ATELIAN REGRESSION (LATE PLEISTOCENE) IN THE CASPIAN SEA

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Introduction

The Atelian suite of deposits for the first time is allocated by Pravoslavlev (1926) in the Lower Volga area. In the North Caspian Region, they include Akhtubian sands and Atelian sandy loams and clay loams with a total thickness of about 20 m, comprising three poorly defined horizons of automorphic and hydromorphic paleosoils, terrestrial and freshwater mollusk shells, and mammal fossil remains of the Upper Paleolithic ("mammoth fauna") faunal assemblage. In their basis numerous traces of the ice deformations and wedges are observed. They are deeply get into underlying beds and represent the marking horizon in the Northern Precaspian lowland. Age analogs of Atelian suite are noted also on other sites of the Caspian Sea Coast.

Atelian-Akhtubian deposits reflect a regressive stage of the Caspian Sea. The Atelian regression was the deepest and longest in the Late Pleistocene history of the Caspian Sea. According to Leontiev et al. (1974) the sea level was at the mark of –53 m during this regression. According to the seismic profiling data (Lokhin, Maev, 1990), the basin level fell down to –140 m. The age estimates of the Atelian deposits are controversial. The age determined by the thermoluminescence method is estimated in the range from 28 to 80 ka (Shakhovets, 1987). According to Chepalyga (2004) representations, Atelian regression answers a maximum of the last glaciation (Late Valdai, Ostashkovo) on the East European Plain (MIS 2). Some researchers (Moskvitin, 1962; Fedorov, 1978) refer the Atelian regression to the Early Valdai (Kalinin, MIS 4) glacial epoch. Svitoch (1991) considers it being longer (from Kalinin to maximum of Ostashkovo glaciation). To a long epoch from the Dnieper glaciation to the Mikulino interglacial period the regression is correlated by Vasilyev (1961). Lavrushin et al. (2014) allocate two Atelian horizons – Paleoatelian and Atelian with Hyrcanian deposits between them. The lower horizon answers to the long (~ 80 thousand years) regression corresponding to a time interval from Mikulino interglacial (MIS 5e) to Kalinin glacial (MIS 4). The upper horizon correspondes to the maximum of the Ostashkovo (MIS 2) glaciation. The main objective of our work - to propose the solution of a questions about scale, age of regression and its correlation with paleogeographic events on adjacent territories on the basis of a complex research of the Atelian deposits opened with engineering-geological boreholes in the Northern Caspian Sea.

Material and methods

We conducted a comprehensive study of the Atelian deposits in the continuous sections of the Quaternary sediments in one of the areas of the Yu. Korchagin field developed by the LUKOIL Oil Company. The area is located in the central part of the North Caspian shelf at a distance of about 140 km from the west coast and 180 km southeast of Astrakhan. The sea

depth is 11–13 m in the studied area. The work involved the processing of about 2000 km of two-frequency seismoacoustic profiles, the profiles of engineering–geological drilling to a depth of 80 m with a volume of about 1800 m, and the profiles of static probing in a volume of approximately 900 m. The laboratory treatment included the lithological and geotechnical study of the deposits composition and properties, and palynological and faunal investigations. The absolute age of the deposits was determined by two modifications of the radiocarbon method: by liquid scintillation at the Institute of Geography, Russian Academy of Sciences, and by AMS in the Lawrence Livermore National Laboratory in the United States. The age was calibrated with the Calpal-2007online software (University of Cologne).

Results

The Atelian regression is well pronounced in the structure of the Pleistocene deposits of the Northern Caspian Sea. It is seen on the seismoacoustic profiles by the depressions under the reflecting horizon in the base of the Khvalynian deposits. The regression strata with a thickness of 4–5 m are not lithologically uniform, taking a stratigraphic position in between the Hyrcanian and Khvalynian transgression deposits. The Aelian deposits are the alternating loams and clays in paleodepressions, while the uplands are formed of sandy loams in association with loams. They are characterized with high densities (2.10–2.15 g/cm3), low humidity (<25–26%) and pronounced fracturing, which suggests that they were transformed in the open air. Deposits contain iron in the form of the gydrotroilit. They have inclusions and layer accumulations of plant detritus and mollusk shells. The composition of fossils characterizes wetland conditions of freshwater or weak and saltish basins with the water poor in biogenous elements, but rich with carbonates. Malakofauna is presented by shells of inhabitants from freshwater or clightly brakish water basins: *Unio sp.*, *Dreissena polymorpha polymorpha*, *Anisus eichwaldi*, *Valvata piscinalis*, *Theodoxus pallasi*, *Limnea stagnalis.* Terrestrial gastropods are met in deposits too. The sediments contain the pollen of water and coastal-water plants (*Potamogeton*, *Sparganium*, *Lemna*, *Myriophyllum*), the remains of freshwater and brackish-water seaweed, and dinocysts (*Pediastrum*, *Botryococcus*, *Spiniferite scruciformis*, etc).

