Iranian National Institute for Oceanography and Atmospheric Science (INIOAS)

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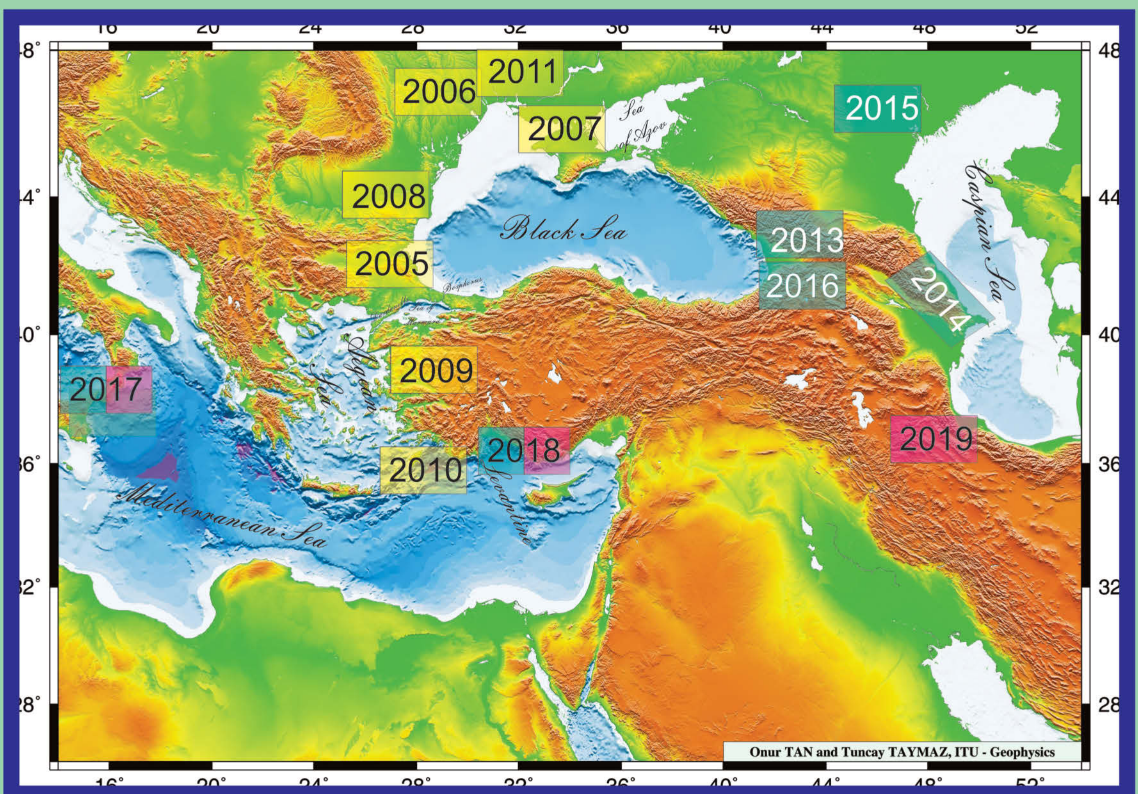
Ministry of Industry, Mine and Trade
Geological Survey of Iran

Iranian National Institute for Oceanography and Atmospheric Science (INIOAS), Tehran, I.R. Iran

October 11-18, 2019



PROCEEDINGS

INQUA IFG 1709 POCAS "Ponto-Caspian Stratigraphy and Geochronology" (2017-2020)

PROCEEDINGS

INQUA IFG 1709 POCAS Third Plenary Meeting
“Ponto-Caspian Stratigraphy and Geochronology“
(2017-2020)

Tehran ◆ INIOAS ◆ 2019

INQUA IFG 1709 POCAS
October 11-18, 2019, Tehran, I.R. Iran

PROCEEDINGS

Organizers and Sponsors:

Iranian National Institute for Oceanography and Atmospheric Science (INIOAS), Tehran, I.R. Iran

Avalon Institute of Applied Science, Winnipeg, Canada

Submitted papers are published in the Proceedings volume in their original state with no added editing. References, however, are formatted to conform to conference style.

Iranian National Institute for Oceanography and Atmospheric Science (INIOAS)

Ministry of Industry, Mine and Trade

Geological Survey of Iran

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AIMS AND SCOPE

The INQUA IFC (International Focus Group) POCAS continues a series of projects (UNESCO-IUGS-IGCP 521, 610; INQUA 501 - http://avalon-institute.ca/projects/) devoted to the Environmental Change and Human Response in the Caspian-Black Sea-Mediterranean Corrıdor (CORRIDOR) during the Quaternary. The CORRIDOR is considered as a single geographic entity (Fig. 1).

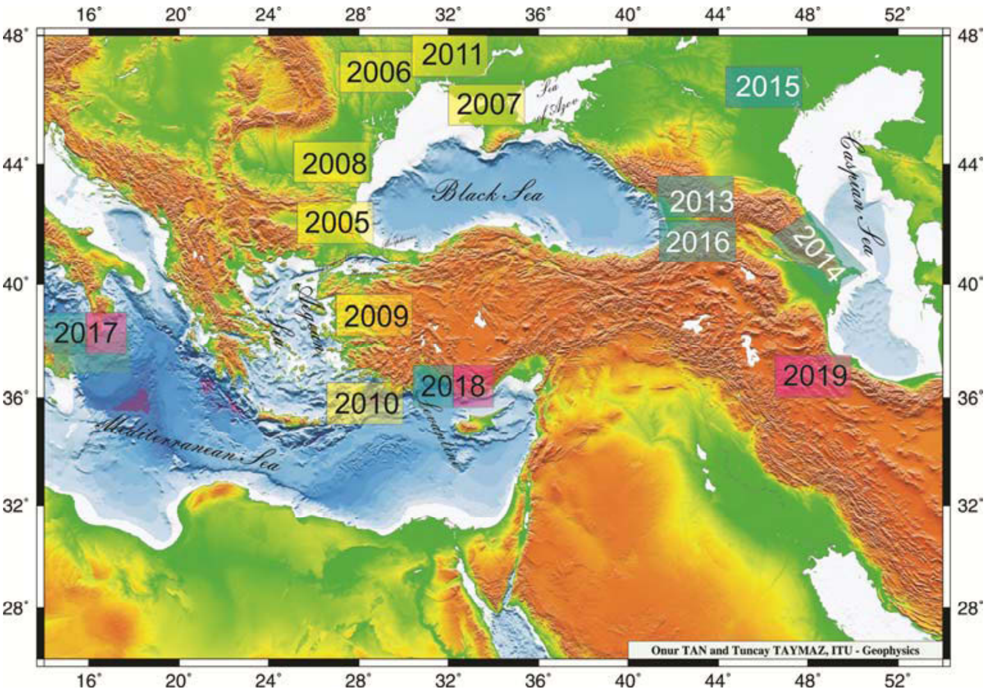

Figure 1. The Caspian-Black Sea-Mediterranean “CORRIDOR” with locations the Plenary Meetings and Field Trips: in yellow - IGCP 521-INQUA 501 (2005 – Istanbul, Turkey; 2006, 2011 – Odessa, Ukraine; 2007 – Gelendzhik, Russia;2008 – Bucharest, Romania and Varna, Bulgaria; 2009 – Ismir, Turkey, 2010 – Rhodes, Greece); in green – IGCP 610 (2013 – Tbilisi, Western Georgia; 2014 – Baku, Azerbaijan; 2015 –Astrakhan’ (Volga Delta), Russia; 2016 – Tbilisi, Eastern Georgia), in green and pink – IGCP 610 and INQUA IFG POCAS (2017 – Palermo, Italy; 2018 – Antalya, Turkey), in pink - INQUA IFG POCAS (Tehran, I.R. Iran)

The project established an international team of multidisciplinary scientists (about 300 people from 27 countries) working in close relation bypassing linguistic/political/disciplinary boundaries, linking continents (Europe and Asia) more closely, and encouraging East-West dialogue and cooperation among researchers

The INQUA IFG 1709F POCAS was created within the INQUA SACCOM for the term 2017-2020. It is concentrated on in-depth study of Quaternary stratigraphy and geochronology in the Ponto-Caspian region. The Ponto-Caspian is defined here as a chain of intercontinental basins that encompasses the Caspian, Black, Azov seas, the Kerch Strait, the Manych Valley, and their coasts. This chain represents a unique oceanographic system of relict Paratethys basins which were repeatedly connected and isolated from each other during the Quaternary. This predetermined their environmental conditions and hydrologic regimes, and imposed specific impacts on diverse biological populations. Due to its geographical location and semi-isolation from the open ocean, this region acts as a paleoenvironmental amplifier and a sensitive recorder of climatic events, in particular glacial-interglacial cycles on the Eastern European Plain and mountains, as well as transgressive-regressive sea-level variations of the World Ocean; thus, it can be considered as a stratotype region where geological history is well recorded in a long series of marine and continental sediments to be used for the development of the Pleistocene stratigraphy and geochronology of the Northern Eurasia.

The Quaternary stratigraphy and geochronology in the Ponto-Caspian dates back to the XIX century. The basic stratigraphic scale was first suggested by N.I. Andrusov and then modified by numerous researchers. This scale is based on the study of outcrops, many of which represent stratotypes for certain stratigraphic units, that were formed on the sea bottom and later exposed by tectonic uplift on coastal terraces. Many of them were observed during abovementioned projects.

The main goal of the INQUA IFG 1709F POCAS is to provide in-depth interdisciplinary study and correlation of the Ponto-Caspian stratotypes and other important outcrops exposed in the field trip localities and to assemble existing and newely obtained data in the up-to-date catalogue supplemented by their pictures, coordinates, lithological, paleontological and paleoecological records, stratigraphic division, and absolute datings. As an additional bonus, this project continues tradition to observe arcjaeological and paleoanthropological records in each particulat part of the CORRIDOR where filedwork takes place.

The First and Second Plenary Conference and Filed Trip of the INQUA IFG 1709F POCAS were carried out in Italy (Palermo) and Turkey (Antalya) jointly with IGCP 610 in order to bring the international communities of both projects together to solve a number of contentious issues involving stratigraphy, geochronology, geological history, archaeology, and anthropology of the CORRIDOR. The IGCP 610 project was completed in 2018. The Third Plenary Conference of the INQUA Focus Group POCAS will be carried out in I.R. Iran (Tehran). It will focus on the late Miocene-Plio/Pleistocene geological history of the South Caspian Coast, Iran along the West Alborz Mountains. This subject is very important in shedding light and achieving a better understanding of tectonic-climatic interactions during the Plio/Quaternary period in this region.

The meeting will cover six days in total. Two days (12-13 October) will be spent in Plenary Sessions, and four days (14-17 October) will be dedicated to the Field Trips (Fig. 2).

The Plenary Sessions, social activities and side-meeting round tables will be held in INIOAS headquareter in Tehran, I.R. Iran. Accommodation is considered in Hotel Hijab/Hotel Alborz, in proximity of the meeting location. The two days of the Meeting will be devoted to oral presentations and posters, and four days will be devoted to geological field trips that focus on of the Miocene, Plio-Quaternary outcrops and archeological sites.

It is expected that the meeting will bring together multidisciplinary scientists from all over the world to enhance the West-East scientific dialogue and provide a foundation for collaboration on correlation and integration of subjects covered by the conference as previous IGCP 521, 610, and INQUA 0501 meetings have done.

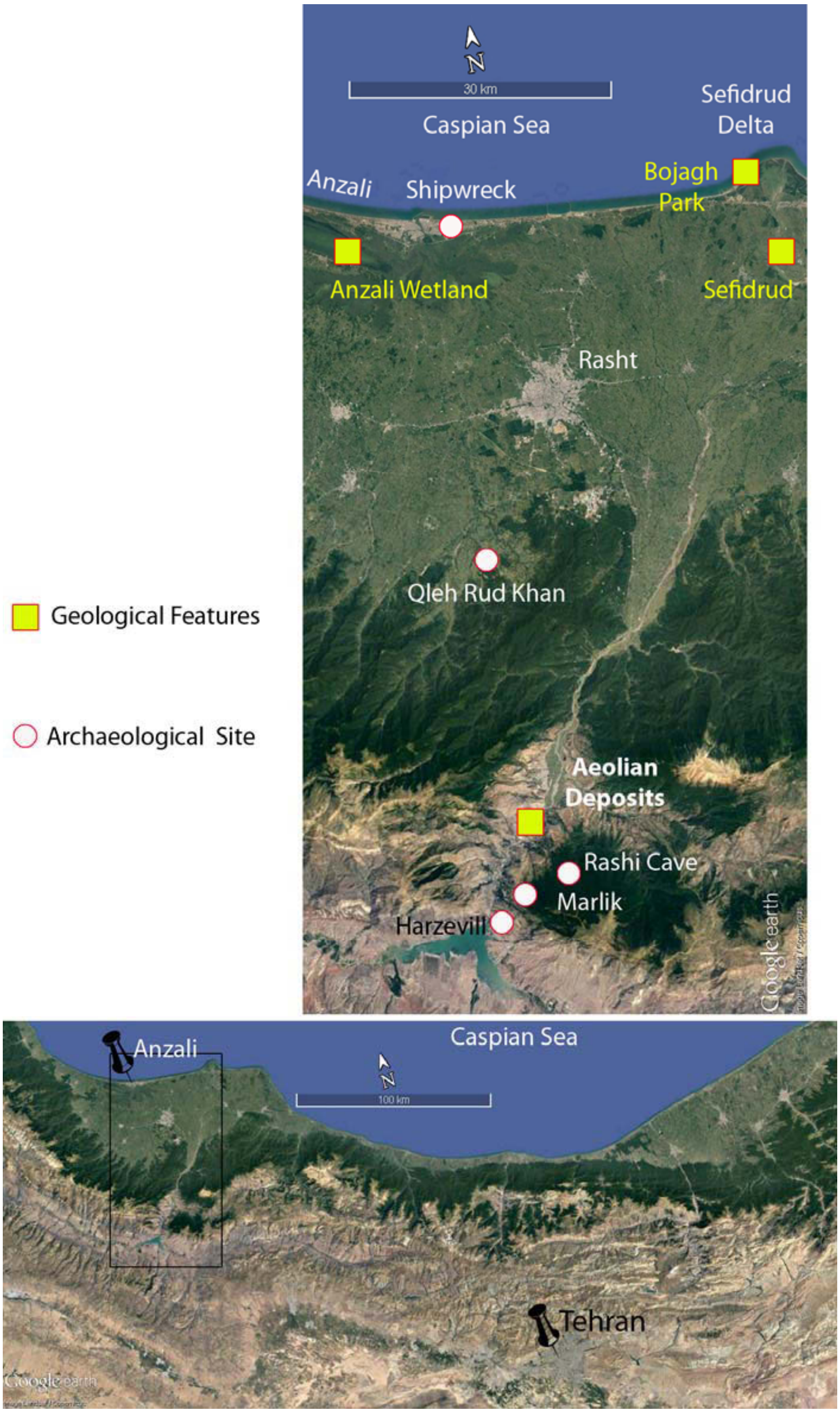

Figure 2. Field trip locations planned to be visited during the INQUA IFG 1709F POCAS meeting

WELCOME

On behalf of the Organizing and Executive Committees as well as the University of Palermo, Italy, and Avalon Institute of Applied Science, Canada, we are delighted to welcome you to the Third Plenary Meeting and Field Trip of INQUA IFG 1709F POCAS that will be held in Tehran and Guilan Province, I.R. Iran, on 11-18 October 2019

It is expected that the joint conference will bring together multidisciplinary scientists from all over the world and in the process enhance West-East scientific dialogue by providing a supportive background for collaboration regarding the correlation and integration of discoveries on the influence of climatically/tectonically induced sea-level changes and coastline migration on humanity. This is an area of strategic importance not only for all coastal countries but also for at least 17 other countries sharing a drainage basin that is one-third the size of the European continent.

The Meeting has been organized and sponsored by the Iranian National Institute for Oceanography and Atmospheric Science, Geological Survey of Iran, and Avalon Institute of Applied Science, Winnipeg, Canada.

We are happy to welcome to I.R. Iran distinguished specialists and students in the Humanities, Earth, and Life Sciences from countries around the world.

We wish you a very pleasant stay in I.R. Iran.

Sincerely,

Organizing and Executive Committees

VENUE

The plenary meeting will be held at the Iranian National Institute for Oceanography and Atmospheric Science (INIOAS) (Persian: پژوهشگاه ملی اقیانوس شناسی و علوم جوی Pazhoheshgah e Melli e Oghianoos Shenasi va Oloum e Javvi) meeting room in the center of Tehran, 3 Etamadzadeh St., West Fatemi Ave., Tehran, I. R. Iran) (Fig. 2).

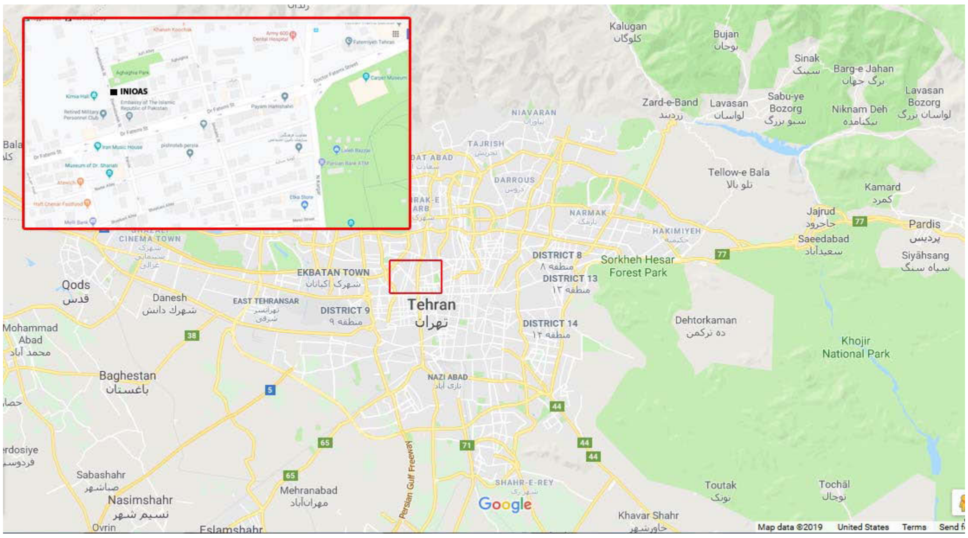

Figure 2. Tehran map.

The INIOAS is located between two major universities, Tabiat Modares Unv. in the north around 300 m and Tehran University in South around 700 m. Here we use oriention by geographical directions as very high mountains of Alborz located in the north of Tehran

The INIOAS is a research center established by Iran's Ministry of Science, Research and Technology in 1992 under the name 'Iran Oceanography Center' to perform research in the field of oceanography. In March 2010, the organization was renamed to 'Iranian National Center for Oceanography (INCO)'. In June 2013, the organization was again renamed to 'Iranian National Institute for Oceanography and Atmospheric Science (INIOAS).

Upon its completion, INIOAS will have the Khalije Fars sea explorer at its disposal to conduct oceanographic research.

Tehran is the capital of Iran and Tehran Province. With a population of around 8.7 million in the city and 15 million in the larger metropolitan area of Greater Tehran, Tehran is the most populous city in Iran and Western Asia, and has the second-largest metropolitan area in the Middle East. It is ranked 24th in the world by the population of its metropolitan area.

In the Classical era, part of the territory of present-day Tehran was occupied by Rhages, a prominent Median city. It was subject to destruction through the medieval Arab, Turkic, and Mongol invasions. Its modern-day inheritor remains as an urban area absorbed into the metropolitan area of Greater Tehran.

Tehran was first chosen as the capital of Iran by Agha Mohammad Khan of the Qajar dynasty in 1796, in order to remain within close reach of Iran's territories in the Caucasus, before being separated from Iran as a result of the Russo-Iranian Wars, and to avoid the vying factions of the previously ruling Iranian dynasties. The capital has been moved several times throughout the history, and Tehran is the 32nd national capital of Iran. Large scale demolition and rebuilding began in the 1920s, and Tehran has been a destination for mass migrations from all over Iran since the 20th century.

The majority of the population of Tehran are Persian-speaking people, and roughly 99% of the population understand and speak Persian, but there are large populations of other ethno-linguistic groups who live in Tehran and speak Persian as a second language.

Tehran has an international airport (Imam Khomeini Airport), a domestic airport (Mehrabad Airport), a central railway station, the rapid transit system of Tehran Metro, a bus rapid transit system, trolleybuses, and a large network of highways.

