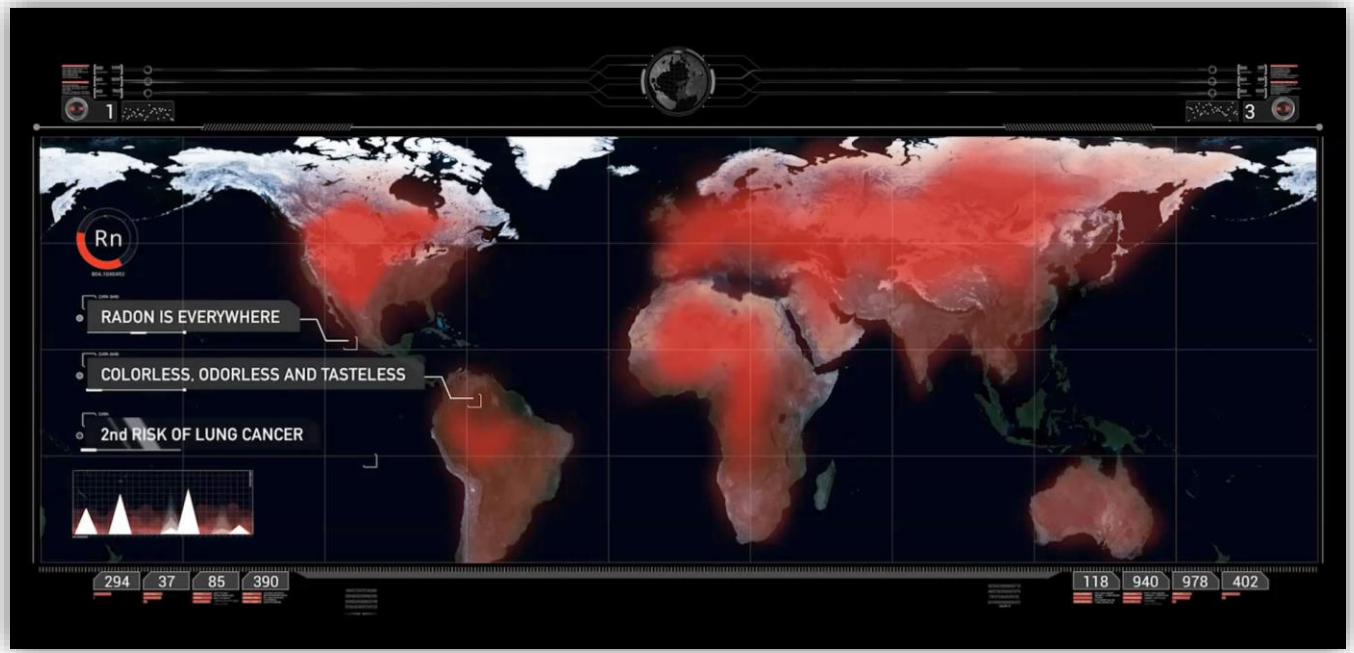
SOIL GAS MONITORING

CARST MEETING

APRIL 25, 2017

BT-D46.DA

RADON – A DANGER FOR THE HEALTH



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RADON ENTRY WAYS

A. Cracks in Concrete slabs
B. Spaces between brick veneer that rest on uncapped hollow brick foundations
C. Cracks and pores in concrete blocks
D. Floor – wall joints
E. Exposed soil as in sump pump areas
F. Drain tile to sump
G. Mortar joints
H. Loose pipe penetrations
I. Open top block walls
J. Rock walls
K. Water

