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SOME CHARACTERISTIC FEATURES OF THE SOIL COVER IN THE ŽITNÝ OSTROV

L'auteur traite la pédogenèse du territoire constitué par les alluvions du Danube nommés Žitný ostrov (Ile de blè). Dans l'origine des sols foncés riches en matières organiques, l'influence décisive est accentuée de l'hydromorphisme précédent. Un changement ultérieur de ces sols se produit après la dessiccation du terrain où la plupart des sols cesse d'être influencée par la nappe souterraine. Ce processus, s'appelle la steppification. La couverture de sol présente le reflet de ce processus. Spécialement, il traite les carbonates et la caractéristique des minéraux argileux de différents sols et des sédiments.

1. BRIEFLY ABOUT THE TERRITORY

We call the Žitný ostrov (Grain Isle) the territory included between the Danube and Little Danube rivers. Its lenght is about 100 km and its breadth 15 to 20 km. Geomorphologically, according to Hromádka (12), it forms an independent unity within the wider Danubian lowland.

A more detailed geomorphological regionalization of the Žitný ostrov was made by Lukniš and Mazúr (19). It is virtually a young structural plain originated by the accumulative activity of the Danube (Lukniš calls it a terrestrial delta) during constantly occurring tectonic subsidences. The sediments' age is considered to be recent, except the core of the Žitný ostrov which, according to several authors, pertains to the Pleistocene (18, 19). Owing to repeated, rather frequent inundations, along the banks of the Danube and its arms, there originated relatively higher aggradation ramparts elevated by 2—3 m over the environing plain. By further evolution of the Danube and its arms, these ramparts were incessantly translocated and thereby, along the river and its arms, a system of riverain aggradation ramparts, and between them, a system of relatively weaker accumulated depressions, i. e. a system of different types of cut-off lakes „from vholly silted ones up to arms without any sedimentary filling" (19) arised.

It is known from historical sources that the territory of the Žitný ostrov, especially its lower part, was strongly water-logged in the past. Szekfü (22) (in Lednár) reports that as late as in the XVIIth century, two thirds of the Žiný ostrov were swampy.

Martinka (20) writes that the Žitný ostrov, in the historical epoch, has not been a compact island, as it is now, but a complex of islands and water planes. The interferences of man, such as the construction of dams or drainage-channels, gave it

successively its existing character. Jurko (15) shows that systematic building of dams along the Danube and Little Danube began approximatively in 1824, but after Lednár (16) more radical water conservation arrangements were only introduced after foundation of the Water Sonservancy Co-operatives (in Komárno 1876 and Šamorín 1882). According to a study of the Hydroprojekt (13), these interferences proved well mainly in the island's upper part, where the Danube arms were cut off from the water, and consequently, the underground water level here sank deeply to its actual state of 3—7 m beneath the terrain.

According to detailed observations, the existing groundwater regime exhibits a certain fluctuation which, after Duba and Supek (3) is primarily influenced:

a) by littoral infiltration from the rivers,

b) by infiltration of atmospheric precipitations and consumption of groundwater by evapotranspiration,

c) by discharging the groundwater through the system of drainage-channels,

d) by inflow of underground waters from higher lying neighbouring areas. Lehký and Gyalokay (17) report that the deepest groundwater levels now occur in the upper Žitný ostrov (cca 7 m on the Pleistocene core with an increase of 2 m towards the Danube) and the highest ones in its lower part (about 1 — 1,5 m, in local depressions even 0 — 0,5 m).

The minimum, maximum and average groundwater levels of the Žitný ostrov were worked up statistically and cartographically too (2, 3, 5). Hydrochemical research showed that, in the entire Žitný ostrov area, the underground waters were of bicarbonate-carbonaceous or bicarbonate-magnesic types (14).

