Building materials of volcanic origin as a source of indoor radon concentration and gamma radiation in Caprarola town (Viterbo, Italy).

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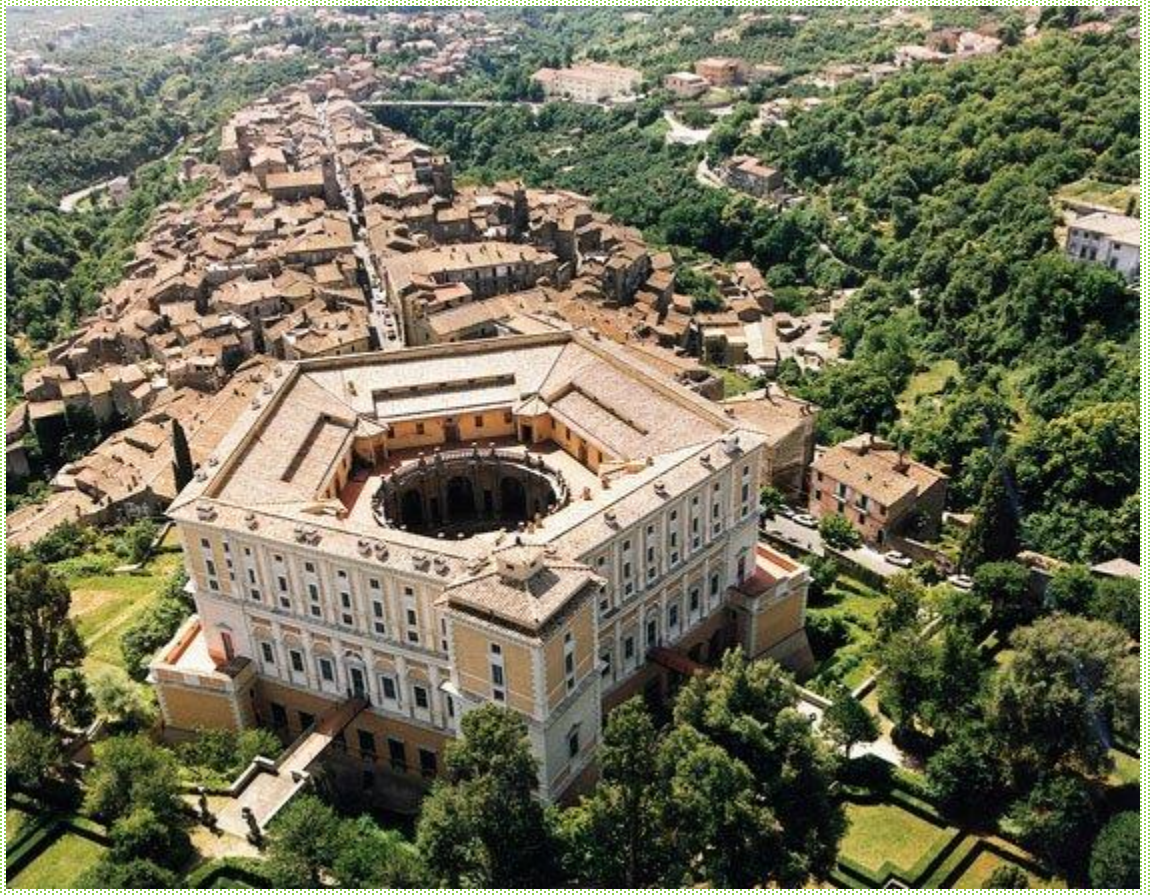
Outline of the presentation

- Introduction and goal of this study
- Use of building materials of volcanic origin in the study area
- Geological setting
- Materials and Methods
- Results
  - ^{222}Rn and ^{220}Rn exhalation rates
  - Contribution of building materials to indoor radon
- Future perspective
  - Classification scheme of building materials
  - Experimental model room

Introduction and goal of the study

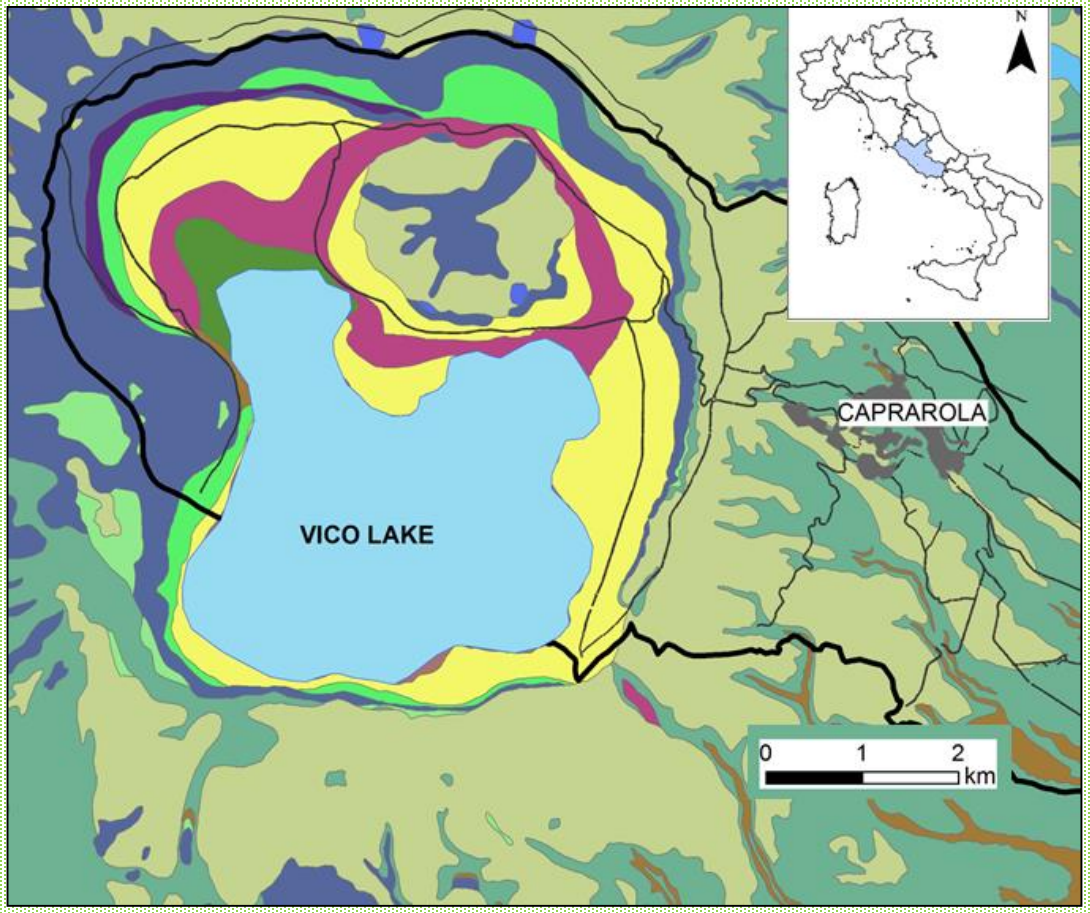
Caprarola (VT, Italy) is one of the study sites of LIFE-RESPIRE project (Radon rEal time monitoring System and Proactive Indoor Remediation).

RESPIRE
Radon real time monitoring system



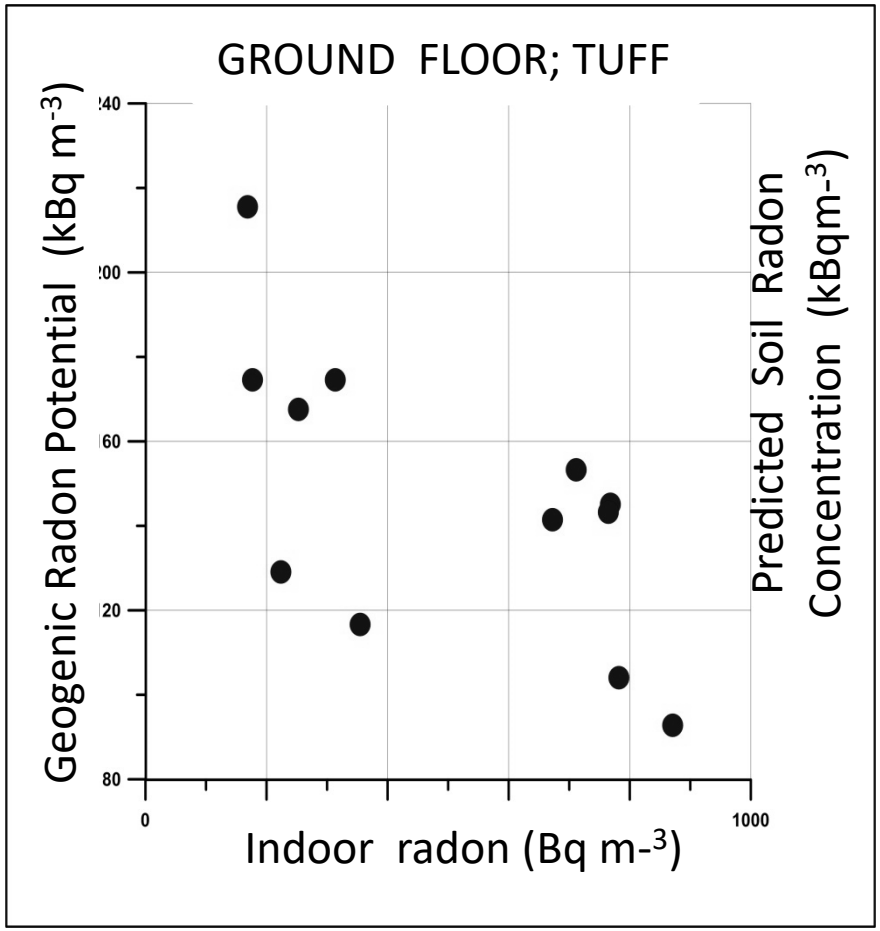
Introduction and goal of the study

Caprarola stands on a volcanic substrate and its edifices are built with ignimbrites and phreatomagmatic products. High indoor radon and gamma radiation dose are recorded. We investigate the role of building materials of volcanic origin.



