

ENVIRONMENTAL-GEOCHEMICAL MAP OF STREDNÉ POVAŽIE REGION, SLOVAKIA

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Abstract: The methodology and basic principles of synthetic environmental-geochemical map compilation are presented in the paper. Both spatial and local anomalies of significant concentrations of chemical elements are figured in the map. Groundwater, surface water, soils, stream sediments, radon risk and natural radioactivity parameters are evaluated. Quantitative hydrogeological characteristics of the rock environment is base for description of potential contamination spread in the lithological settings.

Key words: Environmental-geochemical map, contamination, Slovak Republic

Introduction

In the last decades large amount of environmentally-themed maps in the geological research also reflects strong interests of geological science in the environment. The main tasks are to describe and evaluate various geological phenomena with relation to the environment. In Slovakia the geology-environment relation has been assessed for more than 10 years particularly via the maps of geological factors of environment. This set of maps consists of around 15 monothematic maps projecting the investigated regions. As it is obvious there is need to summarise somehow all achieved information and to compile connected synthetic maps describing the geological environment. Related geochemical studies of Rapant et al. (1998), Vrana – Pivovarči (2001), Bastos (2000) among others are worth of notice here. Such synthetic maps are suitable for rough and simplified environmental evaluation of investigated region.

Proposal methodology of the *Environmental-geochemical map* compilation is described below. The proposal has been designed within the project „Regional map set of geological factors of environment in the Stredné Považie region“ (Rapant et al., 1994). The main objectives of the map are a) to serve simplified description of geochemical background in region, and b) to define the most anomalous concentrations of contaminants in individual

factors of geological settings with potential negative effects on biota and public health in the investigated regions.

Basic principles of environmental-geochemical map compilation

Data of chemical content and qualitative parameters of groundwater, surface water, soils, stream sediments, radon risk and natural and artificial radioactivity are synthetically evaluated and mapped in environmental-geochemical maps. These map targets show a distribution of environmentally significant concentrations of elements and compounds, indicating either geogenic or anthropogenous contamination of environment with potential negative effects on biota and human being. Only the most contaminated areas are set up in the map. Contamination-free sites are not described. The following colour pattern is recommended to use for definition of polluted and anomalous sites in individual environments:

- water contamination – blue shades,
- stream sediments – brown shades,
- soil contamination – green shades,
- natural and artificial radioactive contamination – red shades.

If anomalies from the individual environments overlay, the hierarchical principle is used for combining of contaminated (anomalous) sites according to above-mentioned pattern. That means, for water anomalies only the blue shades, for stream sediments and water anomalies the brown shades, for soils and stream sediments or/and water anomalies the green shades are used. If at least one of contamination parameters stands for natural radioactivity, the red shades are applied. In the case of local anomalies, the contamination is expressed by dots sharing the colour pattern of the special anomalies.

Determination of significant anomalous environmental concentrations

Environmental-geochemical map regards results and locates significant environmental anomalies of elements/compounds from the other basic geochemical maps of geofactors. Definition of significant anomalies of individual parameters is related to environmental pollution either of anthropogenous or natural origin with potential negative affects on natural ecosystem. Environmental standards, normative regulations, critical, maximum concentration, respectively give the indication values for individual abiotic environments. Furthermore, experimental studies, statistical analysis and simulation modelling are also among tools of how to design the indicative values.

As the total contamination of geological environment is figured, the most contaminated areas are displayed in the synthetic map. The robust criteria are used predominantly for map compilation. Selection and method of expressed environmental-geochemical information are strongly subject to natural condition and degree of contamination in individual regions. For instance different criteria standardise the water contamination in water-head (mountainous) areas and lowland locations. So, the parameters and their critical values can be modified and different for individual regions.

Presented normative standards and critical values used for localisation of anomalies and contamination must be introduced in map legend.

Determination of anomalies in ground and surface water

Determination of ground and surface water anomalies comes from outcomes of „The map of natural water quality“. Areas with slightly contaminated ground and surface water are determined according to particular standards rooted in Slovak Technical Standard (STN) No. 75 7111, *Potable water* – for groundwater and STN No. 75 7221, *Classification of surface water quality*. Quality classes C and D are relevant for thinking of groundwater contamination. Surface water is polluted in case of quality classes 4 and 5 (Rapant-Bodiš, 1996).

The combined approach based upon the legislative and statistical procedures is employed in highly polluted areas. The contamination index (C_d) stands for summarised values of all assessed elements exceeding the standards (Rapant et al, 1996). The critical C_d value indicating the level of contaminated water areas is stated according to degree of contamination load in the region (e.g. >3 , >5 , >10).

