NATURAL RADIOACTIVITY CONTENT AND RADON EXHALATION RATE MEASUREMENTS OF ZEOLITES FOR Project *ZEOGYP-BOARD*

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RESEARCH ACTIVITIES ON NATURAL RADIOACTIVITY (I)

Gamma spectroscopic determination of natural radionuclides (^{238}U, ^{226}Ra, ^{210}Pb, ^{232}Th, ^{40}K etc) in:

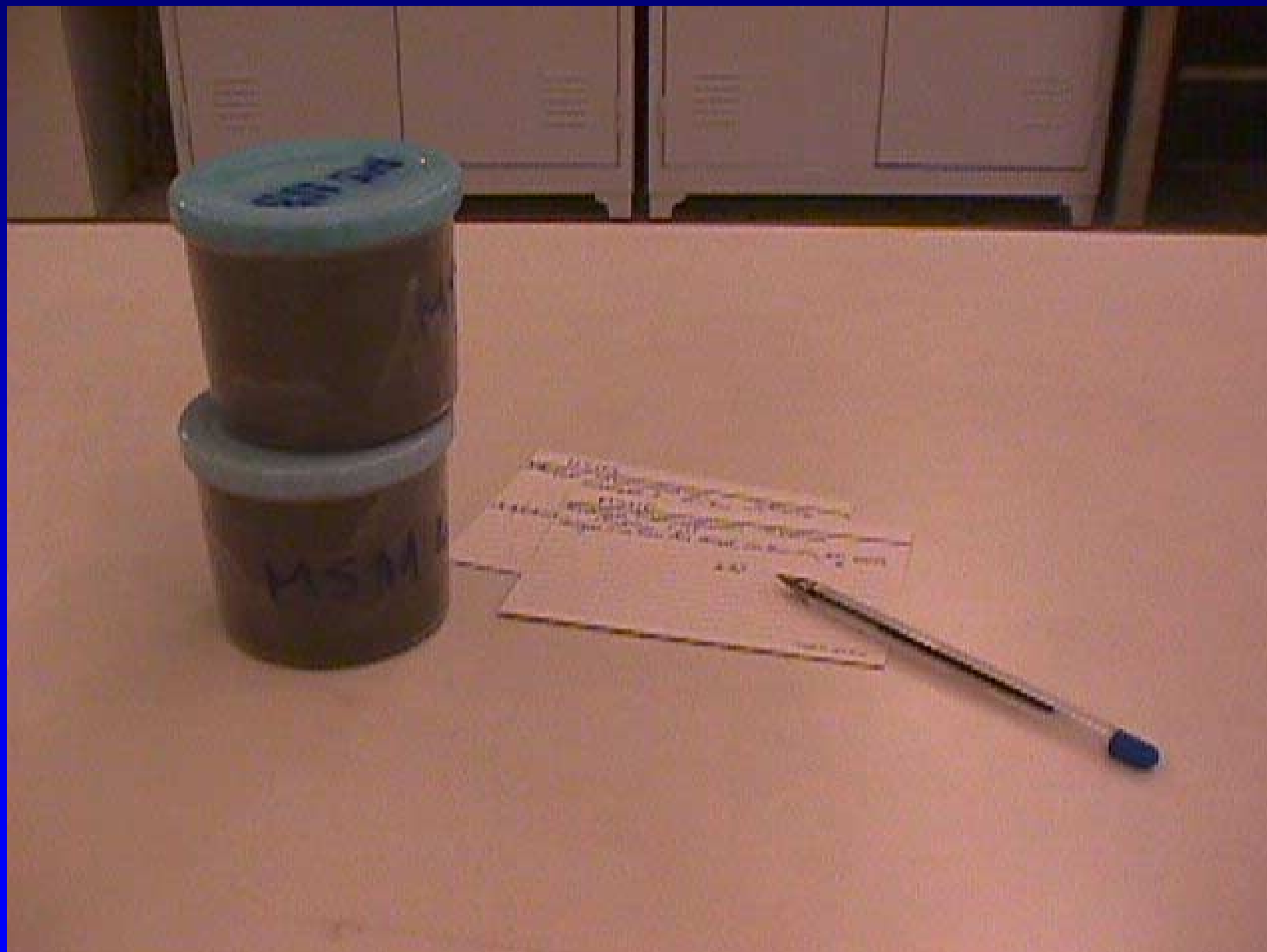
- Soil (more than 2000 surface soil samples have been collected and analysed over Greece and Yugoslavia - Kossovo).
- Lignites and ashes produced in Lignite-fired Power Plants (more than 500 samples).
- Building materials (more than 200 samples).
- Foodstuff .

