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Hydrogeochemical mapping in Slovakia

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Abstract. A review of hydrogeochemical research and hydrogeochemical mapping of Slovakia is presented in the paper. Main methods applied to hydrogeochemical research since the 1970s and hydrogeochemical map specimens are shown together with methods used in their construction.

Key words: hydrogeochemistry, hydrogeochemical maps, Slovakia.

Introduction

Water is an important asset in terms of economy, ecology and social development of a society. Thus, governments recognize that knowledge of quality and quantity of water sources available in their countries is a priority. Primary information on the groundwater quality is obtained through hydrogeochemical research and exploration which are of particular importance in Slovakia since more than 80% of potable water is supplied from groundwater sources.

As is the case in other earth sciences, the extensive and extremely variable hydrogeochemical data can best be summarized in the form of maps. In Slovakia, hydrogeochemical knowledge attained a very high standard during systematic hydrogeochemical mapping realized since the 1970s.

This paper describes briefly the history of hydrogeochemical research and exploration in Slovakia and gives details about the results of hydrogeochemical mapping.

History of hydrogeochemical research in Slovakia

The knowledge of Slovakia's hydrogeochemical conditions is closely associated with the development of Slovak geology and hydrogelogy. Systematic basic and applied research into the geology of Slovakia started in 1940 when the National Institute of Geology was established in Bratislava. In1953 it was renamed to Dionýz Štúr Institute of Geology (GÚDŠ) and existed as a separate institution until 1995. The establishment of the institute roughly coincides with the beginning of intensive development of Slovak industry and economy which brought about an ever increasing consumption of water. At the same time, the problem of environment pollution, notably contamination of surface and ground waters, became more and more critical. Resulting hydrogeological problems gave rise to a small team of hydrogeologists at the GÚDŠ in 1954 which was transformed into a separate hydrogeological department in 1959. However, the number of hydrogelogic tasks to be solved continued to grow so that specialized hydrogeologic units had to be set up (Hanzel – Vrana, 1990).

The prime task of the GÚDŠ in the field of systematic hydrogeological research was to prospect for groundwater resources. Regional hydrogeological investigations included hydrogeochemical research which, in turn, comprised field, laboratory and interpretative works. It significantly contributed to the knowledge of the genesis of groundwater-chemistry as well as of qualitative properties of groundwaters in Slovakia, and in many regions it resolved hydrogeological problems in complicated geologic-tectonic settings.

In 1969, the GÚDŠ established a hydrogeochemistry department to carry out regional and methodical research into Slovakia's hydrogeochemical conditions. Its initial objective was to solve the basic regional factors controlling groundwater chemistry. Later its activities focused on the protection and rational exploitation of groundwater. Most regional data on the amount and quality of groundwater of Slovakia was obtained during the period 1961–1990 when six state projects were completed (for more detail see Hanzel – Vrana 1990).

From a methodological point of view, the classification and interpretation of groundwater chemistry were based on Gazda's classification of groundwater chemical types (Gazda, 1972).

One stage of regional hydrogeochemical research was concluded in the mid-1970s by the compilation of the Genetic Classification of West Carpathian Groundwater (Gazda, 1974) in which processes controlling primary chemical composition of groundwaters in the water - rock system along with the human factors were defined and explained.

The ever increasing knowledge of regional hydrogeochemistry gave rise to works of thematic and special hydrogeochemical character, such as monitoring of snow-blanket quality, calculations of matter balances through model drainage basins, experiments in the soil - rock - water system, hydrogeochemical prospecting and palynology, which was applied hydrogeochemistry to clear up groundwater origin.

All regional hydrogeochemical data were obtained from hydrogeological exploration of groundwater sources carried out mostly by IGHP, s.p. Žilina and its successors INGEO, a.s. Žilina, GEOCONSULT, a.s. Košice and GEOS, a.s Bratislava. Further hydrogeochemical information was provided by detailed hydrologic and hydrogeologic studies by water-management organizations, notably by the Water Management Research Institute (VÚVH) in Bratislava. Between 1981 and 1984, VÚVH compiled maps of qualitative and technological properties of Slovakia's ground and surface waters. However, these illustrate only water-management and water-treatment properties and give no quantitative geochemical characteristics of groundwaters. Slovak Institute of Hydrometeorology (SHMÚ) in Bratislava is another major source of hydrogeochemical information. Of particular interest is the groundwater-quality monitoring which has been carried out systematically since 1982 and offers regionally significant hydrogeochemical data which allow to assessment of the evolution of groundwater quality in time. In 1994, SHMÚ coordinated the compilation of the General rules of groundwater protection and rational exploitation which supplied further important information on the country´s groundwater chemistry.

