In situ measurements of soil gas permeability using PRM3 permeameter.

Paola Tuccimei[1,] , Mauro Castelluccio[1], Gabriele De Simone[1], Carlo Lucchetti[1], Massimo Moroni[2]*

[1] Università "Roma Tre", Dipartimento di Scienze, Roma, Italy
[2] GEOEX s.a.s., Albano Laziale (Roma), Italy
* Speaker

Outline of the presentation

- Soil gas permeability and indoor radon risk
- Theory
- Field determinations using RADON v.o.s. probes
- PRM3 permeameter
- Experimental data

  Air flows versus pressure gradients

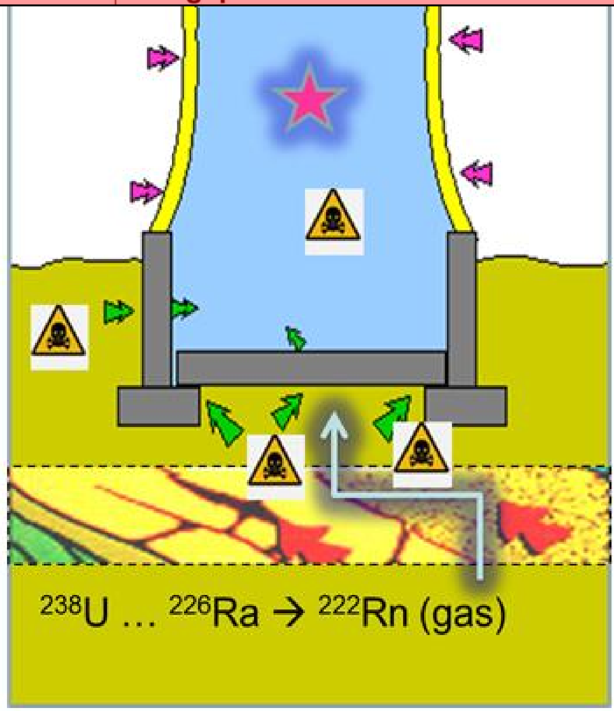
  Soil gas permeability (PRM3) versus intrinsic permeability (RADON JOK)
- Detection limits
- New simplified experimental set-up

Soil gas permeability and indoor radon entry rates

Check protocol

$^{222}Rn \rightarrow {}^{218}Po \rightarrow {}^{214}Pb \rightarrow$

Radon index	Principle of protection
Low	No special protection is required.
Medium	The basic measure is a **radon-proof insulation.**
High	Radon-proof insulation is usually combined with: • **sub-slab depressurization** • **air gaps ventilation**



RI	Soil Radon concentration (kBq/m^3)		
Low	$^{222}Rn < 30$	$^{222}Rn < 20$	$^{222}Rn < 10$
Medium	$30 \leq {}^{222}Rn \leq 100$	$20 \leq {}^{222}Rn \leq 70$	$10 \leq {}^{222}Rn \leq 30$
High	$^{222}Rn > 100$	$^{222}Rn > 70$	$^{222}Rn > 30$
	$< 4 \cdot 10^{-13}$	$4 \cdot 10^{-13} \leq k \leq 4 \cdot 10^{-12}$	$> 4 \cdot 10^{-12}$
	Low	Medium	High
	Permeability (k, m^2)		

Radon index

Soil gas permeability is crucial for environmental hazard assessment and remediation practices:

Å volatile pollutants intrusion into basements
Å transport of organic compounds from contaminated sites to groundwater
Å check the efficiency of soil venting or soil vapor extraction remediation procedures
Å migration of gases from landfills
Å pesticide volatilization for the production of high value crops such as strawberry and tomato

