Conclusions

The main task of geology in national Radon Programme was to delineate the areas, where a substantial fraction of dwellings exceeds the guidance level for indoor radon concentration. The distribution of the track-etch detectors for one-year indoor radon measurements is therefore oriented preferably into these areas, where enhanced indoor radon concentrations can influence the human health. Fulfilling this task would not be possible without applying the results of research projects aimed to precise the methodics and instrumentation of soil gas radon measurements and their countrywide application in radon mapping programme. Practically, the geological results enabled to concentrate the radioprotection activities into confined areas classified by high risk which saved the number of time-consuming indoor measurements and human power, payed mostly from the state budget. In the concluding part we shall try to summarize the basic achievements of the geologically oriented part of the Radon Programme of the Czech Republic.

1. During pilot studies the attention was concentrated to development of the uniform method for soil gas radon measurements, which could be easily performed not only by scientific and research institutions, but also by the private companies. From the beginning it was found that soil gas radon measurements cannot be performed using single-point measurements, as these measurements do not respect the local inhomogeneities of geological bedrock and soil cover on particular test sites. Therefore the 15 points method was widely applied together with using of sampling probes with lost tip sucking the soil gas from depth of 0.8 m, which avoided the possible growth of radon with depth namely in granitoid rocks. Due to the presence of possible local tectonics and radon growth with depth the main radiometric parameter for radon index classification was determined as the third quartile of the 15 points data set on the test site. Together with development of method and instrumentation of permeability measurements the whole method for radon index classification was finally approved by the State Office for Nuclear Safety and became the legal instrument for soil gas radon measurements in the Czech Republic.
2. The reliability of measurements and mutual data comparison was achieved by setting up the Radon chamber for checking the instrumentation (State Institute for Nuclear, Biological and Chemical Protection) and development of reference test sites for testing the method of soil gas sampling during field conditions (Faculty of Science, Charles University in Prague).
3. The first two steps enabled to develop the radon mapping programme starting sice 1990. The first maps at a scale 1 : 200 000 were based on the brief radiometric characterization of geological units and rock types, the latter radon risk map at a scale 1 : 500 000 was already based on the growing number of soil gas radon measurements obtained both from the state financed projects and from the private data of building site assessment (Association Radon Risk). This map, being compared to georeferenced indoor radon measurements, clearly showed the differencies in soil gas- and indoor radon concentrations within particular rock types and gave rise to demand for more detailed radon index maps at a scale 1 : 50 000, covering the whole state territory.
4. The detailed radon mapping programme began in 1999 and was finished in 2005 by publishing the radon index maps from bedrock (214 map sheets 1 : 50 000), covering the whole state territory. The maps are based on the digitized geological maps (Czech Geological Survey) and the radon database (9500 test sites, 8544 of them georeferenced). For each geological unit or rock type the statistically prevailing radon index is set and together with raster topography layers these maps represent the powerfull tool for further radioprotection work of the National Radiation Protection Institute and municipal bodies involved in Radon Programme of the Czech Republic.
5. Development of computer processing methods and their applicability in ArcGIS environment as well as the release of detailed topographical data in the database form enables to precise the determination of radon index up to the parts of municipalities. The public access to radon index maps is ensured by publishing the maps in the form of CD-ROM and internet application – Map Server of the Czech Geological Survey.
6. The different projects studying the relationship of soil gas radon and indoor radon concentrations have confirmed the major influence of radon release from bedrock on the radon concentrations in dwellings. The most radon prone areas were confined in syenite-durbachite bodies of the Čertovo břemeno type (Central Bohemia) and Třebíč syenite massif (Moravia). Generally in all magmatic rocks of Variscan age (granodiorites and granites) the indoor radon measurements should be performed with greater density compared to geological basement of younger sedimentary rocks. The further research projects respect the demands of the national Radon Programme and should be oriented to following themes:

   - Detailization of radon index maps in high radon index areas up to the scale 1 : 25 000 and their comparison with existing radon index maps
   - Precisioning of radon index determination in geologically complicated areas (contact metamorphism, intermediate Quaternary sediments on high radon index bedrock)
   - Development of building site assessment oriented to technical parameters of dwellings (Radon Index of Building)
   - Development of probability maps for municipalities using both soil gas and indoor radon data sets
   - Comparisons and exchange of radon data with bordering EU countries
   - Development of geostatistical methods for construction of the European Atlas of Natural Radiations.

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