Results of the palynological analysis of 10 samples from the 4.8-meter thickness of the Atelian deposits testify to the considerable changes occurring within the environment during their accumulation. In the course of the palynological analysis, it was revealed that within the studied samples, along with pollen and spores of rather good preservation, strongly damaged and/or mineralized grains of pollen and spores from Pleistocene deposits, and pollen and spores from Pre-Quaternary deposits (from Carboniferous to Neogene) were redeposited. Among them: *Gorgonispora appendica*, *Vallatisporites variabilis*, *Psilohymena* cf. *mirabilis*, *Murospora aurita*, *Gleicheniidites* sp., *Toroisporis* sp., *Tripartites* cf. *vetustus*, *Toroisporis vulgaris*, *Triquitrites trivialis*, *Labiadensites macroduplicatus*, *Ruffordiaspora australiensis* and *Sciadopityspollenites macroverrucosus*. The picture of the dynamics in climate and vegetation is clearly reflected by the representative spores and pollen ranges of samples from a depth of 26.20-26.25 m, 25.2-25.4 m, 24.72-24.75 m and 23.25-23.30 m. They are represented by well preserved pollen and spores, full size grains with quite fresh sporodermy.

Deposits from the base of the Atelian thickness probably were formed in a rather humid and cool climate, in a phase dominated by pine and fir woods and alder thickets (with lesser amounts of fir and larch). The pollen of coniferous species (*Picea sect. Picea*, *Pinus sylvestris*, *P. subgen. Haploxylon*, *Abies*, *Larix*, ~ 60% of the total AP pollen) and an alder (*Alnus incana*, *A. glutinosa* – 37%) also testify to it. Pollen of cereals (Poaceae), sedge (Cyperaceae), different grasses (Liliaceae, Asteraceae, Polygonaceae, Fabaceae, etc.) and the spores of ferns (Polypodiaceae, *Botrychium*) dominate among grassy and low shrubby plants. The spores and

pollen range of sample from a overlying interval perhaps fixes an interval of climate aridization in the development of desert-steppe or dry steppe landscapes, with primary development of wormwood associations in the open spaces and alder trees in the valleys and hollows on the most humidified sites. In this range, there are no spores of the higher spore-bearing plants, the pollen of herbs and low shrubs represented in the main by Chenopodiaceae, *Artemisia subgen Seriphidium*, *A. e.gr. euartemisia* (about 75%) prevails, and within the group of trees and bushes, alder pollen (*Alnusincana*, *A. glutinosa,* about 70%) dominates. The share of pollen from coniferous trees was considerably reduced, and juniper pollen (*Juniperus,* about 10%) reaches a noticeable quantity.

It is possible to draw a conclusion about the growth of climatic humidity, expansion of the area of woody vegetation, and development of periglacial forest-steppe landscapes on the basis of the spore and pollen range in sample from the middle part of the Atelian deposits. In the vegetation cover, the biotopes of alder and pine-birch trees with *Betula sect. Nanae* in the shrubby circle prevailed together with different cereal grasses and Chenopodiaceae associations. In this sample, the tree pollen (60%) of alder (*Alnusincana*, *A. glutinosa*), birch (*Betula pubescens*, *B. sect. Albae*), and pines (*Pinus sylvestris*) prevails, the amount of wormwood pollen is considerably reduced (to 4%), the role of cereals and different grasses (Liliaceae, Asteraceae, Polygonaceae, etc.) increases, and the pollen of shrubby birch, the spores of Bryophyta (*Bryales*, *Sphagnum*), and ferns (Polypodiaceae) appear.

