PRACTICAL ARRANGEMENTS:

Radon Exhalation

Course IAEA-UC

IAEA
International Atomic Energy Agency

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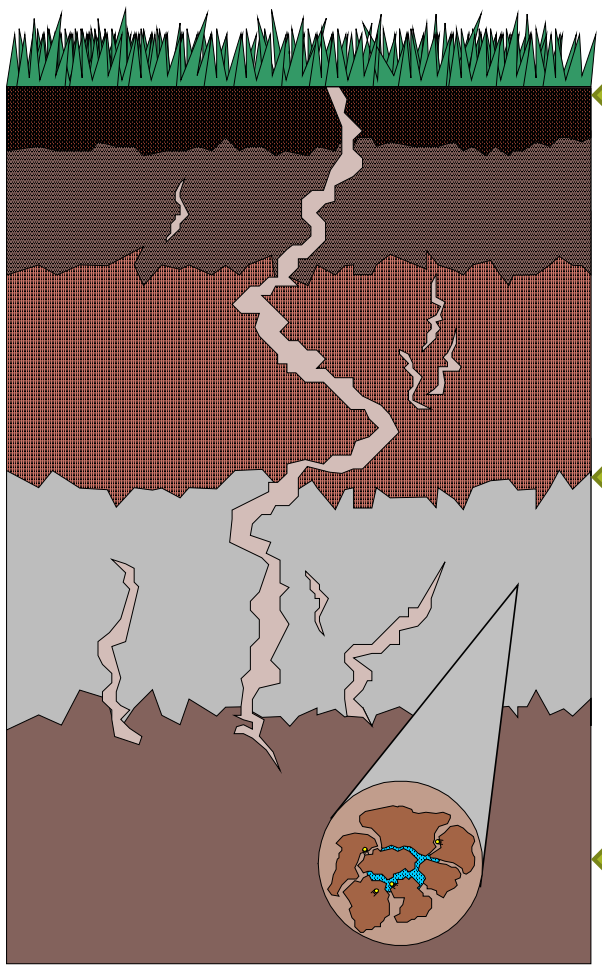
Radon exhalation



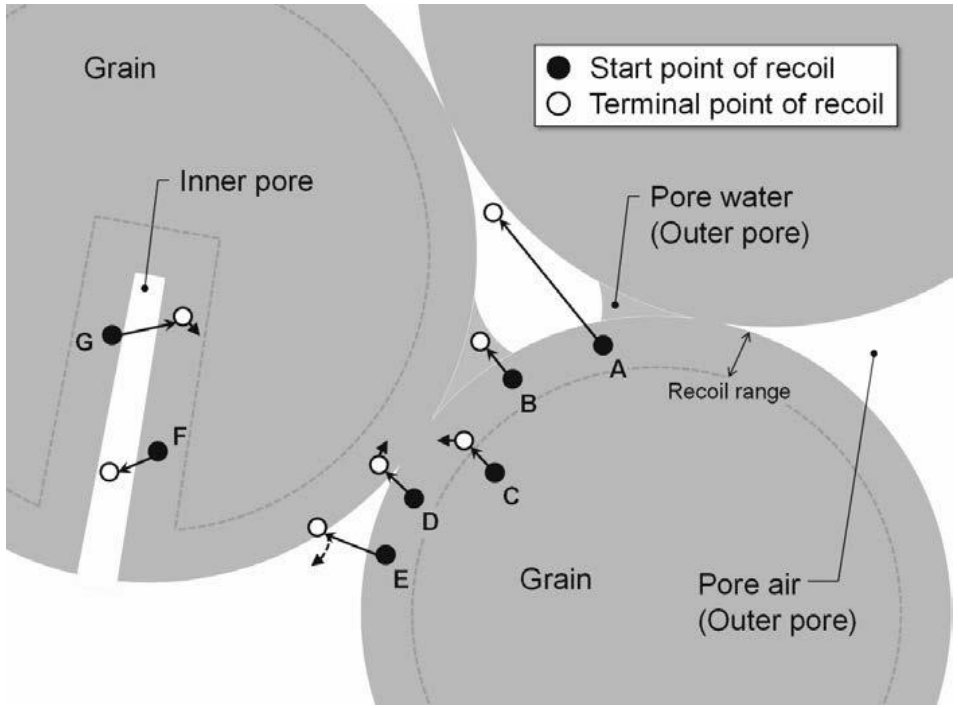
Exhalation — Escape of radon gas from soil to atmospheric air

