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GEOCHEMICAL LANDSCAPES OF THE MIDDLE MAZOVIA (ENVIRONS OF WARSAW)

A rational management of natural environment resources requires an investigation of chemical features of the elementary landscape units (geocomplexes) which make up this environment. Of essential help in this respect are methods of geochemical-landscape research. They serve to define conditions of migration and accumulation of natural and technogenic chemical substances in a physico-geographical landscape and create a basis for modelling precesses that change a state of natural environment.

Situated within a range of influence of the Warsaw agglomeration the fragment of Middle-Mazovian Lowland can be treated as a natural spatial system of casscade construction. Yet during the last Ice Age it was functioning as a consistent system. It was composed of two entry links — the Rawska and Kałuszyńska Uplands and the outlet — Warsaw Basin, filled at that time by varved clays of marginal lake (Fig.1) The one-sided geochemical bond of gravitational nature was maintained in this system by a hydrological migrational stream.

Remodeling of the structural features has taken place at the end of Vistulian icing. Erosion processes removed varved clays and older Pleistocene sediments and created the lowest hypsometrically situated and youngest lanscape unit, that is the Warsaw Basin. The Vistula Valley formed at the same time divided a homogenous system into two parts. A landscape system on the Eastern side of the Vistula practically kept all its structural features. A role of the lowest step of the geochemical-landscape cascade was taken on by "rejuvenated" Eastern side of the Warsaw Valley where the deposed varved clays were replaced by alluvial sands. In the landscape system situated to the west of the Vistula Valley, a role of the lowest step of the cascade has been almost completely taken over by the Błońska Plain. The water migration stream flows in this direction from the South from the Rawska Upland and from the East — from the Warsaw Plain. The main exit (the Bzura River Valley) is located on the Western side of the Błońska Plain.

A change of direction of hydrological stream within the limits of the Błońska Plain from the Northern (the deepest part of the marginal lake was to be found in the place of the present Warsaw Basin) to Western one was a consequence of young-Pleistocene events (Fig.1) At the end of Vistulian icing, a flow of substan-

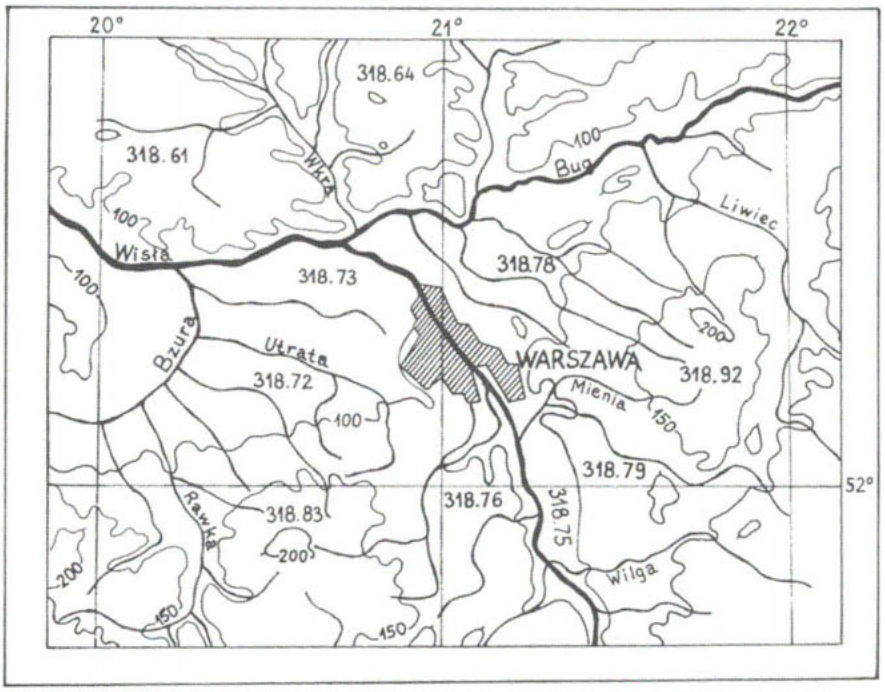

Fig. 1 Physico-geographical regions of Central Mazovia (Kondracki J., 1978): 318.61 – Płońsk Upland; 318.64 – Ciechanów Upland; 318.72 – Błońska Plain; 318.73 – Warsaw Basin; 318.76 – Warsaw Plain; 318.78 – Wołomin Lowland; 318.79 – Garwolin Lowland; 318.83 – Rawska Upland; 318.92 – Kałuszyńska Upland; 318.75 – Middle Vistula Valley.

