NATURAL RADIOACTIVITY AND RADON RISK ASSESSMENT IN THE VULSINI VOLCANIC DISTRICT (CENTRAL ITALY)

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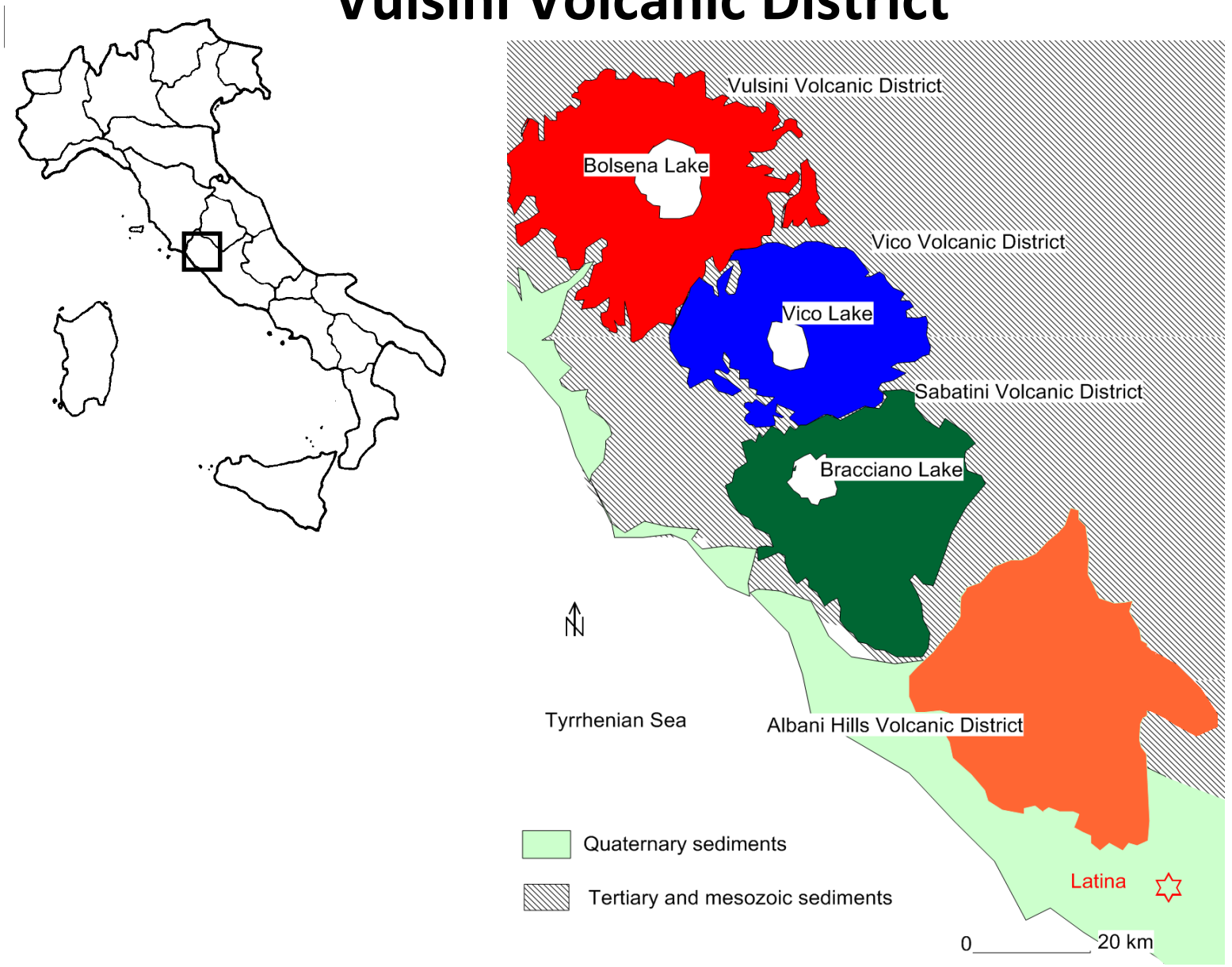
University of Bologna, Alma Mater Studiorum

Vulsini Volcanic District



after Vezzoli et al, 1987, modified

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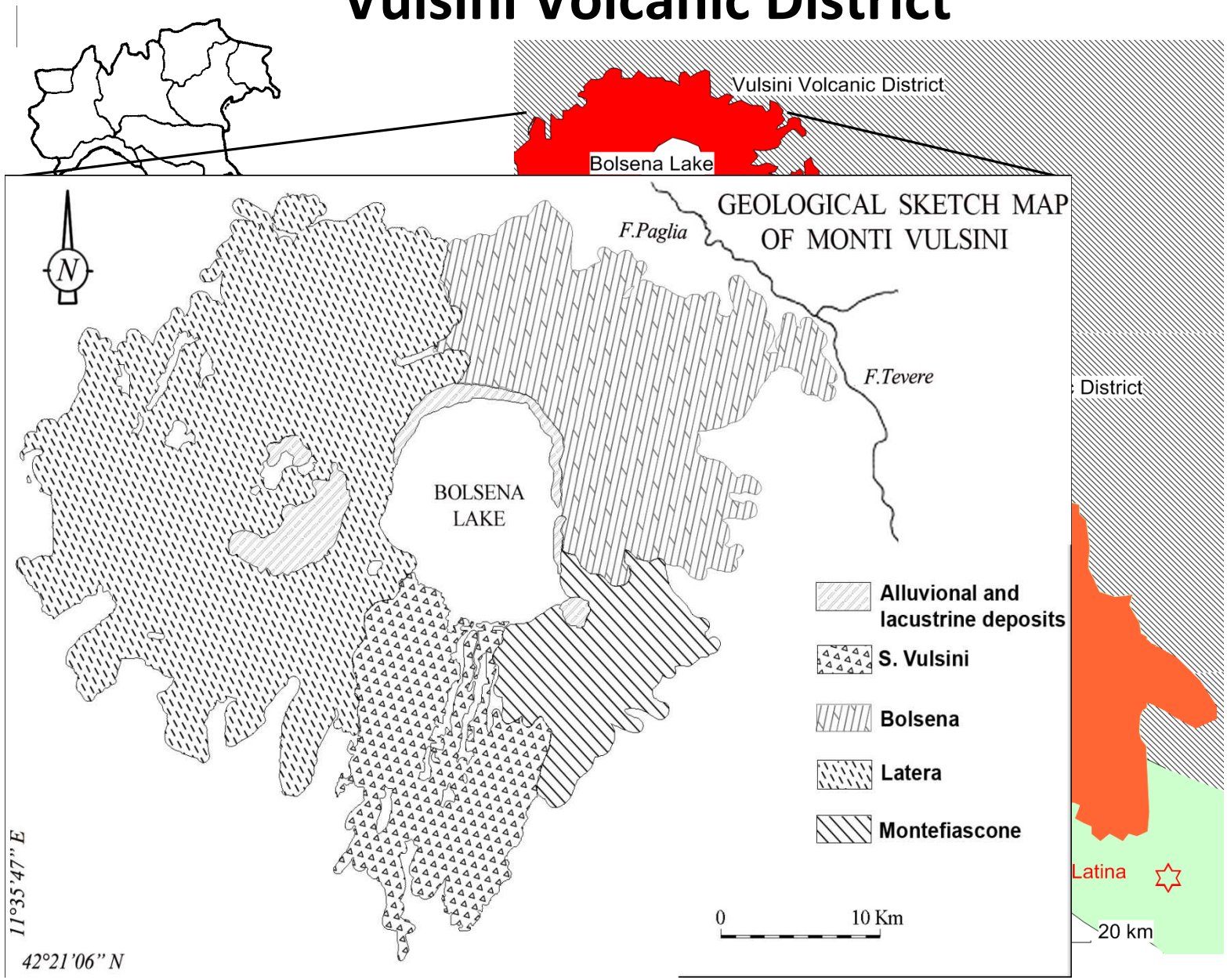