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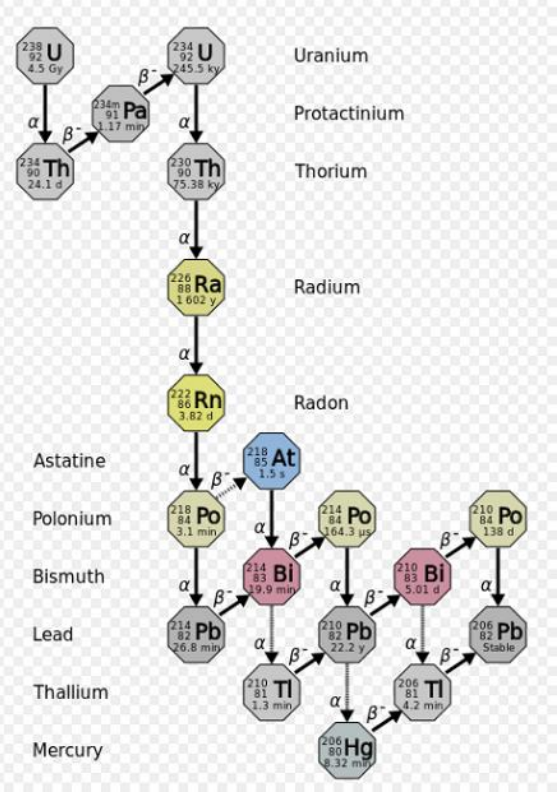
TRANSPORT OF RADON

- Emanation is the process by which radon is transported from a solid to a gas or liquid medium. Only a fraction of the radon atoms so created is able to emanate from the mineral grains and enter the void space, filled either by gas or water. From here, radon moves further by *diffusion* and, for longer distances, by *advection* dissolved either in water or in carrier gases.
- This transportation of radon throughout soil is primarily accomplished through *alpha recoil* and the mechanical flow of air and water throughout the soil.
- -Alpha recoil is defined as the process by which an atom (radon) recoils in the opposite direction from the path of particle ejection following the radioactive decay of its parent atom.



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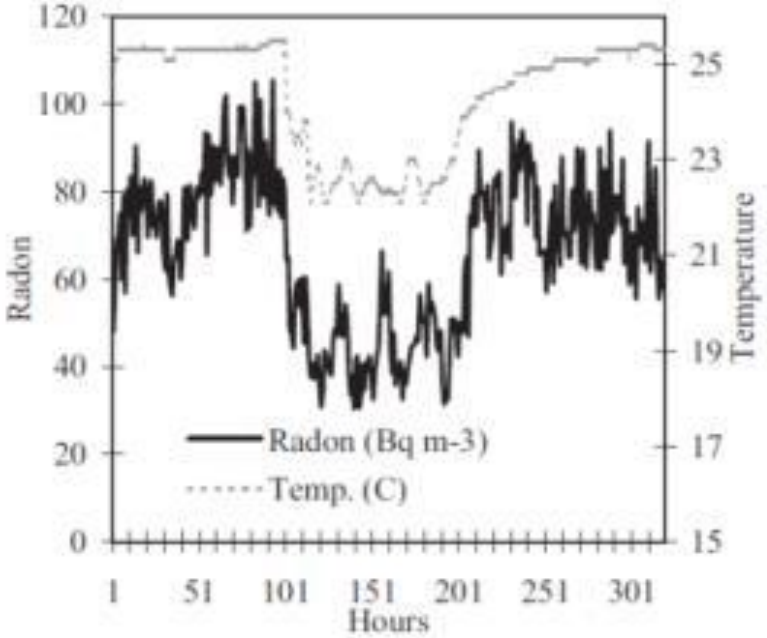
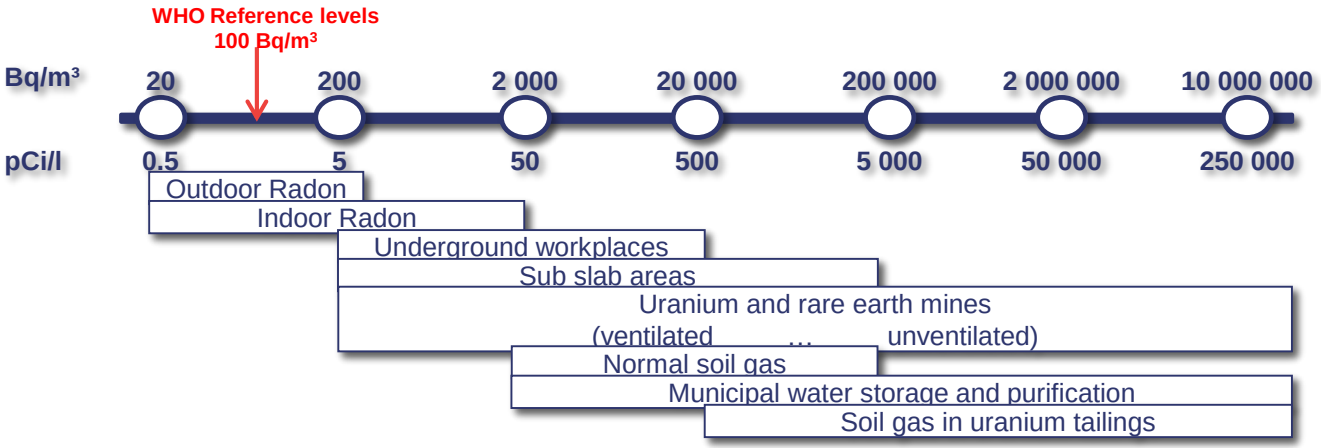
RADON TRANSPORT