Transport — Diffusion and convection through pore volume of soil

Emanation — Release of radon atoms from soil/rock grains into pore volume

Emanation

- Recoil distances for Rn-222:
  - 20-70 nm for common minerals
  - 100 nm for water
  - 63 μm in air
- Radon emanation coefficient is the fraction of radon atoms that escape from a Ra-226 mineral grain into the adjacent pore space
- Representative value of radon emanation suggested by UNSCEAR is ε=0.2 in soils (within the range 0.01-0.8)
- Radon emanation is affected by many factors, such us: grain sizes, moisture content, porosity, permeability,…



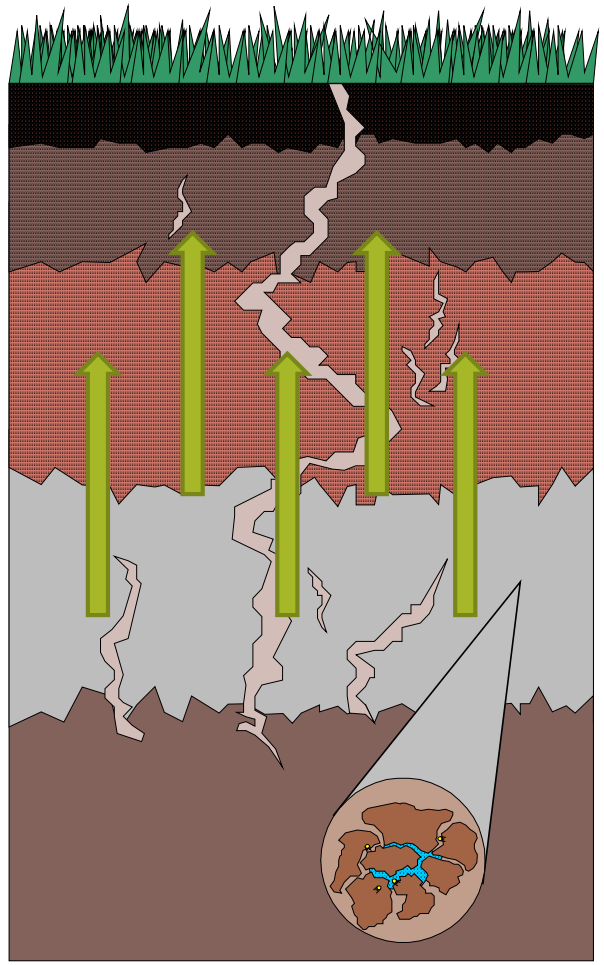
Transport

- Diffusion: depends on the concentration gradient
- Convection: induced by pressure and temperature gradients
- First Fick's law:

$$E = -D_e \nabla C_{Rn}$$

- Diffusion length:

$$L = \sqrt{D/\lambda}$$

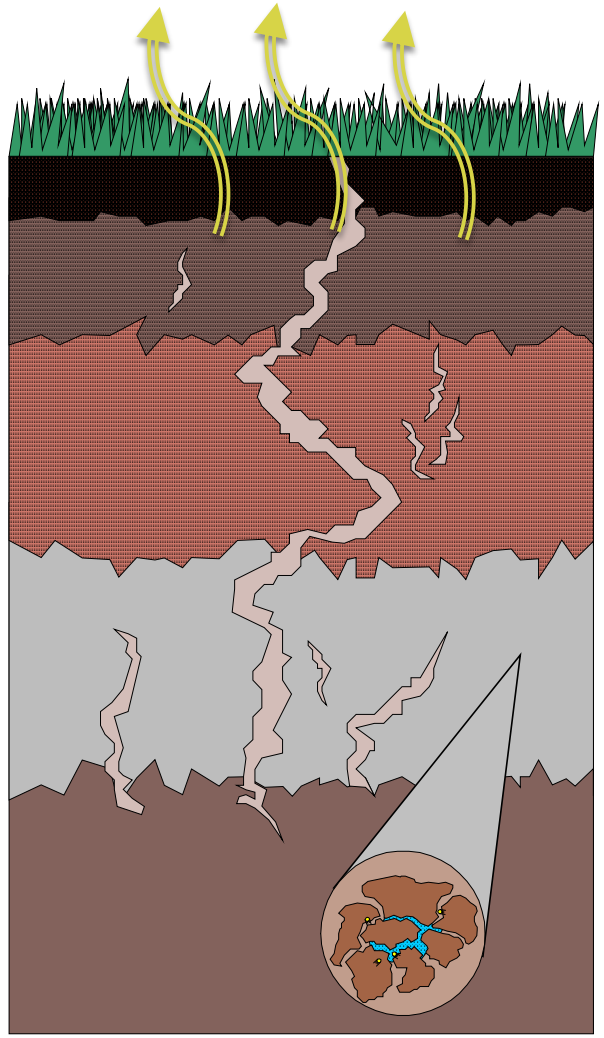


Exhalation

- Solution of diffusion equation:

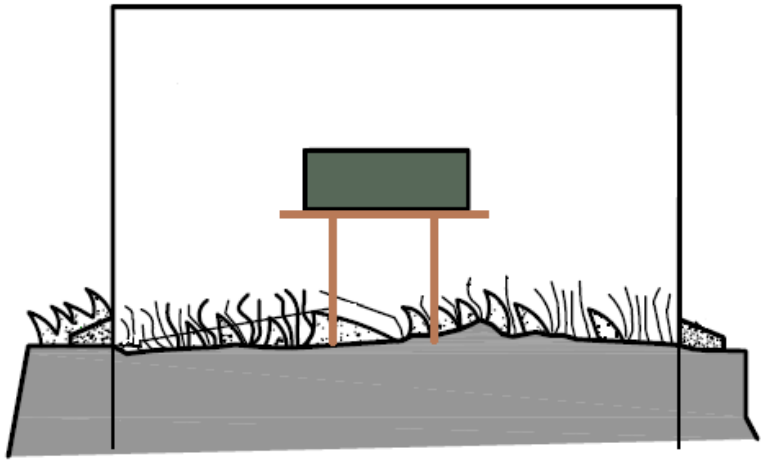
$$E = \varepsilon R \rho_b L \lambda \tanh\left(\frac{Z}{L}\right)$$

- Factors affecting radon exhalation rate
  - Moisture content
  - Pressure
  - Wind speed
  - Daily variations

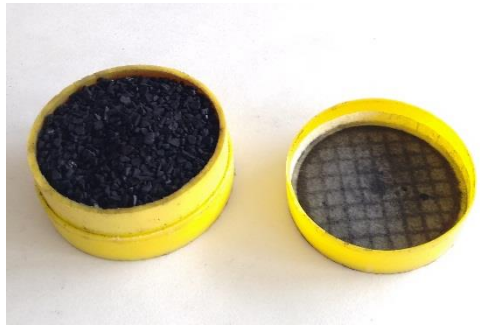


Radon exhalation measurement techniques

Accumulation method



Activated charcoal canisters



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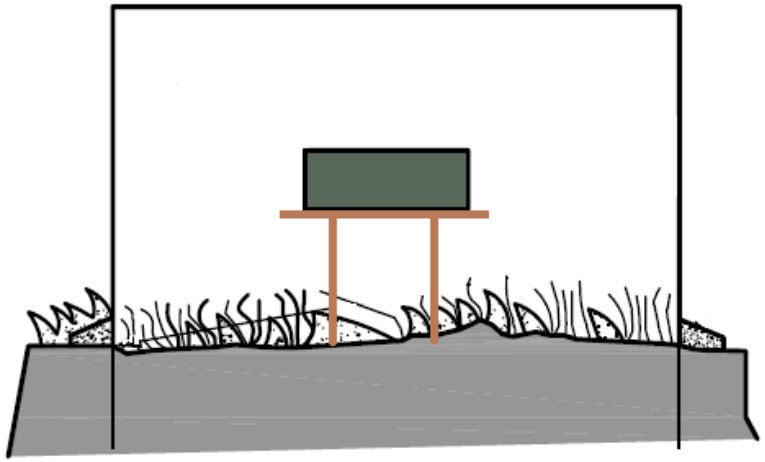
Accumulation method



