Using $^{222}Rn/^{220}Rn$ activity ratio and CO_2 concentration in soil gas to trace advective fluxes.

Carlo Lucchetti, Mauro Castelluccio, Paola Tuccimei

Dipartimento di Scienze Geologiche, Università "Roma Tre",
Largo San Leonardo Murialdo 1, 00146 Roma, Italia

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Two gas transport mechanisms control gas flux in porous media:

Diffusion **and** **Advection**

$$J_D = -D\nabla C$$

$$J_A = -\frac{K}{\mu}\nabla P$$

J_D = diffusive flux

C = gas concentration

D = Diffusion coefficient

∇ = Gradient operator

J_A = advective flux

K = soil permeability

μ = gas viscosity

P = pressure

Closer Source of the gas

Deeper Source

Fractured and permeable bedrock

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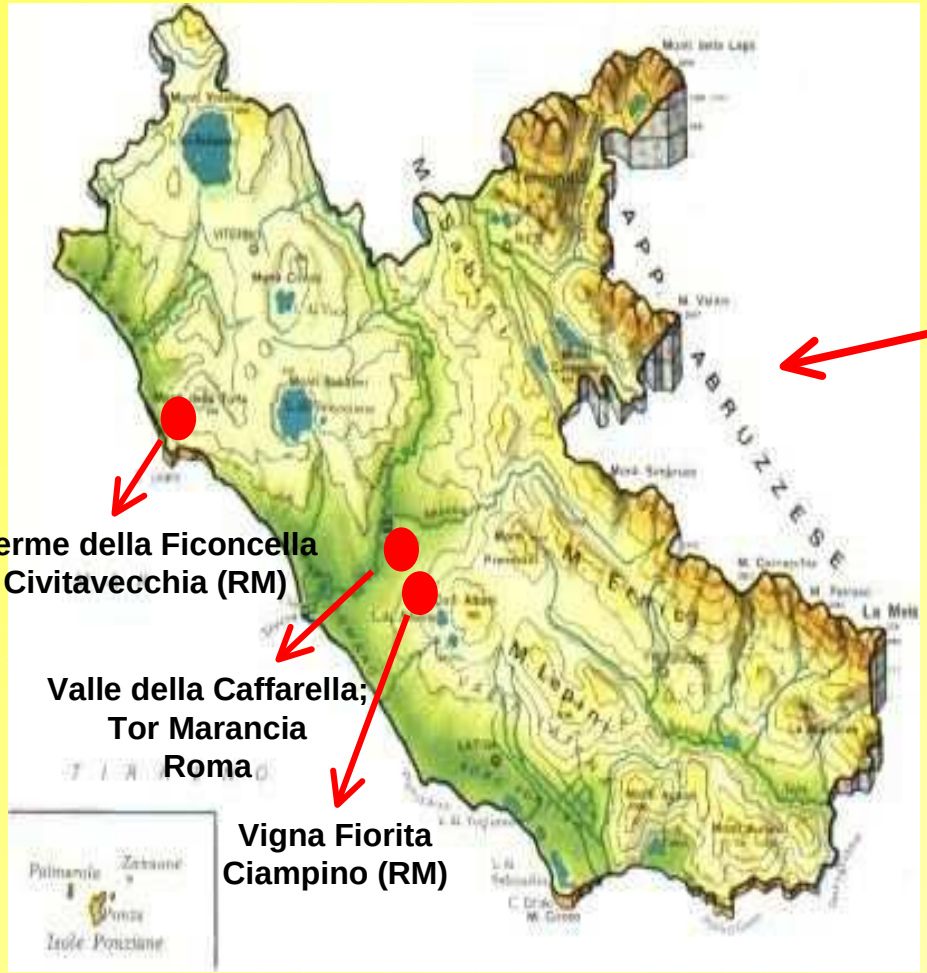
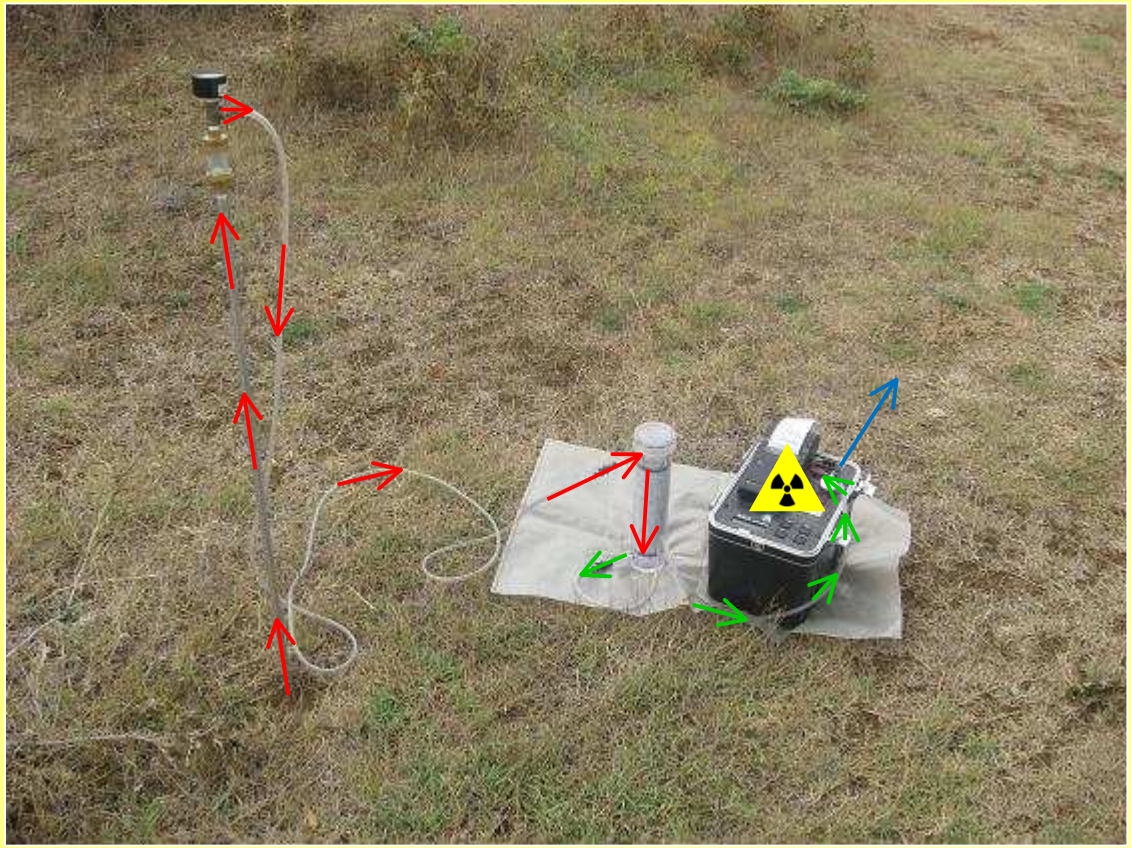
Geological setting



