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THE INFLUENCE OF GENESIS AND POSTGENETIC PROCESSES ON THE ENGINEERING-GEOLOGICAL PROPERTIES OF CLAYS AND LOESSES

E. SERGEYEV, R. ZIANGIROV, Z. KRIVOSHEYEVA,
A. MINERVIN, V. OSIPOV (*)

RÉSUMÉ

Les processus génétiques et postgénétiques déterminent la composition chimique et minéralogique et la microstructure dont dépendent les propriétés des argiles et des lœss. Il est démontré que les argiles d'origines différentes ont des résistances, des propriétés chimiques et autres caractéristiques différentes. D'autre part, les argiles de la même origine ont une série de propriétés communes. La genèse a une influence particulièrement marquée sur les premiers stades de la lithogenèse : les différences existant dans la zone de catagenèse s'estompent.

Le processus d'altération météorique peut détruire des propriétés génétiques des sols. Les lœss offrent un très bon exemple de la réduction des différences originelles après altération. Parmi les lœss qui, comme les argiles, peuvent avoir différentes origines, il y a des lœss typiques supposés d'origine éolienne possédant une subsidence élevée : l'altération météorique peut transformer un type quelconque de lœss en lœss typique montrant une subsidence. Les principales propriétés des lœss ne résultent pas de leur consolidation pendant la formation du dépôt comme on l'a supposé auparavant mais bien de leur reconsolidation résultant de l'évolution postgénétique.

Quatre conclusions principales peuvent être déduites des résultats obtenus :

1. Les propriétés en géologie de l'ingénieur des argiles et des lœss au premier stade de la lithification sont régies par leur genèse, mais au cours des stades suivants, elles dépendent de processus postgénétiques qui peuvent être des formes progressives ou régressives de lithogenèse.
2. En utilisant les méthodes de la géologie de l'ingénieur exposées ici, des problèmes fondamentaux de géologie générale peuvent être résolus.
3. L'investigation de l'action des processus génétiques et postgénétiques sur les sols — et spécialement de l'altération résultant des propriétés en Géologie de l'Ingénieur — est nécessaire pour reconstituer l'histoire géologique de toute région et inversement.
4. Les résultats exposés sont d'un intérêt immédiat pour l'application en génie civil.

It is well known that the properties of clay and loess soils depend on their chemico-mineralogical composition and microstructure which, in their turn, are governed by the genesis of these soils and the postgenetic processes. We shall dwell on the data obtained by R. Ziangirov [1], who studied the correlation between the

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(*) Geological Department, Moscow State University.

deformation and the classification indices of clays with different genesis. About 900 soil samples have been studied. These mainly belonged to the Quaternary period and were as a rule taken from the depth of $1+15$ m. The correlative relationship between the compression coefficient C_c and the void ratio ε was established. The regression equations and correlation coefficients are given in table 1.

TABLE 1. — *Regression equations for different genetic types of soils*

Genesis, lithology and age	C_c^r/ε	Regression equation	$\frac{1-r^2}{\sqrt{n}}$	Applicability limits with respect to r
Clay deposits, Qal	0.69	$C_c = 0.38\ \varepsilon - 0.12$	0.05	0.40-1.30
Clays, Qal	0.74	$C_c = 0.35\ \varepsilon - 0.10$	0.07	0.55-1.35
Loams, Qal	0.60	$C_c = 0.40\ \varepsilon - 0.12$	0.08	0.45-1.05
Sandy loams, Qal	0.73	$C_c = 0.25\ \varepsilon - 0.09$	0.12	0.55-0.80
Clay deposits, Qeld	0.66	$C_c = 0.45\ \varepsilon - 0\ 16$	0.05	0.50-1.10
Clays, Qeld	0.63	$C_c = 0.29\ \varepsilon - 0.06$	0.10	0.65-1.10
Loams, Qeld	0.74	$C_c = 0.59\ \varepsilon - 0.25$	0.05	0.50-1.00
Clay deposits, Qfgl	0.77	$C_c = 0.51\ \varepsilon - 0.19$	0.05	0.40-0.90
Clays, Qfgl	0.72	$C_c = 0.69\ \varepsilon - 0.32$	0.13	0.60-0.90
Loams, Qfgl	0.48	$C_c = 0.29\ \varepsilon - 0.04$	0.15	0.45-0.75
Sandy loams, Qfgl	0.72	$C_c = 0.32\ \varepsilon - 0.11$	0.13	0.40-0.75
Moraine deposits, Qgl	0.68	$C_c = 0.22\ \varepsilon - 0.02$	0.08	0.30-0.70
Clay deposits, Qlal	0.68	$C_c = 0.26\ \varepsilon - 0.04$	0.08	0.40-1.15
Clays, Qlal	0.85	$C_c = 0.45\ \varepsilon - 0.24$	0.06	0.65-1.15
Loams, Qlal	0.45	$C_c = 0.26\ \varepsilon - 0.02$	0.18	0.45-0.90
Sandy loams, Qlal	0.80	$C_c = 0.32\ \varepsilon - 0.09$	0.13	0.40-0.80
Highly plastic clay deposits of different genesis	0.82	$C_c = 0.42\ \varepsilon - 0.20$	0.05	0.70-1.30
Clay deposits in total, Qal, eld, dl, aldl, lal	0.68	$C_c = 0.37\ \varepsilon - 0.11$	0.03	0.40-1.30
Highly plastic clay deposits of different genesis (pre-Quaternary)	0.88	$C_c = 0.27\ \varepsilon - 0.12$	0.04	0.70-1.50
Highly plastic clay deposits of different age and genesis	0.87	$C_c = 0.26\ \varepsilon - 0.08$	0.02	0.70-1,50

It is seen from this table that the parameters of regression equations for different genetic and lithological groups differ. Thus, with the same correlation coefficient the parameters of regression equations for alluvial and alluvial-lacustrine soils happen to be different in groups which are lithologically similar. The parameters of regression equations for alluvial, eluvial-diluvial and lacustrine-alluvial clays also differ.

So, with clay soils of different genesis having common regression equations, the parameters of these equations differ substantially from one another. This is associated with the influence of clay soil composition and structure, which, in their turn, depend on the genesis of clays.

