Final Report

to the
Office of Health and Environmental Research
Office of Energy Research
U.S. Department of Energy

Organization and Operation of the
Sixth International Symposium on the
Natural Radiation Environment (NRE VI)

Held in Montréal, Québec, Canada
June 5 to 9, 1995

Prepared by
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Under Grant DE-FG02-94ER61784

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INTRODUCTION

An important source of human exposure to radiation is the natural world including cosmic rays, cosmogenic radionuclides, natural terrestrial radionuclides, and radon isotopes and its decay products. Considerable effort is being expended on a worldwide basis to characterize the exposure to the natural radiation environment and determine the important pathways for the exposure to result in dose to tissue that leads to injury and disease. The problem of background exposure to naturally occurring radioactivity has been the subject of research since the initial discovery of the radioactivity of uranium and thorium. However, with the advent of artificial sources of radiation with both benefits (medical x-rays and nuclear medicine), and harm (Chernobyl fallout), the nature and magnitude of the natural radiation environment and the effects on various populations are important in the development of overall public health strategies as ALARA principles are applied.

To facilitate the exchange of information and the review of uncertainties and scientific research priorities, a series of 5 international meetings on the subject of the Natural Radiation Environment (NRE) have been held beginning in 1963 in Houston and continuing through the 1987 Meeting in Lisbon, Portugal and the 1991 meeting of NRE V in Salzburg, Austria. This conference is unique in that its subject matter covers the range of natural radiation environments that give rise to human exposure and dose. Currently, there are significant on-going research programs around the world. A principal research focus in recent years has been on radon through programs supported by the U.S. Department of Energy (DOE), the Commission of the European Communities (CEC), and the International Atomic Energy Agency (IAEA) as well as studies in a number of other countries such as Sweden and Germany to examine the relationship between indoor radon and the incidence of lung cancer. However, other studies of the natural radiation environment are continuing and need to be integrated into our understanding of the overall natural background exposure and dose. Thus, much new information is being obtained on pathways leading to exposure, the variability in exposure conditions, exposure/dose relationships, and the biochemical pathways leading from dose to the onset of disease.

To obtain the maximum benefit from the investments being made in these research programs, it is critical to exchange information among the various groups performing the studies. Each of the individual groups such as the DOE, CEC, and IAEA hold periodic co-ordination meetings to exchange information and focus the research onto the critical uncertainties that limit our understanding of the exposure/dose/response relationship. As has been seen with the past NRE and other related
meetings (Bombay, Capri), the opportunity to meet with our colleagues from around the world, present recent findings, and discuss the nature of the remaining research problems, provides a major stimulus to research productivity and synthesis of knowledge leading to identification of the critical pathways to reducing uncertainties in the risk estimation and providing for better mitigation of those risks. Thus, to sustain the continuing communication among these research efforts to characterize and understand the role of the natural radiation environment in the context of the overall human.

The Sixth International Symposium on the Natural Radiation Environment was held in Montreal, Quebec, Canada between June 5 to 9, 1995.

SYMPOSIUM OBJECTIVES

The purpose of the 6th International Symposium on the Natural Radiation Environment is to provide a high quality scientific forum for the exchange of information and the assessment of the state of knowledge concerning the potential health impacts of natural radiation and radioactivity on the human population. The symposium will stimulate discussions on the state of the art in the field, to help identify the gaps in our knowledge base, assist in setting priorities for future research, and to provide the opportunity to perform this research in a coordinated manner so as to minimize duplication and overlap. The topics to be covered in the Symposium include: natural radioactivity sources including enhancement of the natural radioactivity by anthropogenic activities, environmental concentration and transfer pathways, environmental impacts of natural radiation, public health effects, radiation technologies, exposure, dose, and risk assessment, and risk management strategies.

SYMPOSIUM ORGANIZATION

The symposium was under the general chairmanship of Dr. Philip K. Hopke, The R.A. Plane Professor of Chemistry at Clarkson University. Professor Hopke was assisted by an Organizing Committee and a Technical Program Committee. The members of these committees are given in Tables 1 and 2.

Table 1. Organizing Committee

<table>
<thead>
<tr>
<th>P. Duport, AECB-Ottawa</th>
<th>F. Marcinowski, EPA-USA</th>
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</thead>
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<tr>
<td>P. Hopke, USA</td>
<td>M. Olast, CEC-Brussels</td>
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<tr>
<td>A. Janssens, CEC-Luxembourg</td>
<td>S. Rose, DOE-USA</td>
</tr>
<tr>
<td>W. Lowder, USA</td>
<td>J. Sinnaeve, CEC-Brussels</td>
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</tbody>
</table>
Table 2. Technical Program Committee

S. Abe, Japan        A.C. James, USA        G.M. Reimer, USA
T. Borak, USA        E. Knutson, USA        A. Renoux, France
S. Conrath, USA      J.P. McLaughlin, Ireland C. Samuelsson, Sweden
A. Craig, USA        J. Miles. U.K.         S. Schery, USA
T. Gesell, USA       U.C. Mishra, India     R. Sextro, USA
C. Gogolak, USA      R. Mosely, USA        F. Steinhäusler, Austria
N. Harley, USA       J. Porstendörfer, Germany L. Tommassino, Italy
R. Holub, USA

