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SOME SOIL-GEOGRAPHICAL DIFFERENCES BETWEEN THE DANUBIAN AND THE EAST SLOVAKIAN LOWLANDS

In the present study we show, in a very concise way, the chief soil-gegraphical differences between the Danubian and the East Slovakian Lowlands. We note especially the unlikeness in the extension of automorphic soil types and we explain them by climatic influence.

I. CONCISE SKETCH OF THE CHIEF SOIL-GEOGRAPHICAL DIFFERENCES IN THE LOWLANDS OF SLOVAKIA

1. *The Danubian Lowland*

Most of it is occupied by plains (alluvial valleys) and loess hillocks. On the plains there are mostly developed associations of hydromorphic soils in which the individual types extend chiefly according to geomorphological-hydrological conditions (5, 7, 21, 22). Beside the prevailing meadow soils there are developed mostly chernozemic soils and alluvial ones, all mostly carbonaceous. The loess hillocks have automorphic soil types which are arranged according to a lowland bioclimatic vertical zonality (12). From the south, in the direction of the mountains, the following soils alternate in the hillocks:[1] myceloid carbonaceous chernozems, leached chernozems, degraded chernozems, typical burozems, illimerized soils (typical), illimerized pseudogley soils, in places pseudogley soils.

Further it is necessary to point out the following facts. In the Danubian Lowland the northern boundary of the chernozems is only at a distance of 8—14 km. from the foot of the mountains, in places somewhat more, or less. The northern boundary of the burozems very often, reaches up to the foot of the mountains. This may be seen for instance with the Little Carpathians, especially in the northern part. Similarly, the burozems reach up to the southern and south-eastern foot of the Považský Inovec and, in broad circles, up to the Štiavnické pohorie (chain). Meanwhile the breadth of the belt of burozems varies from 8—14 km.

Oftener, however, between the burozems and the foot of the mountains there is a belt of illimerized soils, varying in breadth from 2 to 4 km. This belt is broader only between the Považský Inovec and the Strážovská hornatina (hillocks) (8—12 km). The southern boundary of illimerized soils in the Danubian Lowland is therefore roughly only 2—3 km. distant from the foot of the mountains.

To complete the picture of western Slovakia let us consider the Slovakian part of the

[1] The classification and nomenclature are according to Němeček 1962, 1963 and Šály 1962.

Low Moravian Dale. Near Skalica, the chernozems locally reach up to the western end of the White Carpathians and in places there are myceloid carbonaceous chernozems. More towards the south, between the chernozems and the foot of the White Carpathians, there is a wedge of burozems which, south of Senica, extends to a breadth of about 20 km. (measured from west to east). The illimerized soils do not form here either a continuous belt. It is only 2—3 km. broad.

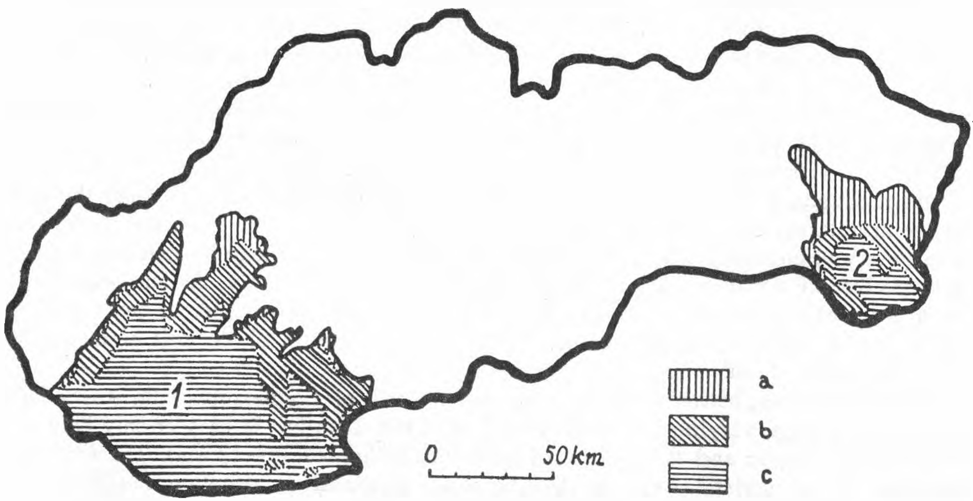
2. *The East Slovakian Lowland*

The neogenic hillocks are here developed on a much smaller area than in the Danubian Lowland. There is also little loess here. Much more important are the territories with alluvial river valleys, which has for consequence that the hydromorphic soils, mostly of the alluvial type, take up much of the area of the Lowland, so that the boundary between the automorphic soil types may be in some places reconstructed only on the basis of their island-like occurrence.