In contrast, clay soils of one and the same genesis have much in common. L. G. Koff, A. S. Polyakov and E. M. Sergeyev [2], for example, have shown that Holocene clay shelf deposits of the Barents, Caspian and Black Seas acquire, in the process of diagenesis, common microfabric features with which their porosity, natural water content and cohesiveness are connected (fig. 1). It is of particular

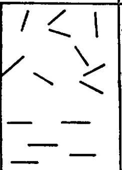
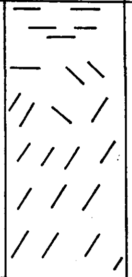
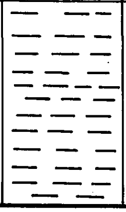
Microfabric layers	Microfabrics		Porosity %	Natural water content (W)	Strength Kg/gm^2
First *ℓ*	Non orientated, weakly orientated to plane of bedding		from 65 to 95 from 50 to 65	W ≳ Wf	from 0,01 to 0,05 from 0,15 to 0,5
Second *ℓ*	Orientated >45° to plane of bedding		35-45	Wf ≥ W ≥ Wp	1,0 -1,5
Third *ℓ*	Orientated to plane of bedding		< 35	W ≲ Wp	> 1,5

FIG. 1. — *Changes of marine clay sediment microfabrics in the process of diagenesis.*

interest that all marine deposits acquire, at a certain stage of their diagenesis, the orientation of microaggregates and clay particles at an angle of 45° to the bedding plane (fig. 2) and only later become arranged parallel to the bedding (fig. 3).

Genesis affects the engineering-geological properties of clay and loess soils, determining their composition, structure and thereby their properties. What chemico-mineralogical composition is being acquired by clay soils in the process of genesis is especially important.

Clay minerals constitute the most significant part of clay soils. These minerals are subdivided into two groups with sharply differing properties. Kaolinite and halloysite belong to the first group and hydromica, montmorillonite, vermiculite and the majority of mixed-layer minerals to the second.

The minerals of the first group have a double layer crystal lattice, the basal surfaces of the elementary structural packet of these minerals being of different crystallochemical types: one of them is of the hydroxilic and the second of the oxygen type (fig. 4). Isomorphic substitutions are practically absent in the minerals of this group, therefore their crystal lattice is electroneutral.

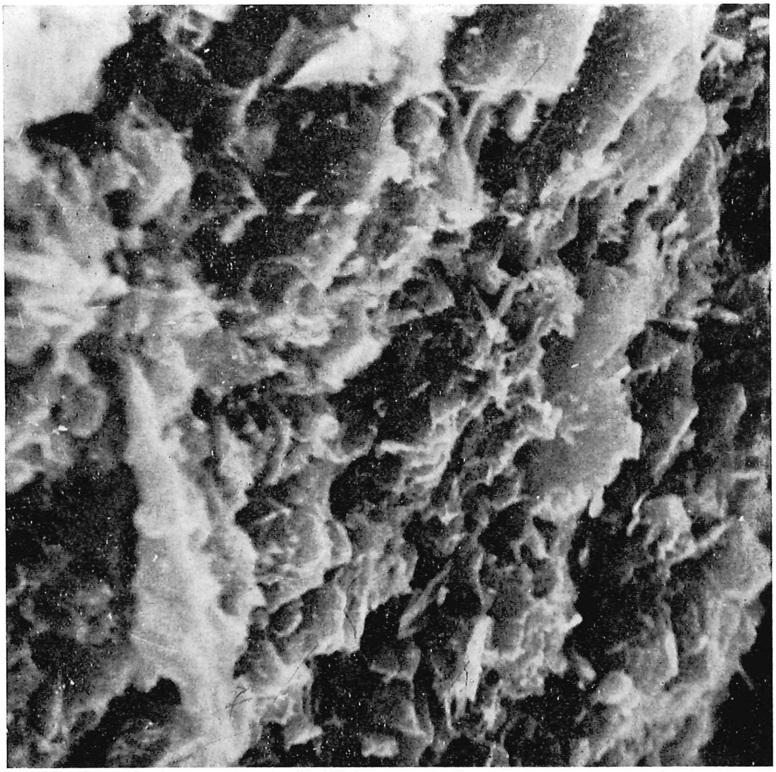


FIG. 2. — *Microfabric of young clay sediments orientated at an angle* $> 45°$ *to the bedding plane.*

The minerals of the second group have a triple layer elementary structural packet with homogeneous (oxygen) basal surfaces (fig. 5). The minerals of this group are specifically characterized by a high degree of non-stichiometric isomorphic substitutions in their crystal lattices, which results in the particles of these minerals having a highly negative structural charge.

The peculiarities of the crystal lattice structure and the energy state of clay minerals directly affect the character of the microstructures formed in young clay sediments during the process of sediment accumulation. Thus, the absence of exchangeable cations on the basal surfaces of kaolinites and the poor hydration of these surfaces create favourable conditions for the particles to be aggregated on the basis-basis principle under the influence of molecular attracting forces (fig. 6). Interactions of the basis-face and face-face types are less characteristic of kaolinites [3]. It should also be noted that the composition of exchangeable cations does not influence significantly the character of interaction between kaolinite particles and the microaggregate formation.