2. THE ACTUAL SOIL CONDITIONS IN ŽITNÝ OSTROV

In the last time, several authors dealt with the study of the Žitný ostrov soil conditions (6, 15, 21, 23). Disadvantage of these studies was that, more or less, limited spaces were investigated and only smaller quantities of profiles were evaluated. In 1962—63, under the principal methodic leading of the author of this contribution, a detailed complex pedological survey was accomplished with a great density of probes (one test pit per 12 ha), whereby each probe was analysed. The occurrence of soils was cartographically worked up in 1:10.000 maps, and by successive generalization, to the scales of 1:50.000 and 1:200.000. The map of genetic soil representants and that of the granular composition to the scale of 1:200.000 are demonstrated in this work. Some partial results were already published (1, 4, 7, 8, 9, 10, 11). These detailed maps of soil types, supported by a sufficient amount of analytical materials and an abundant number of works from other natural sciences, rendered us possible to obtain a new view of the Žitný ostrov soil cover and its genesis.

It appears that after a complicated evolution the present-day soil conditions of the Žitný ostrov are relatively simple and the incidence of each concrete soil substantially depends on following factors:

a) on the grundwater level depth, conditioning the intensity of the accumulation of organic matters and the intensity of gley processes in the soil profile,

b) on the time (epoch) of the dominating hydromorphic conditions,

c) on the time (epoch) of the dominating automorphous conditions arising in the Žitný Ostrov after the water conservancy arrangements,

d) on the granular composition of the sediments which modify the soil profile's water regime at the same groundwater level and the same time of dominating hydromorphic or automorphic conditions.

On accounting the above mentioned conditions we find on the territory of Žitný ostrov the following soil types:

2.1 Alluvial soil

Alluvial soils are widespread along the water streams, especially along the Danube, Little Danube, Váhodunaj and the brook Čilíz. They are very young soils, under which there are frequently buried older soils (Prof. Scharpensel and Prof. Tammers at the Soil Science Institute in Bonn, FRG, determined, by the method of dating, by means of the C^{14} isotope and though the benzole synthesis, the age of such an older soil from Trhové Mýto taken under the Little Danube alluvion, to be 2.460 ± 60 B. P.; I thank them cordially for it). On these sediments, the age of which is below 2500 years, and which were probably deposed by last, large flood phase of the Danube (proved by the regularly arranged sequence of sediments throughout the profile, without any humus interlayers) we observe a very shallow humus accumulation, and sometimes, in the profile's lower parts, manifestations of the gley process, mainly in the places where the groundwater level is, up to the present, relatively high. In conformity with these evolutional tendencies, we divided the youngest alluvial soils into the following subtypes:

a) alluvial soil (the humus horizon is slightly developed, shallow, up to 30 cm),

b) chernozemic alluvial soil (deeper humus horizon, more expressive intermediate horizon, similar to the chernozem),

c) gleyed alluvial soil (with more expressive gley processes in the profiles lower parts and in the mother rock closely beneath the profile.