SITE	GEOLOGICAL BEDROCK
Terme della Ficoncella	Travertines
Valle della Caffarella-Tor Marancia	Quaternary ignimbrites (referred to the activity of Colli Albani)
Vigna Fiorita	Lahar flows of Colli Albani

Measurement systems



Measurement system of Rn activity concentrations (at 80 cm depth):
hollow probe (Radon v.o.s. corp.) attached to a **drying unit** and to the **continuous radon monitor** (RAD 7, Durridge Co.), connected in series.

Measurement system of CO_2 concentration (at 80 cm depth):
infrared detector
(Dräger X-am 7000).

Measurement of ^{220}Rn activity concentrations in soil gas
(using a correction factor)

Air flow meter used to measure properly the RAD7 pump flux

^{220}Rn half-life:
~ 1 minute

Time required to deliver the soil gas from the sampling spot to the counting chamber of RAD7 (sampling time):
1.5 ÷ 2 minutes

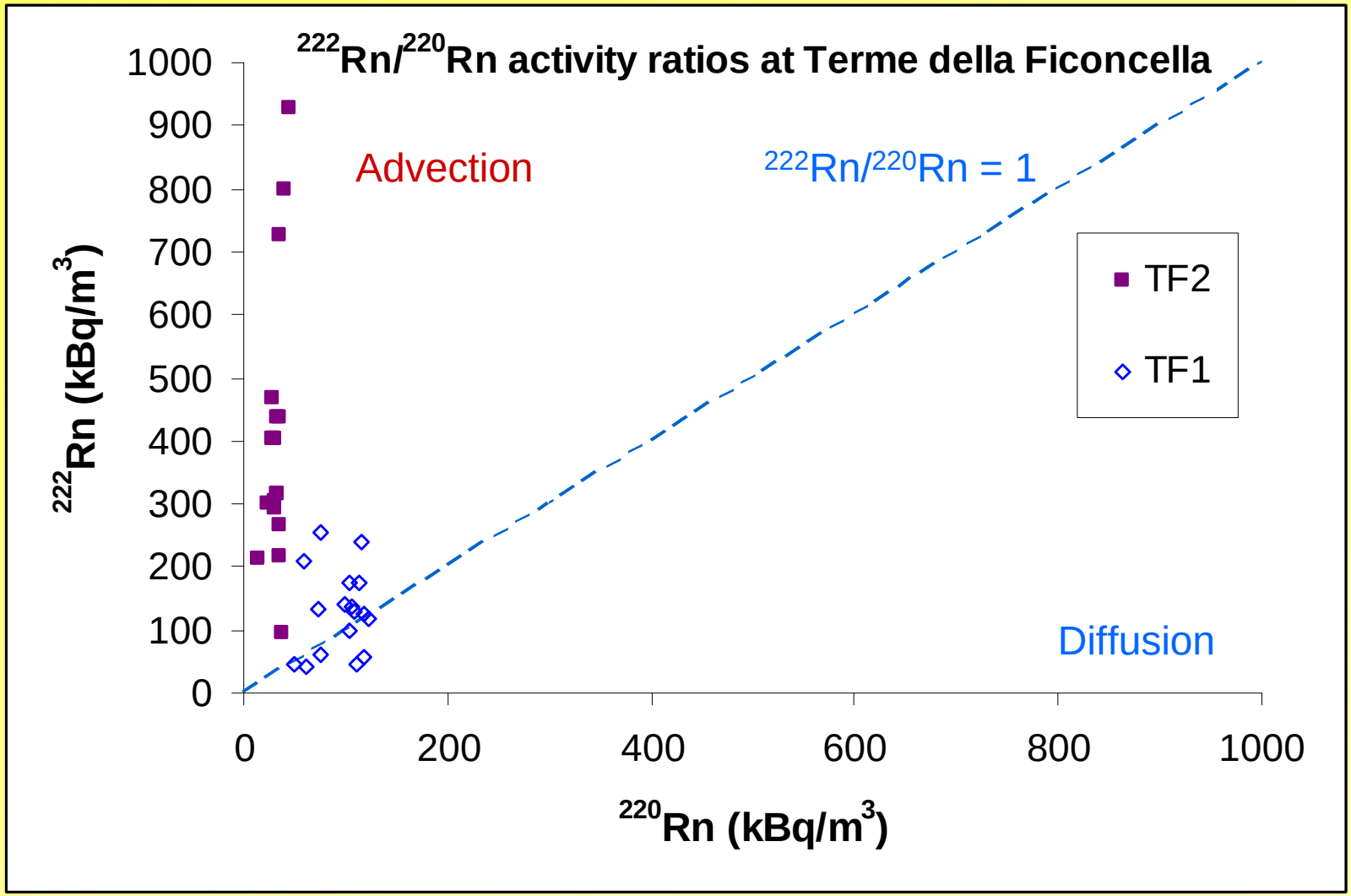
We have to correct measured value in order to obtain real value

