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GENETICS, GEOGRAPHY AND PROPERTIES OF EUROPEAN SOLONETZ SOILS

Les solonetz existent dans plus de 12 pays d'Europe; leur étude présente une grande importance sur les plans théorique aussi bien que pratique.

L'existence et la répartition des solonetz sont toujours en étroite liaison avec les conditions climatiques, géologiques, hydrologiques et géographiques de chaque région.

Dans son article l'auteur décrit la distribution des solonetz dans différents pays d'Europe ainsi que la morphologie et la répartition géographique des principaux types de solonetz connus en Europe. Il étude aussi les processus de formation de ces sols et leurs possibilités d'utilisation agricole.

Salt affected soils are wide-spread in all continents and their study has both theoretical and practical importance. The occurrence and distribution of salt affected soils are always closely related to climatical, geological, hydrological and geographical conditions of the given area. The properties of the salt affected soils depend on the conditions of their formation and therefore the investigation of salt affected soils is possible only together with the through study of their environmental conditions.

In Europe among the salt affected soils the most wide-spread group is the group of solonetz and solonetzlike soils which represents more than 75 % of all salt affected soils in Europe, where according to a rough estimate the area of solonetz-like soils is over 20 million hectares.

Solonetz soils occur on vast, adjacent territories in Bulgaria, Czechoslovakia, France, Hungary, Romania, Spain, USSR, Yugoslavia etc. and they may be found in smaller spots among other soils in Austria, Greece, Italy, Portugal, etc. (2, 9, 14, 15, 17).

Aside from the considerable extent and frequent occurrence of solonetz and solonetz-like soils the fact that they mostly occur in areas where the agricultural potential is otherwise favourable makes it absolutely necessary for us to study these soils, to acquire a full, detailed knowledge of them and to reclaim them (2).

Solonetz soils frequently occur together with non-salt affected soils in complex or microcomplex association. In these cases, their very low fertility disadvantageously affects the productivity of the whole area (19). Thus by ameliorating the solonetz soils, agricultural utilization of areas by far larger than those occupied by be solonetz and solonetz-like soils, can be attained.

The utilization of solonetz soils for irrigation and salinization or alkalinization occurring due to the effect of irrigation (in the course of which secondary salt affected soils are formed whose properties closely resemble those of solonetz soils (present other special problems (4).

Fig. 1. Salt affected soils. Photo L. Lörinczy.

THE GENETICS AND PROPERTIES OF SOLONETZ SOILS

The term *solonetz* is well-known and widely used all over the world for the denomination of a group of salt affected soils. Still it is necessary to summarize our knowledge of the formation, morphology and properties of these soils, because there are countries where various, sometimes absolutely different names are used for them.

Solonetz soils always have a structural B horizon in their profiles. This horizon always has a well-developed structure, mainly columns. It can be easily distinguished from the horizon above it, which is less compact and the structure of which is less developed. This B horizon determines the genetic type of these soils, their main physical, chemical, physico-chemical and biological properties, as well as their fertility together with the possibilities of their agricultural utilization *(Figure 2)*.

The structural B horizon is situated at various depths, depending on local circumstances. In some cases it is at the surface (the A horizon completely lacking).

The structural B horizon always markedly differs from the A horizon not only in morphology, colour and structure, but also in its physical, chemical, physico-chemical and biological properties. *Figure* 3 schematically represents some of the chemical, physical and physico-chemical properties of a solonetz soil. (Adapted in modified form from Kovda). It demonstrates that at a given depth below the surface (in this case at about 30 cm) an illuvial horizon, that is an accumulation horizon, may be found. This is named B or B_1 horizon. In this horizon the accumulation of clay particles and sesquioxides may be observed and the water soluble organic matter content as well as the ESP values show their maxima, while the ratio of SiO_2/R_2O_3 is the lowest.