More information about Tehran and its surroundings is available at the following website:

https://en.wikipedia.org/wiki/Tehran

ACKNOWLEDGMENTS

We gratefully acknowledge the support and hospitality of the Iranian organizers, the the Iranian National Institute for Oceanography and Atmospheric Science for hosting the Third Plenary Meeting and Field Trip of INQUA IFG 1709F POCAS. Support has also been received from the Avalon Institute of Applied Science, Canada.

We are indebted also to Behrooz ABTAHI and Hamid LAHIJANI the President and the Chairman of the Organizing Committee of the Coneference, for the extraordinary efforts in organizing the conference and field trips.

Furthermore, we are also very grateful to Zahra NEZHADFALLAH, Executive Secretary, and Fahimeh FOROGHI, member of he Organizing Committee of the Conference.

We gratefully recognize the assistance of Prof. Dr. Valentina YANKO-HOMBACH for layout of the Conference Proceedings.

To the Scientific Committee, we offer sincere thanks for evaluating submissions and managing the abstract review process.

For her prompt action, we extend our appreciation to the Project and website administrator Dr. Irena MOTNENKO.

Prof. Dr. Valentina Yanko-Hombach

Leader of INQUA POCAS Focus Group

Executive Director of the Meeting

PART I. INQUA IFG 1709F POCAS PROGRESS REPORT (2018)

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2. Outline of the Project

The International Focus Group POCAS (IFG) “Ponto-Caspian stratigraphy and geochronology“ was created within the INQUA SACCOM for the term 2017-2020. It is devoted to the study of the geology of the Ponto-Caspian region during the Quaternary as a single geographic entity, bypassing linguistic/political/disciplinary boundaries, linking continents (Europe and Asia) more closely, and encouraging East-West dialogue and cooperation among researchers.

The main activities of IFG POCAS are oriented toward solving the existing contradictions, employing new work in the field if needed. This will be done by involving a wide range of multidisciplinary scientists and modern research methods and equipment. The major challenge will be the involvement of young scientists as well as graduate and undergraduate students to participate in the research and integration of available and newly obtained data. It is of great importance to do this because, so far, there are few specialists (particularly in the developing countries) trained in modern methods and techniques (e.g., isotopic analysis, geochemistry, paleontology, and different types of dating).

3. List of countries involved in the project

INQUA POCAS community includes about 260 scientists from 21 countries: Azerbaijan, Belgium, Bulgaria, Canada, Georgia, Germany, Greece, France, Israel, Italy, Kazakhstan, Latvia, Romania, Russia, The Netherlands, Switzerland, Turkey, Turkmenistan, UK, Ukraine, and USA.

4. Brief summary of activities and accomplishments during 2017-2018

The main activities of POCAS IFG in 2017-2018 focused on three main fields: I. Carrying out the meetings and field trips of POCAS group; II. Field research in various areas of the CORRIDORS; III. Development of IFG POCAS website.

In 2017 POCAS IFG carried out the first international meeting in Palermo, Italy; organized ECR training during Field Summer Training School in the Caspian Sea Region in Astrakhan, Russia; promoted international cooperation in practical research, especially in development of new numerical chronology and unified stratigraphical scheme of the

Ponto-Caspian region. The first international meeting was organized as a Joint Plenary Conference and Field Trip of IGCP 610 and INQUA IFG POCAS. This event was hosted by the University of Palermo, Italy. The Meeting and Field Trip were held in Palermo and Agrigento, respectively. The Joint Plenary Conference and Field Trip made provided opportunity to discuss the actual status of both projects and progress made by participants. Particular attention was paid to scientific approaches for integrating environmental, anthropological, ethnological, and archaeological data in order to trace the history of ancient humans from the Caspian to Mediterranean during the entire duration of the Quaternary. During the Field Summer Training School in the Caspian Sea Region in Astrakhan a group of 15 students from 7 different countries took part in field research. Main focus during this training was application of modern methods and techniques widely applied in Quaternary research around the world.

In 2018 POCAS IFG carried out: (1) the Second International Meeting in Antalya, Turkey (together with IGCP 610 Sixth Plenary Conference and Field Trip). This event is hosted by the University-Cerrahpaşa, Department of Geology, Faculty of Engineering, Turkey, October 14-22, 2018. It is focused on the late Miocene-Plio/Pleistocene geological history of the eastern Mediterranean of southern Turkey along the central Taurid Mountains. This subject is very important in shedding light and achieving a better understanding of tectonic-climatic interactions during the Plio/Quaternary period in this region. For details see http://www.avalon-institute.org/IGCP. (2) The International Scientific Conference “LoessFest 2018 Diversity of loess: properties, stratigraphy, origin and regional features” was held under the auspices of two focus groups: INQUA Loess Focus Group and POCAS September 23-29, 2018 in Volgograd, Russia on the base of the Volgograd State University. For details see http://loessfest2018.ru/?page_id=213. (3) The POCAS Session and an exhibition of photographs of young scientists and students - members of expeditionary research in the Ponto-Caspian region was organized at the Moscow State University in the framework of the scientific conference dedicated to the 50th anniversary of the research laboratory of the Pleistocene paleogeography of the Geographical Faculty of, June 7-8, 2018. (4) The POCAS Special Session in the framework of the LXIV session of the Paleontological Society of Russia "Fundamental and Applied Paleontology", St. Petersburg, Russia, April 2-6, 2018. (5) The POCAS Special Session for young scientists and students at the School-Conference of Young Scientists “Meridian: From Theory to Practice in Research of Nature and Society”, Kursk, Russia, May 31 - June 3, 2018.

The website http://avalon-institute.ca/projects/ has been created by Dr. Irena MOTNENKO, the Avalon Institute of Applied Science, Canada.

5. Linkage with other projects and organizations

EU-ITN programme "Drivers of Pontocaspian biodiversity rise and demise" (2015-2019)

EU-WAPCOAST BS-ERA.NET 076 “Water Pollution Prevention Options for Coastal Zones and Tourist Areas: Application to the Danube Delta Front Area”

Uncovering the Mediterranean salt giant (MEDSALT) COST Action CA15103

ICOMOS The International Council on Monuments and Sites

COCONET “Towards COast to COast NETworks of marine protected areas (from the shore to the high and deep sea), coupled with sea-based wind energy potential,” supported by EU

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Project № 12-05-31281 “Khvalynian epoch in the history of the Caspian region: Paleoclimates and environmental evolution,” supported by the Russian Foundation for Fundamental Research (2012-2014)

Project № 14-04-00227 "Environmental evolution of the Caspian and Black Sea under climate changes," supported by the Russian Foundation for Fundamental Research (2014-2016)

5. Social benefits

Implementing cultural heritage projects, open-air site museums, training centers in schools with the possibility of conducting experimental research, working together with local Governmental and Non-Governmental Organizations across the Caspian-Black Sea-Mediterranean Corridors that we study as a single geographic unit, bypassing linguistic and political boundaries, and thus encouraging East-West dialogue, cooperation, and integration of researchers from different countries into the international R&D community; enhancing our understanding of the links between environmental change and human adaptation, contributing to an improvement in human living conditions (especially for those at risk from coastal flooding), and promoting the wise use of the Earth as a human habitat; and preserving human heritage by addressing and clarifying existing archaeological, ethnological, and paleoanthropological questions concerning the evolution of human subsistence strategies, social and ideological spheres in the light of environmental change, and human physical and cultural adaptation theory.

6. Educational, training or capacity building activities

The Project has enabled participants to visit relevant sites in the Black Sea and Caspian region of the CORRIDORS under the guidance of local experts with on-site discussion of scientific issues; formed a platform for young undergraduate and postgraduate students to benefit from international exposure and interaction with scientists from different parts of the world and varied specialties in order to cultivate traditions of "European style" scientific fora as well as scientific discussion and informal meetings. This also promoted their interest in particular specialties and motivated them to learn foreign languages in order to improve communication skills with western colleagues.

It has also promoted a multidisciplinary approach in paleoenvironmental studies; this has encouraged students in geology to take archaeological courses, and vice versa. This has also stimulated teachers to modify their curricula for undergraduate and graduate students, and promoted the preparation of several MA and PhD theses on subjects within the IGCP 610 project.

It has encouraged the establishment of direct contacts between western and eastern youth, creating the background for better understanding of modern priorities in the developing world of science and humanities.

It has exposed the younger generation in developing countries to new analytical techniques and state-of-the-art data interpretation in the field of sustainable development and environmental risk protection, as well as human cultural development; it has also informed the wider public about the evolution of the environment during the Quaternary.

7. Activities planned

Efforts are ongoing:

To maximize the Project exposure via diffusion of results in key international journals and updates of our web pages to ensure wide accessibility and increased interactive potential for project participants, the scientific community at large, relevant agencies, and the public

To consolidate scientific achievements as a basis for developing future strategies

To continue to augment the funding base with upcoming and submitted research proposals through various funding agencies

To publish the next special volume of *Quaternary International* devoted to the achievements of INQUA POCAS

To publish the paper summarizing INQUA POCAS activities in *Quaternary Perspective*

PART II. PROCEEDINGS

CULTURAL AND CHRONOLOGICAL ATTRIBUTION OF EARLY HOLOCENE COMPLEXES OF EASTERN CASPIAN (BASED ON MATERIALS FROM DAM-DAM-CHESHME 2)

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Keywords: Southeast Caspian, Turkmenistan, Mesolithic, lithic industry, ancient migration, Trialetian

Introduction

The Early Holocene chipped stone industry in the Eastern Caspian has been attributed to Trialetian Lithic Industry by S.K. Kozłowski (Kozlowski 1996), different researchers have repeated such attribution following Kozłowski (Brunet 1999, Shnaider 2015). Trialetian was originally introduced by M. K. Gabunia in 1976 as a name of Mesolithic industries from sites of the area of Khrami River in Georgia, based on the assemblages from two sites: Edzani and Zurtaki (Gabunia, 1976). Later, Kozlowski has added to the original Trialetian area (Edzani) and includes the southern (Kamarband, Ali-Tepeh, Hotu) and eastern (Dam-Dam-Cheshme-2) Caspian. In determining the main characteristics of these complexes of this region and clarification of its technological features materials of the Dam-Dam-Ceshme-2 site plays an important role in constructions of S.K. Kozlowski, the materials of the Dam-Dam-Cesme-2 site take an important place. The lithic assemblages of this site appear in all cultural and chronological schemes of Mesolithic industries development in the Central Asian region (Okladnikov 1966; Ranov, 1988; Shnaider, 2015; Kozlowski, 1996). But at the same time, these materials has not yet been analysed in detail and published in full.

Dam-Dam Cheshme-2 is located near the station of Djebel (50 km from Ashhabad), on the south-eastern hillside of the Bolshoy Balkhan mountains, at Krasnovodsk peninsula in Turkmenistan. The site was investigated between 1949 and 1952 by Okladnikov, he excavated several test pits, including a 40m2 trench in 1952, but the main investigations were undertaken in 1963 and 1964 by Markov, who excavated over 250 m2. The materials obtained during the excavations of G. E. Markov, published in full. The materials obtained during the excavations of the first stage were not subjected to detailed analysis, only the most representative part of this collection is given in the publications. This article presents the results of an attribute analysis on the lithic assemblage from Dam-Dam-Cheshme – 2. Performed investigation of lithic collection and description of industries from the Mesolithic layers Dam-Dam-Cheshme-2, are in conflict with the attribution as Trialetian complexes. This work is attempt to revise this attribution to find out whether the Mesolithic of the south-eastern Caspian should be regarded as a part of Trialetian or it denotes to a separate industry.

Lithic industry

A total of 4492 lithic artifacts from six cultural layers from Dam-Dam-Cheshme-2 were obtained by A.P. Okladnikov. They consist of a variety of tools, cores, and production debris. Of this total, 268 are flint pieces from layer 2 (the second layer below the surface), just few of which are worked and the remaining 182 are production debris. Most of the worked artifacts from layer 2 are scrapers and notched. Cores vary are single-platform cylindrical forms. Layer 3 yielded 598 lithic, they include 110 retouched pieces (scrapers, notches, and drills, together with many geometric microliths as trapezes and triangles), and 303 pieces of unworked debris. Lithic material from layer 4 consist of 669 pieces, with few number of tools (85) and 584 unworked microliths (symmetrical trapezes, horn trapezes), and scrapers on flakes and blades. Cores are regular single-platform conical shape. Layer 5 was considered the upper and lower part separately by A.P. Okladnikov. The lithic industry of layer 5 is more variable, with the upper and lower part of this layer producing 2977 pieces (2515 of which are unworked), including well-made end and side scrapers on blades and flakes, some with notches on the distal end. Asymmetrical triangles and lunates (retouched blade "segments"), backed pieces with different modifications. Tools from Layer 5 also include many notches and denticulated bladeletes and flakes. Cores in the lower part of layer 5 are regular and include conical varieties. It is remarkable that the number of geometrics are decrease in layer 4, and increase again in layer 3. The results of the research also demonstrate that in the Mesolithic layers (5 and 4) most of bladelets and microblades has morphological and metric features of soft hammer use. At the same time, there are bladelets, microblades and cores, which demonstrate the use of pressure technique. But it is worth noting that in layer 3, bladeletes and blades demonstrate the evidence of soft hummer using pressure technique.

The varieties of geometric microliths in layer 5 suggested to A.P. Okladnikov that the Dam-Dam-Cheshme-2 was probably first occupied in Early Mesolithic, and that the strata immediately above this layer therefore dated from the Mesolithic to the Early Neolithic. Numerous fragments of pottery were retrieved in and above layer 3, but very small pieces were found in layers 4 and 5. Layer 3 is thus the earliest layer with convincing evidence of ceramic artifacts. It displays much lithic continuity with layer 4, including the use of geometric microliths. It therefore probably dates to the early Neolithic. Layer 2, which has no microliths, was dated by Okladnikov to the Late Neolithic or Bronze Age (especially on the grounds that the bronze artifact was found in it).

Correlations

Similar characteristics to the lithic industries of Dam-Dam-Cheshme-2 site demonstrate the materials from Djebel, Dam-Dam-Cheshme-1 sites in Eastern Caspian. Remarkable similarities industries of Djebel and Dam-Dam Cheshme-2 are found in types of tools, raw material strategies, and the knapping technology. These complexes are characterized by cylindrical cores for blades and bladeletes by soft hummer direct percussion. Similarity in the toolkit between these complexes are indicated by notched pieces on the blades and bladelets, backed pieces, drills, end and side scrapers.

For understanding the cultural and chronological attribution of the Early Holocene Eastern Caspian industries we provide the correlation with Southern Caspian industries. The chipped stone assemblage of Dam-Dam-Cheshme-2 finds some analogies with materials from Epipaleolithic layers of Kamarband, Hotu, Alitepeh and Komishan sites. The materials of the Mesolithic complexes of the Kamarband (Belt) cave (layers 7-8) show the most similarities with the materials of the Dam-Dam-Cesme-2 industries, wich were dated

11760-11420 B.P (McBurney, 1968). Analogies between these industries are reflected in chipped technology and toolkit.

Discussion

A.P. Okladnikov defined the main trends in the interpretation of Mesolithic industries of the region. He proposed to consider the materials of sites, located the Eastern Caspian region (Djebel, Dam-Dam-Cesme-1, 2, Kaylu) attributed to the technological line "Mesolithic", and characterized by bladelets technique with the dominance of geometric microliths (Okladnikov, 1966, P. 217). According to A.P. Okladnikov, these industries are part of the circle of microliths cultures are common in southern Asia, Europe, Australia and Africa. Unlike A.P. Okladnikov, V.A. Ranov noted the genetic affinity of the industries, considering the industries from Iran (Belt, Hotu) (Ranov, 1988). In 1970's G.E. Markov highlighted in wide areas of Eastern and Southern Caspian, Kyzylkum desert, Central Iran and Northern Iraq, the Caspian archaeological ethno-cultural province, where assigned Balkhan area which included the Eastern Caspian region (Markov, 1975). Later, Prof. S.K. Kozlowski hypothesized that the Mesolithic complexes of the Eastern Caspian are similar to the materials of the Trialetian Mesolithic culture (Kozlowski, 1996). According to the author, the main marker of the Trialetian is massive microliths – asymmetric trapezoids, segments and asymmetric triangles. Following him, F. Brunet also linked the origin of the Eastern Caspian Mesolithic industries with the Trialetian complexes, which extends to the Caucasus and Zagros (Brunet, 2002).

In 2016, the Iranian archaeologists V. Nasab and M. Jayez proposed to separate the materials of the Mesolithic complexes in the South-Eastern coast of the Caspian sea from industry of Trialetian Mesolithic culture which has been pointed by S.K. Kozlowski (Jayez et al, 2015). According to these authors, Mesolithic Trialetian culture, which has been allocated on the basis of Edzani and Zurtaki sites (Georgia) may not be similar to the Mesolithic complexes of the Southern and Eastern Caspian. Given the differences in environmental conditions, commodity strategies, stone industries and the patterns of life in these two regions, the it is suggested to separate the industry of South-Eastern Caspian sea be from the Mesolithic Trialetian culture. However, they do not deny a cultural link with the territory of the Caucasus (Jayez, et al., 2015).

Thus, there is no consensus among researchers in determining the cultural and chronological phenomena of the late Pleistocene and early Holocene of the Eastern Caspian. Based on the data that we have now, we think the Markov's hypothesis about Caspian ancient area, which in essence is the main idea of Jayez and her colleagues is more plausible. The social exchanging between Eastern and Southern Caspian was possible by the migration made possible by climate change, sea level and hydrographic networks.

Conclusion

Based on the detailed description of the archaeological collection from Dam-Dam-Cheshme-2 site, correlation with the materials of the adjacent territories we revealed similarities with the Mesolithic complexes of the Southern Caspian. Presumably, the sites in the Eastern and Southern Caspian are different in their industry from other classical Trialetian sites from Caucasus. This allows us to make a reasonable assumption, according to which regions of Northern Iran and Western Turkmenistan were one cultural area during the final Pleistocene – early Holocene (12-10 BP).

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STRUCTURE OF THE SOUTH CASPIAN UPLIFT OF THE BASEMENT

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Keywords: SCB, uplift, depression, Paleocene, Eocene, Cretaceous, Mesozoic

Introduction

A special place in a complex and mosaic structure of the SCB is occupied by an uplifted along the crystal basement the South Caspian protrusion-massif. For the first time is was determined according to gravimetric data. In the gravitation field the uplift corresponds with a large positive anomaly 20-25 mGal in the form of gradient on the background of a weak negative field (-10 ÷ 15 mGal) of the basin. To clarify its tectonic nature and structural character is one of very important problems of the Caspian geology. Some research workers think that it is morphologic element formed in the zone of bend and blowing of the oceanic crust in the subduction zone (R. Gajiev, 1965; E. Khalilov, 1983 et al.) and the others think that it is uplifted fragment of the structure of "intermediate massif" type of the preCambrian or the Paleozoic consolidation where the whole SCB is located ostensibly (Goryn, 1969; Shikhalibeili, 1984, Gasanov, 1966 et al.). However, the deep structure of the SCB is not studied very well enough and the geophysical information about it is not sufficient.

Direct seismic information about the deep structure of the South Caspian along the sublatitudinal regional profile "Byandovan-Okarem" allowed to clarify structural peculiarities and the occurrence depth of the base uplift in its north periphery. The seismic section distinctly shows an uplift of the acoustic base of an arc-horst type at depth 13.5-15 km. It is nearly 5-7 km higher than the depth showed in the 2D model of the DSS-9 profile in the cross point with profile by CDP. In the model of profile CDP at depth 13-15 km one can identify a high velocity series confined to the upper Mesozoic (Guliyev et al, 1988). The same inexactness in the estimation of the base depth according to data of the DSS and CDP was determined in the Black Sea and in many other deep-water depressions (Tugolesov et al., 1985).

On the seismic sections the surface of the empty arc and microblocks which in the form of terraces go down in the south-west direction are traced very well. This surface by peculiarities of the wave field is erosion surface. Sedimentary layers lean against its slopes. Conjugation of the uplift with the adjacent south trough occurs along the faults. This is typical for the flanks of the rift depressions. The substrate below the acoustic base surface possess all specific features (weak interrupted or stroky recording with chaotic located elements) typical for the consolidated crust.

Thus, summarizing data of different and independent geophysical studies about thickness of the crust and velocities of seismic waves therein the consolidated crust in the South Caspian uplift is close to the subcontinental crust of "intermediate" type. The tectonic block differs from the basalt crust underlying most of the SCB. This uplift by the same indices differs from the buried blocksmassifs in the Trans-Caucasian microcontinent (TCMC).

Results

Seismic time section of the South Caspian south part (materials of "Kaspmorneftegeofizrazvedka", papers of D. Babayev and P. Mamedov, 1995) 29 Hence, geological data about the Iranian coast and objective data of seismometry CDP and seismotomography allow to make a conclusion that Godin's protrusion being a substrate of the pre-Alpine consolidation separated from its north slope at the end of the Cretaceous or in the Paleocene and during intensive back-arc volcanism and extension in the Eocene it moved 150-200 km to the north-east.

