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Tectonically enhanced geogenic radon

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Since geogenic radon (Rn) is an important control for indoor Rn, which in turn is acknowledged as a major health hazard (second cause of lung cancer after smoking), areas with enhanced geogenic Rn are of particular interest. This is reflected by recent regulations, most importantly the EU directive on basic safety standards for protection against ionizing radiation (BSS, [1]) which must be transposed into national law by EU members. The BSS Directive requires delineation of Rn priority areas, where prevention and remediation of high indoor Rn concentrations should be taken with priority.

Soil Rn concentration is enhanced in active tectonic areas. In fact, elevated radon concentrations in soil gas are frequently associated with seismogenic faults and fault creeping, potentially creating radon anomalies in the vicinity of the fault trace at surface. Therefore, it seems desirable to consider locally confined phenomena, such as areas of tectonically enhanced geogenic Rn (TEGR), in Rn mapping and develop respective routines. This has been discussed for some time in the framework of European Rn mapping [2] and also on a national scale.

Implementing TEGR into Rn mapping is an interdisciplinary challenge. Remote sensing techniques (e.g. LIDAR) can be used for the identification of faulted areas, whereas field structural geology analysis can be conducted to define and classify fault type and geometry, fracture density and width of fracture zones. Sub-surface faults need to be unveiled by geophysical measurements.

Soil gas surveys are an effective tool to trace open fractures and faults that can act as conduits for endogenous gas migration, especially if faults are buried under an unconsolidated sedimentary cover. The association of Rn with high concentrations of carrier gases (e.g., CO_2 and CH4), which significantly increase the migration distance of Rn, can confirm the presence of gas leaking faults at surface.

We present an overview of the physical, geological, geophysical and geochemical background of TEGR, focussing on recent studies. We also review studies on the relationships of TEGR with indoor Rn concentration, (i.e. distance to the nearest fault should be investigated to assess Rn risk). We then address the question of how to reasonably include TEGR as a spatially limited and linear feature in coarser scale mapping; small anomalies have little effect on the mean over a larger geographical unit such as a 10 km x 10 km grid cell, as used in European mapping, or a municipality, but they do influence the occurrence probability of extremes, which may be an alternative measure of geogenic Rn hazard. As a first step, however, a measure of "geographical intensity" of faults could be developed, which would serve as a control quantity for spatial estimation of the TEGR and which could be estimated from available databases.

[1] Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation etc., http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2014:013:FULL&from=EN

[2] European Atlas of Natural Radiation, https://remon.jrc.ec.europa.eu/About/Atlas-of-Natural-Radiation