Data supporting this study

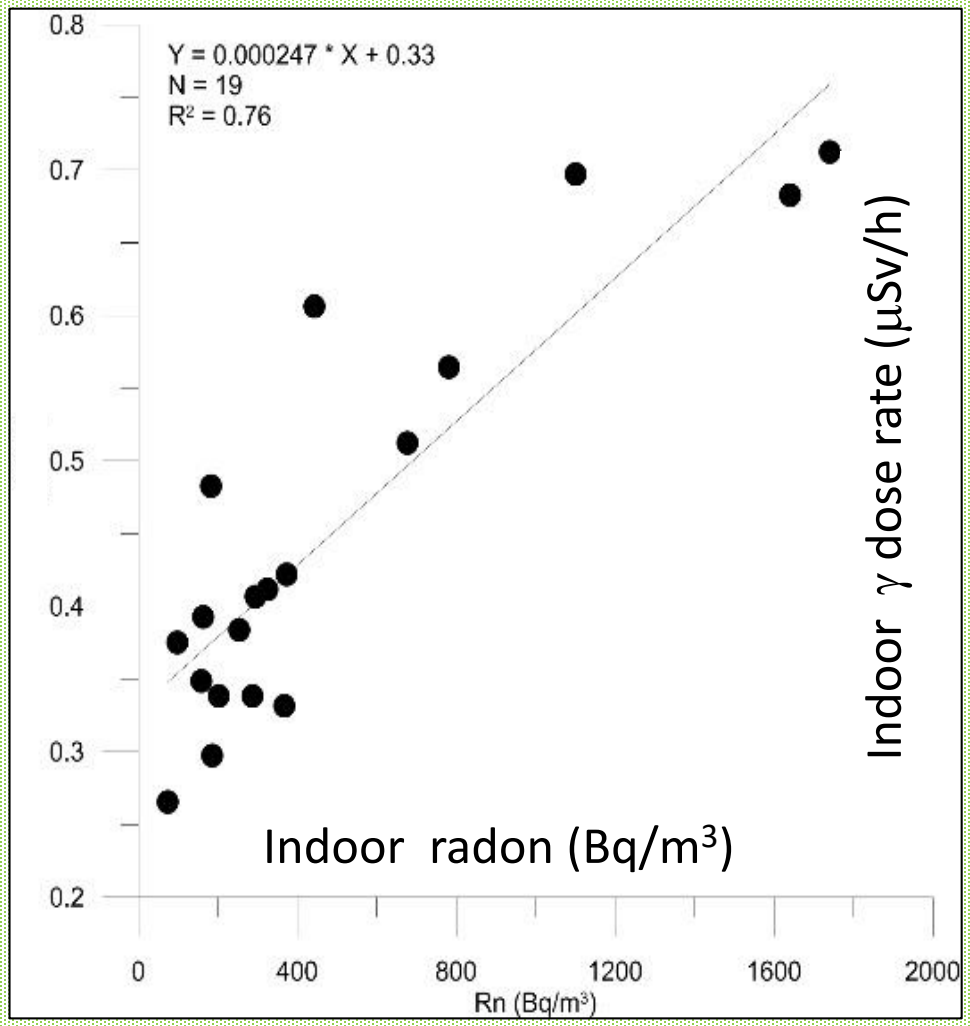
NO CORRELATION BETWEEN SOIL RADON AND INDOOR RADON IN SELECTED GROUND FLOOR ROOMS OF TUFF-MADE BUILDINGS



Ruggiero et al. (2018), this workshop

Data supporting this study

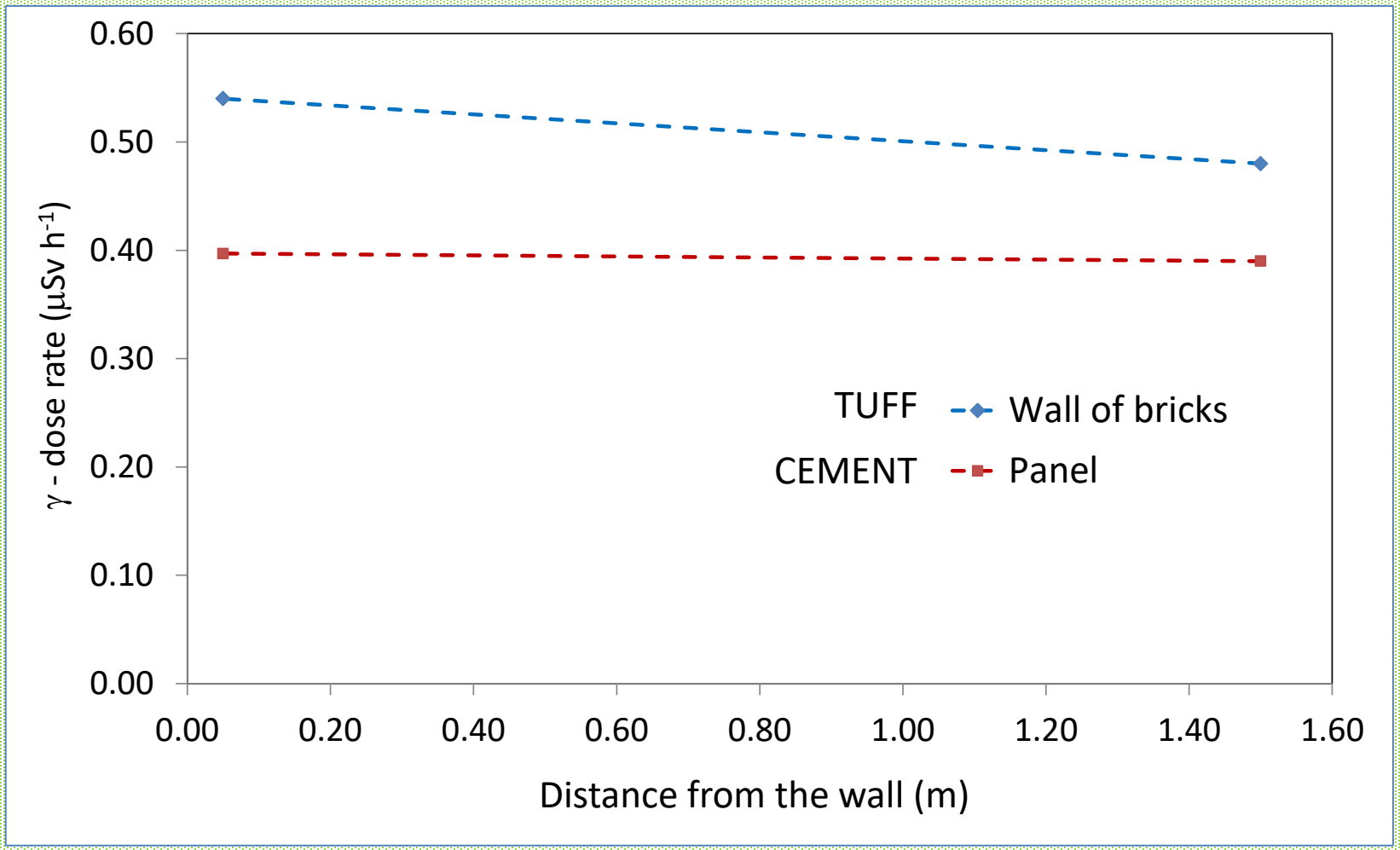
GOOD CORRELATION BETWEEN INDOOR RADON AND INDOOR GAMMA DOSE RATE IN TUFF-MADE BUILDINGS



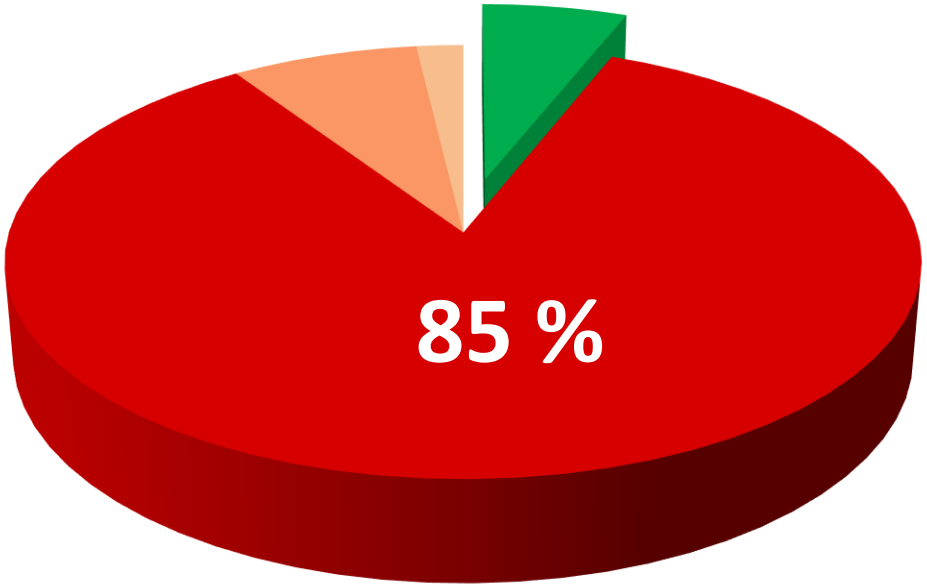
Ruggiero et al. (2018), this workshop

Data supporting this study

Building materials as a source of indoor γ–radiation



Building materials employment in Caprarola edifices (VT, Italy)



