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# LATE PLIOCENE - EARLY PLEISTOCENE STAGE OF RELIEF DEVELOPMENT IN THE CENTRAL AND EASTERN PARTS OF RUSSIAN PLAIN

**ABSTRACT:** ALEKSEEVA V.A., ANANYEVA E.G. & VOSKRESENSKY I.S., *Late Pliocene - Early Pleistocene stage of relief development in the central and eastern parts of Russian Plain.* (IT ISSN 1724-4757, 2003).

Complex study of relief forms and sediments was carried out in the Central and Eastern parts of Russian Plain. For the first time the fragments of ancient denudation surfaces and ancient fluvial valleys, the end-moraine seedbeds and the fluvioglacial fields of Late Pliocene-Early Pleistocene have been determined basing on the lithologic-mineralogical, palynological data and definitions of absolute age by the radiothermoluminescent (RTL) method. These new data not only compliment but also import a new sight on the relief and sediments development of the central and eastern parts of Russian Plain.

KEY WORDS: Relief evolution, Pliocene-Pleistocene, Russian Plain.

## INTRODUCTION

The forms of relief of the Central and Eastern parts of Russian Plain are of different origin. The after Eocene history (the last 30-35 mln. years) of relief and sediments development is very complicated. According to modern investigations, the glacial and fluvial relief forms of after Middle Pleistocene age are morphologically expressed on the territory under study, which connected with the prevailing of continental glaciations and fluvial activity among other geomorphological processes in Middle Pleistocene-Holocene (Lazukov, 1980, Spiridonov, 1978, Sudakova, 1982).

Up to now there are still a lot of problems in the determination of the origin and age of relief forms and sediments of this region. The age of buried relief forms and sediments is not completely established and is taken within wide limits from Eocene till Middle Pleistocene in a comparison with neighboring regions on Russian Plain.

Study of relief forms and sediments was carried out in the Oka, the Vetluga (tributary of the Volga river), the Kama and the Vjatka river basins in 1995-2000 (fig. 1). The aim of this study was to get new and additional information about the facial-genetic peculiarities of glacial and fluvial deposits, which develop the relief in the Central and Eastern parts of Russian Plain, and to use these new data for the reconstruction of stages of relief development in Late Pliocene-Early Pleistocene.

## METHODS

The stratification of Late-Cenozoic (Pliocene-Pleistocene) sediments was based on determination of absolute age, lithologic and mineralogical composition of sediments and arrangement the strata in relief. The determination of the genesis and facial features of sediments, deposition mediums was mainly based on lithological-mineralogical analysis of sediments that is a part of complex lithological approach. The lithological-mineralogical analysis of more than 25 sections of sediments of different origin of the Late Cenozoic has been done. It was based on the optical microscopic investigations of light and heavy fractions of fine sand (0,1-0,25 mm), mineralogical and petrographic composition of fine (1-2 mm) and coarse gravel material. The absolute ages of sediments under investigation have been obtained by radiotermoluminescent analysis (RTL). The spatial correlation of morphologically expressed and buried relief forms of glacial and fluvial origin has been done.

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FIG. 1 - The studied area.

Location of the studied territories in the Central and Eastern parts of Russian Plain.

1. The Upper Oka River basin.
2. The Vetluga River Basin.
3. The Kama and the Vjatka River Basins.

## RESULTS AND DISCUSSION

According to new data obtained we determined some stages in history of relief development.

*Before Pliocene Stage* of relief development is very complicated and is not completely understood yet because of insufficient amount of data (fig. 2). We can say only that the studied territory was under the influence of denudation and erosion processes in conditions of calm tectonic movements from the beginning of Middle Palaeogene. The processes of accumulation and fulfillment in river valleys began in the second part of Miocene.

The studied fragments of the denudation-accumulation level are probably of Palaeogene-Neogene age (tab. 1). They are spread in the central parts of top surface with altitudes of 200-270 m.

Sediments of this level in the Upper Oka river basin are presented by the weathered and washed up product of Cretaceous sandstones ($K_1ab$ - $K_2s$). These are pebbles, gravel and clay sand. The detritus and pebbles are mainly of local origin-limestone, flint and sandstone. The pebbles are well rounded and weathered. Mineralogical composition of heavy fraction of fine sand shows the prevailing of stable minerals such as ilmenite, garnet, tourmaline, staurolite, rutile and zircon. There are also typical for the sea deposits minerals such as glauconite and aragonite.