The belt of illimerized soils is here continuous and extends over a considerable breadth. East of Milič and of the southern part of the Prešov Mountains it encroaches on the lowland only 4—6 km. and borders upon about a 6 km. wide strip of illimerized burozems, but to the south of the Ondava Highland and of the Vihorlat the illimerized soils encroach on the lowland up to 20 km., and in places even more. They border upon a relatively broad strip of illimerized burozems. Still further south there are degraded chernozems.

For completion we must say that already in the Bodva district of the Košice Basin — south of the Spiš Ore Mountains — there lies a strip of illimerized soils, 8—9 km. wide.

These data concerning the soil conditions in the Danubian and East Slovakian Lowlands are illustrated on the map No. 1, where the individual bioclimatic belts are delimited



Map 1. Bioclimatic belts of the chief automorphic soil types in the Danubian and East Slovakian Lowlands. 1. Danubian Lawland. 2. East Slovakian Lowland. a, b, c — bioclimatic belts of soil types, ... — boundary between the bioclimatic belts, a — belt of illimerized soils, b — belt of burozems, c — belt of chernozems.

on the basis of the extension of automorphic soils. For a better survey all the hydromorphic soils and those on the extreme substrates (sands, marls and others) are left out.

3. *Fundamental differences in the extension of automorphic soils between the Danubian and the East Slovakian Lowlands*

Concisely they may be summarized as follows:

a) The illimerized soils in the Danubian Lowland as well as in the Slovak section of the Lower Moravian Dale are developed in disconnected and relatively narrow strips of 2—4 km broad. In the East Slovakian Lowland they form a continuous belt, the southern boundary of which is 20 km or more from the mountains. The illimerized soils of the Danubian Lowland have a profile index (index of textural differentiation) ca. 3. In the East Slovakian Lowland the values of the index vary from 3—4. Illimerized pseudogley soils to pseudogley soils are much spread.

b) Burozems in the Danubian Lowland and in the Low Moravian Dale are developed in wide strips (8—14 km.) and mostly in the form of the sub-type of a (typical) burozem, but the illimerized burozem is less developed. The former — at the boundary with chernozems — have a profile index of 1.4—1.6, the latter — at the boundary with illimerized soils — 2.0—2.3 (2). In the East Slovakian Lowland the burozems are developed chiefly in the form of illimerized burozems.

c) Chernozems in the Danubian Lowland and in the Slovak section of the Low Moravian Dale are represented by sub-types of chernozems: myceloid carbonaceous, leached and degraded, while their boundary with the burozem is relatively near the mountains — only 8—14 km. Near Skalica the myceloid carbonaceous chernozems extend even up to the foot of the White Carpathians. In the East Slovakian Lowland there is a strong prevalence of degraded chernozems. Leached chernozems were found there only locally, and carbonaceous chernozems have not been found at all.

According to one of us (Bedrna) even the manner of degradation of chernozems in both territories is different. While in the Danubian Lowland there arise degraded chernozems after the leaching of carbonates chiefly by intra-soil weathering (see Hraško 6), in the East Slovakian Lowland this type is being formed with the strong participation of the process of illimerization.

The differences in the spatial extension of the soils between both the Lowlands stand out expressively especially when we realize that at a distance such as the one from the southern boundary of the illimerized soils in the East Slovakian Lowland up to the foot of the mountains, in the Danubian Lowland there alternate all the soils from the pseudogley up to the myceloid carbonaceaus chernozems.

II. CLIMATIC DIFFERENCES AS THE CHIEF CAUSE OF THE SOIL-GEOGRAPHICAL DIFFERENCES BETWEEN THE DANUBIAN AND THE EAST SLOVAKIAN LOWLANDS

