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Dependence of Loess-Like Loams Lithology on Composition of Underyling Rocks in Central Russia

Zależność cech litologicznych utworów lessopodobnych od ich podłoża w Rosji Środkowej

Зависимость литологии лёссовидных суглинков от подстилающих пород в центральной России

ABSTRACT

Based on comparative analysis of the covering loess-like loams, glacier sediments and rocks of the source provinces a close dependence of the mineralogical composition of the covering loams on composition of the underlying moraine has been determined. The revealed character of spatial differentiation of the mineralogy is used for deducing of the loams genesis and their stratigraphy.

A problem of specific lithology of loesses is closely related to the solution of the key question on its genesis, composition and source material, on the ways and mechanisms of its supply (A. A. Velichko 1973, N. J. Kriger 1965, K. K. Markov et al. 1965, A. J. Popov 1967, E. V. Shantser 1970). In this relation a revealing of a role of source terrigenous-mineralogic provinces for the loess-forming process presents a principally important goal of the study. A fulfilled systematic study of mineralogy of loesses, moraines and rocks of the source provinces in the centre of the Russian Plain and obtaining of the mass analytical material for rather large area make a favorable ground for such solution.

In the central glaciated areas of the Russian Plain, in the zone of the Moscow (Warta) moraine, the loess-like loams are widely distributed being, in contrast to the typical southern loesses, slightly calcareous (2 to 4%), more clayish, often layered at the base of the profile and having the particular geomorphologic localization. Based on character of the occurring, peculiarities of texture and composition, their generations of different age are distinguished (N. G. Sudakova and L. I. Bazilevskaya 1976).

In the result of comparative analysis was determined a close dependence of the loess-like loams on the composition of the underlying moraine which was controlled, in its turn, by both local and distant glacial material.

Analysis of a series of the maps made based on generalization more than 2000 mineralogical analyses of moraines reveals certain regularities of spatial distribution of individual minerals and their associations. Complex distribution displays, for example, such key mineral as hornblende. Its background content decreases southwards. Radial pattern of the hornblende distribution is especially clear within the Protva and Rybinsk extents of the ice sheet. At the same time the hornblende content increases in the latitudinal direction (Table 1) from the Ladoga sector of the glaciation to the Omega one (from 20 to 25%, on average)

Table 1. Areal variations of arithmetic means of the key minerals' percentage * in the loess-like sediments (numerators) and in the Moscow moraine (denominators)

	Oka extent of ice sheet	Mozhaisk-Borovsk district	Dmitrov-Moscow district	Yaroslavlskoe Povolzhe area
Quantity of samples	15 / 43	39 / 84	33 / 102	109 / 89
Hornblende	22.5 / 17.0	26.8 / 25.7	21.5 / 22.4	27.5 / 25.0
Garnet	18.3 / 30.5	24.0 / 20.8	21.7 / 18.9	16.0 / 16.4
Epidote	5.8 / 3.0	4.7 / 6.0	7.9 / 9.9	16.9 / 16.5
Ilmenite	17.5 / 22.6	16.2 / 11.9	18.5 / 11.4	14.9 / 14.9

* Percentage share of the given mineral of the heavy fraction of 0.25 - 0.1 mm size.

at the expence of decrease of garnet content that agrees with variations in mineralogical composition of the exaration areas of the Baltic shield. Besides, the anomalously high contents of hornblende are observed in the zones of positive glacio-structures.

Epidote distribution in the moraine follows to some order too. Contrary to hornblende the higher content of epidote (up to 15—20%) is localized to the north-eastern provinces where epidote-enriched Triassic rocks occur. Epidote content in the Moscow moraine decreases south-westward from 15 to 5%, on average, that coincides with the general direction of its transport from Timan-Ural region. Therefore a structure of spatial distribution of epidote in the Moscow moraine indicates on the prominent local and transit sources of its supply.

For garnet a more complex areal distribution is typical. On the one hand its sectorial differentiation can be seen. Maximum accumulation of garnet is observed at the areal of the western sector of the glaciation (20—25%, on average). In the eastern Onega sector its content decreases (less than 20%, on average) that is in a good accordance with the composition of pre-Quaternary distant and transit sources. On the other hand a radial distribution occurs being especially prominent within the Protva extent of the ice sheet where garnet content in the moraine decreases in the distal direction from 25 to 10%. Except the north-south and east-west variations the local anomalies are observed being due probably not only to the local sources but to the glacier dynamics also. The spatial structure of the garnet distribution is of sectorial-zonal character.

The important additional information on peculiarities of mineralogic composition of the Moscow moraine is provided by the spatial analysis of the main accessory minerals. The results of this analysis permit to subdivide the area under study into two parts: the western zircon-bearing one and the eastern disthene-staurolite-bearing one. The comparison shows that for the given area zircon and disthene are the minerals-antipodes. The southward and eastward decrease of zircon content along with the prominent radial direction variations of the parameters permits to consider it as an exotic component transported by the glacier from the Baltic source area. On the contrary, the areal distribution of tourmaline-disthene-staurolite triad indicates mainly on the local origin of these minerals which main supplier were the Mesozoic rocks.