Conclusions

According to some research workers in a vast territory from the Black Sea till Afghanistan there were formed transform faults of the SW-NE direction. They dissect a new Jurassic-Cretaceous lithosphere of the South Caspian.

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RETURNING TO THE PROBLEM OF THE BAER KNOLLS ORIGIN

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Keywords: morphology, sedimentation, granulometric analysis, sand ridges

Researches of the Baer knolls, widespread in the Northern Caspian Lowland continues. In the last few years, detailed work has been carried out in the Volga Delta (where BK are the most pronounced), as well as in the outcrops along the Lower Volga. However, based only on the study of these forms in the Volga delta, it is difficult to make the correct conclusion about their origin. The fact that the erosion of the sea during the Novocaspian transgression and then by numerous delta branches significantly transformed the original relief. Deposits that form BK were studied in these outcrops. Most often BK have the following structure: the marine lower khvalynian deposits lie at the basement, they overlain by two main layers (the lower and the upper layer), and holocene sediments of various origin are on the top. The units often are separated by angular unconformities and represent a multistage formation during the Late Pleistocene and Early Holocene, after the Early Khvalynian transgression. Layers are rich in organic material: detritus, debris and whole valves of marine and freshwater redeposited shells *Didacna catillus*, *D. praetrigonoides*, *Dreissena rostriformis*, *Hypanis plicatus* etc. We carried out granulometric analysis of samples taken from the upper and lower layers. The upper layers are more coarse-grained deposits, the lower – contain clay with admixture of silt and clay (Fig, 1 a, b**)**.

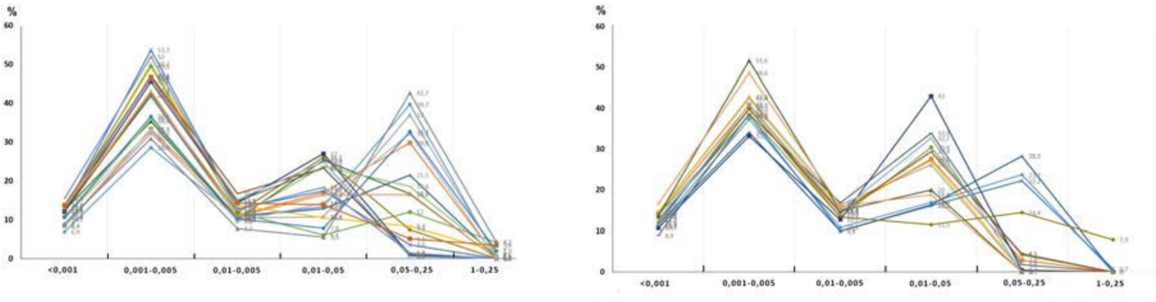

Figure 1. a –upper layers; b –lower layers

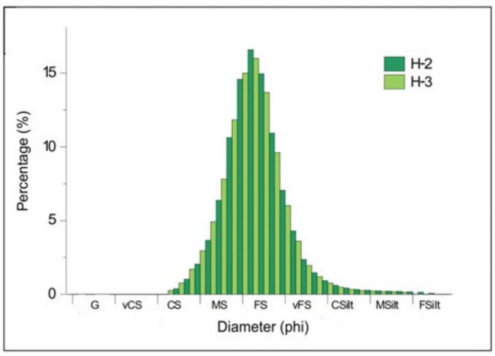

Figure 2. Granulometric composition of underwater sand ridges

But, it should be emphasized that judging by the nature of sediments, they were not formed on the underwater slope of the open sea, as some researchers believe (Svitoch A. A. & Kluvitkina T., 2006**)**. The granulometric composition of underwater sand ridges formed on the shelf is shown in figure 2 **(**Durán et al., 2017**)**. It is obvious that due to hydrodynamic processes the sediments are separated here and more fine-grained materials always move down to a greater depth.

Figure 3. Closed depressions between BK ridges

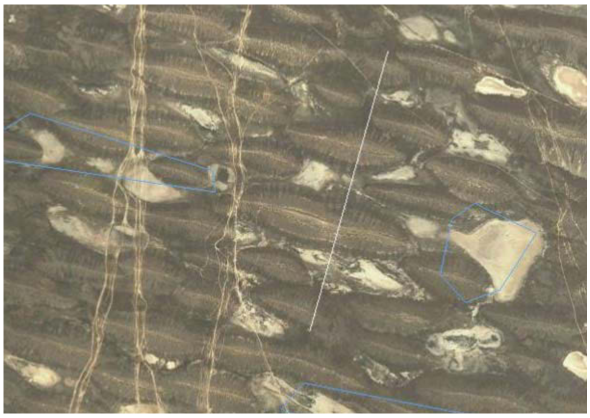

Figure 4. Unusual BK near the settlement Manat (Kazakhstan)

The morphology of the BK relief also does not speak in favor of their formation at the bottom of the open sea. Their study in detail during field seasons and the involvement of images showed that the BK are not separate extended ridges, but a system of ridges, connecting bridges, between which there are closed depressions (Fig.3). In other areas BK forms interesting relief, also unusual for the marine underwater sand ridges (Fig.4).

It should be noted another feature of the BK morphology – moving to the south, they gradually increase in height and at the same time the distance between them increases too (Fig. 5). Such situation could probably be when the water flows from the vast lagoons (Badyukova, 2018).

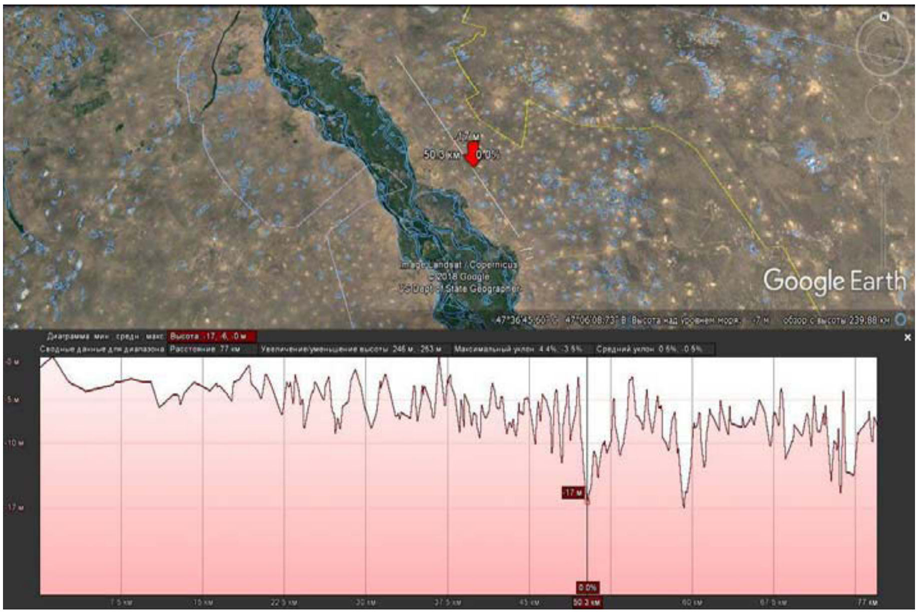

Figure 5. Gradually increasing of the BK heights

The character of morphology, stratification and granulometry indicates that, likely, BK were formed in subaquatic conditions, where a weak current occurred. Simultaneously with the accumulation of sandy material and interlayers of redeposited shells, there was a background deposition of clay particles.

Acknowledgments

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CORRELATION OF THE PONTO-CASPIAN BASINS DURING THE MIS 2 BASED ON STABLE OXYGEN ISOTOPE ANALYSIS

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Introduction

Global climate changes were fundamental for both the transgressive-regressive state of the Ponto-Caspian basins, as well as for glacier formation and retreat on the East European Plain. Isotopic composition changes reveal the influx of fresh water in the basins as well as it reflects global climatic changes. Thereby we show the correlation between transgressive-regressive events among Ponto-Caspian basins and glacial-interglacial epochs at the East European Plain during the MIS 2.

Material and methods

Over the past years our group of researchers from Lomonosov Moscow State University and OAO «MorInzhGeologia» studied Late Pleistocene sedimentary evolution of the North Caspian basin and the Lower Volga reference sections (Bezrodnykh et al., 2015, 2016, 2017; Bolikhovskaya et al., 2017; Sorokin et al., 2018; Yanina et al., 2018; Van de Velde et al., 2019) and in the Black sea (Sorokin et al.,2018; Zenina et al., 2018; Krijgsman et al., 2019). Here we report on stable oxygen isotope analyses of cores KOP-4 and IGS-1 from the Caspian North-Western area, BC-2Б from the Western Black sea area and RBH-16 from the Eastern Black sea area and complex study of the Srednyaya Akhtuba, Chernyj Yar, Kopanovka sections. The studies are based on drilling material from the edge of the shelf and outcrops. Oxygen isotope analysis was carried out on ostracod shells.

Results

Combining the obtained oxygen isotope and microfaunistic results with published materials we created the Ponto-Caspian paleoreconstruction for the MIS 2 highlighting 4 main stages:

1. *Second half of MIS3 – beginning of MIS2.* Caspian transgressive stage at the beginning of the Late Valdai glaciation, when against the background of a general climate cooling, there was an increase in the water balance positive components, a decrease in evaporation and an increase in the relative humidity and the continental river flow.

2. *Beginning of MIS2 – Last Glacial Maximum (LGM).* The regressive stage of the Caspian and Black seas as a result of climate severity. Significant sea level fall, desalination and isolation of both seas (lake type functioning).

3. *Deglaciation and postglacial time.* After a deep regression during the Last Glacial Maximum both Caspian and Black Seas evolution began according to a single scenario. Moreover both basins were substantially desalinated. Glacial melt waters flow intensification and permafrost melting together with increasing temperatures in the northern hemisphere led to Caspian level increase. Due to the sea level rise along the ingressive bays chocolate clays probably accumulated. As a result of ice sheet degradation and occasional large melt water influx the transgressive stage of the Caspian and Pont with complex internal dynamics began.

However after the maximum levels culmination during the postglacial time the same global climate events began to reflect differently in Khvalynian and Neoeuxinian basins despite the existing connection between the seas. While Caspian Sea level was rising, Black Sea level reaction to the same climatic events turned out to be the opposite. These differences manifest themselves most clearly during the interstadials Bølling and Allerød. The most important role was played by the water discharge from the Khvalynian into the Neoeuxinian basin through the Manych corridor, which made it possible to maintain a higher level of the Black Sea during the Oldest Dryas, thereby shifting the transgressive-regressive rhythm by a step relative to the Caspian.

Even during the transgressive phase Black Sea level did not reach high positive absolute marks and was about -25 m due to the low level of the Bosphorus threshold (bedrock here lies at a depth of -100 m, modern position is -35 m). At the same time, the Khvalynian Sea level was much higher due to the Manych threshold position probably more than 26 m, so the influence of melt water could be much more noticeable, and increasing evaporation less affected the changes in Caspian water balance.

Interruptions in the chocolate clays accumulation in the Caspian region occurred during the cold phases, which is probably an indirect sign of sea level fall. At the same time the water discharge along Manych allowed the transgressive phase in the Black Sea to continue. The level of the Bosphorus was reached only at the warm phases, when the Caspian Sea level was higher again due to the increased meltwater flow. So the changes in the Black Sea level seemed to be late in relation to the Caspian.

Thereby we assume the following basins dynamics during the postglacial time:

Oldest Dryas – Caspian Sea level fall as a result of a meltwater flow reduction and maintaining or raising of the Black Sea level due to Caspian water discharge during the maximum Khvalynian trangressive stage.

Bølling – Caspian Sea level rise, increasing runoff and the chocolate clays accumulation. Black Sea level fall due to the water discharge through the Bosphorus and evaporation increase.

Older Dryas – Caspian Sea level fall as a result of a meltwater flow decrease and Black Sea level rise due to Caspian water discharge during the Khvalynian trangressive stage at the level of 20-22 m.

Allerød – overall recurrence of Bølling events with Caspian Sea level rise, increasing runoff and the next phase of chocolate clays accumulation. As well as Black Sea level fall due to the water discharge through the Bosphorus and probably evaporation increase.

Younger Dryas – regression of both basins against the background of the harsh cold climate condition confirmed by various analyzes and noticeably heavier oxygen isotopic composition.

4. *Holocene beginning (MIS1).* The both seas level rise with a sharp warming; continuation of the Black Sea transgressive phase as a result of the two-way communication establishment with the Atlantic, and therefore Black Sea water salinization; the regressive Mangyshlak phase in the Caspian basin as a result of evaporation increasing and runoff decreasing. As the fifth stage Holocene transgressions of both seas, when basins developed independently, can be called.

As a result, the history of Black Sea level fluctuations during the postglacial time was smoother, without the high-amplitude pulsations characteristic of the Caspian.

Conclusions

We established the paleogeographic stages in the history of the Ponto-Caspian during the MIS 2. Oscillations of the oxygen isotope curves for the Caspian and Black Seas correlate with the main climatic episodes recognized throughout the northern hemisphere. There is an inextricable link between glacial-glacial rhythm and transgressive-regressive events in the Ponto-Caspian basin.

The climatic factor played a major role in Ponto-Caspian sea level changing during MIS 2. The connection of the Caspian and Black Seas with global climatic events in the northern hemisphere at the postglacial time is multidirectional.

Moreover calculation of the basins paleohydrological parameters using the unified formulas for oxygen isotope data in the Ponto-Caspian region is impossible. They require the introduction of adjustments based on special studies.

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TAXONOMIC COMPOSITION OF PALYNOFLORAS FROM THE EARLY KHVALYNIAN DEPOSITS IN THE NORTHERN CASPIAN REGION

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Introduction

At maximum stage of the Early Khvalynian transgression – one of the most significant transgressions in the Pleistocene history of the Caspian Sea, – a series of 'chocolate clays' was formed in the Northern Caspian Region.

Multidisciplinary stratigraphic-paleogeographic studies of the Early Khvalynian sediments, including the chocolate clays, are conducted from the mid-20th century (Shantser, 1951; Britsina, 1954; Fedorov, 1957; Moskvitin, 1962; Zubakov et al., 1974; Varushchenko et al., 1987; Rychagov, 1997; Svitoch, Yanina, 1997; Badyukova, 2000; Lavrushin et al., 2014; Svitoch et al., 2017; and others).

In the publications summarizing the results on the entire complex of the Early Khvalynian sediments in the Northern Caspian region the most debatable problems are those related to chocolate clays – their age and environments of deposition.

More than 30 radiocarbon dates obtained using scintillation and AMS techniques for chocolate clay samples from sections Cherny Yar, Tsagan-Aman, Srednyaya Akhtuba, Raygorod, Svetly Yar in the Volga valley and Mergenevo, Kharkino, Inder (the Ural River valley) as well as the dates obtained using OSL and U-Th techniques for chocolate clay probes from the Srednyaya Akhtuba, Raygorod, Leninsk sections show that the deposition of the clays occurred in the course of a relatively short interval of the Ostashkov Late Glacial, that is 13 to 11 ka BP (16-13 cal ka BP) (Svitoch, Yanina, 1997; Leonov et al., 2002; Arslanov et al., 2016; Kurbanov et al., 2017; Svitoch et al., 2017; Yanina et al., 2017).

When dealing with controversial questions of the Late Pleistocene paleogeography of the Caspian Sea basin a great importance is attached to the palynological analysis that formed the basis for reconstructions of changes in climate and vegetation at the time of the Early Khvalynian transgression.

The representative palynological data and reconstructions of the climate and environment changes in the Lower Volga region at the Early Khvalynian time (corresponding to the chocolate clay deposition as well as underlying and overlying layers) are presented in a number of papers (Grichuk, 1952; Chiguryaeva, Voronina, 1960; Obedientova, Gubonina, 1962; Lavrushin et al., 2014).

It should be noted that some differences in opinions on the allochtonous and autochtonous components in the samples became noticeable since the beginning of the studies. For example, A.A. Chiguryaeva and K.V. Voronina (1960) who studied Khvalynian deposits including the chocolate clays in many places of northern Caspian region interpreted a considerable part of the coniferous pollen as well as Polypodiaceae, *Lycopodium* and some others to be redeposited. Based on that results they conclude that their pollen data do not confirm the existence of a taiga forest phase identified by V.P. Grichuk (1952) in the Early Khvalynian vegetation history.

Recently there have been published results of palynological analysis of the Lower Khvalynian sediments studied by E.A. Spiridonova in Srednyaya Akhtuba, Kolobovka, and Tsagan-Aman sections (Lavrushin et al., 2014). The detailed palynological analysis of the chocolate clays performed by E.A. Spiridonova, as well as the analysis of the overlying and underlying Lower Khvalynian sediments, have not identified the "taiga phase" at the time of their deposition either. A high proportion of *Picea* pollen (up to 40%) was found in the assemblages recovered from the upper half of the chocolate clay horizon exposed in the Kolobovka section. The palynological data obtained from three studied sections made possible reconstructions of the forest and forest-steppe vegetation during three Late Valday interstadials (namely Rauniss, Bølling and Allerød); steppe formations were dominant during the Late Ostashkov coolings (Younger, Older, and the Oldest Dryas). The Allerød optimum was marked by widely spread pine-spruce and spruce-pine forests with admixture of birch and – more rarely – of elm and linden trees. Regrettably, the author (E.A. Spiridonova) does not give the complete list of the palynoflora identified in the studied horizons (Lavrushin et al., 2014).

Subject of investigation and results

The chocolate clays in the Srednyaya Akhtuba section have been palynologically studied in detail by author (Bolikhovskaya, Makshaev, 2019). The studies were aimed at making more complete list of the Lower Khvalynian palynoflora and at reconstructing the climate-phytocoenotic successions at the maximum stage of the Early Khvalynian transgression.

The Srednyaya Akhtuba section (48°42′ N, 44°55′ E) is on the left bank of the Akhtuba River (0.5 km south of the settlement of the same name). The section displays ~17 m series of the Late Pleistocene marine, fluvial, and subaerial deposits crowned by modern chestnut soil and including several paleosol horizons dated (11 dates) to the interval of 112 630±5400 to 720±70 yr BP (Kurbanov et al., 2017; Yanina et al., 2017). The OSL dates 15 000±1000 and 13 000±500 yr BP obtained on the chocolate clays agree well with the earlier published radiocarbon dates (Leonov et al., 2002), the clay accumulation is correlatable with the degradation of Ostashkov stage of the Valday Ice Age on the East European Plain.

There have been performed a detailed pollen analysis of 12 samples taken from the chocolate clays and the underlying and overlying sediments, from the depth interval 1.2–4.0 m (the upper part of the sequence).

During the entire history of investigations into palynoflora of the time of maximum stage of the Early Khvalynian transgression it is for the first time that reliable data have been obtained on arcto-boreal and arcto-alpine taxa presence in considerable proportion in the majority of spore-pollen assemblages and their almost constant participation in palynoflora. Among the most typical representatives of those taxa are *Betula fruticosa*, *B. nana, Alnaster fruticosus, Juniperus communis*, *J.* sp., *Dryas octopetala*, *Botrychium boreale*, as well as Siberian pine (*Pinus sibirica*), characteristic of tundra, forest-tundra and northern taiga phytocoenoses (Bolikhovskaya, Makshaev, 2019).

As follows from the results of a thorough palynological analysis, the studied autochtonous Early Khvalynian palynoflora includes about 100 taxa of various ranks. The tree and shrub pollen group (AP – arboreal pollen) includes pollen of 34 taxa: fir (*Abies* sp.), spruce (*Picea* sect. *Omorica*, *Picea* sect. *Picea*, *Picea abies* (L.) Karst.), pine (Pinus s/g *Haploxylon* (sp. indet.), Siberian pine (*Pinus sibirica*), Siberian larch (*Larix sibirica*), Scots pine (*Pinus sylvestris*), birch (*Betula* sect. *Albae, Betula pendula*, *B. pubescens*), shrub birch (*Betula* sect. *Fruticosae, B. fruticosa*), dwarf birch (*Betula* sect. *Nanae*, *B. nana*), Manchurian alder (*Alnaster fruticosus* after S.K. Cherepanov (1973)), shrub alder (*Duschekia fruticosa* (Rupr.) Pouzar./), European alder (*Alnus glutinosa*), speckled alder (*A. incana*), hazel nut (*Corylus avellana*), linden (*Tilia* sp., *Tilia cordata*), oak (*Quercus* sp., *Quercus robur*), ash (*Fraxinus* sp.), elm (*Ulmus* sp., *Ulmus laevis, U.* cf. *pumila*), oleaster (*Elaeagnus*), wild grape (*Vitis sylvestris* C.C.Gmel.), willow (*Salix* spp.), juniper (*Juniperus* sp., *J. communis* L.), red currant (*Ribes rubrum* L.), common hop (*Humulus lupulus*) and others.