Theory – Darcy equation

$$k = \frac{\mu \cdot Q}{F \cdot \Delta P}$$

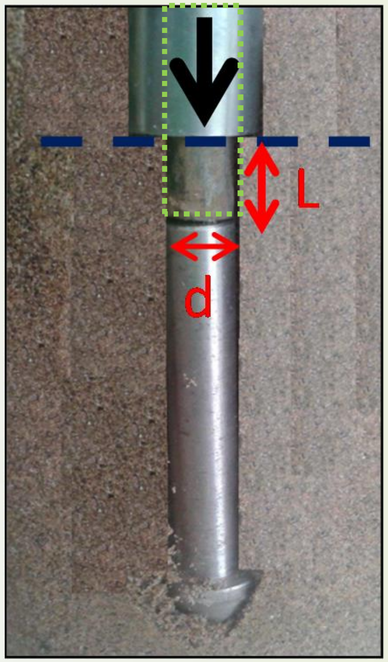
F = 0,149 m, using RADON JOK probe

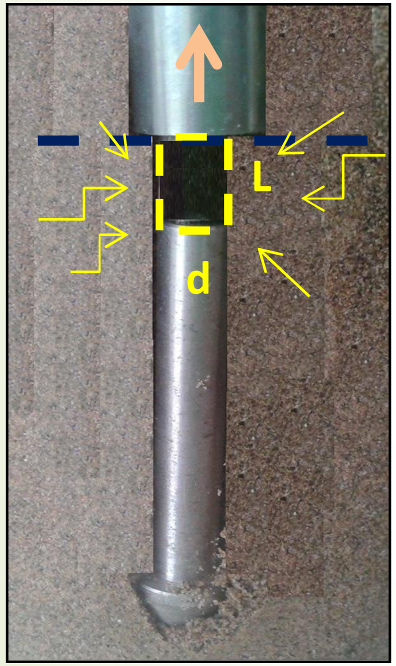
D = depth of gas sampling (825 mm)
L = length of the active area (50 mm)
d = diameter of the active area (12 mm)

where:

k (m^2) is the soil gas permeability
μ (Pa s) is the dynamic viscosity of air
Q ($m^3\ s^{-1}$) is the air flow through the probe,
F (m) is the shape factor of the probe
ΔP (Pa) is the pressure difference between surface and the active area of the probe.

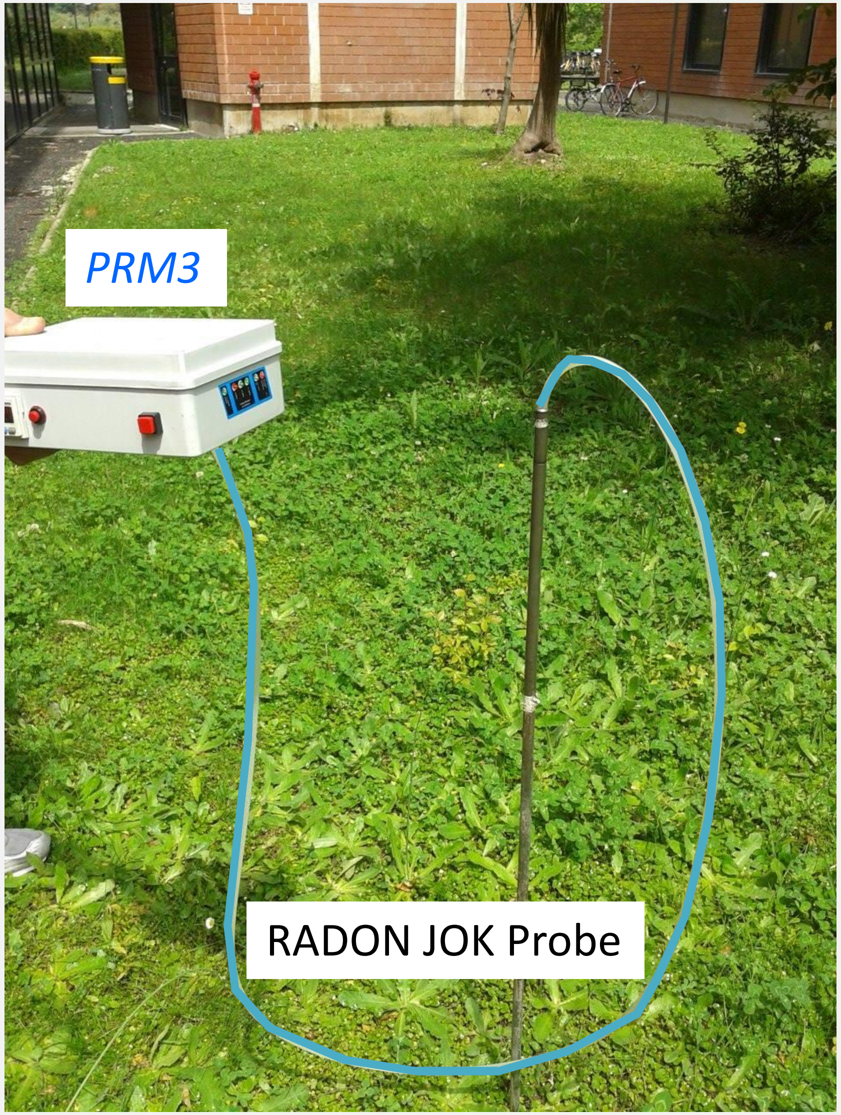
$$F = \frac{2\pi L}{\ln\left(\frac{2L\sqrt{(4D-L)/(4D+L)}}{d}\right)}$$