Quantitative relations of the most informative key and accessory minerals in the Moscow moraine permit to subdivide the central part of the Russian Plain into seventeen terrigenous-mineralogic provinces groupped into two large regions: the western zircon-hornblende-garnet one and the eastern disthene-epidote-hornblende one (N. G. Sudako-

v a 1982) being in a good accordance with the spatial relations of local, transit and distant source provinces.

The spatial differentiation of the glacier material in relation with the general characteristics of the glaciation lithogenesis leads to the sector--by-sector zonality of the erratic material on the one hand and to the provincial (as the extreme case of the locality) character of local components on the other hand. These inherited peculiarities of the moraine composition are combined with the newly acquired genetic peculiarities which are due to the spatial inhomogeneity and irregularity of the glacier sorting of the initial material. The mentioned above variability of composition of the moraines makes the significant corrections in paleographic and stratigraphic models as well as makes a basis for the comparative analysis with the composition of the loess-like loams.

An experience of study of the loess-like loams' mineralogy in the glaciation areas permits to conclude that their mineral composition has been mainly formed under the influence of the glacier deposits and has similar with them areal variations due to the changing of the glacier source and terrigenous-mineralogic provinces.

As a result of study of 94 profiles of the loess-like sediments the inheritage of composition of loess-like sediments on the underlying moraine has been found. The background and accessory minerals in the loess-like sediments are the same indeed as in the Moscow moraine: garnet, ilmenite, hornblende, epidote, as well as disthene, staurolite, tourmaline, zircon. Iron hydroxides, lithic fragments and aggregations of mineral are rather abundant. At the most part of the profiles a tendency of increase of contents of the unstable minerals, especially hornblende, in the loess-like sediments comparing to the moraine can be seen. Accordingly a coefficient of stability of the mineralogical spectrum in the loess-like sediments is lower. The exceptions are the profiles of the southern part of the Kaluga region (Likhvin, Tarusa) where the loess-like sediments are enriched in heavy and stable minerals. In these profiles the loesses are separated from the moraine by one or two horizons of the buried soils that indicates on the multiple redeposition of the moraine material in the loess-forming process.

Zonal variations of the mineralogic composition of the loess-like loams are confirmed by the south-south-eastward decrease of hornblende which is a typical representative of the distant Baltic source area. For example, in Yaroslavskoe Povolzhe (on the Volga) area the hornblende content in the loams decreases from 34% at Rybinsk area to 24% at Tutayev area. For the western part Moscow area and for Kaluga area the same tendency has been found: the hornblende content decreases from 30 to 7% from north (Ruza profile) to south-east (Tarusa profile) i.e. to the glacier

periphery. The exceptions are the profiles of the end moraine formations at the area of middle course of Protva river where the hornblende content increases drastically both in the Moscow moraine and in the overlying loess-like sediments. Analagous tendency is found for the profiles at Moscow and northern part of the Moscow areas.

The sectorial zonality in composition can be seen best of all on the example of variation of contents of the background minerals which are garnet and hornblende (Table 1). For the profiles of Yaroslavskoe Povolzhe area belonging to the Onega sector of the glaciation a predominance of hornblende over garnet is typical. The garnet contents are not more than 20%, on average, while the hornblende contents are practically anywhere more than 23—25%. Crossing the ice divide between the Onega and Ladoga sectors of the glaciation at Zagorsk area one can see the reversal situation: garnet predominance over hornblende. The especially high garnet contents are noted in the western profiles: at Shanya river area, at Masalsk and Borovsk areas. Sometimes the anomalous "spikes" of the high hornblende are observed being related with the positive glacio-structures where the glacier exaration and, therefore, the local material capture were minimal. The mentioned variations in the background minerals' contents are due to the character of geologic pattern of the distant source provinces.

The provincial differences in mineralogical composition of the loess-like sediments are due to inhomogeneous composition of the local source areas. It can be seen, first of all, on the example of content of epidote entering in large amounts into the Pleistocene sediments from the Triassic rocks. The increased epidote content is typical for the sediments of Yaroslavskoe Povolzhe area where the Triassic rocks are widely distributed. Moving from north-east to south-west the epidote content decreases both in the loess-like loams and in the moraine. If in the loess-like sediments of the Yaroslavl area the epidote content is as high as 20—28% so in the sediments of the Kaluga area only near to 5%. Another background mineral, ilmenite, is mainly supplied by the Carboniferous rocks. This is why the ilmenite content in the loess-like sediments of the western part of the Moscow area and Kaluga area is high. For example at the profiles near Masalsk town, at river Shanya and river Popolta areas the ilmenite content is higher than 20—25%.