The non-arboreal pollen group (NAP) includes more than 50 families, genera, and species of herbs, grasses and dwarf shrubs as follows: Ericales, grasses (Poaceae), sedges (Cyperaceae), hemp (*Cannabis*), *Ephedra* sp., sagebrush, wormwood (*Artemisia* sp., *Artemisia* subgenera *Seriphidium*, *Artemisia* subgenera *Euartemisia*); families: Chenopodiaceae (including *Atriplex cana* C.A.M., *A. litoralis* L., *A. verrucifera* M.B., *Halostachys capsica* (Pall.) C.A.M., *Kochia prostrata* (D.) Schrad. and others); Plumbaginaceae (including wide-leaved sea lavender *Limonium latifolium* /Smith./ O.Kundze), Apiaceae, Fabaceae, Polygonaceae (*Polygonum, Fagopyrum*), Campanulaceae, Caryophyllaceae, Ranunculaceae, Scrophulariaceae, Rosaceae (including *Dryas octopetala*), Portulacaceae, Rubiaceae, Violaceae (among them wild pansy *Viola tricolor*), Plantaginaceae (*Plantago*), *Urtica,* Fabaceae, Linaceae, Iridaceae, Liliaceae (*Tulipa*), Alliaceae, Asteraceae, *Xanthium*, *Ambrosia*, Cichoriaceae, and others. There are present in the NAP group some pollen of aquatic and near-shore plants: milfoil (*Myriophyllum*), pondweed (*Potamogeton*), duckweed (*Lemna*), waterwort (*Elatine alsinastrum*), water-plantains (Alismataceae), reed mace (*Typha*), and bur-reed (*Sparganium*).

In the group of higher spore (cryptogam) plants there were identified the following taxa: green mosses (Bryales), sphagnum moss (*Sphagnum*), ferns of Polypodiaceae family (including mountain bladder-fern (*Cystopteris montana* (Lam.) Desv.), ferns of Ophioglossaceae family (*Botrychium boreale* (Fr.) Milde, *B. virginianum* (L.) Sw., *Botrychium* sp.), club-mosses . (*Lycopodium clavatum*, L. sp.), horsetail (*Equisetum* sp.).

All the spore-pollen assemblages obtained from the Lower Khvalynian sediments are typically periglacial. The palynological record of paleoclimatic events in the lower reaches of the Volga during the last 11 500 years was reconstructed by N.S. Bolikhovskaya (2011; Bolikhovskaya, Kasimov, 2010) based on pollen analysis and radiocarbon dating of lacustrine (oxbow lake) sediments of the Solenoye Zaimishche locality (130 km southeast of the Srednyaya Akhtuba section). The comparison of the palynological records and the reconstructed paleoclimatic events of the Holocene and the epoch of the Early Khvalynian transgression of the Paleo-Caspian Sea shows unambiguously that the deposition of the studied Lower Khvalynian sediments took place under climatic conditions of a glacial period.

The Lower Khvalynian layers are distinct for the joint presence of species typical of tundra, boreal forest, and desert-steppe floras in the spore-pollen spectra; that suggests the deposition in periglacial environments. Among the species identified there are *Betula nana*, *B. fruticosa, Alnaster fruticosus, Dryas octapetala*, *Botrychium boreale*, *Abies* sp., *Picea* sect. *Picea*, *Picea abies*, *Pinus sibirica*, *Larix sibirica*, *Pinus sylvestris*, *Betula pendula*, *B. pubescens, Ephedra* sp., *Artemisia* s.g. *Seriphidium*, *A.* s.g. *Euartemisia*, species of Chenopodiaceae family (*Atriplex cana*, *A. litoralis*, *A. verrucifera*, *Halostachys capsica*, *Kochia prostrate* and others).

The plant communities typical for a glacial climate – tundra-steppes, periglacial forest-steppes, periglacial steppes, periglacial parklands and periglacial forests – were widespread over the studied region throughout the period of the studied Lower Khvalynian series deposition. A wide occurrence of microthermic plants making a part of the periglacial vegetation in the region (dwarf birch formation of *Betula nana* and dwarf shrubs of *Betula fruticosa*, *B. nana, Alnaster fruticosus*, *Juniperus*) is indicative of severe climate and, possibly, of sporadic permafrost existence during the cold intervals (stadials) of the Ostashkov Late Glacial (the latter attribution is based on the absolute dating).

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CORRELATION OF REGIOSTAGES AND HISTORY OF MARINE PONTO-CASPIAN BASINS AT THE BOUNDARY BETWEEN NEOGENE AND PLEISTOCENE

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The stratigraphic interval between the Neogene and the Quaternary periods has recently undergone significant changes after the lowering of the Quaternary boundary from 1.8 to 2.6 million years ago.

The subject of the scientific study is the lower boundary of the Pleistocene within the inner Eurasia regiostages, clarification of its position on the boundary of paleomagnetic epochs of Gauss and Matuyama, i.e. just in the middle of Akchagylian regiostage. In this connection it is necessary to correct the stratigraphic scale of the Ponto-Caspian Sea in the light of the latest decisions of the Russian Stratigraphic Commission. But then it will be necessary to draw a Neogene-Quaternary border within the Akchagylian regiostage of the Caspian Sea and the synchronous Kuyalnikian one of the Black Sea, which contradicts the provisions of international and Russian stratigraphic codes. Then it is necessary to integrate the separated parts of the Akchagylian and Kuyalnikian regiostages into larger stratigraphic units. In Russia, these subdivisions are: the upper Pliocene (Lower Akchagylian), which corresponds to the Piacenza regiostage, and Paleopleistocene (Upper Akchagylian), which corresponds to the Gelasian of the Mediterranean.

Akchagylian sediments are widespread within the Caspian depression. In the north and west of the Caspian depression, the Akchagylian sediments extend northward along the valleys of the Volga, Kama, Belaya and Ural rivers (Chel'tsov, 1965), as well as westward through the Manych (or Stavropol) Strait to the Azov and the Northern Crimea, where the Azov-Kuban Gulf of the Akchagylian Sea is formed.

The scientific study of this regiostage has a long history, and yet there are many unresolved issues. In particular, there is a problem with the stratotype. Stratotype of the Akchagylian regiostage was established in 1902 by N.I. Andrusov on the Krasnovodskiy peninsula in Akchagylian tract. However, the author did not describe the section in this area, so it became necessary to distinguish the lektostratotype from those mentioned by N. I. Andrusov and the followers of the sections starting from 1889. L.A. Nevesskaya proposed that the section near the Usak well should be used as a lektostratotype of Akchagylian (Chepalyga, 1997). Here, the Akchagylian sediments with a thickness of about 100 m lie on the red clays of the middle Pliocene and are overlaid with sediments of the Apsheron regiostage.

Initially, the Akchagylian regiostage was subdivided by A. A. Ali-Zade into three substages: the lower one with a thickness of 21 m; the middle one - 25 m; and the upper one - 59 m Akchagyl (Ali-Zade, 1961). Later, Yu. G. Cheltsov recognized the following substages in the section of Akchagylian near the Usak well: lower (17.8 m); middle (22.2 m); upper (up to 60 m).

L. A. Nevesskaya and V. M. Trubikhin proposed a new two-fold division of Akchagylian based on the results of paleontological and paleomagnetic studies and also based on the analysis of the history of the Akchagylian basin (Chepalyga, 1997). It is based on the identification of two large Akchagylian transgressions, on the specific composition of the fauna and the history of development of these two basins. Representatives of such molluscs as: Akchagylia, Avimactra, Cerastoderma, Raricardium, and Pirenella, which are close to the original genera Mactra, Cerastoderma, and Pirenella penetrated from the Piacenzian basin of the Mediterranean Sea, are found in the sections of early Akchagylian. Later, numerous endemic Akchagylian fauna, derived from these genera, appeared: Andrussella, Miricardium, Aktschagylocardium and Avicardium (Chepalyga, 1997; Danukalova, 1996).

As a result of paleomagnetic studies, normal magnetization of the Gauss paleomagnetic epoch was recorded in the sediments of the Early Akchagylian transgression. In the Upper Akchagylian sediments with rich fauna, the reversal polarity of the lower Matuyama epoch was found. The boundary between them is at the level of 2.6 million years. Lower Akchagylian correspond to the Gauss paleomagnetic epoch aged between 3.6 to 2.6 million years. The Upper Akchagylian deposits fall into the upper part of the paleomagnetic epoch of Matuyama from the border with the Gauss epoch to the Olduvei episode (2.6-1.8 million years) (Krijgsman et al., 2019).

The two-fold division of Akchagylian is also confirmed by the correlation with the regiostages of the Mediterranean, where the analogues of Akchagylian could be seen in two separate substages: Piacenzian and Gelasian. These are belong to different periods of the modern stratigraphic scale: the Piacenzian regiostage belongs to the Upper Pliocene and Gauss epoch (3.6-2.6 My) while Gelasian - to the beginning of the Quaternary period and has a reversal magnetization of the lower Matuyama period (2.6-1.8 My). It turns out that the lower boundary of the Quaternary period (2.6 My) passes within the Akchagylian regiostage, as evidenced by the history of links between the Ponto-Caspian Sea basins and the Mediterranean.

The first one, the Early Akchagylian transgression, was accompanied by the penetration of the waters of the Piacenzian Sea basin from the Mediterranean through the Euphrate Strait into Caspian depression about 3.6 My ago (Popov, 1969), as evidenced by the initial fauna of molluscs of the genera Cerastoderma, Mactra, Pirenella. The sea waters of this basin did not extend beyond the level of the Caspian Basin; only in the north of Caspian depression the area was flooded. In general, this transgression was much smaller than the Late Akchagylian one, but judging by the fauna, it had a bilateral connection with the Piacenzian basin. The second, Late Akchagylian transgression, was the largest on a scale. In the north, it reached the Kama and the Belaya River valleys, and in the west, its waters penetrated the Stavropol Strait and formed the Azov-Kuban Bay.

Chronologically Kuyalnikian regiostage of the Black Sea almost completely coincides with the Akchagylian (3.6-1.8 Ma), but is distinguished by external connections. It was a completely isolated brackish basin with no connection to the Mediterranean. However, the history of the Kuyalnikian basin has much in common and in terms of fauna composition it is also clearly divided into two transgressions. The Early Kuyalnikian, dated back to the Gauss paleomagnetic age (3.6-2.6 Ma), contains a rich molluscan fauna with numerous

Pliocene elements (*Dreissena theodo*ri, etc.). The area of the Early Kuyalnikian basin, as well as the rate of transgression, was considerably smaller than that of the Late Kuyalnikian one. Thus, in the history of the Kuyalnikian basin, as well as in the history of the Akchagylian basin, there are two major stages, which are correlated with transgressions: the Early Kuyalnikian basin (3.6-2.6 Ma) and the Late Kuyalnikian basin (2.6-1.8 Ma). They correlate with the Piacenzian and Gelasian regions, respectively.

Eopleistocene Ponto-Caspian (1.8-0.8 My) is represented by Apsheronian and Gurian regiostages. The Apsheronian regiostage of the Caspian corresponds to the Mediterranean Calabrian one, and is divided into two substages by mollusk fauna: the Lower Apsheronian one with poor refreshing fauna (Dreissena, *Corbicula apsheronica*, etc.) and the Upper Apsheronian one with the appearance of rich endemic fauna belonged to genera Apsheronia, Parapsheronia, Hyrcania, etc. The boundary between them is based on the paleomagnetic event Cobb Mountain (about 1.2 million years). This makes it possible to distinguish the change of two types of marine basins: the Early Apsheronian demifresh water basin with one-way water exchange by spill to the Mediterranean Sea (Calabrian basin) and the Late Apsheronian completely isolated basin of the Caspian type.

In the Black Sea, the Gurian regiostage is the analogue of Apsheronian and Calabrian. In the history of the Gurian basin there are also two types of basins: the Early Gurian demifresh water basin with poor fauna of genera Pyrgula, Micromelania, etc., and the Late Gurian completely isolated basin of Caspian type with endemic fauna of genera Digressodacna, Submonodacna, Tshaudia and the first appearance of the recent Caspian genus Didacna.

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VERTIC FEATURES IN THE PLEISTOCENE PALEOSOLS OF VOLGA-AKHTUBA LOWLAND

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Keywords: Vertisol, slickensides, XRD, micromorphology

Preface

Vertisols commonly appear in conditions that are seasonally humid climate or subjected to occasional droughts and floods. The main areas of distribution of these soils are located in India, Australia, Central Africa, the United States, and to a lesser extent in South America. However, vertic features may appear in different soils under a various climatic condition. The ability of Vertisols to shrink and swell is determined by their mineralogical composition, which is inherited from the parent rocks. These soils have a high content of clay with swelling minerals of the smectite group. The main morphological markers of these soils are slickensides (sliding surfaces) and wedge-shaped aggregates. Vertisols may also form specific gilgai microrelief (Fig. 1).

Figure 1. The microrelief of gilgai, formed in the liman of the Volgograd region

Many studies of buried Vertisols have appeared over the past 20 years. These objects are interesting for paleopedology, since they retain some morphological features (slickensides, the specific wedge-shaped aggregates) after burial, as well as the depth of the horizons due to high density of Vertisols. Buried Vertisols are important for paleolandscape reconstructions because they indicate climates with high seasonality (Sheldon and Tabor, 2009) and/or landscapes with fluctuating ground water table.

Materials and methods

The loess-paleosol sequences of the Volga-Akhtuba were comprehensively investigated in geological studies (Moskvitin, 1962; Pravoslavlev, 1926; Svitoch, Yanina, 1997 and others). However, a study of the genesis of buried soils has not yet been conducted.

The Raygorod outcrop is situated on the right bank of Volga river (Svetloyarsky district of Volgograd region) near Raygorod village (48 ° 25'46.3 "N 44 ° 57'20.0" E) (Fig. 2).

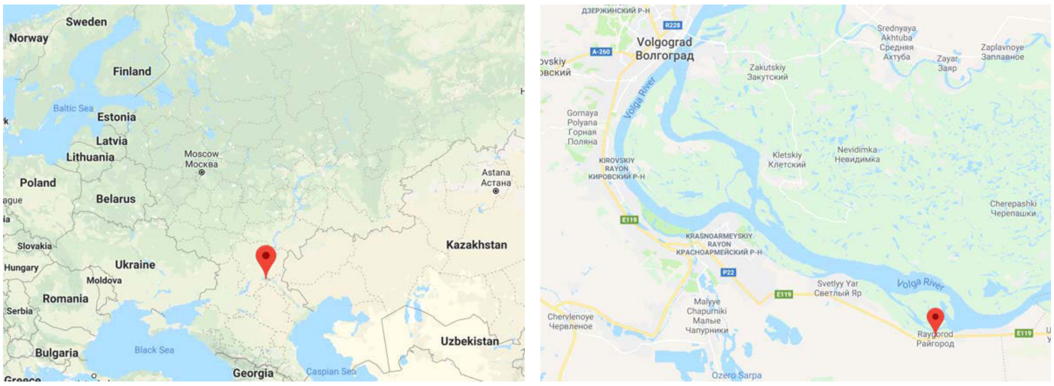

Figure 2. The geographical position of the study site

e've identified eight levels of buried soils associated with loess interlayers. At a level of 17.6 m from the present surface, we described the paleosol of the MIS5 stage, formed in silty clay loam (Fig. 3). The soil profile shows vertic features represented by slickensides

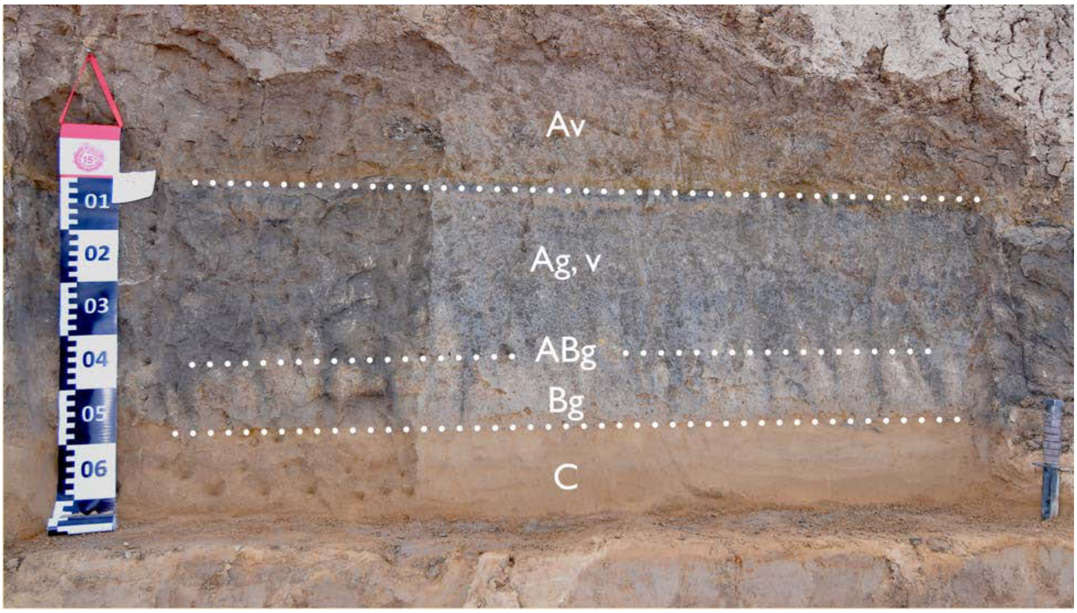

Figure 3. General view of the studied profile

Results

The key soil horizons include: [Av] – [Ag,v] – [Bg] – [C]. The thickness of the buried soil is about 50 cm. Slickensides were described in heavy loam horizons – [Av] (reddish brown) and [Ag, v] (grayish). In the upper horizon [Av], we noted the most prominent vertic features - glossy wavy slickensides, varied in size from large (about 40 cm) to small. Sometimes they are formed around gypsum crystals up to 2-3 cm in size (Fig. 4).

Fig. 4. Gypsum crystal and slickensides of different sizes in the horizon A

Horizon boundaries are clear and smooth. [Ag,v] horizon is defined by color. Morphological signs of vertic features are less pronounced - the slickensides are smaller, more dull, with horizontal or sub horizontal orientation. However, wedge-shaped aggregates typical for Vertisols are present here (Fig. 5).

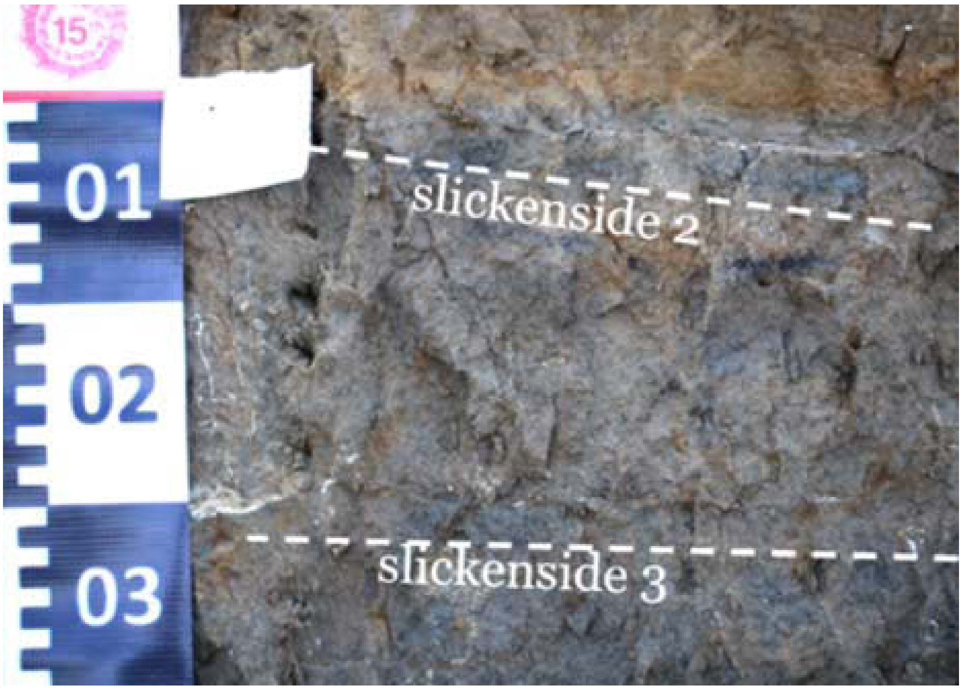

Figure 5. Slickensides in the [Ag] horizon

There are few thin (about 2 cm thick) dark layers on the contact of [Av] and [Ag, v] horizons. The boundary between [Ag, v] and [Bg] is abrupt due to the soil texture change (from loamy to sandy loam) and wavy because of permafrost wedges. The horizon [Bg] is characterized by abundant iron mottles and concretions (Fig. 6) and has an abrupt boundary with a layer of well sorted fine sand ([C] horizon).