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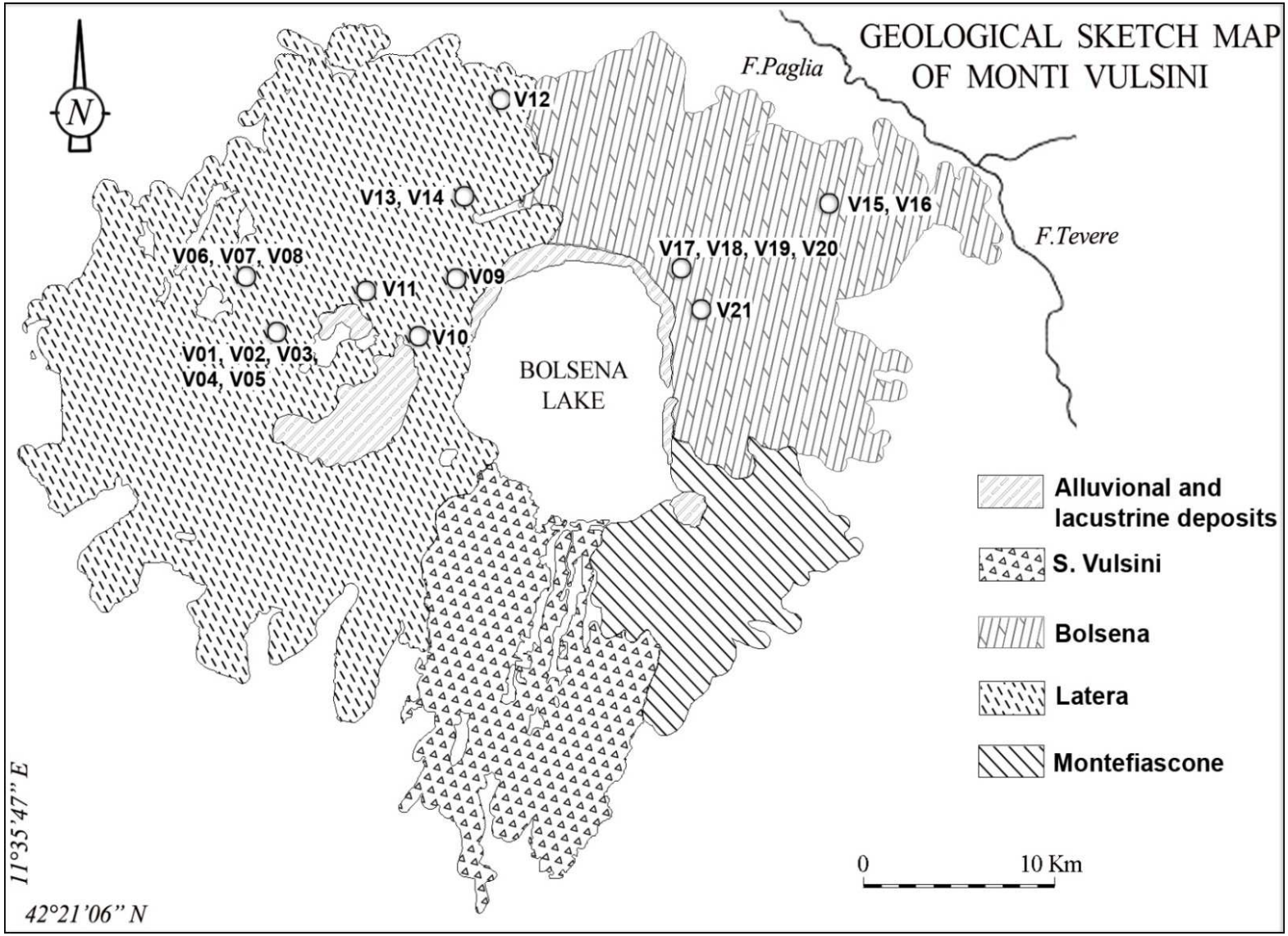
Bolsena (VT)

Rock Sampling



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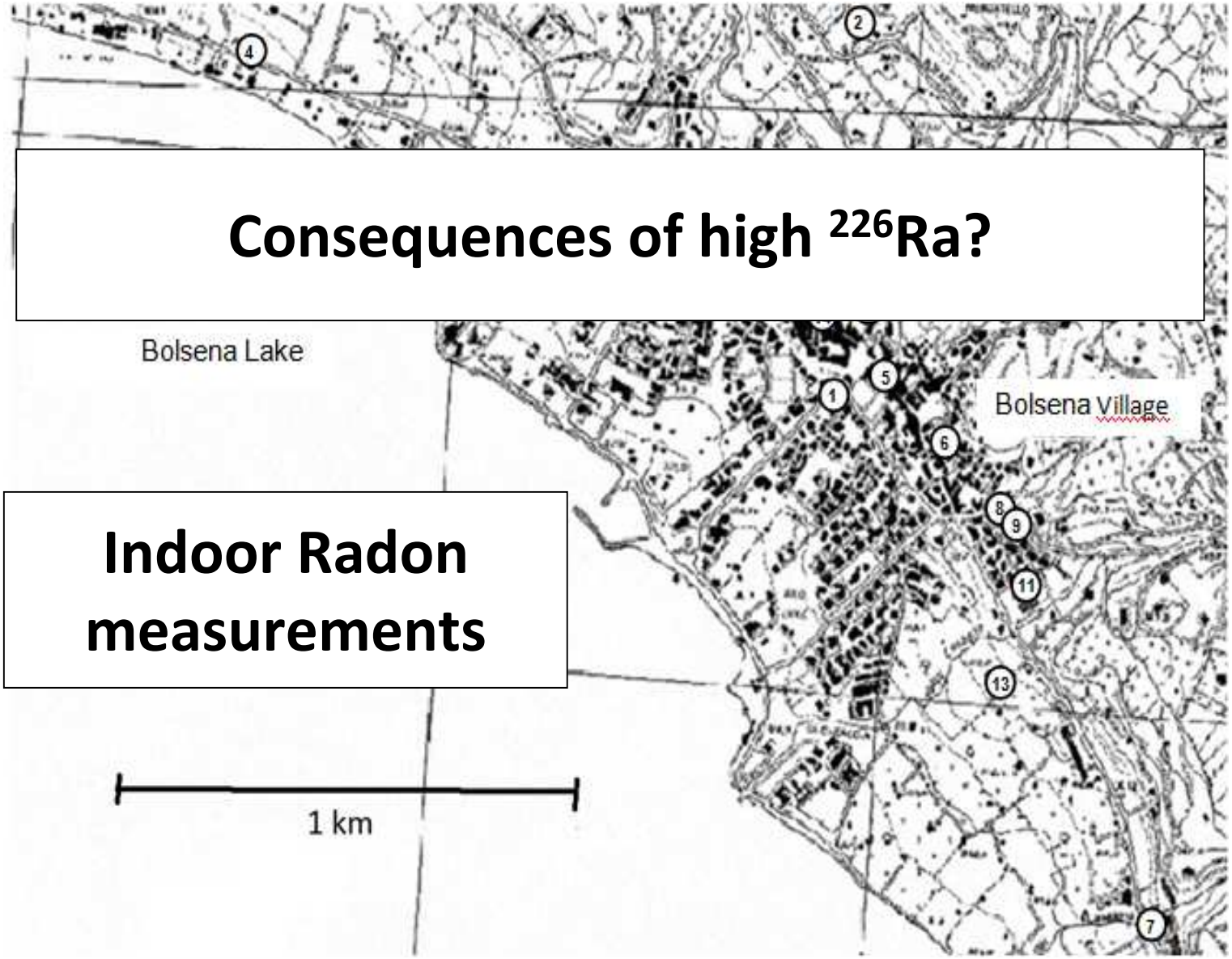
Activity concentartion (Bq/kg) of natural radioisotopes by gamma-spectrometry, values of emanation power and Radioactivity Index

