THE SOIL COVER OF THE BARABA LOWLAND AND ITS MODERN USE

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ABSTRACT

The structure of soil cover (SSC) is an integral characteristic of the landscape. Component composition of the soil cover reflects the spatial differentiation of elementary soil processes. The soil cover of the Baraba Lowland in Western Siberia is very compound. The spatial distribution of the soils depends on the nature of the surface, meso- and microrelief. The main characteristics of the soils on the territory are hydromorphism, salinization, solodization. They determine the type of land use in agricultural production.

INTRODUCTION

The Baraba Lowland is a vast low drainless plain in south of Western Siberia. Its area is 17 million ha, or 170 thous. km^2. In conditions of semi-arid climate it formed as an area of accumulation of soluble salts. However, the spatial distribution of them in Baraba most of all depends on the nature of the surface, meso-and microrelief, which varies greatly in different parts of the lowland.

Intensive land use in agricultural production in the last 30-35 years has led to a significant deterioration of properties of the soils and other landscape components: vegetation, microclimate and hydrological conditions. Nature- and land protection direction in land use and ecological adaptation of agriculture become important concept. This circumstance gave new impetus to studies of the soil cover structure. Kozlowski F.I. has formulated the basic principle of SSC concept development: integration of soil studies and enclosing geosystem. It contains"coded" information about the soil cover as well as other ingredients and a geosystem in whole, including its history and modern modes" [Kozlowski, 2003]. The soil cover structure is an integral characteristic of the landscape. Component composition of soil cover reflects the spatial differentiation of elementary soil processes, but geometric characteristics (number and area of elementary soil areas (ESA) and elementary soil structures (ESS)) give the possibility for quantitative assessment of spatial distribution of these processes. Development of quantitative methods for studying the structure of soil cover provides the basis for the implementation of information technology, particularly, geographic information systems (GIS).

OBJECTS AND METHODS

Comparative geographical method was applied in our study [Friedland, 1972]. The Baraba Lowland is a huge accumulative plain. In the course of geological development taken place in this territory three geomorphological regions were emerged: the Ob plateau, high and low geomorphological steps of Baraba, which are in geochemical connection and consider as 'makrokatena'. The highest point of the lowland is located 160-200 m above sea level on the Ob plateau. The lowest point is located 100-115 m above sea level at Lake Chany and near the Chany depression. Makrokatena has an overall slope to the south-west. Its length is about 350 km. Key areas (1, 2, and 3) chosen for our study characterize each geomorphological region (Figure 1).