- Radon emanation (Flux rate) to air depends mainly on Ra-226Ra concentration and mineral grain size, its transport in the earth is governed by geophysical and geochemical parameters
  - Soil Porosity
  - Meteorological factors;
    - moisture, humidity, atmospheric pressure
- The radium content of surface soils in the Canada is in the range 10-100 Bq/kg.
- Soil is the dominant source of radon.



TYPICAL RN CONCENTRATIONS

- Wide measuring range:
- 2 Bq/m3 – 10MBq/m3, e.g. low outdoor air concentration up to very high concentrations like in mines or in soil gas



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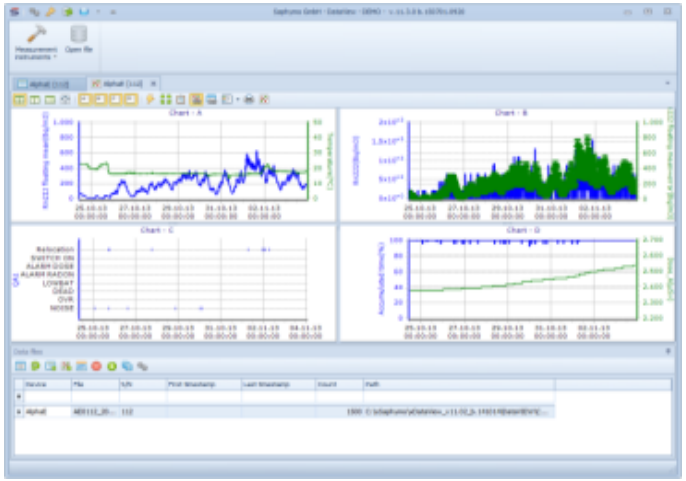
LIMITING FACTORS

- The Radon-222 gas flux rate out of the soil into a house are:

a.) its half-life of 3.8 days
b.) the geochemical composition and geophysical properties of the soil under and around the house
c.) the type of the building foundation
d.) the construction techniques implemented
e.) the level above the ground
f.) the dimensions of the rooms
g.) the ventilation rate
h.) meteorological and seasonal parameters
i.) living and working conditions



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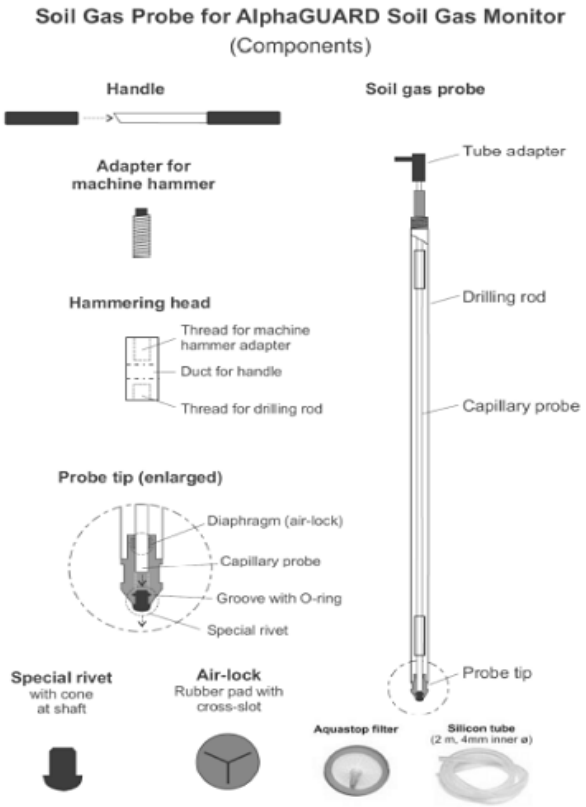
RADON SOIL GAS MEASUREMENT