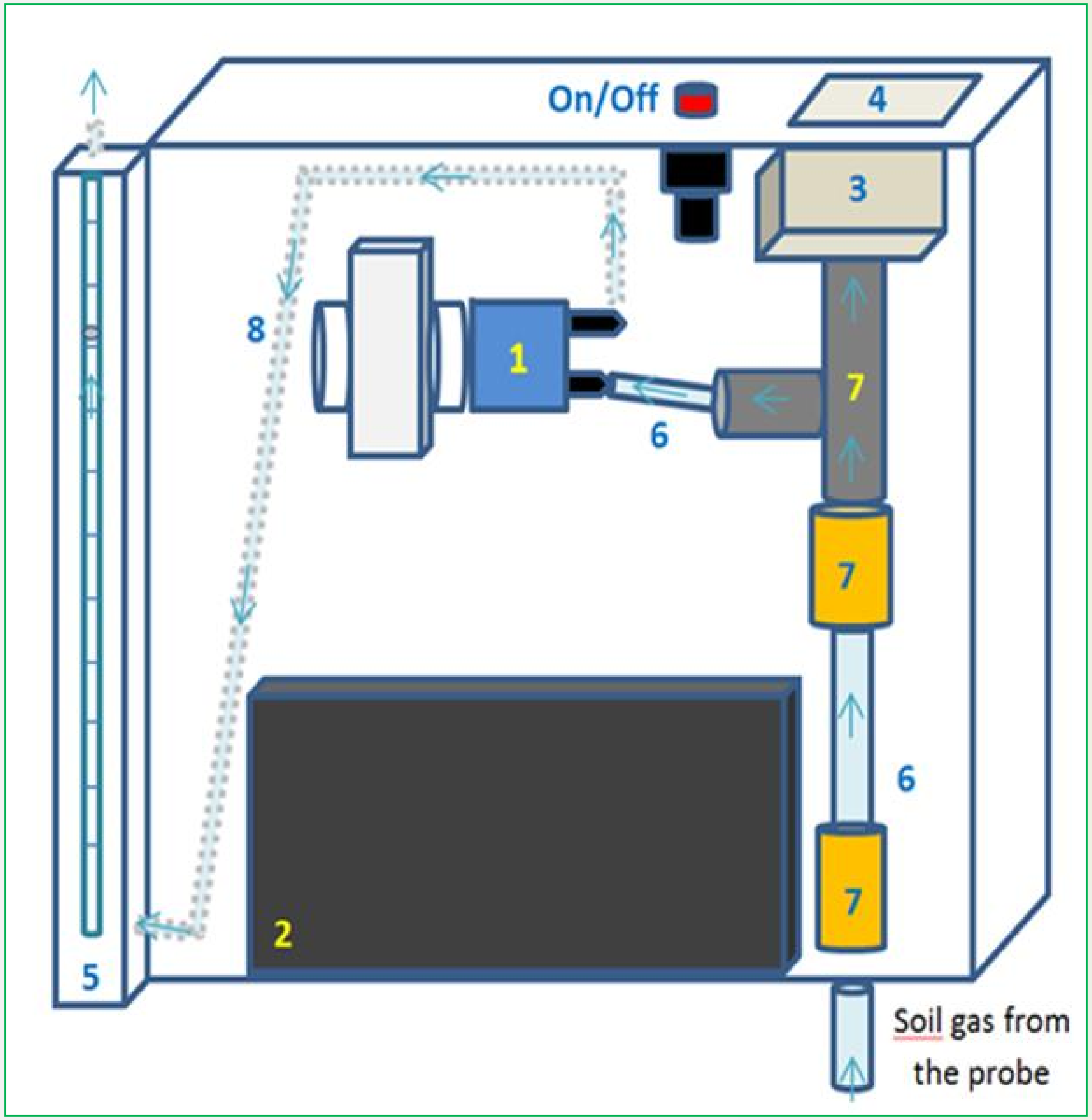


Field determination using RADON JOK probes and PRM3 permeameter

PRM3 Permeameter



PRM3 permeameter



It consists of:

1. vacuum pump
2. battery
3. vacuometer **(ΔP)**
4. digital display
5. fluxmeter **(Q)**
6. vynil tubings
7. metal connectors
8. tubings connecting the pump output to the fluxmeter inlet

