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Influence of volcanic subsoil on indoor radon levels in Olot (NE Spain)

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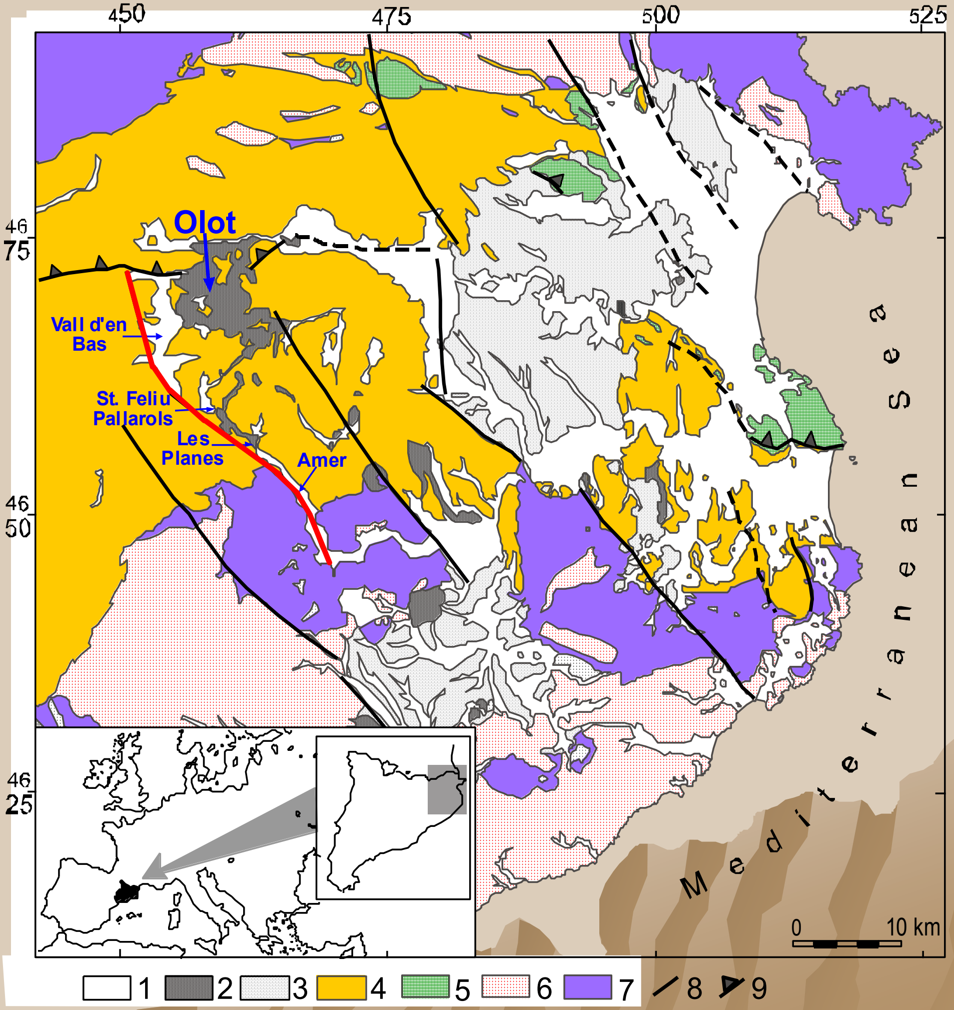
Contents:

The Volcanic Region of La Garrotxa:

- Quaternary volcanic materials over a Tertiary substratum.
- System of faults (Amer fault with evidences of recent activity).

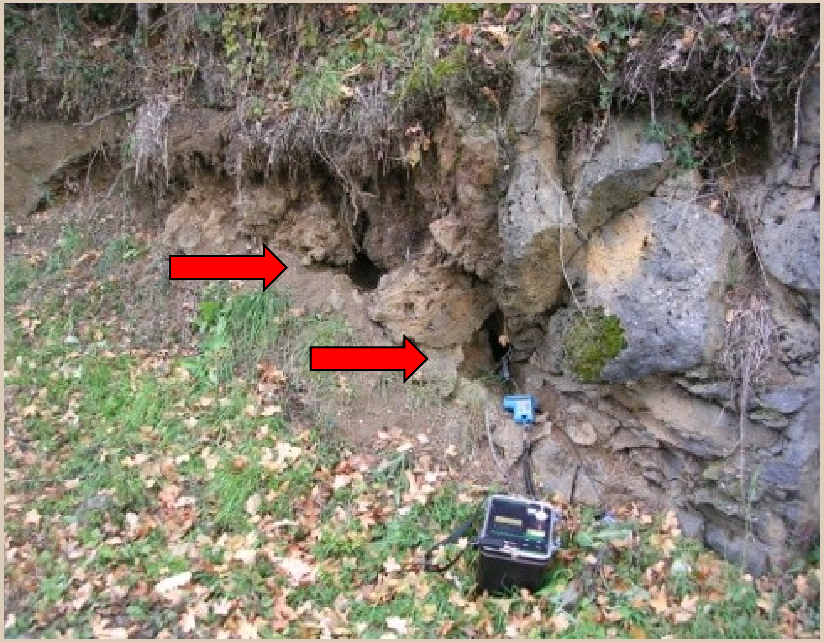
1: Quaternary sediments,
2: Neogene and Quaternary volcanic rocks,
3: Neogene sedimentary rocks,
4: Palaeogene sedimentary rocks,
5: Mesozoic sedimentary rocks,
6: Palaeozoic granitoids,
7: Palaeozoic metasedimentary rocks,
8: Faults,
9: Thrusts.