- From various research studies, we know:
- Average reported flux rate from undisturbed soil into the atmosphere are 0.015-0.048 Bq m2/s for 222Rn.
- A typical radon entry rate into a single-family dwelling of 10-15 kBq h -1 can be accounted for by weather-induced pressure-driven flow through moderately to highly permeable soils.
- The soil-gas radon concentration may vary, often very greatly, over a small distance
- Occurrence of inhomogeneity often indicates the presence of faults or tectonic zones.



RADON IN SOIL GAS MEASUREMENT

Easy-to-use soil gas measuring probe for sampling as well as for continuous monitoring of radon in soil gas

- Sampling and continuous monitoring
- Robust and reliable set-up for long-term use
- Field-proven sampling method and protocol
- Option: DPS –Diff. Pres. Sensor

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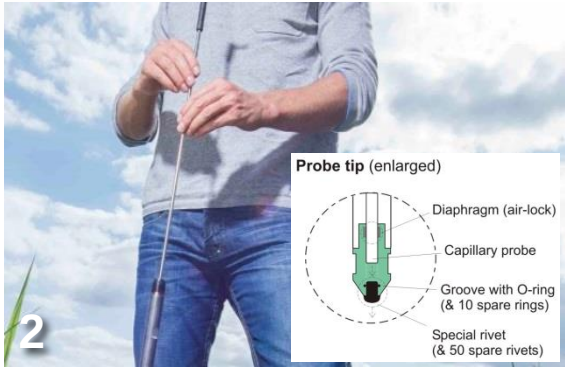
Radon in soil gas – sampling method Rn222 – Rn220 discrimination



Sampling method, developed in cooperation with GGD Leipzig:

1. Driving the drilling rod into the soil. Tearing back the drilling rod for ca. 5 cm
2. Inserting the capillary probe and pressing out the closing rivet
3. Connecting the tube and the Aquastop filter
4. Sampling with connected AlphaGUARD in Radon/Thoron discrimination mode (1 or 2 l/min)

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Radon in soil gas - continuous monitoring: volcano watching in Sicily, Italy

Continous radon in soil gas monitoring system for permanent operation at a remote location in the open air

Measurements incl. wind speed data are managed by AlphaGUARD and are read out by the headquarter via cellular phone network (GSM modem)

The station includes:

- 1 AlphaGUARD PQ2000PRO
- 1 Soil gas probe
- 1 Wind speed sensor
- 1 DataGATE (former version of COM Server)
- 1 GSM Modem

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Building Site Sample Measurements

- To ensure reliability of the results, it is required to make at minimum of 15 soil-gas sample measurements for averaged concentrated value for an quarter acre building site.
- The minimum sampling depth of 1 meter at the foundation level of building represents a relatively compromise between the reduction of weather effects and the practicability of the field conditions.
- Other parameters, including vertical and horizontal changes in soil and rock profile, should also be taken into consideration.
- The backfill in various construction can vary widely and needs to be considered to ensure measurements are not in backfill areas.