		^{214}Bi (Bq/kg)	^{214}Pb (Bq/kg)	^{226}Ra (Bq/kg)	^{228}Ac (Bq/kg)	^{40}K (Bq/kg)	REP ε	U (ppm)	Th (ppm)	K (%)	RI
V04	Lat-A	102	115	122	240	1490	0.11	10	59	4.8	2.1
V07	Lat-A	166	174	220	309	1559	0.23	18	76	5	2.8
V08	Lat-A	150	149	201	272	1724	0.25	16	67	5.6	2.6
V03	Lat-C	132	131	157	208	2325	0.16	13	51	7.5	2.3
V05	Lat-D	170	180	215	322	1564	0.19	17	79	5	2.8
V06	Lat-D	82	83	133	232	1668	0.38	11	57	5.4	2.2
V01	Lat-E	60	45	80	126	586	0.34	6	31	1.9	1.1
V02	Lat-E	56	61	86	151	808	0.32	7	37	2.6	1.3
V09	Lat-F	75	66	92	150	260	0.23	7	37	0.8	1.1
V13	Lat-F	99	105	112	180	227	0.09	9	44	0.7	1.3
V14(z)	Lat-F	79	80	95	155	769	0.16	8	38	2.5	1.3
V11	Lat-Pit	113	118	133	197	2175	0.13	11	48	7	2.2
V10(h)	Lat-Pit	235	250	262	333	1218	0.08	21	82	3.9	2.9
V15	Bols	175	186	234	306	1855	0.23	19	75	6	2.9
V16(z)	Bols	144	147	228	327	1694	0.36	18	80	5.5	3.0
V17	Bols	140	151	199	240	2377	0.27	16	59	7.7	2.7
V18	Bols	197	206	232	278	2289	0.13	19	68	7.4	2.9
V19	Bols	64	73	177	273	2472	0.55	14	67	8	2.8
V20	Bols	125	124	141	256	2487	0.12	11	63	8	2.6
V21	Bols	214	217	293	335	2106	0.27	24	82	6.8	3.4
V12	Lat	319	320	394	487	2443	0.19	32	120	7.9	4.6
Reguar soil[a] (Median)								3	8	1.3	
Range								1-5	3-16	0.5-3	

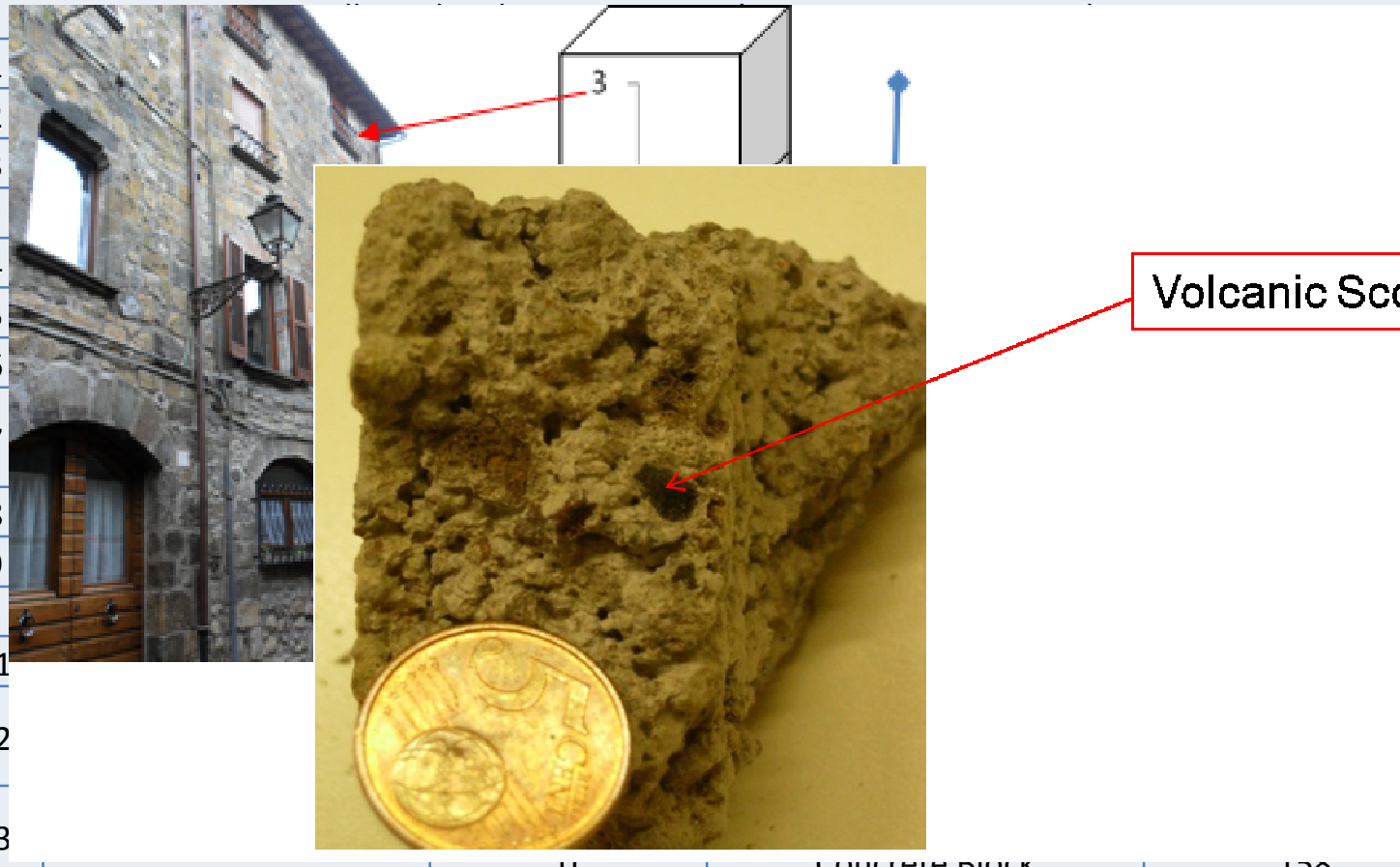
[a] UNSCEAR 2000; (h) Hydrotermalizated; (z) Zeolitizatated

Consequences of high ^{226}Ra?