Arrows indicate air flow within the experimental apparatus

Calibration of PRM3 against RADON JOK

Field measurements were carried out in a variety of geological settings (tuffs, travertine, flysch and sands) outcropping in Lazio Region (Italy)

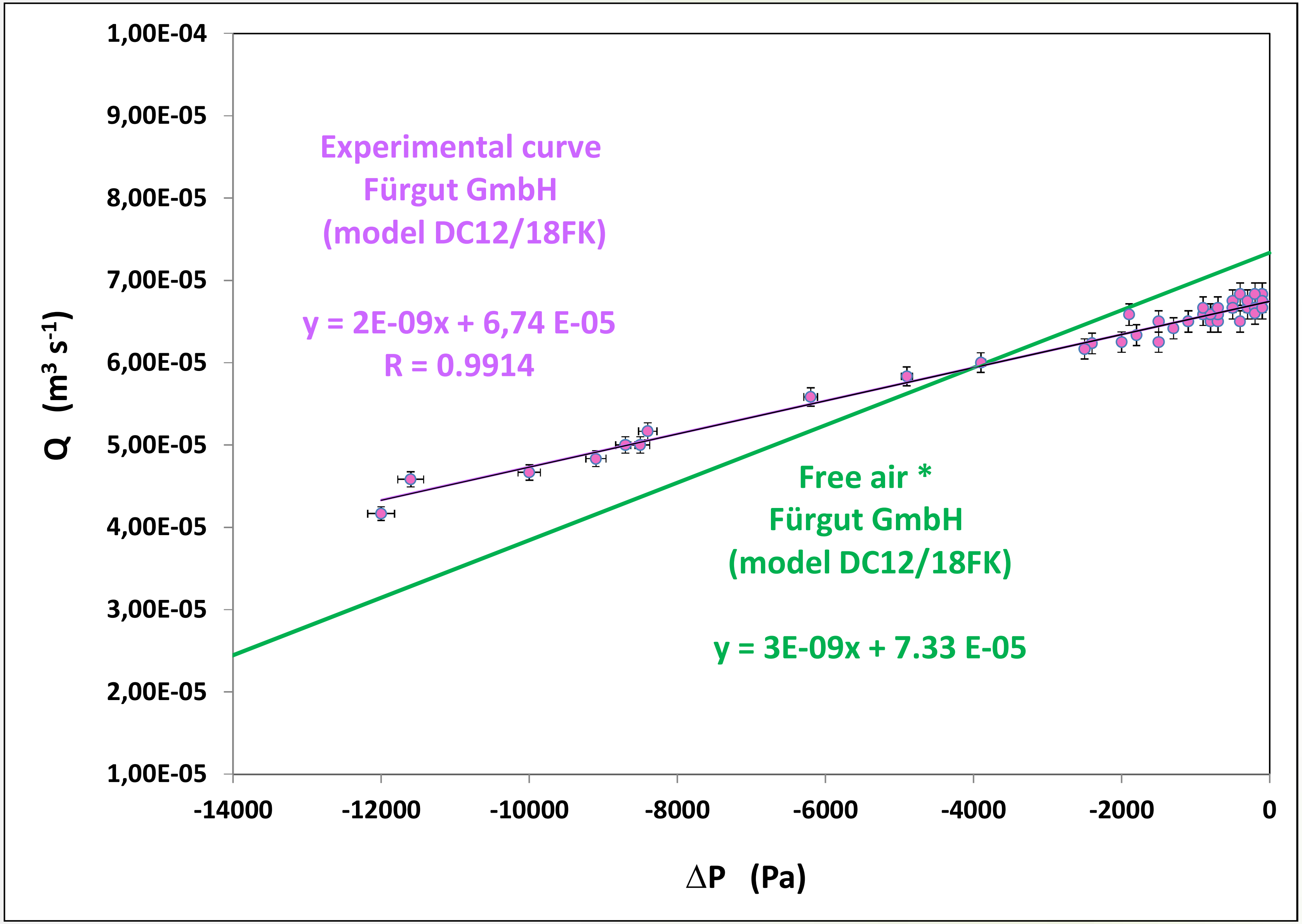
$$k = \frac{Q \cdot \mu}{F \cdot \Delta p}$$

