Solid phase characteristics of the Greyzemic Phaeozems Albic as a reflection of their polygenesis (Bryansk region, Russia)

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Abstract. The solid phase of Greyzemic Phaeozems Albic was studied in the paper as an archive of palaeoenvironmental information. Textural differentiation of soil profiles was observed by the granulometric fractions content. The features of second humus horizon formation were described based on water regime, granulometric composition, mineralogy, porosity, specific surface area studying. Such characteristics as texture similarity index and loessation coefficient are also involved for this purpose.

1. Introduction
The problem of the soil genesis of the Central Russian opol’e landscapes remains unresolved to the present. There are more than a ten theories of the second humus horizons origin in their profiles – paleobotany, aeolian, illuvial, paleocryogenic and others [1-3]. Among the opol’e landscapes of the Russian Plain (Vladimir, Podolsk-Kolomna, Pushchino, etc.) the soils of Bryansk region, specifically, Trubchevsk opol’e, stand out because of the specific topography of the latter, the most ancient, formed of the Dnieper glaciation. That's why its microlief is the most contrast compared with the Vladimir opol'e, and the soil humus horizon exceeds the thickness of its northern counterparts. Another interesting feature of this landscape is the presence of thick sandy loess strata, which recorded the cryogenic deformations of Late Glacial.

It is important to emphasize that all the territories studied are inhabited by man from the end of the Pleistocene and are currently plowed.

As shown in our previous studies [2] series of buried horizons of different ages were found in the profiles of the studied soils. Thus, the most ancient study horizon with data 16500±230 BP (18600-16900 BC; Ki-17414) is close to the “Trubchevsk soil” and Lascaux interstadial. It lies at a depth of 2.5-2.8 m and is represented by a light loam with thin layers of sand, carbonates through the pores and Fe-Mn-concretions. Below it the clayey carbonate BCb horizon lies (2.8-3.0 m) which is underlain by ferruginate and carbonate sandy horizon (3.5-4.2 m) – Bcfe,b. Perhaps the study horizon crowned permafrost level with processes of carbonates and iron pulling. Dated horizon is covered by noncarbonate loess (1.0-2.5 m) with humus streaks and Fe-Mn-concretions. Also the paleosol with profile Bb-BCb-Bcfe,b-Gb has good spatial expression. Buried soil with age 12930±170 BP (14200-12400 BC; Ki-17413) (interstadial Belling) lies at a depth 1.80-2.00 m and has a deformed character and stands out in the lenses of humified loam material between ferruginate sandy layers. It has a profile Bca b-Bca,fe b-Gb. Second humus horizons Ab with data 2180±60 BP (390-90 BC; Ki-17415) and 1650±60 BP (257-539 AD; Ki-18775) distinguished in the soils of microdepressions at a depth of...
0.5–0.8 m by black color, relatively high humus content (2.6%), more than in the modern plow horizon with data 330±50 BP (1454–1649 AD; Ki-17415).

On the other hand, we have previously shown [4] that the most informative archive for paleoecological recovery of the palaeoenvironment are such inertial solid phase characteristics as granulometric composition, specific surface area, mineralogy, magnetic susceptibility, porosity, bulk chemistry composition and iron content.

Thus, the goal of this study was to clarify the genesis of Greyzem Phaozems Albic (Bryansk region), based on the studying of relic soil solid phase characteristics.

2. Materials and Methods

The studied sites are located in the Bryansk region on the territory of Trubchevskoe Opol’e, where the Greyzem Phaozems Albic formed on the Late Wurm loess. Trubchevskoe Opol’e situates on the high right bank of the middle course of the river Desna (on the watershed of the rivers Desna and Sudost) in the middle latitudes of the Russian Plain (52°34’80”N, 33°38’52”E). The average annual temperature in the study area is +5.4°C. Amount of the precipitation varies from 550 to 590 mm [5]. Different types of Greyzem Phaozems Albic were formed on different elements of the landscape: their varieties with the second humus horizon - in saucer shaped micro-depressions, gleyic variants - in the middle parts of slopes and gley ones - at footslopes, deeper depressions; there are also soils without second humus horizon on the micro-elevations.

The water regime was studied in early spring by drilling using casing tubes and subsequent thermostat weighing of samples. The redox potential was measured by the potentiometer with the platinitized electrode.