Indoor Radon measurements

Site	Building Type	Floor	Building Material	Indoor Radon Activity(Bq/m^3)
1				
2				
3				
4				
5				
6				
7				
8				
9				
11				
12				
13				
		0	Concrete Block	158
14	Apartment G	3	Tuff	1140
		2	Tuff	1139
		1	Tuff	1277
		0	Tuff	2513
		-1	Tuff	2662



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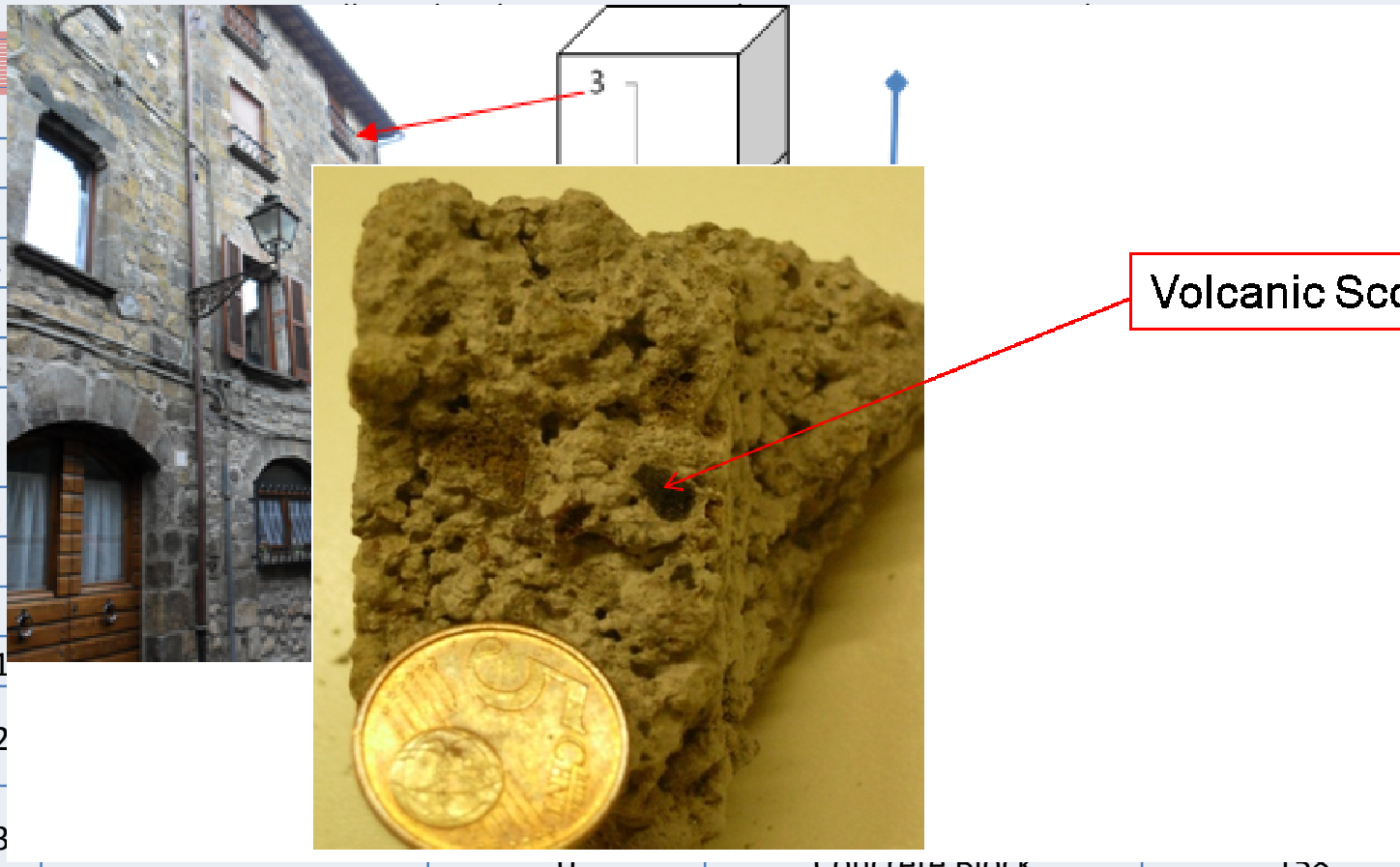

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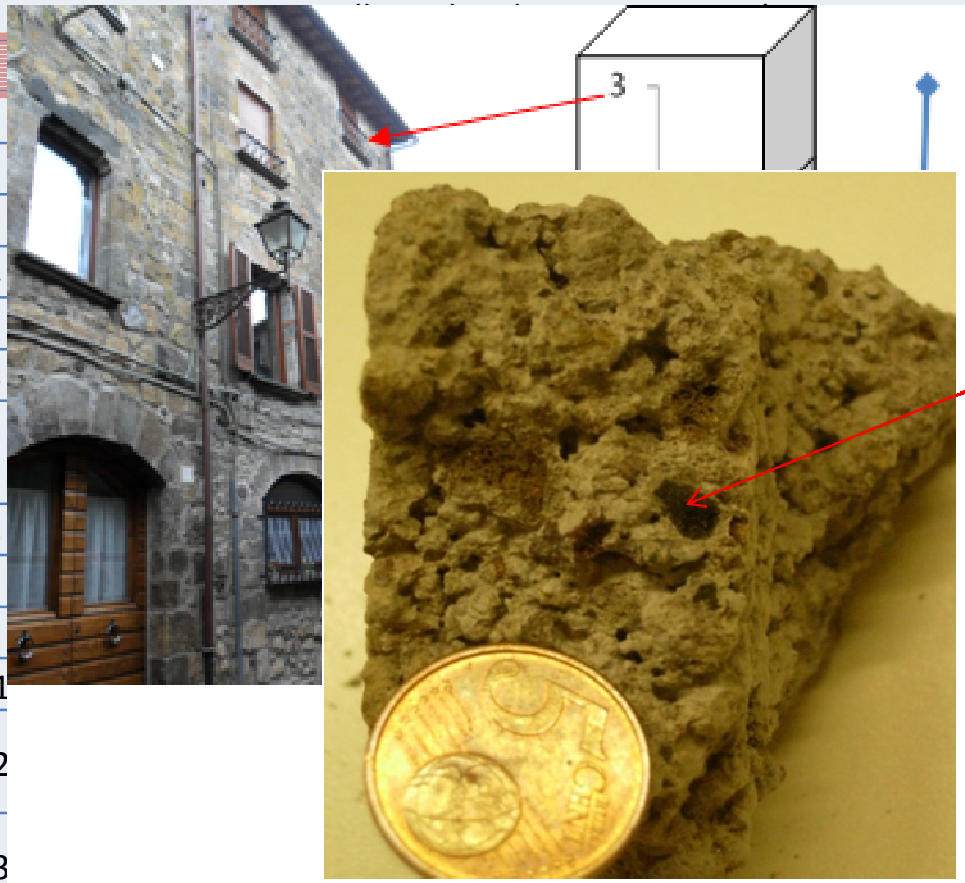
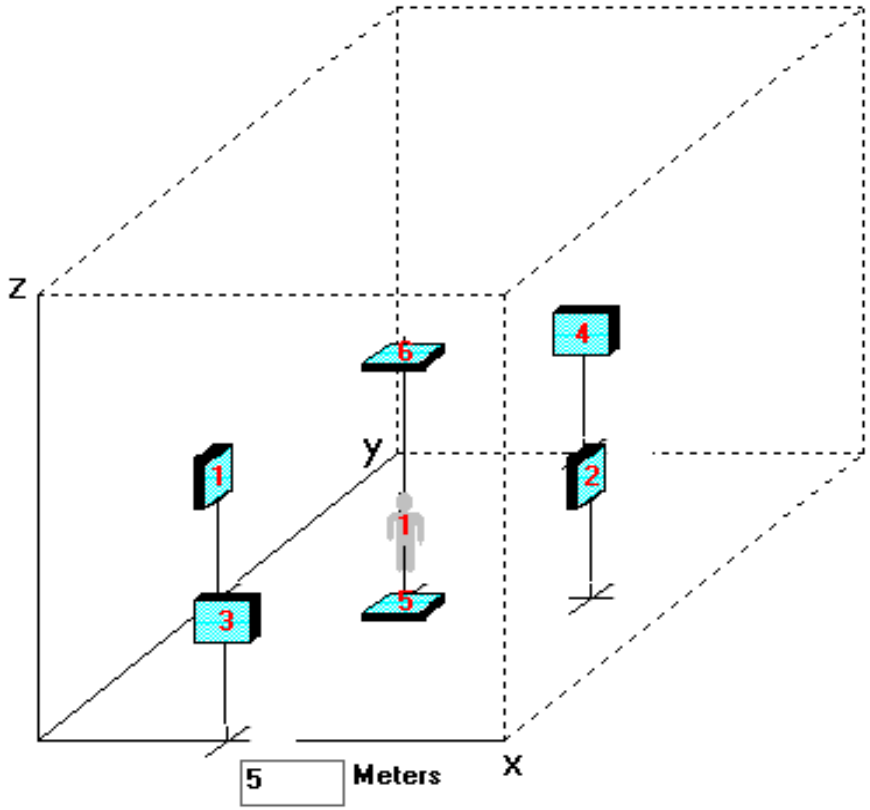