- Radon accumulation inside the container box

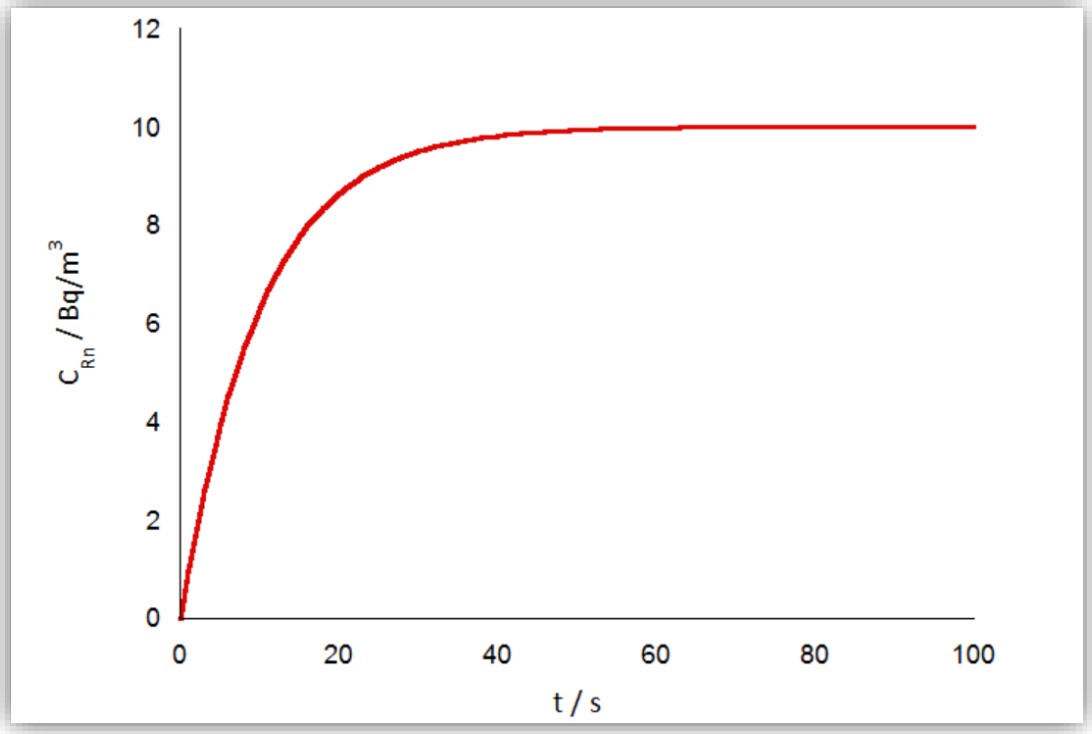
$$C_{Rn}(t) = C_0 e^{-\lambda' t} + \frac{ES}{V\lambda'}\left(1 - e^{-\lambda' t}\right)$$