Accessory minerals (disthene, staurolite, tourmaline, zircon) are good indicators of presence of the Cretaceous rocks in the local sources. The most percentage of them in the loess-like sediments has been found at the Shestikhino and Krasnaya-Gorka profiles, near Yaroslavl city, along the Moscow-Yaroslavl highway, at the vicinities of Kaluga and Tarusa.

Thus, according to their mineralogy the loess-like loams of the centre

of the Russian Plain are mainly composed of the local material supplied by the glacial accumulations being here the relief-forming rocks. At the 0.25—0.1 mm size fraction of the loams the erratic material, nontypical for the local deposits is absent.

Inheriting the composition of the glacial sediments the covering loess--like loams have similar with them spatial variations in mineralogy: zonality of the composition due to the distance from the glaciation centres, sectorial variability due to the transition from the Onega to Ladoga glacier sector, provincial variations due to specifics of local source provinces.

So the revealed close dependence of composition of the loess-like sediments on the composition of the underlying moraine and absence of the exotic components in them within the vast territory do not permit to consider the eolian factor as a decisive one in the loess-like deposits accumulation within the areas under study. It is evident also that the lithologic comparability of the loess-like loam horizons of different age has the certain territorial limitations and is possible only taking into account the mentioned above characteristic of their composition.

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STRESZCZENIE

W środkowych rejonach Równiny Rosyjskiej w strefie występowania moren zlodowacenia Moskwy (=Warty) powszechnie spotykane są glinki lessopodobne. Różnią się one od lessów typowych, występujących dalej na południe, mniejszą zawartością węglanów (tylko 2—4%), większym udziałem frakcji ilastych oraz warstwowaniem często zaznaczonym w dolnych ich częściach. Rozmieszczenie różnowiekowych generacji tych utworów związane jest z rzeźbą terenu.

Na podstawie badań terenowych i laboratoryjnych około 100 profili stwierdzono ścisłą zależność między składem glinek lessopodobnych oraz podścielających je utworów morenowych. Analiza porównawcza składu mineralnego wykazuje analogiczne prawidłowości zróżnicowania przestrzennego:

1. Wyraźne zmiany w kierunku południkowym udziału hornblendy w poszczególnych sektorach zasięgu lądolodu. W sektorze Onegi hornblenda przeważa nad granatem, zaś w sektorze Ładogi w glinkach lessopodobnych dominuje granat.

2. O strefowości składu glinek lessopodobnych świadczy w szczególności zmniejszanie się w kierunku dystalnym udziału hornblendy — charakterystycznego reprezentanta Fennoskandii (od 35 do 20—10%).

3. Różnice prowincjonalne wyrażają się zmniejszaniem się w kierunku południowo-zachodnim od 20—15 do 5—2% udziału epidotu, występującego w znacznych ilościach w mezozoicznych skałach podłoża i morenach północno-wschodniej części obszaru. Natomiast domieszka dystenu, turmalinu i staurolitu wzrasta w sąsiedztwie płytkiego występowania w podłożu skał wieku kredowego.

Skład mineralny glinek lessopodobnych kształtował się więc w zależności od cech miejscowych utworów lodowcowych. Wykazuje on przy tym pewne prawidłowości zróżnicowania przestrzennego, odpowiadające zmianom charakteru prowincji alimentacyjnych lądolodu. Dlatego też korelacje glinek lessopodobnych na podstawie cech litologicznych mogą być dokonywane tylko w ograniczonym zasięgu terytorialnym.

РЕЗЮМЕ

В центральных ледниковых районах Русской равнины в полосе развития московской(=вартинской) морены широко распространенные лёссовидные суглинки, в отличие от типичных южных лёссов слабо карбонатны (2—4%), более глинисты, нередко слоисты в основании толщи. Их разновозрастные генерации имеют определенную геоморфологическую приуроченность.

В результате полевых и лабораторных исследований около 100 разрезов установлена тесная зависимость вещественного состава лёссовидных суглинков от состава подстилающей морены. Сравнительный анализ минерального состава выявляет у них аналогичные закономерности пространственной изменчивости:

1. Изменения в широтном направлении в разных секторах оледенения заметны у роговой обманки. В Онежском секторе оледенения она преобладает над гранатом, тогда как в Ладожском секторе в суглинках доминирует гранат.

2. О зональности состава суглинков свидетельствует, в частности, уменьшение в дистальном направлении доли роговой обманки — характерного представителя Фенноскандии — с 35 до 20—10%.

3. Провинциальные различия сказались на сокращении с 20—15 до 5—2% в юго-западном направлении содержания эпидота, которым богаты мезозойские породы и морены северо-востока территории. Примесь дистена, турмалина, ставролита возрастает вблизи неглубокого залегания пород меловой системы.

Таким образом минеральный состав лёссовидных суглинков сформирован под влиянием местных ледниковых отложений и испытывает закономерные пространственные изменения в связи со сменой ледниковых питающих провинций. Следовательно, литологическая сопоставимость лёссовидных суглинков имеет определенные территориальные ограничения.