Simulation of a “standard room” using RESRAD-BUILD code



Main Parameters:

Room width, length and height:
4, 5 and 2.8 m
20 cm thick walls
with a density of 2.35 g/cm^3

0.8 occupancy factor
0.25 air building exchange rate (1/h)

215	Bq/kg	^{238}U
322	Bq/kg	^{232}Th
1564	Bq/kg	^{40}K

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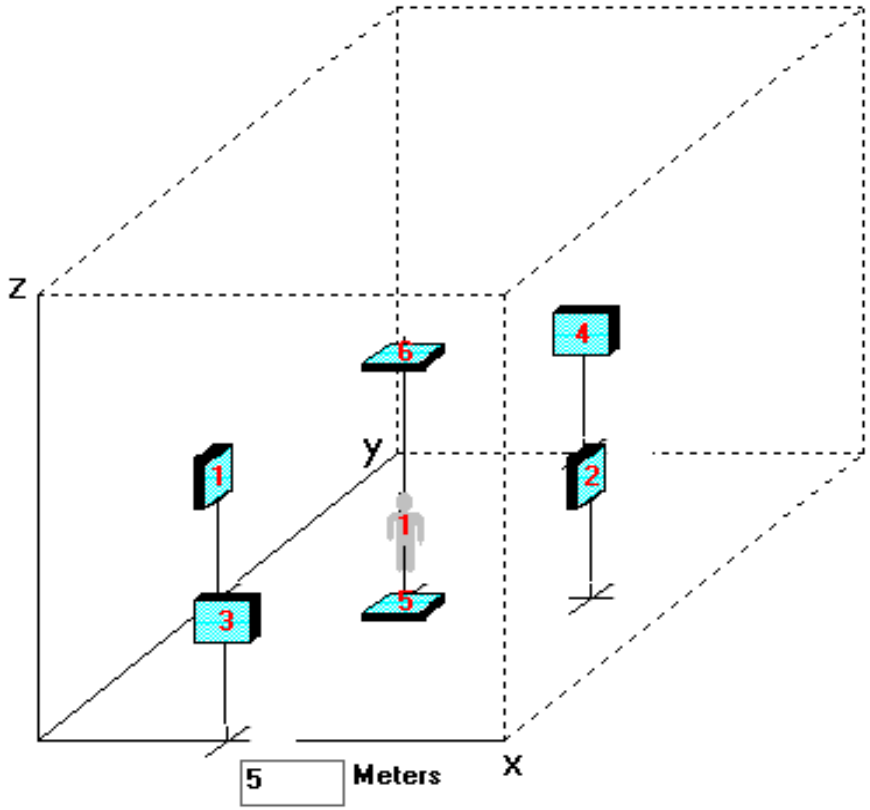