The main hydrophysical characteristic was determined by tensiometric method (using a horizontal capillarimeter), by the method of sorption equilibrium and by calculations. The total specific surface of the soil was determined from the desorption curve of water vapor using the BTE equation in the region of the relative pressure P/P₀ 0.05-0.35 created with saturated salt solutions (LiCl₂ · H₂O, CH₃COOK, and CaCl₂ · 6H₂O). External specific surface area – in the region of relative pressures P/P₀ 0.55-0.98 [6]. The mineralogical composition of the coarse fraction was studied by immersion method. The content of macronutrients was determined by x-ray fluorescence method on the device Tefa-6111. The magnetic susceptibility of soils measured by kappameter KT-5.

The studies of the density of the solid phase, bulk density, soil texture were carried out using conventional methods [6].

The total iron (Fe₉) was determined by complexometry, the nonsilicate iron (Fe₉₉) was determined by the Mehr–Jackson method, the amorphous iron (Fe₉₉) was determined by the Tamm method, and the iron bound to organic matter (Fe₉₉₉) was determined by the Bascomb method [7]. The content of iron in the Tamm and Mehr–Jackson solutions was determined using a Hitachi 180-80 atomic-absorption spectrophotometer in an acetylene–air flame (detection limit 0.01 mg/l). These methods separated the groups of silicate (Fe₉–Fe₉₉) and nonsilicate (Fe₉₉) iron. The latter was subdivided into amorphous (Fe₉₉) and total crystallized iron (Fe₉₉₉–Fe₉₉₉). The determination of amorphous and crystallized iron involves some assumptions: oxalate and dithionite solutions can incompletely extract nonsilicate iron and, simultaneously, displace iron from the silicate crystal lattice.

Along with the chemical extraction of iron, the magnetic susceptibility of the soils was determined using a KLY-2 Kappa bridge for the qualitative characterization of the iron in the soils studied. The particle-size distribution was determined by the laser diffraction procedure [8].

The statistical processing of the data included (1) the calculation of the confidence interval of the mean, (2) the estimation of the significance of the difference between the means and of the mean difference by the t value, and (3) the calculation of correlation coefficients. Microstatistics (Statistica software) was used. The normal distribution hypothesis was verified by the Wilkie–Shapiro criterion [5].
Radiocarbon analyses of extractable humic acids were carried out at the Kyiv Radiocarbon laboratory (Institute of Environmental Geochemistry, Ukraine). Calibration of radiocarbon dates was performed in the program OxCal v4.2.4, based on the calibration curve IntCal 13 [9].

3. Results and Discussion

3.1. Water regime of Greyzemic Phaozems Albic
A pronounced microrelief in the form of “steppe saucers” and depressions, which determines the water regime, is the most typical and significant character of the landscape in Bryansk region, including Trubchevsk opol’e (figure 1).

A contrasting character of the water regime was observed for the different landforms. The soils of the micro-elevations are not subjected to short waterlogging even in the periods of snow melting as
compared with the soils of the accumulative components of the landscape in Bryansk opol’è. A percolative water regime is observed in the Greyzemic Phaozems Albic of micro-elevations irrespectively of the atmospheric precipitation in a particular year. The Greyzemic Phaozems Albic with a second humus horizon in the micro-depressions are characterized by the complete saturation of their profiles with water and the formation of a layer of perched water after the snow melting (from March to the second third of April). The Greyzemic Phaozems Albic of the foot of slopes (depression) in Bryansk opol’è are characterized by their stagnant percolative water regime and the maximal water saturation of the soil profile (table 1). The gley soils are characterized by the presence of groundwater, the table of which in some years does not fall below 80 cm from the soil’s surface up to early July. These hydrologic features determine the morphogenetic soil properties and the redox conditions. For example, oxidation conditions dominate in the humus horizons of the soils on micro-elevation (up to 510 mV), whereas weakly reductive ones (340 mV) dominate in the micro-depressions in the early spring.