Commercial use (6%)

Residential use (94%)

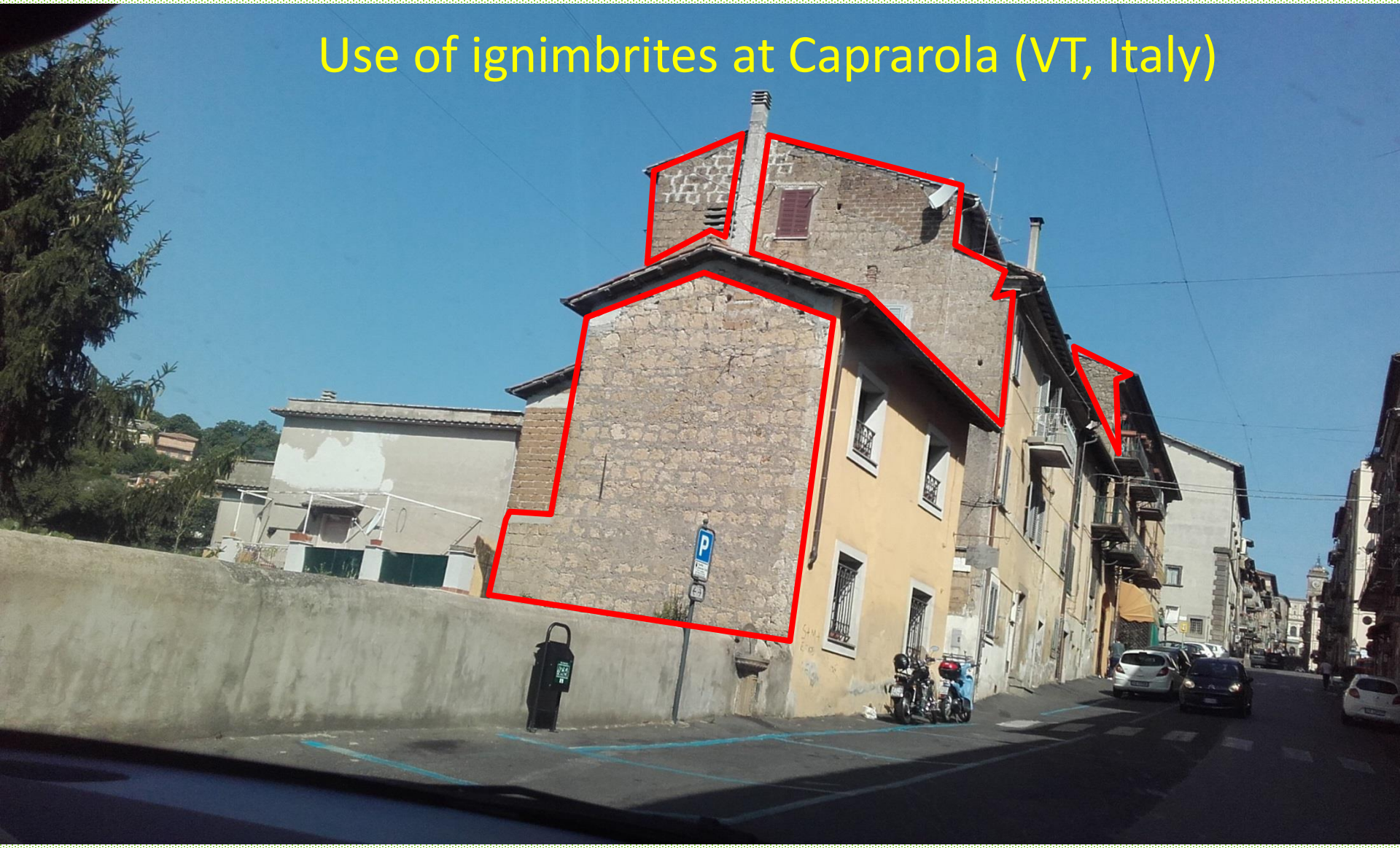
1

2 **Ignimbrites bricks**

3 **Concrete**

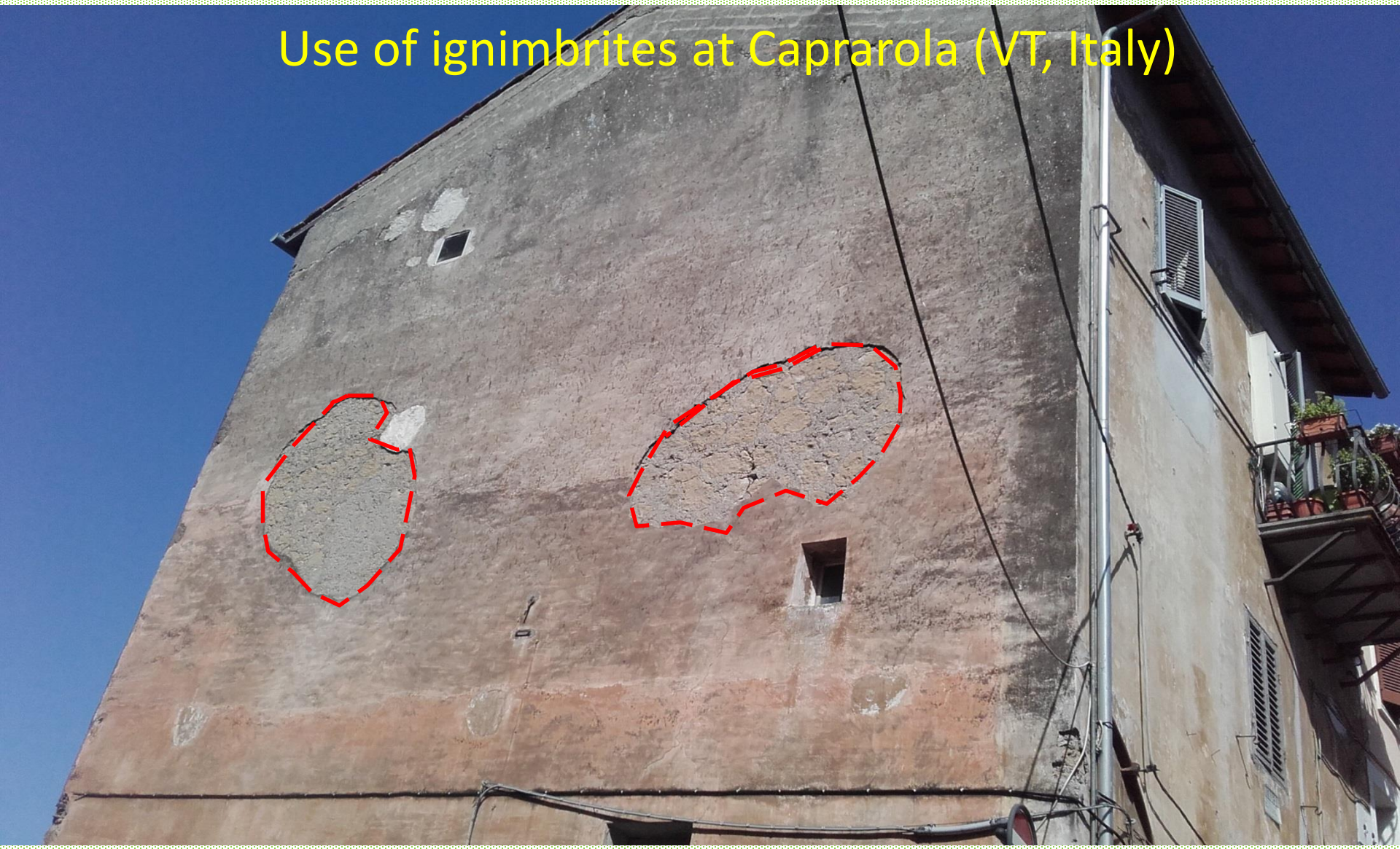
4 **Steel, wood ….**

Use of ignimbrites at Caprarola (VT, Italy)



«Tufo Rosso a Scorie Nere» ignimbrite has always been used to build edifices at Caprarola town (Viterbo, Italy).

Use of ignimbrites at Caprarola (VT, Italy)



Bricks of tuff are generally covered with plaster that may deteriorate with age and fall away from the building, revealing the underlying surface.

