INDOOR RADON RELATED TO GEOGENIC RADON

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Introduction

Radon production in the subsurface and radon transfer from building ground into houses are the essential agents controlling indoor radon concentrations (1,2,3,4,5,6). A geogenic radon potential can be derived from the mapped distribution of geological units and accompanying measurements of *in situ* permeability and radon concentration in soil gas to serve as a regionalised geology-based prediction tool for radon concentration in houses. For planning purposes, a series of maps of the geogenic radon potential in Germany have been produced by a distance-weighted interpolation of radon activity concentration in soil gas using approx. 2000 measuring sites and taking into account geological boundaries (Fig. 1). High values occur especially in regions with granites and basement rocks of Paleozoic age. Many of these regions are also known for their enhanced indoor values. Increased values likewise occure mainly in regions with outcrops of folded and metamorphic basement, but also of some Meso- and Cenozoic sediments with increased uranium contents and/or higher emanation coefficients. Low radon contents, where protective measures against radon usually have not to be considered, are found in the geologically rather homogeneous part of northern Germany with unconsolidated Cenozoic sediments, covering about 25 % of the total country.

First Approach

To validate this source-based areal prediction using GIS techniques, the soil-gas database was correlated with a set of about 33000 long-term indoor radon measurements between several month and one year in living rooms of 3237 municipalities (Fig. 2).The indoor radon concentrations in living rooms were averaged for the respective municipalities as the smallest administrative unit, because exact geographic positions of each indoor data were not available. The centre of each municipalitiy is coded with the generalised geological characteristics of the specific area, giving correct assignments in regions with homogeneous geology, but is critical in municipalities with a highly varying geology. Distance-weighted interpolation on a 3 km raster basis within the boundaries of similar geological units yield comparable data sets of radon concentration in soil gas and indoor air (Fig. 1, 2). The results demonstrate a fairly good correspondence of regions of increased geogenic radon and increased indoor values. The interpolated raster data of both groups are a log-normally distributed with values ranging between 6 and 2106 Bq/m³ for the indoor data and between 2 and 1003 kBq/m³ for the soil gas data. Main drawbacks of this general approach to validate the geogenic prognosis are:

- lack of sufficient precision of the geographic position of the indoor values, critical especially in regions with high variability of the distribution of the geological units,
- information concerning mining areas and other technical human activities are not included,
- age and specific properties of the dwellings are not taken into account.

Recent Work

To improve the outlined method of prediction, the Federal Office of Radiation Protection has launched a research project to elaborate empirical transfer functions for the estimation of radon contamination of houses in the Federal Republic of Germany. In six testing areas with different geogenic radon potential (Fig. 2) detailed investigations are done in cooperation between the Institute of Geology of Bonn University and the consulting company Kemski & Partner. For statistical evaluations of the correlation between soil gas radon measurements near houses and corresponding long-time indoor measurements in a spot-to-spot assignment, approx. 1200 soil gas measuring sites were selected to sample the relevant geological units. In 1400 exactly located dwellings one-year-measurements of indoor radon were performed and comprehensive specifications to the properties of the houses were made by the occupants. To study the influence of the building ground on the indoor radon values one detector was exposed in the basement and one detector in the ground floor in the living room. The main topic of this work is to obtain specific transfer functions for different geological environments and to specify the radon relevant properties of houses e. g. constructing type, age, foundation and other site and building specifications.

Additionally, in the research project the geogenic prognosis should be tested. The Bayerischer Wald in the south-eastern part of Bavaria, the northern part of the Schwarzwald and the Sauerland in the north eastern Rhen-

ish Massif are characterized by rather high geogenic radon potential. Here a higher frequency of enhanced indoor values as well as a higher median value are expected. This dependence should be stronger reflected in the basement values than in the ground floor values. In Schleswig-Holstein in the northern part of Germany the difference between areas with older ice drift sediments (Elster, Saale) composed of material with a relatively low radionuclide content and areas with younger ice drift sediments (Weichsel) characterized by enhanced radionuclide contents due to granitic material from Scandinavia should be visible. The testing areas in Franken in northern Bavaria and in Pfalz in the southwestern part of Germany with flat lying geologically homogeneous Mesozoic sediments were choosen a representatives for rather medium or low geogenic radon potential.