Fig. 6. Neoformations in the horizon [Bg]

Micromorphology provides additional insight to the genesis of Vertic features.

Specific wedge-shaped aggregates, highly striated b-fabric and stress-coatings along cracks are most prominent in the [Av] horizon (Fig. 7).

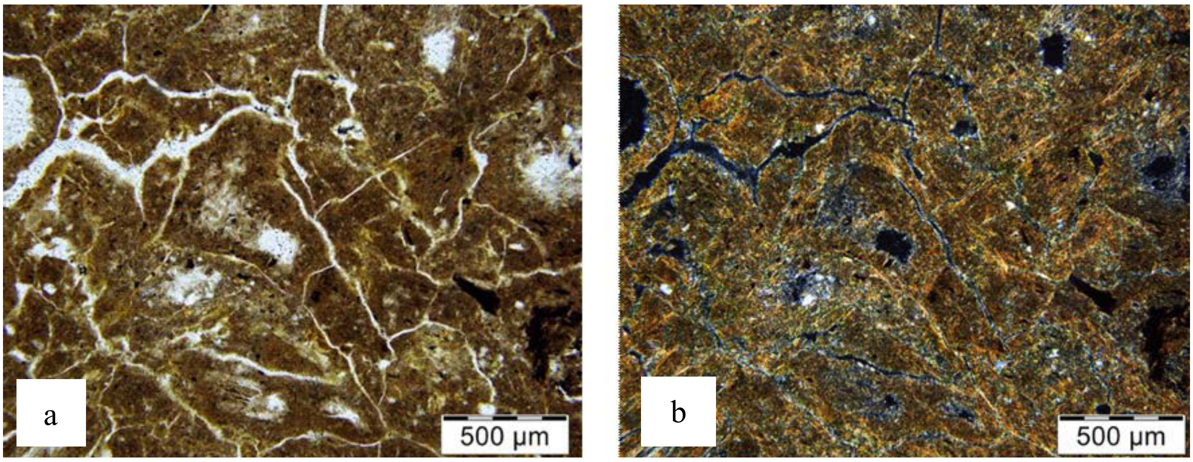

Figure 7. Angular-blocky and wedge-shaped aggregates in the [A] horizon

Charcoal particles are abundant in the upper 5 cm of the [Ag] horizon (Fig. 8a), most probably indicating former soil surface in the past. Redoximorphic features are widely distributed as microzones of iron-clay micromass in the lower part of horizon (Fig. 8b, c). Micritic pore infillings are also noted.

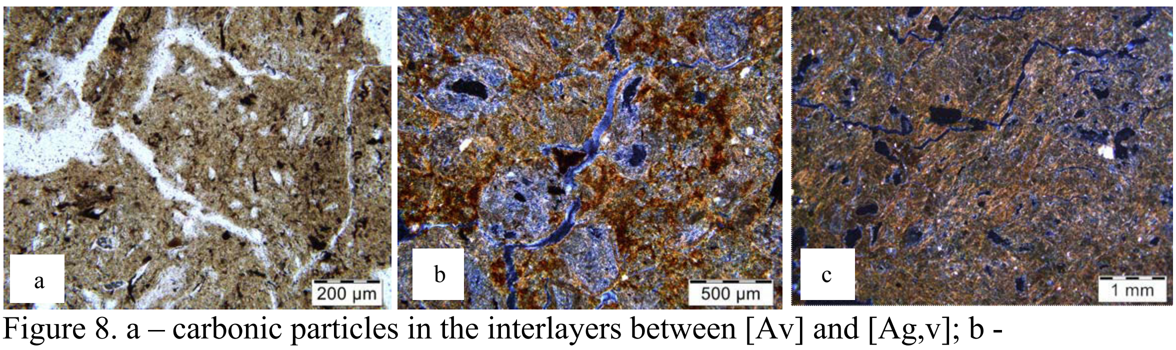

Figure 8. a – carbonic particles in the interlayers between [Av] and [Ag,v]; b - heterogeneous ferriferrous impregnations [Ag,v]; c – striated b-fabric

The transitional horizon is presented by a low-carbonated material of wedges, where shell fragments were found. Whereas the material between wedges shows heterogeneous areas of formation of iron oxides (massive ferriferous coatings along the pores) and carbonate accumulation (intensive micritic impregnation, Fig.9). Rounded microaggregates (ooids) point out to intense cryogenic influence in the past.

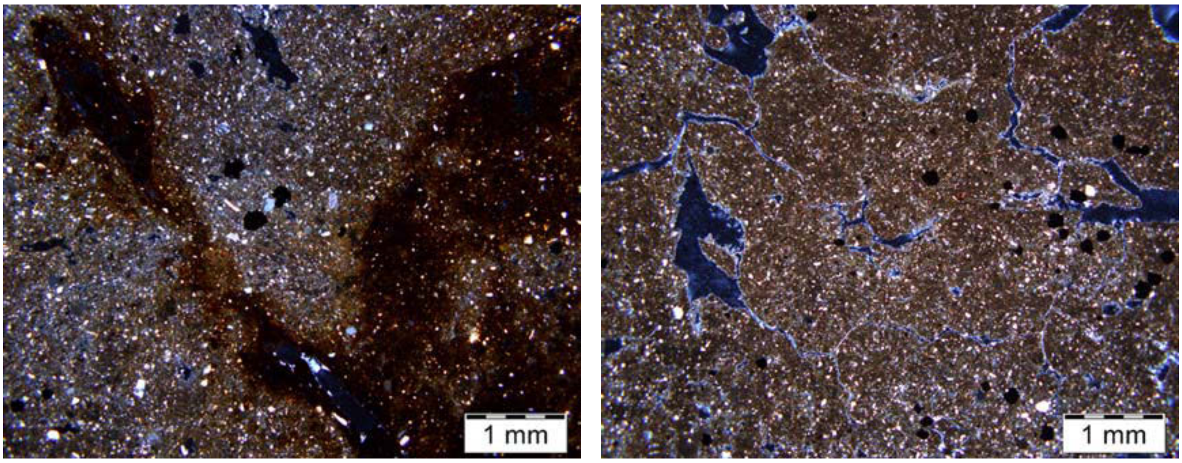

Figure 9. Material between the wedges

Since the Vertic features (shrinking and swelling, resulting in slickensides) are closely related with their mineralogy. An XRD of clay fractions (<1 μm) shows dominance of smectite (about 80%), that is typical for modern Vertisols. A specific feature of diagnosed smectite is the calcium form of cation filling. Associated minerals are chlorite, imperfect kaolinite and highly hydrated illite. (Fig. 10)

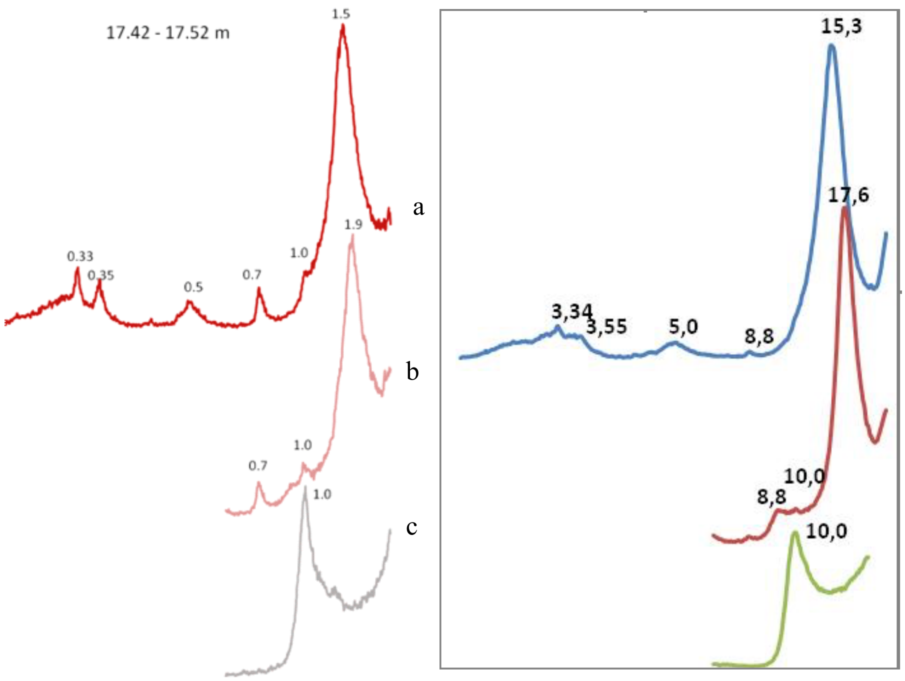

Fig. 10. XRD of clay fractions (1– studied paleovertisol, 2 - modern vertisol (I. Kovda et.al., 2017)), a – air-dry sample, b – ethylene glycol saturated, c - 550°C heated

Mineralogical and micromorphological studies indicate a former intensive development of Vertic features, while at the macromorphological level these signs are less pronounced.

Conclusions

The presence of Vertic properties (slickensides) confirms that soils have been formed on a floodplain with fluctuating water table. This is also supported by well sorted sand at the bottom of soil profile and redoximorphic features in the middle horizons. At the same time, secondary carbonate accumulations (soft powdery lime and impregnation of pores) indicate extensive dry seasons. Together with cryogenic features they point out to cold and arid environment with long seasonal flooding.

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GAS HYDRATES IN THE BLACK SEA

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Keywords: BSRs, seismic reflection, shallow gas, gas hydrate distribution, gas hydrate stability, Turkish Black Sea

The Black Sea is a back–arc basin generated by the northward subducting Tethys Ocean (Robinson et al., 1996), and comprises western and eastern sub–basins separated by the regional Mid-Black Sea Ridge. The Black Sea has an extensional origin; however, the tectonic setting changed to a compressional system during the Eocene, and its margins are currently characterized by a compressive deformation. A very narrow continental shelf (up to 10 km wide) and a steep continental slope (with inclinations exceeding 25°) exist along the eastern and southern margins, while the shelf is well developed in the W and NW margins. It has a continental rise with gentle slopes and a smooth abyssal plain at max. 2200 m water depth.

Studies on the gas hydrates in the Black Sea basin started in late 1980s (Korsakov et al., 1989). Figure 1 summarizes these studies on the Black Sea map. Gas hydrates were sampled at some mud volcanoes in the Black Sea basin (Ivanov et al., 1996). The first bottom simulating reflections (BSR) on the seismic sections are reported by Lüdmann et al. (2004) along the Dnieper Canyon. Zillmer et al. (2005) investigated the same area using ocean bottom seismometer (OBS) data in order to quantify the gas hydrate and free gas saturations. In 2006, the first multiple BSRs are reported by Popescu et al. (2006) along the levees of the Danube Canyon.

Römer et al. (2012) mapped the gas hydrate mounds using an autonomous underwater vehicle (AUV), and they sampled gas hydrates in the Kerch seep area. Minshull and Keddie (2010) mapped the BSR distribution using 3D seismic dataset of Turkish Petroleum Co. and calculated the geothermal gradients for offshore Batumi. Pape et al. (2011) analyzed the gas concentrations using gas hydrate samples for the same area. Hillman et al. (2018) investigated the Danube Fan using P–cable 3D seismic data, and Zander et al. (2018) investigated the impacts of gas hydrate exploitation on the slope stability for the same area. As compared to the N and NW margin, studies on the gas hydrates along the Turkish Black Sea margin are poor. Dondurur et al. (2013) reported possible connection between gas hydrate dissociation and massive slope failures in western Black Sea offshore Zonguldak.

Bottom simulating reflections (BSRs) on the seismic sections coinciding with the base of gas hydrate stability zone (BGHZ) are considered as one of the most prominent indication of the subsurface gas hydrate occurrence. Characteristics of the Black Sea BSRs are as follows (Fig. 2):

- They often crosscut the reflections from normal subsurface stratigraphy and generally mimics the seafloor.
- BSRs are of negative polarity with respect to the seafloor reflection.
- The amplitudes of the BSRs are generally high with respect to the surrounding reflections.

- Depth of the BSRs from the seafloor generally increases with increasing water depth.
- They are often associated with gas chimneys and acoustic turbidity zones beneath, which indicates free gas below the gas hydrate stability zone.

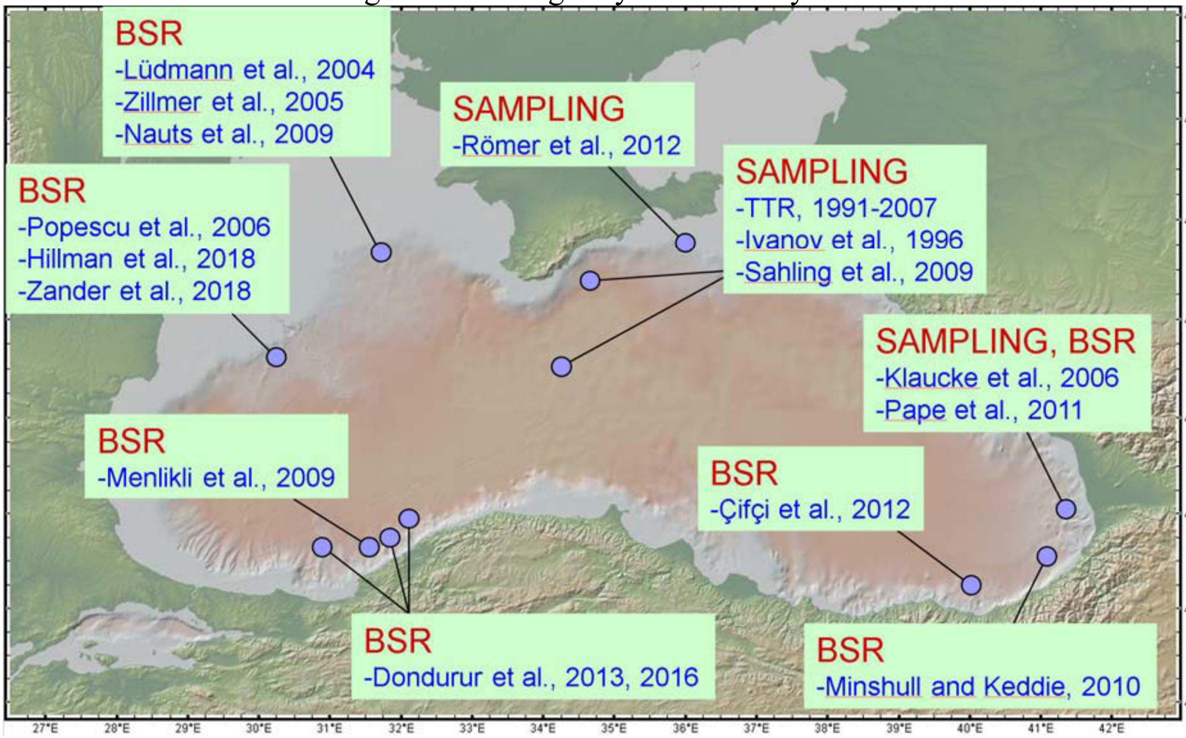

Figure 1. Summary of the studies on gas hydrates in the Black Sea basin

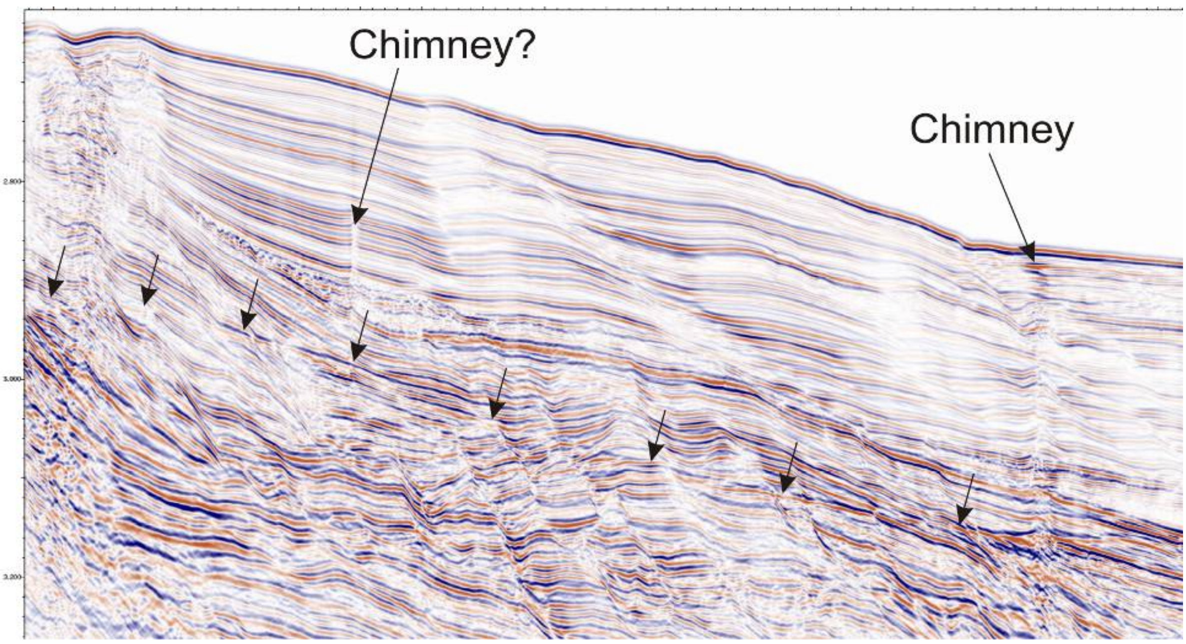

Figure 2. A seismic data example of BSR (arrows) from Turkish continental margin

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WESTERN TURKEY DELTA DEVELOPMENTS AND THEIR EFFECTS ON THE WORLD CIVILIZATION AND CONSEQUENCES

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Keywords: Western Turkey, deltas; Luwis, Ancient Towns, Troia, Ephesus

Introduction

Most people tend to consider the maps of the world map as fixed. However, in geological timescales our land-sea boundaries are in a continual state of change. The seabed stretching off many of our coasts, now covered in tens of meters of water, was once dry land. These areas supported a terrestrial biota including, at a certain point in time, early human populations. The sea level has and continues to fluctuate greatly throughout time. On a day to day basis, the sea level changes according to the tide but the sea level also changes on a much grander time scale too. These changes in sea level are normally caused by ice ages or other major global events. The sea level changes for a variety of reasons. These reasons can be put into two cateGoryes, eustatic and isostatic change, depending on if they have a global effect on sea level or a local effect on the sea level.

The Aegean is the sea that is surrounded between the coasts of mainland Greece, the coasts of western Turkey and Crete. The current geomorphological condition of the Aegean is the result of three main parameters: the tectonism, the volcanic activity and the eustatism (i.e. the rise and fall of the sea level). The history of the Aegean begins about 35 million years ago, when, during Oligocene, land emerged from the sea for the first time. The eustatic moves, i.e. the rise and fall of the sea level, due to the alternation of the glacial and interglacial periods, were causing expansion or reduction of the land areas and change of the land connections between them. Finally, during the Holocene, with the end of the last glacial period, the sea level rises and the Aegean region gradually acquires its current geography. The Eastern Aegean islands are cut off from Asia Minor and the Cyclades islands are permanently isolated from one another. There are two distinct types of continental shelves surrounding the Aegean Sea: (i) narrow (1-10 km) and (ii) broad (25-95 km) shelves. The shelf break in narrow shelves is primarily controlled by major bounding faults and generally occurs between 130 and 150 m with very steep slopes (up to 1:20) leading into deep basins. In most regions between the islands there is no clear shelf-break and the morphology of the sea-floor exhibits linear shore-parallel troughs. The broad shelves occur predominantly along the eastern and northern Aegean Sea. Except for the outlet of the Dardanelles, all are found seaward of major present-day deltas. The shelf-break in broad shelves occurs between 95 and 120 m water depth and denotes the topset to foreset transitions of deltas prograded during the end of last glacial period, immediately prior to Holocene transgression.