By contrast, in the minerals of the second group, due to a large diffusion layer, the bond between the basal surfaces of two adjacent particles is weak. In this case the angles and the lateral faces of particles are the most hydrophobic, therefore particle aggregation interactions of the basis-face and face-face types are quite

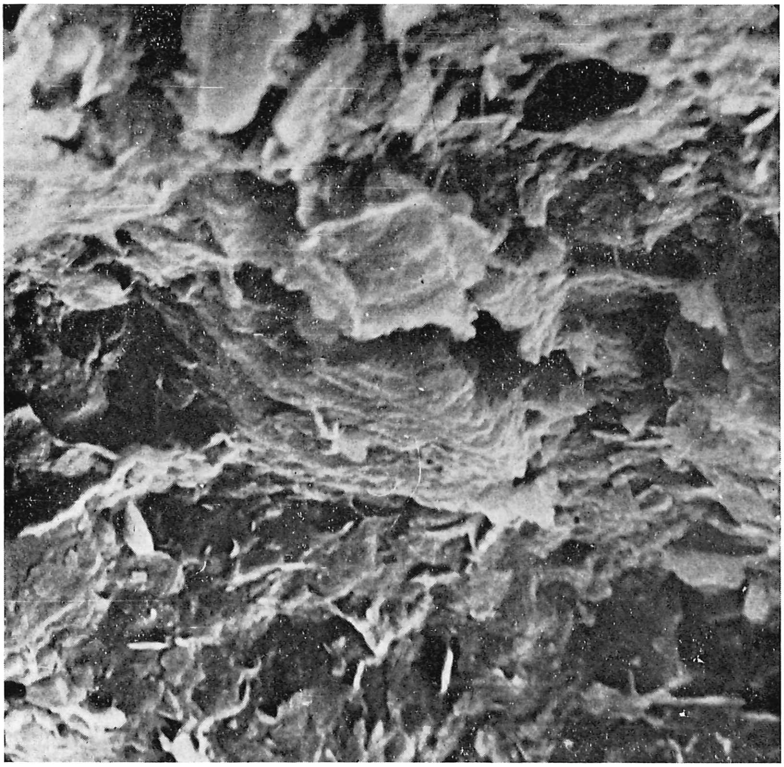


FIG. 3. — *Microfabric of young clay sediments orientated parallel to the bedding plane.*

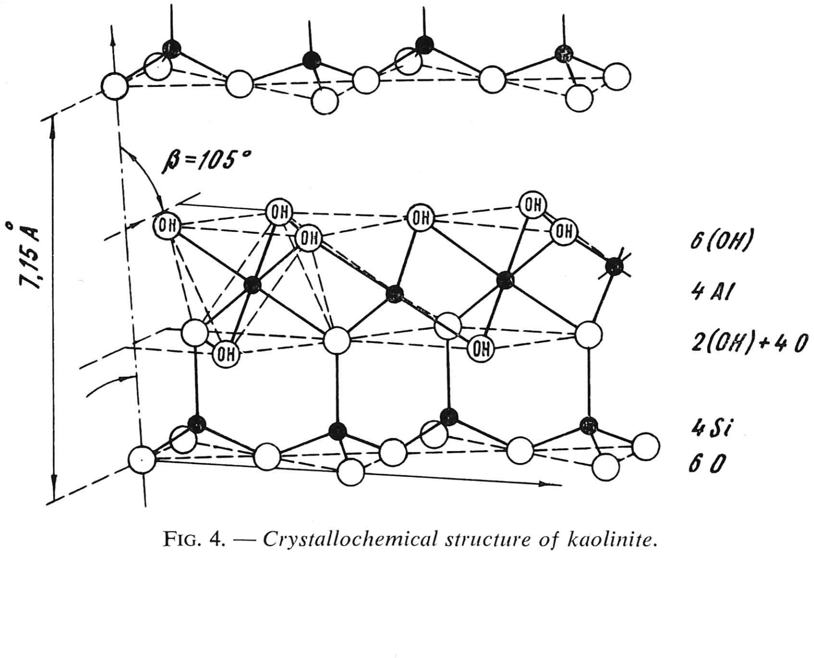


FIG. 4. — *Crystallochemical structure of kaolinite.*

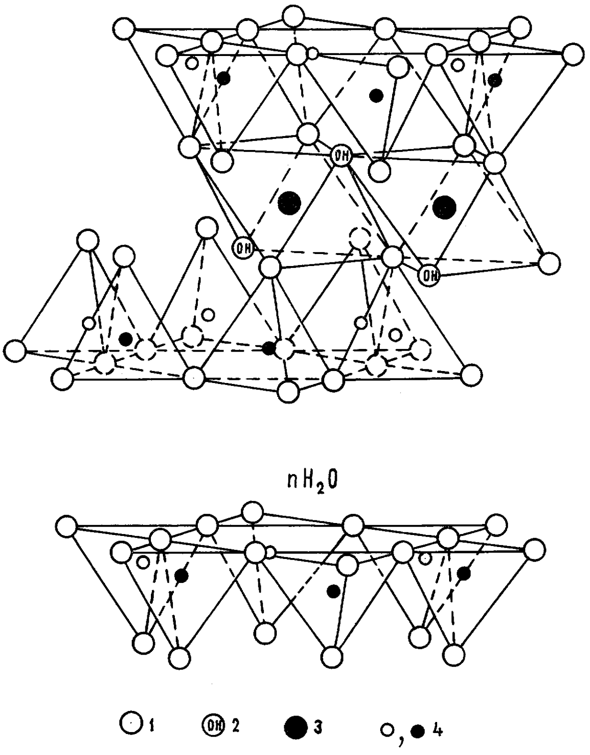


Fig. 5. — *Crystallochemical structure of montmorillonite. 1. oxygen; 2, hydroxyl; 3, aluminium, iron, magnesium; 4, silicon, sometimes aluminium.*

common in montmorillonite (fig. 7). In the sediments of these minerals the character of the microstructure depends to a substantial degree on the composition of exchangeable cations: the increase of cation valency and the expansion of their ionic radii results in decreasing the thickness of diffusion layers on clay particle basal surfaces, which favours the increase of aggregate dimensions and the formation of basis-basis type contacts between particles.

The foregoing indicates that there is an interconnection between the mineralogical composition and the character of sediment structure. However, it would be wrong to think that the microstructure of clay sediments depends exclusively on their chemico-mineralogical composition. The character of the structures and, consequently, the properties of clay sediments are substantially affected by their genesis, i.e. the conditions in which the sediment accumulation process is taking place.