ces in the hydrological stream practically vanished and transportation of material in the atmospheric migration stream directed to the East came to the fore. The Mazovian Lowland was undergoing aeolic processes. In their primary phase, in the Błońska Plain appeared parallelly set embankments of fine-grain sands (Mizeria 1947). They partitioned meridional fragments of several valleys, at the border of Błońska Plain and Warsaw Hollow they took over a role of surface watershed and in consequence stopped the free flows to the North. In the area previously drained to marginal lake area, appeared numerous geocomplexes devoid of surface runoff playing a role of local geochemical-landscape systems of concentration (Glazovskaya 1986).

In the second, slightly younger phase of this episode, the Błońska Plain and fragments of the Warsaw Plain have been covered by a thin coat of dust deposit. A successive third dune-creative phase caused strong transformations mainly in the area of the Warsaw Basin, Wołomin Plain and on the neighbouring slopes of the Kałuszyn Upland. The big complexes of sandhills appeared there, and their role in the landscape was deined by the morphological-lithological features of bed and surroundings.

Within the area of the central parts of Warsaw Basin, dunes gave rise to eluvial landscape units of acid, oxidizing regime of weathering processes, and the depressions dividing them to acid, gleyic superaquatic landscapes (Fig. 2). A transportation of mineral substances is stimulated here chiefly by the atmospheric migrational stream. Its load of mineral components amounts to around 0.03 g/dm^3. In the situations where dunes appeared on the slopes performing a role of transit landscapes, a hampering of gravitational flow of substances in the aquatic ground-and-soil solutions could be seen. In front of a dune-barier the new landscapes emerged of gleyic (anaerobic) character of enviroment hipergenesis. Before the front of such a physical barrier, in effect of disturbance of balance of flowing solutions, quite often a supersaturation by calcium carbonate from depths series of bed deposits occurred, and sometimes a precipitation of strata of meadow chalk took place. On the external side of such a geocomplex of the calcite class of migration (Perelman 1975, Fortescue 1980), certainly in the warmer Holocene periods, from the arriving solutions started to be released i.a. iron and manganese hydrates which formed concretions and limonite blocks. Enforced by the presence of dunes, barriers serve in the physico-geographical landscape of Mazovia as the essential filters on the road of migration of water solutions. An additional natural shield of the hinterland of dunes are collections of meadow vegetation. To open a free flow by means of digging through a dune means a complete destruction of such a natural system of protection.

The dunes do not constitute a mechanical barrier in the situations where they filled up a fragment of a dry valley or were deposited in the lower part of a slope built from well permeable compositions. Solutions that infiltrate into their base are acquiring reduction qualities and are enriched i.a. with active forms of iron manganese and other elements. Entering an aeration zone in the hinterland of dunes, these elements as a result of oxidation are released from solutions and, as hydroxides, cement depth series of the surrounding sediment. These zones are called the oxidizing geochemical barriers (Perelman 1975). When there is no significant contrast in the oxygen regime of waters reaching a hinterland of dunes, no barier effect appears. Substances occurring in the water stream penetrate as a whole on a far-away distance, and can be caught in the process by a biotic component of landscape and also in an intake of a drinking water.

In many spots of an Eastern part of the Middle-Mazovian Lowland, dunes were not found within a range of a transit stream of water migration. Their appearance caused crossover of a surface from transit to autonomous position and formation of a composition of eluvial and superaquatic, land-scape-geochemical units. Within the limits of a lower part of the Kałuszyńska Upland slope and on the Wołomin and Garwolin Plains, the lowering of the level of underground water is levelled out being 1-2‰ (Kolago, Ciechanowska 1986). Under these circumstances, both Plains play a function of transit surfaces. Water solutions here have inert and weak acid reaction and mineralization 0.3–06.g · dm^3.