2.2 Meadow soil

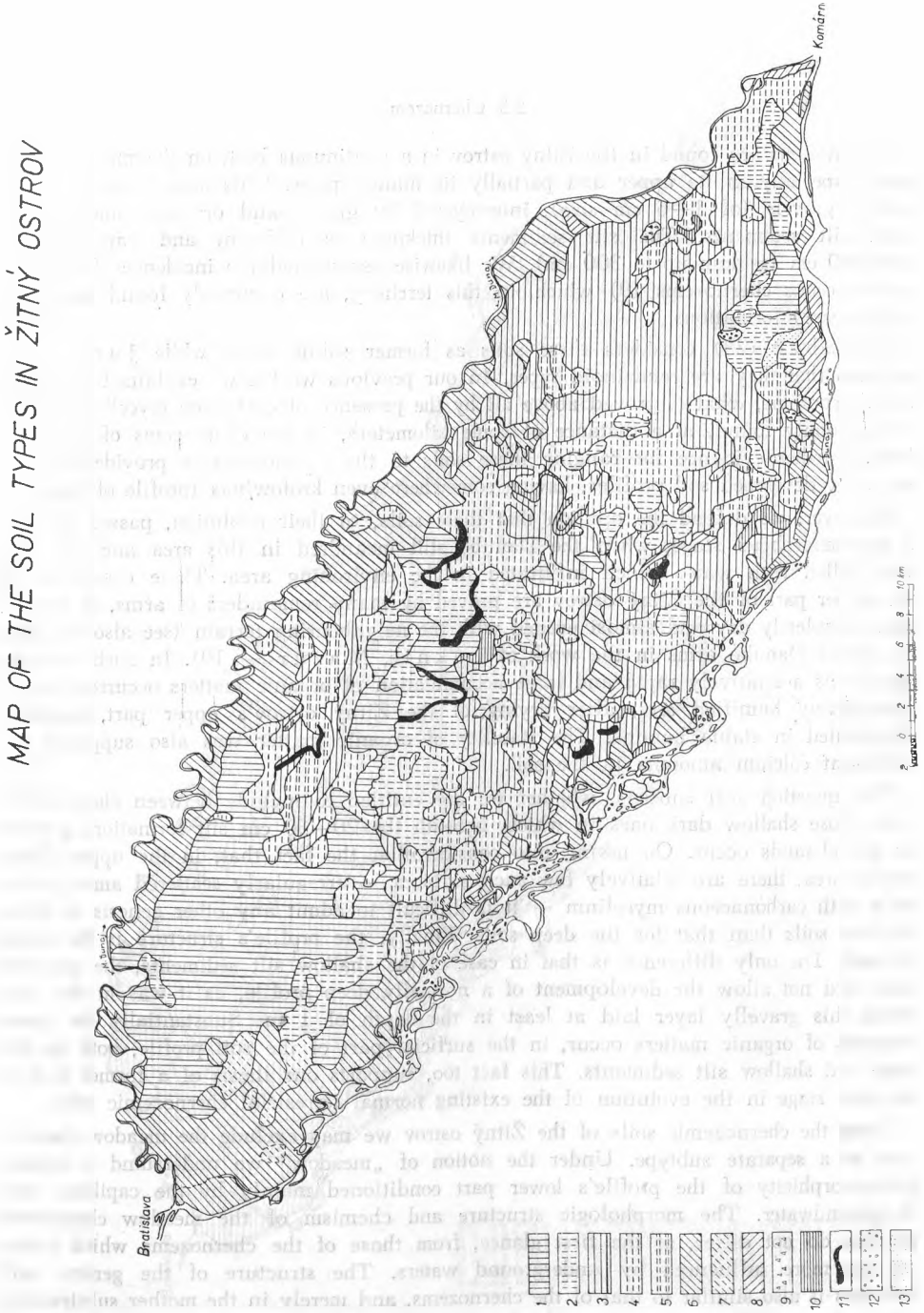
Meadow soil is the most widespread soil type in the Žitný ostrov. Under them, we understand soils in which the organic matter accumulation proceeded at higher underground water levels (thus in hydromorphous conditions) which, to a certain measure, lasts up to now and causes a systematical or periodical watering of one part of these soils. In the presence of a high content of carbonates and abundant vegetation, due to the sufficient amount of moisture, there occurred accumulation of a considerable content of sufficiently stable organic matters (humus) and a quite deep profile humousity.

The gley process, i. e. the activation of iron, and reduction of iron and manganese compounds, in the majority of these soils, is little intensive. More expressive marks of the gley process are oberved, in typical meadow oils, mostly in the depth of about 1 m. They manifest themselves chiefly in form of a rusty spottedness, very scarcely only in form of a reduced gley horizon. In accordance with the gley process and its depth in the profile, we divide the meadow soils in the following subtypes:

a) chernozemic meadow soil, if the oxided gley horizon only slightly reaches into the profile's lower parts,

b) meadow soil, if the oxided gley horizon reaches into the soil profile and, in the mother rock, manifestation of reduction is observed,

c) gleyed meadow soil, in which expressive gley processes and reduction of the iron and manganese compounds are already observed in the depth of 40—50 cm.



Map. 1. Map of the soil types in Žitný Ostrov. 1 — Carbonate chernozem, 2 — Carbonate meadow chernozem, 3 — Meadow soil, 4 — Chernozemic meadow soil, 5 — Gley meadow soil, 6 — Alluvial soil, 7 — Chernozemic alluvial soil, 8 — Gley alluvial soil, 9 — Regosol, 10 — Muddy soil, 11 — Peat soil, 12 — Alkali soil, 13 — Meadow chernozem in complex with alkali soil.