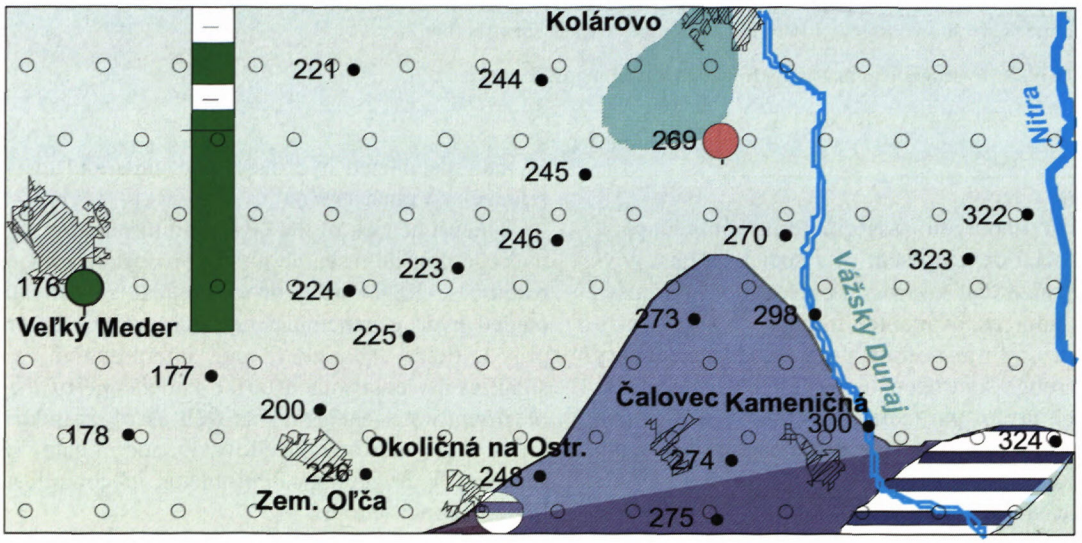

Fig. 1 Map at 1 : 200 000 scale showing groundwater chemistry. A segment from the Nitra sheet map. The chemistry type, expressed by predominant cations or anions, is shown by color, while the total mineralization is shown by color´s intensity. Blue – $CaHCO_3$ type, green – Na-Cl type, violet $Na\text{-}HCO_3$ type. Fully colored areas represent basic types (> as 50 eq% of cation). Horizontal strips show transitional water types (< as 50 eq% of cation and anion) and colors indicate predominat components.