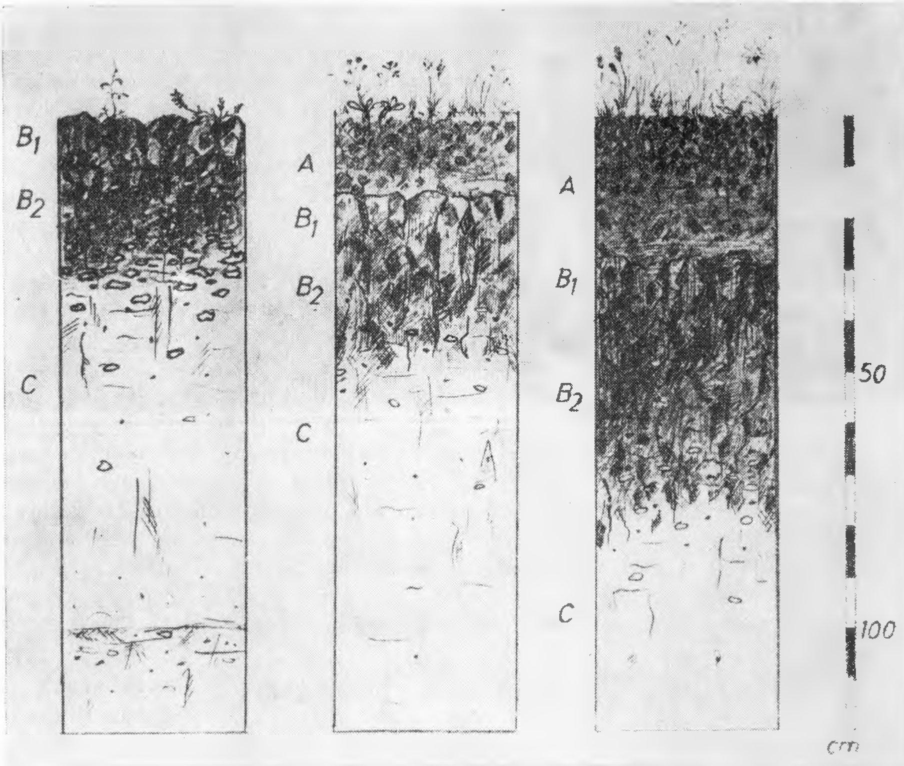


Fig. 2. Schematic profiles of solonetz soils with structural B horizons.

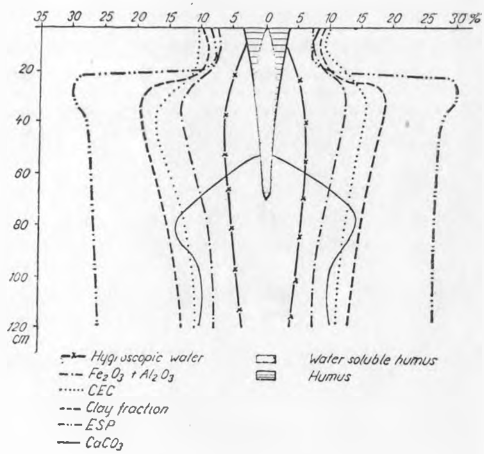


Fig. 3. Schematic representation of some of the physical, chemical and physico-chemical properties of a solonetz soil (after Kovda, in a modified form).

(Silicon compounds are comparatively in minimum). In Figure 3 this horizon is between 20—30 cm, as is often the case in nature, but it frequently occurs at depths other than this (12, 13). Naturally in these cases the respective maximum and minimum values may be found at the depth where the B horizon developed.

It may be seen in Figure 3 that — as regards the movement and accumulation of materials — in the A horizon the situation is just the contrary. The A is the elluvial horizon.

The thickness of the A horizon is a very important feature of solonetz soils. The fertility of these soils is in direct proportion to the thickness of their A horizons. For one thing, it determines the amount of water retained and available for plants. The B horizon is much more compact than the A and the penetration of plant roots into it is always impeded. Besides — as clearly shown in Figure 3 — the amout of exchangeable sodium and water soluble sodium salts harmful to plants is lower in the A than in the B horizon.

It is obvious that the thickness of the A horizon has always been taken into consideration in the grouping and classification of solonetz soils. Naturally the limit values of the thickness of the A horizon — on the basis of which the solonetz soil is included in a certain group — depend to a large extent on local conditions. Depending on climate, geochemistry, plant nutrition and other factors, sometimes thicker and sometimes thinner A horizons correspond to a given water and nutrient economy. The following grouping is intended only to give a general directive with regard to the division of solonetz soils into three groups according to the thickness of the A horizon.

Name	*Thickness of the A horizon*
Shallow solonetz soil	0— 6 cm
Middle solonetz soil	7—16 cm
Deep solonetz soil	thicker than 16 cm

One of the important characteristics of the B horizons of solonetz soils is their high exchangeable sodium content (5). It is generally agreed, that the high exchangeable sodium content is reponsible for the poor physical and water regime properties and the compact structure of the B horizons of solonetz soils. The exchangeable sodium content is usually expressed in m. e./100 g of soil or, even more frequently, as a percent of the cation exchange capacity (CEC). If this percent is as high as about 5—7, the first signs of the development of the compact B horizon may be observed in the profile. If the exchangeable sodium content amounts to about 20 per cent, the columnar, compact B horizon is already developed and the characteristic solonetz profile may be observed. Naturally the limit values given above are also approximate and may vary depending on soil properties and local conditions (7, 8).