- If $t \ll \lambda^{-1}$ and $\lambda' \approx \lambda$

$$E = \frac{V}{S}\frac{\Delta C_{Rn}}{t}$$

Radon exhalation measurement techniques

Accumulation method



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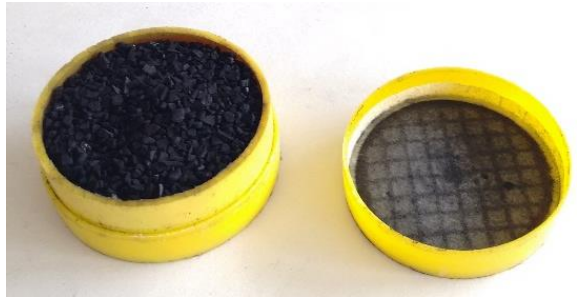
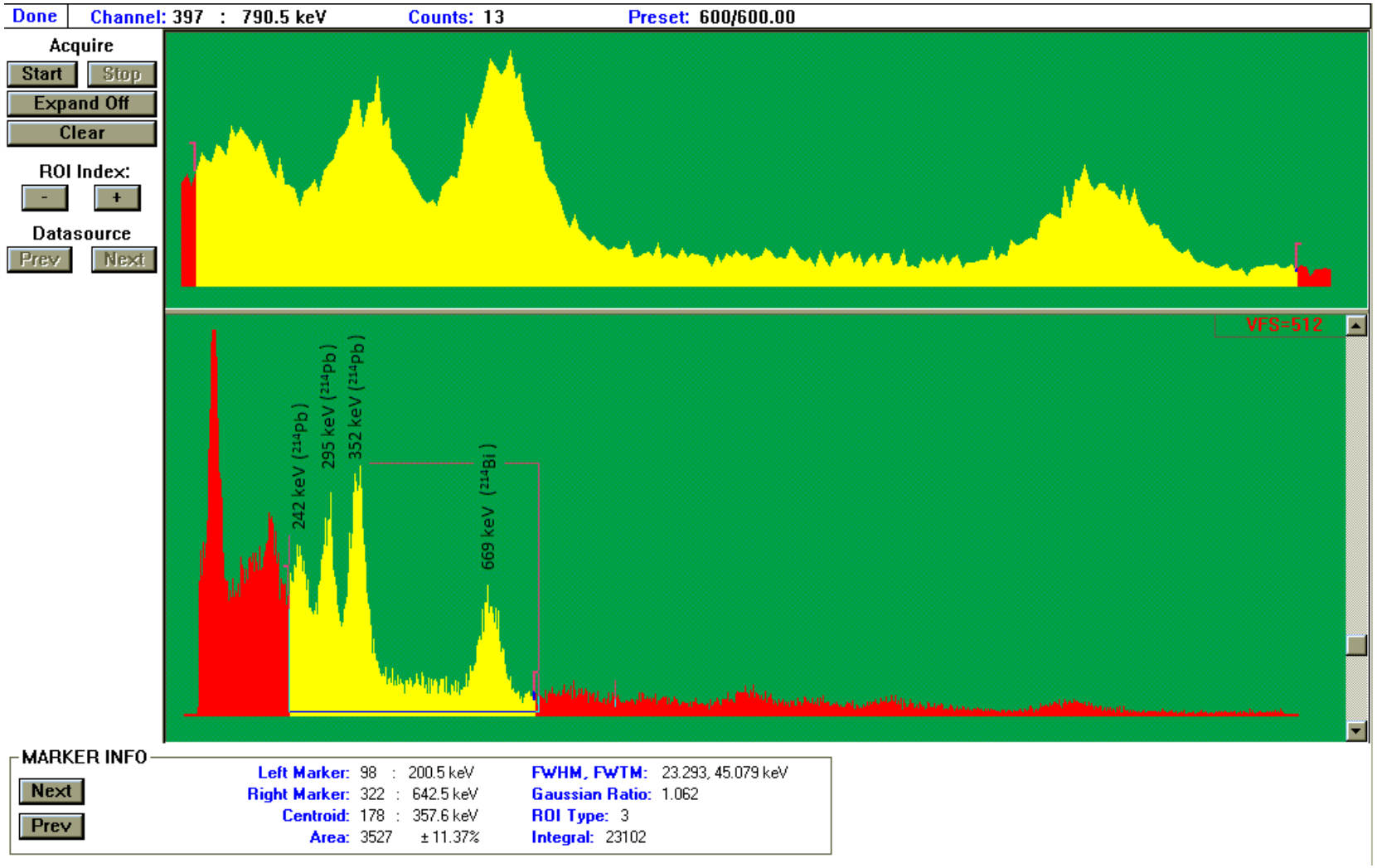


- Radon adsorption in the activated charcoal canisters
- Determination of superficial radon exhalation rate:

$$E = \frac{\lambda^2 N e^{-\lambda t_e}}{\epsilon S (1 - e^{-\lambda t_m}) h}$$

- Influence of moisture content
- Measure by gamma spectroscopy


Done
Channel: 397 : 790.5 keV
Counts: 13
Preset: 600/600.00
Acquire
Start
Stop
Expand Off
Clear
ROI Index:
-
+
Datasource
Prev
Next
VFS=512
242 keV (214Pb)
295 keV (214Pb)
352 keV (214Pb)
669 keV (214Bi)
MARKER INFO
Next
Prev
Left Marker: 98 : 200.5 keV
Right Marker: 322 : 642.5 keV
Centroid: 178 : 357.6 keV
Area: 3527 ±11.37%
FWHM, FWTM: 23.293, 45.079 keV
Gaussian Ratio: 1.062
ROI Type: 3
Integral: 23102