Figure 1. Western Anatolia rivers and ancient towns

Rivers of Büyük Menderes, Küçük Menderes, Gediz, Bakırçay and Karamenderes have the very important delta plains and they have significant effects on geomorphologic changes during the geological period in western Aegean Shoreline (Fig. 1). On these deltas there are ancient towns such as: from south to north, Miletus, Ephesus, Smyrna, Pergamum and Troia. It should be noted that a rising sea level would occasionally inundate an area of low gradient such as the Aegean Sea, creating massively extensive new marshlands and new environments which could support adapting coastal and aquatic life styles. Populations certainly moved and adapted in response to such change of climate and sea level and there is a need for significant further research to track these movements. In order to understand where people could live and hunt or forage in these at different dates and different stages of the glacial-deglacial cycles, we need to analyze the details of sea level change and ice cap limits through time. With the rise of sea-level all these people must have migrated to uplands naturally. During the ice-age all the eastern Aegean islands were connected to the mainland Anatolia. All the towns of these islands face towards to the mainland Anatolia.

Part of the exposed shelves in the Aegean Sea, covered by ice caps and were, therefore, not available for occupation, but the extent to which people lived closed to the ice and exploited the peri-glacial megafauna is still uncertain. We cannot understand the whole story by studying only the present dry land record and ignoring the submerged seabed of the continental shelf. Did the fluctuating climate zones and migrating coastlines and river valleys influence where people lived? Did the falling and rising sea level create cultural experiences and responses that are still felt on and had impact in the historic world of writing and oral history.

Ancient People of the Anatolia

The early civilization was started in the SW Turkey around the Harran plains where the first wheat was cultivated there about 12 ka then spread to the Central Anatolia (10 ka) then to the Thrace (8 ka). The first town was established called URFA (which was claimed to be founded by Noah). It is again starts with UR (means city in Proto-Turkish). Antique site of Gobeklitepe which is about 10 km east of Urfa, has just been discovered 10 to 15 years and it would give more insights into the prehistory of this area. Wheat is the important food because it contains both protein and carbohydrates. Protein is essential food for the development of brain. This region is a rich mining area as well as plenty of obsidian (flint stone) volcanic rocks. That is why the area was the starting point of the civilization (Fig. 2).

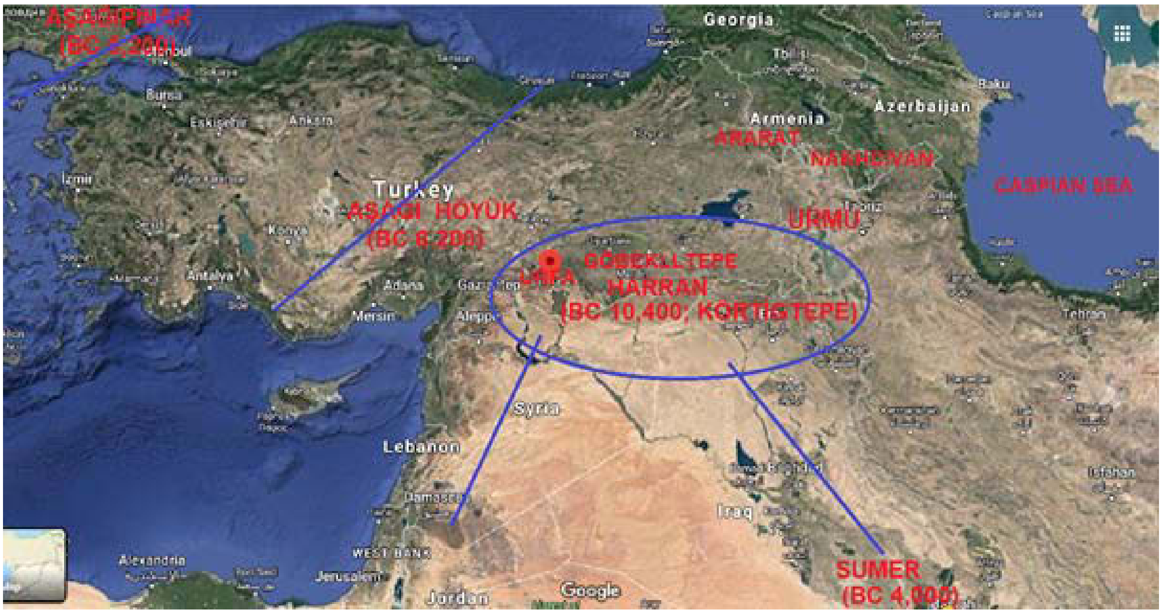


Figure 2. Wheat cultivation in the SW Turkey (Harran) in around BC 10,400, and its spreading to Turkey, Mesopotamia and Palestine

With the end of ice-age, Anatolia had become habitable with the change of paleogeography. Wheat is the starting point of civilization at around the Harran plain at around 12 ka (Fig. 2). The earliest civilization moved northward and westward reaching to Thrace around 8 ka (possibly the Straits of Dardanelles and Bosporus were not opened up yet). The civilization Sumer started at around 6 ka. During the ice-age all the eastern Aegean islands were connected to the mainland Anatolia. The people of Luwi (people of light; with high culture; called themselves as MA/MU), who were the first occupant of the most part of Turkey and were the ancestors of Hittites, Frigians and Lydians were the first people established states in Anatolia. Phrygian and Lydian states were established after dissolution of the Hittite state. By looking up the map of the Western Turkey, all the towns of the Aegean islands face the mainland Anatolia.

During the Iron age, the most of Western Anatolia was ruled by ruled by Lydians (the name of the founder king Lyduns). Although their precise origins are unclear, they seem to descendants of people who set up a neo-Hittite state, called Arzawa, in the same area in the 12th century B.C. (At the height of their power, they ruled over an area that encompassed most of what is now Western Turkey, with its capital at Sardis. The Homeric name for the Lydians was Μαίονες, cited among the allies of the Trojans during the Trojan War, and from this name "Maeonia" and "Maeonians" derive and while these Bronze Age terms have sometimes been used as alternatives for Lydia and the Lydians, nuances have also been brought between them. It was here in the fifth century B.C. the historian Herodotus described the first coins being minted, probably the reign of King Alyattes (&10-550 B.C.). In a possibility development Herodotus also credits the Lydians with having built the permanent shops. A Lydian language is known to have existed right up to the first century B.C., but little is known about it. Ditto the situation with the Lydian pantheon of gods, which include a Cybele-like mother goddess (MA) and a Teshub-like thunder god (Sanda). The common language of this region must be known as the Luwian language because the place names of this part of the Anatolia down to the Mediterranean coasts in the south.

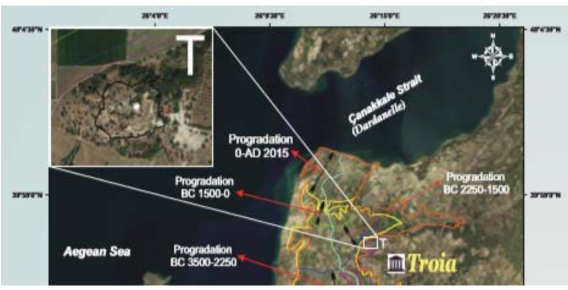
Croesus (595-547 B.C.) ruled Lydia and occupied Phrygia (Gordion) and extended up to Kızılırmak (Halis) river neighboring with the Med Empire which was then succeeded by the Persian Empire (550 B.C.). Croesus lost to the Persian leader Cyrus in 547 B.C. Sardis was captured and declared the capital of Western Anatolian Strap of the Persian Empire. Persians established the “King Road” from Sardis to Susa in Iran which connected the two civilizations creating important link between them. With this, the Greeks started to influence the coastal areas of the Aegean region. Macedonia Alexander the Great captured this area after defeating the Persian army in 334 B.C. and then the Hellenic period was started. This area was occupied by Romans in 188 B.C. But Sardis served as the capital of this region during all these periods.

Western Turkey deltas and ancient towns

As it was mentioned before, the rivers of Büyük Menderes, Küçük Menderes, Gediz, Bakırçay and Karamenderes (which runs in N-S direction in the Biga Penisula) have the very important delta plains and they have significant effects on geomorphologic changes during the geological period in western Aegean Shoreline (Fig. 1). On these deltas there are ancient towns such as: from south to north, Miletus, Ephesus, Smyrna, Pergamum and Troia. These are discussed below one by one (Fig. 4). The Luwian names of these rivers and towns were explained.

Karamenderes (Troia)

When sea-level rise slowed and stopped about 6000 BP in Karamenderes (Scamander) plain, alluvial aggradation and deltaic progradation began to dominate coastal processes. Barrier-lagoons were not usual in the inner parts of the transgressive embayment’s. This implies a river dominating deltaic progradation about 7000-5000 yr ago at the maximum transgression of the sea into the river valleys. Troia city, geographically very convenient location, from BC 3000 up to AD 500 permanent settlements have been seen. After the excavations, 10 different urban strata and more than 50 buildings were found here. Troia word means: (A)dr(a)-uwa- (a)da = Druwada (or Truwada) meaning a place having Adra (Husband) Praying in Luwi Language. Besides, Scamander(Karamenderes) word means; Ska (Peninsula)-Ma-Andra-Arda (Peninsula Mother Goddess Husband's River) in Luwi Language.



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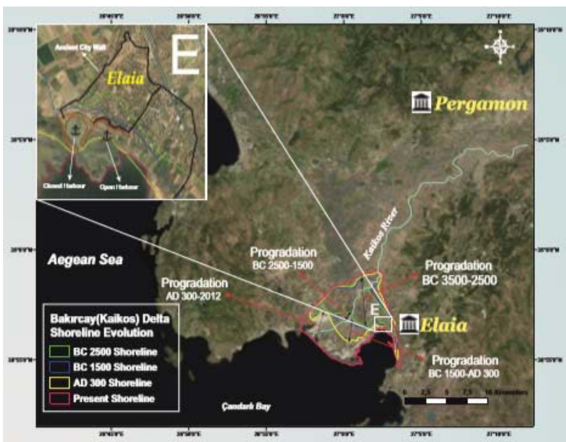

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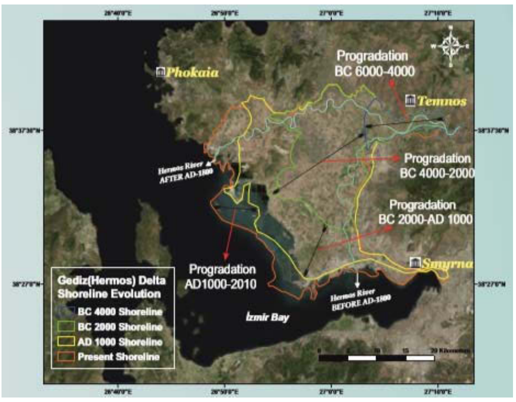

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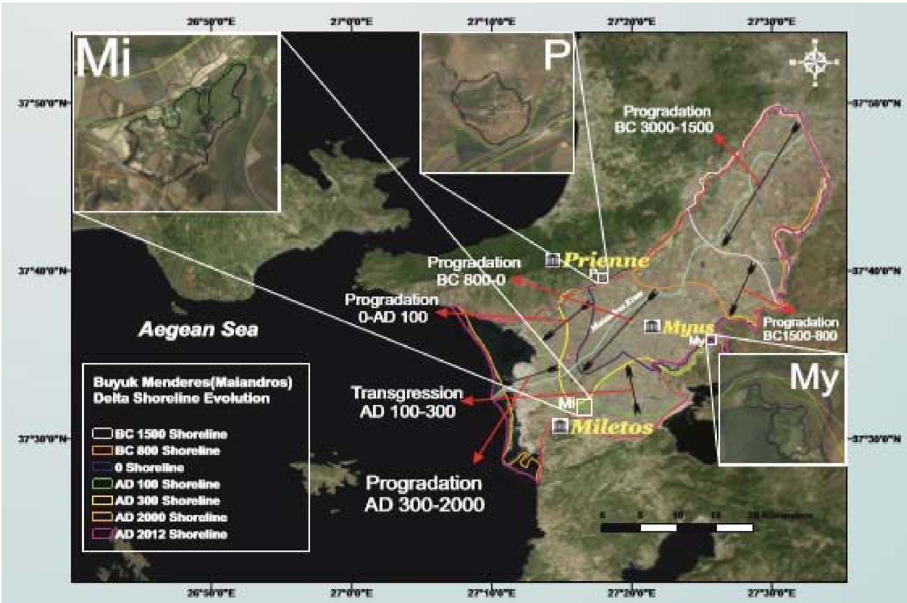

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Figure 3. Delta developments and ancient towns in Western Turkey: (a) Kara Menderes and Troia; (b) Bakırçay and Pergamum; (c) Gediz and Smyrna; (d) Küçük Menderes and Ephesus; (e) Büyük Menderes and Miletus

Bakirçay (Pergamon And Eliea)

This map shows the change of the progradation of the delta due to the alluvial deposits which has brought by the Bakırçay (Kaikos) River where it is located in Bakırçay Delta plain, in western Anatolian between BC 2500 and present. At the present day, Elaia Harbor that was a very important port during its period, stayed underwater by the rising of the waters due to the changes in sea level. During Hellenistic and Roman times, Elaia, the harbor city of ancient Pergamum, was an important place of trade and traffic at the western coast of Asia Minor. Elaia is a word of Helen, meaning "olive grove". However, a name actually derived from the word "Ela" in the name of Elaia may have been introduced in the name of Helen, for example, "Passage, throat" from Luwi, just like "Ela-uwa". And Parga(u)ma=Pargama word means: High Place People in Luwi Language.

Gediz (Symrna)

The extension of Gediz Graben started in the late Miocene and is characterized by numerous east-west trending grabens that are bounded by active normal faults. The graben and the intervening horst control the west flowing drainage systems of western Anatolia. Izmir Bay, an active graben itself, is situated at the western end of the Gediz graben in which the Gediz river flows. The name of this river is Hermos in latin and Ermos in Greek. The derivation of this word is from Swa-Ma-Arda (Sacred Mother Goddess River) later it was turned to Smardos (then to Ermos in Greek). The Gediz Graben plains had hosted many ancient civilizations during the ages. For example, Smyrna, with the conclusions of ten uninterrupted settlements dating from the 11th to the 4th century BC, has been a center of commercial and political activity for 3 centuries beginning with the 7th century BC. In addition to, Phocaea is one of the 12 Ionian cities and is located to the north of Ionia. The meaning of Smyrna (İzmir) word comes from: S(wa)-M(a)- ur(a)-(wa)na in Luwi Language. Also it means: Sacred Mother Goddess Country in English.

Küçük Menderes (Ephasus)

Stretching in a west-east direction of about 80 km, the Küçük Menderes graben ends in the Aegean Sea approximately 70 km south of Izmir. It is surrounded by the Menderes Massif, a 300 km by 200 km mountain range with elevations up to 2000 m. Ephesus harbor, which is the significant trade center especially in Roman period, has exposed to alluvial deposits brought by Küçük Menderes (Kaystros; in Luwi language Running Stream) River. It has lost their importance due to ongoing the deltaic progradation. Now, it is far from the sea about 7 km. The name of Ephesus comes from the Luwi language: Apa-Assa (Water City).

Büyük Menderes (Miletus)

This map shows the changes of shoreline and the progradation of the delta due to the alluvial deposits which has brought by the Büyük Menderes (Maiandros) River, located in the Büyük Menderes Graben between BC 1500 and present. Between AD 300 and AD 100, the transgression has occurred depend on sea-level changes. And the shoreline had gone to the backwards until Myus almost 7.8 km in the southwestern of graben. Miletus, Priene and Myus ancient settlements have been affected by sediments of the Büyük Menderes River. According to results of offshore surveys, the Büyük Menderes River formed four superimposed deltas, or a delta complex with four deltas in the Aegean Sea during the Last Pleistocene, the new one occurring just after the Last Glacial period. The Miletus word means MILANWANDA (M(a)-ila wanda in Luwi language). Mother Goddess praying passage place in English at the same time. The name of Priene is: Pria (Castle)-Wana (Place).

Remarks and Conclusions

The Anatolian people moved to westward from the birth of civilazation in the SE Turkey (Harran Plain) after the cultivation of wheat that is the starting date of agriculture (about 12 ka). Wheat cultivation reached the Central Anatolia by 10 ka then to the Thrace by 8 ka. In the meanwhile, the Aegean deltas were started to be formed at around 6 ka after the sea level reaching to the optimal status. All the towns of Miletus, Ephesus, Smyrna, Pergamum and Troia were developed on these deltas at around 5-6 ka. The first known language of this is known as Luwian the name given to them by Hitites. It means the “People of Light”. But these people called them as “AMADA” or “MADA” (in Turkish “AMA” sacred woman), is which meant the people of Mother Goddess. Bilge Umar says that there is no other older language than Luwian language. Selahi Diker proved that this language is Proto-Turkish as the Sumerian language. German geoarcheologist Eberhard Zangger has stated that the Luwian people were the first people of the Western Anatolia and their language and culture were prior to the Greek language and culture.

Cultural heritage belongs to the all humanity; they are treasure and wealth for everybody. We preserve the past memory of the humankinds in our cultural heritage and we build our future on this cultural inheritance. As Ataturk said: "***We should always seek the reality and if we are convinced about it we must be the persons to state it".***

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CASPIAN SEA, WATER FLUCTUATIONS AND THE EFFECTS

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Preamble

The Caspian Sea is the largest enclosed inland body of water on Earth by area, variously classed as the world's largest lake or a full-fledged sea. It is in an endorheic basin (it has no outflows) and located between Europe and Asia. It is bounded to the northeast by Kazakhstan, to the northwest by Russia, to the west by Azerbaijan, to the south by Iran, and to the southeast by Turkmenistan. The Caspian Sea lies to the east of the Caucasus Mountains and to the west of the vast steppe of Central Asia. Its southern part, the Caspian Depression, is one of the lowest points on earth (Fig.1).

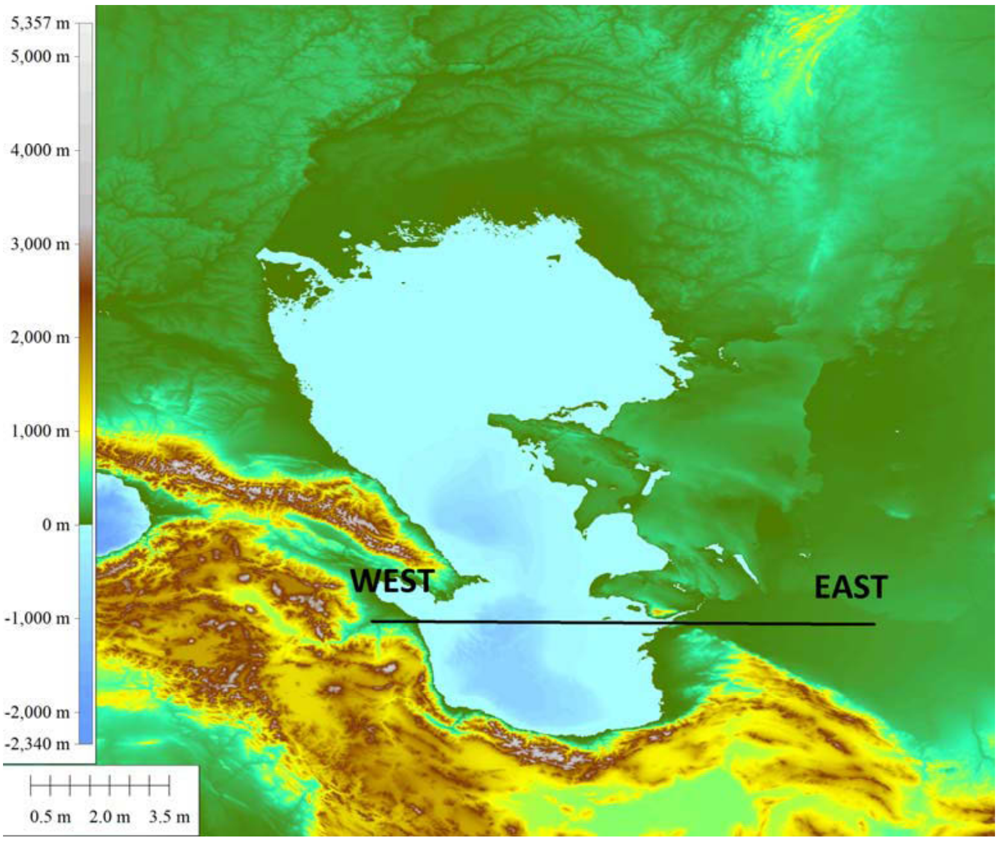

Figure 1. Topography of the Caspian Sea (East-West Section)

The Caspian Sea, like the Aral Sea (which is almost depleted now), Black Sea, Lake Urmu, is a remnant of the ancient Paratethys Sea. It became landlocked about 5.5 million years ago due to tectonic uplift and a fall in sea level. During warm and dry climatic periods, the landlocked sea almost dried up, depositing evaporitic sediments like halite that were covered by wind-blown deposits and were sealed off as an evaporate sink when cool, wet climates refilled the basin. Due to the current inflow of fresh water, the Caspian Sea is a freshwater lake in its northern portions. It is more saline on the Iranian shore, where the catchment basin contributes little flow. Currently, the mean salinity of the Caspian is one third that of the Earth's oceans.