Simplified geological map of the north-eastern Catalonia



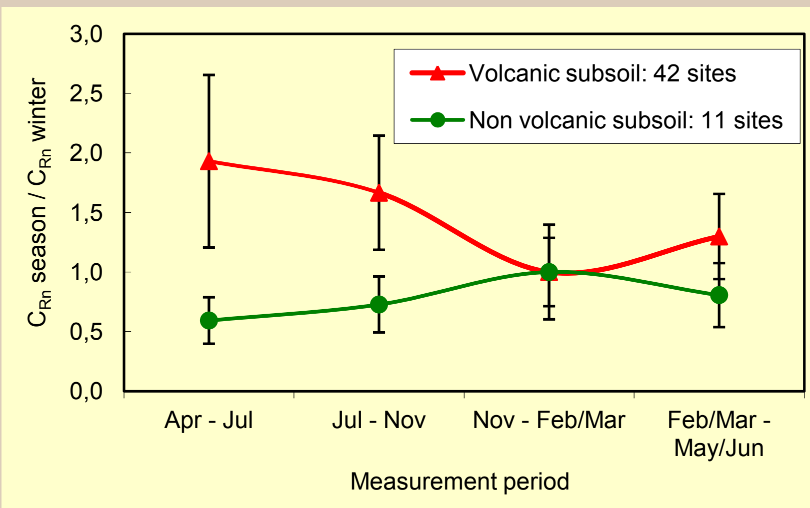
Blowholes in the Volcanic Region of la Garrotxa:

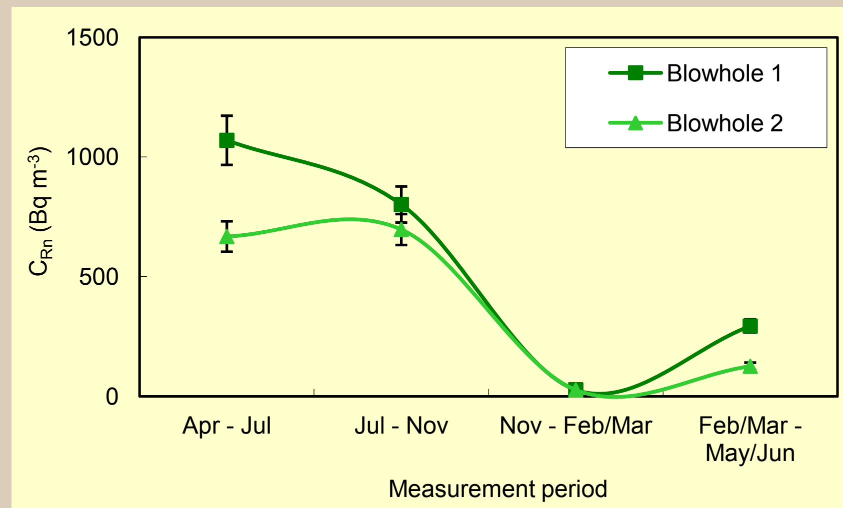
- Definition: Natural holes in the volcanic soil that blow cold air in warm days.
- Traditionally, very appreciated by inhabitants.



Previous surveys in the Volcanic Region of la Garrotxa:

Type of survey	2002	2003	2004	2005	2006	2007	Measurement points	Type of measurement	C_{Rn} ($Bq \cdot m^{-3}$)
Indoor radon: Preliminary survey	■						27	Integrated	14 – 717
Indoor radon: Survey			■	■			125	Integrated	15 – 1465
Radon and Thoron: Blowholes						■	26	Punctual	7 – 9460