Table 1. Some physical properties of Greyzemic Phaozems Albic.

| Horizon | Depth (cm) | MCBa (%)d | FCB (%) | MWCc (%) | Clay components | Sand components |
|---------|------------|------------|---------|----------|------------------|------------------|
|         |            |            |         |          | Fe                | Kf              | αf (mcm) | n f |
|         |            |            | f       | K        | α                | n               |
| Micro-depression | | | | | | |
| Ap      | 0-30       | 18,5       | 26,0    | 31,0     | 28.5             | 0.60            | 39.0     | 3.27 |
| A       | 30-61      | 19,5       | 27,0    | 32,5     | 35.1             | 0.61            | 46.5     | 3.10 |
| Ab      | 61-92      | 22,0       | 30,5    | 37,0     | 43.7             | 0.62            | 33.5     | 2.57 |
| AEBb    | 92-143     | 19,0       | 29,5    | 33,5     | 20.9             | 0.82            | 34.5     | 2.57 |
| Bb      | 143-150    | 19,5       | 24,0    | 25,5     | 23.0             | 0.88            | 35.0     | 2.57 |
| BCBb    | 150-200    | 18,0       | 26,0    | 30,5     | 26.4             | 0.56            | 39.0     | 2.96 |
| Micro-elevation | | | | | | |
| Ap      | 0-20       | 16,0       | 26,5    | 34,5     | 22.8             | 0.60            | 42.0     | 2.96 |
| AE      | 20-52      | 16,0       | 26,5    | 34,5     | 22.8             | 0.60            | 42.0     | 2.96 |
| Ab      | 52-88      | 15,5       | 24,5    | 33,0     | 18.2             | 0.62            | 43.0     | 2.96 |
| ABBb    | 88-142     | 16,0       | 22,0    | 28,0     | 24.5             | 0.53            | 42.5     | 3.27 |
| BCb     | 142-170    | 15,0       | 21,0    | 26,0     | 15.2             | 0.56            | 39.7     | 2.82 |

a MCB- moisture of capillary bond (0.7 MWC)
b FC - field capacity
c MWC - maximum water capacity
d % of volume
e Fe - clay (< 0.0063 mm) component content (%)
f K - clay component character
α - average diameter of sand components
hn - sand grading

These present-day characteristic variations between the hydrological and redox regimes in the Greyzemic Phaozems Albic differing in their gley intensity determine the content and composition of all the mineral compounds, such as iron, clay and others.

Analysis of the hydrophysical properties of the studied soils reveals sharp differences between the horizons in terms of porosity values, indicating their polygenetic character (table 2). The second humus horizons differ from the surface by the character of the pore space. Thus, the maximum porosity, as well as the maximum moisture content, is typical for the second humus horizon. The
smallest number of pores and minimum moisture content are characteristic of horizon Bb of soil in the micro-depression. The parameters of the main hydrophysical characteristics for this soil indicate that the second humus horizons are a water-conducting funnel for the entire profile of soils and the landscape as a whole.

3.2. Particle size composition and distribution in Greyzem Phaozems Albic

Analysis of particle size distribution (table 2) detects texture differentiation in all studied soils. In soils of micro-elevations sandy loam composition dominated. The upper modern horizons of the soils in micro-depressions have a predominantly light-loamy composition. The granulometric composition is the heaviest – medium-loamy - in the second humus horizon. The local maximum of the silt fraction in the B horizon shows the removal of silt particles from the second humus horizon and speaks of the eluvial-illuvial redistribution of the material, that is, the passage of the processes of podzolization in these soils, which is confirmed by the presence of abundant silica powder in the profiles.

The content of fine sand in the second humus horizon is lower than in modern soil, the content of silt particles in it is maximum. The dominant fraction in the surface and buried soils – coarse dust, its content is from 42 to 58%, which is typical for soils of opol’e, developed on loesses. The content and profile distribution of sand fractions is practically unchanged in the soil of micro-elevation. On the contrary, in micro-depressions the soil parent rock is heterogeneous. There are pronounced maximums in horizons AE and EB and minimums in the horizons Ap and Ab of the sand content in its profiles.