Correction factor ↔ sampling time ↔ RAD7 pump flux ↔ soil gas permeability

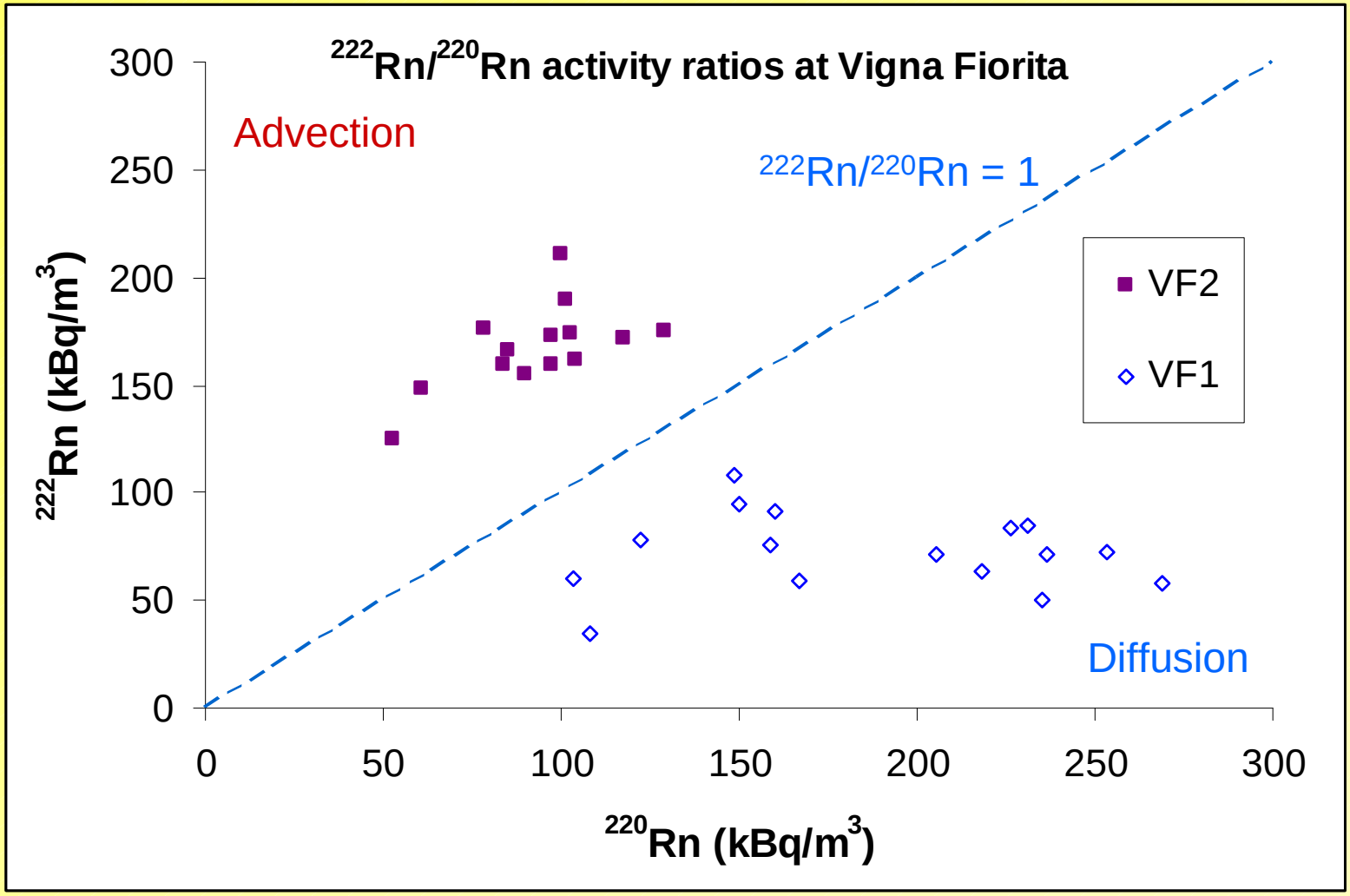
Methods to trace advective fluxes

- *^{222}Rn against ^{220}Rn activity concentrations in soil gas*
- *Soil ^{222}Rn seasonal fluctuations*
- *^{226}Ra and ^{232}Th content in soils*
- *^{222}Rn* emanation coefficients
- *^{222}Rn against ^{220}Rn exhalation rates of soil samples*
- *CO_2 concentration in soil gas (as possible radon carrier)*