As long as 65 million years ago, the Paratethys was connected both the Atlantic and Indo-Pacific Oceans. 5 million years ago, through shifts in the Earth's crust, a large landlocked sea had been formed where the Caspian and its surroundings would later take shape. The waters became fresher, but then a link to the ocean was again established and a marine environment returned. About 2 million years ago that link to the ocean was closed, and inland waters again became much fresher, through rainfall and the melting of glaciers. Eventually the Caspian Sea severed its connection to the Black Sea and became permanently landlocked.

Water level fluctuations

Eustatic change is when the sea level changes due to an alteration in the volume of water in the oceans or, alternatively, a change in the shape of an ocean basin and hence a change in the amount of water the sea can hold. Eustatic change is **always** a global effect.

During and after an ice age, eustatic change takes place. At the beginning of an ice age, the temperature falls and water is frozen and stored in glaciers inland, suspending the hydrological cycle. This results in water being taken out of the sea but not being put back in leading to an overall fall in sea level. Conversely, as an ice age ends, the temperature begins to rise and so the water stored in the glaciers will reenter the hydrological cycle and the sea will be replenished, increasing the sea levels.

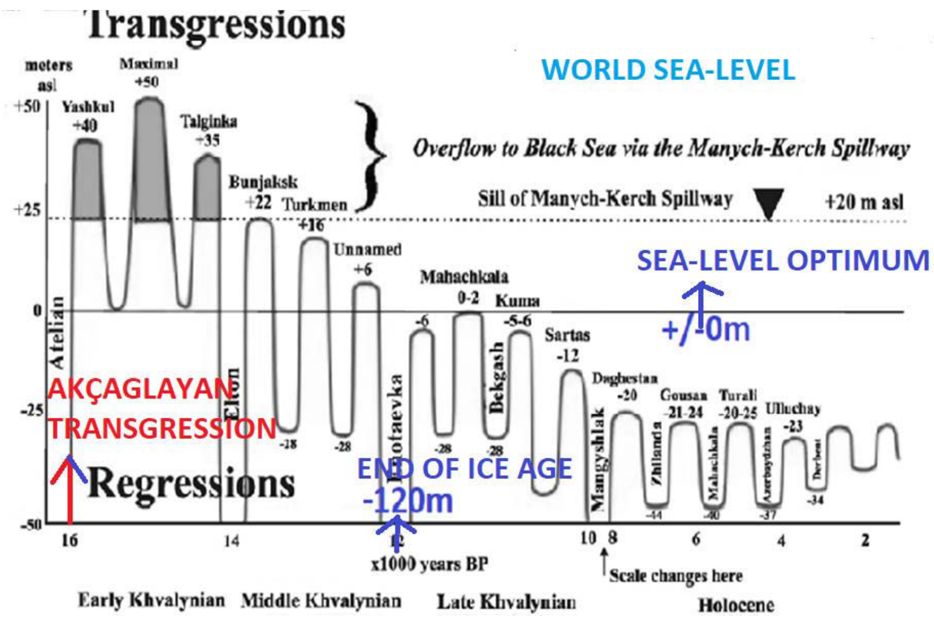

Figure 2. The late glacial flood in the Ponto-Caspian basin (Chelpalyga, 2007). Notes: Akçaglayan Transgression (15000 years ago); End of the Ice-Age: 12000 years ago; Sea-level Optimum reached at about 6000 years ago

The paleogeography of the Caspian Sea first of all is the history of fluctuations of its level (Yanina, 2014). Historic and paleogeographical data give evidence to considerable level oscillations, whose amplitude was more than 100 m during Pleistocene and Holocene (Fig.2). In the Late Pleistocene the leading role belonged to the global climatic changes; those were manifested as alternating cold and warm epochs and resulted from variations in insolation due to changes in the Earth orbit elements (Milankovitch cycles).

The Caspian Sea appears to have the epicenter of the flood and the most sensitive indicator of the related events (sea-level rise, coastline shift, and coastal lowland flooding). This basin concentrated the bulk of the flood water, altered water composition and marine environment, while excess water escaped into the Black Sea. In the process of flooding, the Caspian Sea expanded over an area of about one million km^2 (presently 371,000 km^2), up to 1.1 million km^2 if the Aral-Sarikamish basin included.

The Manych-Kerch Spillway is a large trough, deeply eroded into solid rock, which connected the Caspian and Black Seas. It was inherited from an older strait between the two seas, which existed (with interruptions) since the Late Pliocene Akcaglayan (White Waterfall) basin. The total length of the spillway amounted to 950-1000 km (depending on the location of sea level), with maximum and minimum width of 50-55 and 10 km, respectively. Its depth attained 30-50 m.

Although the rise of the sea after the last glaciations took about 12,000 years, the change would nevertheless have been perceived as a continuous retreat of the shoreline and loss of land which was quite noticeable in one generation. These matters were more devastating for the marginal seas such as the Black Sea and the Caspian Sea because the fall of sea level was much more the open ocean waters. Given the fertility of coastal plains, both for the terrestrial fauna on grasslands and resources in marshes, deltas, and wetlands, the continuous loss of such land must have been an unfortunate aspect of life in the Late Paleolithic and Mesolithic periods.

It should be noted that a rising sea level would occasionally inundate an area of low gradient such as the North Caspian seafloor, creating massively extensive new marshlands and new environments which could support adapting coastal and aquatic life styles. Populations certainly moved and adapted in response to such change of climate and sea level and there is a need for significant further research to track these movements. In order to understand where people could live and hunt or forage in the Caspian area at different dates and different stages of the glacial-deglacial cycles, we need to analyze the details of sea level change and ice cap limits through time.

Akcaglayan transgression

Mangerud et al. (2004) have identified only two periods when drainage was diverted toward the Caspian and Black Seas. Interestingly, it was two different drainage areas that were affected alternately. The first time the drainage of the West Siberian Plain, including the Yenissei and Ob rivers, was forced towards the Aral, Caspian and Black Seas by the advancing Barents–Kara Ice Sheet. The second time the drainage was re-routed southward was during the LGM, about 18–17 ka. This time the Scandinavian Ice Sheet blocked the drainage toward the Baltic Sea and melt water from a considerable sector of the ice sheet flowed over the watershed to the Volga River. This possibly caused the Caspian Sea to overflow along the Manych Pass at 26 m a.s.l. to the Black Sea. The last overflow from the Caspian Sea lasted from 19 to 13 ka (16–11 ka 14C-years) and was interrupted by a regression at 17–16 ka. The sudden end of this regression occurred at 15 ka The reason of this interruption was that the ice-dam broken down and water flooded down to the Caspian basin through the Aral Sea and Uzboy channel. Water level was risen to +50m from about -150m (Fig.3). The name of this transgression is Akcaglayan Transgression (White Waterfall in Turkish).

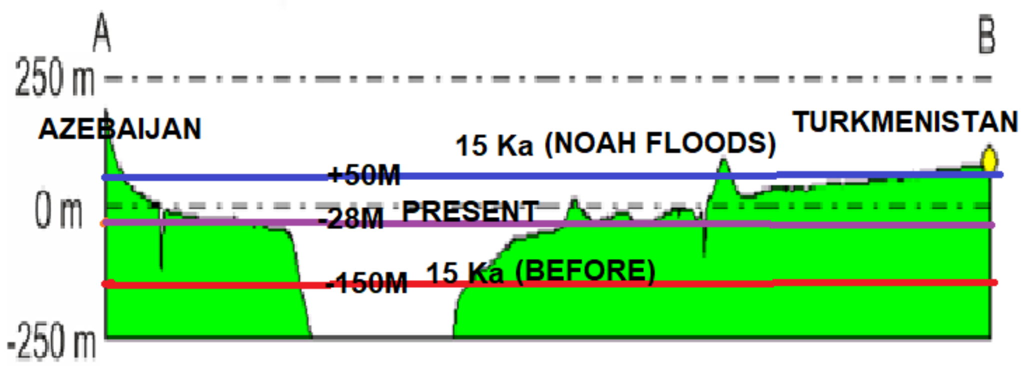

Figure 3. East-West section through the South Caspian Sea. Present Water Level: -28m; Water Level at 15 ka: -150m; Water Level After Floods: +50m

What is the Noah's Flood

Many other flood myths have existed throughout history in many cultures, but most of these likely arose independently, as virtually all of them were written by societies that resided near regularly flooding bodies of water. Generally the myth of the global flood refers to the one of Noah and the Ark in Judeo-Christian mythology. The story of a global flood occurs as a common myth in many cultures. Some speculate that such myths originate in real historical floods, possibly in the Caspian region, which is known to have been prone to epic floods, and which lies in the right region for Biblical legends (not too far from Ararat).

We must consider the climate as well as paleogeography during the ice-age period (from 120 to 12 ka). Since all water was kept at the polar regions during the ice-age, water levels of the oceans were around 120/130m below sea-level and these periods are very dry times with almost no rain. Therefore, the wide areas of the world (from 40/45°latitudes up to equator are subtropical (deserts with no water). Living things could only occur at the boundary of ice covered regions and the narrow equatorial areas. The southern Caspian Sea and its surroundings were the most possible living environment for the homo sapiens (Neatherthandal people disappeared at around 40 ka due to harsh climate of the ice-age).

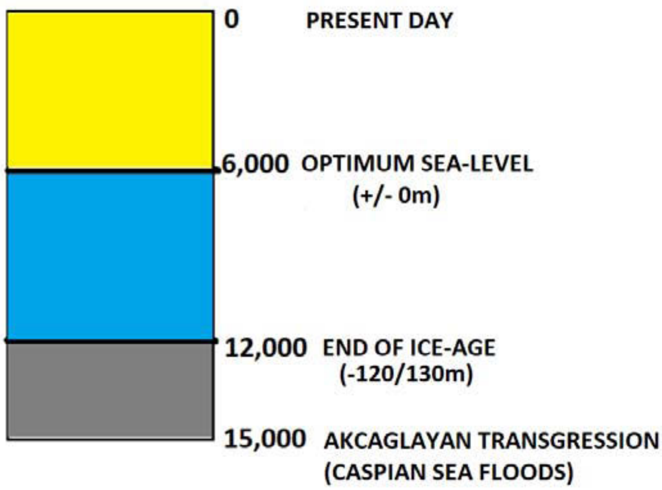

Figure 4. The important events of the Caspian Sea area for the last 15 ka: 15 ka Akcaglayan Transgression; 12 ka the end of ice-age; 6 ka optimum sea-level for the formation of deltas

As explained above the Akcaglayan Transgression took place at the Caspian Sea at around 15 ka with the shattering of ıce-dam at the north of Aral Sea (possibly strike of a meteorite) and water following through the Uzboy Strait filling the Caspian Sea from about -150m up to +50m for the short time (Fig. 2 and 3). Therefore, this is the ideal location to explain the dramatic events of flooding (Chelaypga, 2007). People could not escape to the south because of the Elburz Mountains.

The escape routes to the west Azerbaijan through the Aras River (Ara Su which means in Turkish PURE WATER) to the Ararat Mountain (AK MOUNTAIN in Turkish; means White "Sacred" Mountain). There is an Azerbaijan town called NAKHCIVAN (City of Noah) at the east of the Mountain Ararat. There are rock drawings at about 65 km west of Baku called GOBUSTAN which dated 14 ka in Azerbaijan. There is a town and the lake named URMU in SW of Iran. UR means city in Turkish. MU (People of Sun) is the name of the lost continent (Churchward, 1935). The early civilization was started in the SW Turkey around the Harran plains where the first wheat was cultivated there about 12 ka then spread to the Central Anatolia (10 ka) then to the Thrace (8 ka). The first town was established called URFA (which was claimed to be founded by Noah). It is again starts with UR. Antique site of Gobeklitepe which is about 10 km east of Urfa, has just been discovered 10 to 15 years and it would give more insights into the prehistory of this area. This region is a rich mining area as well as plenty of obsidian (flint stone) volcanic rocks. There is also rich in water resources (Tigris and Euphrates rivers). That is why the area was the starting point of the civilization. Wheat is the important food because it contains both protein and carbohydrates. Protein is essential food for the development of brain.

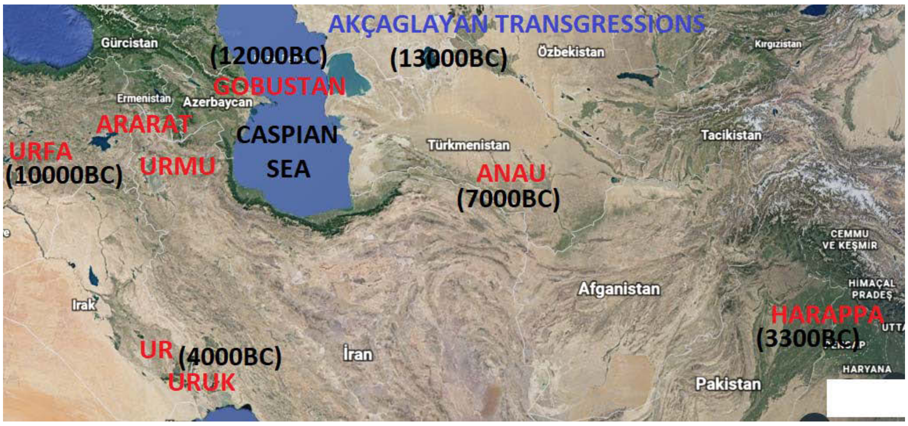

Figure 5. Cultures developed around the Caspian Sea

After the formation of deltas (6 ka) people had moved southeastwards to Mesopotamia delta area and established several towns called Ur, Uruk, Lagash and the others crating early Sumerian culture and first writing in the world. Sumerians called themselves KENGERS which is a Turkish tribe. Sumerian language is proto-Turkish (Cıg,2008 and Gerey, 2003).

The east of the Caspian Sea is Turkmenistan where the archaeological site Anau was established 9 ka at the east of Ashgabat. The first archaeological site in the Indian subcontinent is in the north of Panjab is called Harappa established in 5.3 ka which is long after Anau. The language of Sanskrit (which is not spoken now) has affinity with the Caspian region.

The Dravidian language of India is in the south India and has roots from the equatorial region. Also the Semitic languages (including Coptic "Egyptian" language too) have roots in Ethiopia (equatorial) area. These people moved northwards along to the Nile valley and established Egyptian culture around 5 ka.

Conclusions

The global flood is a fairly self-descriptive, catastrophic, mythical event found in the book of Genesis. The majority of modern biblical scholars interpret the flood story allegorically; for example, they see it as a lesson of God's mercy toward the faithful (Noah and his family). Fundamentalists, as usual, miss the forest entirely and end up focusing on the leaves of the trees, insisting on the literal historicity of the flood account because if this was made up, the entire Bible must have been made up. From this assertion, the entire "science" of flood geology has been formed. As a result, the global flood and the supposed geological facts to back it up are an integral part of young earth creationism and creation science. Many other flood myths have existed throughout history in many cultures, but most of these likely arose independently, as virtually all of them were written by societies that resided near regularly flooding bodies of water. Generally the myth of the global flood refers to the one of Noah and the Ark in Judeo-Christian mythology.

We must understand the paleogeography quite well in accordance with climatic and environmental circumstances. During the ice-age period (120 to 12 ka) all waters were kept in the polar regions up to 40-45°latitudes. From here down to equator all the earth surface was covered with desert because of very little rain. Living things could only survive at the narrow band of equatorial region, and the suitable place at the boundaries of 40-45°latitudes. The South Caspian Sea is the ideal location for life. Noah Flood is the most probably occurred there with lash of water pouring down from Aral Sea and Uzboy Strait at around 15 ka due to breakage of ice-dam in the western Siberia.

With the end of ice-age at around 12 ka people moved westward to Azerbaijan (Nakhcivan and Urmu cities) towards the Harran Plain (City of URFA "Noah's City") and cultivating wheat at the same time. Wheat is the triggering commodity for the civilization (Contain both protein and carbohydrates). Then these people started going around in the region. Sumerian culture produced by them in Mesopotamia after the development of deltas at around 6 ka. Similarly, people who escaped eastward established similar cultures in Turkmenistan (Anau site of 9 ka). Sumerian language and Turkmen language are very similar agglutinative (Proto-Turkish). The earliest culture in Indian subcontinent is Harappa (North Panjab, Pakistan) dated only 5.3 ka. The old language of Sanskrit has some roots in the Caspian region too.

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NORTHERN HEMISPHERE CONTINENTAL GLACIATION INFLUENCE ON THE EVOLUTION OF THE BLACK, CASPIAN, AND MEDITERRANEAN SEAS IN THE PLIOCENE-PLEISTOCENE

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Keywords: Akchagylian Sea, Sarmatian sea, mathematical calculation, flood

Introduction

In the last at least 10 million years, extensive continental glaciation has regularly occurred in the northern hemisphere of the Earth. During the glaciers melting periods, the flow of rivers flowed into the Black and Caspian seas increased significantly, and the volume of fresh water flowed through the straits into the Mediterranean Sea increased. Freshwater runoff periodically caused water desalination in the eastern basin of the Mediterranean Sea and the intensive development of freshwater fauna. It seems appropriate to estimate the volume of moving fresh water and describe, at least in a first approximation, the mechanism of formation of transgressive water bodies during periods of melting glaciers.

Methodology and results

To solve this problem, the following regularity of the reservoir formation was used. When the river filled the depression, with increasing depth of the reservoir, its area increases and consequently the volume of evaporating water increases. When the volume of evaporating water becomes equal to the volume of inflowing water, the process stabilizes and a stable coastline is formed. If we know the area of the ancient sea and knowing the modern evaporation coefficient, we can approximately determine the water discharge flowed into the reservoir and construct a dynamic model of the reservoir evolution using the equation that we proposed in the article (Esin et al., 2018). The calculations showed that the ancient Sarmatian sea-lake was created by the flow of fresh water with the water discharge of 2200 km^3/year. The sea level elevation was +(115-120) m. The Akchagylian Sea is formed by a flow with water discharge of about 780 km^3/year. According to our calculations the level of this sea was at around +63 m. The question of where the water that created the Akchagylian Sea came from is under discussion. There are two main points of view: water came from melting glaciers (Moskvitin, 1962) and water came from the Mediterranean Sea through the Black Sea (Svitoch, 2014). But water flow through the Black Sea to the Caspian is impossible, because the Black Sea level and the World Ocean level were lower than the level of the transgressive Akchagylian Sea, which was at +100 m (Svitoch, 2014). It follows that the water from the Black Sea flows into the Caspian, the level of the Black Sea should be raised by at least 101 m. Only in this case, water can flow into the Caspian Sea and create the Akchagylian Sea with the level at +100 m. But in order to raise the level of the Black Sea, it is necessary to raise the level of the World Ocean to the same height, which will lead to the Flood, a global ecological catastrophe and the creation of the Paratethys Sea. As you know, neither one nor the other was in the Pleistocene. Thus, it can be argued that the hypotheses about the entry of water from the ocean into the Caspian Sea are untenable. The variant of water inflow from the Mediterranean Sea would lead to salinization of water in the Black and Caspian Seas.

In the present work, it was shown that there was no prolonged supply of salt water to the Caspian Sea in Akchagylian time. The calculations were performed for the conditions of the Arctic Ocean. They showed that if water from the ocean in the volume of 480 km^3/year and fresh water from rivers in the amount of 300 km^3/year flowed into the Akchagylian Sea, then there would be an annual increase in the salinity of sea water by 0.12 ‰. Therefore, after 1000 years, the salinity of the water in the sea would be 112‰, i.e. it would be a brine in which flora and fauna would perish. According to the results of geological studies, the salinity of the sea in the whole Akchagylian time has increased only to (20-25)‰. According to the research P.F. Fedorov (1957), the salt at that time came from local sources - from the Kara-Bogaz-Gol Bay and from the salt domes of the Northern Caspian. Thus, there is no physical reason to talk about the prolonged supply of salty ocean waters (according to the laws of physics, water cannot flow upward) or geological.

Conclusions

Our model shows that in the Pliocene-Pleistocene, the course of the levels of the Black and Caspian Seas does not correlate with each other, because the level of the Black Sea depends on the level of the Mediterranean Sea and on the volume of water discharged into the Black Sea. And the change in the level of the Caspian Sea is determined by the difference in the volumes of inflowing and evaporating waters. This is confirmed by the data of field observations (Svitoch, 2014, Balabanov, 2009).

