to research applications related to health and the environment. Radon progeny are now recognized to be the single largest source of ionizing radiation dose to the general public (NRC,1990). Due to the years of experience with radon research, the NMIMT group has expertise and equipment capable of dealing with a broad range of radon-related research topics. Choice of investigative topics has tended to be flexible to meet the needs of a less-structured academic environment where personnel such as graduate students can have changing talents and interests. Large-scale projects, programmed projects requiring rigid timetables and elaborate facilities, and standards and calibration facilities have usually been avoided, felt more suitable for institutions like the national labs.

Much of our recent research related to health and environment has been sponsored by the DOE. In broadest terms this research has dealt with the physical processes controlling the concentration and transport of radon, thoron, and their progeny in soil and the indoor and outdoor atmospheres. Some of the high points of this prior research are:

1. In collaboration with Stewart Whittlestone of the Australian Nuclear Science and Technology Organisation (ANSTO) the first continent-wide survey of radon and thoron flux from Australian soils (Schery et al., 1989). This survey was unique for its coverage of thoron flux, and was important for studying factors causing variability of radon and thoron flux over a range of soils. Variation in the escape coefficient was one factor unexpectedly identified to be significant.

2. The first comprehensive study of the sorption of radon on a range of porous materials and establishment of the importance of sorption in control of movement of radon in dry materials (Schery and Whittlestone,1989; Schery and Lopez,1991). This work was cited by Nazaroff (1992) as a significant recent development in radon transport research.

3. Extensive one-of-a-kind study of thoron transport including direct evidence that soil is a major source of indoor thoron (Li et al., 1992) overturning a consensus in the early 1980's that soil was an insignificant source (UNSCEAR 1982). Completion of a review chapter on environmental thoron (Schery and Grumm, 1992). Generally we have done a significant amount of research in the

area of radon transport through porous media (Schery et al.,1988a; Schery et al., 1988b; Holford et al.,1992).

4. Presentation of evidence that progeny size information is important for outdoor progeny modeling, and can significantly improve conventional outdoor models. Revised models provide theoretical support for previously controversial observations of progeny/parent activity ratios greater than one (Schery et al., 1992).

5. Design and construction of a one-of-a-kind two-filter monitor that can simultaneously measure low levels of radon and thoron in unattended operation (Grumm et al., 1990). The thoron capability is at present probably unique in the US.

6.Financial support and research experience for undergraduate students (10), graduate students (5), and post-docs (3) since 1985.

B.3. Progress Report

Within the past several months a detailed progress report on current activities has been submitted (Schery,1992) and will not be repeated here in full. The appendix contains abstracts and title pages of some of our most important publications during the last three years. Here we will focus on those current activities that are most relevant to the proposed new research.

Several years ago Dr. Whittlestone of ANSTO sought our help in trying to interpret outdoor radon progeny data from the Cape

Grim meteorological station. He found it puzzling that the equilibrium factor was so small for concentrations extending to many meters height. What mechanism was so effective for removing radon progeny? About the same time Robert Holub, U. S. Bureau of Mines, was reporting equilibrium factors greater than one, and progeny/parent activities ratios greater than one, under special meteorological conditions near ground at the EPA Robinson Brickyard superfund site in Denver (Holub et al.,1990). Were these data valid? If so, what mechanism could preferentially remove a parent relative to a progeny? These issues seemed quite fundamental to radon research and ultimately relate to our ability to predict disequilibrium and dose at the breathing level. We therefore initiated a review of conventional outdoor models such as Jacobi and Andre (1963), Roffman (1972), and Beck and Gogolak (1979) and became convinced they had major weaknesses. Important among these were the omission of any breakdown of the progeny into size groups and unrealistic assumptions about turbulent transport near the earth's surface. Some of our ideas to correct these shortcomings have been incorporated into new numerical models that we have coded (Schery,1990; Wang, 1991). These models seem to contain steps in the right direction and indicate circumstances where it is possible to have progeny/parent activity ratios greater than one (see fig. 1) and substantial disequilibrium among radon progeny even at many meters height (Schery et al., 1992).