In order to have a general understanding of the role of genetic factors, we can consider, by way of illustration, how the formation of clay sediment microstructures is influenced by the pH of the medium. The influence of this factor on the character of clay particle interaction can be appraised proceeding from the results of experimental studies on the energy state of lateral faces in clay mineral particles carried out first by Van Olphen [4] and then also by Schofield and Samson [5], Osipov and Sergeyev [6]. These studies have shown that electrostatic active centres are formed on crystal faces of clay minerals, the density and sign of these

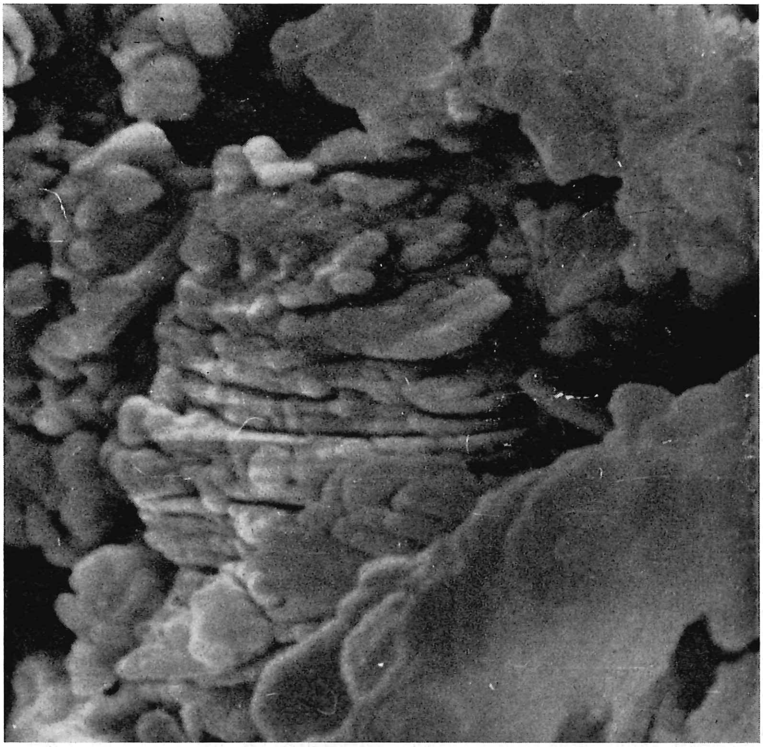


FIG. 6. — *Interaction of the basis-basis type between kaolinite particles.*

centres depending on the reaction of the medium. In the acid medium, due to the dissociation of aluminium compounds following the alkaline pattern, the lateral faces of clay particles are charged positively (fig. 8*a*), and in the alkaline medium, because of the dissociation of aluminium and silica following the acidic pattern, negative active centres are formed (fig. 8*b*). On the basis of these data we can explain, on the one hand, the active aggregation of clay particles in the acid medium resulting in the formation of a very loose sediment with the "house of cards" structure, described in literature by Lambe [7], Tan Tyong-Ky [8] and Rosenqvist [9] and, on the other hand, the formation of a sufficiently compact and well dispersed sediment with good particle orientation in the alkaline medium.

This can be confirmed by the data of V. I. Osipov who studied the volume of sediment obtained from 100 cm^3 of 1 % Na-kaolinite suspension depending on pH of the medium. Definite pH values were preassigned by adding a small quantity of HCl into the suspension for the medium to have the acid reaction, or NaOH for it to have the alkaline reaction. From the data obtained (fig. 9) it is possible to make the following conclusions: *a*) in the acid medium kaolinite has a very loose structure, its density being 6-7 times lower than that of the microstructure formed in the alkaline medium; *b*) the changeover from a loose to a compact sediment, i.e. the change of its microstructure occurs very sharply and in a narrow interval of pH values ($pH = 7.8 + 8.2$). This latter phenomenon indicates

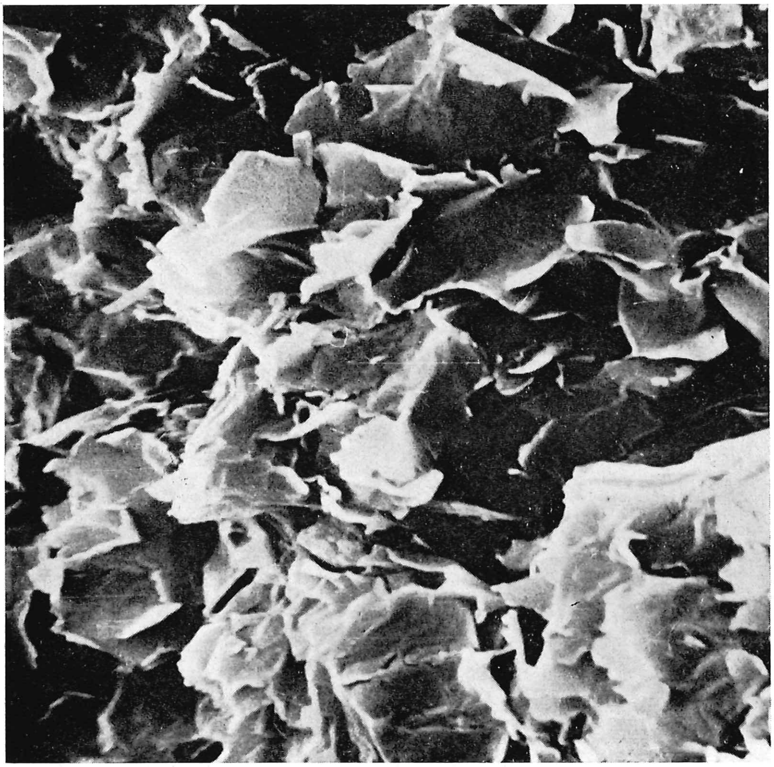


FIG. 7. — *Interaction of the basis-face type between montmorillonite particles.*