Technical Program

The program was developed from the 261 abstracts submitted prior to the deadline for initial submissions. In addition, 32 abstracts were submitted to the Late-Breaking Poster Session so that a possible 293 scientific papers were included. However, there were several that were withdrawn at the copy of the final program is given in the Appendix. This program lists the plenary as well as the platform and poster session papers. To sort the papers between and poster and platform sessions, the abstracts were grouped into logical topic areas and assigned to 2 members of the Technical Program Committee for review. They provided as coordinated set of recommendations for the placement of the papers as well as helping to recruit the session chairs. The Technical Program and Organizational Committees both assisted in the selection of those people to whom financial assistance to attend the meeting would be given. It was thus possible to have a number of eastern Europeans and Asian participants who would not otherwise have been able to attend.

As a result of the Symposium, 204 manuscripts were submitted for peer-review and potential inclusion in the proceedings issue. Prior to the meeting and with the concurrence of the Organizing Committee, we had arranged to publish the papers in a special issue of The Science of the Total Environment. The Editor-in-Chief, Dr. Eric Hamilton, had been fully informed of the number of abstracts and the likely number of manuscripts that were expected. The vast majority of the papers were mailed to the Secretariat before the meeting or collected at the meeting venue. A few manuscripts were submitted subsequent to the end of the meeting sessions. All of the manuscripts submitted were sent out for review within 3 weeks of the end of the meeting. However, in early
July, Dr. Hamilton decided that there were too many manuscripts and he would only allow publication of those manuscripts that he would select from all that were submitted and reviewed. This was clearly an unacceptable situation and thus, we withdrew from our association with this journal. At this late date, *Environment International* was contacted and Dr. A. Alan Moghissi indicated an interest in publishing the proceedings. However, since he had already committed to other projects, we have now agreed to publish the proceedings as a supplementary volume of the journal. It will still be distributed to all of their regular subscribers so it will be archived in libraries. A copy will be provided to each Symposium participant including the representatives of the sponsoring bodies. As a result of some of the problems with publication, 17 manuscripts were withdrawn.

After review, 32 manuscripts were rejected, and thus, these papers will not be published. The authors can submit them elsewhere using the reviews provided as guidance to improve their manuscript. As with any large group of papers, we had several papers for which we had trouble getting reviews, but as of February 1, 1996, all of the papers had been peer-reviewed and returned to the authors for correction. Of the remaining manuscripts, 155 have been accepted and forwarded to Dr. Moghissi for final review and publication. When we were last in touch with Dr. Moghissi, we were told that the proceedings volume will be published and distributed in early fall of 1996 or a little after the end of the meeting.

The scientific content of the meeting is provided in detail in the proceedings papers. It will be seen that, in general, we have obtained a much more detailed understanding of the natural radiation environment and in particular, we have gathered a considerable amount of information on \(^{222}\text{Rn}\) behavior, entry pathways, measurement methods, dosimetry, and potential risk.

In terms of new research needs, there are several that appear to be significant. Potential exposure to manmade or technologically enhanced natural radiation in many areas of the world needs to be reduced. Such reduction will require the removal of radiation from massive quantities of material. Clearly, site remediation in the presence of a natural background presents a significant future problem in deciding the limits to which sites should and can be mitigated.

There are also additional details to be studied regarding the most significant source of exposure to natural radiation, \(^{222}\text{Rn}\) and \(^{220}\text{Rn}\). For example, there is still uncertainty as to how effective retrospective radon exposure assessments can be using embedded radon decay products. Improvements in these techniques would make ongoing residential epidemiology more effective. We have made significant progress over the past 10 years in our understanding of radon-related
phenomena. However, with planned large reductions in support for further work in this area, it appears that it may be some time before these additional details are researched fully.

We believe that the meeting fulfilled its objectives and provided a forum for the exchange of information and views on natural radiation related issues. It is hoped that this useful series of meetings will be permitted to continue in the future.
APPENDIX
Final Program for NRE-VI
Monday, June 5, 1995

08:15  Opening of the Symposium, Grand Salon B
       Welcome: Philip K. Hopke

08:20  Plenary Lecture: Roger Clarke
       Control of Exposure to Natural Radiation: An ICRP Perspective

09:10  US Department of Energy, Office of Health and Environmental Research

09:25  Environmental Protection Agency, Office of Indoor Air and Radon

09:40  Commission of the European Communities, DG-XI-A-1 Radiation Protection

09:50  Commission of the European Communities, DG-XII-D-3 Radiation Protection
       Research Action

10:00  International Atomic Energy Agency, Coordinated Research Programme on Radon in
       the Human Environment