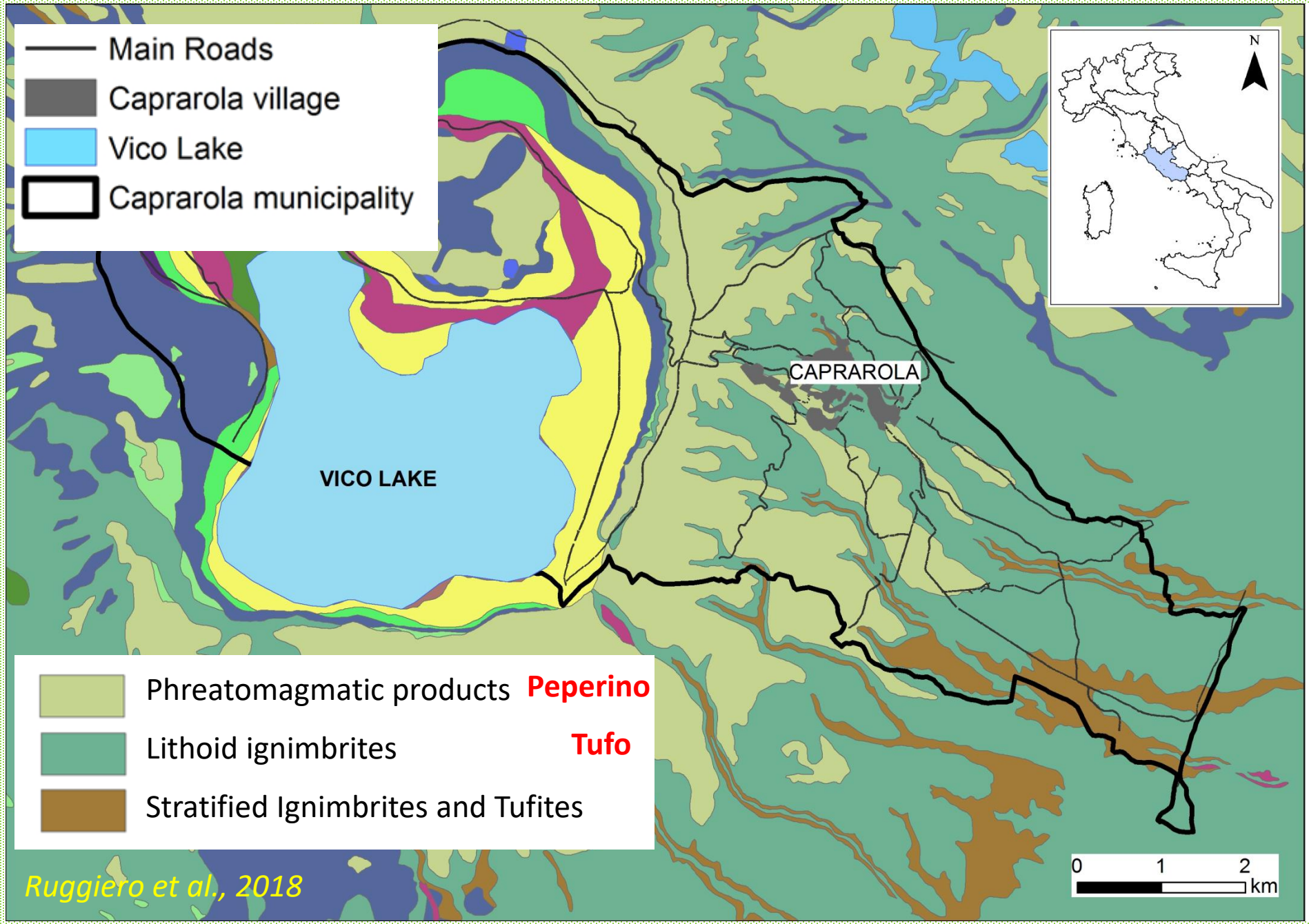
Use of phreatomagmatic products at Caprarola (VT, Italy)

«Peperino» stone is employed to make steps, thresholds and decoration.

Use of phreatomagmatic products at Caprarola (VT, Italy)

As an example, the tresholds of this pharmacy are made of «Peperino» stone.

Geological map of Caprarola area

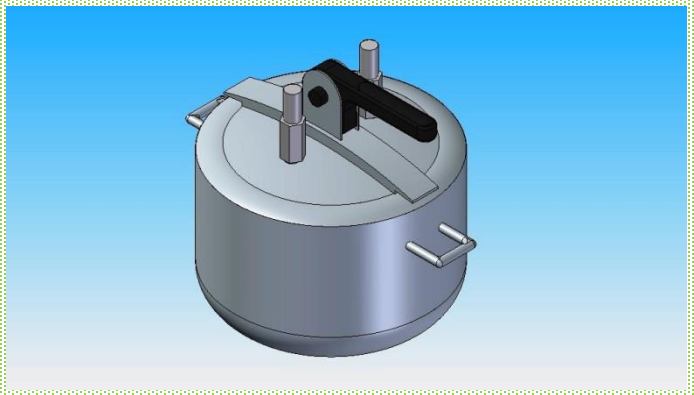


Building materials bought in building materials store in Caprarola

Materials sampled in an artificial cave below Caprarola

METHODS

1. 15 cm x 10 cm x 5 cm block or 1 kg of incoherent material are dried at 100°C for 24 hours

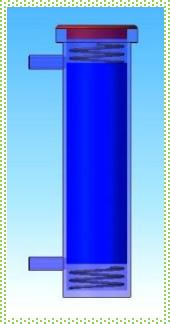


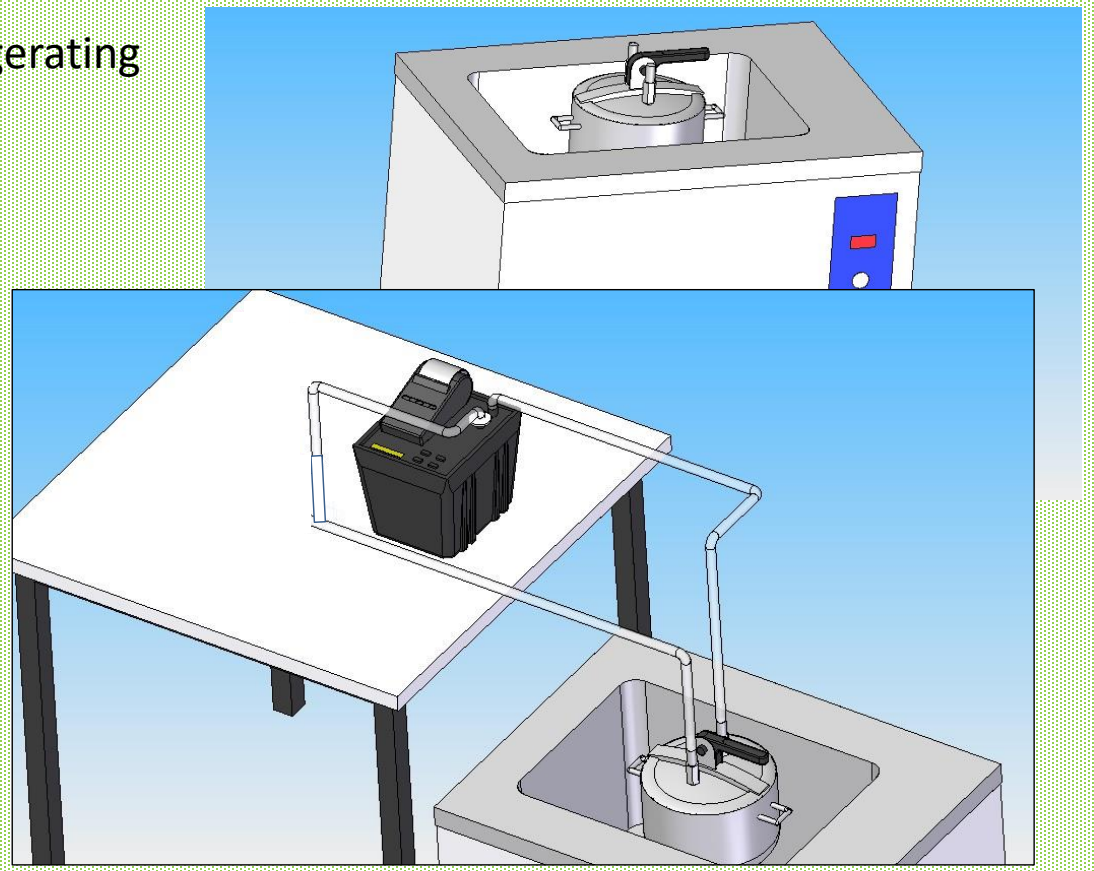
2. … then placed in the accumulation chamber

3. … the chamber is located in a refrigerating thermostatic bath (set at 30°C) …

4. … the chamber is connected to a radon monitor (RAD7, Durridge Co.) via vinyl tubings …

5. … no desiccant is employed during the test …





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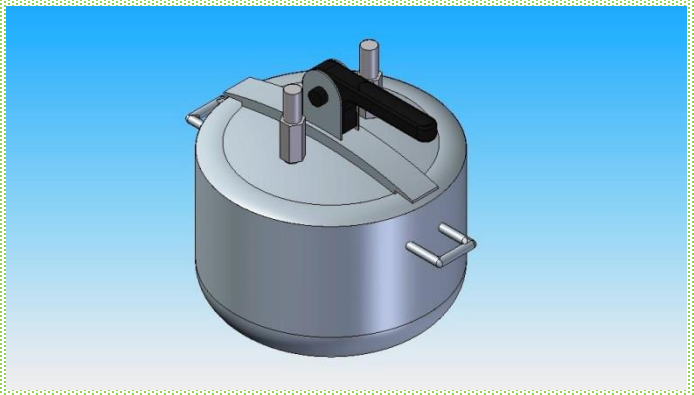