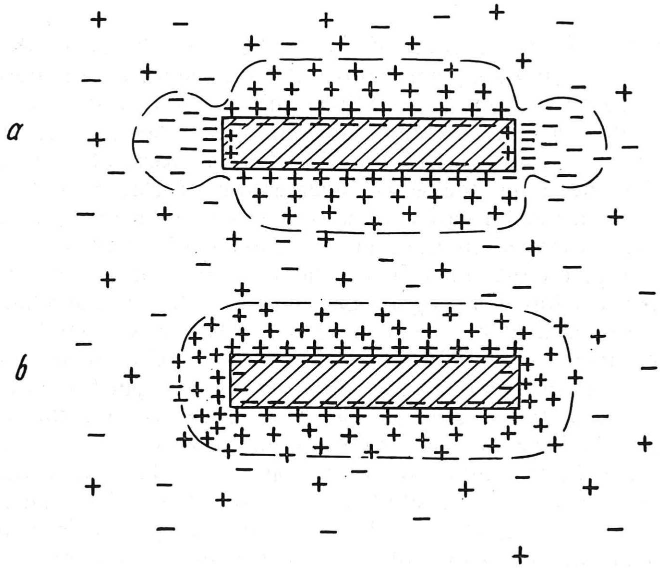


FIG. 8. — *Structure of the micelle in the acid (a) and the alkaline (b) media.*

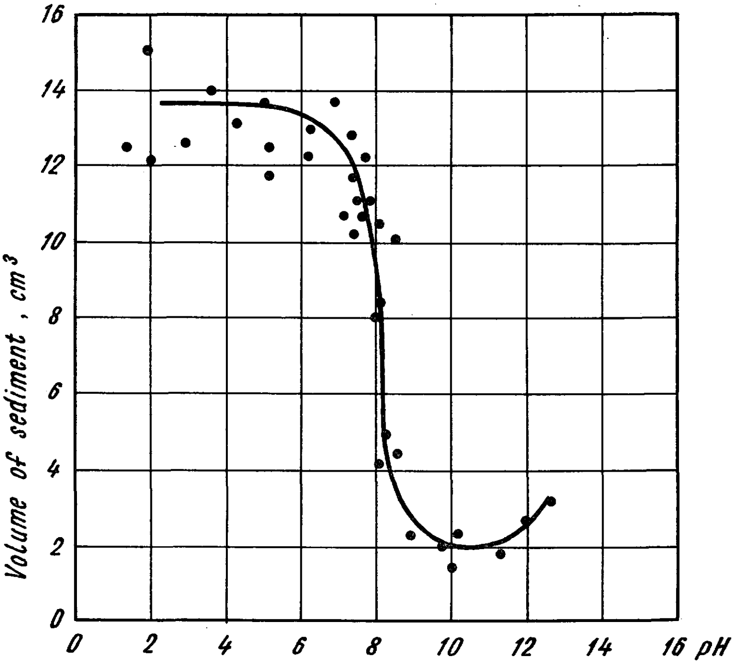


FIG. 9. — *Volumetric change of* Na-*kaolinite sediment depending on pH of the medium.*

that the microstructure of clay sediments in the majority of water bodies with a normal acidity of the medium (neutral or alkaline) can be radically changed even with minor pH fluctuations one or the other way.

Thus, at the stage of sedimentogenesis the main factors conditioning the state and the properties of the young clay sediments formed are their chemico-mineralogical composition and genesis. The influence of these factors remains decisive also at the first stages of the process of sediment diagenesis. This can be proved by the character of kaolinite sediment consolidation, the sediments having been produced in the acid and alkaline medium conditions and having a different microstructure (fig. 10). The data obtained indicate that up to pressures of the order of 50-80 kg/cm^2 each sediment retains its "individuality," determined by its composition and conditions of formation. At higher pressures the influence of the chemico-mineralogical and genetic peculiarities of a clay soil on its state and properties becomes less apparent. This is, first of all, explained by the fundamental change in the character of structural bonds in clay soils at these pressures, viz. the formation of strong point or phase contacts between particles characteristic of soils with cementing structural bonds.

Cementing structural bonds are formed due to postgenetic processes (consolidation of the soil and its dehydration, deposition of cementing materials at particle contacts, composition and distribution of cementing materials at particle contacts, etc). Therefore with the degree of clay lithification increasing we observe more and more clearly the "erasure" of the influence of clay composition and