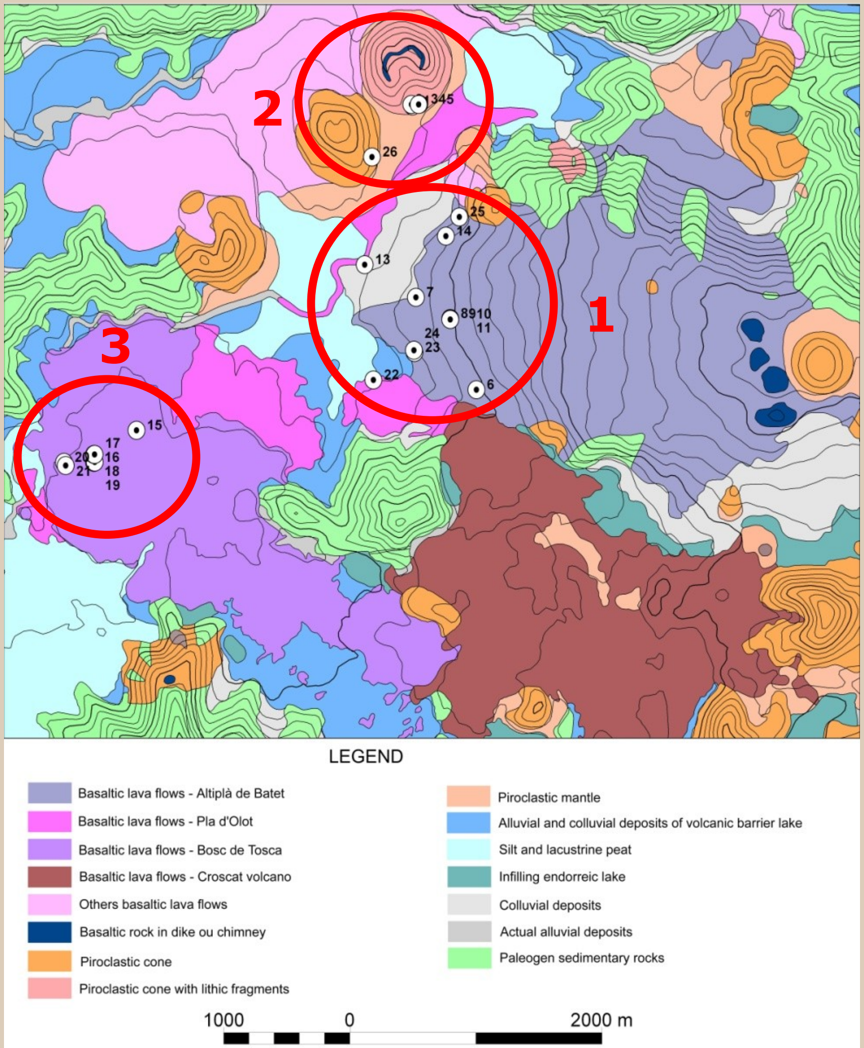


Baixeras, C., Bach, J., Amgarou, K., Moreno, V., Font, Ll., 2005. Radon levels in the volcanic region of La Garrotxa. Radiation Measurements 40, 509-512.

Moreno, V., Baixeras, C., Font, Ll., Bach, J., 2008. Indoor radon levels and their dynamics in relation with the geological characteristics of La Garrotxa. Radiation Measurements 43, 1532-1540.

1. Introduction, Motivation and Objectives

◆ Blowholes of the Volcanic Region of la Garrotxa (2007):



26 blowholes identified:

19 outdoor

7 indoor

Located in different geological units:

1. Batet and Olot plain lava flows
2. Garrinada and Montsacopa volcanoes
3. Bosc de Tosca lava flows

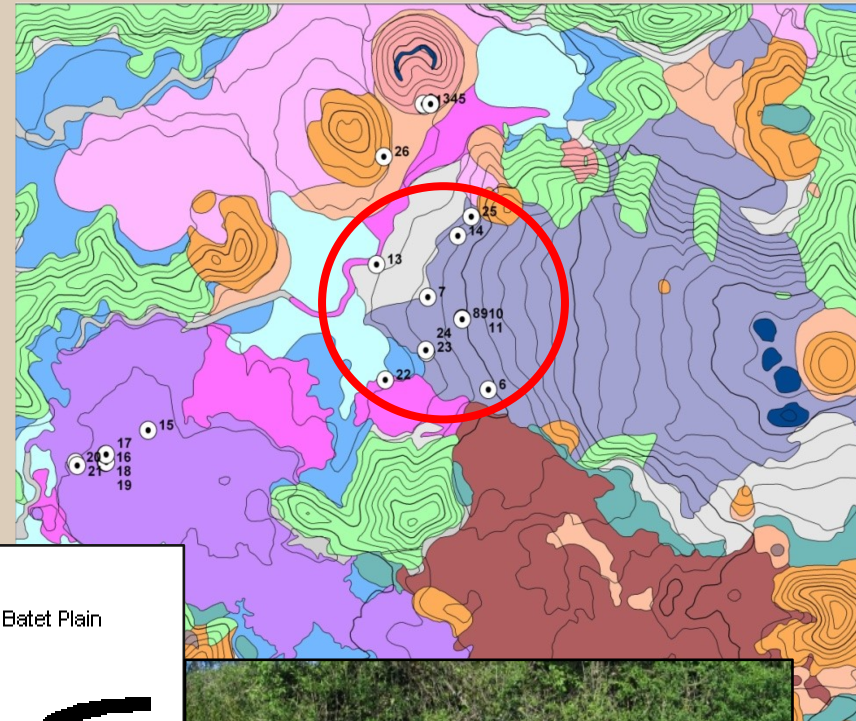
Geological unit	v_{air} ($m \cdot s^{-1}$)	C_{Rn-222} ($Bq \cdot m^{-3}$)	C_{Rn-220} ($Bq \cdot m^{-3}$)
1	**0.01 – 0.83**	**7 – 9460**	**39 – 2540**
2	0.01 – 0.36	5 – 1100	8 – 1850
3	0.01 – 0.08	7 – 93	112 – 1020

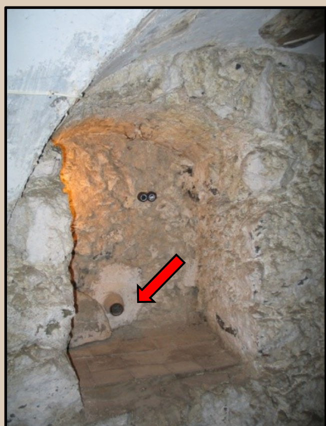
Moreno, V., Bach, J., Baixeras, C., Font, Ll., 2009. Characterization of blowholes as radon and thoron sources in the volcanic region of La Garrotxa. Radiation Measurements 44, 929-933.

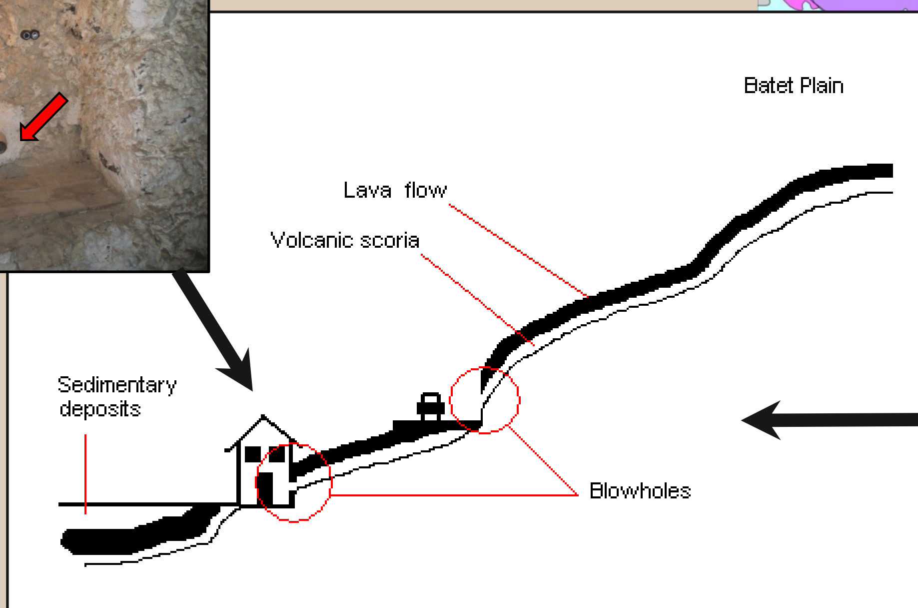
1. Introduction, Motivation and Objectives