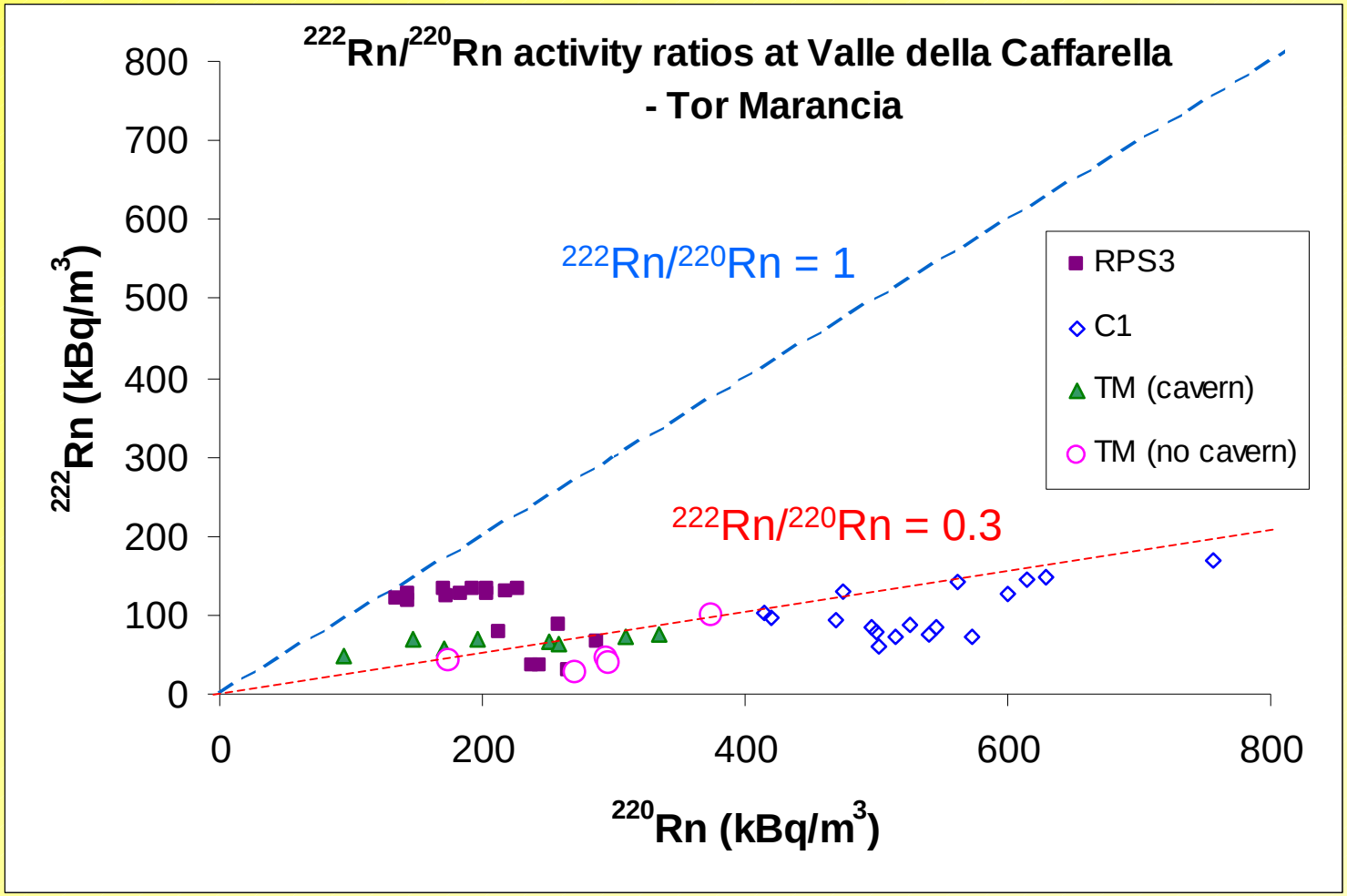
^{222}Rn against ^{220}Rn activity concentrations in soil gas measured at station TFF1 and TFF2 (Terme della Ficoncella area, Civitavecchia)