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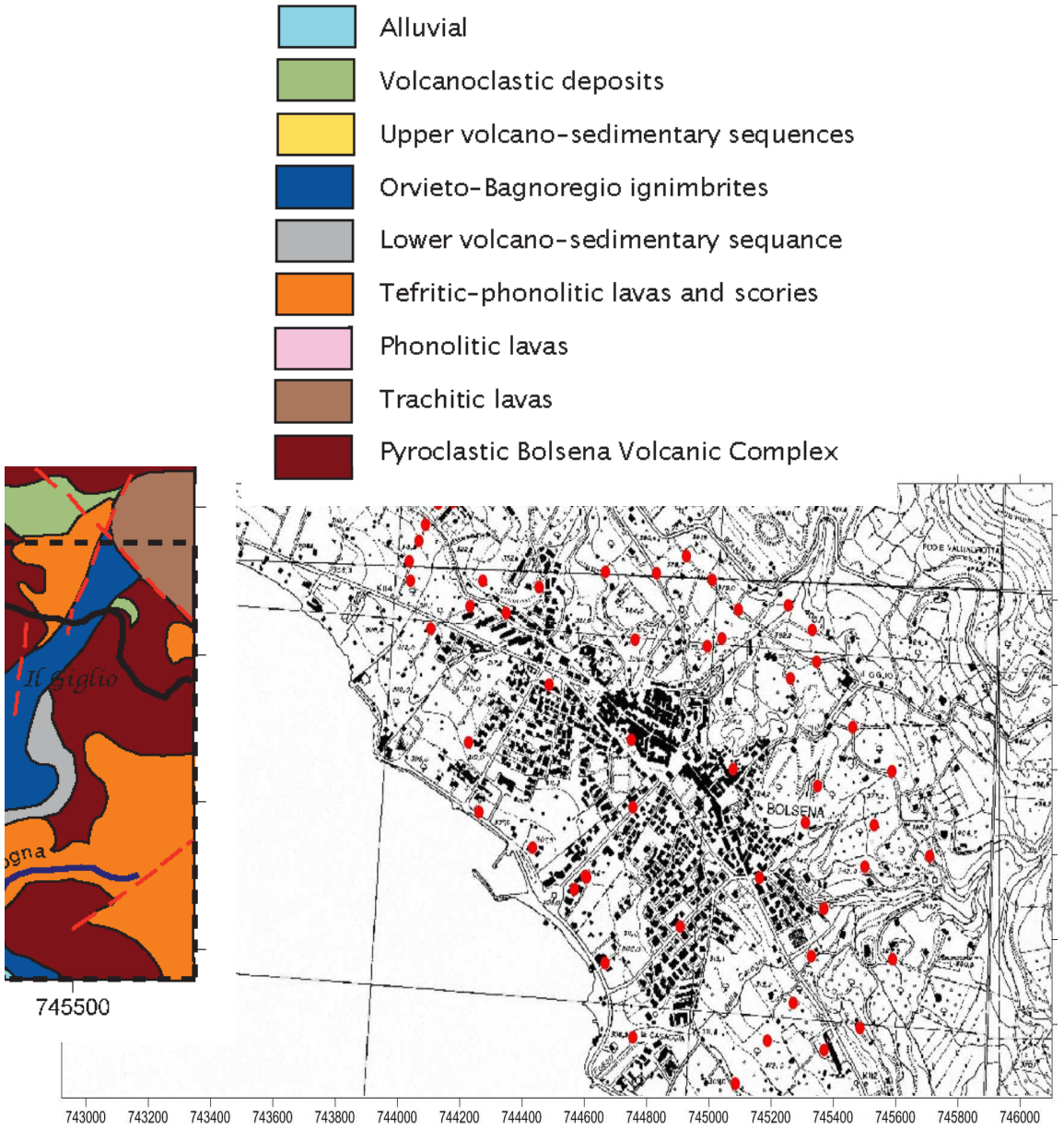
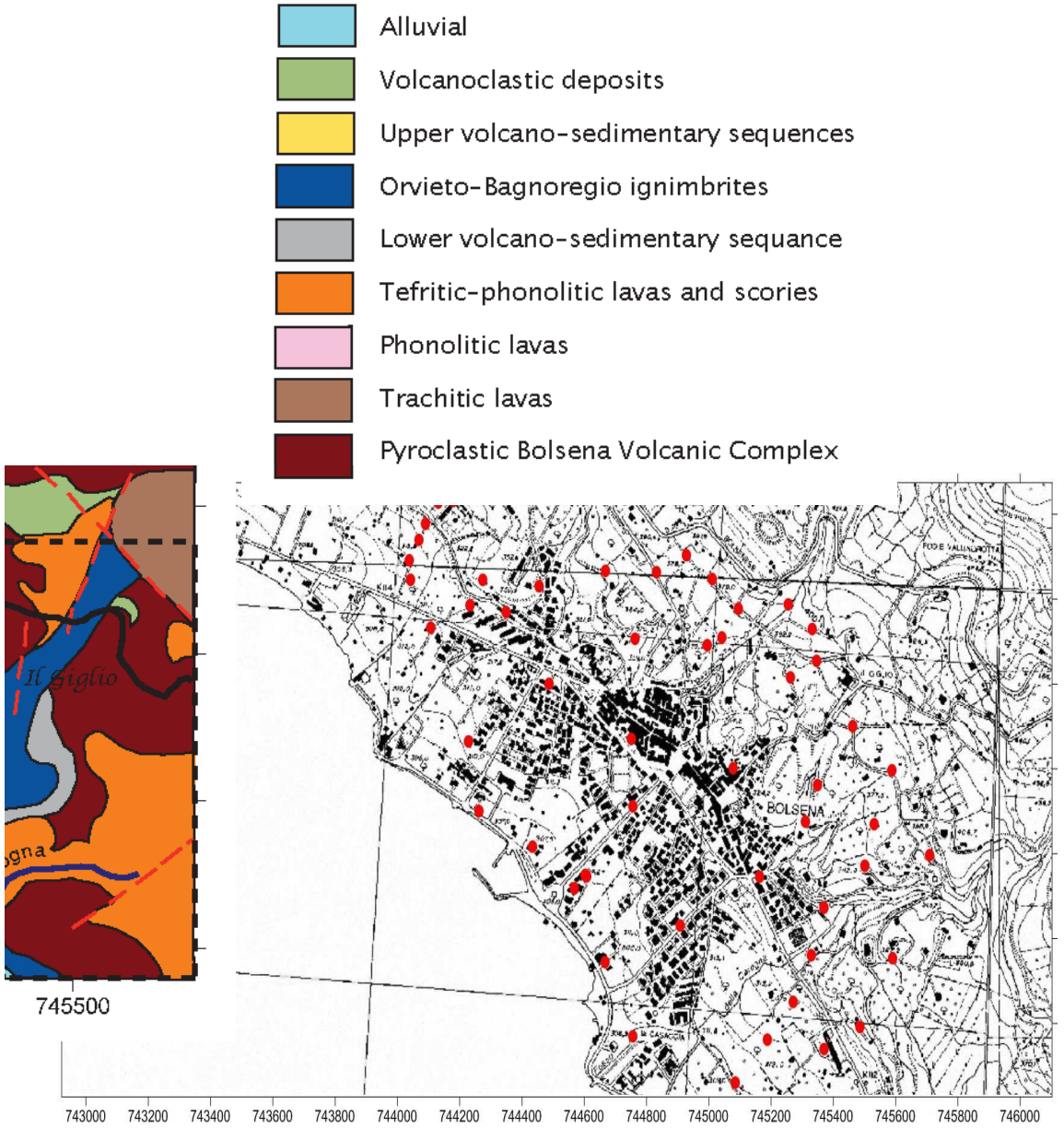
220 Bq/m^3 ^{222}Rn



after Renzulli 1988, modified

Which is the geological source of Soil Gas and Indoor Radon Gas?



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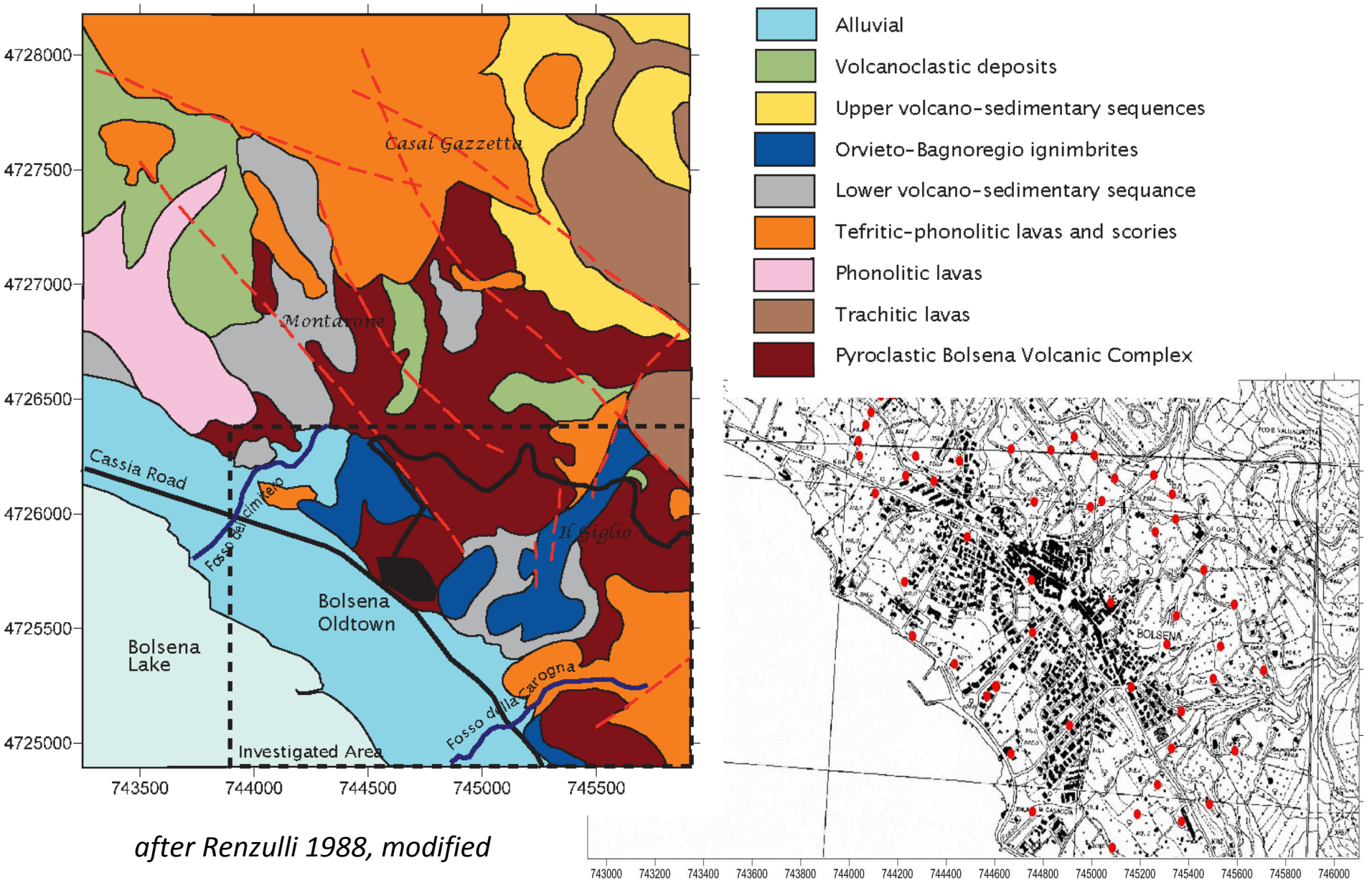