- **Blowholes in Batet and Olot plains lava flows (Unit 1):**

  Natural holes in a volcanic scoria levels under a slim and massive lava flow stratum.

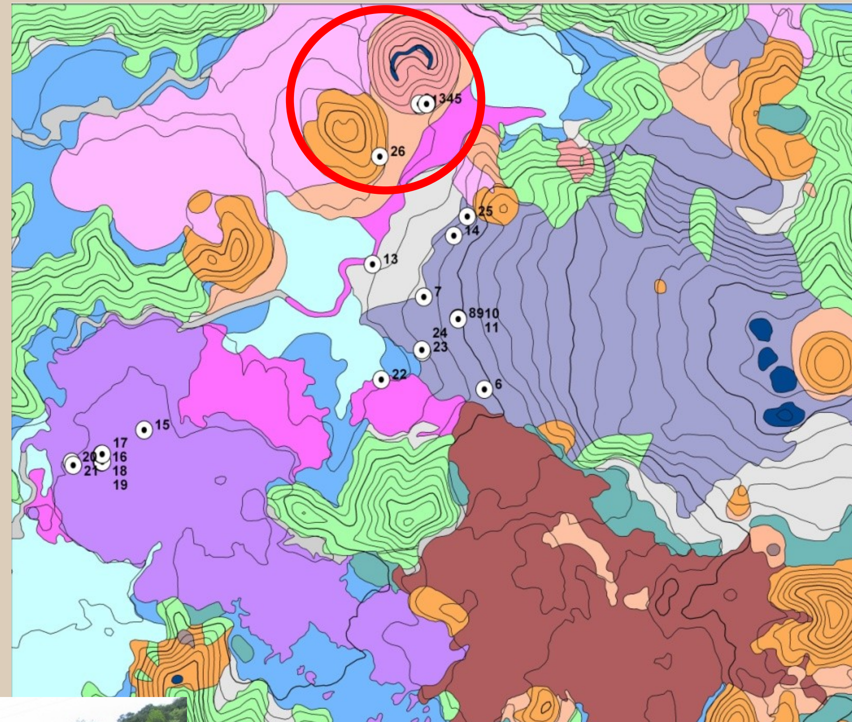






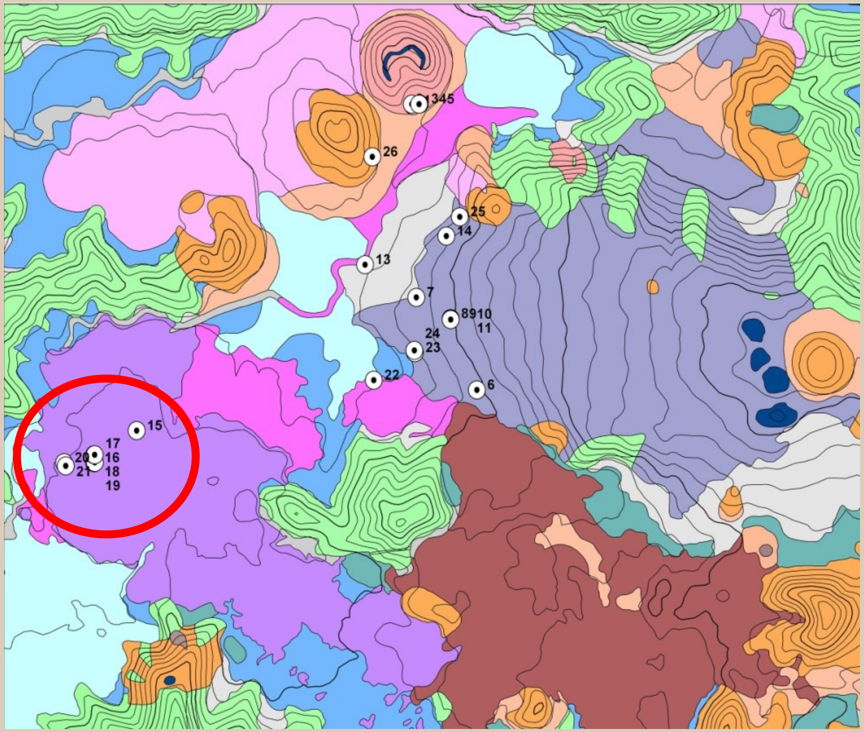
Blowholes in Garrinada and Montsacopa volcanoes (Unit 2):

Natural holes among the pyroclastic materials that form the volcanic cones.



- **Blowholes in Bosc de Tosca lava flows (Unit 3):**

  Artificial holes or cavities in the field walls build over the broken and permeable surface of the lava flow.