| Table 2. Particle size composition and distribution in Greyzem Phaozems Albic. |
| --- |
| Horizon | Depth (cm) | Specific density of the solid phase (g/cm³) | Bulk density (g/cm³) | Total porosity (%) | Particle size distribution (%) |
| | | | | | Glay | Silt | Sand |
| | | | | | < 0.002 | 0.002-0.063 | 0.063-2 |
| Micro-elevation |
| Ap | 0-30 | 2.60 | 1.45 | 44.2 | 8.6 | 69.2 | 22.2 |
| AE | 30-35 | 2.64 | 1.44 | 45.1 | 7.7 | 56.9 | 35.4 |
| Ab | 36-45 | 2.68 | 1.36 | 49.3 | 10.0 | 52.5 | 37.5 |
| ABb | 45-85 | 2.68 | 1.28 | 52.2 | 15.9 | 52.6 | 31.5 |
| Bb | 85-99 | 2.70 | 1.24 | 54.4 | 10.0 | 56.6 | 33.5 |
| BCb | 99-120 | 2.70 | 1.21 | 55.2 | 6.5 | 54.5 | 39.0 |
| Micro-deprepression |
| AE | 35-40 | 2.68 | 1.48 | 44.5 | 9.4 | 50.1 | 37.5 |
| Ab | 50-85 | 2.70 | 1.22 | 54.8 | 19.3 | 64.2 | 16.4 |
| AEB | 85-125 | 2.70 | 1.37 | 49.3 | 1.0 | 77.4 | 21.5 |
| Bb | 125-140 | 2.70 | 1.49 | 45.0 | 5.1 | 72.9 | 22.0 |
| Foot of slope |
| Apg | 0-40 | 2.65 | 1.32 | 50.2 | 5.1 | 72.9 | 22.0 |
| Abg | 40-60 | 2.55 | 1.14 | 55.3 | 12.5 | 71.5 | 16.0 |
| AEBg | 60-80 | 2.68 | 1.38 | 48.5 | 21.1 | 45.3 | 33.6 |
A different pattern is observed in the soil of a foot of the slope. It has the heaviest granulometric composition in comparison to the soils of the watershed – from light loam in the upper horizon Apg to loam in AEbg. And the maximum content of silt particles is confined to the eluvial horizon of AEbg. Such distribution of clay components in gleyed soils indicates the intensification of coarse soil particles destruction process in a stagnant-leaching water regime and leads to the dominance of this process over the removal of fine material from eluvial horizons.

There is another criterion for evaluation of parent rock uniformity. It is the Texture similarity index (table 3) or the sum of the minimum values of all fractions of the particle size distribution in two compared samples [6]. The calculation of the index reveals the different genesis of the lower and upper horizons of the soil profile with the second humus horizon in the micro-depression.

It is characteristic that the second humus horizon is distinguished by the highest values of the Loessation coefficient (the ratio of the coarse dust to the contents of the physical sand) too (table 3). Most likely, the upper and lower parts of the profile were formed from loess strata of different ages (table 3) and different genesis. The heterogeneity of the horizons is also enhanced by the podzolic process, and of the Ap horizons – by anthropogenic impact. In the soil of micro-elevation all horizons with the average values of this coefficient are lithological homogeneous.

The heterogeneity of the soil horizons in the depressions (foot of slopes) is associated, apparently, with the disaggregation of soil particles by the gley formation. It is the bare horizon that is characterized by the lowest values of the Loessation coefficient, they have been least exposed to cryogenic weathering.

### Table 3. Some solid phase characteristics of Greyzemc Phaozems Albic.

| Horizon | Depth (cm) | Age     | Loessation coefficienta | Texture similarity indexb |
|---------|------------|---------|-------------------------|---------------------------|
| Micro-elevation                          |          |         |                         |                           |
| Ap      | 0-30       | 1552 AD | 0.70                    | 86.7                      |
| AE      | 30-35      |         | 0.57                    | 95.5                      |
| Ab      | 36-46      |         | 0.61                    | 89.4                      |
| ABb     | 46-85      |         | 0.52                    | 92.5                      |
| Bb      | 85-99      |         | 0.59                    | 90.8                      |
| BCb     | 99-120     |         | 0.54                    |                           |
|         |            |         |                         |                           |
| Micro-depression                         |          |         |                         |                           |
| Ap      | 0-30       |         | 0.71                    | 76.5                      |
| AE      | 30-50      |         | 0.59                    | 75.8                      |
| Ab      | 50-85      | 290 BC  | 0.76                    | 80.5                      |
| ABb     | 85-125     | 5615 BC | 0.71                    | 90.3                      |
| EBb     | 125-140    |         | 0.73                    | 92.2                      |
| Bb      | 140-175    |         | 0.71                    | 97.5                      |
| BCb     | 175-220    | 17750 BC| 0.69                    |                           |
| Foot of slope                            |          |         |                         |                           |
| Apg     | 10-40      |         | 0.78                    | 72.6                      |
| Ab      | 40-60      | 398 AD  | 0.48                    | 91.9                      |
| AEbg    | 60-80      |         | 0.48                    |                           |

a,b explanations are given in the text
Indicator $K$ (table 1) reflects the participation of coarse material in the composition of clay components, regardless of their total content ($F$). In the studied soils $K$ index is very high, clay components of all horizons are coarse. The clay components ($F$) content increases with depth with maximums in the second humus and subsoil horizons in the micro-depressions.