Removal of the substances migrating in the hydrological stream, from a transit link of the Middle-Mazovian Lowland to the East of the Vistula, takes place

by two roads. One exit are the trans-aquatic landscapes of the river valleys, and the other — underground runoff towards the Warsaw Hollow and the Vistula valley. In locations morphologically privileged (for example, erosion edge of the Vistula valley), the surface flows of water solutions disappear; they are transformed into the ground ones which leads to the formation of hidden geochemical barriers that keep only a part of transported substances. Below the erosion edge, the main mass of dissolved elements is transported at much greater depths, within the area of Young-Pleistocene terraces occupied by autonomous and strongly oxygenated and acidified eluvial landscapes. These elements remain inaccessible to the biotic landscape components, but before feeding the Vistula waters they can still be caught in communal and industrial intakes of water.

On the Western side of the Vistula Valley, on the Rawska Upland, the hydrological circulation is joined by mineral components supplied by an atmospheric current, and those freed in the process of weathering of grounds which are peculiar to the phase of mobilization of substances. The intensive washing-out of active components is favoured by a rinsing water regime and high oxygenation of the aired zone. Of considerable significance is also the fact that the Upland's landscapes long before entering into a Holocenese cycle of development were subjected to the hydrological regimes of interglacial and periglacial. Hence the actual domination here of acid environments of chemical reactions with participation of water solutions of low mineralization (Wicik 1972).

Within the area of the Northern slopes of the Rawska Upland, hydraulic descent of the water migration stream is about 5‰. This surface of quite homogeneous morphological features is covered mostly by non-carbonate sands and eluvias of glacial compositions. They are sediments of good permeability and showing little sorption capacity. The environment of chemical reactions of hypergenesis zone is mostly acid and shows high oxygenation capacity, and a load of mineral substance carried in the hydrological migration stream is not large. Contents of iones Ca^{2+} in shallow ground waters amount to about 40mg · dm^3, and iones Mg^{2+} — 4-7 mg · dm^3. The cases of waters that are practically devoid of magnesium are also numerous. Among dominating transit landscapes, mainly in the lower parts of the slope, a considerable participation of superaquastic geocomplexes persists.

At the foot of the Upland's slope, in the zone of its contact with the Błońska Plain, a decrease of the level of ground waters diminishes to 1-1.2‰. Such a rapid change of thermodynamic parameters of the water migration stream (i.a. fall of velocity of flow and concentration of gas components contained in it) results in precipitation from solutions of large amount of mainly $CaCO_3$. Hence strongly carbonate soils and deposits of meadow lime generally met here. This border zone shows all features of geochemical barrier where — like on a natural, many-kilometers long filter — chemical elements are concentrated which are made active in oxygenated weak-acid and acid environments of hypergenesis. On the southern side of the barrier there is an abundant collection of iron compounds (for example, limonite blocks weighing a dozen or so kilograms) which two

thousand years ago were a raw material for the needs of ancient metallurgy of Mazovia (Wicik, Woyda 1986).

The Błońska Plain lays a role of a landscape link taking over water coming from the South, from the Rawska Upland and its slope. Small falls of a ground water level (0.2 - 0.4‰) and lithological and morphological features bring about the landscapes of Upland having mostly super-aquatic geocomplexes properties. Shallow ground waters contain about 60 mg $Mg^{2+} \cdot dm^3$, over 200 mg $Ca^{2+} \cdot dm^3$, and also up to about 300 mg $SO_4^{2} \cdot dm^3$. Gleyic landscapes are prevalent, often with strongly reducing properties (presence of H_2S). In the hypsometrically lowest spots weak-alcaline conditions of chemical reactions persist. Property of this kind of hypergenesis environment favours accumulation (stabilization as sulfides and carbonates) i.a. of lead, barium, strontium, cadmium and other chemical elements. Penetration of dissolved mineral substances in the hydrological stream from the Błońska Plain to the Warsaw Basin is effected mainly in those places where erosion edge incised fragments of valleys or deeper water-bearing levels (Wicik 1987).