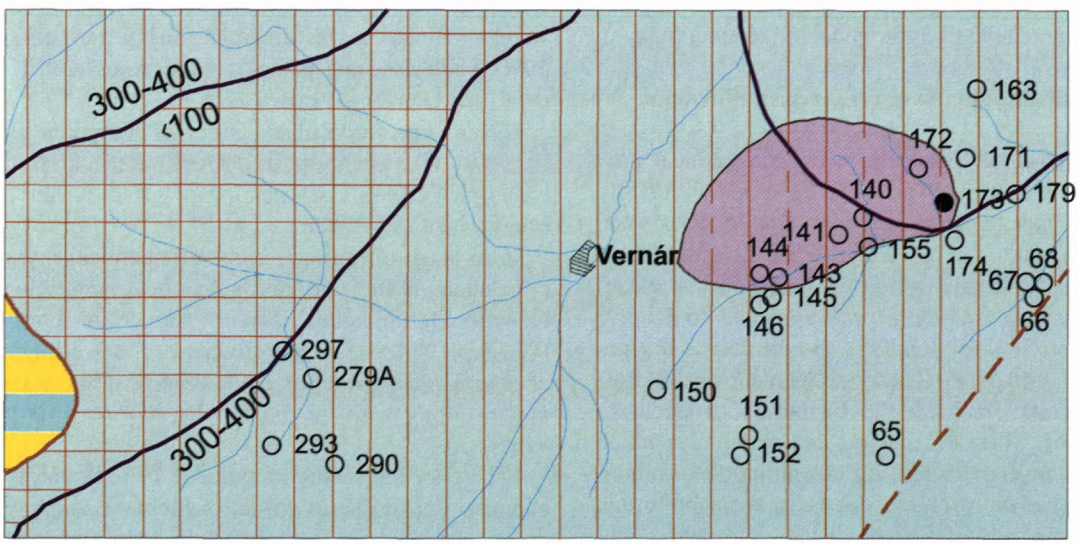

Fig. 2 Hydrogeochemical map at a scale 1 : 50 000. A segment from the Hydrogeochemical map of Slovenský Raj. Colors stand for combinations of main typomorphic ions whose contents exceed 50 eq%. Blue – $Ca\text{-}HCO_3$, violet – yellow $CaSO_4$. The magnitude of total mineralization is expressed by isopachs showing the mineralization values. Horizontal strips show the second cation within the range 25–50 eq% and vertical strips the second anion ranging between 25 and 50 eq%.

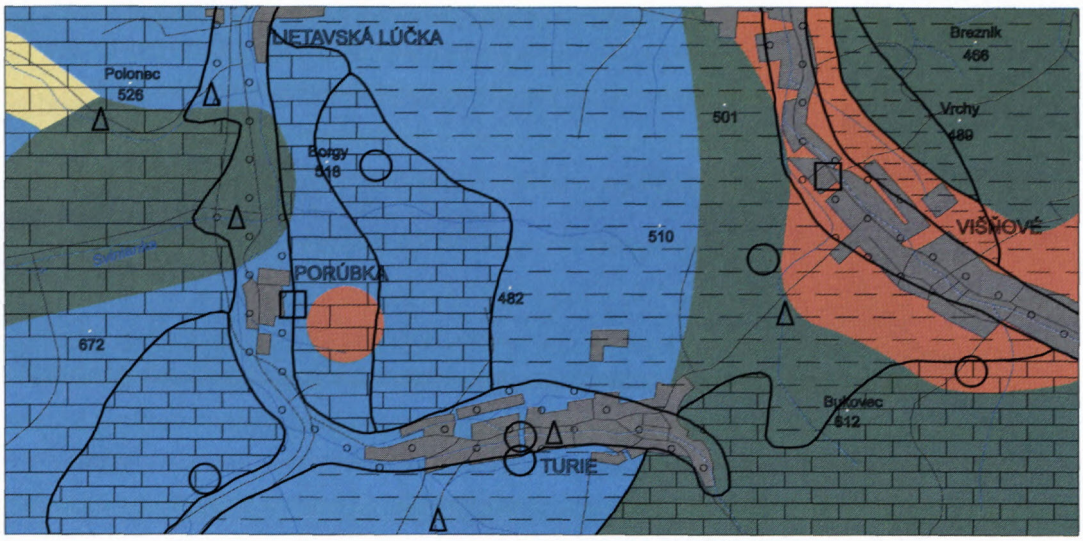

Fig. 3 Map of natural water quality at 1 : 50 000 scale. A segment of the Malá Fatra Mts.. Colours show qualitative properties of natural water. Trafic lights were used to show the water quality: ***blue*** *represents the best quality water and red – most contaminated water. Rasters represent the type of permeability.*

Hydrogeochemical mapping in Slovakia

The first important stage of the regional hydrogeochemical research was the edition of Maps showing groundwater chemistry at 1 : 200 000 scale (1971–1979). These maps were constructed by the employees of the Geologický ústav Dionýza Štúra (GÚDŠ) as part of a national edition of double-sheet Basic hydrogeological map of ČSSR at 1 : 200 000 scale.

These maps (Fig. 1) illustrate regional chemical types, mineralization classes and genetic types of groundwaters of the first aquifer. Points were used to mark occurrences of mineral and thermal waters as well as waters of anomalous chemistry (e.g. mine waters; tectonic dispersal of deep waters in the first aquifer). Symbols indicate the components significant in terms of water management and hygiene (Fe, Mn, aggr. CO_2, toxic metals) including secondary groundwater contaminations (nitrates, sulphates, chlorides). Vertical columns show chemistry changes in groundwater intersected by drilling.

Since the 1980s, the hydrogeochemical investigations in Slovakia were either incorporated into hydrogeologic, or into environmental-geochemical research and as a result, maps of selected regions at scale 1 : 50 000 were constructed. Previously, chemical compositions of groundwater was shown on the map basically as a combination of main typomorphic ions, degree of total mineralization, and type of rock environment in which the groundwater circulated (Fig. 2).