The amount of clay components in soils of micro-elevations sharply decreases to the rock with maximum of their content in B horizon, which also indicates the differentiation of these soils.

Sand components, on the contrary, are the most resistant to destruction part of the granulometric composition of soils and soil-forming rocks. Their content reflects the duration and intensity of the impact of destructive factors. The content of sand components in soil with a second humus horizon is quite high, which indicates a low degree of processing of their material. In all horizons of the studied soils these components are coarse. The coarsest material is observed in AE horizons in soils of micro-depression.

The grain size of the sand components is average in all profiles, but the second humus horizon is distinguished by fine-grained composition. Under the same conditions, the average diameter of the sand components indicates the time during which the initial rock was exposed to the action of forming factors. At the same age, a smaller diameter indicates a greater intensity of the hypergenetic processes. With the strengthening of the soil formation processes the sorting of sand components increases. In the studied soils the sorting of sand components mostly weak. It is slightly increased only in the modern humus (plowing) horizons of soils of the micro-depression (probably due to anthropogenic factor) and in the AB horizon at micro-elevation.

Thus, sharp differences in the analyzed indicators demonstrate the heterochronic and polygenetic soil horizons. The high content of clay components in the second humus horizon, the lowest values of grain and high of Loessation coefficient indicates a high intensity of cryogenic processes in the past. Increased granularity and low sorting coincide, as a rule, with the polymineral composition of sand components with a significant proportion of minerals of low stability (feldspar, plagioclases, etc.). The decrease in grain size and the increase in sorting is accompanied by a change in the mineralogical composition to predominantly quartz with the participation of other strong minerals.

The mineralogical composition of soils correlates with the composition of the soil-forming rock. Quartz abruptly prevails in all loess horizons, grains of feldspar are affected by weathering processes. Soil mineralogy is closer to the dnieper and the first prednieper loess with such characteristics as: the presence of iron hydroxide; the low content of hornblende; the grain of almost all minerals affected by weathering. Accumulation of ferruginous minerals in the middle and lower part of the profile evidence ancient hydromorphism of the studied soils and the unusual distribution of quartz can be explained by the imposition of the podzolization process on the pre-existing soil profile.

Due to molecular ratios, presented in table 4, it can be seen that the formation of soils in microelevation is influenced by the podzolization processes, which began after the formation of humus horizons. The maximum value of ratio $[\text{SiO}_2]/[\text{clay}]$, showing the degree of enrichment of silt with silica, is achieved in the eluvial horizons, decreasing in the horizon AB.

The maximum values of the ratio $[\text{R}_2\text{O}_3]/[\text{clay}]$ in the AE horizon characterize its contrast redox regime in the early spring. The profile distribution of the ratios $[\text{SiO}_2]/[\text{clay}]$ and $[\text{R}_2\text{O}_3]/[\text{clay}]$ in the soil with the second humus horizon of the microdepression as a whole is the same. This distribution of ratios shows that, despite the presence of the podzolization processes, the modern conditions of moistening influence on the soil formation in the micro-depressions mainly.

The ratio $[\text{SiO}_2]/[\text{clay}]$ decreases with depth in the soil profile of the depression (foot of slopes), which is explained by the disaggregation of the mineral part under the stagnant water regime.

The distribution of the ratio $[\text{R}_2\text{O}_3]/[\text{clay}]$, as well as the ratio $[\text{SiO}_2]/[\text{clay}]$, is characterized by a uniform decreasing down the profile. But simultaneously, these are the minimum values, especially in gleic horizons, comparison with soils of watershed landscapes.
3.3. Some physical properties of Greyzemtic Phaozems Albic

Specific surface area values correlate well with the results of the analysis of soil granulometric composition – with the content and distribution of silt particles ($r=0.76-0.78$, $P=0.99$), and with the content of humus ($r=0.70-0.95$, $P=0.99$) [5]. Thus, the maximum value of the specific surface area ($54.8 \text{ m}^2$) in the soil at micro-elevation in the horizon B corresponds to the maximum value of the silt fraction content (15.9 %).