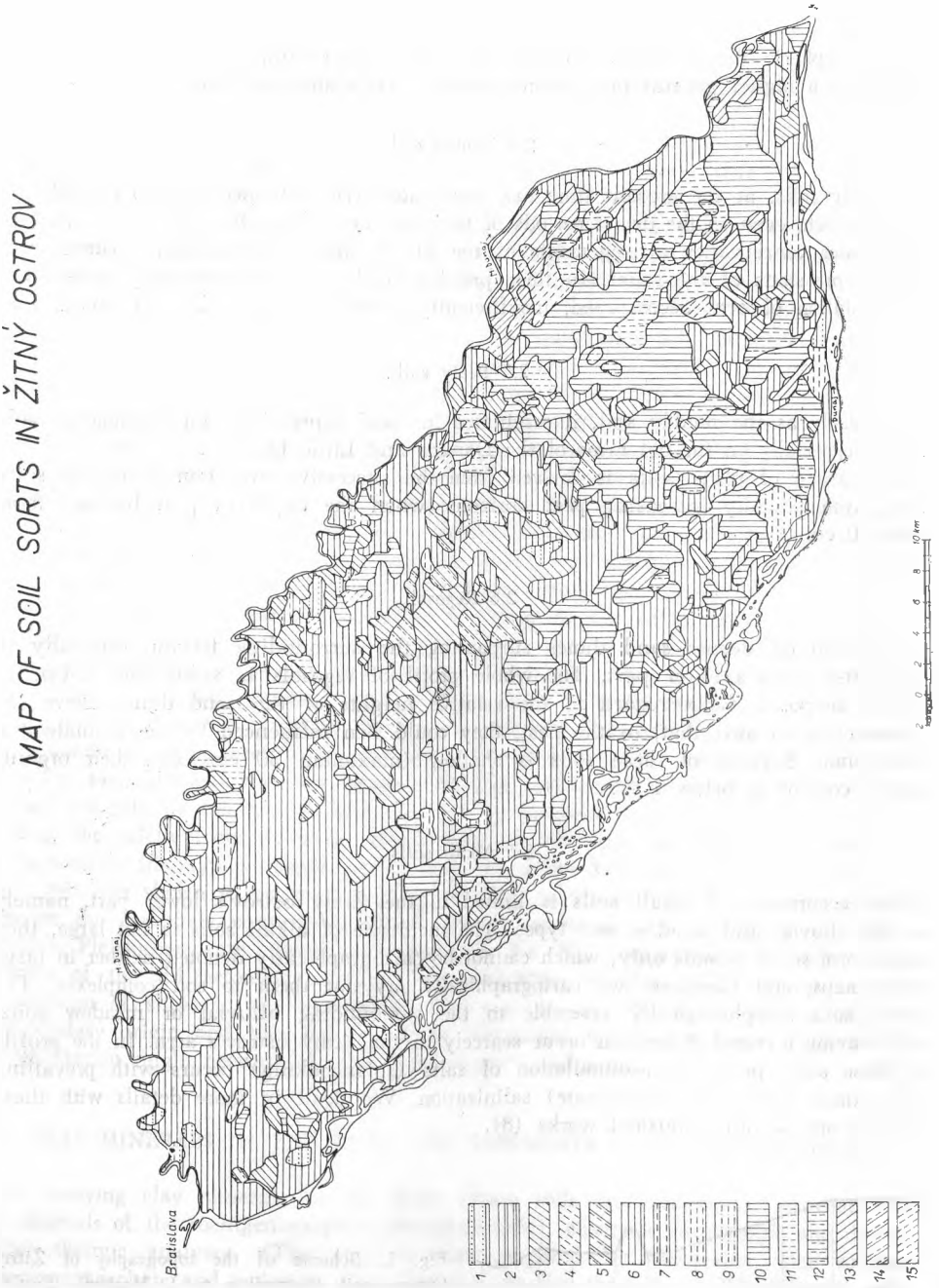
Chernozems are found in the Žitný ostrov in a continuous belt, on the morphological core, especially in its upper and partially its middle parts. This area is mainly built up by gravels (of 1—6 cm size), interlayered by gravel-sand or sand, and covered with silt sediments. The silt sediments thickness is different and varies within 20—200 cm (seldom up to 300 cm). We likewise ascertained the incidence of mycelial carbonaceous chernozems (9) which, in this territory, are commonly found in deeper silt (loess?) formations.