Due to the influence of local circumstances solonetz soils have diverse characteristic and properties. Some of them have considerable amounts of water soluble sodium salts even in the upper layers (more than 4 millimhos) while others are practically devoid of salt in the entire profile. Of the water soluble sodium salts, sometimes bicarbonates, sometimes sulphates or even chlorides prevail. With regard to the maximum accumulation of water soluble salts in the profile, as a rule, it occurs in the lower part of B_1 and the upper part of B_2 horizons, but depending on the conditions of soil formation, it may also occur in other layers, either above or below the B horizon. The pH value of solonetz soils, may also vary to a considerable degree. In some cases a strongly alkaline pH may be observed from the surface, sometimes the pH of the top layer is neutral or even slightly acid, and there are solonetz soils in the profiles of which a strongly alkaline pH does not occur at all. In the B horizon, however, where the maximum exchangeable sodium percentage (ESP) may be found, the pH is always over 7 except in a few cases of strongly developed solods.

In the B horizon the sodium ions are mainly in exchangeable form, adsorbed on the soil colloids the maximum of which also occurs there. These exchangeable sodium ions — depending on the dynamics of the equilibrium conditions between the soils solide and liquid phases — are capable of alkaline hydrolysis. This is influenced by the CEC and ESP values, by the chemical composition and concentration of the soil solution, especially its CO_2 tension, and by many other factors (6, 16). Because of this, the alkaline hydrolysis of the soil colloids, saturated with sodium to a greater or lesser degree, results in more or less alkaline conditions in this horizon. It is evident that — with the exception of solonetz soils affected by strongly developed solod forming processes — in the B horizon, where sodium compounds capable of alkaline hydrolysis play a dominant role, alkaline hydrolysis usually takes place, due to the interaction of the solid and liquid phases of the soil (18). Thus the solonetz, as a type, must be included in that group of soils in which the tendency of soil forming processes is determined by sodium salts capable of alkaline hydrolysis. The basic principles of the classification of 'Sigmond (14) and Kelley (10, 11) must be accepted, just as the Subcommission on Salt Affected Soils of the International Society of Soil Science did in elaborating the schema of the World Map of Salt Affected Soils. Naturally, there are solonetz soils whose pH is definitely acid in the A horizon. But even in those cases the pH value of the B horizon is more than 7, as is obvious on the basis of the above described regularities of solonetz formation.

The sodium salts responsible for solonetz forming processes are of various origins (3). Three main categories may be distinguished in this respect.

1. Steppe solonetz soils

The mineralized ground water is situated at such a great depth (more than 6—8—10 meters) under these solonetz soils that it exerts practically no influence on soil formation processes. The sodium salt solutions effecting solonetz forming processes get into the soil profile from other sources in another way. Under arid or semiarid conditions, the weathering of minerals and the decomposition of organic and inorganic compounds or the transport of water soluble salts by the surface waters may constitute such sources. Depending mainly on climatic conditions the sodium salt solutions form the profiles of these soils which — although they have all the features characteristic of solonetzes — noticeably differ from those developed under the influence of ground waters.

These soils occur mainly in relatively arid regions. In Europe thay may be found in the Transvolga territory of the USSR, the Ukrainian SSR, Romania, certain places in Spain, etc.

2. Solonetz soils turning into steppe formation

In the earlier stages of their development these solonetz soils were under the influence of mineralized ground waters, which may affect them even at the present time. In the profiles of these soils, however, the leaching out processes prevail and a slow decrease in both the salt and exchangeable sodium contents may often be observed. The water table is situated at a depth of 4—6 meters under these soils. This soil type is wide-spread in Europe in the Ukrainian SSR, Romania, Hungary, etc.

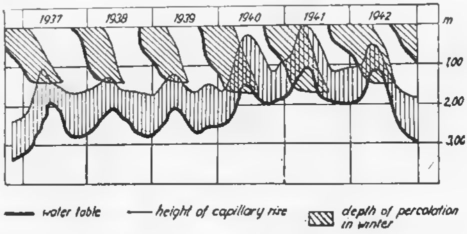


Fig. 4. The ground water and precipitation conditions in a solonetz area in Hortobágy (Hungary) in six years (after Mados).

3. *Meadow solonetz soils*

The soil profile and upper layers are capillarily linked with the mineralized ground water.

In this case solonetz formation is intertwined with solonchak formation. In these soils it is the fluctuation of the water level that determines the upward and downward migration of sodium salt solutions. These migrations are very important in solonetz formation.

The water level is situated at a depth less than about 3—4 meters under these soils.

Meadow solonetz soils are wide-spread in Czechoslovakia, Hungary, the Camargue (France), Bulgaria, the USSR, etc.