Because the basic project is now more environmentally oriented (Research into geologic factors of the environment of Slovak Republic, Vrana 1991), the recent concept of hydrogeochemical maps (Rapant – Bodiš 1994) stresses visualization of environmental characteristics of water, origin and degree of natural water contamination, but mainly qualitative properties of ground and surface water in relation to valid norms for potable water (STN 75 7111) and surface water (STN 75 221) (Fig. 3). Geochemical mapping of Slovakia's groundwaters was one of the most important tasks incorporated in the Geochemical Atlas Project in 1991 - 1995. This kind of regional geochemical mapping employs extremely complicated methods. A fundamental problem is the selection of parts of the hydrosphere to be sampled so that representative and interpretable results can be obtained. The objective of the first aquifer sampling (springs, wells, drillholes) was to illustrate in the hydrogeochemical maps the regional distribution of elements, components and parameters that are most important in Slovakia in terms of environment and water-management. Through consultation with specialists, the objects of sampling were selected so as to fit Slovakia's hydrogeologic conditions. The mapping also incorporated another essential geochemical requirement - sampling density to ensure acceptable reliability of resulting maps. Although, the average projected and actual sampling density is 1 sample per 3 km^2, it may vary by area in response to hydrogeologic structure and complexity of geologic-tectonic and hydrogeologic conditions. Consequently, the results of the groundwater geochemical mapping can be used for interpretation of both the whole Slovak territory, and separate hydrogeologic units whose databases are sufficiently representative as to the quality and quantity of data.

The graphic and interpretative part illustrates groundwater chemistry (Fig. 4,5) of the first aquifer in the Slovak territory at the time of sampling (1991-1994). However, the results of the regional hydrogeochemical mapping are valid more generally as they respect basic hydrogeologic variability of the Slovak territory and assess the role of primary and secondary factors in the formation of groundwater chemistry at a regional scale. Be acquired hydrogeochemical data (16, 359 groundwater samples) will be used at both national and regional scales