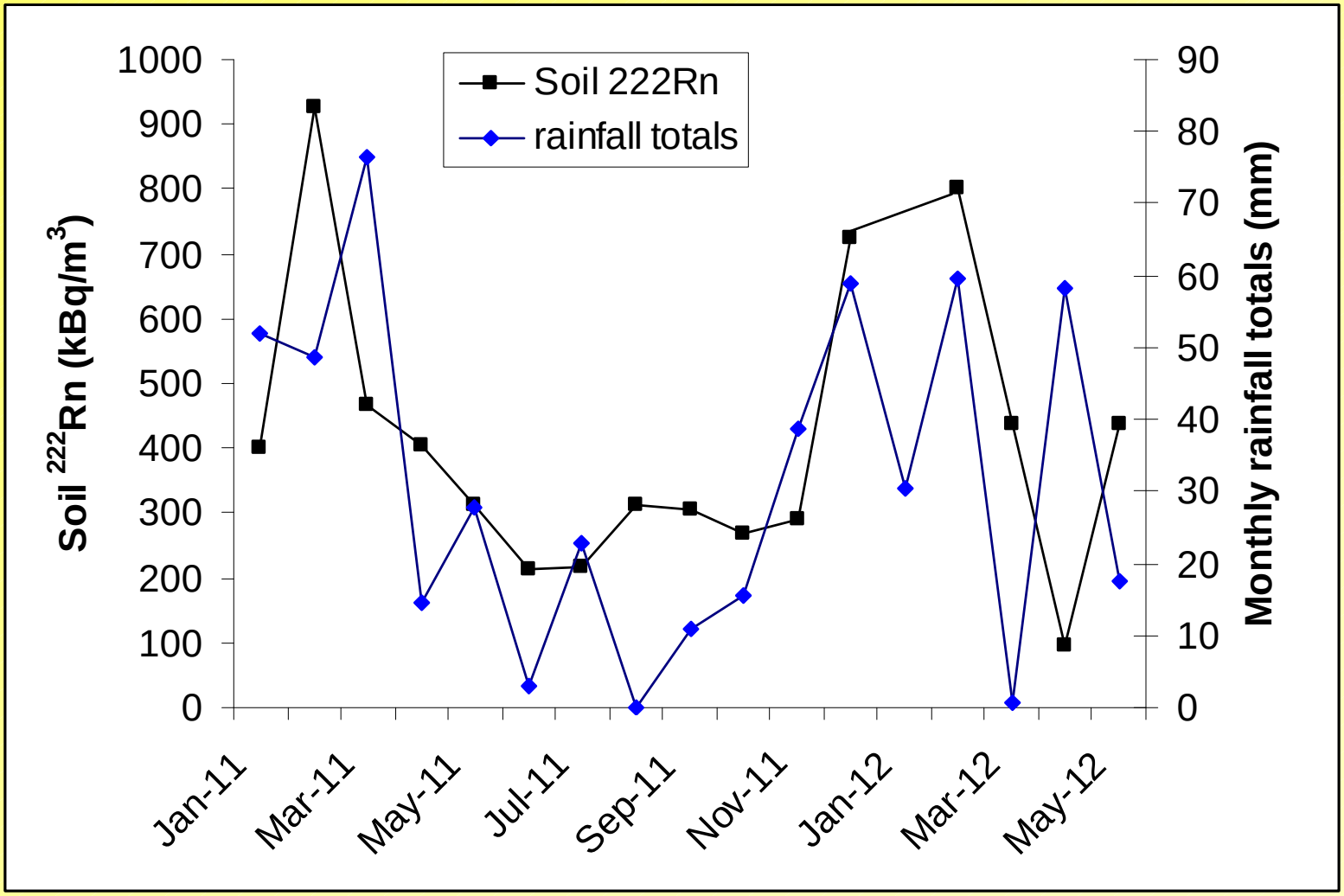
^{222}Rn against ^{220}Rn activity concentrations in soil gas measured at station VF1 and VF2 (Vigna Fiorita area, Roma)



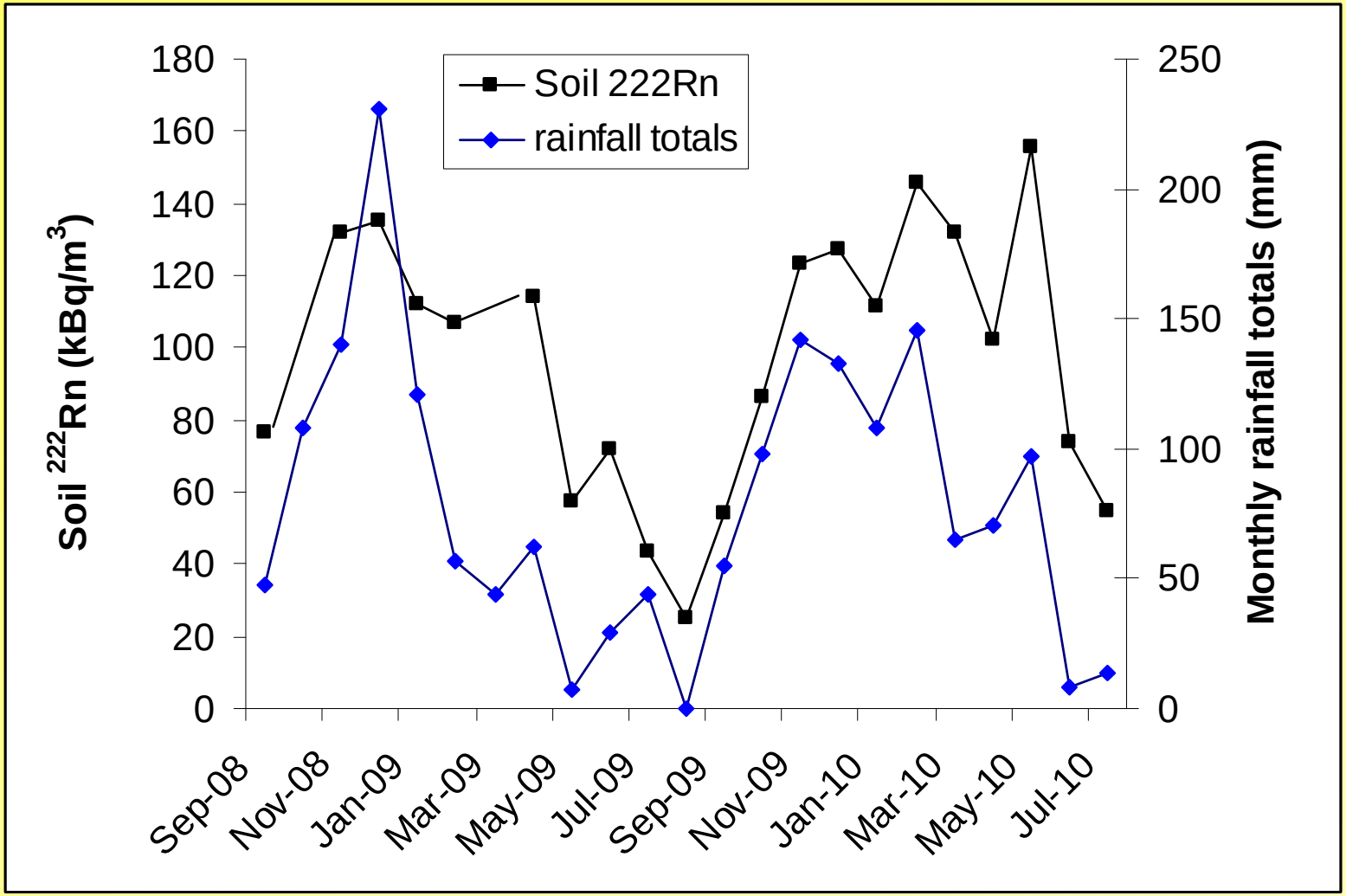
^{222}Rn against ^{220}Rn activity concentrations in soil gas measured at station RPS3 and C1 (Valle della Caffarella, Roma) and some further spot in the adjacent Tor Marancia site