Naturally, apart from the ground water, precipitation also influences the migration of the solutions in the soil. *Figure 4* demonstrates the ground water and precipitation conditions in a solonetz area of the Hungarian Lowland during a six-year period. It may be seen that in most years the precipitation water penetrating the soil meets the capillary ground water at certain times. The accumulation horizon of soluble salts may usually be found where the upward and downward movements of the solutions meet. The distribution of the soluble salt accumulation within the profile depends on whether the upward or downward solution movements are dominant. This is clearly indicated by the situation of the accumulation horizons of Na_2SO_4, $CaSO_4$ and $CaCO_3$ in the profiles.

The depth and chemical composition of the ground water play decisive roles in the development of the solonetz soil properties. According to the above described grouping, three schematic cases may be mentioned.

1. The profile is not linked with the ground water.
2. The profile is temporarily linked with the ground water.
3. The profile is permanently linked with the ground water.

When dealing with the improvement and utilization of solonetz soils, the effect of ground water on the soil profile must be taken into consideration because under solonetz soils the ground water always contains water soluble salt, including sodium salts.

1. If the profile is not linked with the ground water, the salt content in the upper layers of the profile should be mainly considered in selecting an amelioration method. When present, natural soil formation processes assure to a greater or lesser degree the leaching of water soluble salts, drainage should be satisfactory. These soils are frequently only moderately solonized and/or solodized. Their exchangeable Na^+ content is often less than 10—15 % of the cation exchange capacity in a comparatively deep layer, more than 15—20 cm below the surface.

With these soils, it is possible to employ in expensive and simple reclamation methods with good results because the basic aim of reclamation is to facilitate natural leaching processes. The climatic conditions, the possibility of irrigation, etc. are also decisive factors when proper methods are selected to remove the salts and improve the physical properties of the soil. Chemical amendments, deep-ploughing and subsoil loosening may be used as indicated later, but the use of proper agrotechnics and the selection of the most suitable plants are very important. Soils belonging to this group include steppe solonetzes, solods, solonetz-like, and other soils.

2. If the profile of a solonetz or a solod soil is only temporarily linked with the ground water, and the salt content of the A, A_1 and B horizons is lower than in the case of soils belonging to the next group, drainage is not always necessary. In these cases the application of chemical amendments (gypsum and/or others) as well as deep-ploughing and subsoil loosening may be useful. If in the B_2 and C horizons the quantity of water soluble sodium salts is not high and a considerable amount of gypsum is present, by deep-ploughing it can be be utilized as reclamation material. Depending on local conditions, amelioration may be carried out either with or without irrigation. Under irrigated conditions, however, the provision of good drainage is very important. Soils belonging mainly to this group include meadow solonetzes and solod soils turning into steppe formation.

3. In the case of solonetz and solod soils where the soil profile and the top layers are capillarily linked with the salty ground water and the horizons (A_1, A_2, B_1, B_2) contain over 0,2 % water soluble salts in the surface layer and 0,5 % at a depth of 40—50 cm, leaching and drainage are essential. In this case the reclamation of solonetz and solod soils may be similar to that of solonchak (salty) soils. Leaching may be carried out either by applying irrigation water of good quality after providing good drainage or — under more humid climatic conditions, where the annual precipitation is enough to leach out the salts — by lowering the water level below the critical level. Chemical amendments should also be applied parallel with the above mentioned measures or afterwards, especially in the case of heavy textured soils, to replace the adsorbed Na^{+} with Ca^{++} in the colloidal fraction. Sometimes solonchak-solonetz soils may also be reclaimed in this way.

The meadow solonetz and meadow solod soils belong to this group.

The above described three types of reclamation and utilization of solonetz and solod soils must be carefully selected and adjusted to local conditions. The chemical type of the salt content is very important and it must be taken into account when selecting a proper reclamation method. For instance, in the case of sodic soils, the limit values of the admissible salt content in the soil profile are much lower than when salinity is caused by neutral sodium salts.

As compared with neutral salts, sodic soils require not only a lower level of salinity for successful amelioration, but also the application of acid chemical amendments — as one factor of reclamation.

The above facts prove that of all classifications and groupings of solonetz soils, the one based on the depth of the water level is very important not only from the point of view of soil genesis but also from that of reclamation and utilization. These three groups reflect also that — depending on the conditions of their formation — the solonetz soils differ from one another in their morphology, as well as in their physical, chemical, physico-chemical and biological properties.