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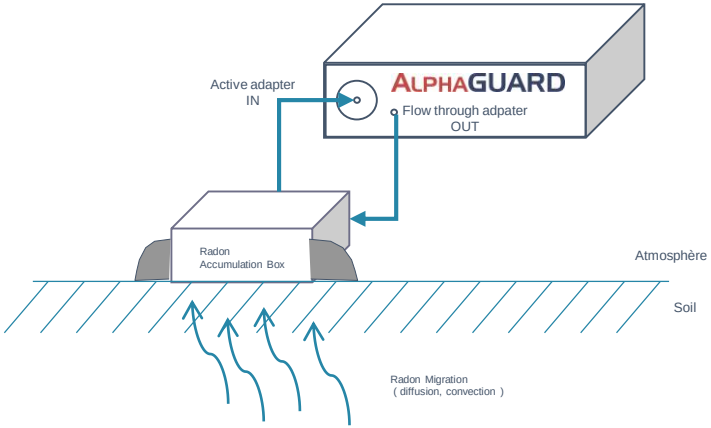
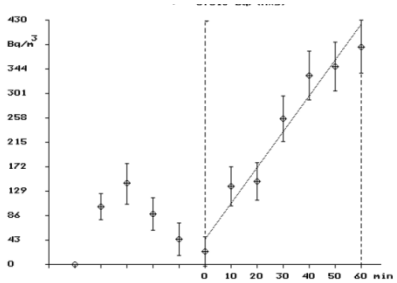
DETERMINATION OF RADON FLUX RATE

- Determination of Radon exhalation (flux) rate from soil was measured using the Exhalation Box (EB) and the same AlphaGuard monitor and pump.
- The air was circulated in the closed circuit for about 90 min and the concentration of radon accumulated in EB was recorded.
- The barometric pressure and temperature should be recorded during testing.





SOIL PERMEABILITY MEASUREMENT

PERMEABILITY DETERMINATION becomes the challenge since more issues are connected with this determination of soil permeability. The factors influencing the permeability (soil moisture, density, porosity) need to be taken into consideration and reviewed for several samples to describe the heterogeneous geological environment.

Soil permeability -The pressure difference between soil air and open air (1P) and flow rate (Q) are measured by the AlphaGuard system.

The soil permeability is calculated using a modified equation of Fick's law of diffusion (Janik, 2005):

ksoil = μ Q W ·1P ,

(ksoil is soil permeability (m2), μ is dynamic viscosity of air (Pa s), W is depth parameter of the soil-gas probe (m), Q is soil gas flow rate (m3/min), and 1P is pressure difference measured (Pa) (Zuni ˇ c et al., 2006)

RADON RISK CLASSIFICATION

- The classification developed uses a correlation between the radon concentration in soil gas and the associated soil permeability.
- This Radon risk classification of foundation soils provides a bases for additional study and correlation to potential indoor radon levels to base preventative measures of radon infiltration within the building.
- The results of radon risk classification should allow to choose an optimal building technology based on three categories of risk is semi-quantitative.

CATEGORY	RADON CONCENTRATION IN THE SOIL GAS ($kBq \cdot m^{-3}$)		
	soil permeability		
	low	medium	high
low risk area	< 30	< 20	< 10
medium risk area	30 -100	20 - 70	10 - 30
high risk area	> 100	> 70	> 30

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MODEL TRANSPORT

In addition a recently developed models, simulates transport of radon through unsaturated soil and compares calculated soil radon activities against field-measured values.

This model adds consideration of air temperature changes and air flow driven by barometric pressure change to the other soil variables currently used.

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Sensitivity analysis and simulated results have clearly demonstrated the relative importance of barometric pressure change, rainfall events, changes in water content, gas advection, and radon source term in radon transport process.

Comparison between measured and simulated soil radon activities showed that models can provide realistic estimates of long-term radon activity concentration in the soil profile.

RADON ASSESSMENT IN NEW HOMES

In new homes typically are not required to meet specified radon levels prior to sale.

- The practical applicability of radon soil gas survey results, - to define a single parameter (radon availability or flux) for characterizing of the radon potential within a building site. The correlation of potential indoor radon levels to design the preventative mitigation measures of radon infiltration within the building.
- The results allow builder to choose an optimal building technology, and mitigation of the intrusion of Radon into of home during construction.

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CONCLUSIONS

- Knowing the Radon Soil Gas activity concentration – measured at sufficient depth to building grade – provides key information in designing radon reduction methods for an energy efficient home.
- Providing a methodology to measure the associated correlation between Soli Gas concentration and potential flux rate of Radon gas released.

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- 1000+ AlphaGuards operating worldwide
- In more than 40 countries

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▷ Prestigious customer references

- National Research Council
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