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The landscape and geochemical system of the Stolowe Mountains

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Abstract

Studies utilising landscape and geochemical research methods can be extremely useful in this respect. The prevailing area of the Stolowe Mountains National Park is a part of the Central Sudety mountains, built of sandstones and Cretaceous marl. The degradation of the forest and accelerated mineralisation level of the forest litter may result in a strong pollution of the area, among others concerning contamination of groundwater and surface waters with heavy metals. The region of the Stolowe Mountains is also the area of alimentation for water used in the nearby spas.

Key words: Stolowe Mountains, geochemical system, natural environment

Both the rational utilisation and the effective protection of the natural assets of any given place on the Earth should take into account its unique character determined by its location, structure and processes illustrating its functioning. Studies utilising landscape and geochemical research methods can be extremely useful in this respect. These are mainly methods aimed to investigate processes related to chemical elements building up the individual landscape components and transported between them in migration streams. The streams bind varying landscape units into one coherent whole, and their composition and intensity usually determines the migratory structure of landscape. In forest landscapes of temperate climate zones, the atmospheric and hydrological migrations streams, in addition to the biological stream, are regarded as crucial. Therefore, in the study of the Stolowe Mountains National Park (Park Narodowy Gór Stołowych – PNGS), an area representing a unique spatial system, the collected material illustrates – among other things – the characteristics of the atmospheric stream at the "input" (the chemistry of precipitation – snow water in this case) and the hydrological stream at the "output" of the system (water chemistry). The field and in-house research was conducted in the years 1995–1999 and was connected with the Protection Plan for the PNGS. It was summarised in the publication "*Góry Stołowe*" ["The Stolowe Mountains"], edited by Marek Zgorzelski, the general coordinator of the Plan.

The prevailing area of the Stolowe Mountains National Park is a part of the Central Sudety mountains, built of sandstones and Cretaceous marl. Its characteristic feature is the occurrence of two lithological and morphological levels. The upper level, occurring at an altitude of 820 to 900 metres above sea level, with the mountain massifs of Szczeliniec Wielki, Błędne Skały [The Errant Rocks] and Narożnik [The

Cornerstone], is formed by a bloc of joint sandstones, belonging to quartzites. These weathering-resistant rocks are mainly built of quartz; feldspar accounts for 0.7–3 per cent, and mica – for merely 0.7 per cent (Jerzykiewicz 1968). The mineralogical paucity of this type of quartz is evidenced by their chemical content: SiO_2 accounts for 98% of the rock mass, Al_2Os – for 0.52%, Fe_2O_3 – for 0.46%, CaO – for 0.31% and MgO – for 0.08% (Kozłowski 1986). The rock-mantle of joint sandstones, representing the parent sediments of podzolic soils, dominant in the area, show very low sorption capacity, owing to the granulometric composition of loose sand. They contain 85–90% grains with a diameter of 1.0–0.1 mm, 7–15% grains with a diameter of 0.1–0.02 mm, and 2–4% grains with a diameter smaller than 0.02% (Kabała et al. 2002). The "plate" of joint sandstones has up to 30 metres in thickness and is broken up, by a network of fissures and cracks, into a number of structural blocks of varying sizes, with characteristic weathering forms, such as the rock "towns" and mazes of Szczeliniec and Błędne Skały, island mountains in the area of Pasterka and other (Pulinowa 1989). The lower structural level, occurring at an altitude of 750–800 metres a.s.l., is made up of Middle Turonian marl, also referred to as mudstones. The rocks here are composed of quartz (approximately 26.5% of content), plagioclase (3.4%), muscovite (2.7%) and cryptocrystalic binding material (approximately 68%). They also contain varying quantities of calcium carbonate (20–50%). The rock-mantle of Turonian margle are deeply delimed (100–150 cm), their granular content is characteristic for medium and heavy clay, sometimes of loam or silt. They are hardly permeable, and their cubic density varies between 1.80 and 2.15 g/cm^3. Clay minerals from the verniculite, hydrobiotite and kaolinite groups prevail (Chodak 2002). The area's surface, covered with the mudstone rock-mantle, is occupied by brown leached soils and brown acid soils, frequently gley, and depository-gley. The mountain ridges in the Stolowe Mountains receive on average 850 mm of annual precipitation, while their rain-shadow, south-eastern and eastern fringes – approximately 720 mm. The influx of air loaded with substances emitted by the huge industrial and power centres in Germany and Czechia (40% and 30%, respectively) prevails in the area. Precipitation in the area of the PNGS is characterised by an acid reaction and contains 25–27 mg/l of main ions. A particularly high acidification level was shown in the samples of snow water (average pH – 3.9), collected in the winter of 1997. The snow water also contained large quantities of organic coal (ca 3mg/l), building up – among others – particles of soot and dust; hence their oxidisability was 8–10 mg O_2/l. In addition, precipitation provides huge contents of trace elements (Tab. 1). Their concentration series is the following: Zn>Cu>Ni>Pb>Cd. These elements, in the conditions of a proper development of plant cover, are to a considerable extent retained in the growing mass of organic substance. In the case of the PNGS, their biogenic accumulation occurs in spruce tree communities. Here, significant quantities of chemical elements, including heavy metals, are accumulated at the level of forest litter (Tab. 1). In this material, the concentration series is as follows: Pb>Zn>Cu>Ni>Cd. Also, an extremely high concentration of lead is visible in peatbog deposits of the region. In the case of forest degradation (dying of needles, soil overdrying, etc.), when the supply of plant fall and utilisation of the products of its decomposition is disturbed, huge quantities of chemical elements accumulated in the forest litter are released. They enter the hydrological