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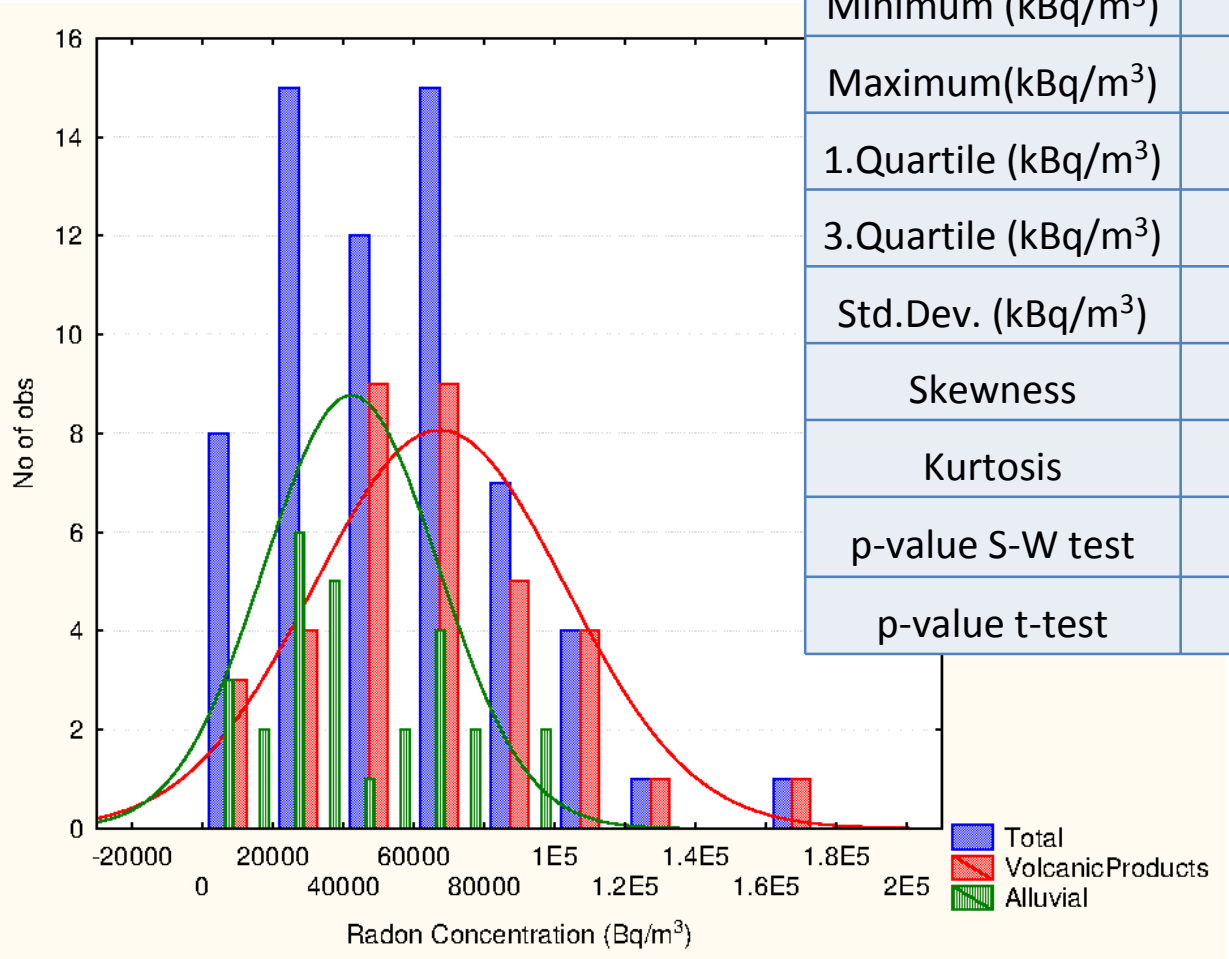
	Total	Volcanic Products	Alluvial
Valid N	63	36	27
Mean (kBq/m^3)	56.2	66.9	42.0
Median (kBq/m^3)	52.4	66.2	36.9
Minimum (kBq/m^3)	7.0	9.3	7.0
Maximum(kBq/m^3)	176.0	176.0	90.9
1.Quartile (kBq/m^3)	29.6	42.9	24.2
3.Quartile (kBq/m^3)	75.6	86.3	63.2
Std.Dev. (kBq/m^3)	33.5	35.6	24.6
Skewness	0.93	0.81	0.49
Kurtosis	1.47	1.27	-0.73
p-value S-W test	0.0084	0.1886	0.1257
p-value t-test		0.0028	



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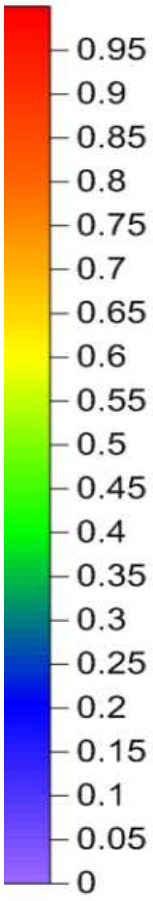
Maps of percentage of high Radon Index