The spore and pollen range from sample from the top of the Atelian deposits reflects considerable strengthening of cold temperatures and, perhaps, a climate continentalization. It pushed the tundra-forest-steppe environment to the final stage of its formation. The content of pollen from trees and bushes decreased to 40%, and the role of spores increased (to 25%). In the AP group, the pollen grains of coniferous species (a fir-tree, a cedar-pine, and an ordinary pine) dominate with more than 55% of the total; at noticeable quantity is pollen of a shrubby birch (*Betula sect. Nanae* – about 20%), and an alder forest (*Alnaster* – 5%) that all indicate a cold climate. Among the spores of the higher spore-bearing plants, the remains of bryophytes (*Bryales*, *Sphagnum* – making up 60% of the total) and ferns (Polypodiaceae) prevail. The finding of spores from the frost-resistant fern *Cryptogramma crispa* growing nowadays in mountain-tundra, alpine, and subalpine belts of Eurasian highlands is of interest. Pollen of grassy-bushy plants includes ephedra *(Ephedra* – 5%), cereals (16%), a wormwood (*Artemisia subgen Seriphidium*, *A. s.g. Euartemisia* – 18%), Chenopodiaceae (13%), Liliaceae and Asteraceae (25% of the sum), and the remains of water plants of pondweed and milfoil (*Potamogeton*, *Myriophyllum*) (12% of the sum). Results of the spore and pollen analysis testify to the heterogeneity of climatic conditions and landscapes of the Lower Volga region during the Atelian epoch.

For the humic acids emitted from the Atelian deposits from paleodepression the radio-carbon datings lying in the range of 36680±850 – 40830±100 years, the calibrated age of 41191±750 – 44390±180 years are received. The results of dating performed by the radiocarbon method modifications at different laboratories (Institute of Geography of the Russian Academy of Sciences, Moscow, and the Lawrence Livermore National Laboratory, USA) match together. They indicate that the closing stages of the Atelian epoch in the Caspian Sea (filling of regressive cuttings with sediments of freshwater basins) occurred in the initial stages of the Valdai interstadial epoch on the East European Plain. OSL dating of Atelian deposits from the section at Srednyaya Akhtuba (the basal section of the Lower Volga area) confirm this conclusion (Yanina et al., 2017).

The structure of Atelian thickness in the Northern Precaspian, directly decrees howling on severe conditions of the initial stages of its accumulation, does not contradict the received

results. Let's remind that in its basis periglacial Akhtubinsk sediments lies, wedges getting into the underlying horizons (MIS 5 soils according Yanina et al., 2017) and the containing tundra and steppe palynological data (Grichuk, 1954). They answer a maximum of a cold snap of the Early Valdai glacial epoch.

The problem of correlation of the Atelian regression in the Caspian Sea with events in the Black Sea is under discussion. Marine Karangatian transgression in the Black Sea (MIS 5) during the epoch of the maximum cold snap (the glacial regression of the Ocean) was replaced by considerable decrease (up to –100 m) the level of the Sea (History …, 1988). Marine conditions were replaced by brakish water (History …, 1988). A maximum of Postkarangatian regression of the Black Sea we correlate with a maximum of Atelian regression of the Caspian Sea.

Conclusions

The Atelian regression is well pronounced in the structure of the Pleistocene deposits of the Northern Caspian Sea which were studied by seismoacoustic profiling, static sounding and opened with engineering-geological wells to the depth of 80 m. It is seen on the seismoacoustic profiles by the depressions under the reflecting horizon in the base of the Khvalynian deposits. The Caspian Sea level was 100 m below the actual one at those times. The regression strata are not lithologically uniform, taking a stratigraphic position in between the Hyrcanian and Khvalynian transgression deposits. The palaeontologic material proves the fresh-water or slightly brackish-water conditions of shallow basins filled with biogene-poor but carbonate-rich water. The results of spore-pollen analysis revealed a complex climate oscillations and dynamic change of natural environments of the area under study during the Atelian regression of the Caspian Sea.