Tarábek (23) considers these soils as former saline soils, while Jurko (15) believes that they are rendzinoid types. In our previous works, we explained that they are chernozems, what is proved above all by the presence of carbonate mycelium, which is commonly found, at a distance of some kilometers, in the chernozems of the loess hills. Further evidence for ranging these soils to the chernozems is provided by the normally developed soil profiles, having somewhere even krotowinas (profile of Hubice).

However, we defend the opinion that these soils, in their evolution, passed through a hydromorphous stage, when the Danube still meandred in this area and its arms were filled with water which infiltrated in the environing area. These conditions in the upper part of the Žitný ostrov are proved by many remainders of arms, of course, now completely dry and almost evened with the neighbouring terrain (see also the map of cut-off Danube arms in the work of Lukniš, Mazúr — 19). In such swampy conditions a relatively rapid and large accumulation of organic matters occurred, which successively humified and, after drying of the Žitný ostrov's upper part, partially dehydrated in stable humins. The stability of organic matter was also supported by sufficient calcium amounts in the soil.

The question still subsists, whether we are entitled to include between chernozemic soils those shallow dark ones in which, beneath the 20—30 cm silt formation, gravels or gravel-sands occur. On taking into consideration the fact that, in the upper Žitný ostrov area, there are relatively few such surfaces — irregularly scattered among deep soils with carbonaceous mycelium — it is difficult to admit any other genesis of these shallow soils than that for the deep soils. Finally, the profile's structure is the same as well. The only difference is that in case of the shallow silt sediments, the gravelly layer did not allow the development of a normally deep profile, as it was in the case when this gravelly layer laid at least in the depth of 1 m. Substantially the same contents of organic matters occur, in the surficial part of the soil profile, both in the deep and shallow silt sediments. This fact too, supports our thesis of a former hydromorphic stage in the evolution of the existing normal terrestrial chernozemic soils.

From the chernozemic soils of the Žitný ostrov we may exclude the meadow chernozem as a separate subtype. Under the notion of „meadow" we understand a certain hydromorphicity of the profile's lower part conditioned mainly by the capillary rise of groundwater. The morphologic structure and chemism of the meadow chernozem profiles do not differ, at the first glance, from those of the chernozems which today are no more influenced by underground waters. The structure of the genetic soil horizons is also similar to that of the chernozems, and merely in the mother substratum, we meet a slight manifestation of gley processes. This indicates a certain seasonal wetting, but an expressively reduced horizon is missing. The underground waters occur in the depth of 2,5—3,5 m. Their respective laying out is important also from the practical standpoint, because higher lying groundwater levels are more expressively influencing especially the water regime, the active balance share of which, besides of



Map 2. Map of soil sorts in Žitný Ostrov. 1 — Loamy sand, 2 — Loamy sand — sandy loam, 3 — Sandy loam, 4 — Sandy loamy — loamy sandy, 5 — Sandy loamy — loamy, 6 — Loam, 7 — Loam — sandy loam, 8 — Loam — clayey loam, 9 — Loamy — clayey soil, 10 — Clayey loam, 11 — Clayey loam — loam, 12 — Clayey loam — clayey soil, 13 — Clayey soil, 14 — Clayey — loam, 15 — Clayey — clayey loam.

the atmospheric precipitations, consists also from water supported by capillarity and results in a higher general production capacity of this subtype of the chernozems.

2.4 Muddy soil

Muddy soils, at the present time too, stay under the influence of high groundwater levels which, even in the driest periods of the year, are closely beneath the soil surface. The water conservancy arrangements of the Žitný ostrov limited their occurrence on local depressions of the relief. In their profiles until now a marked gley process and accumulation of semi-decomposed, insufficiently humified organic matters occur.