The initial correlation between the value of the specific surface area and the granulometric composition of soils is observed in the second humus horizons in soils of micro-depressions. Simultaneously, the internal specific surface area is dominated by over the external one in the second humus horizons which is due not only to the increased content of humus, but also with its qualitative composition [5].

Humus horizons of gleic soil of the flow hollow are characterized by the highest values of the specific surface area, which is due to the increased content of humus and the maximum content of non-silicate iron. Simultaneously, the removal of non-silicate iron during the gleying leads to the disaggregation of soil particles and, in accordance with this, to an increase in the specific surface values.

### Table 4. Specific Surface area of Greyzemtic Phaozems Albic.

| Horizon | Depth (cm) | Specific surface area ($\text{m}^2$/g) | [R_2O_3]/[clay] | [SiO_2]/[clay] |
|---------|------------|--------------------------------------|-----------------|----------------|
|         |            | Total                                | Outer           | Inner          |
| Micro-elevation |          |                                      |                 |                |
| Ap      | 0-30       | 45.6                                 | 34.0            | 11.6           | 1.58           | 8.82           |
| AE      | 30-35      | 45.0                                 | 28.7            | 16.3           | 2.04           | 9.42           |
| Ab      | 36-46      | 51.9                                 | 33.6            | 18.3           | 1.44           | 7.39           |
| ABBb    | 46-85      | 54.8                                 | 48.9            | 6.0            | 0.79           | 4.47           |
| Bb      | 85-99      | 39.9                                 | 32.1            | 1.8            | 1.16           | 6.51           |
| BCCb    | 99-120     | 33.1                                 | 17.8            | 15.2           | 1.47           | 9.18           |
| Micro-depression |          |                                      |                 |                |
| Ap      | 0-30       | 50.5                                 | 25.0            | 25.5           | 1.07           | 5.80           |
| AE      | 30-50      | 58.7                                 | 13.7            | 26.7           | 1.34           | 7.98           |
| Ab      | 50-85      | 68.4                                 | 31.6            | 36.9           | 0.64           | 4.11           |
| ABBb    | 85-125     | 31.8                                 | 23.9            | 7.8            | 12.62          | 78.80          |
| EBBb    | 125-140    | 52.4                                 | 43.8            | 8.6            | 2.75           | 15.21          |
| Bb      | 140-175    | 33.4                                 | 32.6            | 0.8            | 1.36           | 7.51           |
| BCCb    | 175-220    | 48.4                                 | 45.8            | 2.5            | 1.52           | 7.99           |
| Depression (foot of slope) |          |                                      |                 |                |
| Apg     | 10-45      | 88.4                                 | 40.7            | 47.7           | 0.83           | 6.34           |
| Abg     | 30-35      | 94.6                                 | 44.3            | 50.3           | 0.49           | 3.78           |
| AEbg    | 60-80      | 28.4                                 | 15.3            | 13.2           | 0.30           | 2.99           |
| G       | 80-110     | 29.6                                 | 13.8            | 15.8           | 0.32           | 2.98           |
The distribution of the forms of iron compounds along the soil profile on a micro-elevation is uniform. The exception is the horizon AB with a maximum content of amorphous iron and its inorganic forms and a minimum content of non-silicate forms of iron associated with organic matter (Fe_{ba}) (table 5). The same horizon is characterized by maximal coefficient Fe_{o}/Fe_{d} values, which diagnoses a high degree of crystallization of free iron oxides and hydroxides. The maximum content of forms of iron associated with organic matter is observed in the second humus horizon and in horizon B. The Fe_{o}/Fe_{d} coefficient in this soil has higher values than in the soil of micro-elevation with a maximum in the subsoil horizon and a minimum in the arable one. The maximum amount of iron compounds in the second humus horizon indicates hydromorphic soil formation conditions. An increase in the iron content in the illuvial horizon B of micro-depression compared with the second humus horizon indicates the podzolic stage of studied soils development in the past. This hypothesis is confirmed by our data of the lignin phenols composition [5].

Low values of magnetic susceptibility in almost all horizons of the soil profile in micro-depression (except arable) also indicate hydromorphic conditions for the formation of soils. Thus, in conditions of excessive moisture, the subsurface humus horizon and buried “Trubchevsk soil” are formed.