The sediments of Neogene age in the Kama river basin are presented by laminated sand with pebbles and gravel. The pebbles are very weathered. Pebbles, gravel and coarse sand are presented by quartz, flint, shale, sandstone and limestone. In mineralogical composition of heavy fraction of fine sand stable minerals prevail-ilmenite 38%, epidote 20%, staurolite 15%, kyanite 7%, rutile, zircon, garnet and tourmaline. Amphiboles, pyroxenes, biotite are in traces. The lithologic-mineralogical characteristics testify that these sediments are, probably, of alluvial-proluvial origin. The absolute age of the sediments was obtained as 3,1-4,6 mln. years.

The sediments of Miocene ($N_1$) were admittedly studied in the ancient valley of the Protva River (the Upper Oka river basin). The sediments are presented by sand

TABLE 1 - Correlation table of sediment stratification and location of the studied sections in the Kama, the Vjatka, the Vetluga and the Upper Oka River Basins

| System | Department | Stratigraphic scale | | Stratigraphic index | Stratigraphic location of studied sections | Age, ka |
|---|---|---|---|---|---|---|
| Quaternary, Q | | Holocene | | Q4 | | 0-10 |
| | Upper, Q3 | Valdai | Ostashkov | Q3os | | 10-30 |
| | | | Monchalov | Q3mls | | 30-50 |
| | | | Kalinin | Q3kl | | 50-90 |
| | | Miculin | | Q3mk | | 90-130 |
| | Middle, Q2 | Near Moscow | Moscow | Q2ms | | 130-190 |
| | | | ? | | | 190-225 |
| | | | | | | 225-280 |
| | | Likhvin | | Q2lh | * | 280-380 |
| | Lower, Q1 | Oka | | Q1ok | * | 380-440 |
| | | Muchkap | | Q1mc | | 440-470 |
| | | Don | | Q1dns | | 470-510 |
| | | Ilin | | Q1il | | 510-560 |
| | | Pokrov | | Q1pk | * | 560-700 |
| | | Petropavlovsk | | Q1pt | | 700-780 |
| Neogene, N | Pliocene, N2 | Upper | | N2-3 | * | 780-1200 |
| | | Middle | | N2-2 | * | 1200-1800 |
| | | Lower | | N2-1 | | 1800-5400 |
| | Miocene, N1 | Upper | | N1-2 | * | 5400-25000 |
| | | Middle | | N1-1 | | |
| Palaeogene, P | Oligocene | Whole | | P | | 25000-30000 |

with pebbles of quartz, flint and limestone and interlayer of quartz-glauconite siltstones. The characteristic feature is the complete absence of magmatic rocks fragments. In mineralogical composition of heavy fraction of fine sand sulfides, siderite and glauconite prevail. Ilmenite, garnet, kyanite, staurolite and tourmaline are presented in traces. This kind of sediments is of wide spread in river valleys of the Central part of Russian Plain.

However, the amount of data existing is insufficient for the detail study of the history of relief and sediments development at this territory in a comparison with neighboring regions (Gorezkiji, 1964).

*Pliocene stage*. The relief forms and sediments of Middle and Late Pliocene ($N_2^{2-3}$) were studied in the Kama, the Vjatka, the Vetluga and the Oka river basins. These are the fragments of ancient fluvial valleys. The river cutting reached 20-40 m under the modern valleys. The level of fulfillment was fixed on the altitudes up to 220 m within modern top surfaces.

The sediments of this age in the Kama river basin are presented by gravel, pebbles and sand. Pebbles and gravel are well rolled and presented by debris of flint, quartz, sandstone, shale, and jasper. The mineralogical composition of heavy fraction of fine sand is heterogeneous. Epidote (36%), ilmenite (16%), staurolite (10%), garnet (5%), kyanite (5%) are prevailed. The accessorial minerals are rutile, zircon, chromite, and amphibole. The absolute age of the sediments was determined as 1,170 mln. years.