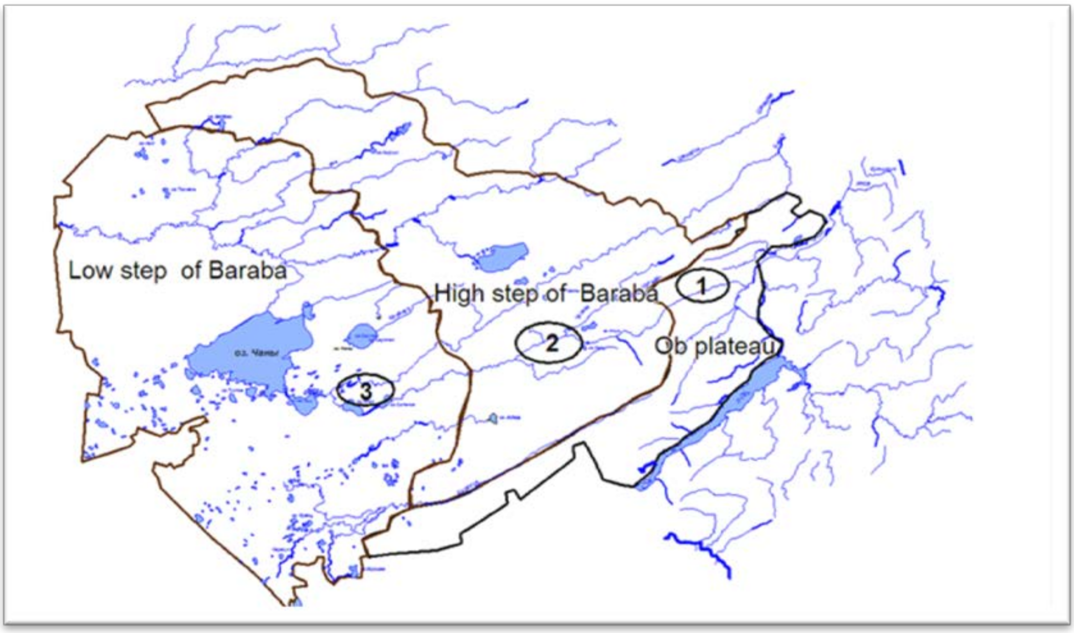

Figure 1: Location of key areas under study on the Baraba territory

The genetic and geochemical connection between elementary areals within key areas has been studied by means of caten approach [Milne, 1935]. Gradient character of ecological factors action is associated with the differences in altitude level and slope and allows for standardization of relief elements by the features. The standardization is based on Polynov's and Glazovskaya's systematics of elementary landscapes [Polynov, 1956; Glazovskaya, 1964]. It reflects the different migratory conditions of water runoff and substances. There are three main types of elementary landscapes or catena positions: eluvial with the dominance of substance removal processes with surface runoff, transit with different ratios of carry-over and substance afflux, and accumulative with predominance processes of inflow substances.

The mesorelief characteristic of three studied key areas varies considerably (Figure 2), and causes the differences in soil cover nature.

Geomorphological profile with length of 16 km on the key Ob plateau area was laid down from the highest point of 164 m above sea level to the lowest point of 107 m above sea level. Soil profiles have been made in soil habitats of the each type of elementary landscape and soil samples were selected. The component composition of soil cover, geometric characteristic of elementary soil areas and soil properties were studied.