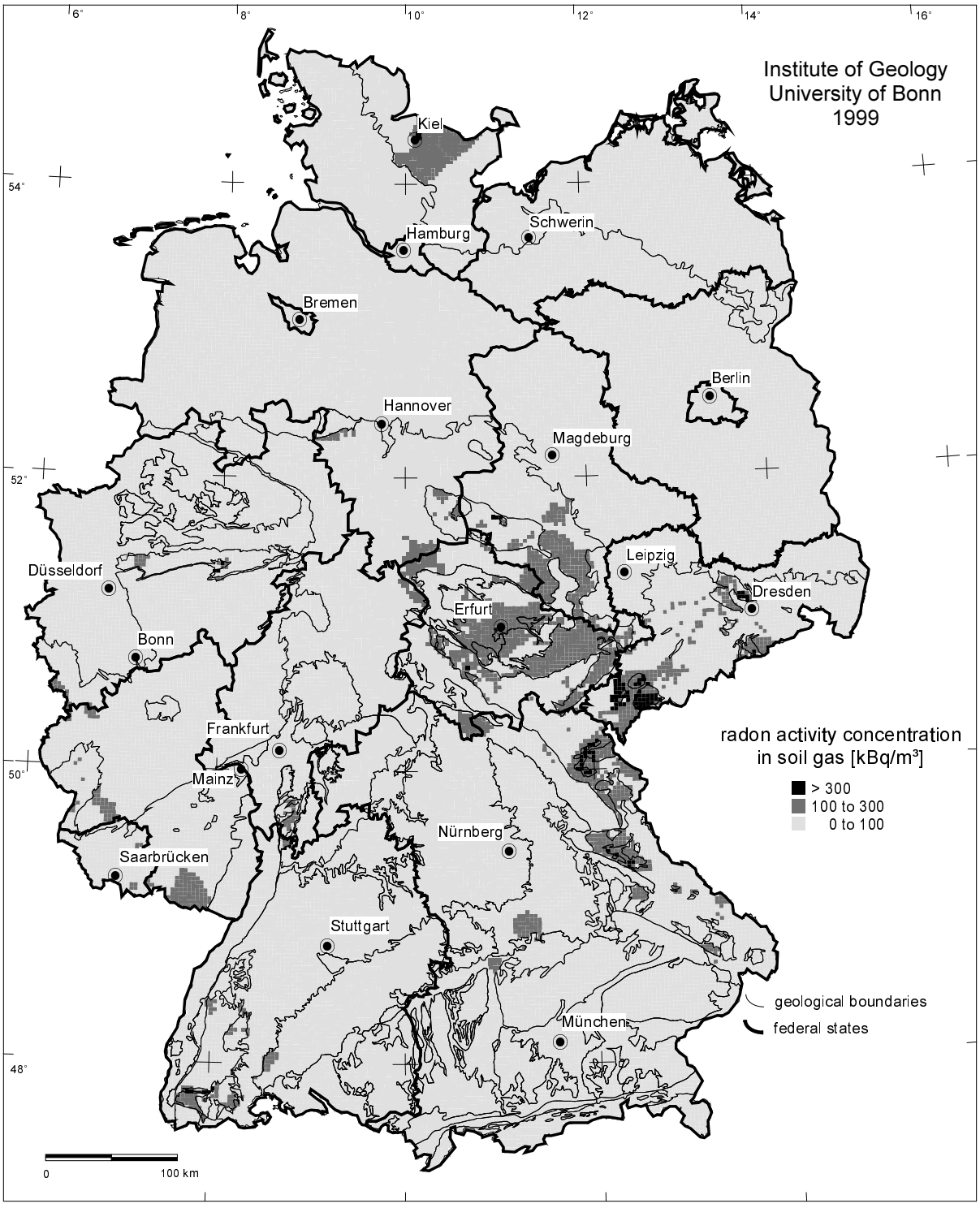

Fig. 1: General map of the radon concentration in soil gas in Germany.