These sediments in the Upper Oka river basin are presented by well-sorted fine whitish sand and ferriferous sandstone. The cleavage is slanting. In mineralogical composition of heavy fraction of fine sand from these sediments stable minerals prevail-ilmenite 28%, staurolite 18%,

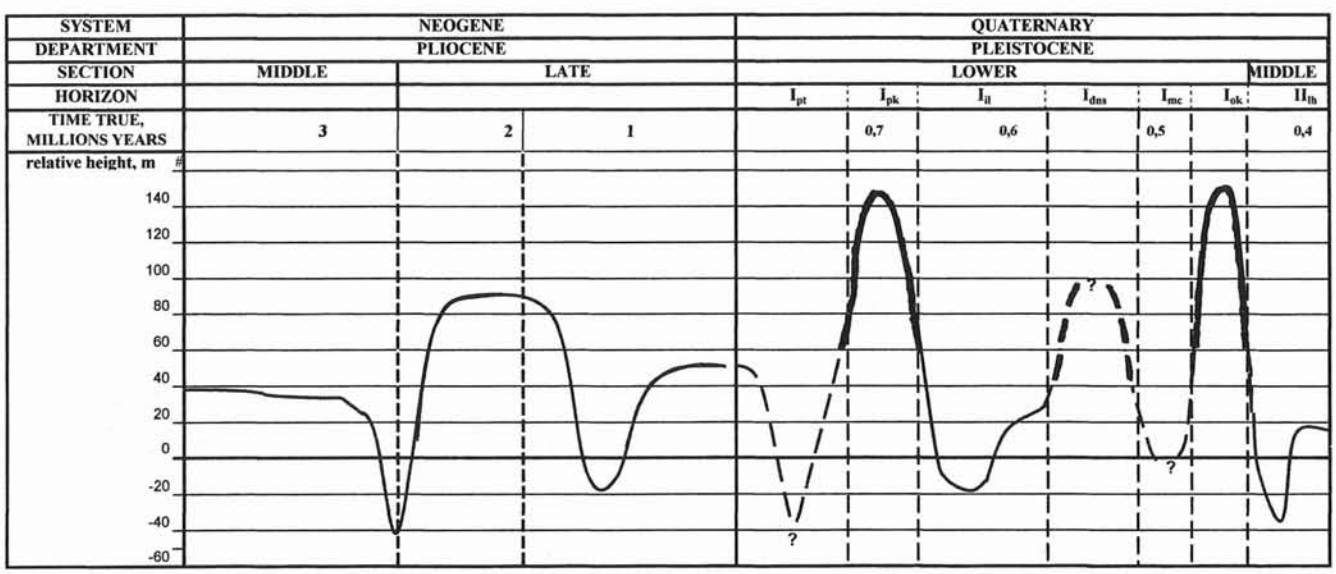


FIG. 2 - The erosion line. a —— b ------ line of fluvial erosion and accumulation, a - established, b - expected;
a —— b ------ line of fluvial erosion and accumulation, a - established, b - expected.

pyroxene 9%, tourmaline 7%, rutile 4%, zircon, and kyanite. The heavy mineral yield was insignificant –0,25%. The lithologic-mineralogical characteristics testify that sedimentation occurred in calm hydrodynamic conditions. Probably, these are sediments of coastal part of lake on alluvial-proluvial plain and are the erosion product of Cretaceous sandstones.

The studied sediments of Late Pliocene ($N_2^3$) in the Kama river basin are presented by heterogeneous sand, gravel and pebbles material with slanting cleavage. There are well rounded fragments of sandstone and ferriferous gravelite among gravel and sand fraction. In the mineralogical composition of heavy fraction epidote (26%), ilmenite (17%), iron hydroxides (21%), staurolite (10%) prevail. The accessorial minerals are rutile, zircon, garnet, kyanite, tourmaline hornblende and pyroxene. The lithologic-mineralogical characteristics, such as frequent changing of lithologic composition, the type of cleavage, intensive ferruginosity, testify that these sediments are of the alluvial-proluvial origin. The absolute age of the sediments was determined as 890±220 thous.years. This kind of sediments was studied in the Oka and the Vetluga river basins. The absolute age was determined as 880-1200 thous.years.

*The Early Pleistocene Stage.* The glacial relief forms of *Pokrov Age* of Early Pleistocene ($Q_1$pk) we have found and described for the first time in the Upper Oka river basin. The fragments of exhibited relief forms of glacial origin remain on the top surfaces. The sediments of this age cover the top surfaces with the altitudes 240-250 m. These sediments are presented by boulder pebbles, gravel and sand. The surface of fluvioglacial accumulation extends on the altitudes 140-155 m. The sediments are presented by interstratifying ferriferous sand, pebbles and gravel. The pebbles are mainly of local origin-limestone and flint (up to 73%). In mineralogical composition of heavy fraction of fine sand both stable and unstable minerals present-amphiboles, garnet, hematite, iron hydroxides, ilmenite and aragonite. Content of minerals is not constant at different depths of the cut. The lithologic-mineralogical characteristics testify that these sediments are, probably, of alluvial (of cold stage) or fluvioglacial origin and have been formed in the course of washing up of Jurassic, Cretaceous and ancient Neozoic sediments. The absolute age of the sediments was determined as 682.000 years. The fluvial relief forms and complicated alluvial-proluvial sediments have been formed during this period in the Kama, the Vjatka and the Vetluga river basins.