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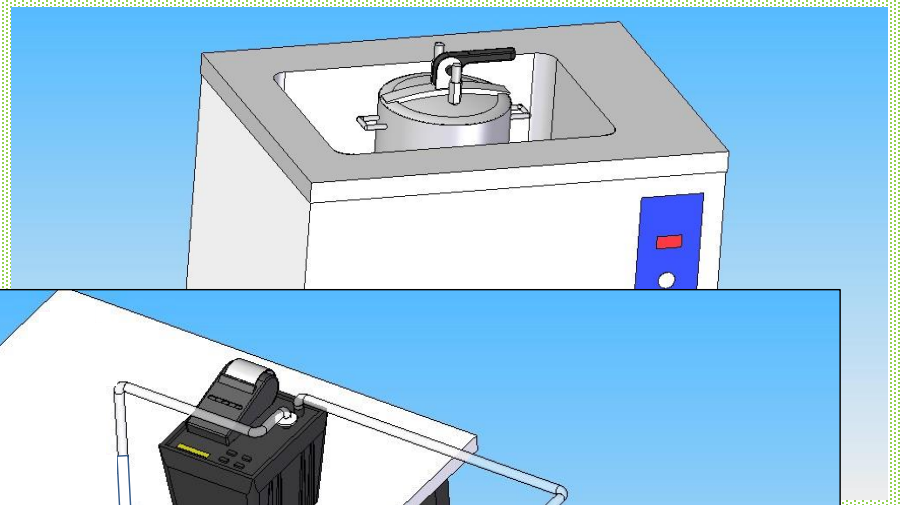

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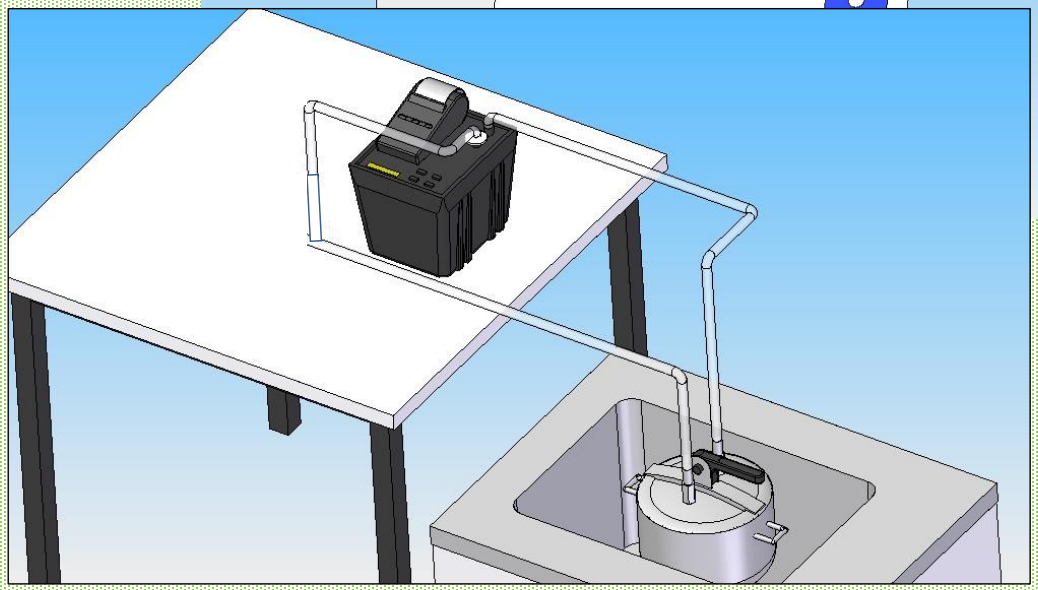
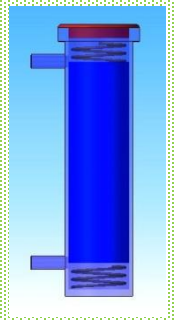
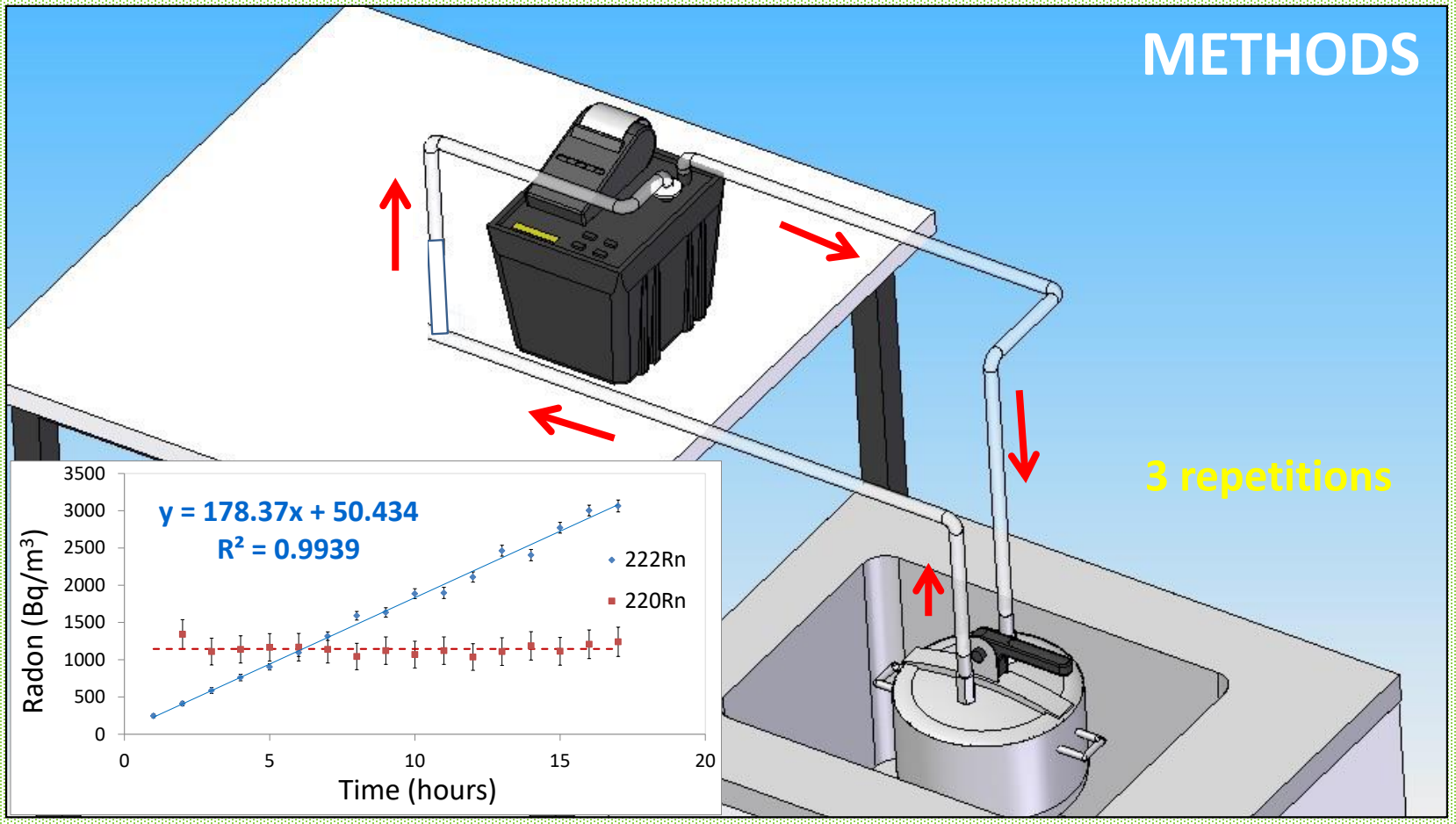


5. … no desiccant is employed during the test …

… because the system is previously dried



METHODS



The ^{222}Rn growth curve and ^{220}Rn average activity concentration in the closed-loop circuit are monitored with cycle times of 1 hour for 16-18 hours in order to calculate radon and thoron exhalation rates, expressed as Bq m^{-2} h^{-1}

RESULTS - Exhalation rates of ignimbrites bricks purchased in a **building material wholesale store in Caprarola**

	^{222}Rn Bq m^{-2} h^{-1}	^{220}Rn Bq m^{-2} h^{-1}
"Tufo di Gallese" ignimbrite	4.68 ± 0.16	6683 ± 552

"Tufo di Riano" ignimbrite	2.13 ± 0.15	4203 ± 271

Sabatini Volcano

RESULTS - Exhalation rates of “Peperino” stone purchased in a **building material wholesale store in Caprarola**

	^{222}Rn Bq m^{-2} h^{-1}	^{220}Rn Bq m^{-2} h^{-1}
“Peperino Grigio” stone	0.78 ± 0.16	2629 ± 329