Figure 5 demonstrates the salt profile of a steppe solonetz soils. The accumulation of water soluble salts may often be found deeper than in meadow solonetz soils. In fre-

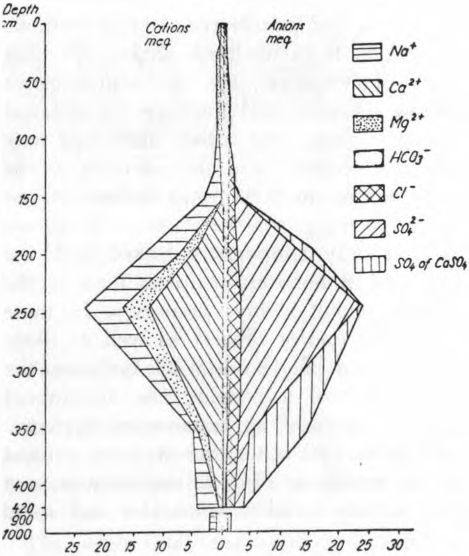


Fig. 5. Salt profile of a steppe solonetz soil (after Kovda).

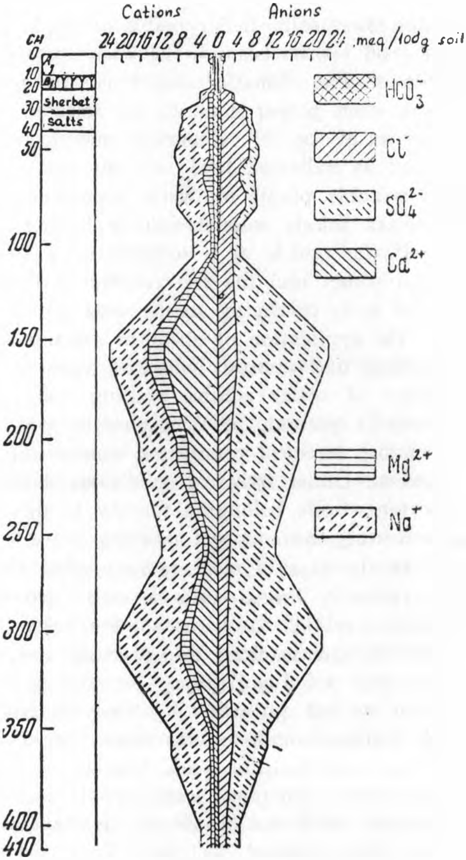
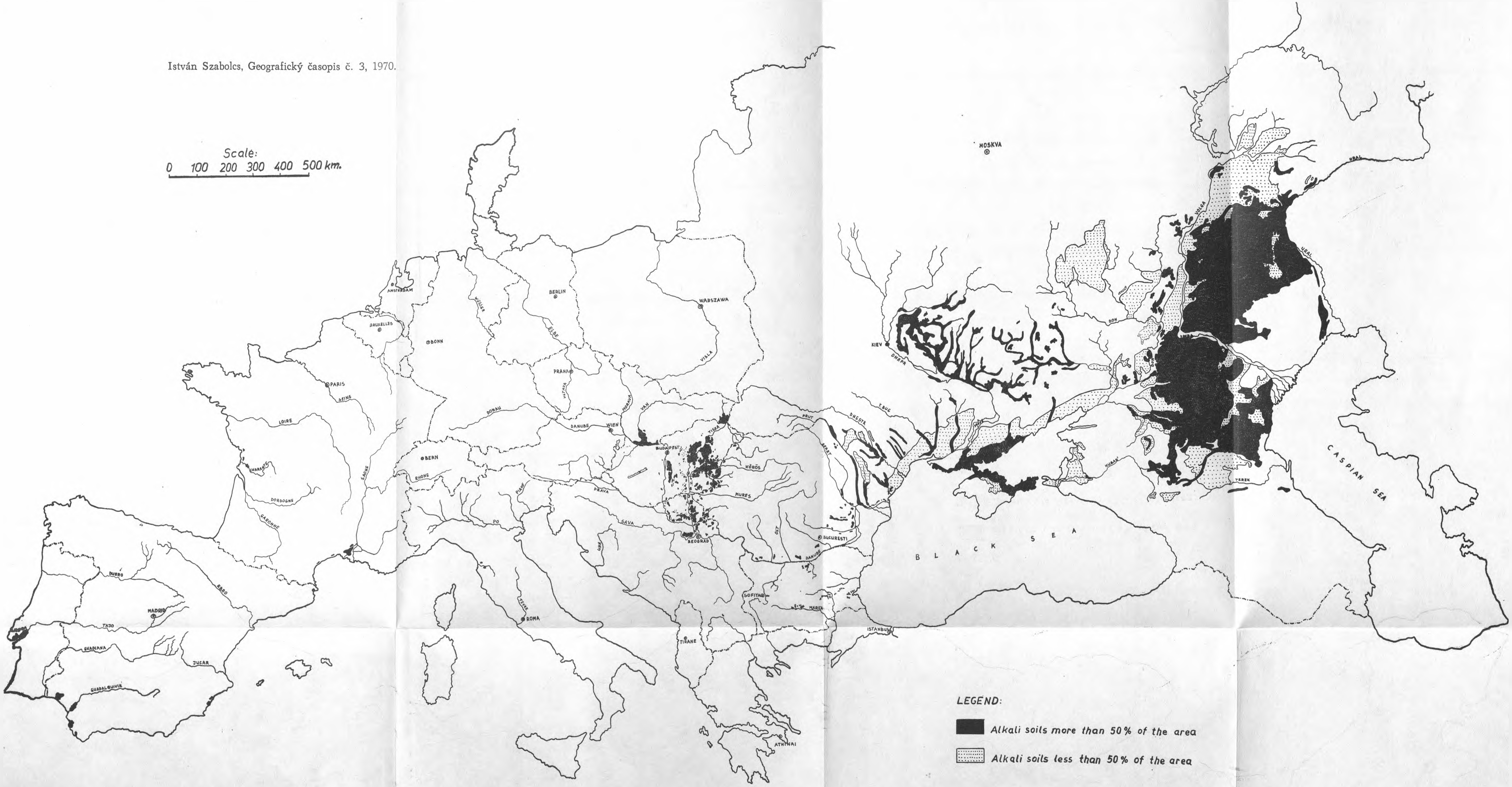