10:10  Refreshment Break

Exposure to Background Radiation I

Co-Chairs: T. Gesell and F. Pernička

10:30  1A1. Uranium Hot Spots in Swiss Teriary
       Jöhnker

       Natural Radioactivity Mapping of Greek
       Surface Soils, S.E. Simopoulos

11:10  1A3. Natural Background Radiation Dose
       Assessment in Taiwan, Y.M. Lin

11:30  1A4. Natural Radiation Exposure in Canada, D.
       Azimi

11:50  1A5. Variations in Natural Background Radiation
       Across Canada, B.L. Tracy

12:10  1A6. Fractal Methods In Environmental
       Radioactivity, T. M. Semkow

Radon Measurement Methods

Co-Chairs: T. Borak

1B1. Monitoring Radon and Radon Progeny
     Using a Scintillating Glass Optical Fiber, A.
     Appleby

1B2. On the Development of a Continuous Tn &
     Rn Concentration Monitor and Evaluation of Time
     Sequential Variation of the Exhalation Rate of Tn
     & Rn from Various Soils and Wall Materials, T.
     Iimoto

1B3. Measurement Of Alpha Emitting Nuclei In
     The Environment By Nuclear Track Detectors.
     Contributions To The Evaluation Of The
     Calibration Factor, O. Sima

1B4. An Analysis of Efficient Measurement
     Procedures for Radon Progeny, R. Rolle

1B5. α Spectroscopy on CR-39 Track Detectors
     for the Dosimetry of Radon Daughters, P. Mozzo

1B6. Study of the Variation of Rn Indoor
     Concentration with Several Passive Detectors and
     an Active Detection System, C. Baixeras

12:30  Lunch Break
Exposure to Background Radiation II.
Co-Chairs: A. Siniscalchi and V. Cuculeanu

13:30 2A1. Analysis of Eighteen Years of Environmental Radiation Monitoring Data, P. Shebell

13:50 2A2. Continuous Airborne Radiation Level Measurements by 4' X 4'NaI Detector with 4 Channel Discriminators, M. Sakanoue

14:10 2A3. Variations of Natural Radiation Background And Their Effect on Detector Response, F. Pernička

14:30 2A4. A Deterministic Method for Identifying the Presence of Radioactivity in Excess of Background, T.B. Borak

14:50 2A5. Spatial and Temporal Variety of Outdoor Radiation Levels in the Netherlands; Results of an Exploratory Data Analysis, R.C.G.M. Smetsers


15:30 Refreshment Break

Radon in Spas and Caves
Co-Chairs: R. Holub and P. Szerbin

2B1. The Radon in Various Environmental Factors in Huruciane SPA From Cerna Valley (Romania), C. Cosma

2B2. Radioactivity of Balneotherapeutic and Speleotherapeutic Facilities in Hungary, P. Szerbin

2B3. Occupational Exposure to Radon in Treatment Facilities of the Radon-Spa Badgastein/Austria, H. Lettner

2B4. Radon Exposure to Tour Guides in Australian Show Caves, S.B. Solomon

2B5. Radon and Radon Progeny in the Carlsbad Cavern, Y.S. Cheng

2B6. Radon Concentrations in Showcaves in Ireland, A. McGarry

Radon in Soil Gas
Co-Chairs: L. Tommassino

3B1. Evaluation of Radon Emanation From Soil With Varying Moisture Content, M.Y. Menetrez

3B2. Spatial and Temporal Variations of Soil Gas $^{220}\text{Rn}$ and $^{222}\text{Rn}$ at Two Sites in New Jersey, A.R. Hutter

3B3. Variation of Radon Concentration in Soil Gas at One Site, A.B. Tanner

3B4. Soil Radon Exhalation Rate as a Function of Rainfall and Soil Suction Pressure, Y.M. Amin

3B5. Measurements and Calculations of Soil Radon Flux at 325 Locations Throughout Florida, K.K. Nielson

3B6. Time-Variation of the Soil Gas Radon Concentration Under and Near a Swedish House, L.M. Hubbard
Tuesday, June 6, 1995
08:30

Plenary Lecture: W. Rönsch,
Mining Site Remediation and Natural Radiation Background,
Grand Salon B

09:30 Poster Session 4 and Refreshment Break

<table>
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<tr>
<th>Radon in Spas and Caves</th>
<th>Exposure to Natural Background</th>
<th>Measurements</th>
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<th>Radioactivity in Water</th>
<th>Radioactivity in Ambient Air</th>
<th>Perturbed Natural Radioactivity</th>
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<tr>
<td>4D2. Natural Radioactivity in the Danube Delta Waters, C. Cosma</td>
<td>4E2. Scavenging of Radon Daughters by Precipitation from the Atmosphere, N. Fujinami</td>
<td>4F2. The Temporal Distribution of $^{210}$Pb and $^{210}$Po in Surface Sediments in the Vicinity of a Phosphoric Acid Production Plant, W.C. Camplin</td>
</tr>
<tr>
<td>4D4. Determination of Dissolved Radon and Radium Content of Water Samples by Track Etch Method, J. Hakl</td>
<td>4E4. $^{222}$Rn Concentration in Outdoor Air at Wakasa District in Japan, Y. Ogawa</td>
<td>4F4. Soil-Fungi Radiocaesium Transfer in Forest Ecosystems in Mexico, N. Segovia</td>
</tr>
</tbody>
</table>
4D5. Transportation of Radionuclides from Western Ghat Area to Major River Estuaries of Coastal Karnataka, India, K. Siddappa