1. *The origin of burozems and its significance*

To understand the kernel of this section it is necessary to deal first with the question of the origin of burozems. Our further considerations start from the principle that the main portion of the burozems has been formed from the chernozem soils. In our literature this subject has been dealt with for instance by Pelíšek (1957). Among the brown forest soils he has the group of chocolate-brown forest soils which occur in two belts: in the lowlands with altitudes of 200—400 m. and in mountain regions of 500—800 m. The chocolate-brown mountain soils are primary soils, while the chocolate-brown soils in the lowlands and on the hillocks are mostly secondary types, arisen through the degrading process of chernozem soils on the loess. (Pelíšek's chocolate brown lowland soils are the burozems of today -see also Němeček 1963 and Šály 1962). In the year 1957 Šály also wrote that "the carbonaceous burozems" which are found in our country, chiefly on the loess, have arisen mostly through the degradation of chernozems (19). The same author in the year 1962 (20) quotes from the resolution of the International Conference of Soil Science (1959) where it was spoken of the necessity of dividing off the burozems of the lowland regions of Czechoslovakia bordering upon the former forest-steppes developed on the loess and similar substrates, with a deeper humous horizon and a distinct illuvial horizon on the level of an independent type, analogic to the grey forest soils. Further Šály writes: "With regard to the bioclimatic conditions and to their development during the Holocene, it may be assumed that these soils are secondary — they have arisen through the degradation of the chernozems." We agree with the above-mentioned views on the origin of the burozem and our further considerations are based on them. We want, however, to point out that a part of the soils which, at present, are grouped in the type of burozem and which is chiefly represented in the form of a sub-type of illimerized burozem, could have arisen through the cultivation of illimerized soils on a weaker degree of illimerization (sol brun lessivé — brauner Lessivé. Compare Němeček 1963). Or it may be assumed that some burozems could have arisen from the former dark-grey forest soils of the former forest steppes (the equivalent of the Russian dark-grey forest soils). Hence not all the soils which we today group with the type of burozems were originally chernozems.

Starting from the principle that most of the burozems arose by transformation of the chernozem soils, we can say that the northern boundary of the extension of burozems in the territories considered, marks the northern boundary of the steppes, or of the forest-steppes in the warmest and the driest period of the Holocene. When, however, we realize that a part of the burozems was originally an illimerized soil, the boundary of the burozems today, as regards the illimerized soils, will not be completely in agreement with the boundary of the former chernozems, i. e. the boundary of the former steppes or of the forest-steppes in the period of their greatest extension, but it will be somewhat shifted towards the mountains. This shifting, however, is not so great that it need be taken into account in the observation of the climatic conditions on the boundary between the illimerized soils and the burozems.

2. *The chief climatic differences between the Danubian and the East Slovakian Lowlands and their significance for the soil-geographical conditions*

Since the present boundary between the burozem and the illimerized soil is roughly conditioned by the former boundary between the steppes, or the forest-steppe and the forest, then the boundary between these two soil types is of a climatic — vegetational character, in other words, there is question here of a bioclimatic boundary. For this reason its expressively different distance from the foot of the mountains in the Danubian and the East Slovakian Lowlands may be cleared up by climatic differences.[2]

[2] For instance the present boundary between the chernozem and the burozem is, in fact, created by man and its course could not be well explained only by climatic influence.

From the soil-geographical differences between the lowlands considered, it follows that the Danubian Lowland had much better conditions for the development of steppes, or forest-steppes, than the East Slovakian Lowland. The latter had again much more favourable conditions for the development of forest associations which here extended from the foot of the mountains more than 20 km. to the south, although the altitude of the lowland is much lower than the altitude of the hillocks of the Danubian Lowland. At first sight this looks like a paradox when we assert that the East Slovakian Lowland which has convincingly a more continental climate, had worse climatic conditions for the development of steppes than the Danubian Lowland lying more to the west, and having a more moderate continental climate. At the present time not a single of our lowlands has a steppe climate. It is sufficient, however, to analyse consisely their present climatic conditions and it will become clear that these are, in the Danubian Lowland, even today, nearer the steppe than in the East Slovakian Lowland. There is no reason to assume that in the warmest and the driest periods of the Holocene the climatic differences between the two lowlands were smaller, or that they did not exist at all. Just the opposite, the extension of the soil types reveals us retrospectively that they existed already at that time.

In our further considerations we analyse the climatic differences in detail. With regard to the significance of climate for the extension of the leading soil-forming factor — namely the individual plant associations — in our case up to the range of formations (steppe, or forest-steppe, decidous forest) and thereby also for the spatial extension of certain soil-forming processes, it is important from our point of view, to analyse chiefly the temperatures, the percipitation and especially their yearly course in the belts of burozems of both the lowlands, as also roughly on the boundary between the burozems and illimerized soils and further some basic climatic differences of the lowlands in question with which the studied soil-geographical differences are connected. We give the characteristic of the climate from the period of the formation of the chernozems, i. e. from the warmest and driest period of the Holocene and then from the contemporary period. Only the latter may be given exactly, because the climate of the past may be only indirectly judged.