Determination of anomalies in stream sediments and soils

Results from „Map of stream sediments geochemistry“ and „Pedogeochemical map“ are used for determination of contaminated areas. Category B according to Resolution *MP SR No. 581/94-540* (so-called Dutch sheets) is relevant for location of spatial anomalies and category C according to the same Resolution is used for detection of local (spot) anomalies. In case of low degree of pollution in region it is recommended to use B category even for detection of local (spot) anomalies.

The contamination index C_d is used as an indicator of contamination in areas with highly polluted stream sediments and soils, e.g. zones where intensive mining activities and metallic ores are.

Determination of anomalies of natural and artificial radioactivity and radon risk

Description of natural radioactivity anomalies is based on the results from „Map of natural radioactivity“. Parameters of total radioactivity and radon risk of rocks are used to localise the contamination (measured are also concentration of potash, thorium, uranium). The total radioactivity $eU_t > 16$ μr and the high radon risk category are reflected in the map. If value of artificial radioactivity is also presented in the radioactivity map, artificial radioactivity of mass activity $^{137}\text{Cs} > 1\,000$ $\text{Bq}\cdot\text{kg}^{-1}$ depicts the pollution.

Those parameters of natural radioactivity of water are considered significant, which exceed the highest-fourth degree of risk (according to Resolution issued by the Ministry of Environment of the Slovak Republic No. 1/2000 on Natural and artificial radioactivity map compilation):

- concentration $U_{\text{natural}} > 0,1$ $\text{mg}\cdot\text{l}^{-1}$,
- activity $^{226}\text{Ra} > 1,0$ $\text{Bq}\cdot\text{l}^{-1}$,
- activity $^{222}\text{Rn} > 200$ $\text{Bq}\cdot\text{l}^{-1}$.

Potential risk of contamination transport in geological settings

Quantitative hydrogeological parameters characterising amount of circulating water, lays grounds for expression of potential risk of contamination transport of chemical constituents in geological environment. The quantitative parameters used for evaluation of potential risk in question are: transmissivity coefficient T [$\text{m}^2\cdot\text{s}^{-1}$] for aquifer with intergranular permeability and specific discharge of groundwater q [$\text{l}\cdot\text{s}^{-1}\cdot\text{km}^{-2}$] for rocks with fissure and karstic permeability.

Five levels of potential risk of contamination transport are distinguished related to amount of circulated water in the aquifer. Individual intervals of risk categories are associated with intervals T and q (after compilation of basic hydrogeological maps at a scale 1 : 50 000, Malík – Jetel, 1994).

Colour pattern describing permeability type and lithological-stratigraphical characteristics of the rock settings shows potential risk of contamination transport (tab. 1).

Rock environment characteristics

Geological composition of main rock types, e.g. rock content, stratigraphical classification and permeability type forms specific pattern and stratigraphical index. Choice and format of described rock characteristics are related to geological composition of assessed

region. Thus the rock parameters are assembled for different region individually. Examples of rock environment characteristics are introduced in Fig 1.

Conclusion

A synthetic environmental-geochemical map of Stredné Považie is presented in the poster. According to the above mentioned methodology the most contaminated areas with anomaly contents of study parameters different from geochemical background values are localised in the map.

The areas with the most polluted zones and the highest risks to affect biota and human health represent danger for living environment. Sense of simple and visual description of mentioned hazards is basic idea to show aspects of abiotic environmental statement at present.

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Tab. 1 Classification scheme of potential risk of contamination transport in geological settings

| risk | index | Quantitative hydrogeological characteristics of the rock environment | |
|-----------|-------|--|--|
| | | transmissivity coefficient T [m ² .s ⁻¹] | specific discharge q [l.s ⁻¹ .km ⁻²] |
| very high | 1 | >3.10 ⁻³ | >16 |
| high | 2 | 3.10 ⁻⁴ –3.10 ⁻³ | 9–16 |
| medium | 3 | 3.10 ⁻⁵ –1.10 ⁻⁴ | 3–9 |
| low | 4 | 1.10 ⁻⁶ –3.10 ⁻⁵ | 1,5–3 |
| very low | 5 | <1.10 ⁻⁶ | <1,5 |

Colour pattern of the rock environment 1 – violet, 2 – red, 3 – blue, 4 – green, 5 – brown

Fig. 1 Examples of rock environment characteristics