Against such a landscape-geochemical background lays an anthropogenic migrational current emited by Warsaw City, which is an industrial centre. Physico-geographical landscapes remaining within its range play a role of receptors. The capital agglomeration which occupies the northern segment of the Warsaw Plain enriches i.a. contents of atmospheric migrational current by around 200 thousand tons of dust and gases annually (*Statistical Yearbook* 1988).

For around 160 days every year, direction of atmospheric curent loaded with a daily portion of 550 tons of dust and gases is opposed to the direction of gravitational flow of matter in hydrological stream. A part of this load is transferred outside the borders of landscape system of the Middle-Mazovian Lowland. Part of it, however, falls out of atmosphere even before the watershed portions of Uplands, where, to various degrees defined by physical and chemical features of the base, it joins the water migration stream and returns to accumulative links of the composition. Natural predisposition of the Warsaw Basin occupied by the Kampinos National Park causes that as much as 54,000 tons of dust and gases annually are sent from the Warsaw centre in its direction by way of atmosphere (27,000 tons is transferred by winds blowing in this direction, and the same quantity flows down with gravitational movement of masses of air during silence periods). Water migration stream is loaded with mineral fertilizers components, including fluorine, cadmium and strontium (Kabata-Pendias, Pendias 1984). Structure of the landscape-geochemical system on the western side of the Vistula river permits the building of the artificial fields of the given spatial units, as well as catching and possible re-use of substances contained in the hydrological migrational stream.

REFERENCES

Fortescue J.A., 1980, *Environmental Geochemistry a holistic approach*, Springer-Verlag, New York-Heidelberg-Berlin.

Głazowska M.A. 1988, *Geiohimiya prirodnyh i tiehnogiennyh landsaftov SSSR*, Moskva, Wyssaya Szkoła.

Kabata-Pendias A., Pendias H., 1984, *Trace elements in soils and plants*, CRC Press Inc. Boca Raton, Florida

Kolaga G., Ciechanowska E., 1985, *Mapa Hydrologiczna Polski*, (Hydrological Map of Poland), Geological Editors, Warszawa.

Kondracki J., 1978, *Geografia fizyczna Polski*(Physical Geography of Poland), PWN, Warszawa.

Mizeraia W., 1947, "Z geologii okolic Żyrardowa i Błonia" (On geology of Żyrardów and Błonie environs), *Bul. P.I.G.* Geological Editors Warsaw

Perelman A.I., 1975, *Gieochimija landszafta*, Moskva, Wyssaya Szkoła

Rocznik Statystyczny Województwa Stołecznego Warszawskiego (Statistical Yearbook of the Warsaw Capital Voivodship), 1988, Main Statistical Office, Warszawa.

Wicik B., 1972, Pasowość zjawisk hipergenicznych na obszarze Wysoczyzny Rawskiej i Równiny Błońskiej (Belt-way of hipergenic phenomena i the area of the Rawska Highland and Błonie Plain)

Prace i Studia Institute of Geography, University of Warsaw, Warszawa.

Wicik B., Woyda S., 1986, Localisation de l'encienne siderurgie et paysages geochimiques en Masowie, *Miscellanea Geographica*, Warsaw University.

Wicik B., 1987, Natural environment and types of geochemical landscapes on the Northern fringe of the Warsaw Lowland., *Polish Ecological Studies*, 13, 3/4, Warszawa.