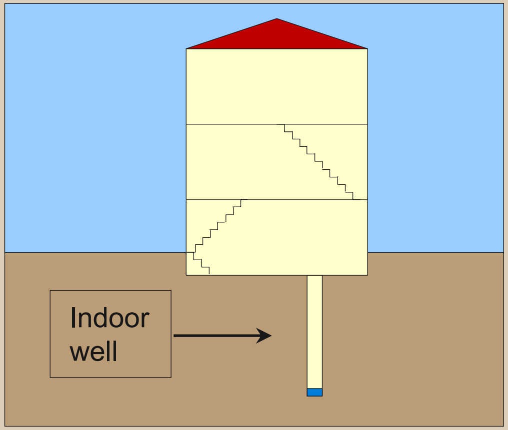


- **Objectives:**

The main objective for the present work is to study in more detail radon dynamics in this volcanic region.

- Confirm the seasonal variation obtained with punctual and integrated measurements.
- Measure continuously radon levels in dwellings with higher values.

- **Selected dwellings:**
  - Located over volcanic materials (unit 1) and with high annual averaged C_{Rn}:
    - A house having a former indoor well (covered): C_{Rn}= (1254 ± 74) $Bq \cdot m^{-3}$
    - A house having a blowhole: C_{Rn}= (429 ± 34) $Bq \cdot m^{-3}$



- **Measurements:**:
  - Integrated measurements (1 – 4 months)
  - Continuous measurements:
    - Initially: 1 week in both dwellings
    - Later (more detailed study of the blowhole): some months

2. Methodology and Instrumentation

- **Active detectors**:
  - PRASSI from Silena (Lucas Cell)
  - RAD7 from Durridge Co (Semiconductor)

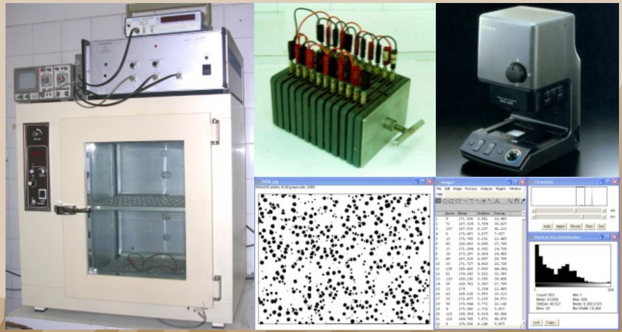
- **Passive detector:**
  - FzK dosimeter based on Makrofol track-etch detector (polycarbonate).

Electrochemically etched (KOH 6N (1:1) ethanol).

Conditions:

- T = 40 ºC
- Frequency: 3kHz
- Electric field strength : 31 kV·cm^{-1}
- Duration: CE (4 h), ECE (1.5 h)

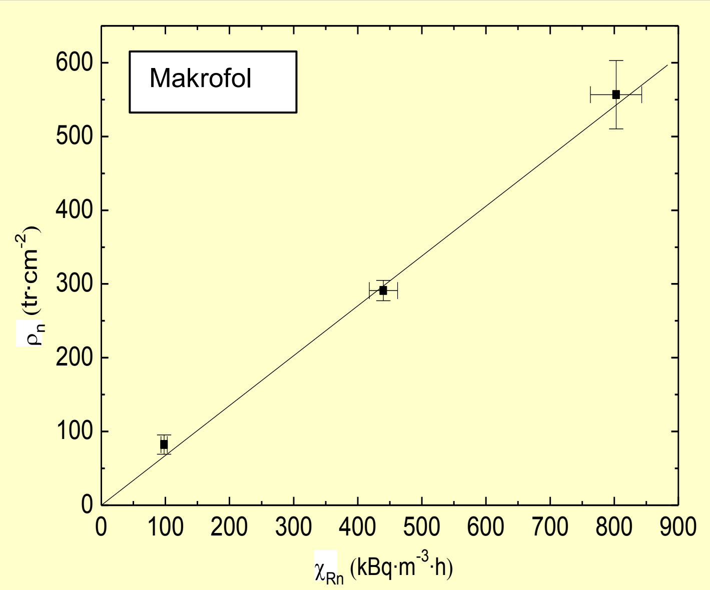
Semi-automatic track counting system: CCD + ImageJ



◆ Calibrations:

- Active detectors (manufacturers and INTE).
- Passive detectors (HPA): Makrofol

  Curve and calibration factor (ρ < 600 cm^{-2}):
  $\varepsilon_{Makrofol}$ = (0.66 ± 0.05) cm^{-2}/kBq·m^{-3}·h

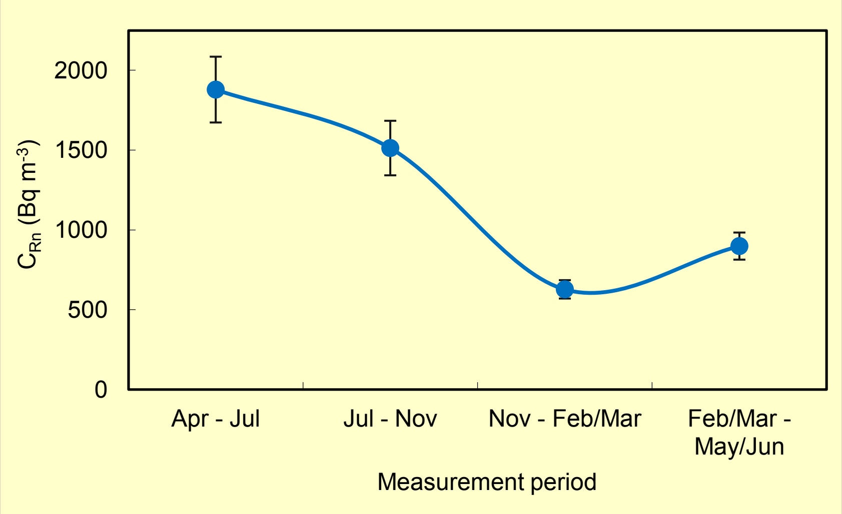


◆ Intercomparisons:

Center	2004	2005	2006	2007	2008	2009	2010	2011	2012	Type of detector
HPA (United Kingdom)	■	■	■	■	■	■	■	■	■	Makrofol
INTE (Spain)		■	■		■					Passive and active
Saelices en Chico (Spain)								■		Passive and active
BfS (Germany)									■	Passive

Dwelling having an indoor well:

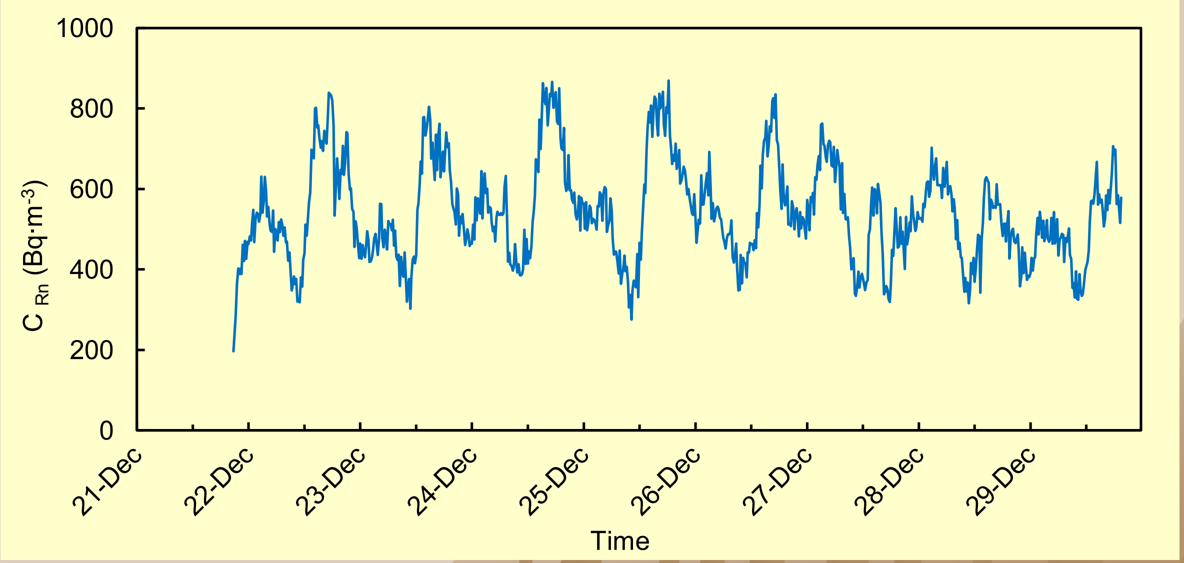
– Integrated radon measurements (Makrofol detectors):



- Higher radon levels in summer.
- Same behaviour of houses with blowholes.

– Continuous radon measurements in winter (PRASSI monitor):

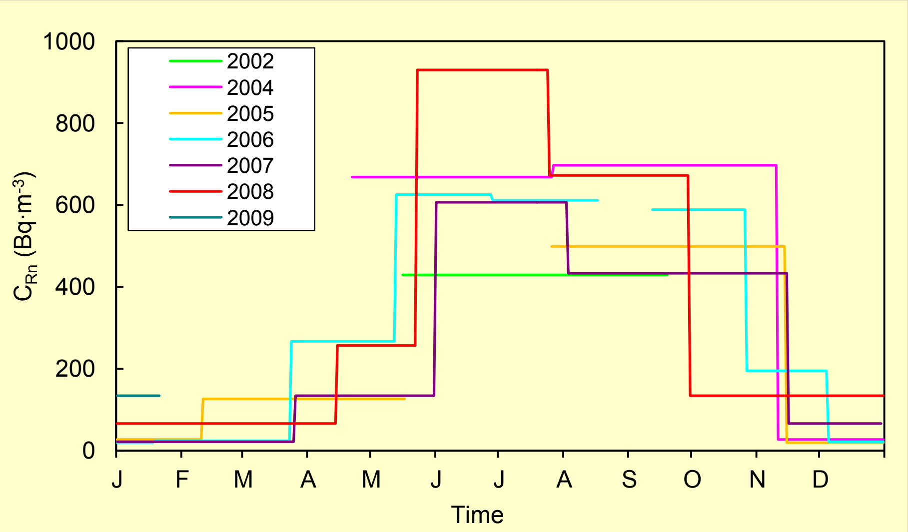
- Daily variations

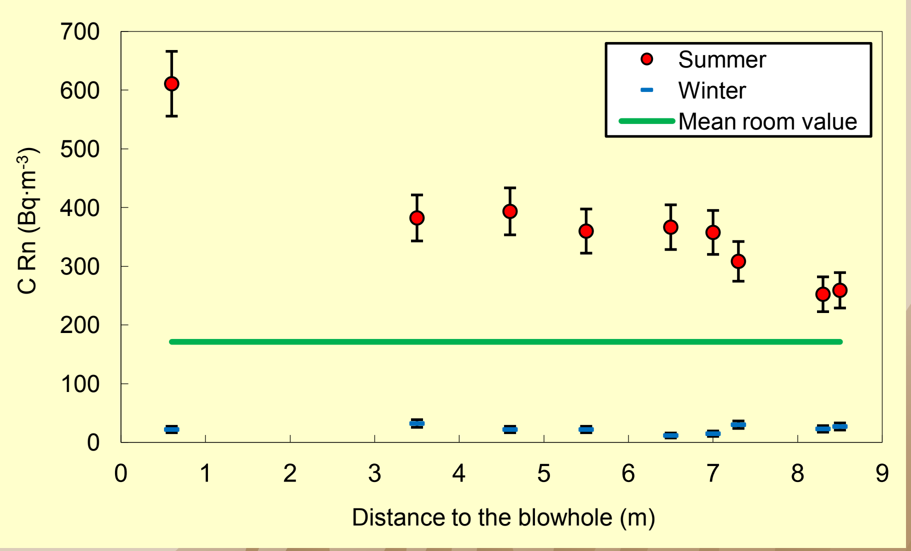


Dwelling having a blowhole:

- Integrated radon measurements (Makrofol detectors) at:
  - 60 cm above the blowhole outlet.