$$k = \frac{V \cdot \mu}{F \cdot \Delta p \cdot t}$$

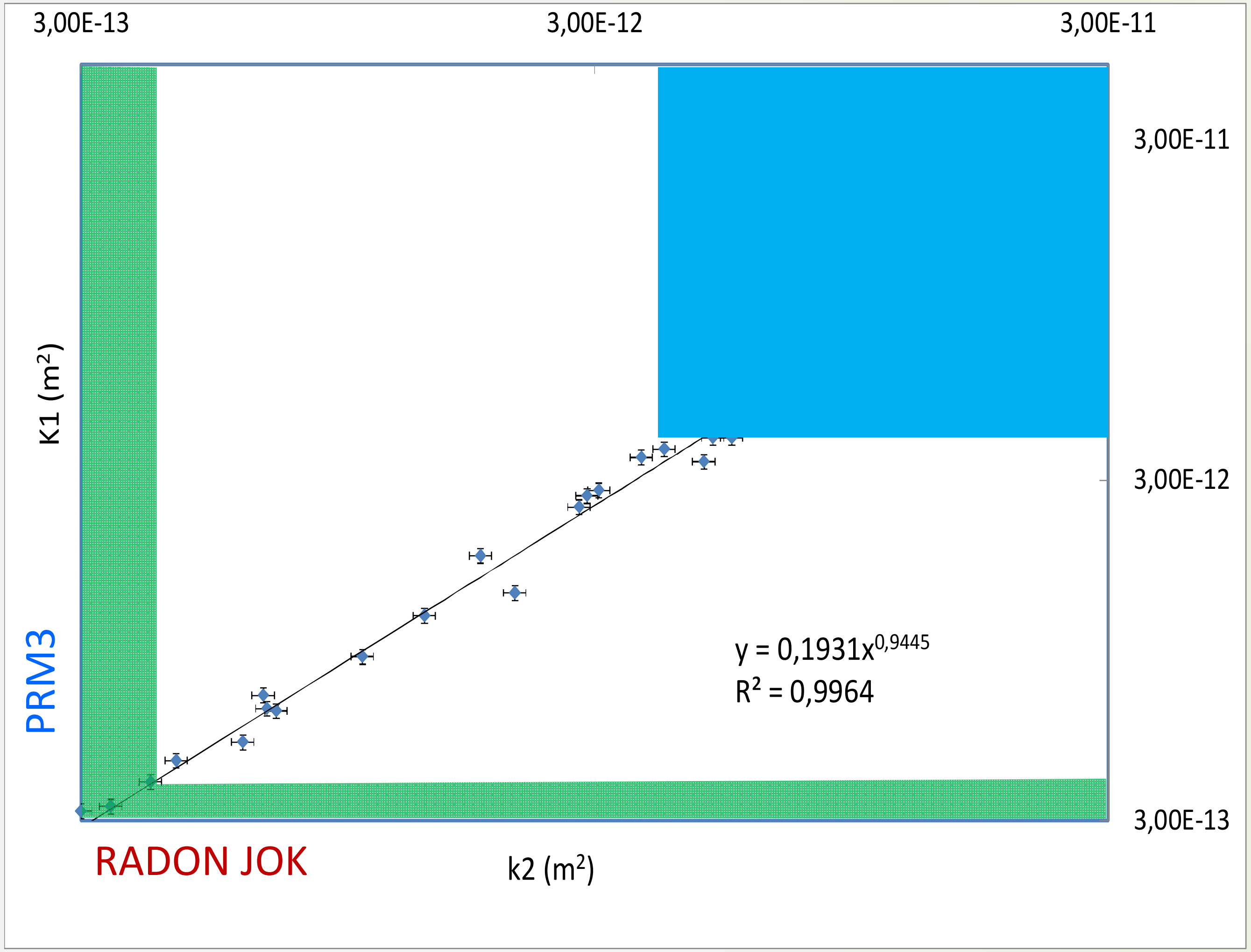
V:
air volume in the expandable cell ($2 \cdot 10^{-3}$ m^3)