2.5 Peaty soil

Similarly as the muddy soil, it originated in local depressions, on organogenic substrata, especially in the old arms of the Danube and Little Danube.

The origin of peaty soils is derived from the successive evolution of muddy soils, from systematically increasing peat horizons, when the depth of peat becomes more than 50 cm.

2,6 Regosol

It arised on deeper sand dunes surpassing the surrounding terrain, especially in the Žitný ostrov's lower part. The whole profil of regosols is sandy and it can be hardly supposed (with regard to the relative heights of the sand dunes above the surrounding terrain) that, in the past, they could ben influenced by the groundwater. The humus horizon of these soils is shallow (maximum 30 cm) and their organic matter content is below 1 %.

2.7 Alkali soils

The occurrence of alkali soils is limted to the Žitný ostrov's lower part, namely on the alluvial and meadow soil types. The incidence of alkali soils is not large, they often form small islands only, which cannot be cartographically denoted neither in large scale maps, and therefore, we cartographically lay out them to soil complexes. The alkali soils morphologically resemble to the surrounding alluvial or meadow soils; soils having textural B horizon occur scarcely in the Žitný ostrov's area. In the profile of these soils, primarily accumulation of salts (solonchaking) occurs with prevailing sodic (most frequently bicarbonate) salinization. We dealt in more details with these soils in one of our published works (8).

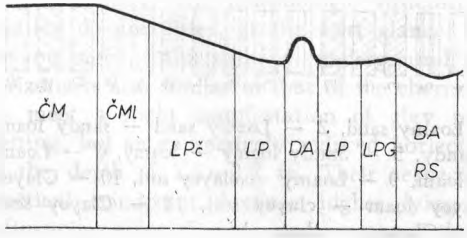


Fig. 1. Scheme of the topography of Žitný Ostrov soil (according to J. Hraško). Explanation of the symbols: ČM — chernozem, ČM1 — meadow chernozem, LP — meadow soil, LPč — chernosemic meadow soil, LPG — gley meadow soil, DA — regosol, BA — muddy soil, RS — peat soil.

3. CARBONATES IN THE SOILS OF THE ŽITNÝ OSTROV

As mentioned above, all sediments, thus the soils of the Žitný ostrov as well, are strongly carbonaceous. The content of carbonates varies here within 5—30 %, in isolated cases still more percents. This fact was still earlier known, but the high carbonicity was attributed to the properties of the Danubian sediments derived from Alpine materials. So Jurko (15), in his monography considers the carbonates of the Žitný ostrov as primary ones. In some previous works already (9, 10), I pointed out that the high carbonicity of the Žitný ostrov's soils was, to a certain extent, of a secondary origin. I came to this conclusion on comparing the content of carbonates in the Danubian drifts with that of the Žitný ostrov's substrates and soils derived from these drifts. I succeeded to confirm my opinion in 1966—67 by more detailed chemical-mineralogical studies, which I had the possibility to perform, as a scholar on the Alexander von Humboldt Foundation, at the Institute of Prof. Mückenhausen in Bonn, FRG.[1] By detailed micromorphological examination of more than 100 slices of various Žitný ostrov soils it could be proved that the major part of carbonates was of secondary origin and was accumulated in the soils and substrata partially by weathering of plagioclases which, at the present time too, the present in these sediments in large amounts. One part of the secondary carbonates got in he soil by successive uprising of bicarbonate-calcareous waters occurring in the Žitný ostrov (see Jacko — 14).

In the weathering of plagioclases, besides of calcium, there is also released sodium which, due to the well drained upper Žitný ostrov (gravelly base of the Pleistocene care), is washed into the underground water, while in the lower Žitný ostrov, where the groundwater lies nearer to the surface, it causes by repeated uprises sodic salinization. The ascertainment was also remarkable that carbonates in the Žitný ostrov were formed not only by calcite ($CaCO_3$), but also by dolomite ($CaMg/CO_3/_2$). For distinguishing the calcite from dolomite, the method of structural analysis by means of a diffractometer (the typical basal calcite lines are 3,04—3,06, while those for dolomite are 2,89) was shown to be most appropriate. The calcite as well as the dolomite are also in the carbonate concretions and carbonate coats on the gravels of the Žitný ostrov's Pleistocene core. Some admixture of the Mg component was determined, besides of the diffractometer method, by evaluation of the DTA curves too. By observation of slices it was ascertained that one part of the dolomites was also of a secondary origin and this led us to the conclusion that some recent (subrecent?) dolomitization might occurred in the Žitný ostrov's sediments.