4D6. Gamma Spectrometric Measurement Of Pb-210 in Environmental Samples, O. Sima

4E5. Radon and Thoron Studies in Japan, S. Kobayashi

4F5. Radioecological Investigation of Soil in Relation to Nuclear Power Siting, M. Mandic

4E6. Estimation of Environmental Radon Levels in Garhwal Himalaya, R.C. Ramola

4F6. The Dependence of the Thoron Progeny on the Safety Protection of Workers in the Plutonium Workplace, H.L. Pai


4F7. $^{137}$Cs Chernobyl Fallout in Greece and Its Associated Radiological Impact, S.E. Simopoulos


4F9. Uranium Leaching in Soils from Phosphate Fertilizer, S. Landsberger

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**Variability of Indoor Radon I.**

Co-Chairs: M. Benes and P. Wasiølek


5B2. Time Variation of Indoor Radon Concentration in Typical Norwegian Homes, T. Strand

5B3. Spatial Variation of Indoor Radon Concentration as Measured by Various Types Radon Detectors, R.H. Mahat

5B4. Diurnal Variation of Radon Progeny in Indoor and Outdoor Air of a Subtropical City, C.-J. Chen

5B5. Characteristics and Temporal Variation of Airborne Radon Decay Progeny in the Indoor Environment in Catalonia (Spain), X. Ortega

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10:20 5A1. Methodical Aspects of Radon Exhalation Measurements; Examples on Uranium Mining Area, J. Hakl

10:40 5A2. Atmospheric Dispersion of Radon From Uranium Mining and Milling Wastes: Tentative Models and Field Data, Y. Belot

11:00 5A3. Rehabilitation of a Uranium-Ore Residues Storage Site at Le Bouchet in the Paris Region, V. Labed

11:20 5A4. A USDOE Remediation Site Case Study, I.M. Fisenne

11:40 5A5. Mercury Ore Processing - A New Technologically Enhanced Source of Natural Radioactivity, M. Krizman

12:00 Lunch Break

13:15 Plenary Lecture: André Renoux
The Discovery and History of Knowledge of Natural Atmospheric Radioactivity, Grand Salon B

Perturbation of Natural Activity II.
Co-Chairs: S.K. Dua and Z. Zunić

14:20 6A1. The Radiological Impact of Discharges of Natural Nuclides from a Phosphogypsum Plant in the UK, W.C. Camplin

14:40 6A2. Applied Geochemistry in Uranium Prospecting and Determination of the Regional Ecological Status, Z. Zunić

15:00 6A3. The Enrichment of Natural and Artificial Radionuclides in the Upper Horizons of Forest and Moor Soils, N. Schleich

15:20 6A4. Problems of Natural Radioactivity in the Beach Sand Deposits of Ilmenite, Zircon and Monazite and in the Mineral Processing Factories in Vietnam, P. Van Duong

15:40 6A5. Radioactive Deposits in Polish Coal Mines and its Influence on the Natural Environment, B. Michalik

16:00 Refreshment Break

Radioactivity in Water
Co-Chairs: G.N. Sandor & C. Samuelsson

16:20 7A1. The Partitioning of Natural Radionuclides Between the Particulate and Soluble Phases in the Fresh Water Ecosystem of a Large Alpine River, F.J. Maringer

16:40 7A2. Radon as a Natural Groundwater Tracer in the Chalk, R. Low

17:00 7A3. Radioactive Disequilibrium of Uranium and Thorium Series Nuclides In Peitou Hot Spring Basin in Taiwan, T.C. Chu

17:20 7A4. Radioactive Contamination of Surface Waters From a Fly-Ash Depository At Lake Velenje (Slovenia), L. Mijač

17:40 7A5. Formation Waters From Oil and Natural Gas Production - Potential Polluting Source by Radium 226, G.N. Sandor

Indoor Radon Surveys I.
Co-Chairs: D.J. Steck and K.S.V. Nambi

6B1. Year to Year Variation of Indoor Radon Concentrations, D.J. Steck

6B2. A Health Risk Assessment Model for Homeowners with Multiple Pathway Radon Exposure, A. Siniscalchi

6B3. A Compact but Effective Nation-Wide Survey of Population Dose Due to Radon and Its Progeny in Japan, S. Abe

6B4. Survey of Indoor Radon Concentration in Austria the Austrian Radon Project, H. Friedmann

6B5. Report on the First Phase Activity of an EU-PROJECT Concerning Coordinated Radon Measurements in Five European Countries, C. Baixeras