circulation and, with the lack of sufficient geochemical barriers, they are discharged to the ground and surface water originating in this region. In the conditions of the PNGS, the ecosystems that are most threatened with degradation are those occupying the upper, sandstone hypsometric level, while the role of the barrier is played predominantly by surfaces built from marl (mudstones). The sandstone hypsometric level manifest the features of autonomous eluvial landscape (Perelman 1971). Here, within a well oxygenated weathering and soil zone, a strongly acid reaction prevails. Chemical elements supplied in the atmospheric migration stream and released in the process of forest litter decomposition are partly retained in the live organic mass, and partly discharged in the hydrological migration stream to other landscape units. Channels for the conduction of water solutions mainly include tectonic cracks in the sandstone rock bloc, while colloidal solutions, predominantly composed of organic and mineral combinations, are the prevailing form of migration. The "output" for the stream of solutions from the sandstone level includes outflows and seepage of water at its base, at the border with the lower level, built up of marl. This level plays the role of the geochemical barrier for the area, characterised by a high sorption capacity. Within the area, a weak acid and neutral reaction prevails, which is conducive to the deposition of many chemical elements in the form of hydroxides. The content of calcium in the water oscillates at a level of 35–50 mg/l, accompanied by little organic substance. The spring water from this part of the mountains is used for municipal and industrial purposes, and "on average" contains the following quantities of elements (mg/dm^3): Zn – 0.125; Pb – 0.0126; Ni – 0.019; Cu – 0.011 (Mroczkowska 1995). These concentration values are much lower than those observed in precipitation water, The degradation of the forest and accelerated mineralisation level of the forest litter may result in a strong pollution of the area, among others concerning contamination of groundwater and surface waters with heavy metals. The region of the Stolowe Mountains is also the area of alimentation for water used in the nearby spas. Increased content of e.g. 3,4-benzopyrene in the water in Długopol Zdrój, Polanica Zdrój and Duszniki Zdrój (Ciężkowski 1985) points to an urgent need to monitor all the components of the natural environment in the region.

Tab. 1 Content of selected chemical elements in precipitation and forest litter of the Stolowe Mountains National Park

Type of material	Zn	Cu	Pb	Ni	Cd
Precipitation water					
mg/l	102.0	5.6	2.6	4.1	0.7
mg/m^2/year	86,700.0	4,760.0	2,210.0	3,485.0	595.0
Forest litter					
Olf level:					
mg/kg	56.0	31.0	99.0	12.0	1.8
mg/m^2	1,008.0	558.0	1,782.0	216.0	32.4
Oh level:					
mg/kg	22.0	26.0	126.0	7.0	1.6
mg/m^2	968.0	1,144.0	5,544.0	308.0	70.4

(The *Olf level* on an area of 1 sqm weighs approximately 18 kg, while the *Oh level* – 44 kg)

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