RESEARCH ACTIVITIES ON NATURAL RADIOACTIVITY (II)

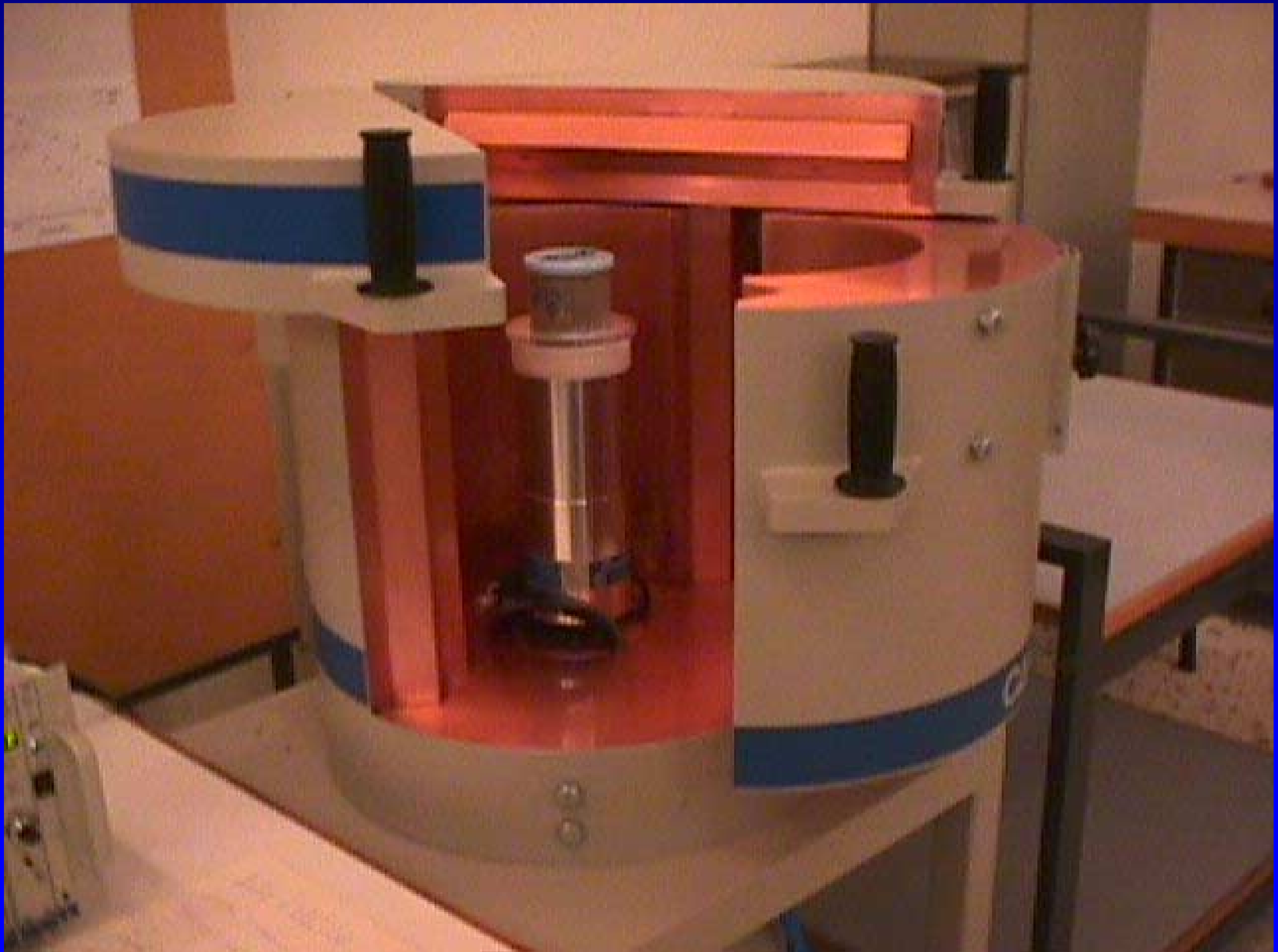
1. Radon (^{222}Rn) exhalation measurements from:
   - raw building materials
   - building structures
2. Radon barrier materials testing.
3. Thoron (^{220}Rn) exhalation rate determination from building materials (under development).
4. Radon concentration measurement instruments calibration.