17:00 Radon Survey
Co-Chairs: A. Renoux & B. Fitzgerald

7B1. Regional and Local Variation of Indoor Radon and Radon Source Potential, S.A. Baynes

7B2. Estimation of County Radon Levels in Minnesota, Based on Sparse Data, P.N. Price

7B3. Identification of Radon Affected Areas in Norway, T. Strand

7B4. Levels of Radon in Houses in the United Kingdom, G.M. Kendal

7B5. Indoor Radon Survey in the Most Populated Areas in Spain, C. Baixeras
18:00  7A6. Radium in Mine Waters in Poland: Occurrence and Impact on River Waters, S. Chakupnik or B. Michalik

7B6. Joint Use of Long- and Short-Term Data To Estimate Annual-Average Radon Distributions by County, P.N. Price

Wednesday, June 7, 1995

08:30 am

Plenary Lecture: Justin Porstendörfer
Radon: Measurements Related to Dose, Grand Salon E

09:30 am  Poster Session 8 and Refreshment Break

Exposure Caused by Waterborne 222Rn

8A1. Radon-222 Concentration in Water and the Exposure to Public, T. Ren

Retrospective Exposure Assessment

8B1. The Measurement and Assessment of 210Po Surface Activity on Glasses in Dwellings, J.P. McLaughlin


8B4. Radioanalysis of Soil and Crops Grown on Former Tin Mining Area, R.H. Mahat

222Rn Exposure Assessment

8C1. Passive Integrating 222Rn and 220Rn Cup Monitors with CR-39 Detectors, T. Iida

8C2. A Calibration Chamber for 220Rn, H. Møre


8C4. Polish Active Dosimeter for Measurement of Individual Exposure of Miners to Radioactive Radon Daughter Products, J. Olszewski


8C6. Continuous Radon Monitors Cross-Checked in 15 Different Calibration Chambers around the Globe, V. Genrich

8C7. Intercomparisons of 222Rn Measurement Systems In European Laboratories, J. Dean
### Radon Progeny Characterization

8D1. Time Integrated Measurement of Unattached Fraction of Radon-222 Daughters by Using an Alpha Track Detector in an Annular Diffusion Channel, G. Tymen

8D2. A Field Diffusion Sampler for Sizing the Radon Progeny Aerosols in Indoor Air, I. Östergren

8D3. A Compact Sampler for Measuring Airborne Activity Weighted Particle Size Distributions, S.R. Hunter

8D4. A System Used for Size Determination of Radioactive Aerosol Particles, L. Fei

### Radioactivity in Materials

8E1. Dose Assessment and Reduction Methods of Indoor Exposure in the Case of Imported Building Materials, S. Pavlović

8E2. Use of Mineral Wastes Containing Natural Radio-nuclides for Building Purposes, R. Lehmann

8E3. Study on the Natural Radioactivity Regulation Standards for Stones as Building Material, C.-J. Chen

### Radioactivity in Tobacco

8F1. Natural Radioactivity Content of Greek Cigarettes and the Effect of Their Smoke to the Indoor Air Radon Daughters Concentration, S.E. Simopoulos

8F2. Measurement of Radioactivity in Tobacco, M.S. Elmegrahi

### Radon in Soil Gas

8G1. Geologic Controls on the Radon Emanation Coefficient, R.R. Schumann

8G2. Radon Distribution in the Phosphate and Limestone Terrain of Florida, G.M. Reimer

8G3. Radon Distribution and Control in the Limestone Terrain of Western Ireland, M. Ort

### Radon Progeny: Measurements

Co-Chairs: J. Porstendörfer & E. Knutson

10:30 9A1. A New Instrument to Measure Individual Size Distribution of Radon Daughters, G. Tymen

10:50 9A2. Size Distribution of 'Unattached' Short-Lived Radon Decay Products in Homes and at Working Places, A. Reineking

### Radioactivity in Materials

Co-Chairs: I. Fissenne


9B2. Development of In-Situ Apparatus for Measuring Thoron and Radon Exhalation Rate, M. Shimo
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<thead>
<tr>
<th>Time</th>
<th>Session</th>
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<tr>
<td>11:50</td>
<td>9A5. Indoor Radon and Radon Daugther Behaviour in a Mediterranean Climate Area F. Bochicchio</td>
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<td>12:30</td>
<td>Lunch Break</td>
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<td>13:30</td>
<td>Ingestion and Uptake</td>
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<td>13:50</td>
<td>Co-Chairs: N. Harley</td>
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<td>14:30</td>
<td>10A2. Effects of Volatile Organic Compounds (VOC) and Water Vapor on the $^{218}$Po$^+$ Cluster Aerodynamic Size Distribution, O.O. Olawoyin</td>
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<td>14:50</td>
<td>10A3. Dependence on the Radon Progeny Size in the Ultrafine Cluster Mode on Environmental Parameters, G. Butterweck</td>
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<td>15:10</td>
<td>10A4. Aerosol Wall Deposition in Enclosures Investigated by Means of a Stagnant Layer with Complex Internal Boundary: Theory and Simulations, M. Benes</td>
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<tr>
<td>15:30</td>
<td>10A5. An Extended Radon Chamber Model, G. Butterweck</td>
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<tr>
<td>15:50</td>
<td>10A6. Exposure Assessment for Showering with $^{222}$Radon Bearing Water Based on a Dynamic Model for the Airborne Activity Size Distribution, V. Darye</td>
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<td>16:00</td>
<td>Refreshment Break</td>
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<td>16:00</td>
<td>11A1. Dose Repartition in Alveoli, Alveolar Ducts and Bronchi Cells of Rats Exposed to Radon and Its Progeny, M. Bisson</td>
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<td>17:10</td>
<td>11B1. Radon Migration in the Ground IV, A.B. Tanner</td>
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<tr>
<td>17:30</td>
<td>Radon Transport I.</td>
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**Radon Progeny: Mechanisms**