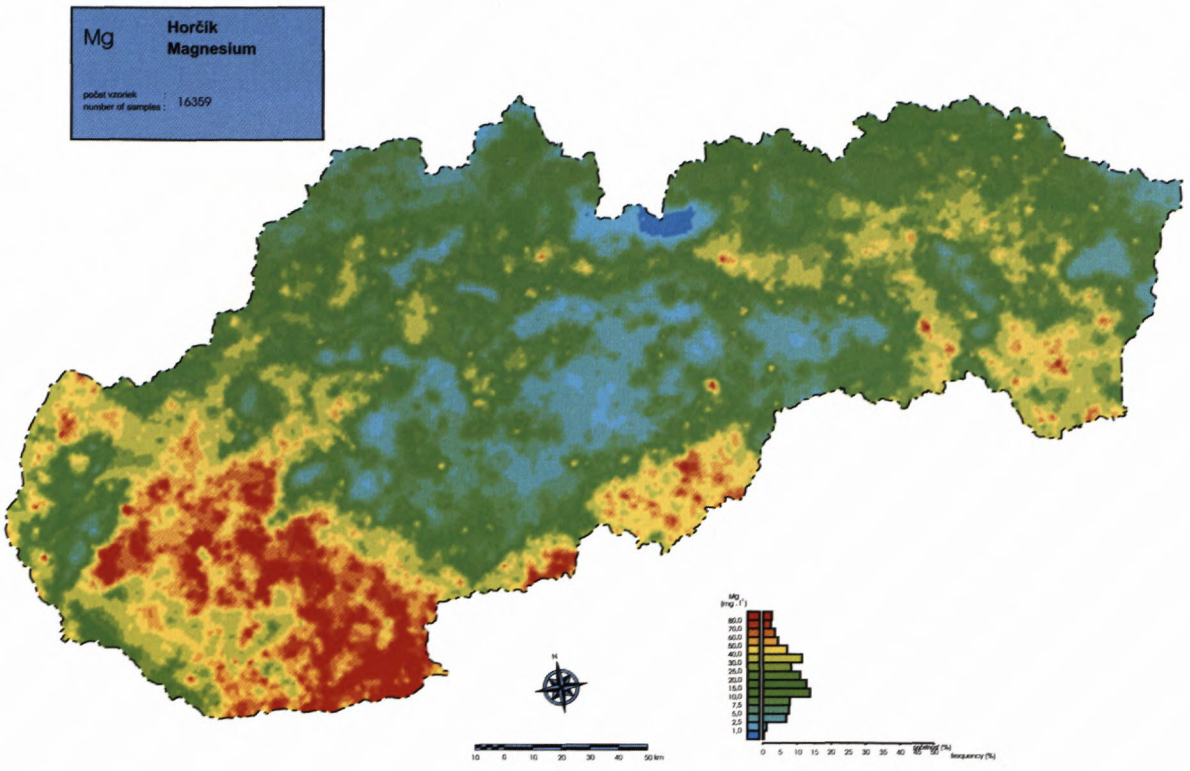

Fig. 4 Geochemical atlas of Slovak republic (1 : 1 000 000) distribution of calcium.

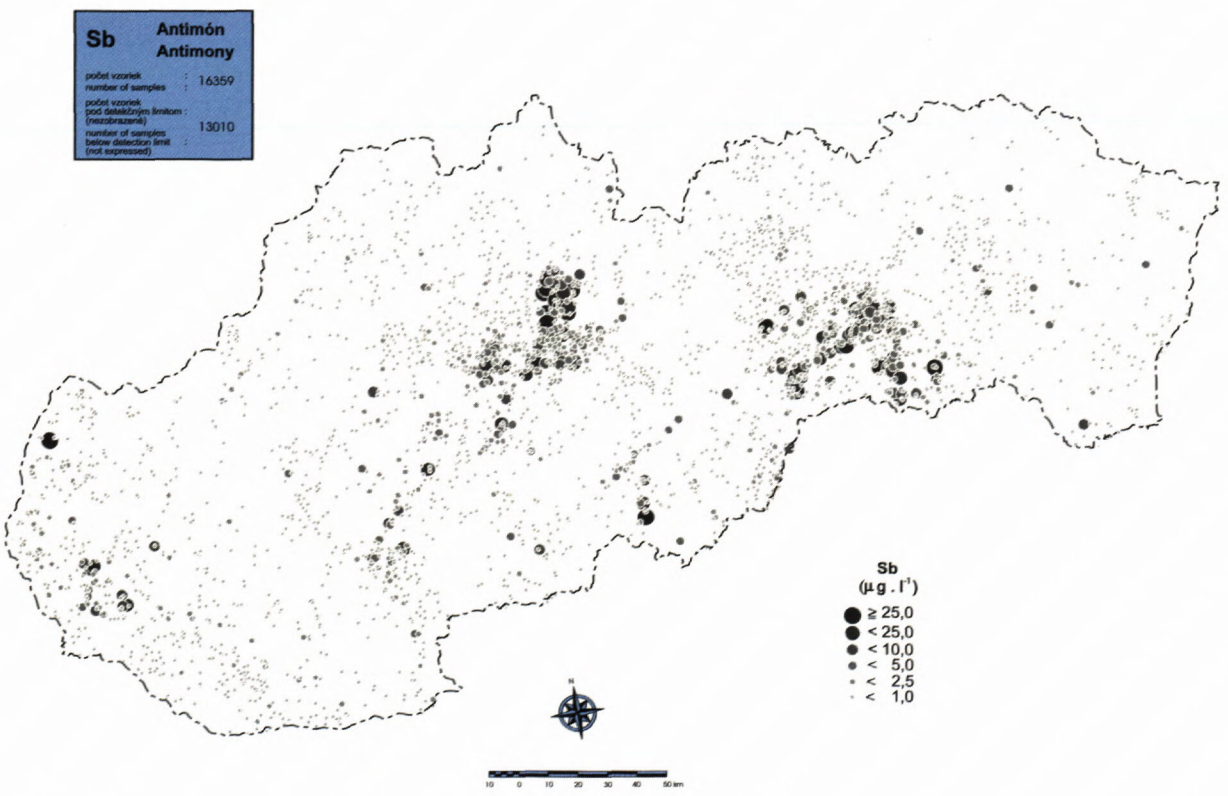

Fig. 5 Geochemical atlas of Slovak republic (1 : 1 000 000) distribution of antimony.

to compare the groundwater quality changes several years ahead. Based on an all-Slovakia project of groundwater-quality monitoring carried out by the Slovak Institute of Hydrometeorology in Bratislava in 1982, the results of regional geochemical mapping should become an important part of information on Slovakia's groundwater quality.

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