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Mean annual ^{222}Rn concentration in homes located in different geological regions of Poland – first approach to whole country area

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ABSTRACT

The paper presents the results of year-long measurements of radon (^{222}Rn) concentration inside 129 buildings in Poland in relation to the geological conditions of their foundation. The authors took into account the division of the country into tectonic units, as well as the lithology of the rocks forming the bedrock of these buildings. As expected, the highest value of mean annual ^{222}Rn concentration (845 Bq/m^3) was recorded in a building situated in the area of the Sudetes, while the highest geometric mean (characteristic of the expected log-normal data distribution) was calculated based on measurements from buildings located within the East-European craton, in the area of Mazury-Podlasie monocline, where it reached 231 Bq/m^3. Such results reflect geological conditions – the occurrence of crystalline rocks (especially U- and Ra-enriched granites and orthogneisses) on the surface in the Sudetes, and of young post-glacial sediments containing fragments of Scandinavian crystalline rocks, also enriched with U and Ra, in the area of Mazury-Podlasie monocline. However, the least expected result of the investigations was finding out that, contrary to the hitherto widespread belief, none of the major tectonic units of Poland can be excluded from the list of those containing buildings with mean annual ^{222}Rn concentration exceeding 200 Bq/m^3. The mean annual concentration of radon for all the buildings were much higher than the mean concentration value (49.1 Bq/m^3) of indoor radon in Poland quoted so far. These results cast a completely new light on the necessity to perform measurements of radon concentration in residential buildings in Poland, no more with reference to small areas with outcrops of crystalline rocks (especially the Sudetes, being the Polish fragment of the European Variscan belt), but for all the major tectonic units within Poland.

1. Introduction

So far, no legal obligations to perform measurements of radon (^{222}Rn) concentration in buildings intended for permanent residence have been introduced in Poland. Therefore, no comprehensive measurements of activity concentration of ^{222}Rn in the air of residential buildings have been conducted on the scale of all Poland, a country with the total land area of nearly 313 000 km^2 inhabited by over 38 million people. For this reason, all measurements of indoor radon concentration in Poland have been conducted solely as a part of scientific research (Nowina-Konopka, 1995; Niewiadomski, 1995; Karpińska et al., 2002, 2003, 2004a,b, 2005, 2010; Kozak et al., 2005b; Wysocka and Chałupnik, 2003; Zalewski et al., 1998) or educational projects (Kozak et al., 2005a; Kozak and Mazur, 2008). Consequently, mean annual values of radon concentration are known only for a small number of

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buildings. This results in the fact that Poland is still 'terra incognita' on radon maps of Europe. Because of this, the few studies, including those conducted by the authors of this paper, have been performed in the way making it possible, at possibly low cost and consequently with a small number of measurements, to obtain a cohesive and reliable picture of spatial variation of the actual and expected levels of indoor radon concentration in Poland. Among other methods, this aim has been achieved by calculating monthly and quarterly coefficients, which can be used to estimate mean annual radon concentration in a particular building based on the measured mean monthly or quarterly value of ^{222}Rn concentration (Karpińska et al., 2004a,b, 2005). Similar solutions have also been employed in other countries (Chen, 2003; Gillmore et al., 2005).

In this paper, the authors present the results of preliminary investigations into mean annual values of ^{222}Rn concentration in residential buildings depending on their location in relation to main tectonic units of Poland. The structure, as well as the mineral and chemical composition (lithology) of the bedrock on which the building stands, are some of the major factors determining the level of indoor radon concentration. Due to the distance of radon migration in the earth crust, the biggest ^{222}Rn source is from rocks lying at the depths of the order of 100–500 m b.s.l., depending on their gas permeability and depending on the extent they are cut by permeable fault zones. So far in Poland such studies have been carried out occasionally and only with reference to small parts of the country (Karpińska et al., 2002, 2003; Kozak et al., 2005b; Wysocka and Chałupnik, 2003), while they are common around the world (i.e. Popit and Vaupotič, 2002; Sundal and Strand, 2004; Gillmore et al., 2005; Sesana et al., 2005; Reimer and Szarzi, 2005). The recent results of these studies were preliminarily summed up for the area of Europe in a paper by Groves-Kirkby et al. (2010).