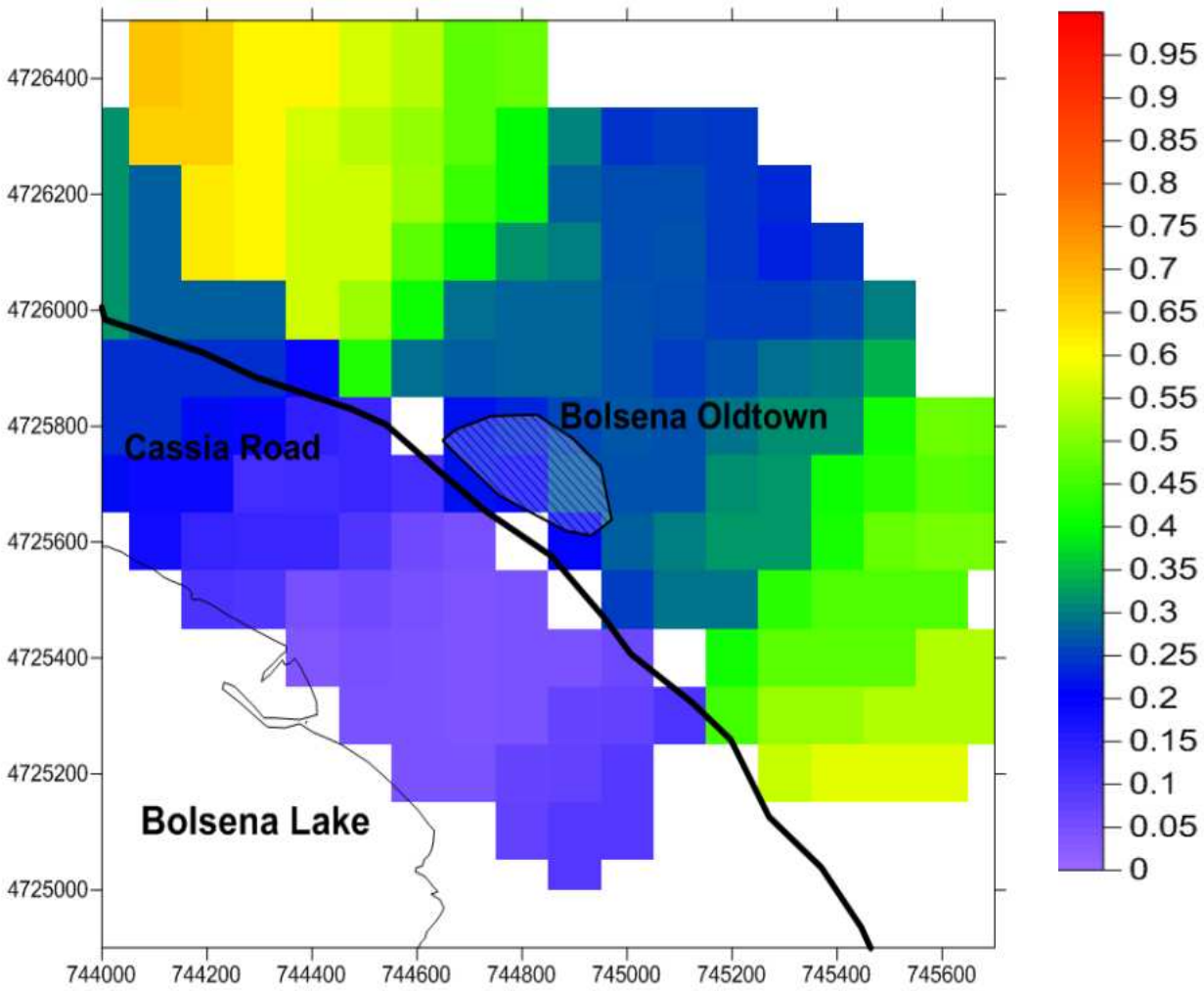
- Cells of 0.01 km^2

- Application of geostatistical techniques to calculate mean radon concentration

$$\%\ highRI = \int_{CL}^{\infty} \exp\left(-\frac{(x-\bar{x})^2}{2 \times {\sigma_g}^2}\right) \times \frac{1}{\sigma_g \times \sqrt{2\pi}}\, \delta x$$

- threshold-CL was fixed at 70 kBq/m^3 (for medium permabilty)


0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0


4726400
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4726000
4725800
4725600
4725400
4725200
4725000
744000
744200
744400
744600
744800
745000
745200
745400
745600
Cassia Road
Bolsena Oldtown
Bolsena Lake
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0.9
0.85
0.8
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0.7
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0.25
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0.15
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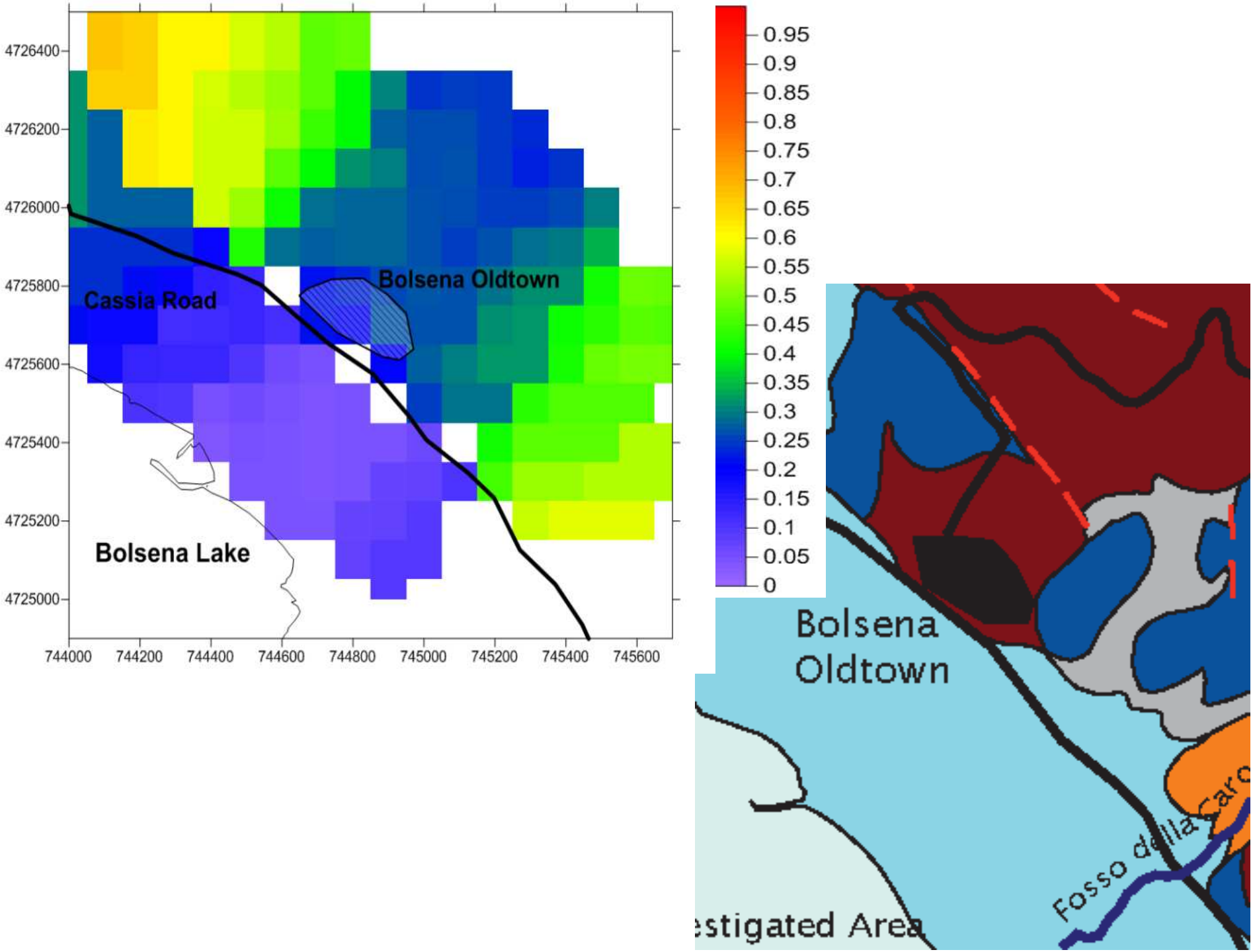
0.05
0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Bolsena
Oldtown
Fosso della Caro
estigated Area

Conclusions

- This study focused on a specific little town, Bolsena, but the results apply similarly to almost every old village and town located in the northern part of Latium because the same volcanic rocks have been used widely as building material and the geological framework as well is the same

- Rocks sampled from the Latera and Bolsena complexes of the Vulsini Volcanic District show high contents of natural radionuclides and all with RI > 1

- High indoor radon concentrations were encountered in Bolsena, the **Vulsini Volcanic District is undoubtedly a Radon-prone area.** The indoor radon concentration estimated using a "simulated standard room" is lower than the what was measured, the code neglects the soil contribution, that in the area investigated appears extremely important

- The radon soil map shows a correspondence between lower radon and alluvial grounds and higher radon with volcanic grounds, respectively, reflecting the different NORM contents.

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Thank you
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