  - Different distances to the blowhole outlet across the room.

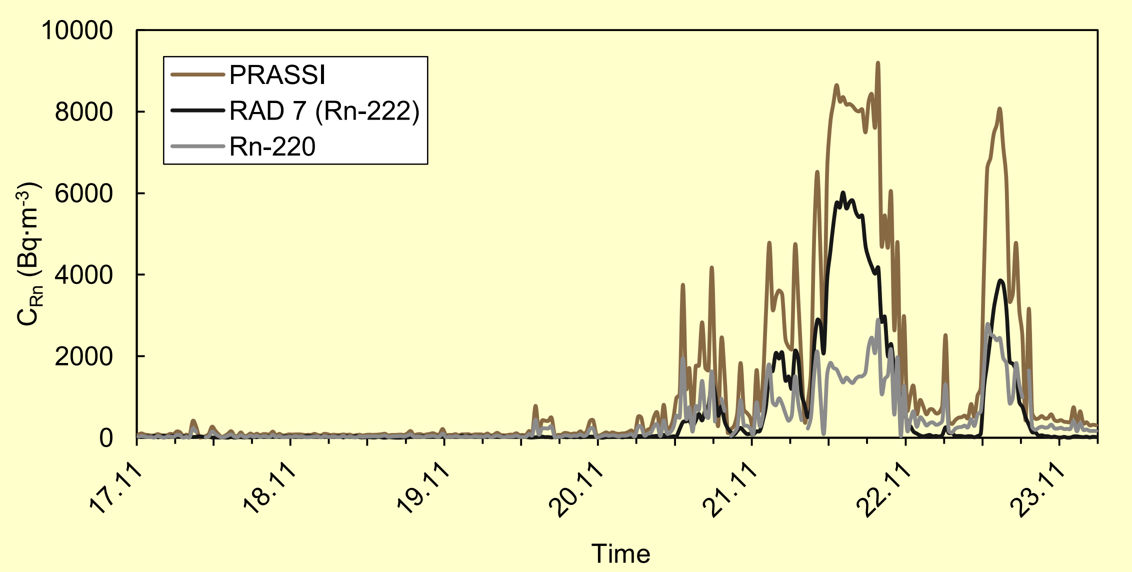




3. Experimental Results

Dwelling having a blowhole:

– Continuous measurement of radon and thoron at the outlet of the blowhole (PRASSI and RAD7 monitors simultaneously):



$$C_{Rn-220} = \frac{C_{Rn}^{PRASSi} - C_{Rn-222}^{RAD7}}{1.73}$$

Airflow (C_{Rn-222} **>** 200 Bq·m^{-3}):

C_{Rn-220} / C_{Rn-222} = 0.6

No airflow (C_{Rn-222} **<** 200 Bq·m^{-3}):

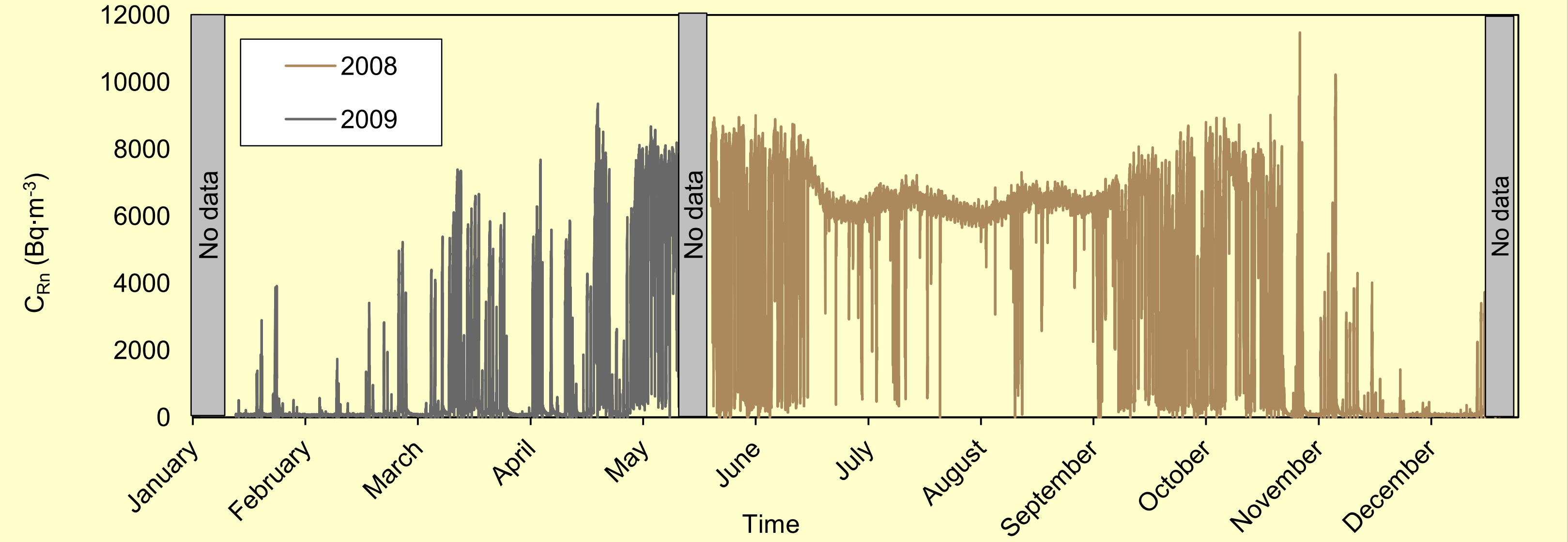
C_{Rn-220} / C_{Rn-222} = 3.5

– Comparison with punctual measurements (RAD7):