Fig. 6. Salt profile of a steppe solonetz soil (after Dimo).

quent cases this is true also of the B horizon, consequently the A horizon is much thicker. Naturally the B horizons of these soils display alkaline reaction — thus they may be considered as media capable of alkaline hydrolysis — but usually free sodium carbonate cannot be found in the upper layers or even in the whole profile and sometimes the amount of sodium bicarbonate is low as compared with that of sodium sulphate or, perhaps, sodium chloride. According to statements of Kovda and Polynov relating to geochemistry, the more arid the conditions are under which these soils develop, the higher is the ratio of chlorides to sulphates in the water soluble sodium salts. Naturally this regularity, though true in the general sense, may be significantly influenced by local conditions. It must also be noted that solonetz soils of high sodium carbonate content may also develop under these climatic conditions, if the parent material contained considerable amounts of soluble carbonates.

Figure 6 demonstrates the salt profile of a steppe solonetz soil surveyed by Dimo in the USSR. It differs from the one presented in Figure 5 both in the depth of salt accumulation and in the distribution of salts. These examples indicate that the properties of solonetz soils — even if they belong to the same group — may differ to a certain extent, depending on local conditions.

István Szabolcs, Geografický časopis č. 3, 1970.



Map 1. The occurrence of salt affected soils in Europe. Výskyt slancových pôd v Európe (podľa Kovdu, modifikované autorom).

Figure 7 represents the salt profile of a solonetz soil turning into steppe formation (surveyed by Julidov, also in the USSR) together with the chemical composition of its ground water. This figure clearly indicates the close relationship between the chemical composition of the soils salt profile and that of the ground water. Obviously the ground water has affected the soil profile.

In the following the description of a shallow meadow solonetz profile from the Hortobágy region of Hungary is presented.
Surroundings: Pasture of poor quality.
Topography: Slightly uneven, flat.
Vegetation: Artemisia monogyna, Polygonum aviculare, Festuca pseudovina.
Depth of the profile: 120 cm.
Effervescence with dilute acid: 32 cm.
Thickness of humus layer: 56 cm.
Alkalinity against phenolphtalein: 50 cm.
Grunod water level: 230 cm.

Genetic horizons:

A	0— 3 cm	Pale grey, moist, weak, many fine roots, ash-like feel solodized sandy loam. Abrupt boundary.
B_1	3— 15 cm	Grey, dry, extremely hard, distinctly columnar structure, clay loam. Roots relatively plentiful. Tops of columns, and at some places the sides, are discoloured, solonized. Abtrupt boundary.
B_2	15— 31 cm	Grey, somewhat darker, moist, slightly hard, fine prismatic structure clay loam. Moderate roots. In $CaCO_3$ abrupt, otherwise gradual boundary.
B_3	31— 55 cm	Brownish grey, somewhat lighter in colour, moist, slightly hard, fine prismatic structure, clay loam. Few roots. Iron mottles and iron concretions growing more frequent with depth. White lime spots, fine lime concretions. Abrupt boundary in colour.
C_1	55— 93 cm	Greyish yellow, moist, moderate hard, coarse prismatic structure, loess-like clay loam. Dark, clayey humus streaks, white lime mottles, a lot of lime concretions. Stains of iron, soft iron concretions. Gradual boundary.
C_2	93—110 cm	Greyish yellow, moist, moderatelly hard, loess-like clay loam. Lime and iron concretions, rusty stains of iron. Greenish grey mottles of gley.
	110—130 cm	Yellow loamy clay, lots of lime and iron concretions.
	130—150 cm	Yellow silty clay, lime and iron concretions.
	150—180 cm	Yellowish grey clay, segregated lime and lots of iron concretions.
	180—210 cm	Grey clay. Some segregated lime and iron. Gley formation.
	210—220 cm	Reddish brown, sticky clay.