According to several authors for instance Wundt (24), Firbas (4), Krippel (11), Vitásek (23), Stejskal and Pelíšek (18), Šály (20) and others, there was a warmer and drier climate than today in the Atlantic and in the Sub-Boreal phases. Both were about equally warm, but the Sub-Boreal was drier. Just at that time there was the maximum extension of the steppe or forest-steppes and the formation of the chernozems in both these lowlands. At that period, according to Krippel, there was also probably the largest extension of the oak in our country. The period lasted probably between 5,500—500 years B. C. Chiefly on the basis of the study of fossilized vegetation it is stated that the period was considerably warmer than the present one, and Büdel (3) assumes that the average yearly temperatures were, at that time, compared to those at present by 1—2 °C. higher. According to Wundt there was question of the warm period within the framework of the fluctuation of the climate caused by the shifting of climatic belts, which is in agreement with the change of the position of the perihelion in the various seasons of the year. During the warm climate of the Holocene the perihelion was in the northern hemisphere in summer and in autumn (today it is so in January). The higher yearly temperatures by 2 °C. than are found today in the Danubian and East Slovakian Lowlands, i. e. about 12 °C. and more, has for instance the southern part of Bulgaria, the climate of which cannot be quite compared with the paleoclimate of the territory of our present chernozems and burozems up to the boundary with the illimerized soils, because we lack exact knowledge about the details of the circulation of the atmosphere in the territory at that time.

During the extension of the steppes there must have been a lesser amount of precipitation in the studied territory because, according to the contemporary conditions on the earth, Köppen has found the boundary between the steppe and forest climate in conditions roughly a uniform distribution of precipitation during the year, when $r = 2t+14$ (where r = amount of yearly precipitation in cm., t = the average yearly temperature). Approximately on the boundary of the burozems and illimerized soils, at the meteorological station at Modra, after replacing the values of the climatic elements in the given formula we get $74 = 33.2$, which means that today there is a greater amount of precipitation here with the given temperatures, and that at the period of the formation of the chernozems there must have been here much less, and this by nearly 400 mm. On account of the lack of knowledge of details about the circulation of the atmosphere at that time, we cannot give the correct value of the average summer temperatures for this boundary when we know only the yearly average; we can, however, determine sufficiently correctly the yearly amount of precipitation. If we keep to Büdel and assume that instead of the average yearly temperature at Modra 9.6 °C. it was 11 °C., then the amount of yearly precipitation at that place must have been, according to Köppen's formula about 360 mm. (today 740 mm.). In the East Slovakian Lowland there are no meteorological stations on the boundary between the burozems and the illimerized soils. When, however, we replace in the formula the values substracted from the climatic atlas (1), we get approximately similar results.

From the contemporary climatic conditions of the studied territory we analyse the absolute yearly average values of temperatures and precipitation, their course during the year and we express in numbers Konček's index of moisture, which exresses the humidity condition of the atmosphere according to the course of the temperatures, precipitation and wind activity during the vegetative period. For the plant associations and for the soil-forming processes, temperatures are the most important factor during the vegetative period. We notice that these are approximately the same in the belts of the burozems of both lowlands. In the East Slovakian Lowland the yearly average temperatures are lower and this on account of its greater winter thermal continentality. Hence they are not comparable with the yearly averages of temperatures in the Danubian Lowland or in the Ultramontane Lowland. The yearly amount of precipitation in the East Slovakian Lowland is, on the whole, higher, but in the belts of burozems of both lowlands it is roughly the same and moves approximately between 600 — 650 mm. or up to 700 mm., and at the boundary with the illimerized soils it is a little more than 700 mm., hence in the Danubian Lowland forming a narrow, and in the East Slovakian Lowland a wider belt. Further, the maximum precipitation is, in the whole East Slovakian Lowland, as against the Danubian Lowland shifted on to the summer, as the result of a greater precipitation continentality. While in the Danubian Lowland the maximum precipitation comes in spring, i. e. in May or possibly June, in the East Slovakian Lowland it occurs in June with an increasing amount in July and August. The average total in the vegetative period (April — September) shows remarkable differences between both these Lowlands. In the Danubian Lowland it amounts to 300 mm. in the driest part of it, 300—350 mm. in the largest part of it and only in a small part it is above 350 mm. As against this, nearly the whole East Slovakian Lowland has at this time up to 400 mm. and in the wide belt south of the Vihorlat 400—450 mm. The difference in the precipitation during the vegetative period between the two lowlands is therefore about 50 — 100 mm. Here it must be emphasized that in the framework of the vegetative period, there are considerable differences in the precipitation precisely in the warmest months, when there is the greatest evaporation, and this in June, July, August and September.