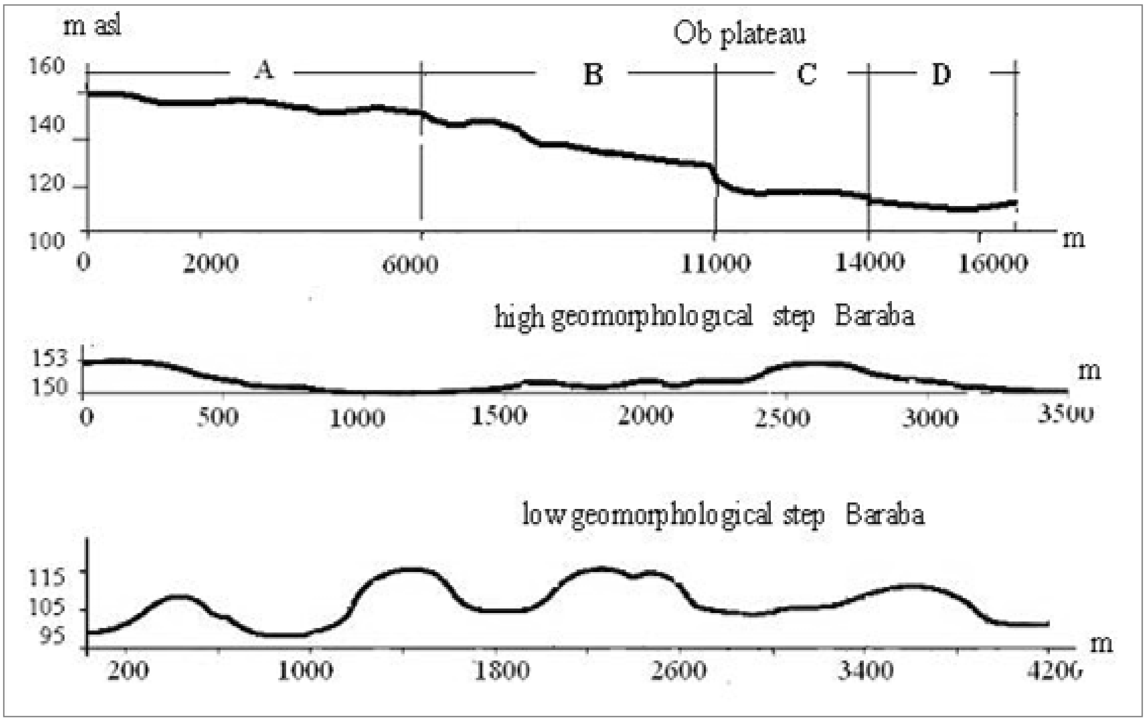

Figure 2: The relief character of key areas of the Baraba Lowland under study

Maps and the results of topographic survey made by the national soil service were used for the study of soils in key areas. A series of geomorphological profiles which were laid down in accordance with the naturally changed geochemical conditions reveals the regularity of genesis and factors of soils differentiation at the different levels of natural systems organization. The list of soil names are given in WRB system, 2006.

RESULTS AND DISCUSSION

The Ob plateau. Continuous ground line gradient from the southwest to the northeast is only 0,2°, but catena of great areal extent (up to 16 km) allows us to observe the manifestation of consecutive increase of hydromorphism and salinization.

The soils genesis was connected with the previous history of the Ob plateau formation. The general for the soil cover as a whole are the following factors: relict hydromorphism, loess carbonate sediments, surface uniformity, and the relative groundwater proximity to the surface. However, the waviness of relief even albeit insignificantly creates the conditions for spatial differentiation of water regime and elementary soil processes: leaching, salinization of soil, solonetzic and solodization. Their different combination depending on the areal location in the relief forms the diversity of soils and soil complexes.

Conditionally, catena can be divided into several sections - first order catena differing in the dominant type of water regime (Figure 2). The plot A with altitudes of 152.5 m above sea level has an angle of slope equals to 0.1°. On closed round-oval with altitudes of 163.72 - 153.75 m asl leached Voronic Chernozems Pachic are formed. These are the eluvial positions (El). In trans-accumulative weakly expressed flat depressions are located the combinations of Calcic Chernozems Sodic and Solodic Planosols Albicare. On the periphery of local depressions is Endosalic Gleysols Sodic. Substances balance in biogeocenoses of eluvial positions is determined mainly by the migration of cyclic type [Mordkovich et al, 1985], performing biological rotation of carbon and nitrogen, partly vertical, entering substances with precipitation, and horizontal, connecting the biogeocenosis with that of in the lower positions. In trans-accumulative position (TA) of the plot A the formation of combinations of Calcic Chernozems Sodic, Solodic Planosols Albic and Endosalic Gleysols Sodic is due to the formation of geochemical solonchak barrier on the border between the areals of leaching and accumulation processes.

The plot B with altitudes of 152.5 - 118.75 m asl has a more expressed slope to the north-east (0.3 °) and ends with steep slope (6.6 °) of ancient lakeside swell. This fact increases the process of surface leaching. On the other hand, a higher level of groundwater compared to the level of A determines the increase of solodization process. Therefore, the main soil cover of this site is constituted by Voronic Chernozems Pachic (Meadow-chernozemics leached) soils in complex with Greyic Phaeozems Albic.

The segment C of the studied mesocatena (118.75-112.5 m height above sea level) is characterized by a predominance of eluvial-accumulative (ElA) environments in which the complexes Calcic Chernozems Sodic with Greyic Phaeozems Albic are formed. However, on local heights automorphic soil was not formed as it was in the areas A and B, but semi-hydromorphic meadow-chernozemics soils. It is due to the vicinity of subsoil water to the earth surface. Areals of Solodic Planosols Albic and Haplic Gleysols Dystric are located in local depressions.

The plot D represents superaqueous (Ak) position of the described mezokatena and characterized by a predominance of concave surfaces with numerous micro-depressions. This fact causes a dominance of accumulation processes in soils differed by the degree of manifestation in microdepressions and associated microelevations. Additive effect of microprocessors solodization, alkalinization, peat formation generates extreme complexity of soil cover. Flow of matter and energy is due to water migration.

The ratio of elementary landscapes area with the appropriate soil combinations (Figure 3) shows the possibility of using soils in plowed field area and, in particular, in arable crop rotation. As seen in Figure 3, about 68% of the farm area falls on the top ridges soils and upper slopes (El, TEl, ElA). Soils of the trans-eluvial-accumulative and trans-accumulative landscapes, often saline, come to 28.1%. Less than 5% of the farm areas are wetlands. This distribution of the soils on the relief elements allows using the most part of the farm area in arable land.