**Table 5.** Iron forms in Greyzemnic Phaozems Albic.

| Horizon | Depth (cm) | Fe_{2}O_{3} (% in annealed sample (Fe_{t})) | Fe_{d} (% of soil weight) | Fe_{o} (% of soil weight) | Fe_{ba} (% of soil weight) | Fe_{o}/Fe_{d} | Magnetic susceptibility of soil (χ · 10^{-6} cm^{3} g^{-1}) |
|---------|------------|-------------------------------------------|---------------------------|---------------------------|----------------------------|--------------|---------------------------------------------------|
|         |            | Micro-elevation                            |                           |                           |                           |              |                                                   |
| Ap      | 0-30       | 2.80                                      | 0.51                      | 0.09                      | 0.03                      | 0.18         | 31.5                                             |
| AE      | 30-35      | 3.52                                      | 0.59                      | 0.08                      | 0.02                      | 0.13         | 31.5                                             |
| Ab      | 36-46      | 3.05                                      | 0.52                      | 0.07                      | 0.01                      | 0.13         | 21.1                                             |
| ABb     | 46-85      | 2.85                                      | 0.46                      | 0.06                      | 0.02                      | 0.13         | 19.5                                             |
| Bb      | 85-99      | 2.62                                      | 0.27                      | 0.05                      | 0.04                      | 0.19         | 16.8                                             |
| BCb     | 99-120     | 2.37                                      | 0.21                      | 0.04                      | 0.04                      | 0.21         | 17.1                                             |
|         |            | Micro-depression                           |                           |                           |                           |              |                                                   |
| Ap      | 0-30       | 2.84                                      | 0.47                      | 0.17                      | 0.05                      | 0.36         | 16.1                                             |
| AE      | 30-50      | 2.91                                      | 0.48                      | 0.19                      | 0.06                      | 0.39         | 11.3                                             |
| Ab      | 50-85      | 2.50                                      | 0.51                      | 0.18                      | 0.09                      | 0.35         | 19.4                                             |
| ABBb]   | 85-125     | 2.53                                      | 0.45                      | 0.14                      | 0.05                      | 0.34         | 13.2                                             |
| EBBb    | 125-140    | 2.71                                      | 0.46                      | 0.15                      | 0.03                      | 0.33         | 13.9                                             |
| Bb      | 140-175    | 2.71                                      | 0.46                      | 0.11                      | 0.00                      | 0.24         | 8.7                                              |
| BCb     | 175-220    | 2.95                                      | 0.51                      | 0.10                      | 0.01                      | 0.20         | 11.0                                             |
|         |            | Foot of slope                              |                           |                           |                           |              |                                                   |
| Apg     | 0-40       | 2.44                                      | 0.58                      | 0.16                      | 0.03                      | 0.28         | 10.5                                             |
| Abg     | 40-60      | 2.41                                      | 0.58                      | 0.16                      | 0.04                      | 0.27         | 10.3                                             |
| AEbg    | 60-80      | 1.24                                      | 0.15                      | 0.05                      | 0.04                      | 0.30         | 3.0                                              |
| G       | 80-110     | 1.61                                      | 0.24                      | 0.03                      | 0.04                      | 0.14         | 2.7                                              |
4. Conclusions

Such characteristics of soil solid phase as particle size composition and distribution, loessation coefficient values, textural similarity index for the different horizons and for the different soils of the Bryansk Opole reflect their polygenetic character, diagnosing the surface nature of the buried humus horizons in the past and the multiplicity of the loess-sand-soil thickness and lithology, generally.

Different climatic epochs correspond to different types of soil and humus formation. Cryogenic features - banding, high values of looseness in cracks, minimum diameters of sandy components - indicate the cryogenic stage of the last wave of Valdai glaciation. The accumulation of iron compounds, low magnitudes of magnetic susceptibility and the characteristics of particle size composition diagnose the hydromorphic stage, apparently the meadow stage of soil formation. The eluvial-illuvial redistribution of particle size fractions, forms of iron, abundant silica powder, diagnosing the forest stage of the formation of humus horizons in the Atlantic period of the Holocene climatic optimum. Apparently, leaching processes intensified during the Late Holocene cold epochs. Soil plowing leads to changes in the initial properties of the soil and the complex nature of the microrelief.

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