- Co-Chairs: N. Montassier and V. Dayte
- 10A2. Effects of Volatile Organic Compounds (VOC) and Water Vapor on the $^{218}$Po$^+$ Cluster Aerodynamic Size Distribution, O.O. Olawoyin
- 10A3. Dependence on the Radon Progeny Size in the Ultrafine Cluster Mode on Environmental Parameters, G. Butterweck
- 10A4. Aerosol Wall Deposition in Enclosures Investigated by Means of a Stagnant Layer with Complex Internal Boundary: Theory and Simulations, M. Benes
- 10A5. An Extended Radon Chamber Model, G. Butterweck
- 10A6. Exposure Assessment for Showering with $^{222}$Radon Bearing Water Based on a Dynamic Model for the Airborne Activity Size Distribution, V. Darye

**Ingestion and Uptake**

- Co-Chairs: N. Harley
- 10B1. Uranium Gastrointestinal Absorption Studies - Design Issues, J.M. Zielinski
- 10B2. The Radiological Importance of Po-210 and Pb-210 In Terrestrial Foodstuffs from England and Wales, D.R.P. Leonard
- 10B3. Estimated Internal Radioactive Burden of Coal and Uranium Miners By Alpha and Beta Radiation Measurements For Some Internal Organs, J. Kőbor
- 10B4. Natural Radioactivity of Drinking Water in Catalonia (Spain), X. Ortega
- 10B5. Assessment of the Natural Radioactivity in the Drinking Water of the
- 10B6. Utilization of Auto-Radiography For U, Th and Isotopic Disequilibrium Study of Siwalik Fossil Bones, B.S. Bajwa

**Radon Dosimetry and Risk**

- Co-Chairs: A.C. James and G. Monchaux
- 11A1. Dose Repartition in Alveoli, Alveolar Ducts and Bronchi Cells of Rats Exposed to Radon and Its Progeny, M. Bisson

**Radon Transport I.**

- Co-Chairs: L.M. Hubbard
- 11B1. Radon Migration in the Ground IV, A.B. Tanner

11B2. The Effects of Root Penetration on Radon Transport in Soil, T.B. Borak


11B3. Direct Measurement of Soil-Gas Entry into an Experimental Basement Structure Driven by Atmospheric Pressure Fluctuations, A.L. Robinson

11E4. Soil Characterization for Indoor Radon Potential at Twenty Schools in New York State, C. Kunz

17:00 11A4. Comparison of Different Modeling Approaches in Current Lung Dosimetry Models, W. Hofmann

11B4. Experimental Evaluation of Geometrical Shape Factors for Short Cylindrical Probes Used to Measure Soil Permeability to Air, R.B. Mosley

17:20 11A5. Risk Assessment Implications of Temporal Variations in Radon Exposures in Schools, A. Siniscalchi

11B5. Indoor Radon Prediction From Soil Gas Measurements, N.R. Varley

17:40 11A6. Variability of the Radon Dose Conversion Factor Affected by Biological Parameters, C. Zock

19:00 Conference Dinner

Thursday, June 8, 1995

Time
08:30

Plenary Lecture: Jon Samet,
Reevaluating the Risk from Indoor Radon, Grand Salon B

09:30 Poster Session 12 and Break

Radon Dosimetry

12A1. Incorporation of Biological Variability into Lung Dosimetry by Stochastic Modeling Techniques, L. Koblinger

12A2. The Variability of Radon Decay Product Dose, N.H. Harley

12A3.