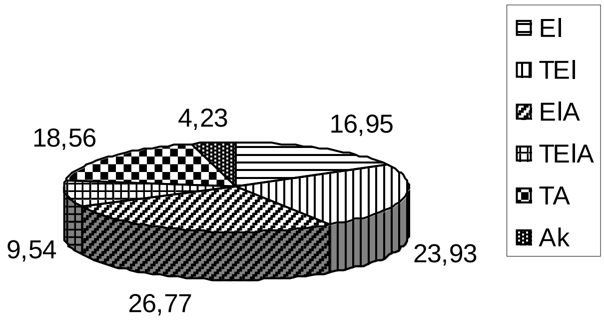

Figure 3: The soil area distribution on elementary landscapes, %
El –eluvial, TEl – trans-eluvial, ElA – eluvial-accumulative,
TElA – trans-eluvial-accumulative, TA – trans-accumulative, Ak – accumulative

As a rule, eluvial, trans-eluvial, eluvial-accumulative positions of relief with automorphic soils and their complexes, as well as the meadow-chernozem soils and their complexes are completely plowed. Often trans-eluvial-accumulative positions with chernozem-meadow complexes are involved in arable land, but their efficiency and technological quality is very low.

High geomorphological step of the Baraba Lowland

The relief of Baraba has been formed as a result of water erosion and accumulation on the background of epeirogenic movements. Pokrass E.P. and Bazilevich N.I. [Pokrass et al., 1954] distinguish the high geomorphological stage - the north-eastern part of Baraba with altitudes of 115-150 m above sea level, and low - southwest -105-115 m asl. Unlike the landscapes of the Ob plateau, the highest position on the high geomorphological step of Baraba cannot be attributed to eluvial elementary landscapes. Low altitude gradient in mesorelief and the vicinity of subsoil water to the earth surface causes semi-hydromorphic conditions.

Elevated meso-relief elements are mild manes, the relative height over the basis of erosion is not more than 3 m (Figure 2). The manes width is 0.5 -1.0 km, length - 2.5-3 km and more. The geochemical situation here is conditioned by two main processes: firstly, the humus-accumulative, migration of cyclic type (biological cycle of carbon and nitrogen) [Mordkovich et al, 1985], and secondly, eluvial-accumulative processes - vertical ascending-descending migration of water and mineral substances. Infiltration of water deeps into the soil profile in low alkaline groundwater helps manifestation solodization process - impoverishment of the humus horizon of meadow-chernozem soil with sesquioxides and the relative enrichment of silica. So, in eluvial-accumulative positions are formed:

1) Elementary areas Luvic Chernozems Sodic (Meadow-chernozemics solodic soils);
2) Combinations of Luvic Chernozems Sodic with Solodic Planosols Albic in microdepressions.

Automorphic (Calcic Chernozems Sodic) soils are characterized by island layout in the high Baraba territory. Their area is only 1.2%. Together with semihydromorphic soils, which amount is 3-9% in different farms, they are used in arable lands. However, because of a large number of microdepressions with Solodic Planosols Albic, there are limitations for winter crops due to their waterlogging and freezing.

The middle part of slopes, that is a transit catena position, is occupied by soils with a predominance of alkalinization processes of the soil profile: Luvic Chernozems Sodic (Meadow-chernozems solonetzic) and Gleyic Solonetz Albic (Solonetzes meadowish). Natric horizon is found at a depth of 12-18 cm. Here are mixed type of substances migrating - vertical and planar. These soils amount to 9-26% of the total farms area. They are characterized by a high density of solonetzic subsurface horizon, its swelling when wet and temporary deterioration aerated soils. These factors have a negative impact on the development of root system of spring wheat, so a high-quality food grain is difficult. Cultures such as rye, barley, mustard, and spring rape are more adapted to this land type.