2. Geological characteristics of Poland

Measurements were performed in buildings situated on all main tectonic units of Poland, taking into account the lithology of rocks lying at the depth of up to about 500 m b.s.l. The units in question were classified based on the latest papers by Narkiewicz and Dadlez (2008) and Karnkowski (2008), and to a lesser extent also by those of others (Stupnicka, 1989; Znosko, 1998; Dadlez et al., 2000; Żelaźniewicz, 2008; Mizerski, 2009). The distinguished tectonic units refer to sub-Cenozoic bedrock, except for the Alpine-Carpathian orogen and the Carpathian foredeep, filled with thick Miocene deposits. The investigations were carried out in the area of three large European tectonic units basically different in their geology and adjoining each other in the area of Poland. These are: the East-European platform (East-European craton), the West-European platform and the Alpine-Carpathian orogen together with the Carpathian foredeep. Their range and subdivision is shown in Fig. 1.

Within the East-European craton, the studied buildings were located in the area of Pomeranian–Płock–Puławy synclinorium and the Mazury-Podlasie monocline. In these tectonic units of Poland, crystalline (igneous and metamorphic) rocks lie at depths from over 200 m to about 1000 m and are covered with sedimentary rocks of the Mesozoic and the Cenozoic. On the surface there are thick covers of glacial and fluvioglacial Pleistocene sediments. The thicknesses of Pleistocene and Holocene sediments range from

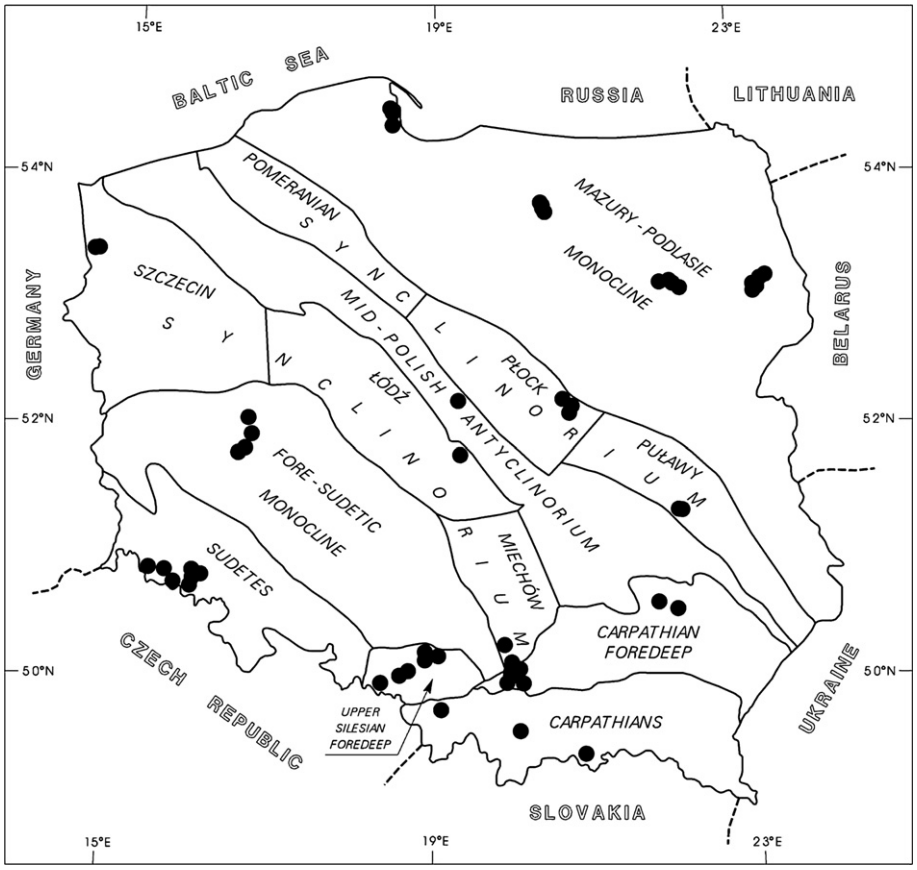

Fig. 1. Location of buildings (black circles), in which measurements of ^{222}Rn activity concentration were performed, on the background of a tectonic map of sub-Cenozoic surface of Poland, except the Alpine units of the Carpathians and the Carpathian foredeep (according to Znosko, 1998; Narkiewicz and Dadlez, 2008; Karnkowski, 2008) with a slightly modified and standardized division into main tectonic units.