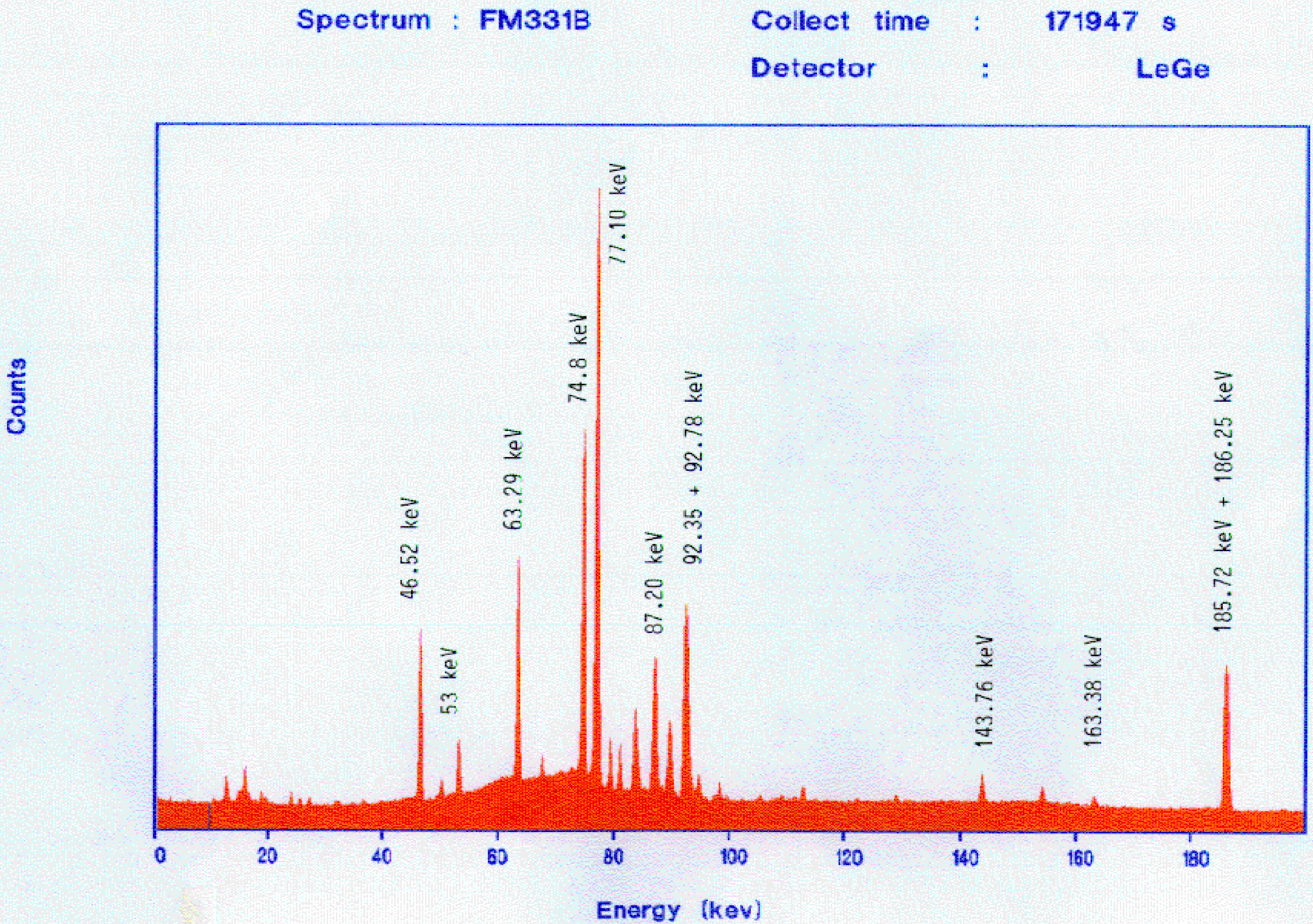
GAMMA SPECTROSCOPY LAB

SAMPLE PREPARATION



SAMPLE MEASUREMENT IN XtRa Ge DETECTOR




Spectrum : FM331B
Collect time : 171947 s
Detector : LeGe
Counts
46.52 keV
53 keV
63.29 keV
74.8 keV
77.10 keV
87.20 keV
92.35 + 92.78 keV
143.76 keV
163.38 keV
185.72 keV + 186.25 keV
0
20
40
60
80
100
120
140
160
180
Energy (kev)

ZEOLITE NATURAL RADIOACTIVITY CONTENT RESULTS (I)