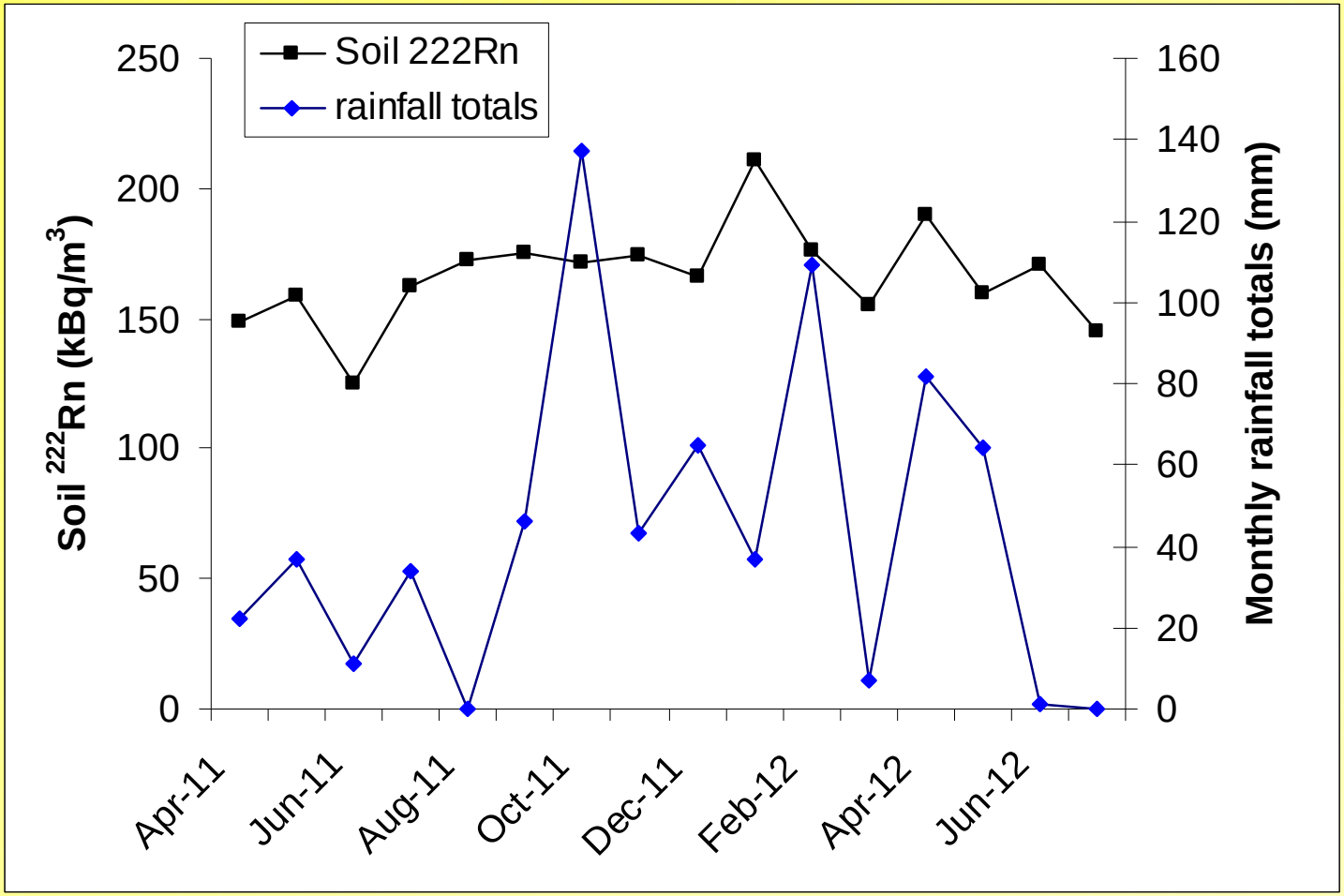
Soil ^{222}Rn fluctuations and monthly precipitation totals from January 2011 to June 2012 at Terme della Ficoncella area, Civitavecchia, Italy).