12A4. Track Structure Predictions of Radon-Induced Biological Effects in Human and Rat Bronchial Epithelium, W. Hofmann

Radon Transport

12B1. A Model for Radon Entry in Dwellings, V. Roca


12B3. Radon From the Soil to the Dwelling: Comparison Between Three Subsoils in Southern Belgium, F. Tondeur

12B4. An Investigation of Factors Affecting the Entry of Radon into Structures on the Island of Guam, J. Burkhart or M. Thornburn

Radon Mitigation

12C1. National Approaches to Controlling Exposure to Radon, P.A. Colgan

12C2. Assessment of Pressure-Field Extension Below Slab-On-Grade Concrete Floors, T. Gregory

12C3. Trails of Radon Remedies in a UK Test House, C. Scivyer

12C4. Effectiveness of Passive Radon-Resistant Construction, B. Dewey
12A5. Deposition of $^{214}$Pb and Nuclear Aberrations in Alveoli of Rats After Exposure to Radon Under Different Conditions, J.P. Morlier

12A6. The Testing of Radiobiological Models of Radon Carcinogenesis Needed for In-Vitro to In-Vivo Extrapolations, D.J. Crawford-Brown

12A7. Deposition Patterns of Inhaled Radon Decay Products in Human Bronchial Airway Bifurcations, T. Heistracher

12C5. U.S. EPA Radon Mitigation Standards, G.L. Salmon


12C7. A Campaign to Reduce the Risks of Lung Cancer from Indoor Radon Gas Exposure in African-American Communities by Increasing Awareness, G.C. Bryan


Retrospective Exposure Assessment
Co-Chairs: A. George

10:30  13A1. Plateout and Implantation of $^{222}$Rn Decay Products in Dwellings, C. Samuelsson

10:50  13A2. On the Validity of Past Radon-Exposure Reconstruction: Person-Exposure - vs Dwelling Exposure-Assessment, F. Steinhäusler

11:10  13A3. Retrospective Assessment of Radon Exposure by Measurements of $^{210}$Po Embedded in Surfaces Using an Alpha Track Detector Technique, L. Nyblom


Radon Transport II
Co-Chairs: G.M. Reimer

13B1. Estimating the Impact on Radon Entry Rate of Steady Wind-Induced Ground Pressures: Predictions with Wind Tunnel Experiments and a k-$\varepsilon$ Turbulence Model of Wind Flow, W.J. Riley


13B3. Enhanced Soil-Gas Entry into a Radon Test Structure Located on Clayey Till, C.E. Andersen


13B5. A Study of the Influences of Diffusion and Adveotive Flow on the Distribution of Radon Activity within the Soil in EPA's Soil Chamber, R.B. Mosley

13B6. Radon Transport in Fractured Porous Media, J. Hakl

12:30 Lunch Break

Radon Risk Assessment
Co-Chairs: S. Conrath


14A2. Application of Risk Models to Indoor Radon Exposure, O. Castrén

14A3. A Study of Radon Induced Lung Cancer in Humans Using the 2-Mutation Model of Carcinogenesis, A.K.M.M. Haque

14A4. Cocarcinogenic Effects in Rats of Combined Exposure to Radon and Ozone, G. Monchaux

14A5. Cocarcinogenic Effects in Rats of Various Agents Following Exposure to Radon and Radon Daughters, G. Monchaux

15:10 14A6. Age Dependent Biokinetics and Dosimetry of Radon, Thoron and Their Decay Products in the Human Body with Emphasis on Blood Forming Organs, A. Kranefeld

Radon Mapping I.
Co-Chairs: J.S. Madden and J.W. Wiegand


14B2. Indoor Radon Mapping in France, P. Pirard

14B3. A Search Profile for Dwellings with Elevated Radon Levels, A. Damkjær

14B4. Classification and Mapping of Radon Affected Areas in Germany, A. Siehl

14B5. Mapping the Radon Potential of the United States: Examples from the Central Lowlands and the Appalachian Highlands, L.E. S. Gunderson

14B6. Radon Map of the Mid-Atlantic States, Based on Prediction and Monitoring, P.N. Price

15:30 Refreshment Break

Radon In Schools and Workplaces
Co-Chairs: G.L. Salmon

16:00 15A1. High Radon Level Schools in Slovenia, P. Stegnar

15A2. Measurements of Radon and Thoron Concentrations in Nuclear Power Stations, Q. Guo

16:40 15A3. Radon and Its Decay Products in Water Purification Plants, A. Reichelt

Radon Mapping II
Co-Chairs: J. Miles


15B3. Map of Natural Radioactivity and Radon-In-Soil in Slovenia, D. Brajnik
17:00  15A4. Radon at Workplaces Other Than Mines and Underground Excavations, M.K. Annanmäki

15B4. Risk Assessment of Geologically and Hydrogeologically Controlled Radon Concentration and Migration in Granitic Areas of South West England, A.K.M.M. Haque


Friday, June 9, 1995

08:30 Plenary Lecture: Keran O’Brien
Atmospheric Cosmic Rays and Solar Energetic Particles
At Aircraft Altitudes, Grand Salon B

LBA002. The Use of Naturally Occurring Radioactive Material as a Shielding Medium, Y.I. Kundiev

LBA003. Electret Ion Chamber Method for Measuring Low Levels of Dissolved $^{222}$Rn and Dissolved $^{226}$Ra in Water, P. Kotrapa

LBA005. Radon in Groundwater Supplies in New York State, M.E. Kitto

LBA007. Some Aspects of Radon Radioactivity in Romania, L.S. Domide

LBA008. Environmental and Regulatory Impacts of Naturally Occurring Radioactive Materials (NORM), A.S. Paschoa