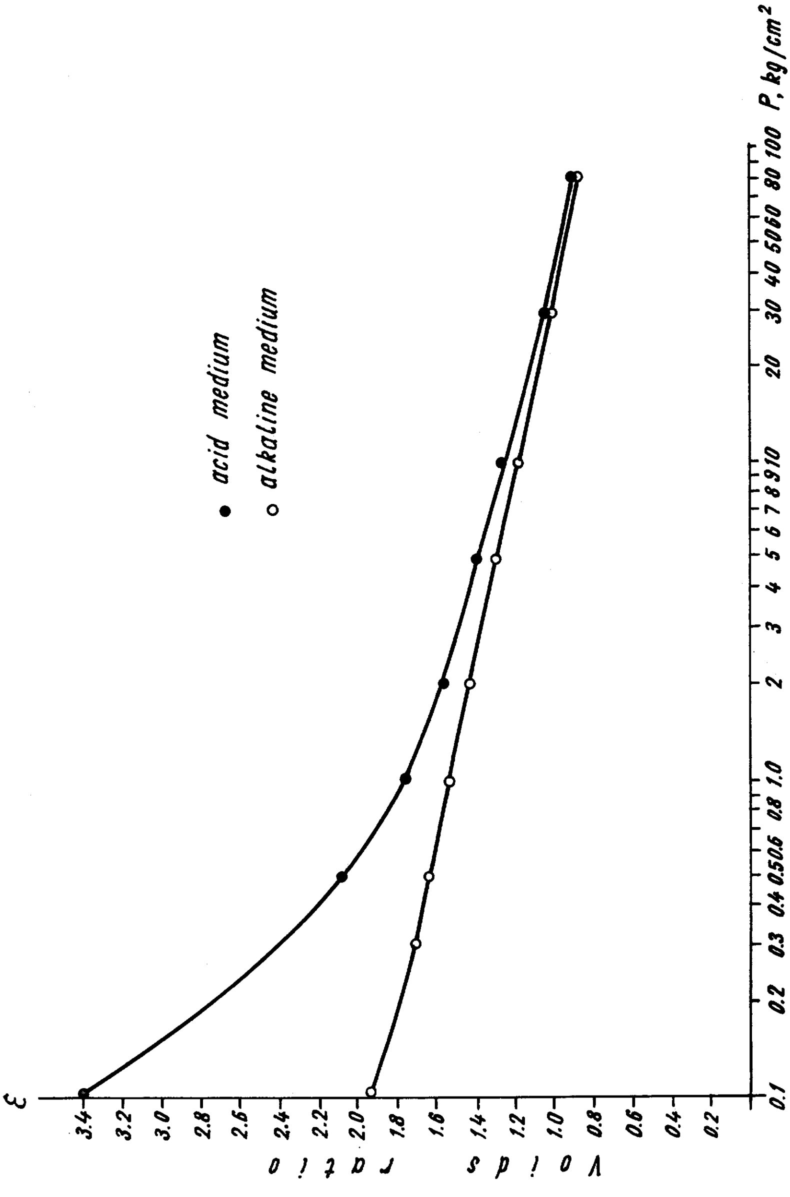


FIG. 10. — *Compaction of kaolinite sediment at different values of pH of the medium.*

genetic features and the growing role of postgenetic processes in forming the strength and other properties of clay soils. This is distinctly seen from the way the soils change in the katagenesis zone, which is subdivided by Z. A. Krivosheyeva [10] as shown in fig. 11.

The zone of katagenesis can be subdivided into three subzones: the early, middle and late katagenesis. The early katagenesis zone (first subzone) goes down from the surface to the depths of 1 400-1 500 m. Predominant temperatures here reach at the lower boundary 40 °C and the pressure is of the order of 270-300 kg/cm^2. The mineralogical composition of clays in the zone described changes with depth insignificantly, remaining practically the same as it was formed during the processes of sedimentation and sediment diagenesis. Only trioctahedral hydromicas disappear. These pass through a series of transition minerals with ordered and nonordered mixed-layer structures of the chlorite-montmorillonite and chlorite-dioctahedral hydromica types into montmorillonite and kaolinite.

The fabrics of clays in this subzone do not display any visible change with depth, retaining their initial make-up and being highly diversified. They have irregular, laminated and clotty mesofabrics with a differing degree of clay particle orientation. The orientation coefficient in different clay interlayers varies from 0 to 70 %.

The physical properties of clays are found to be much more sensitive to the change of conditions with depth. Their specific gravity varies, on the average, from 2.80 g/cm^3 to 2.82 g/cm^3 increasing near the lower boundary of the zone to 2.87 g/cm^3.

In the early katagenesis zone intensive consolidation of clays is taking place as a result of dehydration under the effect of the growing gravitation pressure. The volumetric weight of air-dry clays increases with depth to 2.38-2.40 g/cm^3 (mean values). Porosity change is about 2 % for every 100 m, natural water content drops, reaching the level of the soil plastic limit.

The influence of the primary genetic factors in the upper subzone of katagenesis still manifests itself very distinctly and is confirmed by great scattering of the values of the composition, structure and property indices.

The middle katagenesis subzone (second subzone) is identified within the interval of depths from 1 400-1 500 m to 2 800-3 000 m. The temperature here rises gradually from 40 to 75 °C, the pressure increases to 600 kg/cm^2. The second zone of katagenesis is the zone of transition from the early to the late stage of katagenesis. It is here that the reconstruction of the primary composition and structure of clays is mainly taking place. This is the result of the changing thermodynamic conditions which proves to be decisive in changing the physico-mechanical properties of clays. Starting with depths of 1 500-2 000 m there is a decrease in the content of unstable, in these conditions, clay minerals of the montmorillonite type with a swelling lattice as a result of their transition through the mixed-layer stage into hydromica and chlorite. Kaolinite is also subjected to partial hydromication. When edge and interstitial waters do not have any elements used by clay minerals to create more stable structures (K^+, Mo^{++}, etc.) these minerals change with more ordered polymorphic modifications appearing. In this way kaolinite turns into dickite.

The changes in hydromica manifest themselves as the decrease of the swelling component content in its structure, the increase of its crystallinity and the improvement of its structure.

Detailed studies of the character of changes in the structure and physico-mechanical properties of clays in the second subzone made it possible to subdivide it into three horizons—the upper, middle and lower, each 400-500 m thick (fig. 11).

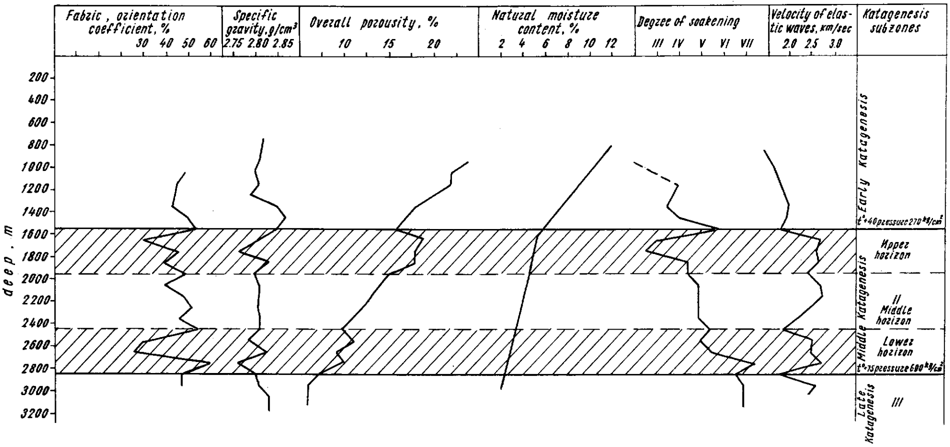


FIG. 11. — *Subdivisions of the katagenesis zone according to Z. A. Krivosheyeva.*

In two of them, the upper and the lower horizons, highly compacted clays, as it was noted above, have anomalous properties as compared to the clays in the over- and underlying layers. Near the lower boundaries of the horizons all the properties level off again acquiring almost the previous values.

Thus, specific gravity which falls sharply starting from the boundary of the upper horizon from 2.87 g/cm^3 to 2.76 g/cm^3 at the depth of 1 950 m increases to 2.80 g/cm^3. Porosity, after increasing from 16 to 19-22 %, at the lower boundary again reaches 15 %.