The sediments of Ilin Age ($Q_1$il) were first described at the Upper Oka river basin. These sediments fill up the fragments of ancient river cuttings at least on the altitude 140 m. They lay in the basis of 1 and 4 river terraces. The sediments are presented by fine clay sands and siltstones with plant fragments and shell detritus. In mineralogical composition of heavy fraction of fine sand minerals of flat shape and little density prevail-mica, hornblende and aragonite. Garnet, ilmenite, rutile, zircon, epidote and pyroxene are presented in traces. The heavy mineral yield was insignificant-up to 5%. The lithologic-mineralogical characteristics testify the sedimentation in shallow lacustrine basin with calm conditions and good access for oxygen. The absolute age of the sediments was determination as 598.000 years.

Glacial relief forms of Early Pleistocene (*Oka stage* ($Q_1$ok)) were first found and described for the Western part of Spas-Demensk Range in the Upper Oka river basin. Moraine and fluvioglacial sediments of this age develop the Spas-Demensk Range on the altitude 260 m. Moraine contains pebbles with boulders of limestone (60%) and flints. In mineralogical composition of heavy fraction of fine sand hornblende 12%, biotite 13%, garnet 9% and ilmenite 7% prevail. It contains also Neogenic calcite and iron hydroxides. Content of minerals is not constant at different depths of the cut. Fluvioglacial sediments lie on the moraine and are presented by alternation of sands, gravel and pebbles. Moraine and fluvioglacial sediments are characterized by the similar petrologic and mineralogical composition. The absolute age of the sediments was determined as 380-410.000 years.

The alluvial sediments of the beginning of Middle Pleistocene (Likhvin Stage - $Q_2$lh) were studied in the Vetluga river basin. In mineralogical composition of heavy fraction of fine sand magnetite, ilmenite, garnet, epidote and iron hydroxides prevail. Zircon, rutile, staurolite and amphiboles are presented in small quantities.

## CONCLUSIONS

1. For the first time the fragments of the denudation-accumulation level probably of Palaeogene-Neogene age were found and described in the Kama and the Upper Oka river basins. In mineralogical composition of heavy fraction stable minerals such as ilmenite, epidote, garnet and staurolite prevail.

2. For the first time the fragments of Late Pliocene river valleys were found in the Kama, the Vjatka, the Vetluga and the Upper Oka river basins. At least 2 cycles of cutting-accumulation during Late Pliocene have been established. In mineralogical composition of sediments from ancient river cuttings epidote, ilmenite, staurolite, garnet and tourmaline prevail.

3. The large exhibited relief forms of glacial origin of Early Pleistocene (Pokrov and Oka Glacial Stages) were established and described. In mineralogical composition of glacial sediments amphiboles, garnet, biotite, iron hydroxides and ilmenite prevail.

4. The buried relief forms of fluvial origin of Early and Middle Pleistocene were established in the Upper Oka and the Vetluga river basins. In mineralogical composition of alluvial sediments mica, amphiboles, garnet and aragonite prevail.

So, it was established that minerals typical for local distributive provinces prevailed in mineralogical compositions of Late Pliocene sediments in the Oka and the Kama river basins. The input of minerals typical for remote distributive provinces increased in Early Pleistocene sediments in Oka river basin due to introducing by glaciers. But at the same time minerals typical for local distributive provinces prevailed in sediments in the Kama river basin.

5. The paragenesis of glacial and alluvial sediments of Early Pleistocene in the Upper Oka river basin was determined: moraine ridges on the west of territory under study and alluvial deposits of the ancient river valleys on the east.

6. The peculiarities of sediments formed in Central and Eastern part on Russian Plain in Early Pleistocene were shown. The glacial sediments (moraine and fluvioglacial) have been developed during the cold periods in the Upper Oka river basin. At the same time alluvial-proluvial sediments have been formed in the Kama, the Vjatka and the Vetluga river basins.

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