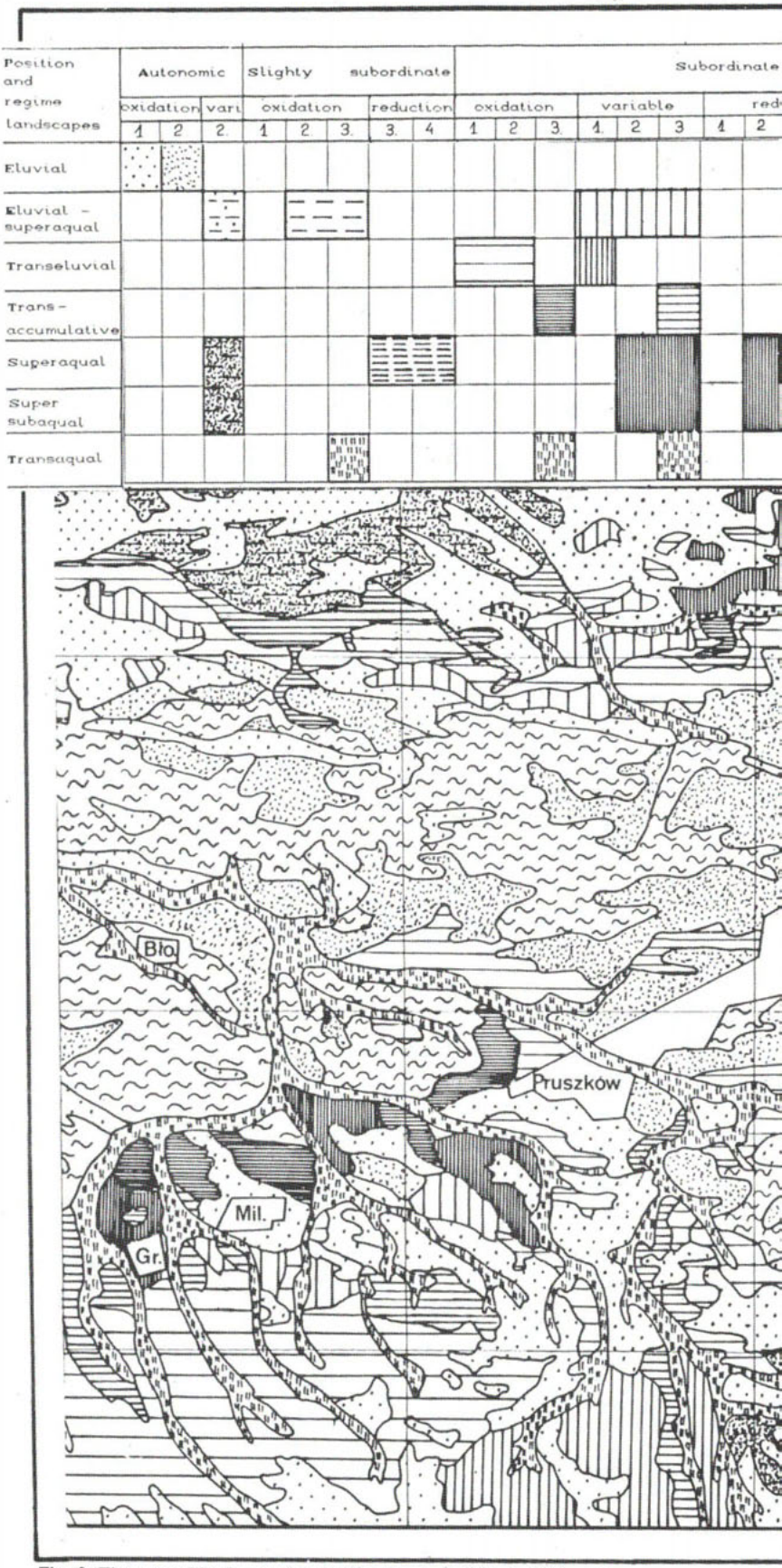

Fig. 2. The map of basic geochemical landscapes of Central Mazovia


0 2.5 5 7.5km
reduction
reduction
3 4 1 3 4
1. Acid
2. Slighty acid
3. Neutral
4. Slighty alcaline
Huta „W-wa"
Ec „Żerań"
Ec „Kawęczyn"
Ziel.
WARSZAWA
Ec „Wola"
Ec „Siekierki"
Ra
Jez.
Piaseczno
Konstancin
Zalesie