We have optimized equipment for measuring attached and unattached progeny outdoors and are currently collecting data at several heights as a function of meteorological conditions and terrain type for a more rigorous test of outdoor models. We have a field site west of the NMIMT campus. To take advantage of more

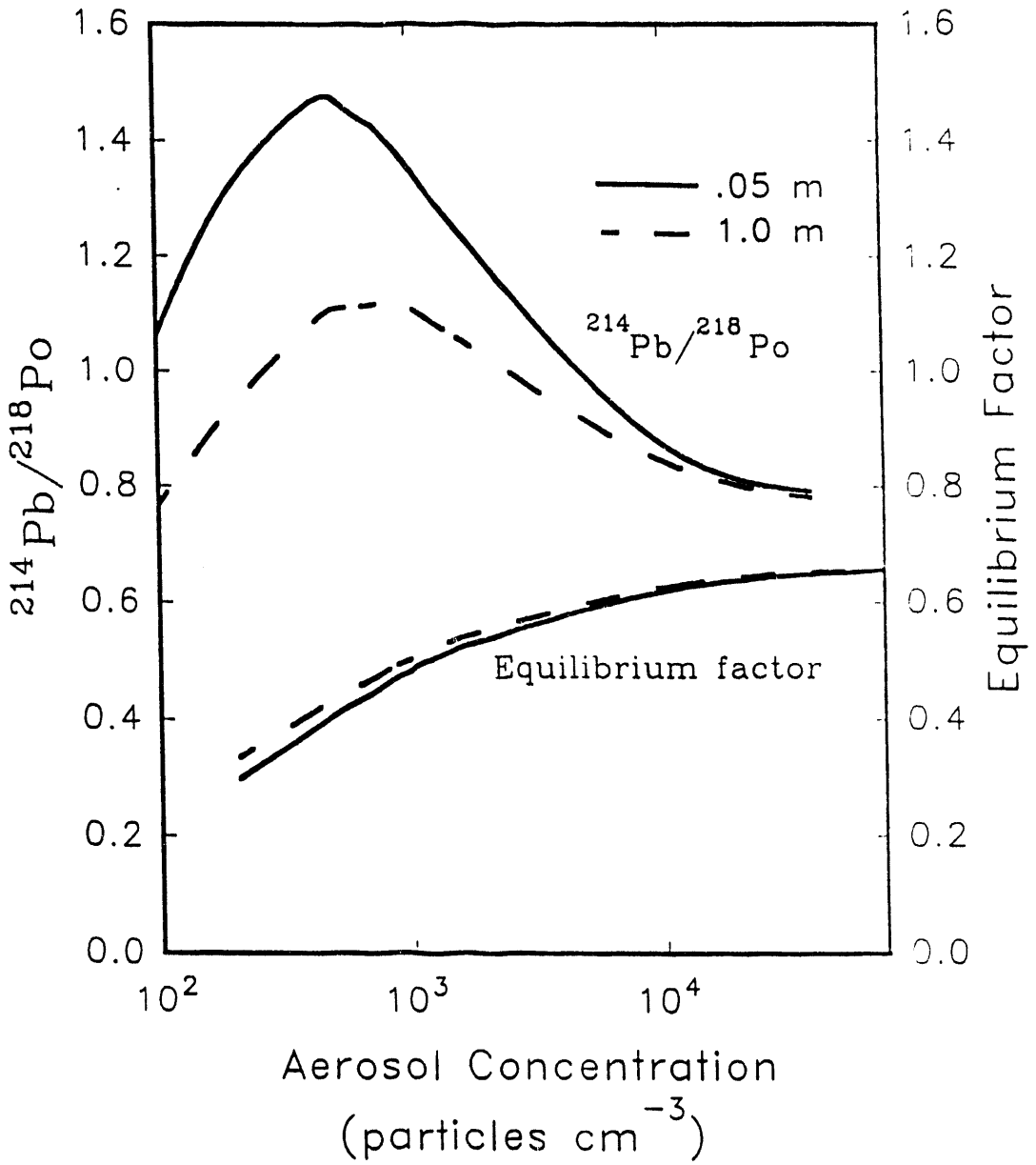

FIGURE 1

Calculations with the code RPOUT (Schery 1990) predicting parent/progeny activity concentration ratios greater than one for heights near ground at moderately low aerosol concentration (Schery et al., 1992).

sophisticated meteorological instrumentation and varied terrain we have collaborated with NOAA groups obtaining data at Mauna Loa Observatory and the Walker Branch Watershed at Oak Ridge, TN. Dr. Wasiolek has had previous experience studying doses from airborne progeny (Wasiolek et al.,1991), and in designing our experimental protocols we keep in mind implications for dose-related issues. Preliminary dose implications from some of our outdoor measurements and a comparison of strengths relative to other sources of ionizing radiation have been discussed in a paper recently submitted for publication (Wasiolek and Schery, 1992).