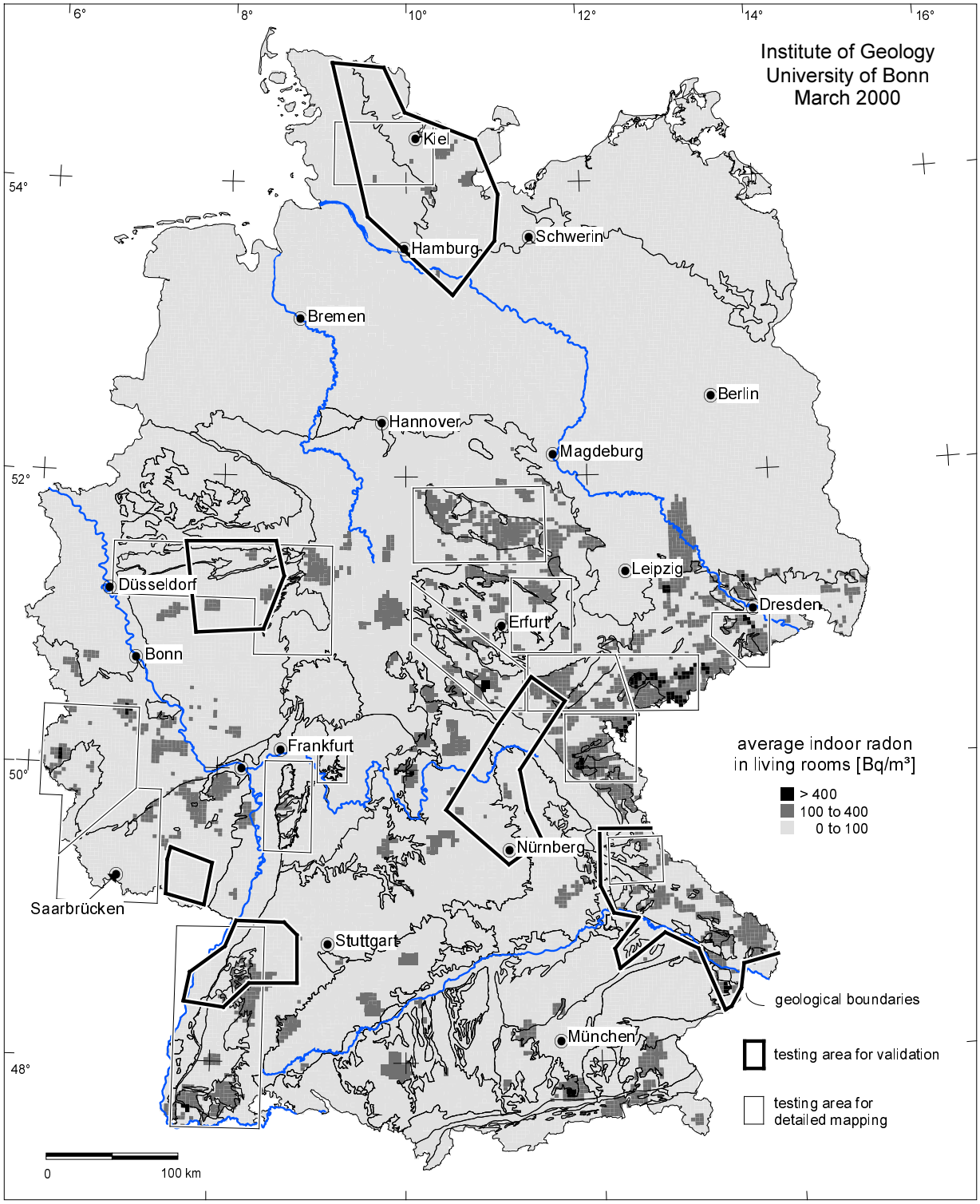

Fig. 2: General map of the average indoor radon in living rooms in Germany.

The first results of the soil gas and indoor measurements provide a good correspondance and confirm the expectations. In the granitic areas of the Bayerischer Wald the highest soil gas and indoor values occur, which differ clearly from the surrounding metamorphic rocks. High radon concentrations are measured too in the black shales of the Sauerland; because of the small outcrop of these rocks just a little area is concerned. The soil gas radon concentrations in the northern Schwarzwald have to be classified as medium due to the rather low radionulide contents of these granites and the covering Mesozoic sandstones. Therefore enhanced indoor values just locally occur. In Schleswig-Holstein the difference between the older and younger glacial sediments is quite obvious. Both soil gas and indoor radon concentrations are higher in the eastern part of this testing areas reflect-

ing the different geological environment. In Franken und Pfalz rather low radon concentrations in soil gas as well as in buildings were measured.

First Results

Generally, this first comparison of soil gas and indoor measurements in geologically different testing areas comes up with a good correspondance between the geogenic radon potential and indoor radon concentrations. In contrast to further campaigns the geological unit of each soil gas and indoor measuring site is known, which enables a geologically based interpretation without any uncertainty. In a second step, taking into account the buildings characteristics, house specific radon transfer functions shall be deduced. These can be used as a prediction tool for other areas, where extensive measuring campaigns cannot not be performed.

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