	Radioactivity Content $Bqkg^{-1}$		
Sample Code	^{226}Ra	^{232}Th	^{40}K
SKL-1	40 ± 2	59 ± 3	918 ± 38
MET-1	80 ± 4	104 ± 5	944 ± 41
2P	121 ± 6	205 ± 10	2010 ± 80
3C	124 ± 6	195 ± 10	2500 ± 125
PEN-1	85 ± 4	122 ± 6	473 ± 19

ZEOLITE NATURAL RADIOACTIVITY CONTENT RESULTS (II)

	Radioactivity Content $Bqkg^{-1}$		
Sample Code/ Grain size (mm)	^{226}Ra	^{232}Th	^{40}K
2P/ 0.9-1.2	122 ± 5	197 ± 8	2016 ± 84
PET-1/ 0.7-1.6	154 ± 6	108 ± 5	1117 ± 50
PET-1/ 0-0.2	160 ± 7	117 ± 5	1202 ± 52

RADON EXHALATION MEASUREMENT METHOD USED

✓ ENCLOSE THE SAMPLE IN A CONTAINER (RADON CHAMBER)

✓ FOLLOW UP THE RADON CONCENTRATION GROWTH INSIDE THE CONTAINER

THE NTUA RADON CHAMBERS

Designed and constructed in Greece by the NTUA Nuclear Engineering Laboratory

- ✓ Radon chamber 1.8 m^3
- ✓ Radon chamber 8.5 m^3

Made of stainless steel, Air-tight and Radon-tight

Computer controlled environmental conditions

(Temperature 12-45 ^oC,

Humidity 15 –95% non-condensing)

THE 8.5 m^3 RADON CHAMBER

FRONT SIDE VIEW

LENGTH: 2.4m,
WIDTH: 1.7m,
HEIGHT: 2.1m

DOOR:

1.1m HIGH,
0.6m WIDE

THE 1.8 m^3 RADON CHAMBER USED FOR THIS PROJECT

FRONT SIDE VIEW
LENGTH: 1.2m,
WIDTH: 1.0m,
HEIGHT: 1.5m

DOOR: 1.1m HIGH, 0.6m WIDE

QUASI-CONTINUOUS RADON CONCENTRATION MONITORING

MATHEMATICALLY EXPRESSED…

$$C = C_o\exp(-\lambda t)+E[1-\exp(-\lambda t)](\lambda V)^{-1} \quad (1)$$

C Radon concentration (Bqm^{-3}) in the container at growth time t(h)

E exhalation rate (Bqh^{-1})

λ Radon decay constant (h^{-1})

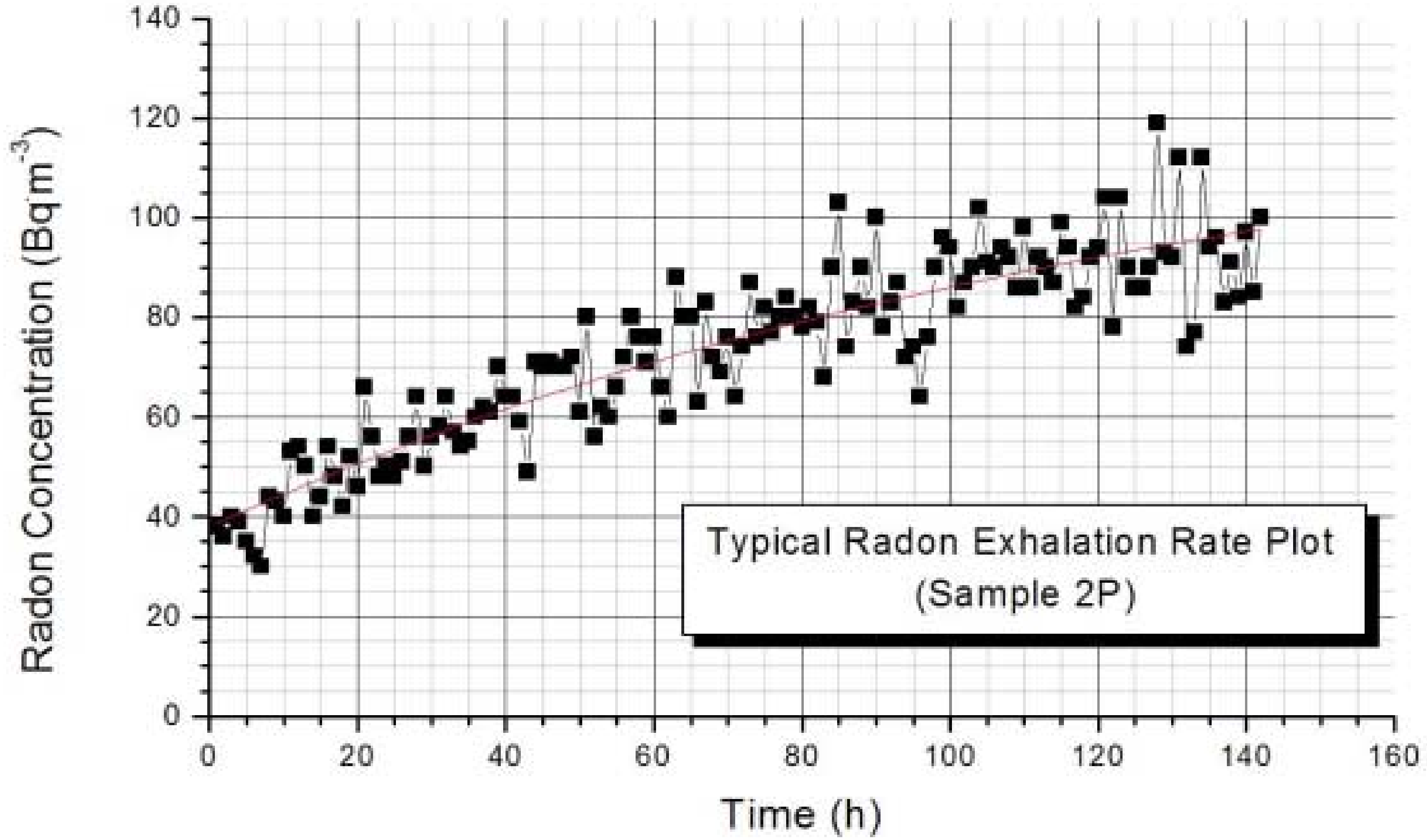
$\boldsymbol{C_o}$ initial Radon concentration (Bqm^{-3}) in the container at time t(0h) – i.e. the background