4. CLAY MINERALS IN THE SOILS AND SEDIMENTS OF THE ŽITNÝ OSTROV

In studying clay minerals in the Žitný ostrov soils and sediments, we combined the methods of the roentgenographic (diffractometric), electrone-microscopic and differential thermic analyses. (The samples were prepared by dispersion with sodium hexametaphosphate and isolation of the fraction smaller than 1 μ.) We followed soils from the gleyed meadow ones up to the chernozems, i. e. a series of soils from the

[1] In this place too, I take the liberty of thanking the A. von Humboldt Foundation for the material support, and Prof. Dr. Dr. E. Mückenhausen for rendering me possible to execute the necessary experimental works in his Institute. Without them it would have been impossible to explain a series of important pedogenetic questions of this area.

most humid to the driest ones. We found that, in all soils, illite was the dominating clay mineral. Similarly, chlorite and vermiculite were found in the clay fractin of all soils. A more expressive representation of montmorillonite was only found in meadow soils of heavier granular composition. Caolinite ocurs in all soils in traces only. The presence of dolomite and quartz in the clay fraction of all soils is also remarkable.

5. TOPOGRAPHY OF THE SOILS IN THE ŽITNÝ OSTROV

The topography of the Žitný ostrov's soils is closely connected with the morphology of this territory. Owing to the geomorphological evolution of the Žitný ostrov, we find in its territory:

1. Drier places, with a relatively deep groundwater level, which can be:
a) older places on the Pleistocene core of the Žitný ostrov,
b) younger places on the Recent aggradation ramparts,
c) local elevated places on sand dunes.
2. More humid places in the depressions between aggradation ramparts.
3. Moist places in remainders of Danube arms, in its medium and lower parts, which are filled with organic-mineral earths, peat, or form still now water surfaces.

On the relatively highest and thus driest surfaces, there occur chernozemic soils; on very young accumulations there are alluvial soils, while on sandy dunes there are meadow soils. In connexion with the increasing hydromorphicity, depending upon the height of the groundwater level at the present time, we can determine the following genetic-topographic soil catena (table 1).

Table 1

Existing conditions		
automorphic	semihydromorphic	hydromorphic
chernozem regosol chernozemic alluvial soil	meadow soil	muddy soil peaty soil
meadow chernozem		gleyed meadow soil

From the topographical point of view, the soils of the Žitný ostrov are situated as follows:

On the aggradation ramparts:
— chernozem, meadow chernozem

In intermediate areas:
— chernozemic meadow soil, meadow soil

In depressions after dead arms:
— gleyed meadow soil, muddy soils, peaty soils

The topography of the Žitný ostrov is schematically demonstrated in the figure.

6. CONCLUSION

We pointed out the common origin of all the existing Žitný ostrov's soils which developed under the dominating influence of high underground waters or wetting of the Žitný Ostrov sediments by infiltrating waters from the river streams and their arms.

The actual soil conditions of the Žitný ostrov resulted from the successive transformation of the hydromorphic soils to steppes which occurred in dependence upon the territorial morphology, on different surfaces in different ways (under steppe formation, we understand a process in which pedogenesis now proceeds in drier conditions than in the past).

This formation of steppes was conditioned especially by the water conservancy arrangements in the Žitný ostrov which, in the last century, caused considerable sinking of the underground waters and cutting-off of the Danube arms from the actual river bed.

The process of steppe formation of former hydromorphic soils took place most markedly in the highest and best drained parts of the Žitný ostrov and on substrata of lighter granularity, whereas the more clayey soils retained longer certain marks of their former hydromorphicity.

From the Slovak translated by J. Belaj

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