The maximum of the Atelian regression and the formation of erosion depressions within the Northern Caspian Sea area coincide with the global cooling during the Kalinin (MIS 4) Ice Age. The final stages of the regression (filling of depressions with the fresh-water deposits) took place during the initial stages of the interstadial (MIS 3) epoch. The maximum of the Atelian regression correlates well with the maximum of the post-Karangatian regression of the Black Sea (Neprochnov, 1980).

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References

Chepalyga, A.L. 2004. Pozdnelednikovoe obvodnenie v Ponto-Kaspiyskom basseyne kak prototip Vsemirnogo potopa (Late glacial flood in the Ponto-Caspian Basin as the Flood prototype), Ecologiya antropogena i sovremennosti: priroda i chelovek, Gumanistika, St.-Peterburg, pp. 83–88 (in Russian).

Fedorov, P.V. 1978. Pleystotsen Ponto-Kaspiya (Pleistocene of the Pont-Caspian region). Nauka, Moscow (in Russian).

Grichuk, V.P. Materialy k paleobotanicheskoy harakteristike chetvertichnykh i pliotsenovykh otlozheniy severo-zapadnoy chasti Prikaspiyskoy nizmennosti (Materials to the paleobotanical characteristic of Quarternary and Pliocene deposits of northwest part of Caspian Depression), *Mater. po geomorfologii i paleogeografiyi SSSR*, Iss. 11, Izd-vo AN SSSR, Moscow, 1954, pp. 5-79 (in Russian).

Lavrushin, Yu.A., Spiridonova, E.A., Tudrun, A. Et al. 2014. Gidrologicheskie sobytiya pozdnego kvartera (The Caspian Sea: hydrological events of the late Quarternary). *Bull. Komissii po izucheniyu Chetvertichnogo perioda* 73:19–51 (in Russian).

Leontyev, O.K., Mayev, E.G., Rychagov, G.I. 1977. Geomorfologiya beregov i dna Kaspiyskogo morya (Geomorphology of coast and bottom of the Caspian Sea). Izd-vo Mosk. un-ta, Moscow (in Russian).

Lokhin, M.Yu., Mayev, E.G. 1990. Pozdnepleystotsenovye delty na shel'fe severnoy chasti Srednego Kaspiya (Late Pleistocene deltas on the shelf of northern part of the Middle Caspian Sea). *Vestnik Moskovskogo universiteta. Ser. 5. Geografiya* 3:34–40 (in Russian).

Neprochnov, Yu.P. (ed.). 1980. Geologicheskaya istoriya Chernogo morya po rezultatam glubokovodnogo bureniya (Geological history of the Black Sea according to the results of deep sea drilling). Nauka, Moscow, pp. 77-86 (in Russian).

Pravoslavlev, P.A. 1926. Kaspiyskie osadki v nizov'yah r. Volgi (Caspian deposits in the Lower area of Volga river), *Izvestiya Tsentral'nogo gidrometbyuro* 6:1-77 (in Russian).

Shakhovets, S.A. 1987. Khronologiya paleogeograficheskih sobytiy pozdnego pleystotsena Nizhney Volgi (po dannym termolyuminestsentnogo metoda) (Chronology of the paleogeographical events of the late Pleistocene of the Lower Volga area (according to termoluminescene method). Disseration, Moscow (in Russian).

Svitoch, A.A. 1991. Kolebaniya urovnya Kaspiyskogo morya v pleistotsene (klassifikatsiya i sistematicheskoe opisanie) (Fluctuations of level of the Caspian Sea in the Pleistocene (classification and the systematic description). Kaspiyskoe more. Paleogeografiya i geomorfologiya. Nauka, Moscow, pp. 5–100 (in Russian).

Vasil'ev, Yu.M. 1961. Antropogen Yuzhnogo Zavolzh'ya (Anthropogene of the Southern Volga Region). Izd-vo AN SSSR, Moscow (in Russian).

Yanina, T.A., Svitoch, A.A., Kurbanov, R.N. et al. 2017. Opyt datirovanija plejstocenovyh otlozhenij Nizhnego Povolzh'ja metodom opticheski stimulirovannoj ljuminescencii (Experience of dating the Pleistocene deposits of the Lower Volga region using the method of optically stimulated luminescence). *Vestnik Moskovskogo universiteta. Serija 5. Geografiya* 1:20–28 (in Russian).