These differences in the humidity are well expressed by Konček's index of moisture. In the substantial part of the Danubian Lowland it moves below the value — 20 showing a dry region. In the driest part of the East Slovakian Lowland its value fluctuates within the boundaries — 20 to 0, which shows a moderately dry region. We notice also that the belts of burozems of both Lowlands have also the same value of the index of moisture; they find themselves mostly in the region of moderately dry, with indices within the limits of — 20 to 0. The boundary line between the burozemic soils and the illimerized soils is found approximately at the beginning of the moderately wet region with the values from 0 to 60. This moderately wet belt is, as may be seen from the Atlas of the climate in the Danubian Lowland, strongly narrowed at the foot of the highlands, while in the East Slovakian Lowland it is wide. It coincides with the belts of illimerized soils in both Lowlands and hence for the extension of this soil type, it is the most exact climatic indicator.

The wetter and the cooler climate of the East Slovakian Lowland is shown us even in a clearer light, when we realize that its surface has roughly up to a 100 m. lower altitude than the Danubian Lowland.

III. SUMMARY

At the end of the first part the given soil-geographical differences between the Danubian and the East Slovakian Lowlands are explained by climatic differences which were realized chiefly through the medium of vegetation as the chief soil-forming factor.

At the present time the summer temperatures reach in both lowlands similar values. The East Slovakian Lowland is, however, by an increasing precipitation continentality, which in the vegetative period (April — September), shows itself by the fact that the amount of precipitation is here roughly higher by 50—100 mm. during the same period as in the Danubian Lowland. Meanwhile it is important to note that within the framework of the vegetative period there are considerable differences in the amount of fallen precipitation precisely in the warmest months, when there is the greatest evaporation. The differences in humidity are well brought out also by Konček's index of moisture. These differences are even more conspicouous when we notice that the East Slovakian Lowland has, as against the other, an altitude roughly 100 m. lower. From what has been said, it is evident that in summer the drier Danubian Lowland has for the present climatic conditions nearer the steppe conditions than the East Slovakian in summer, though it has on the whole a more continental climate. Hence we can say that the present extension of soils shows this retrospectively that in the warmest and driest period of the Holocene when there was in both lowlands the maximum extension of steppes, or forest-steppes with the formation of chernozems, the Danubian Lowland had much better conditions for the development of steppe and forest-steppe vegetation than the East Slovakian Lowland. Hence at that time the (oak) forest extended down from the mountains into the Danubian Lowland mostly only roughly 2—4 km. and this not everywhere, while in the East Slovakian Lowland it reached in places more than 20 km. from the foot of the highlands. This is then connected with the fact that in the Danubian Lowland the illimerized soil is found only in narrow belts, while in the East Slovakian region there is a broad belt of this type of soil. For the reasons given, the Danubian Lowland has much more chernozems and this even up to the present in the form of the sub-type of myceloid carbonaceous chernozems which are not found at all in the Slovakian Lowland. Also with the degradation of chernozems there does not occur in the Danubian Lowlands such an expressive process of illimerization as in the East Slovakian Lowland. Finally, in the latter lowland the burozems are found mostly in the form of the sub-type of illimerized burozems.

With a greater amount of precipitation in the East Slovakian Lowland, and this chiefly in the warm half of the year, will probably be connected also the observed higher degree of illimerization and a greater depth of soils than in the Danubian Lowland. The solution of these last questions is, however, strongly complicated chiefly through the influence of the substrate (for instance through the contents of $CaCO_3$ in the basic rock, granulation, etc.) as also with the various ages of the geomorphological-quaternary formations on which the soils have developed.

In our lowlands the generally recognized and valid assumption does not hold that the conditions for a steppe and a chernozemic soil-forming process are more favourable in a gradual direction from west to east with the increase of climatic continentailty, because with roughly equal temperatures in the vegetative period, the East Slovakian Lowland has more precipitation and a greater humidity of air than the Danubian Lowland. The given climatic differences of both our lowlands may be observed also somewhat more to the south in the territory of Hungary (8). The greater amount of precipitation and humidity of the East Slovakian Lowland are the result of the influence of the Carpathian Chain and they have only a regional significance.