Δp :
2160 Pa (1 weight)
or
3750 Pa (2 weights)

Air flows versus pressure gradients



Soil gas permeability (PRM3) versus intrinsic permeability (RADON JOK)



Permeability (m^2)

High	$> 4 \cdot 10^{-12}$
Middle	
Low	$< 4 \cdot 10^{-13}$

Permeability classes defined by the Check protocol (Neznal et al., 2004)

Detection limits

PRM3		RADON JOK	
Lower limit	*Upper limit*	*Lower limit*	*Upper limit*
$3 \cdot 10^{-13}$ m^2	$8.0 \cdot 10^{-11}$ m^2	virtually no limit, but time consuming	$1.8 \cdot 10^{-11}$ m^2

When measuring low permeability data, PRM3 provides a quicker response

For example, the time required to detect a value of k equal to $3 \cdot 10^{-13}$ m^2 is:

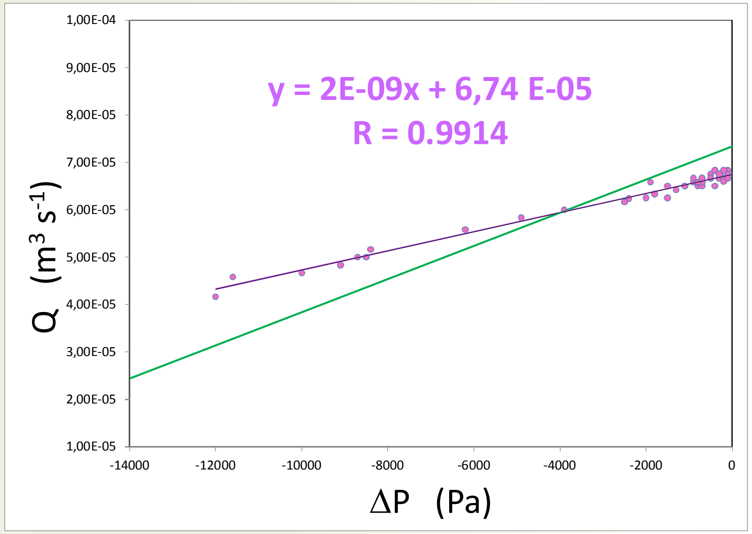
only few seconds using PRM3

about 3–4 min using RADON JOK

New simplified experimental set-up

Since **Q** can be expressed as a function of Δp:

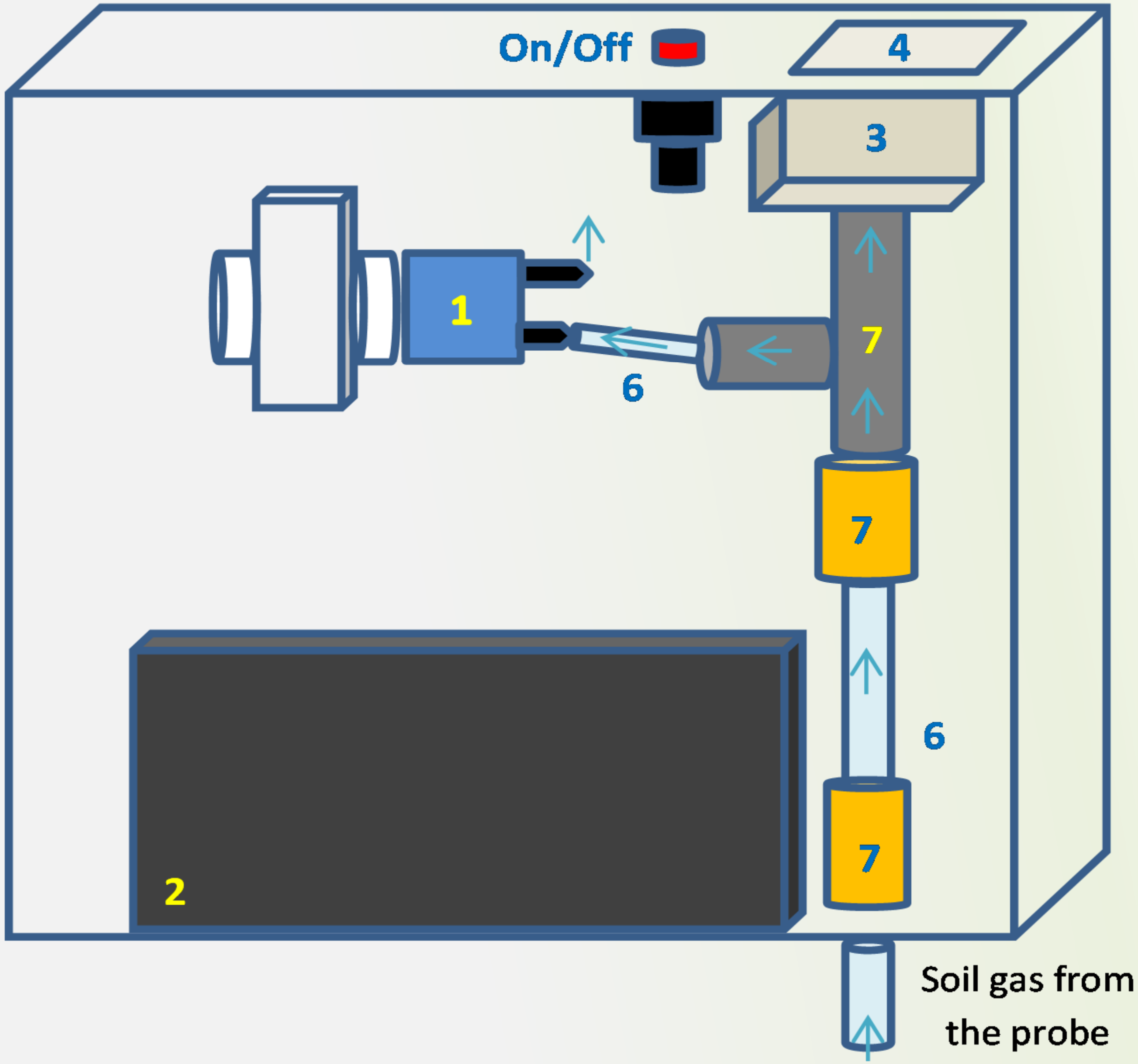
$$Q = (m\,\Delta P + c)$$



The Darcy equation becomes:

$$? \; ? \; \frac{\mu \; ??}{F \; ?\Delta P} \longrightarrow ? \; ? \; \frac{\mu \; ??? \;\; ?? \; ? \;\; ??}{F \; ?\Delta P}$$

New simplified experimental set-up (2)



- No fluxmeter
- No connection pump-fluxmeter

Thank you for your attention

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