Soil type: Shallow meadow solonetz on calcareous loess like clay loam.

Figure 8 demonstrates the water soluble salt content in the 1 : 5 aqueous extract of this profile developed under the influence of the processes described above. In *Figure 9*

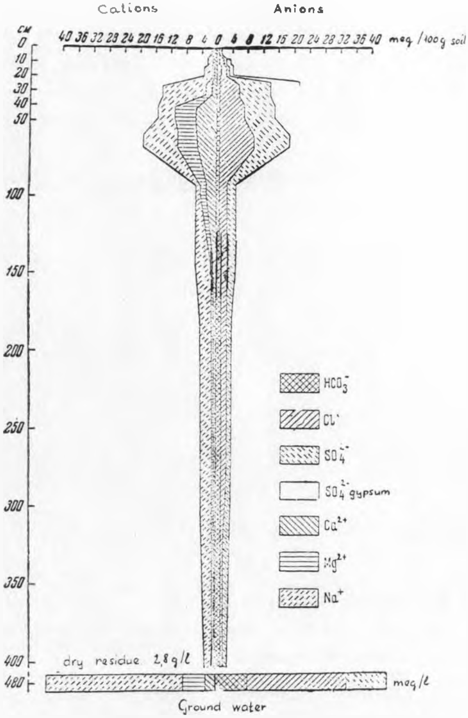


Fig. 7. Salt profile of a solonetz soil turning into steppe formation (after Julidov).

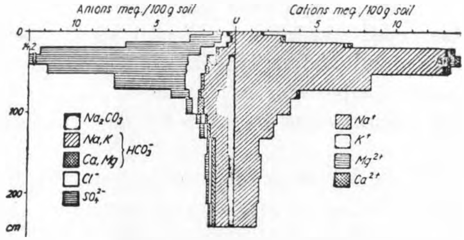


Fig. 8. Water soluble salt content of the 1:5 aqueous extract of a shallow meadow solonetz soil (Hortobágy, Hungary).

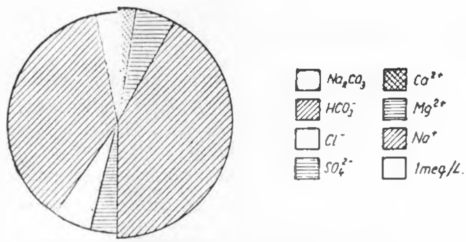


Fig. 9. Chemical composition of the ground water under a shallow meadow solonetz soil (Hortobágy, Hungary).

the composition of the ground water is represented. The close relationship between the chemical composition of the soil profile and the ground water is quite obvious. The sodium carbonate content is considerable both in the soil and in the ground water although — as often the case in sodium carbonate containing solonetz soils — it appears only at a depth of about 25 cm in the profile. It must be added that the depth of the appearance of sodium carbonate may change within the same profile depending on the seasonal dynamics of the soluble salts.

In most of these soils the B horizon is situated near the surface, consequently the A horizon is relatively shallow, or, in certain cases, where the B horizon is at the surface, it is completely missing.

The great majority of sodium carbonate containing solonetz soils have developed through the above described processes, under the influence of mineralized ground waters. They often occur on territories where the climatic conditions are from being arid, for istance in Czechoslovakia, in the Hungarian Lowland, and in the forest steppe region of the Ukrainian SSR, etc.

The solonetz soil profiles described and demonstrated above clearly indicate that their chemical compositions are diverse. Of the water soluble salts, sometimes the sulphates and chlorides, sometimes the bicarbonates or carbonates prevail. That is why the pH values of solonetz soils differ.

These phenomena explain the absolute necessity of selecting the proper methods of reclamation and utilization of solonetz soils with great care in each case.

The differences in the composition of soluble salts in solonetz soils are closely related to the genesis of these soils.