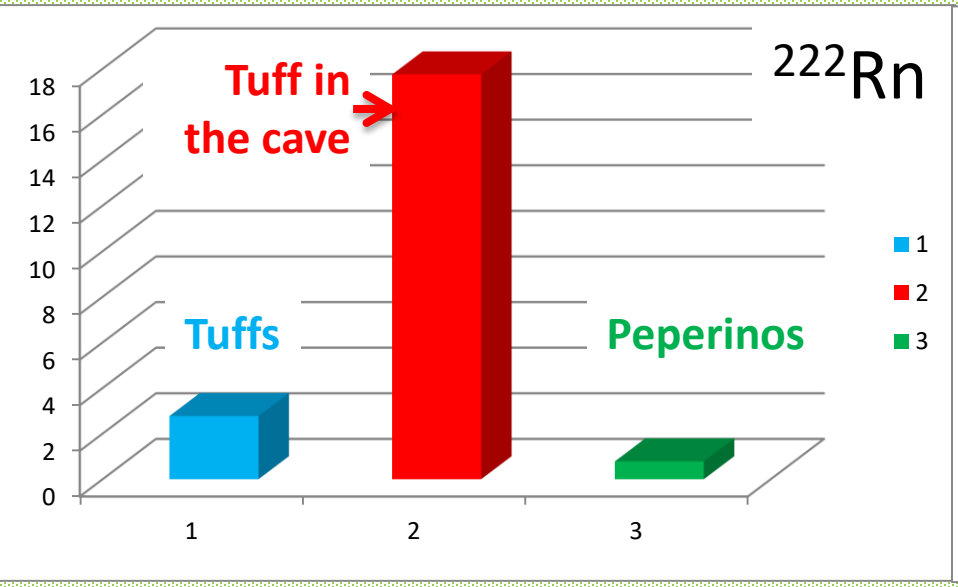
“Peperino Rosato” stone	0.43 ± 0.19	1616 ± 197

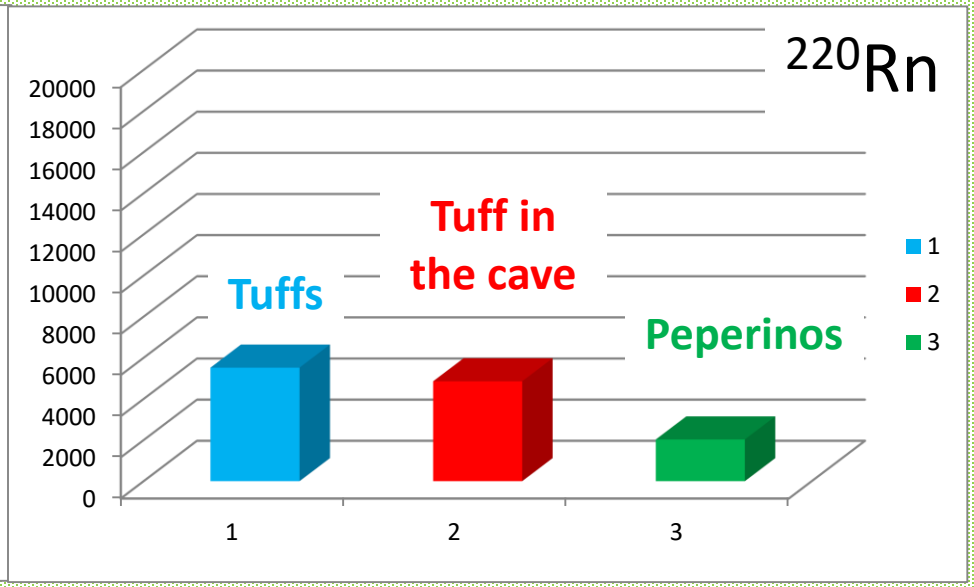
RESULTS - Exhalation rates of ignimbrites sampled in **a cave below Caprarola,** formerly used as tuff quarry

	^{222}Rn Bq m^{-2} h^{-1}	^{220}Rn Bq m^{-2} h^{-1}
"Ignimbrite C"	**17.99 ± 0.05**	4605 ± 370

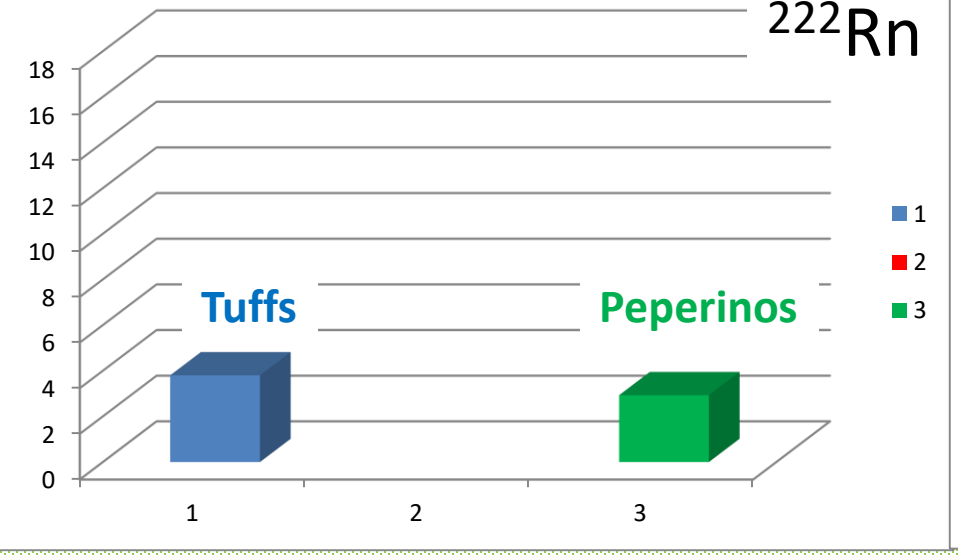
"Weathered ignimbrite C"	1.55 ± 0.19	5344 ± 472

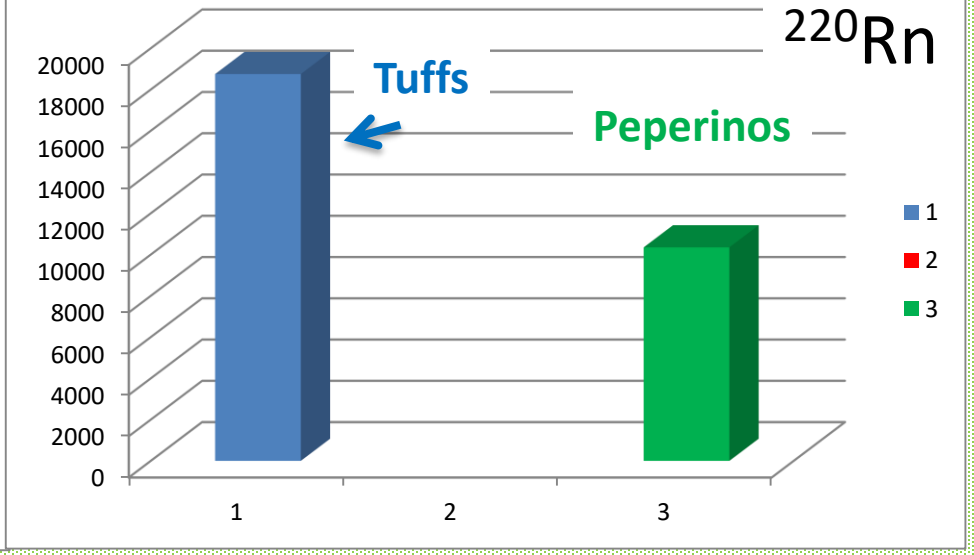
Average of radon exhalation rates of **building materials**