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NIEKTORÉ PÔDNOGEOGRAFICKÉ ROZDIELY MEDZI PODUNAJSKOU A VÝCHODOSLOVENSKOU NÍŽINOU

V práci sa analyzovali zákonitosti rozdielneho rozšírenia niektorých automorfných pôd na Podunajskej a Východoslovenskej nížine. Je nápadné, že napriek tomu, že všeobecne pribúda v Eurázii smerom od západu na východ kontinentalita podnebia, a tým aj predpoklad pre pribúdanie stepných podmienok a černozemných pôdotvorných procesov, na spomínaných nížinách Slovenska vidíme skôr opak. Podunajská nížina má totiž široké bioklimatické pásmo černozemí (z nich automorfné na spraši: černozeme mycelárne karbonátové, černozeme vylúhované a černozeme degradované), vzdialené od úpätí pohorí len 8—4 km, od nich smerom k pohoriam sa nachádza bioklimatické pásmo hnedozemí (hnedozem typická, illimerizovaná), siahajúca často až k úpätiam pohorí. Na niektorých miestach pri úpätniciach je vsunuté 2—4 km široké pásmo illimerizovaných pôd (illimerizované pôdy typické, illimerizované pôdy oglejené a ojedinele pseudogleje). Naproti tomu na Východoslovenskej nížine tvoria illimerizované pôdy široké súvislé pásmo, ktorého južná hranica je vzdialená od pohorí 20 km, ba i viac km. Na juh od neho leží pomerne široké pásmo hnedozemí illimerizovaných a ešte južnejšie bioklimatické pásmo černozemí (černozemí degradovaných s ojedinelým výskytom černozemí vylúhovaných).

Za predpokladu, že hlavná časť našich hnedozemí vznikla transformáciou černozemí počas vlhšieho obdobia holocénu, možno sa domnievať, že dnešná hranica medzi hnedozemou a illimerizovanou pôdou je približne totožná s hranicou medzi stepou, resp. lesostepou a lesom najteplejšieho a najsuchšieho obdobia holocénu, keď sa vytvorili naše černozeme. Dôležitým pôdotvorným faktorom tu boli stepné a lesné vegetačné formácie. Klíma kvalitou prvkov a režimom významne usmerňovala nielen vývoj vegetácie, ale aj vtedajšie a súčasné pôdotvorné deje. Preto tu ide o hranicu bioklimatickú. Podľa niektorých autorov boli v teplejšej dobe holocénu priemerné ročné teploty vyššie asi o 1 až 2 °C ako dnešné. Teda pohybovali sa na hranici bývalej stepi a lesa asi okolo 11 °C, avšak zrážky vzhľadom na tieto teploty v podmienkach prechodu medzi stepou a lesom museli byť menšie asi o 400 mm ročne ako dnes.

Dnešná klíma obidvoch nížin sa líši navzájom — s ohľadom na pôdotvorné procesy — zhruba takto: Priemerné ročné teploty má Východoslovenská nížina nižšie následkom silnejších zím ako dôsledku väčšej teplotnej kontinentality. Letné teploty sú na obidvoch nížinách približne rovnaké. Ročné úhrny zrážok Východoslovenskej nížiny sú väčšie ako na Podunajskej a sú opäť v dôsledku väčšej zrážkovej kontinentality hodne sústredené na letné obdobie. V dôsledku toho na vegetačnom období (najmä v letných mesiacoch) je na Východoslovenskej nížine asi o 50—100 mm viac zrážok ako na Podunajskej nížine. Pásmo hnedozemí a illimerizovaných pôd majú na obidvoch nížinách rovnaké množstvá zrážok v roku (hnedozeme 600—650 až asi 700 mm a illimerizované pôdy zhruba od 700 mm vyššie). Na Východoslovenskej nížine je širšie pásmo s väčším množstvom zrážok, a tým, prirodzene, aj širšie pásmo illimerizovaných pôd ako na Podunajskej nížine. Dobre znázorňuje vlhkostné rozdiely vzhľadom na rozšírenie pôd medzi oboma nížinami aj index zavlaženia podľa Končeka. Zjav väčšieho ročného množstva zrážok na Východoslovenskej nížine treba považovať za vplyv bližších pohorí a má iba regionálny význam.

Mapa 1. Bioklimatické pásma hlavných automorfných pôdnych typov Podunajskej a Východoslovenskej nížiny. 1 — Podunajská nížina, 2 — Východoslovenská nížina, a, b, c — bioklimatické pásma pôdnych typov, ... — hranice medzi bioklimatickými pásmami, a — pásmo illimerizovaných pôd, b — pásmo hnedozemí, c — pásmo černozemí.