10th INTERNATIONAL WORKSHOP
on the
GEOLOGICAL ASPECTS
OF RADON RISK MAPPING

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+ RIM – Radon Intercomparison
Measurement at Radon Reference Sites
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Round table discussion and comments

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1. Radon geogenic map of Europe – classification

It is supposed, that geogenic radon potential will be reported for area units 10 x 10 km. Since there are very different sources of radon data in European countries, as indoor radon data, radon soil gas data, estimated radon potential for geological units outlined in geological maps, orientation single radon data of various origin and none data, it is evident that reported data on radon geogenic potential will be rough estimate. Obstacles to uniformity of reported values are inconsistency (deviations) in radon measurements, inconsistency in conformity of used geological maps, variability of radon indoor data due to complexity of age of buildings, and variability of their construction and variable approaches of national radon data processing and reporting. Despite that fact, rough estimation of lateral radon geogenic potential in European countries would be significant contribution to the knowledge and parameters of the natural radiation environment in Europe. The map will provide basic information on radon prone areas in sense of the applied scale of the map.

Due to above given reasons, the geogenic radon potential should be reported in 4 classes (low to high), in nonlinear vertical scale data, and for area units 10 x 10 km presented in sensitively selected colour scale (rather harmonized colours, than strictly contrasting colours). Single classes should correspond to 1) low radon regions, 2) standard radon potential corresponding to the majority of geological situations, rocks and averages of indoor radon activity concentration, 3) elevated regional values of indoor radon or radon in soil gas, and 4) extreme values occurring regionally (not locally) in the area of Europe (as Alum shales in Sweden). The reported data and the mode of their presentation and comments should be sensitive to map data interpretation in the sense of any radiation danger to population.

2. Radon in soil gas and use of gamma-ray spectrometry maps

Published information on the relation between radon activity concentration in soil gas and content of U/Ra in soil, including published papers presented at Workshops on geological aspects of radon risk mapping, show large variations between above two parameters. Theoretically, one should expect a relation between ^{226}Ra (disintegration product of ^{238}U) and

radon (^{222}Rn) generated by ^{226}Ra.

Radon in soil gas is dominantly estimated by field measurements and the resultant values c_A (kBq/m^3) depend on radon instrument calibration and reference standards, field technique of soil air sampling, measurement mode and data processing. Representativeness of data on radon in soil gas is dependent of the geological (geochemical) variability of soil/bedrock and amount of field estimates per geological unit.

Radioactivity of rocks and content of U/Ra in rocks can be estimated by airborne and ground gamma-ray spectrometry based mostly on detection of gamma rays of ^{214}Bi (1764 keV), a disintegration product of ^{226}Ra and ^{222}Rn.

In general, and for large-scale geological bodies, and under comparison of non-radioactive and radioactive rock, relation between ^{226}Ra and ^{222}Rn is found and gamma-ray spectrometric maps are applicable for regional radon estimates. Published data show low correlation between compared radionuclides in rock environment. Dispersions of correlated data and deviations of single data from regression lines have namely following reasons:

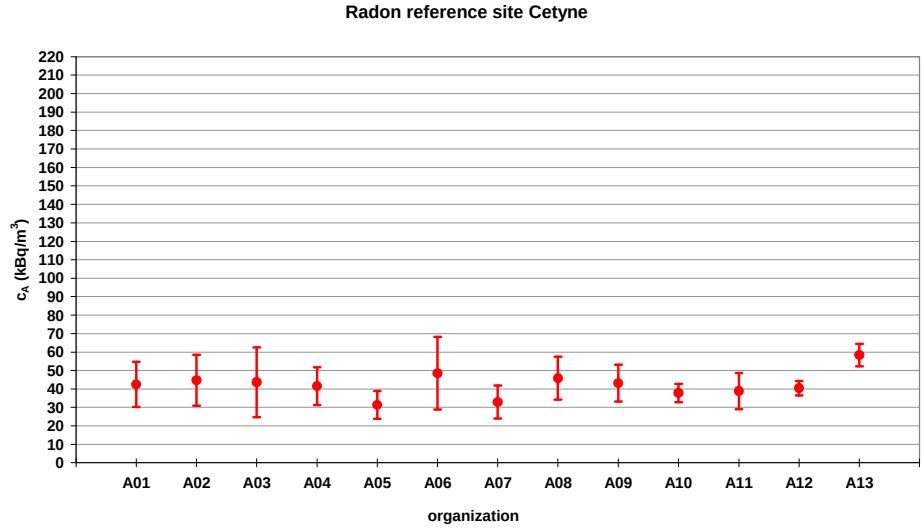
- Difference in depth penetration of applied measuring techniques; for gamma-ray spectrometry the effective depth of detection is 0.35 m, while the source of radon in soil air could be distant meters, or more.
- Measured object; by gamma-ray spectrometry we detect in fact presence of ^{222}Rn bound in the rock grains + ^{222}Rn in soil gas, while by field radon measurement we detect ^{222}Rn in soil gas only. Emanation power of rock/soil changes the ratio of both compared parameters drastically.
- Volume of analyzed rock; for gamma-ray spectrometry, the volume is defined by penetration of gamma-rays in rock (0.5 m), for radon measurement the volume of analyzed rock is function of rock gas permeability (very low to very large).
- Rock/soil moisture; increase in moisture give rise the decrease in gamma radiation (absorption of gamma rays), while increase in rock/soil moisture mostly leads to accumulation of radon under gas impermeable wet layer. However, the situation and relation of radium and radon could be more complex and variable.
- Atmospheric pressure; affects radon measurement and estimates, namely in gas permeable rocks/soil, while gamma ray spectrometry estimates of ^{226}Ra are (generally) independent of atmospheric pressure. The problem is more complex.
- Wind; strong wind reduces radon activity concentration in surface soil (namely in gas permeable soil), while gamma-ray spectrometry is rather independent on wind conditions (majority of ^{226}Ra is in mineral grains).
- Temperature; affects the humidity of soil and thus the escape of radon gas from near surface layer, dependence of gamma-ray spectrometry estimates of ^{222}Ra on temperature can be low and variable.
- Tectonic zones, fissures and fractions; significant increase to zero change have been reported for radon in soil gas over this geological structures in contrast to zero to mild changes in ^{226}Ra content determined by gamma-ray spectrometry.

Application of gamma-ray spectrometry estimates of ^{226}Ra to radon maps should be sensitive and cautious.

3. Comparison measurement of radon in soil gas at radon reference sites in the Czech Republic (RIM 2010).

Any compilation of radon geogenic maps and estimates of radon in soil gas or indoor radon require uniformity of radon data on the country and continental scale.

Comparison measurement of radon in soil gas, performed under participation of organizations from China, Czech Republic, Germany, Italy, Luxembourg, Poland, Republic of South Africa, Romania, Slovenia, Spain and Sweden at three radon reference sites in the Czech Republic, 21 – 22 October 2010, gave for the participant information on the level of their reported radon data in comparison to the group of participants (RIM 2010, N = 13, orientation result depending on the quality of radon estimates of the group), and with respect to radon databases of three radon reference sites, comprising results of 180 organizations which performed the tests in the period 2000 – 2010. Anonymous results can serve for the adjustment of reported values for the purpose of internal country radon research and for compilation of radon maps on continental scale.



Arithmetical means and standard deviations (1 STD) of radon activity concentration in soil gas (c_A) at reference site Cetyne reported by 13 organizations

Radon in soil gas comparison measurements at 3 radon reference sites in the Czech Republic are organized by the Charles University in Prague, Faculty of Science, twice per year, and will be offered at Workshops on the geological aspects of radon risk mapping. Contact e-mail address: matolin@natur.cuni.cz