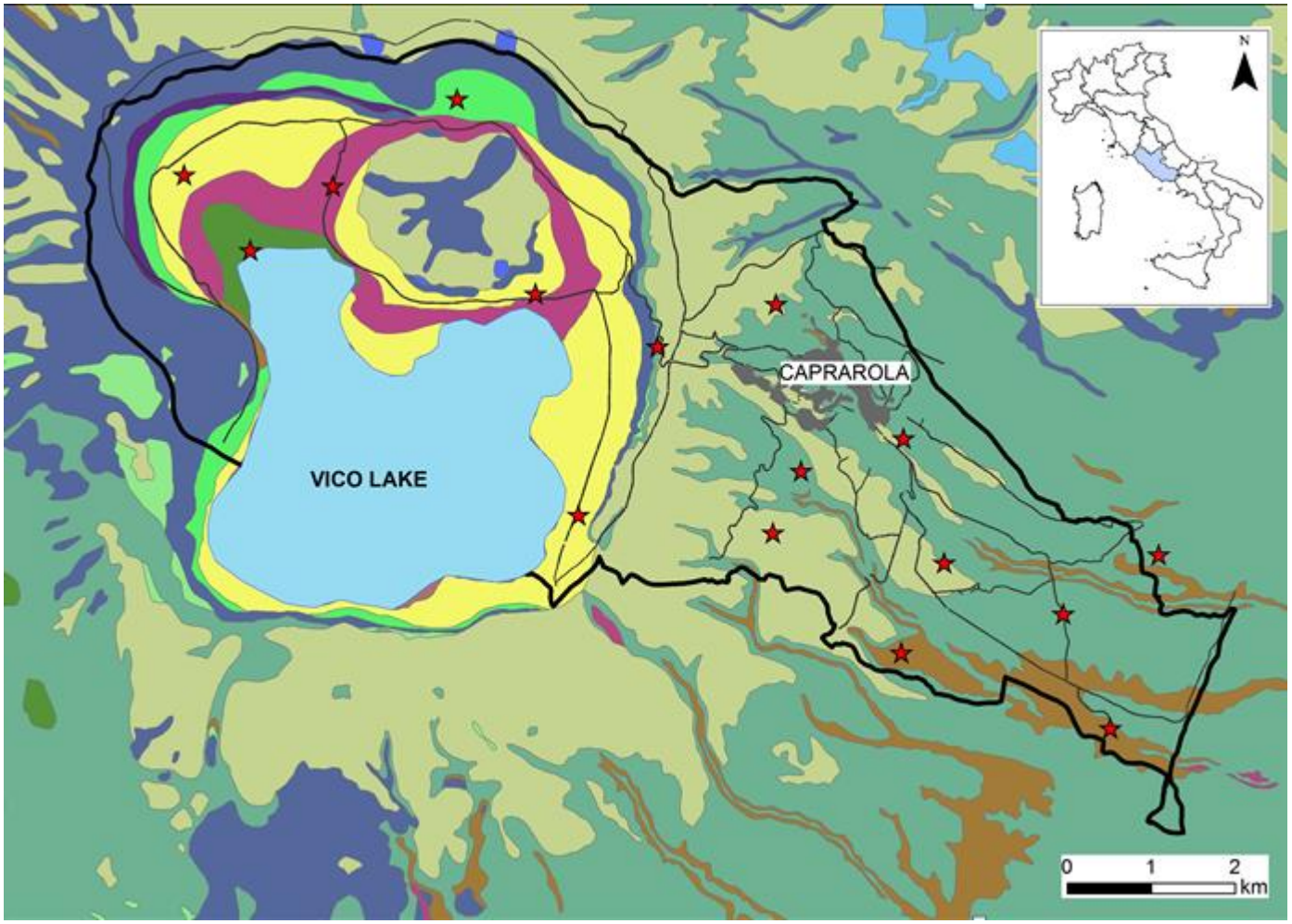


Average of radon exhalation rates of **soil samples**





Exhalation rates of soil samples, measured in the lab



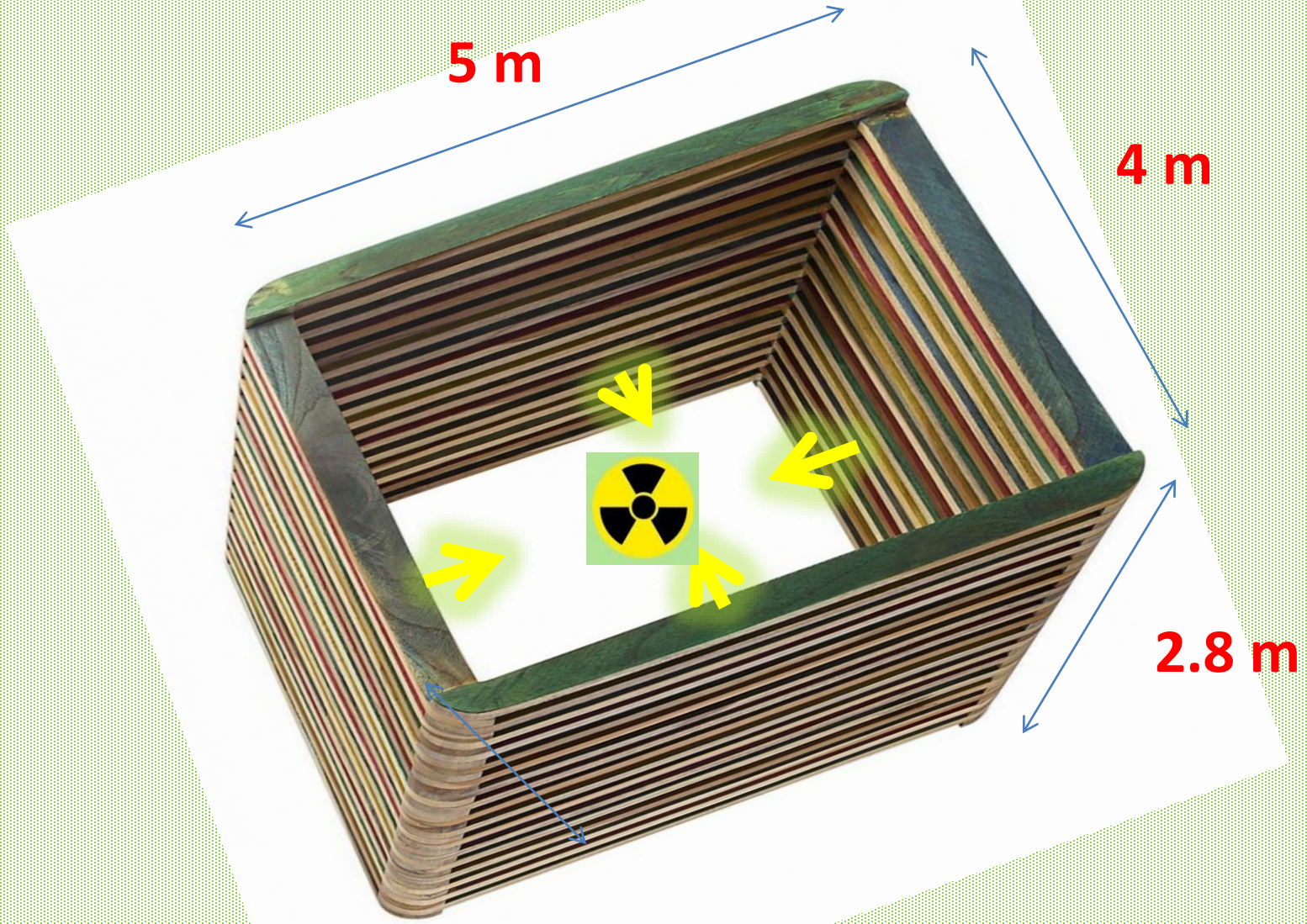
Soil samples

Phreatomagmatic products

Lithoid ignimbrites

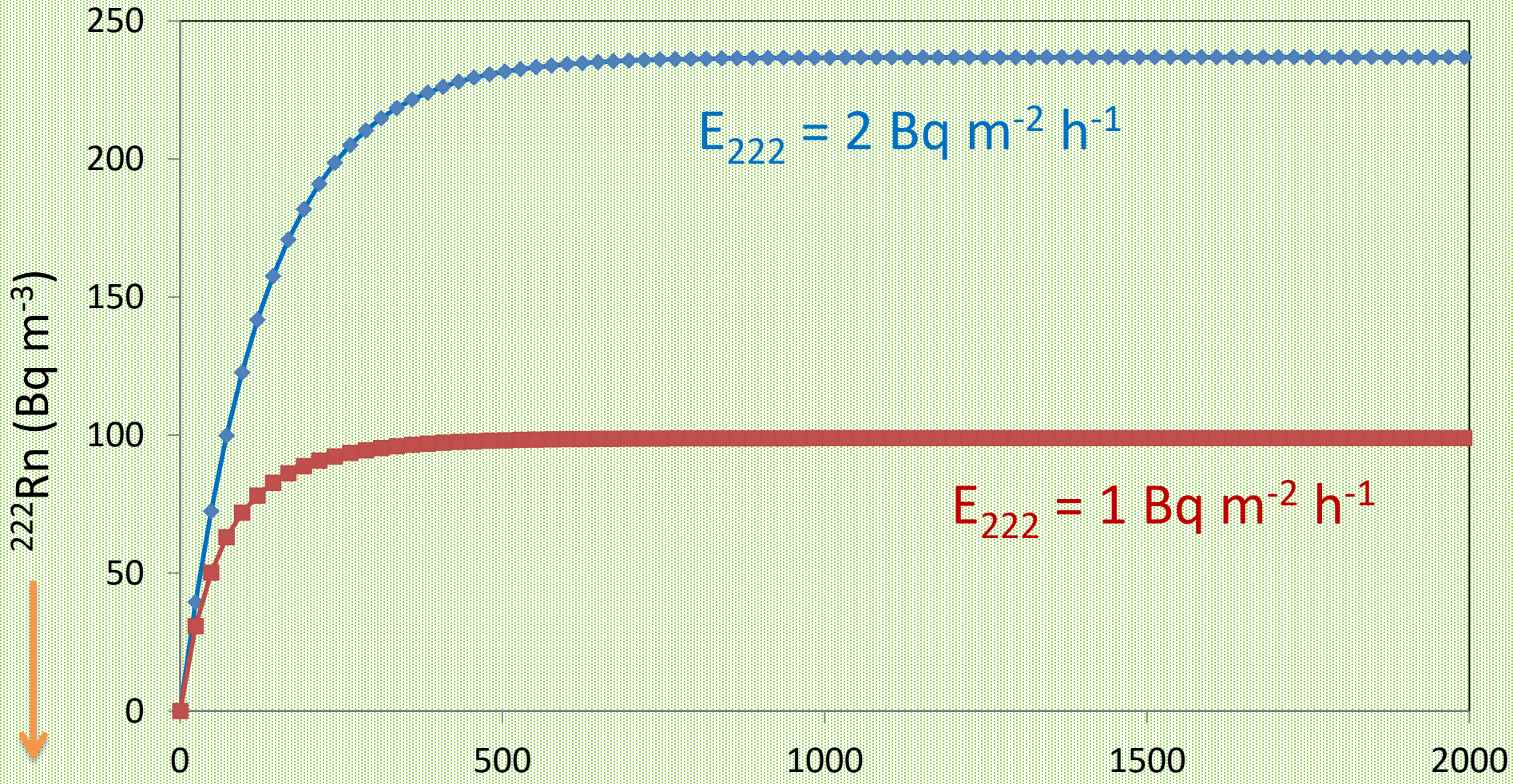
Stratified Ignimbrites and Tufites

CLOSED MODEL ROOM WITH A VOLUME OF di 56 m^3



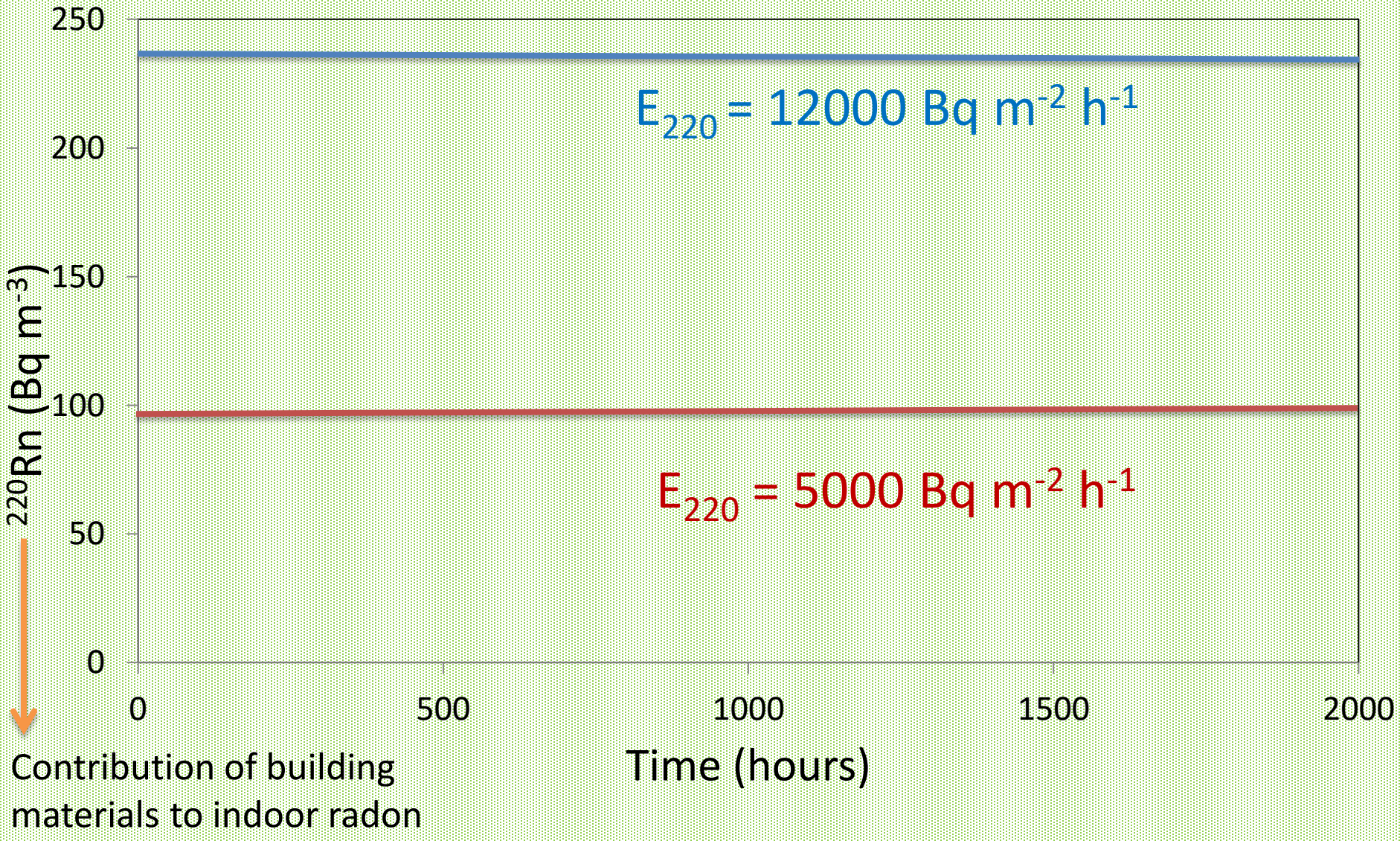
ONLY THE WALLS ARE MADE FROM TUFF - **S = 50.4 m^2**

^{222}Rn increase up to equilibrium in the model room



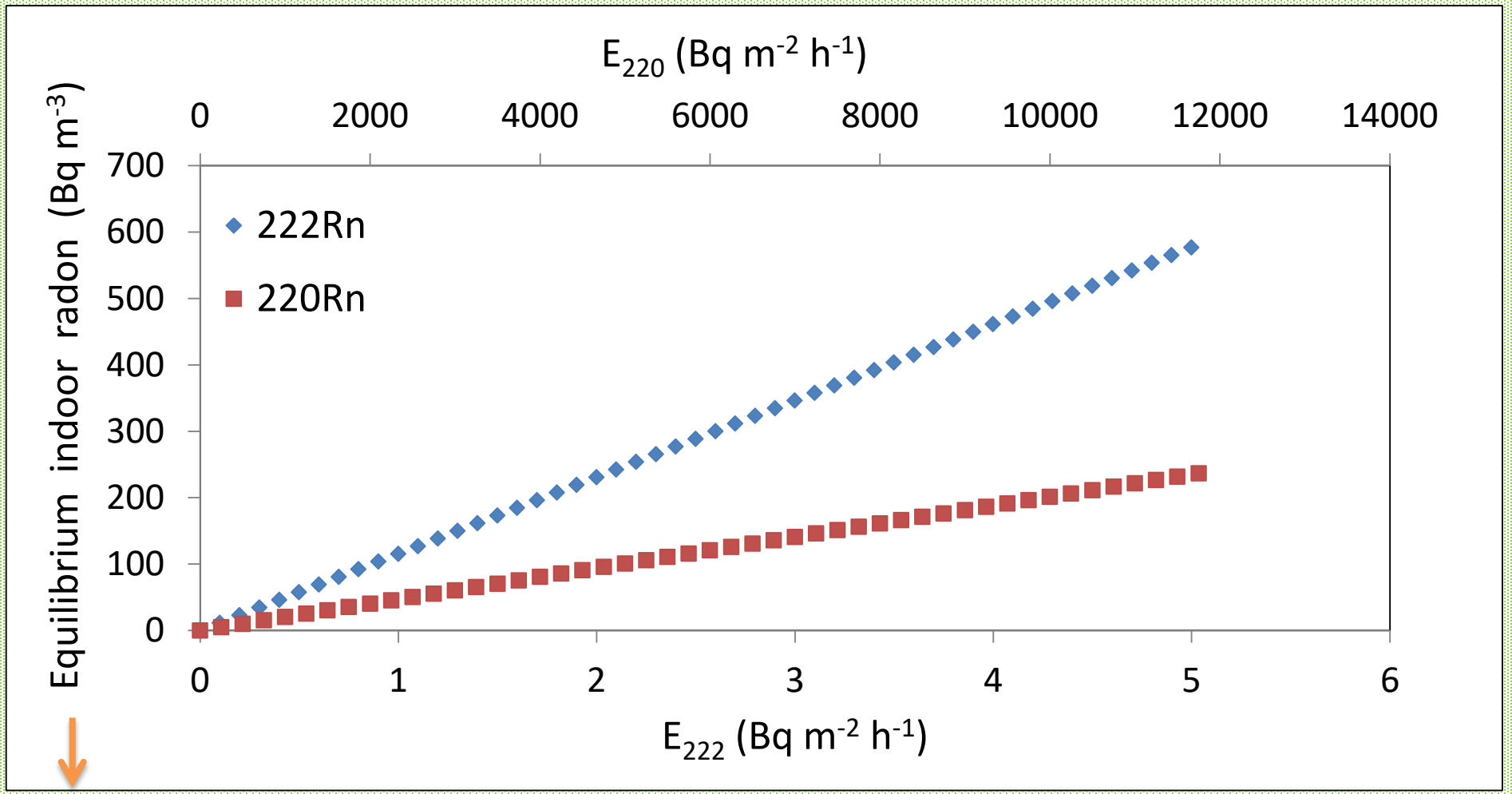
Contribution of building materials to indoor radon

^{220}Rn equilibrium in the model room



Contribution of building materials to indoor radon

Equilibrium indoor radon vs radon exhalation rates in the model room



Contribution of building materials to indoor radon

Classification of building materials based on their **C**ontribution to **I**ndoor **R**adon

Eq. indoor radon due to $^{222}Rn + {}^{220}Rn$ ($Bq\ m^{-3}$)	CIR class
> 1000	I
500 - 999	II
300 - 499	III
100 - 299	IV
< 100	V

Classification of building materials from Caprarola area

Material	(Indoor Radon) Bq m^{-3}	Class CIR
«Peperino Grigio di Vitorchiano»	(145)	IV
«Peperino Rosato di Bassano in Teverina»	(84)	V
«Tufo di Riano»	(399)	III
«Tufo di Gallese»	(692)	II
«Ignimbrite C»	(2234)	I
Deeply weathered «Ignimbrite C»	(293)	IV

Indoor radon in the experimental scale model room consisting of tuff

- Checking indoor radon from 4 walls made from tuff (using Rn-free floor and ceiling)
- Introducing floor
- Introducing ceiling
- Covering walls with different coatings

Implications for the classification of building materials

Thank you for your attention