These spasmodic fluctuations of the physico-mechanical properties of clays in the lower horizon are similar to those observed in the upper horizon, but manifest themselves less distinctly.

The middle horizon is distinguished by relatively constant clay properties almost unchanging with depth, with the exception of porosity which falls from 15 to 10 %. The rate of porosity change in the 1 950-2 450 m interval is considerably lower than in the first subzone and equals, on the average, to 1.2 % for every 100 m. Dehydration and consolidation of clays in this subzone in the conditions of a comparatively small increase of the pressure at low water content 6-2 %), which amounts to 30-40 % of the maximum hygroscopic moisture, seem to be possible only due to the temperatures increasing with depth and the changing crystallo-chemical structure of clay minerals.

Starting with depths of 2 450-2 600 m within the limits of the lower horizon clays begin to assume the aspect of argillites not only because of their high volumetric weight varying from 2.51 to 2.55 g/cm^3 and low porosity of 9-10 %, but also by the first signs of schistosity.

The subzone of late katagenesis (third subzone) is identified below the depths of 2 800-3 000 m. Here clays finally turn into argillites and do not get sodden in water. They are massive, often schistous, but are difficult to split into separate blocks. It is typical for them to have a uniform composition of the clay mineral association, mainly represented by dioctahedral hydromica and chlorite which are the final phase of the subterranean transformation of clay materials with any composition. In the upper portion of the subzone a certain amount of kaolinite is still preserved, and close to the upper boundary there may be present the relics of swelling minerals which form the mixed-layer structures with chlorite and hydromica.

The values of specific gravity, volumetric weight and porosity in the argillites of the third subzone vary within close limits and have a very weak tendency to change with depth. The mean specific gravity values of argillites mainly vary within the limits of about 2.81-2.83 g/cm^3. The volumetric weight reaches high values of 2.58-2.60 g/cm^3. The porosity becomes quite constant and is equal to 4-7 % in different interlayers. The natural water content of argillites decreases to 1-2 %.

In this way, with increasing depth in the zone of katagenesis, clays lose their initial engineering-geological features acquired during the process of genesis and begin to possess new properties resulting from the postgenetic processes in the katagenesis zone. In case of positive tectonic movements clays, having been displaced close to the surface from the deep-lying katagenesis zone, can have high strength parameters, whose value can again decrease under the effect of the decompaction process.

Decompaction of soils and rocks results from the change in the stressed state, caused both by the natural geological processes (denudation, erosion) and by the engineering activity of man (pit excavations, etc.). Decompaction of clays is expressed in: 1) disturbance of the wholeness of the massif, appearance of lateral and bottom thrust joints, subsidence, cleavage, etc.; 2) increase of water content; 3) changed chemical composition. In the end the decompaction of clays results in lowered strength and decreased deformation resistance. Because of this, estimating soil decompaction correctly and establishing the mechanism and the prognosis of its development are especially important in constructing large hydraulic structures when the construction is carried out in asymmetrical river valleys made up of clay soils and deep excavations are necessary.

The experience of engineering-geological studies of construction conditions at Saratov hydropower station site on the Volga River showed that decompaction of clays had complicated the engineering-geological situation and the choice of estimated parameters necessary for designing the power station. Saratov hydropower station has been built on the site where the Volga valley has a sharply defined assymetrical profile (fig. 12).

Neocomian clays underlying the foundation of the power station in the region of the second bottom are at the depth of 24-27 m and are subjected to the natural pressure of 2.8-5.1. kg/cm^2. Under the Volga river-bed they lie at the depth of 30-51 m and are subjected to the pressure of 3.1-5 kg/cm^2, and under the right high bank they lie at the depth of 115-135 m the pressure being 19-22 kg/cm^2. Because of this clays of the same lithology and composition have different density (fig. 13). The curves in fig. 13 indicate that the clays were decompacted substantially when the valley of the Volga River was being formed [11]. After the pit for the power plant had been excavated the second, engineering-geological, stage of neocomian clay decompaction began. This decompaction was observed down to the depth of 50 m and manifested itself in the bottom of the pit rising

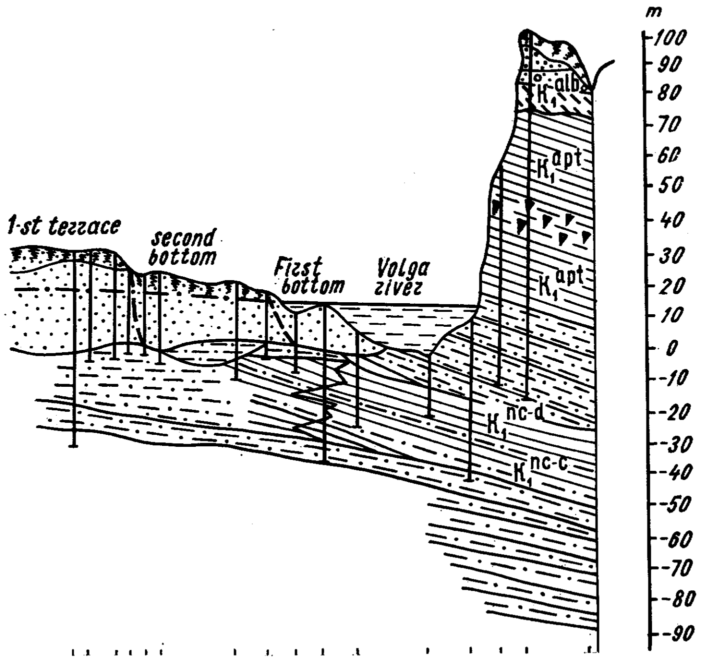


FIG. 12. — *Schematic geological profile across the Volga river valley in the area of Saratov hydropower station.*

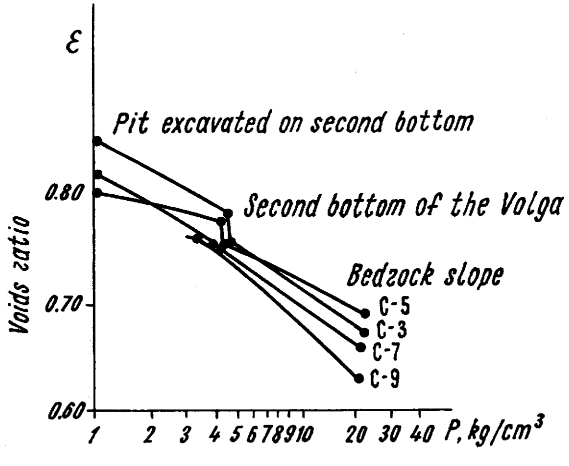


FIG. 13. — *Compaction curves for some varieties of neocomian clays (C packs) under different elements of the Volga river valley.*

by 15-22 cm. As a result of this a larger portion of power plant settlement was caused by the swollen clay soil being compacted to the state of density characteristic of undecompacted clays.