The other major area of emphasis has been a study of sources of thoron in nine NM houses in which radon mitigation systems have been installed. The approach has been to see the effectiveness of mitigation systems, designed for reducing radon transport from soil, on thoron and thoron progeny levels in these houses. This methodology has proven quite successful and has provided strong evidence of the importance of soil as a source of thoron in single family housing (Li et al., 1992). This project has been successful enough that we feel there is not much more to be done within the scope of our initial objectives. This research forms the core of Yanxia Li's dissertation research nearing completion. New questions are arising from our indoor thoron data that now warrant greater priority. These include how well mixed is thoron in and among rooms, and why are measured indoor equilibrium factors for thoron generally higher than predicted by existing models (see Table 1).

HOUSE	MEAN THORON CONCENTRATION C (Bq m^{-3})	MEAN PAEC(Tn) (mWL)	AEROSOL CONCENTRATION ($\mu g\ m^{-3}$)	MEASURED F VALUE Fm	MODEL PREDICTION Fc	PERIOD (days)
AL02	5.7 (3.3-10.4)	1.1 (1.0-1.5)	9	0.053	0.044	5
AL04	1.4 (0.4-2.3)	0.1 (0.1-0.2)	9	0.020	0.044	1
CE11	8.2 (2.2-21.1)	1.9 (1.7-2.1)	18	0.064	0.051	8
PE21	10.7 (5.2-19.1)	2.3 (0.3-3.7)	12	0.059	0.047	2
SF31	6.2 (2.1-8.1)	1.0 (0.7-1.4)	--	0.044	0.045*	2
TI41	4.9 (0.4-10.8)	1.5 (1.2-2.2)	33	0.084	0.055	1
DRJH	13.5 (8.0-22.9)	4.1 (3.8-4.4)	30	0.083	0.055	4
DRSS	26.0 (14.7-30.9)	1.2 (0.9-1.6)	6	0.013	0.038	4

* The aerosol concentration of 10 $\mu g\ m^{-3}$ is used in the calculation.

TABLE 1

Comparison between measured thoron equilibrium factors, F_m, and calculated thoron equilibrium factors, F_c, for eight NM houses. Calculations with the "well-mixed" model tend to underpredict the equilibrium factor (Li et al., 1992b).

B.4. Proposed Research (Experimental Design)

For the forthcoming three-year period we propose emphasis in three areas of research: 1) continued studies of outdoor disequilibrium and dose with increased attention to thoron progeny, 1) studies of indoor thoron and its progeny aimed at better understanding indoor dose and disequilibrium, 3) various instrumentation projects with special attention to improved thoron measurement and flux density measurements of both thoron and radon. Our broad objective will remain improved understanding of the physical processes controlling concentrations of radon, thoron, and their progeny in the atmospheric environment. We have tried to choose topics that compliment, rather than duplicate, other efforts in the DOE radon program. The direct benefit to the DOE radon program will be improved calculations of dose from airborne progeny and better projections of the indoor hazard from thoron progeny. At the same time, we emphasize study of underlying physical science issues so that we hope our work will be of lasting relevance to other DOE interests such as dispersal of airborne radioactivity and deposition of particulates on surfaces. Further details follow.