THE EQUATION IS VALID IF… (I)

- There is <u>no leakage</u> of Radon out of the container.

- The activity concentration in the container air is low compared to the activity concentration in the pore air of the sample – i.e. no <u>back-diffusion</u> effects.

TYPICAL RADON EXHALATION CURVE



ZEOLITE RADON EXHALATION RATE RESULTS (ss=1)

Sample Code/ Grain size (mm)	Radon Exhalation Rate $\mu Bq kg^{-1} s^{-1}$
2P/ 0.9-1.2	115 ± 20
PET-1/ 0.7-1.6	80 ± 3
PET-1/ 0-0.2	100 ± 8

SHORT DISCUSSION (I)

- The ^{226}Ra content of the zeolites examined (40-160) lies within the ^{226}Ra content range of European building materials, i.e. 4 - 4000 $Bqkg^{-1}$
- The Radon exhalation rate of the zeolites examined (80-115) lies within the range of Greek black cement or fly ashes, i.e. 10 – 110 $\mu Bqkg^{-1}s^{-1}$ but it is much lower than that of internationally reported values

SHORT DISCUSSION (II)

- The ^{232}Th content of the zeolites examined lies within the ^{232}Th content range of European building materials, i.e. 0 - 540 $Bqkg^{-1}$
- The Thoron exhalation rate of the zeolites should be further measured, since the experiments already conducted showed measurable Thoron concentrations. (Thoron exhalation measurement methods are currently under development).

SHORT DISCUSSION (III)

The ^{40}K content of the zeolites examined lies within the ^{40}K content range of European building materials, i.e. 25 - 2354 $Bqkg^{-1}$. The respective range for Greek building materials is

1 – 1158 $Bqkg^{-1}$.

SHORT DISCUSSION (IV)

Assuming the worst case scenario that boards are constructed exclusively of zeolites with the highest natural radionuclide concentrations measured, then such a building material would result to an "activity concentration index I" equal to:

$I = {}^{226}Ra \text{ content}/300 + {}^{232}Th \text{ content}/200 + {}^{40}K\text{content}/3000 = 2.8$

SHORT DISCUSSION (V)

"EC Radiation Protection 112 Doc"

- If such a board is used in bulk amounts then it results to a dose higher than the dose criterion of $1 mSv a^{-1}$
- If such a board is used superficially then it results to a dose lower than the dose criterion of $1 mSv a^{-1}$
- The dose due to natural radioactivity from every source has been world-wide calculated to $2 mSv a^{-1}$

CONCLUSION

It is advisable to sample and measure radiologically important parameters in gypsum boards containing zeolite.