The process of sedimentary rock decompaction is not necessarily connected with a previous decompaction at large depths. This decompaction can also occur under the effect of the hypergenesis process. This phenomenon is especially clear if we take loess soils as an example. Loesses as well as clays can be of different genesis. Any genetic type of loess soils can turn into a typical loess under the influence of the hypergenesis process.

The main role in this process is played by the seasonal freezing and thawing of soils. It has been proved [12] that under the influence of freezing and thawing large sand grains crush to the size of 0.05-0.01 mm and that the general siltiness of soils in the freezing zone markedly increases. Water migrates to the freezing front (in case of a closely lying ground water table) and this water, when freezing, conduces to soil swelling and decompacting. When freezing and decompacting, the soils become more porous resulting in subsidences which characterize typical loesses. Hydrocarbonate solutions are also attracted to the freezing front. These precipitate in the process of freezing already as carbonates and increase the general calcareousness in the active zone of soils. Substantial influence of freezing on the subsidence properties of loess soils is confirmed by the fact that loesses of different genesis (diluvial, proluvial, alluvial) lying on young, mainly upper-quaternary, elements of the terrain are apt to considerable subsidence down to the depths of 2-3 m, i.e. the depths of seasonal soil freezing at present. But loesses making up the ancient elements of the terrain (middle- and lower-quaternary) subside down to the depths of 6-7 m. It can be easily supposed that the climate in the olden times of the Quaternary period was more severe and much colder (especially during the centuries of glaciation) which was conducive to the freezing, decompaction and subsidence of soils down to great depths.

The influence of the process of hypergenesis on the subsidence properties of loess soils is manifested especially clearly in profiles with connate soils. Fig. 14 shows a profile of ancient alluvial loess soils of the Yenisei river-terrace. Next to the profile a diagram is plotted showing the degree of possible subsidence of loess soils. It can be seen from this diagram that the maximum subsidence of soils is below the connate and modern soils, and above the connate soils we as a rule have non-subsiding loess soil [13].

The cyclic character of subsidence properties is typical not only for the loess soils of Siberia with its severe sharply-continental climate. Subsidence in loesses lying below connate soils in a number of areas in the Ukraine has been convincingly demonstrated in the works of V. I. Kopeikin [14].

Experimental studies performed by A. M. Voronin in the laboratory and by A. V. Minervin on a long-term observation site in Southern Siberia have clearly shown that the fundamental engineering-geological feature of loesses, i.e. subsidence, results from the decompaction of loess soils of different age and genesis under the influence of postgenetic processes (swelling, ice sublimation in severe anti-cyclic climatic conditions). Therefore typical loesses do not seem to be aeolian deposits, but seem to have appeared as eluvial formations in the process of hypergenesis resulting from the decompaction of loess soils of different genesis.

The foregoing makes it possible to make four conclusions:

1. The engineering-geological peculiarities of clay and loess soils are determined by their genesis at an early stage of lithification and by postgenetic processes with a further development of progressive and regressive lithogenesis forms.

2. Using engineering-geological methods of investigation one can solve fundamental problems of a general geological nature.

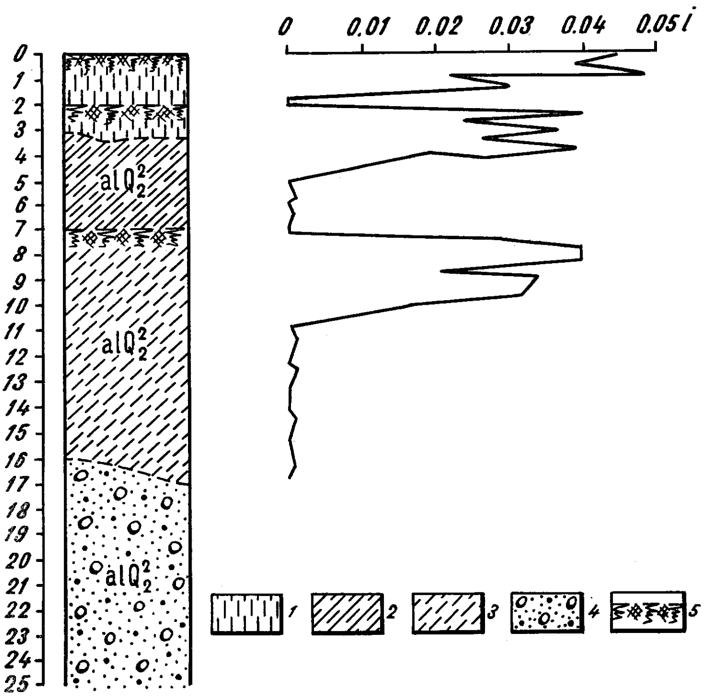


FIG. 14. — *Changes with depth in subsidence properties of loess soils in the 40-meter terrace of the Yenisei River. 1, sandy loam, loessy; 2, light loam, loessy; 3, medium loam; 4, gravel, alternating with sand; 5, connate and modern soils of the chernozem kind.*

3. When conducting engineering-geological studies in any territory it is necessary to restore the history of its geological development, which is impossible without understanding the influence of genetic and postgenetic processes on rocks. It is with such approach only that we can explain the engineering-geological properties of rocks correctly.

4. Without taking into account the genesis of rocks and their further changes under the effect of postgenetic processes construction problems cannot be rationally solved.

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