B.4.1 Outdoor Progeny

Our equipment for measurement of outdoor radon isotopes and their progeny consists of several two-filter systems that can simultaneously measure low levels of radon and thoron at two-hour intervals, and high volume air samplers flowing at 400 LPM. The air samplers are equipped with a 102mm diameter filter/screen sandwich so that they simultaneously measure the attached and unattached fractions. We presently use 400 mesh screens with a particle cut off diameter of about 1.5 nm, but are exploring the use of higher mesh to get a better bite of the unattached fraction. We typically run two samplers simultaneously, at 20 cm and 2 m height, and the resulting two filters and two screens are counted on four scintillation counters with the data logged into two PC's using a custom interface. The data are analyzed using one of several EML protocols (Knutson,1989). For radon progeny we can conveniently take samples once an hour using an 18 minute sampling period. This equipment has been optimized to be adequate for low outdoor levels. For careful tests of our models it is usually important to obtain simultaneous data at several heights since this provides important information on dry deposition (plate out). We have some conventional meteorological instrumentation (temperature sensors, cup anemometers, wind vanes, pyranometer, etc.) but are finding that the subtleties of turbulent transport and dry deposition require more sophisticated equipment. For this reason we are requesting new supporting instrumentation (especially a sonic anemometer and modern aerosol

counter) and will continue to collaborate with other groups possessing special equipment and expertise in this area such as the NOAA group at Oak Ridge.

The approach to testing our numerical models requires careful measurement of attached and unattached progeny at several heights as a function of meteorological conditions and terrain (roughness) conditions. These can be demanding field measurements requiring travel to diverse field locations at inconvenient seasons and time of day. The biggest present gap in our data is data in smooth terrain under very stable conditions. We are discussing collaborations with NOAA's ASTER program and Monique Leclerc (University of Quebec at Montreal) where we can piggyback our measurements on one of their studies at suitable locations. Another option is nighttime winter measurements at little used airports on the plains of Eastern NM. Our goal is to develop models that can adequately predict disequilibrium of progeny, and attached and unattached fractions, as a function of terrain type and meteorological conditions. Our use of attached and unattached partitions in our models has proven a major advancement. The most challenging present subject appears modeling turbulent transport in the few meters of air just above the soil where critical steps in dry deposition take place. So far we have improved our model predictions by modifying the conventional eddy diffusion parameterizations to include a thin "laminar sublayer" just above the soil where the diffusion coefficients for the unattached and attached fractions are different. However, we frequently measure very small gradients of progeny with height (< 1%/meter) suggesting stronger vertical mixing than implied by conventional eddy diffusion models. The recent micrometerological literature (Baldocchi and Meyers, 1988) suggests that vertical

transport near soil can be dominated by occasional large eddies, and this process, inhomogeneous in time and in space, is not handled well by conventional eddy diffusion models. We wish to explore whether this process is important for radon progeny concentrations and, if so, how to incorporate it into models. This work could also provide ideas for improvement in modeling of indoor turbulent transport.

Practically no analysis has been carried out on outdoor dose from thoron progeny, so this is an obvious next step of our research. Although not commonly recognized, on an activity basis, thoron gas concentrations are normally as high as radon gas concentrations near ground. Initial studies will be at the trailer site west of the NMIMT campus. Our existing screen/filter equipment can be used for progeny measurements, although the counting protocols will require extended counting time so that fewer measurements per day will be possible. The present two-filter protocols for thoron gas will be adequate. It will be interesting to see how the dose from thoron progeny compares with that from radon progeny in light of the most recent dosimetry models (NRC,1991).

B.4.2 Indoor Thoron

Our interest in thoron arises in part from a belief that less is known about it as a potential pollutant than radon, and therefore in a research program it warrants some priority. Thoron progeny are estimated to provide from 10 to 20% of the effective dose equivalent from indoor airborne radioactivity and thus are a significant pollutant, although not as important as radon progeny. Not enough survey information is available to identify if there are geographical locations or types of housing construction where thoron is a special problem, and there may be surprises that await us. Our recent research has focused on studying sources of thoron by measuring changes in concentrations of thoron and its progeny when subfloor depressurization mitigation systems have been turned on. We have found important evidence that soil is a major source of thoron and feel the initial research along these lines is nearly complete. Follow up research would involve similar studies in a wider range of construction types and geographical regions, particularly houses with basements in the northeast. While not ruling out participation in such studies (we have discussed collaboration with R. H. Socolow's group at Princeton University), for a small group we feel we might more effectively follow up some interesting questions that have arisen in regard to our indoor thoron and thoron progeny data . Thoron progeny disequilibrium factors, important for estimating dose, appear larger than predicted by simple "well-mixed" models (Schery and Grumm, 1992, Porstendorfer et al., 1987), perhaps in part due to incomplete mixing of the short-lived parent thoron gas (Li et al., 1992b). Our preliminary

data show interesting diurnal patterns in indoor thoron gas (such as a maximum in the late afternoon) that we as yet cannot adequately explain. Due to thoron's short half-life its concentration should not be affected by ventilation changes. Possible explanations for observed changes include variation in the source term (usually soil) or variation of mixing within or among rooms.