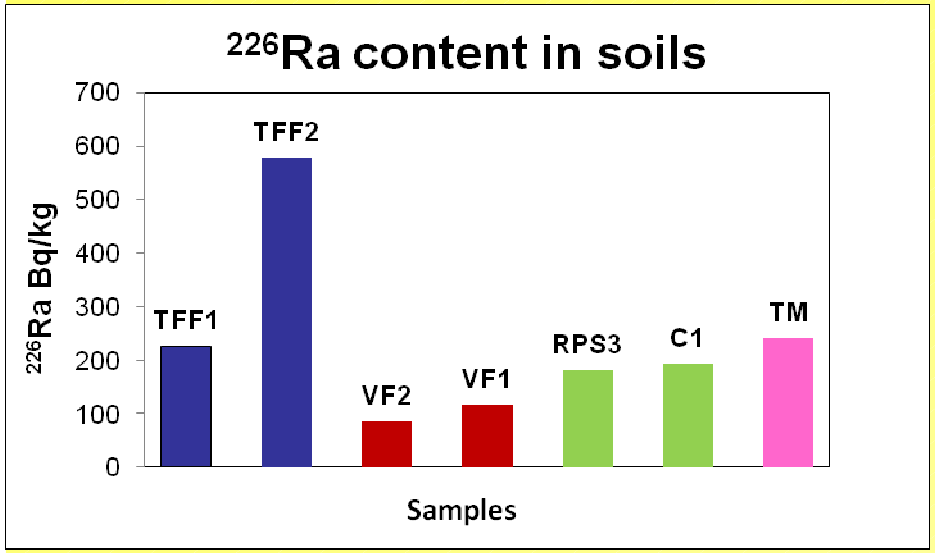
Soil ^{222}Rn fluctuations and monthly precipitation totals from September 2008 to July 2010 at Valle della Caffarella area, Roma, Italy).



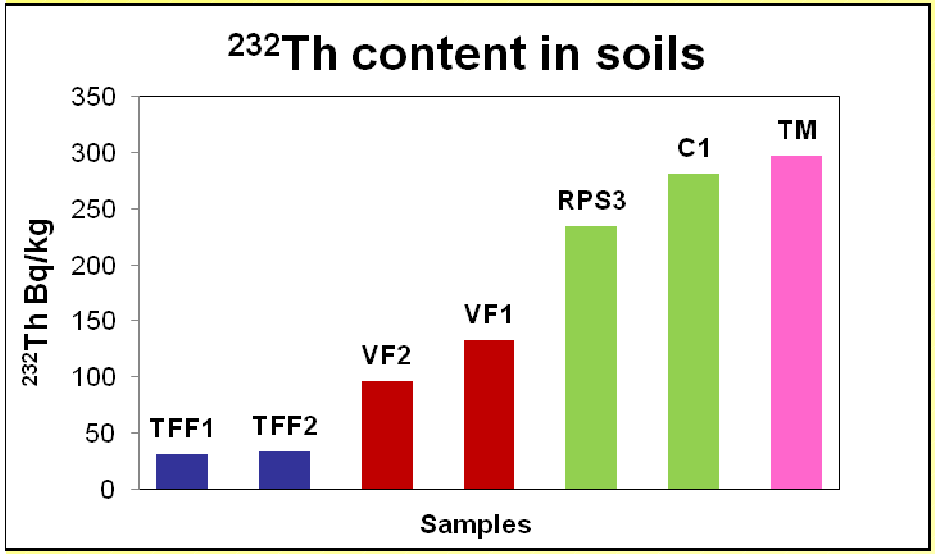
Soil ^{222}Rn fluctuations and monthly precipitation totals from April 2011 to July 2012 at Vigna Fiorita area, Roma, Italy).

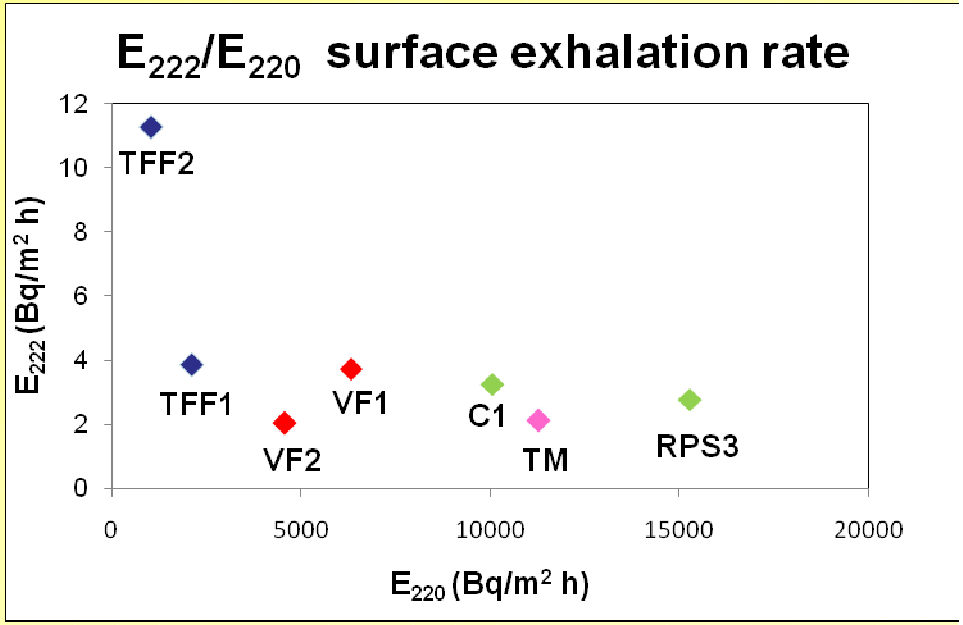


Results of laboratory experiments on soil samples: gamma spectrometry and exhalation rates