Lower slopes with a small angle form a trans-accumulative catena position. It is characterized by a significant influence of saline groundwater on the whole soil profile. Type of migration is predominantly vertical, exudation-flushing water regime in this position results in the formation of complexes Endosalic Gleysols Sodic (Meadows solonetzic and solonchakous) with Solodic Planosols Albic. These soils amount to 44-58%. They are cold lands with slight biological activity, sustained waterlogging bottom of the soil profile. The types of use are hayfields and pastures.

Catena ends with extensive undrained depressions where is accumulation of organic matter and salts as a consequence of surface runoff from the upper biogeocenosis and salts from the groundwater. Haplic Gleysols Dystric (Meadow-boggy humus), Histic Gleysols Dystric (Peaty and peat boggy), often slightly saline in the lower part of the soil profile, seldom solonchakous are formed on this territory. These soils amount to 22-39%. It is most reasonable to use wetland spaces for water protection purposes.

The main trend in the current soil cover development is wetlands drying and their areas reducing. On releasing under the water spaces the concentration of salts in the upper horizons enhances and meadows solonchakous soils are formed.

Low geomorphological step of the Baraba Lowland

Alternation of narrow and extensive unidirectional ridges on the background of spacious wetland imparts the unique appearance of terrain and creates a special hydrological regime. Slopes of ridges are often terraced that emphasizes water-accumulative and water-erosion origin of ridges. The eluvial landscapes are formed on the ridges. On the general background of waterlogged areas the drainage ridges create conditions for the development of local automorphic processes due to which chernozem soils are formed. As a rule, soil profile still has the signs of alkalinity in the form of relatively heightened sodium amounts in the composition of absorbed cations and water-soluble salts. This type of land is a major part of the arable fund in farms used by grain-and-fallow rotations for the production of food grain. Often there are microdepressions on the ridges. They are occupied by Endosalic Gleysols Sodic (meadow solonetzic) loamy soils with predominance physical sand or chernozem-meadow loamy. The last are usually occupied by birch and aspen groves.

On the upper slopes under Luvic Chernozems Sodic (meadow-chernozemics solonetzic soils) are located chernozems solonetsous. They are also formed on the low flat ridges or elevated areas of interfluves, and are periodically influenced by groundwater. The characteristics of gleying are glaucous and rust stains on the bottom of the profile showing the modern overwetting processes. There are processes typical for trans-eluvial-accumulative elementary landscapes. On the flat lower ridges Gleyic Solonetz Albic (solonetzes meadowous deep) are formed. Natric horizon is usually located nearer to day surface as they reduce the height above sea level. Adverse agrophysical properties, moderate soil toxicity limit the crop rotation placement oriented to receive food grains. This type of lands is preferable for cultivation of forage crops. There are rational crop rotations with oats, barley, sunflowers, oilseed radish, etc.

The increase of the accumulation processes intensity results in the formation of chernozem-meadow alkaline soils, passing from decreasing altitudes to meadow solonchakous. Unfavorable soil properties prevent the use of this type of land in arable land, but here it is possible to obtain high-yield meadows.

The slope ends with salt marshes or meadow-boggy soils of inter-ridges spaces in the central part of which we often can see the lake water surface. The soils are characterized by constant waterlogging with stagnant regime, high salinity, and low biological productivity. Their use in intensive agricultural production is not effective. However, they are of large space with unique flora and fauna, which should be protected as environmental zones.

As the ridge slopes are very short, the change in soils is fast, sharp increase in salinity leads to the formation of contrasting soil cover on the slopes of ridges, especially in the lower position. In general, the territory is characterized by a dominance of accumulative elementary landscapes.

CONCLUSION

Summing up the analysis of geomorphological profiles, it should be noted that there is a relationship between soil combinations and relief positions with a certain geochemical conditions, which determines their similarity in genetic traits: a set of soil varieties, types of substances migration, the mechanism of soils differentiation that together create a certain type of elementary landscape.

As a rule, eluvial, transeluvial, eluvial-accumulative relief positions with automorphic soils and their complexes, as well as meadow-chernozem soils and their complexes have been ploughed up. Most often transeluvial-accumulative position with chernozem-meadow complexes is involved in arable land, but their efficiency and technological quality is very low. It requires a deep agroecological analysis to adapt the production to these conditions.

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