As mentioned earlier, in the literature of the English language the term „alkali“ or „alkaline“ has been used in a sense similar to that of „solonetz“. In the group of alkali soils, however, not only solonetz soils but also non-structural soda solonchak soils are included. The so-called solonetzized or solonetz-like soils, in which the compact B horizon is not yet columnar and the exchangeable sodium content (about 5—7 per cent of CEC) is lower than in solonetz soils, belong to „alkali“ soils, too.

Many soils included in the „alkali“ or „alkaline“ group have a slightly acid pH in their top layers and often neutral sodium salts prevail in their aqueous extracts, so the question arises why should they be named „alkali“ soils.

In order to clarify this problem it is necessary to study the questions of the formation of solonetz soils and the essence of the solonetz forming process.

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Do redakcie došlo 26. 3. 1970

István S z a b o l c s

GENÉZA, GEOGRAFIA A VLASTNOSTI EURÓPSKYCH ZASOLENÝCH PÔD

Spomedzi soľných pôd v Európe najrozšírenejšími sú slance. Vyskytujú sa vo viac než 10. európskych krajinách, najmä vo východných a juhovýchodných častiach kontinentu.

Slancové pôdy sú značnou prekážkou poľnohospodárskej výroby, pretože svojou nepriaznivou úrodnosťou robia obťažným obrábanie pôdy aj na takých miestach, kde úrodnosť okolitých pôd je dobrá.

Profil slancových pôd je veľmi charakteristický pre tento pôdny typ a podľa novej klasifikácie subkomisie Medzinárodnej pôdoznaleckej spoločnosti pre zasolené pôdy nazývame pôdy patriace k tomuto typu „alkalickými pôdami, ktoré majú štruktúrny B horizont".

Autor v práci podrobne uvádza genetické vlastnosti slancov, ich charakteristický profil, ako aj najdôležitejšie zvláštnosti profilu v horizontoch A a B.

Umiestnenie a hrúbka horizontov A a B v slancových pôdach je dôležitá nielen z hľadiska genetických zvláštností profilu, ale aj z hľadiska poľnohospodárskeho využívania takýchto pôd a možností ich zlepšenia. Čím hrubší je A horizont slanca a v dôsledku toho čím hlbšie leží horizont B, tým lepšia je prirodzená úrodnosť pôdy a tým ľahšie je aj jej zlepšenie. Keď je B horizont dostatočne hlboko pod povrchom, slance sa dajú pomerne jednoducho a lacno zlepšiť vhodnými agrotechnickými metódami, malými dávkami zlepšovacích látok alebo aj bez nich. No keď je B horizont na povrchu alebo v jeho bezprostrednej blízkosti, zlepšenie pôdy je ťažšie a nákladnejšie. Keď slancový profil obsahuje značné množstvá vodorozpustných solí, potrebné je aj vymývanie týchto solí.

Je hodne takých pôd v Európe, v ktorých množstvo vymeniteľných Na-iónov v horizonte B nedosahuje medzné hodnoty charakteristické pre slance (15—20 % zo všetkých vymeniteľných katiónov), ale sa k nim iba blíži. Tieto pôdy nazývame slancovými pôdami.

Európske slance vo všeobecnosti dostávajú vodorozpustné sodíkové soli, potrebné na ich vznik, z dvoch zdrojov: 1. za značne suchých klimatických podmienok zo zvetranín, nahromadených na povrchu pôdy alebo jeho blízkosti; 2. z viac-menej mineralizovanej spodnej vody, ktorej hladina je v blízkosti povrchu. Prvý typ pôdy je stepný slanec, kým druhý je lužný slanec.

Z maďarčiny preložil Jozef Belaj

Obr. 1. Zasolené pôdy. Foto L. Lörinczy.

Obr. 2. Schematické profily slancov so štruktúrnym B horizontom.

Obr. 3. Schematické znázornenie niektorých fyzikálnych, chemických a fyzikálno-chemických vlastností slancov (podľa Kovdu, modifikované autorom).

Obr. 4. Šesťročné priebehy hĺbky hladiny podzemnej vody a zrážok v oblasti slancov, Hortobágy, Maďarsko (podľa Madosa).

Obr. 5. Graf výskytu solí v profile stepného slanca (podľa Kovdu).

Obr. 6. Graf výskytu solí v profile stepného slanca (podľa Dimoa).

Obr. 7. Graf výskytu solí v profile stepného slanca, ktorý prechádza do stepnej formácie (podľa Julidova).

Obr. 8. Obsah vodorozpustných solí (výluh 1:5) v kôrkovom lužnom slanci (Hortobágy, Maďarsko).

Obr. 9. Chemizmus podzemnej vody pod kôrkovým lužným slancom (Hortobágy, Maďarsko).

Mapa 1. Výskyt slancových pôd v Európe.