LBA009. High $^{222}$Rn Levels, Enhanced Surface Deposition, Increased Diffusion Coefficient, Humidly and Air Change Effects, B.E. Leonard

LBA010. The TH-100 Radon/Thoron Gas Discriminator, G.E. Vandrish

LBA012. Lung Deposition in Rodents During Exposure to Attached Radon Progeny, J.C. Strong

LBA013. Surface Deposition of Airborne $^{222}$Rn Decay Products in Still Air and Low Air Change Rates-Boundary Layer Formation, B.E. Leonard

LBA014. Identification and Assessment of a Small, Geologically Localized Radon Hot Spot, W.E. Hobbs

LBA016. Thorium Determination By Liquid Scintillation Counting Using An Extractive Cocktail, G. Wallner

LBA017. Ground Radon Prognostics in Sweden, J. Lindgren

LBA018. Continuous Measurements of Radon and Related Parameters in Soils, B.-M. Ek

LBA019. Radium and Uranium Concentrations in Two Eskers with Enhanced Radon Emission, J. Ek

LBA020. Integrated Measurement of Potential Alpha Energy (PAE) Due to Short Lived Decay Products of Radons 220 and 222, F. Sarradin
LBA021. Rotating Filter Device for Integrated Measurements of Radon and Thoron Decay Products in the Air, P.P. Kritidis

LBA022. Measurement of $^{222}$Rn in Soil Gas by Combination of Thermoluminescent and Solid State Nuclear Track Detectors, P.P. Kritidis

LBA023. Comment on ICRP Recommendations on Radon, and Revised Background Doses from Indoor Radon, L.M. Lowe


LBA025. The Acute Exposure From $^{222}$Rn and Aerosols from Drinking Water, G.P. Bernhardt IV

LBA026. Subslab Ventilation System: Installation and Follow Up in a High Radon House in Brittany, France, Y.C. Bonnefous

LBA027. Activity Variations and Concentration Factors For Natural Radionuclides in a "Soil-Plant-Honey" System, G. Djuric

LBA028. Recent Figures of Cas-Control Recruitment in the International Ardennes-Eifel Study on Radon and Lung Cancer, A. Poffijn

LBA029. Radon Measurements In Karst Caves in Slovenia, P. Jovanović

Cosmic Rays

Co-Chairs: W. Lowder

10:30 17A1. To The Aircraft Members Exposure to Cosmic Radiation, F. Spurný

10:50 17A2. From a Complex Cosmic-Ray Stack to a Simple Dosimeter System for Aircrew Exposure, L. Tommasino

11:10 17A3. Chromosome Aberrations in Aircrew Members, A. Heimers

11:30 17A4. Response of a Shielded G-M Counter to Cosmic Radiation, K. Gmür

11:50 17A5. Estimated Distribution of Cosmic and Terrestrial Radiation Levels in JAPAN, K. Fujitaka


12:30 Lunch Break

Thoron & Decay Products

Co-Chairs: S. Schery & V. Cuculeanu


Radon Mitigation I

Co-Chairs: R. Mosely

17B1. EPA’s Strategy to Reduce the Risk of Radon, D. Wagner


17B3. Putting the ICRP Recommendation on Radon Into National Practice - Possibilities and Problems, S. Przyborowski


17B5. Radon Control Criteria from Two-Dimensional Cost-Benefit Optimization of Concentration and Confidence Limit, V.C. Rogers

17B6. Can Cost-Benefit Analysis Assist with the Choice of Reference Levels for Radon In Existing Spanish Dwellings?, P.A. Colgan

Radon Mitigation II

Co-Chairs: R. Sextro

18B1. Radon and Ventilation in Newer Single-Family Houses, K. Ulbeck
13:50

14:10 18A2. Thoron and Thoron Progeny in Buildings in Sweden, L. Mjönes

14:30 18A3. Some Results of Special Thoron Measurements, G. Keller

14:50 18A4. Measurements of the Spatial Distribution of Indoor Thoron, Y. Li

15:10 18A5. Thoron Measurements in Monazite Areas of India - A Review, K.S.V. Nambi

15:30 Refreshment Break

16:00 19A1. Experimental and Model Studies of Thoron Decay Products Near the Earth’s Surface, P. Wasiolek

16:20 19A2. The Simulation of Time Variation of $^{222}$Rn and It’s Short Lived Daughter Products Concentrations in the Atmosphere, T. Sakashita

16:40 19A3. A Mysterious Spot on the Concentrations of Radon and Thoron, K. Yamasaki

17:00 19A4. Fractal Dimensions of the Outdoor Radon/Thoron Dynamical Series, V. Cuculeanu

17:20 19A5. The Local and Periodical Fluctuations of Airborne Tn Daughters, E. Yunoki

17:40 19A6. Surveys of Radon and Thoron Concentrations in In-door and Outdoor Air, S. Kobayashi

18:00 End of the Symposium, Grand Salon B