The experimental protocol will be to make more complete measurements of thoron and thoron progeny in nearby NM houses. Measurements at the Colorado State University facility test structure would also be valuable. We will extend progeny measurements to include attached and unattached fractions using the same instrumentation as for outdoor measurements. Subsidiary measurements of total progeny levels will be obtained with commercial instrumentation (Scintrex WLM 30 and alpha track devices of RAD, Inc.). These measurements with commercial devices are more convenient but do not provide the sensitivity of our high volume air samplers and provide no information on the unattached fraction. The most challenging part of this measurement program will be the thoron gas itself. Currently our only reliable option is to use the two-filter systems which are bulky and inconvenient to operate at more than one location. It may be possible to expedite sampling at various positions by using multiple intakes and a rotating valve arrangement. However, the better solution would be to develop cheaper, simpler units so that simultaneous measurements could be made at a number of locations. This issue is addressed further in the instrumentation section below.

In order to work up the data for comparison with indoor "well mixed" and other models it will be necessary to have subsidiary measurements of ventilation, aerosol concentration, and

perhaps turbulence with a sonic anemometer. We can measure ventilation with a SF6 automated release system and gas chromatography previously used on an EPA project in NM (Turk et al., 1991). Our aerosol counter (Rich 200) is obsolete and not working properly so we need a more modern system (TSI 3025). The sonic anemometer requested for the outdoor work can do double duty for the indoor work. To analyze patterns in the variation of the thoron concentration we well also need information on temperature, pressure, and wind at various locations which can be obtained with existing instrumentation used on the EPA project.

Our analysis of data will start with the "well mixed" model (Porstendorfer et al. 1987; Schery and Grumm,1992) and our goal will be to find trends and parameterization that will help predict thoron progeny dose as a function of thoron concentration, aerosol concentration, surface to volume ratios, ventilation, and construction factors. There is a strong need for experimental measurements of deposition velocities for attached and unattached particles and attachment coefficients to aerosols for use in indoor dosimetry. This is core information and should be relatively straightforward to obtain. Data important for dosimetry is evolving and we will remain alert for other information besides sizing and attachment that may be needed. To understand issues such as mixing of thoron gas in a room, or the implication of high levels of thoron gas in a basement for levels in upper stories, more sophisticated modeling is in order. We have prototype turbulent diffusion models that can be refined or we might consider adapting some of the models from the Berkeley group (Gadgil et al., 1992).

B.4.3. Instrumentation and Metrology

There is a need for instrumentation development to support the above tasks. In addition we anticipate certain other instrumentation projects to support special DOE requirements and collaborations with DOE groups.

Our most critical need is for a more convenient instrument to measure indoor thoron gas. For research modeling it is important to study the gas itself, not just the progeny which are generally easier to measure. We are exploring a collaboration with the Australian Radiation Laboratory to develop a flow-through charcoal sampler. A small pump would draw air through a charcoal canister preceded by a filter. After sampling from 12 hours to several days the canister would be gamma counted (probably Tl-208 lines) at the laboratory. Issues to investigate are optimization of size and flow for adequate sensitivity, and to what extent temperature and moisture are a problem. Due to thoron's short half-life it may be possible to design canisters with a breakthrough time much larger than thoron's half-life and render temperature and moisture corrections unnecessary. We need purchase of a high purity germanium detector to use with this project. In addition, this gamma detector will do double-duty in our indoor thoron work assaying source material of soil and building materials.

