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Radon data processing and outputs for the needs of State Office for Nuclear Safety (according to the Czech Radon Programme)

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Abstract. Great part of population living in the Czech Republic is exposed to radiation from natural sources, especially to radon effect. The aim of geological research defined by State Office for Nuclear Safety (SONS) was to detect areas with estimated high radon concentration in soil gas.

The uniform method of measurements and uniform methodology of radon risk category assessment of geological units as well as centralized radon database was established. Radon risk classification was based on statistical evaluation of soil gas radon concentration and permeability in investigated geological units. Prognostic radon risk maps in various scales were the main outputs of this research. With the help of GIS tools spatial analyses were made to find correlation between soil gas radon values in selected geological units and indoor measurements in dwellings.

After verification of the efficiency of track etch detectors placed in dwellings with the help of prognostic maps 70–80% reliability of these maps was proven. This reliability of analyses induced the SONS to widely use radon risk maps to determine areas with predicted high radon risk category.

1 Introduction

The Czech Geological Survey (CGS) has been participating in solving the problems of the inhabitants' irradiation caused by natural radionuclides since 1990. The Radon Programme of the Czech Republic (CR) started within the scope of the Governmental Decision No. 538 in 1999. Present research of radionuclides in dwellings has revealed that the CR is one of the countries with the highest level of average ^{222}Rn concentration in buildings (more than 140 Bq.m^{-3} equilibrium equivalent concentration). Significant part of the territory of the CR is formed by Bohemian Massif which belongs to the European Variscan belt represented by the Proterozoic and pre-Variscan Paleozoic crystalline basement. (Mísar at al., 1983).

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The main target of research work was to process all data and information from available databases and approve the existing relationship between increased indoor radon values and rock types in bedrock.

2 Data sources

Geologically based radon data originates from CGS measurements and also from more than 100 private companies. Data sources used for GIS applications come mostly from state organizations.

- Czech Geological Survey (CGS): Soil gas radon database (8900 test sites in rock units), vectorized geological maps (214 map sheets 1:50 000).
- Czech Office for Surveying, Mapping and Cadastre: Raster topography.
- Ministry for Regional Development of the Czech Republic: Database - UIR (special data register of regional identification), contours of cadastres, database of residential units and other details of measured dwellings.
- National Radiation Protection Institute: Indoor radon database (indoor radon measurement – 130 000 points, geometric mean in cadastre – 6299 cadastres).
- Czech Statistical Office: Database of geographic position (of measured dwellings) and character of dwellings.

3 Data processing

Field method of soil gas radon measurements and methodology of radon risk category assessments are standardized (Czech Technical norm, 1996). All data are placed in centralized database administrated by CGS. Sufficient number of measurements (nearly 9000 measured test site with 15 measurements at each and 29 items in database for every test site)

makes the statistically reliable data set enabling to determine radon risk from bedrock in particular geological units and rock types (Miksova and Barnet, 2002).

The construction of radon risk maps is based on contours of geological units. The division of rock types in prevailing radon risk categories is done with the help of statistical methods using soil gas radon concentration and permeability. The rock units are classified into four categories: low (younger sedimentation formations from Cretaceous to Neogene), interstage (inhomogeneous Quaternary sediments), medium (Paleozoic sediments and crystalline gneisses), high (granitoids).

The spatial analysis was made to find significant information about relationship between soil gas radon concentration and indoor measurements. Three different approaches for spatial comparison of cadastre's polygons and contours of geological units were tested. The way combined the demand for geographical preciseness and the demand for statistical reliability for further analyses was chosen. This method comprised the selection of cadastres with centroidal point situated inside the contour of rock unit, but the border of cadastre was partially intersecting the contour of geological unit (Barnet et al., 2002).

4 SW platform

The source soil radon gas database was based in Visual FoxPro, for radon map production converted to Oracle 8i. The data model for geological maps was originally created in ArcInfo (ESRI corp.). Later this model was converted into MicroStation (Bentley Systems corp.) – MGE (Intergraph corp.) – Oracle (Oracle corp.). This model was also used for radon risk maps formation. The spatial analyses were done in ESRI software Arc GIS.

5 Outputs

In 1998 the CGS issued the Digital Atlas GEOCR500 – the geological, radiometric and radon risk maps on the scale 1: 500 000 together with eight maps with geoscientific topic. This radon risk map was based on the vectorized contours of geological units and on the results of gamma dose rate measurement. This Atlas was published on CD-ROM in GIS project for ArcView 3.0 (Barnet and Miksova, 2001).

In 1998 the CGS finished the vectorization of geological maps at the scale 1: 50 000. These maps covered the whole state territory. This fact allowed the formation of more detailed radon risk maps based on geological maps. Since 1999 about 125 map sheets of Radon risk maps at the scale 1: 50 000 (from total count of 214 sheets) have published in print form and also in GIS application on the CD-ROM .

All results of our research are available through web pages of Czech Geological Survey.

6 Conclusions

By comparing the values of radon concentration in dwellings and the measured values on the test sites in geological units, the close correlation between the radon concentration and geological bedrock was established, especially in the areas where igneous and metamorphic rocks were found.

The data processing based on vectorized geological maps was proven as a highly efficient and relevant tool for determination areas where increased indoor radon values caused by radon exhalation from bedrock can be detected.

After verification of the efficiency of track etch detectors placed in dwellings with the help of prognostic maps at the scale of 1: 50 000, 70–80% reliability of these maps was proven. The outputs of geological research are used by regional centers of SONS and municipal authorities to set the priority for distributing the track-etch detectors into dwellings. In the case of randomly distributed track-etch detectors only 2% of measured dwellings exceeded the guidance level 200 $Bq.m^{-3}$ EEC. Using radon risk maps on a scale 1: 50 000 for setting of detectors into areas with assumed medium or high radon risk category in bedrock the number of affected dwellings increased to 20%.

Predictive radon risk maps were issued by CGS in the form of printed maps or on interactive CD-ROM in GIS projects.

Presentation of radon research work, especially radon risk mapping, are accessible to the wider public on the portal of CGS – www.geology.cz – radon mapping – in Czech and English versions.

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