Date	T (ºC) (±0.01)	RH (%) (±0.01)	v_{air} (m·s^{-1}) (±0.01)	^{222}Rn (Bq·m^{-3})	^{220}Rn (Bq·m^{-3})	$C_{Rn-220}/C_{Rn-222}^{RAD7}$
01 Jun.	14.0	81.4	0.06	(71 ± 18)·10	(40 ± 32)·10	**0.56**
03 Aug.	13.7	95.4	0.72	2682 ± 50	(168 ± 14)·10	**0.63**
24 Nov.	8.9	77.3	-	7 ± 7	39 ± 22	**5.57**

◆ Dwelling having a blowhole:

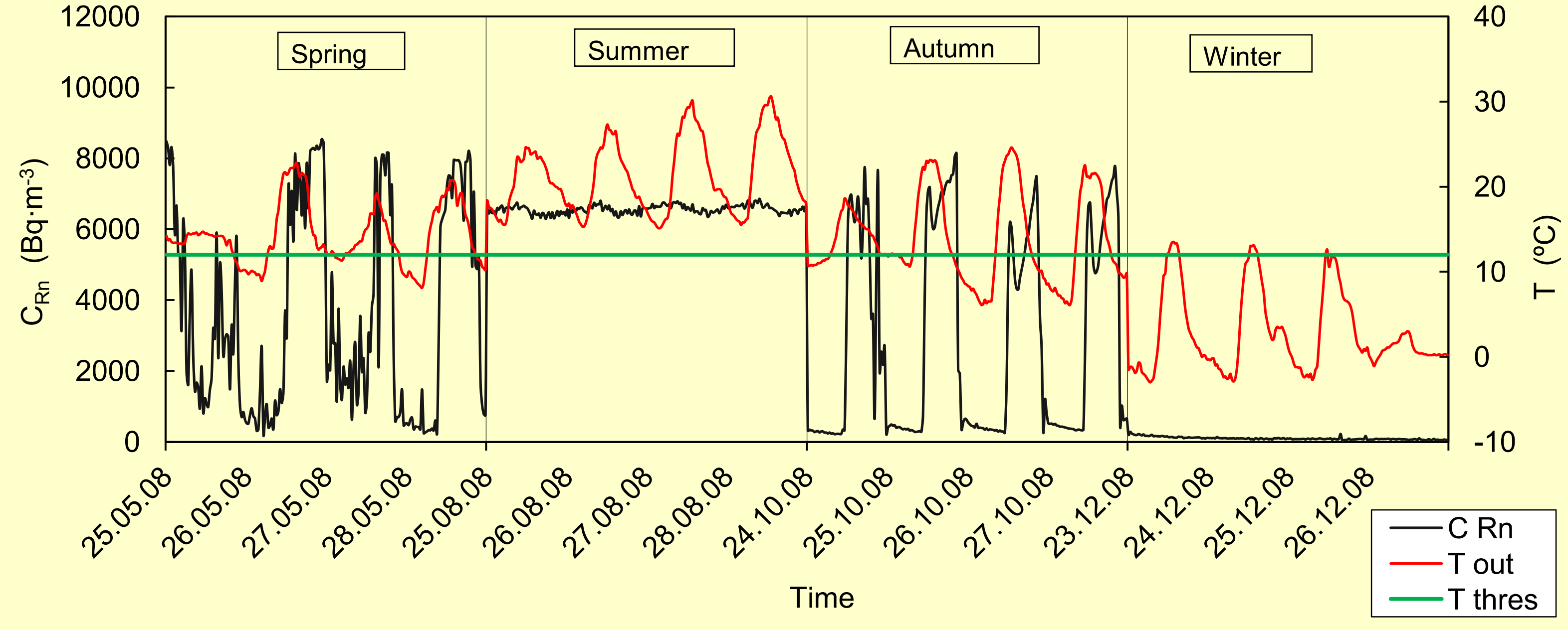
– Continuous measurements of radon at the outlet of the blowhole (PRASSI monitor):



- Important daily and seasonal variations.
- What can explain this behaviour?

◆ Dwelling having a blowhole:

– Relation with atmospheric air temperature (T out).



- Threshold temperature = T soil = 12 ºC
- If T out > T thres at least for 3 h: rapid increase of radon levels.
- Soil-outdoor temperature difference is the most influent parameter for indoor radon levels in dwellings with blowholes.

Conclusions:

- Continuous measurements carried out confirm previous seasonal results and show important daily variations.
- The behaviour of radon levels in a house having an indoor well and another having a blowhole is opposite to that observed in houses in general and similar to underground places (caves, tunnels, mines,..)
- The main radon entry mechanism in the studied houses is a convective flow due to the soil-outdoor temperature differences, which drive the seasonal variations.
- The results of this volcanic region could be observed in other volcanic regions with similar characteristics.

- **Perspectives:**
  - Continue exploring the origin of the radon in this region (volcanic rocks, lower substrates with high radium content (granites), mantle degassing (and transport through fractures in crust, as the Amer fault).
  - Measure other gases that can have deep (CO_2, H_2S, …) or shallow origins (He, …) at the identified blowholes.
  - Measure soil radon and thoron concentrations and radon and CO_2 fluxes at different volcanic materials of the region.
  - Model radon concentration dynamics in the studied indoor blowhole.

Thank you