There are other instrumentation and metrology projects we anticipate being involved in. In addition to intercomparison exercises sponsored by EML, we would be interested in participating in IAEA "section IIIP" activities involving study of exhalation measurement techniques. We have extensive experience in this

area (Schery et al., 1989; Schery, 1988; Schery, 1989) and could look further into the issue of surface accumulator measurements for predicting thoron and radon availability of soil. The Australian Radiation Laboratory has identified a need for accumulator measurements of thoron and has contacted our group about possible collaboration. Our present filter/screen equipment and protocols for measuring outdoor progeny have been optimized more for measuring PAEC than the progeny/parent activity ratios that have been a controversial issue in the experimental literature. To make more careful measurements of disequilibrium among progeny we need to go to a system of a smaller filter and employ alpha spectrometry. Design of such a system uses known principles and equipment and should be straightforward. However, it will require careful calibration to check efficiencies of different alpha peaks and could require purchase of a new large-area silicon detector.

C. BIOGRAPHICAL SKETCHES AND PERSONNEL

The personnel involved with the proposed research would include Dr. S. D. Schery, Professor of Physics, Dr. Piotr Wasiolek, Environmental Physicist, a part-time lab manager/administrative assistant, a graduate student, several part-time undergraduate students, and occasional visiting scientists and consultants such as Dr. Stewart Whittlestone, ANSTO. Dr. Schery has over 13 years experience with radon research and has been leader of NMIMT's atmospheric radioactivity group since 1985. Dr. Wasiolek's dissertation research was on indoor radon in Ireland and he has held a post-doc position with Dr. Hopke before coming to NMIMT as an environmental physicist. Vitae of Dr. Schery and Dr. Wasiolek follow.

8/4/92

RESUMÉ

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EMPLOYMENT BACKGROUND:

Permanent Appointments:

9/90 - Present	Professor (Physics Dept.) and Research Physicist (Geophysical Research Center) - New Mexico Institute of Mining and Technology.
7/84 - 9/90	Associate Professor (Physics Dept.) and Research Physicist (Geophysical Research Center) - New Mexico Institute of Mining and Technology
6/79 - 6/84	Research Physicist and Assistant Professor of Physics - New Mexico Institute of Mining and Technology; Atmospheric and Environmental Radiation Research, Nuclear Physics; teaching in Physics Department
9/74 - 6/79	Assistant Professor - Department of Marine Science, Texas A & M University, Galveston, Texas; Introductory Physics, Modern Physics, Nuclear Engineering, Instrumental Analysis for the Marine Sciences
9/68 - 5/70	Instructor - Cassville High School, Cassville, Missouri; Physics, Chemistry, Computer Math, 7th grade math

Visiting or Part-time Positions:

5/90 - 8/90	Visiting Scholar - Environmental Sciences, Australian Nuclear Science and Technology Organisation
7/87 - 1/88	Visiting Scientist - Yale University, Department of Geology and Geophysics, Geochemistry of Pb 210 and Rn 222
3/86 - 8/86	Visiting Senior Scientist - Physics Section, Environmental Science Division, Australian Atomic Energy Commission; Radon/thoron flux density survey of Australian soils; surveys at Ranger and Tom Price Mines; radon adsorption experiments
6/75 - 8/78	Visiting Professor - Cyclotron Laboratory, Michigan State University; Beam Optics, Neutron Time-of-Flight Measurements, Neutron Elastic Scattering
5/74 - 9/74	Research Associate - University of Colorado; Nuclear Instrumentation, (p,p) and (p,n) Scattering
6/73 - 5/74	Visiting Assistant Professor of Physics - Kenyon College, Gambier, Ohio, Atomic and Nuclear Physics, Intermediate Mechanics, Modern Physics
6/67 - 9/67	Research Assistant - Field Research Laboratory, Mobil Oil Co., Dallas, Texas; Non-Newtonian Flow of Liquid Crystals

Consulting: Cyclotron Lab, MSU, Kerr McGee Corp.; Los Alamos National Labs

ACCOMPLISHMENTS:

Listed in "American Men of Science"
NDEA Fellowship, 1968
Phi Beta Kappa, 1967
Sigma Pi Sigma, 1967
Graduated Cum Laude, 1967
Principal Investigator, National Science Foundation, "Neutron Matter Distribution from (p,n) Quasielastic Scattering," 1977-1979
Co-principal Investigator, Sediment Dating Project, Texas A & M Organized Research Reserve, 1978
Member, graduate faculty, Texas A & M University, 1978
Co-principal Investigator, "Source Characterization and Transport Processes Affecting Levels of Radon and its Decay Products in an Indoor Environment," DOE, 1982-1986
Principal Investigator, "Direct Measurement of Uranium and Thorium Series Isotopes Using L X-rays," SMARI, USDOI, 1983-1985
Principal Investigator, "Physical Processes Important to Airborne Radioactivity in an Enclosed Environment," DOE, 1986-1989
Principal Investigator, "Modeling Transport of Radon and Thoron Through Porous Materials," DOE, 1988 - 1990
Project Manager and Co-Principal Investigator, "The Entry and Control of Radon-222 and Thoron in New Mexico Residences," EPA, 1989 - 1992
Co-Principal Investigator - "Research Experiences for Undergraduates in Atmospheric Sciences," NSF, 1990 -
Principal Investigator, "Transport of Radon and Thoron at the Earth's Surface," DOE 1991 -

COMMUNITY ACTIVITIES:

Science Advisor - Jamestown Elementary School, Jamestown, Colorado, 1972-1973
Science Teacher Volunteer - Mt. Vernon State Hospital, Mt. Vernon, Ohio, 1973
American Red Cross, 1975-present
Tutor - Central Middle School, Galveston, Texas, 1978-1979
New Mexico Wilderness Preservation Groups, 1979 -
New Mexico State Superconducting Super Collider Site Evaluation Committee, 1985 - 1987

PROFESSIONAL ORGANIZATIONS:

American Physical Society, 1973 -
Health Physics Society, 1984 -
American Geophysical Union, 1980 -
Sigma Xi, 1988 -

PUBLICATIONS

"Topics in Numerical Analysis for High School Mathematics," S. Schery, THE MATHEMATICS TEACHER 4, 313 (1970).

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E. FACILITIES

The atmospheric radioactivity group is part of the Physics Department and Geophysical Research Center at NMIMT and occupies about 2000 square feet of lab and office space in Weir Hall. In addition we operate an enclosed trailer at a field site about one mile west of campus. Because the lab has been involved with radon research since the 1950's, it possesses a great deal of relevant instrumentation although there is an ongoing need for repair and modernization. Our equipment includes: two, two filter systems for radon and thoron gas; three, filter/screen systems with data logging electronics for progeny measurements; meteorological equipment including cup anemometers, pressure transducers, temperature sensors, and data loggers; a TSI 3030 aerosol size analyzer; three separate radon flask counting systems; a Rich 200 CN counter; Pylon sources for radon and thoron gas; a custom built electrostatic precipitator system for progeny measurements; an M800 portable MCA; a Scintrex WLM 30 monitor;an IBM model 70 and an IBM model P70 personal computer; custom accumulators for flux measurements; and a sulfur-hexafluoride release system for ventilation measurements. The computer center of NMIMT maintains a system of SUN computers which are available for use. The Institute also maintains a professionally staffed machine shop.

Our greatest need for upgrading is in the area of aerosols, gamma counting, and turbulence measurement. Our TSI 3030 system (aerosol size analysis) is obsolete and unable to log data at programmed intervals. The most desirable solution is a more modern system but as a cost compromise we propose purchase of an upgrade package permitting interfacing of the TSI 3030 to a PC, and more versatile control and data logging. Our RICH 200 CN counter is also obsolete and despite returns to the factory cannot be adequately calibrated and cannot measure low aerosol concentrations. We propose purchase of a modern design CN counter (TSI 3025). Our 10-year old germanium detector has been damaged and we propose replacement with a modern, portable unit (such as an ORTEC GEM 30-195). This system will be used for assay of source materials and counting of the charcoal canisters for the thoron detector project. The study of dry deposition both indoors and outdoors demands a high performance anemometer for measurement of turbulence. We propose purchase of a three-axis sonic anemometer (Applied Technology SWS-211/3SX). Finally, by the end of the proposed project (almost five years from this writing) our PC's will almost certainly require upgrading and replacement so we propose purchase of an up-to-date system (currently a 486 machine).

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