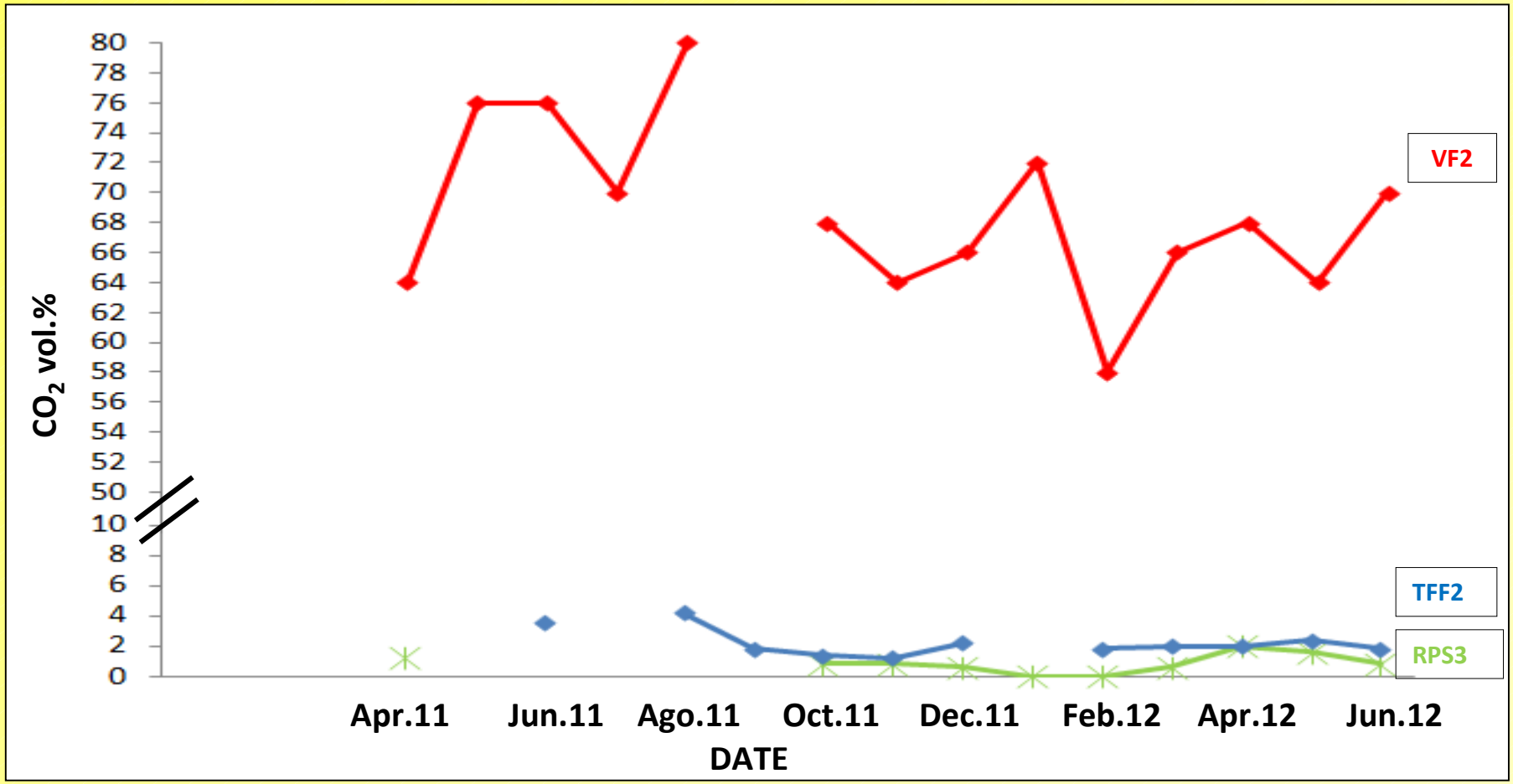


222Rn emanation coefficient	
TFF2	0.50 ÷ 0.58
TFF1	0.41 ÷ 0.48
VF2	1.38 ÷ 1.61
VF1	0.43 ÷ 0.50
RPS3	0.40 ÷ 0.47
C1	0.39 ÷ 0.45
TM	0.17 ÷ 0.20





Soil CO_2 fluctuation at Valle della Caffarella (RPS3), Terme della Ficoncella (TFF2) and Vigna Fiorita (VF2)



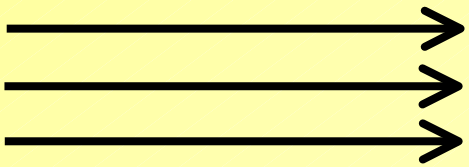
Conclusions

Advective flux indicators	Caffarella (RPS3)	Ficoncella (TFF2)	Vigna Fiorita (VF2)
$^{222}Rn/^{226}Ra$ soil gas	0.5	12.5	1.8
$^{226}Ra/^{232}Th$ content in soil samples	0.77	17.6	0.90
$^{222}Rn/^{226}Ra$ exhalation rates of soil samples	0.18 E-3	10.88 E-3	0.45 E-3

Advective flux indicators	Caffarella (RPS3)	Ficoncella (TFF2)	Vigna Fiorita (VF2)
^{222}Rn soil gas (kBq/m^3)	102	407	166
^{222}Rn soil gas seasonal fluctuation	Very marked	Marked	Minimum
CO_2 concentration in soil gas (vol. %)	0.8	2.2	69

Range of ^{222}Rn emanation coefficients is:

- *0.40 ÷ 0.47 for **RPS3**;*
- *0.50 ÷ 0.59 for **TFF2**;*
- *1.38 ÷ 1.61 for **VF2**.*



Radon transport is:

Diffusive

Diffusive and advective

Mainly Advective

Values higher than 0.5 ÷ 0.7 can be used to trace advective fluxes of deep gases (Schuman, 1993).