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## Exploration of radon-rich waters in crystalline terrains by gamma method in spite of radioactive disequilibrium

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Radioactive mineral waters (rich in dissolved  $^{222}\text{Rn}$ ) are highly valued for their medical use. Therefore they have been intensively explored in last years (2005–2014) in Orlica-Sněžník dome and Krkonoše-Jizera crystalline areas. Springs of radioactive medicinal water are bound up with the Cambrian/Ordovician orthogneisses (the Krkonoše, Kowary and Jizera orthogneiss).

For these purposes an exploration method has been developed as a combination of GIS (ArcMap 9.1–10.1) for the area preparation followed by field radiohydrogeochemical mapping. As basic GIS layers a geological map 1:50000, topography, airborne gamma spectrometry, linear structures from Remote Sensing were used.

The field radiohydrogeochemical mapping was realized in scale 1:10000 in perspective areas selected by GIS preparation. All water manifestations (wetlands, springs, man-made objects) were measured by gamma as an indicative method. In case of positive results (increased gamma in water) the water was sampled and a passportized field record was written.

The exploratory groups were equipped with sensitive field scintillometers RP-11 with RFS-05 gamma probes. The  $^{222}\text{Rn}$  activity in water samples was determined by the emanometric method (RP-25) at the field base. Control analysis in the laboratory by LSC (QUANTULUS) was made. Standardization of all methods is commonplace.

More than 50 water sources with activity above 1500 Bq/L (i.e. “radioactive mineral waters”) were found in the whole territory. The highest radon activity reaches 6215 Bq/L in case of the Michael spring near Nové Město p. Smrkem. Waters are cold (5–9.5 °C) and low-mineralized (TDS < 100 mg/L),  $^{222}\text{Rn}$  is the only important component.

Gamma activity of fresh flow water is close to zero; it is free of the short-lived  $^{222}\text{Rn}$  gamma active progeny ( $^{214}\text{Pb}$  and  $^{214}\text{Bi}$ ). Field measuring of fresh water gamma activity growth indicates its effective age about 7 minutes only. But the gamma activity is really detectable in frequent cases where there is a slowdown in the flow and mud or sediment of organic material is created. In fact, we have a lot of evidence from the field Gamma dose rate in water reaches 4624 nGy/h.

Relationship of gamma (gamma dose rate in water) and radon-in-water activity is complicated; both quantities correlate freely. It depends on the specific situation of every single spring. Generally we can say that the gamma dose rate is a function of radon-in-water activity, water velocity and flowing water volume:  $D_w = f(A_v, v, V)$ .

Gamma method, in spite of radioactive disequilibrium, is useful for exploration of radon-rich waters in crystalline terrains on the basis of our empirical findings in the field, much better than the “blind” method.

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