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UNIQUE MINGECHEVIR OCCURRENCE OF PLEISTOCENE VERTEBRATES AMONG BAKU AND ABSHERON DEPOSITS OF BOZDAGH AND GARAJI

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Mingachevir occurrence of Pleistocene vertebrate fauna is located in Western Azerbaijan on the southern shore of Mingechevir reservoir. Structurally it is confined to a central segment of Chatma-Ajinohur zone within the northern flange of Middle Kur depression. Geological section of the area includes marine and continental facies of Akchagyl (Upper Pliocene) – Absheron (Eo-Pleistocene) – Lower Pleistocene terrigenous series, building up the low-mountain ranges of Bozdagh and Garaja.

Uniqueness of Mingachevir deposit consists in its' solid length, abundance of bone material and plant remains, and in the fact that new portions of these remains are exposed annually fur to seasonal water level fluctuations in Mingachevir reservoir. Length of the shore equals 120 km between the eastern margin of Mingachevir reservoir and the western margin of Shamkir reservoir. Southern shore of Mingachevir reservoir only is at least 70 km long on a straight. Total length of the outcrops is much longer, as the shore has a lot of minor bays across its' extension (Fig. 1).

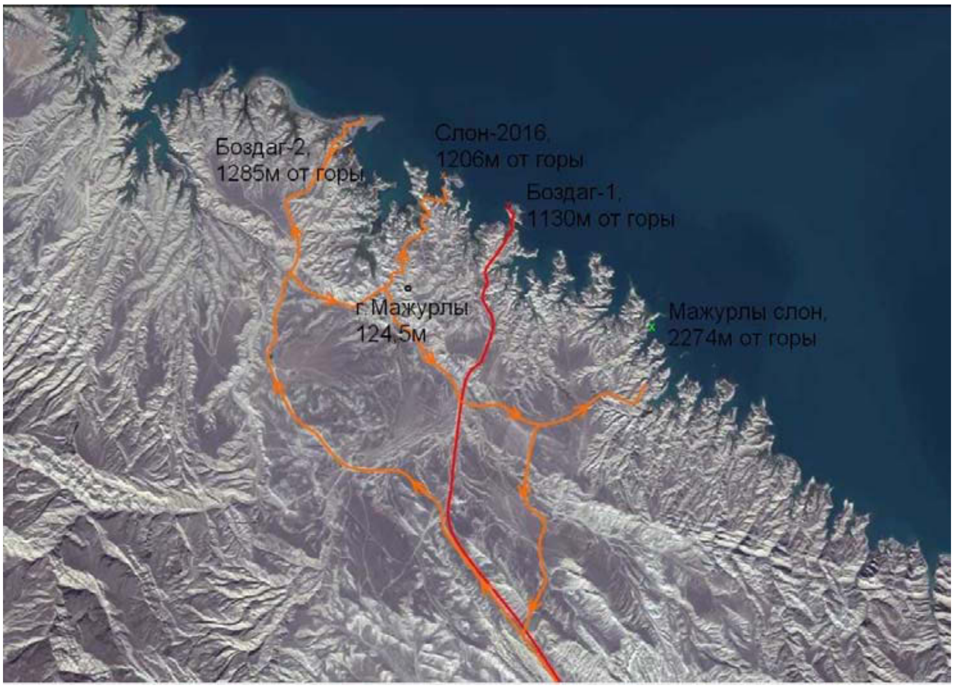

Figure 1. Rugged southern slope of Mingechevir reservoir in the area of fossil fauna discoveries

Main part of the outcrops is exposed on the northern offsets of Bozdagh and Garaji ranges (Fig. 2).

Figure 2. New rich deposit of Garaja

Only several fossil discoveries were made in the area until early 2000's. In 1936, S.A. Kovalevsky had detected an elephant tusk among Upper Absheron deposits of Bozdagh and described its' location in his article describing the geological structure of Ajinohur (Kovalevsky, 1936). In 1960, remains of a gigantic camel (*Paracamelus gigas*) were discovered from the same series by N.I. Burchak-Abramovich and F.M. Akhundov (Burchak-Abramovich, 1960). By that time, it was the most ancient fossil of gigantic camel which had ever been discovered in the territory of USSR. In 1961, J.D. Jafarova described lower jawbone with last jaw-tooth of an *Archidiscodon meridionalis* discovered in the area of Mingechevir reservoir (Jafarova, 1961). In 1971-72, within the framework of geology-stratigraphic studies implemented in the Upper Neogene – Lower Cretaceous series of the Western Azerbaijan, N.A. Lebedeva collected osteological material from the previously discovered deposits of Absheron vertebrates, detected in the structure of Guzguntapa, Palantokan and Hojashen ranges (Hajiyev, 1976; Lebedeva, 1971).

In 2000, three skulls and skeleton bones of a southern mammoth, as well as the fragments of deer antlers have been discovered on the northern slope of Bozdagh by employees of the Natural History Museum of ANAS. In 2001, almost complete skull of a southern mammoth (with only lower jaw-bone missing) was found several kilometers to the west of the previous discoveries (Fig. 3).

Figure 3. Skull and teeth of southern mammoth *Archidiscodon meridionalis* from Bozdagh

The fact that M^2 teeth and partly M^3 tooth plates have been remained on a skull, allowed concluding that the elephant was 40-50 years old when it died, and that it belonged to a later form of the southern mammoth (*Archidiscodon meridionalis)*, representing its' evolutional transition into the steppe mammoth.

Starting from 2012, large amounts of Acheulian stone implements and fossil remains of big animals have been found all over the northern slope of Bozdagh and Garaja ranges. In 2015, remains of elephant and rhinoceros (Fig. 4, 5), and separate fragments of Cervidae gen cf. *Praemegaceros*, *Bison sp., Bovidae gen indet*. (Fig. 6), *Eqvida sp.,* were detected among the Garaja area's Baku deposits.

Figure 4. Rhino skull fragment from Garaja

Figure 5. Rhino *Stephanorhinus hundsheimensis* from Bozdagh

Figure 6. Bulls from Garaja

M^2 teeth of the elephant have narrow coronas and well distinguished sinuses. According to these and other characteristics (e.g. dental plate frequency and length, enamel thickness), discovered elephant was characterized as a forest elephant *Palaeoloxodon antiquus* (Fig. 7), which was the first fossil remain of this kind ever discovered in the territory of Azerbaijan.

Figure 7. Skull fragment of elephant *Palaeoloxodon antiques* from Garaja

On the other hand, morphological and morphometrical characteristics of its' teeth, the rhino was characterized as a species of *Stephanorhinus* cf. *Hundsheimensis*. Discovered remains, including plenty of fossilized wood (Fig. 8), allowed reconstructing a forest-steppe landscape which used to prevail on the ancient seashore characterized by vast forested spaces.

In the fall of 2018, following fossil remains were found on the northern slopes of Bozdagh among the area's Absheron series:

- Incomplete skull of a southern mammoth *Archidiskodon meridionalis meridionalis* with M^1 to M^2 transition of teeth;
- Isolated mammoth teeth;
- Complete skull of rhino with lower jawbone;
- Separate fragments of *Equus* sp., Cervidae gen.

According to dp^4, M^1, M^2, M^3 signs, teeth of the mammoth are similar to those of *Archidiskodon meridionalis meridionalis*, typical for late Villafranchian stage of the Europe and the Western Siberia.

At first, remains of the rhino were deemed to belong to the *Diceros Merki*, but later it was identified that its' skull parameters are similar to those of *Stephanorhinus hundsheimensis* from the end of the Europe's Early Pleistocene. This species used to be quite typical in the Western Europe during late Villafranchian – Early Galerian stages (analogues of Tamanian faunistic complex). Stratigraphic spread of this taxon in the Eastern Europe is yet unclear due to a fragmentary nature of discovered Early Pleistocene rhino remains. Large amounts of fossil tree and shrub remains speak to a presence of forest-steppe landscapes with prevailing steppes.

Figure 8. Fossil tree remains from Garaja

As demonstrated by the study outcomes, surroundings of Mingachevir reservoir represent an exceptionally long (over 100 km) cemetery of various fossil vertebrates, holding important position in the list of the geological monuments of Azerbaijan. Being a stone chronical for the one of the most important stages of Caucasus and Middle East Cenozoic epoch, this object deserves to be given a status of a natural monument with worldwide importance.

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THE GEOCHEMISTRY AND ORIGIN OF GAS SEEPING OUT FROM MUD VOLCANOES OF THE SOUTH EAST OF CASPIAN SEA, IRAN

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Keywords: chemical composition, stable carbon isotopes, gas source, sedimentary volcanism, Gorgan plain

Mud volcanisms (MVs) and other fluid venting structures are common phenomena in onshore and offshore South Caspian Basin which is among the oldest hydrocarbon bearing province in the world. These structures are formed by the emission of gas (hydrocarbon mainly), liquid and solid material and often founded in gas and oil fields. A wide range of geological, aero-satellite, geochemical, geophysical studies have been applied to MVs of this basin in order to elucidate their origin and tectonic structures controlling their formation. These investigations revealed that the MV sediments are mostly derived from underlying the Oligocene-Early Miocene sediments of the Maykop Series and occurs along faults and fault-related folds (e.g. Bonini et al., 2012; Planke et al., 2003; Mazzini et al., 2009; Oppo et al., 2014).

Gorgan Plain is located in north of Iran and south east of Caspian Sea and regarded as the southern prolongation of a larger delta that outcrops in Turkmenistan. Four active MVs namely Neftlijeh, Gharenyaregh, Sofikam and Incheh have been identified in this Plain which experienced the impressive eruptive events during the recent years. They are outcropped in a tectonically active area and rest on the crest of buried anticlines and the conjunctions between fault systems (Rezvandehy et al., 2011). Several dormant and buried MVs are also recognized in Gorgan Plain (Rezvandehy et al., 2011; Omrani and Raghimi, 2018).

This study is aimed to investigate the gas sources feeding MV structures in Gorgan Plain for first time. To reach this goal, gas samples were taken from gas vents in all the mentioned MVs by using a funnel positioned above gas bubbling points and connected to pre-evacuate Giggenbach gas bottles through a silicon tube. The collected gas samples were analyzed for their chemical and carbon isotope signatures using GC and GC-MS at Laboratory of Fluid Geochemistry of the Department of Earth Sciences (University of Florence, Italy). The results showed that methane was the dominated hydrocarbon gas with concentration from 44.5% to 97.5%. The variable amounts of higher hydrocarbon compounds such as ethane, propane, i-butane and n-butane also were measured. Concentrations of N_2 ranged from 1.5% to 51.4%, whereas those of CO_2 and O_2 were

<3.40% and <1.89%, respectively. N_2/Ar ratio was varied from 50.0 to 79.4 depicting both Ar and N_2 have an atmospheric origin.

The diagram C_1/C_{2+} ratio versus $\delta^{13}C_1$ values (Bernard et al., 1978) are widely used to discriminate two main organic gas domains e.g. thermogenic and biogenic gases where the first is characterized by strongly negative $\delta^{13}C\text{-}CH_4$ values (<-50‰ V-PDB) and $CH_4/(C_2H_6+C_3H_8)$ ratios >1000, whereas heavier isotopes and $CH_4/(C_2H_6+C_3H_8)$ ratios <100 can be regarded as thermogenic origin. In this plot, the gas samples from Gorgan's MVs represented the occurrence of a mixed biogenic-thermogenic origin with no significant influence of secondary geochemical process (molecular fractionation) that were commonly recognized in gases from their counterparts pertaining same geodynamic setting such as Turkmenistan and Azerbaijan. The mixed source of discharged gases from Gorgan's MVs can be also confirmed by the presence of biogenic gas accumulations observed during the drilling of petroleum exploration wells in the shallow formations, as well as, gas layers identified in Cheleken formation during seismic survey (Rezvandehy et al., 2011).

The positive carbon isotopic ratio of CO_2 was also detected in gas samples from Neftlijeh MV is typically indicative of secondary methanogenesis following hydrocarbon biodegradation (Pallasser, 2000; Etiope et al., 2009). This secondary geochemical process has been extensively effected on gases from Azerbaijan MVs where the reservoirs are generally shallower than 2000 m with temperatures below 60–80 °C.

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CHANGES IN THE HYDRODYNAMIC INTENSITY OF BOSTEN LAKE AND ITS IMPACT ON EARLY HUMAN SETTLEMENT IN THE NORTHEASTERN TARIM BASIN, EASTERN ARID CENTRAL ASIA

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Keywords: Bosten Lake, silk road, grain-size partitioning, westerlies, climate change, suspended silt

The climate of eastern arid central Asia (ACA) is extremely dry and early human settlement in the region were dependent upon a unstable water supply. Thus, knowledge of the hydrological fluctuation history is essential for understanding the relationship between humans and the environment in the region.

Here we present a record of lake hydrodynamic intensity based on the grain size of suspended lacustrine silt isolated from the sediments of Bosten Lake, which feeds a river flowing to the northeastern Tarim Basin.

The results show that lake hydrodynamic intensity was very weak during the early Holocene (12.0–8.2 ka); and then increased with two distinct centennial-millennial-scale intervals of weak intensity occurring during 4.7–3.7 ka and 1.2–0.5 ka. Notably, increases in lake hydrodynamic intensity occurred 2.2 kyr prior to an increase in local precipitation. We speculate that this was a consequence of relatively high early summer temperatures during 8.2–6.0 ka that resulted in an increased water supply from melting snow and ice in mountainous areas of the catchment. Thus, we conclude that changes in the hydrodynamic intensity of Bosten Lake during the Holocene were affected by changes in both temperature and precipitation.

The variations in the hydrodynamic intensity of Bosten Lake also influenced water availability for the human population that occupied the downstream area of the northeastern Tarim Basin. A drastic decrease in hydrodynamic intensity at around 400 A.D. likely caused the degradation of oasis environments and desertification which resulted in the emigration of the inhabitants of Loulan.

COMPARISON OF NORTHERN AND SOUTHERN SLOPES OF ALBORZ MOUNTAIN CHAIN BASED ON PRESERVED EVIDENCES IN MODERN AND PALEOSOLS

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Keywords: paleosols, soil development, geochemical indices, weathering, Alborz mountain chain

Introduction

Since the beginning of the development of pedology, numerous semi-quantitative and quantitative methods have been proposed in relation to soil morphology, description and classification of soils (Osat et al., 2016). Quantitative methods increase the use of knowledge in analyzing past, present and future research in the field of knowledge. Descriptive, semi-quantitative (Harden, 1982) and quantitative criteria for geometrical, climatic, (micro) morphology, physicochemical, biological, topographic and remote sensing (Jenny, 1941) are presented. Also, morphological, chemical, physical, biological, geochemical and other types of indicators are currently used in soil science (Bockheim et al., 2014). Soil profiles tell us much about the environment and history of a region as well as warn us about potential problems in using the land. Figure 1 shows the relative soil evolution and their weathering degrees and their general climatic and vegetation conditions (Weil and Brady, 2017).

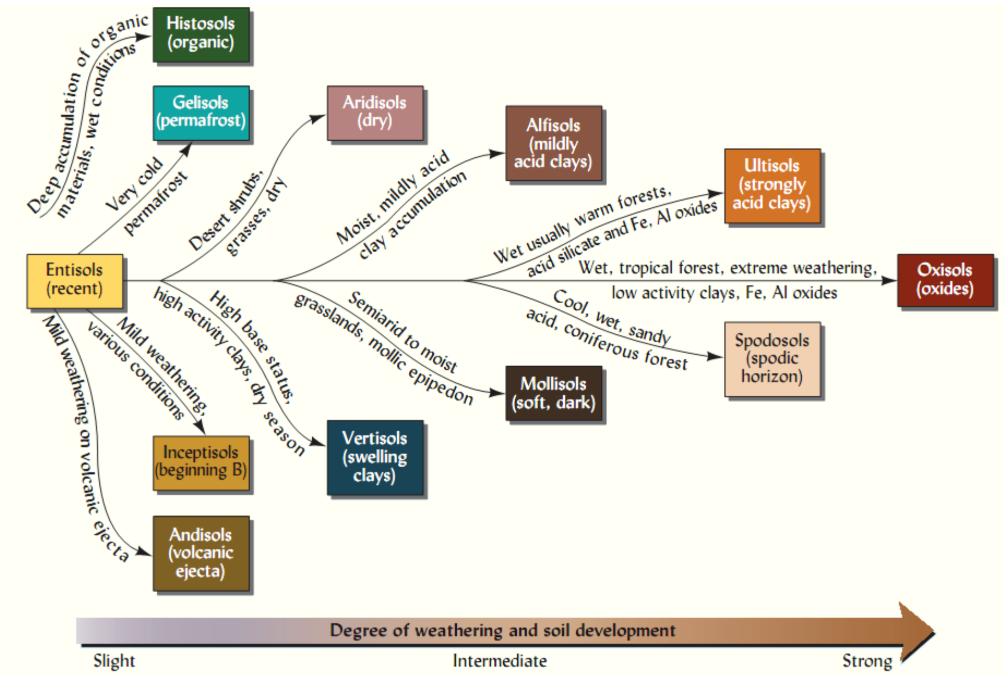

Figure 1. Degree of soil orders weathering and their general climatic and vegetation conditions (Weil, Brady, 2017)

Soils are open systems that receive various amounts of energy and substance from their adjacent environment. The stable properties of soil require being compatible with the existing conditions within the soil. They are the results of either the active soil-forming processes, or have been formed in past environments but are stable enough to persist under current conditions (Buol et al., 2011). The environmental factors including climate, organisms (mainly vegetation cover), relief (topography), parent materials and time comprise the main soil forming parameters which is known as Jenny (1941) the factorial model of soil development. Simultaneous with soil forming factors, four categories of processes including (1) additions to a soil body, (2) losses from a soil body, (3) translocation within a soil body, and (4) transformation of materials are active in soil body. The results of interactions between soil forming factors and soil forming processes are different soils with severely diverse properties around the world. Soil thickness, horizonation, soil structure, soil organic and inorganic carbon contents, particle size distribution (PSD), type and content of clay and clay minerals, pedogenic carbonates, gypsum and soluble salts in arid and semiarid zones, and geochemical weathering status are some of the most important historical records that may have been persisted in soils.

In order to quantify the weathering intensity, the mass transfer coefficient (τ) in the studied pedons was calculated according to equation 1:

$$\tau = \frac{R_s}{R_p} - 1 \qquad \text{Eq. 1}$$

Where τ is the mass transfer coefficient and varies between -1 showing complete mobilization and +1 showing external addition of a defined element.

Taking into account the soil formation data and the records obtaining from different soil it would be possible to reconstruct the prevalent environmental conditions in present and past. This study compares the soils developed in northern and southern slopes of Alborz Mountain Chain across the most western up to the most eastern areas.

Materials and Methods

The Alborz mountain range stretches along a part of the western and entire southern coast of the Caspian Sea located in northern Iran. Based on its changing direction this mountain range is divided into Western, Central, and Eastern parts. The Alborz mountain range forms a very high barrier (up to 5610 m in Damavand mount) between the plate of Caspian and the plate of Iranian plateau. Soils developed in separated areas including Gomishan (50000 ha), Haji Ghoshan (62000 ha), Kheiroud (10000 ha), Kelardasht and Marzanabad (2000 ha), Ramsar (100 ha), Landevil (100 ha) in northern Alborz Mountain Chain about 124000 ha in total were studied. Furthermore soils developed in several areas in southern Alborz including all of Alborz province (580000 ha), Tehran province (30000 ha), Qazvin province (40000 ha) and Ardabil province (10000 ha) which totally is about 660000 ha (Fig. 2).

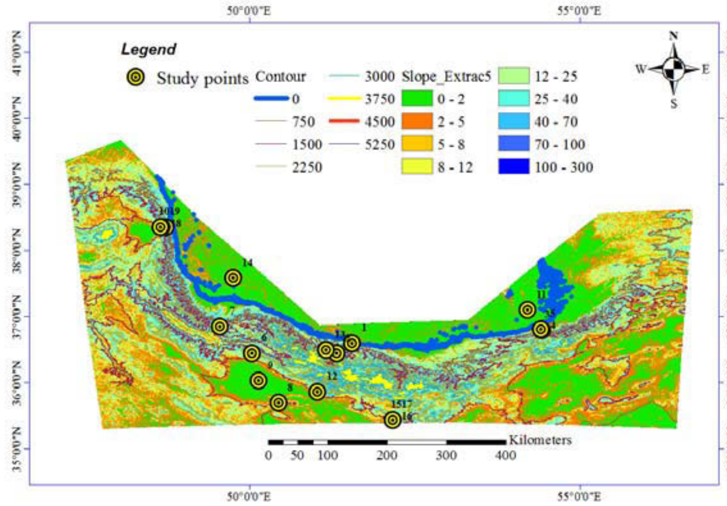

Figure 2. The location, hypsometry and slope classes of study areas in the northern and southern slopes of Alborz Mountain Chain

The geological setting of the study area is illustrated in Fig. 2.

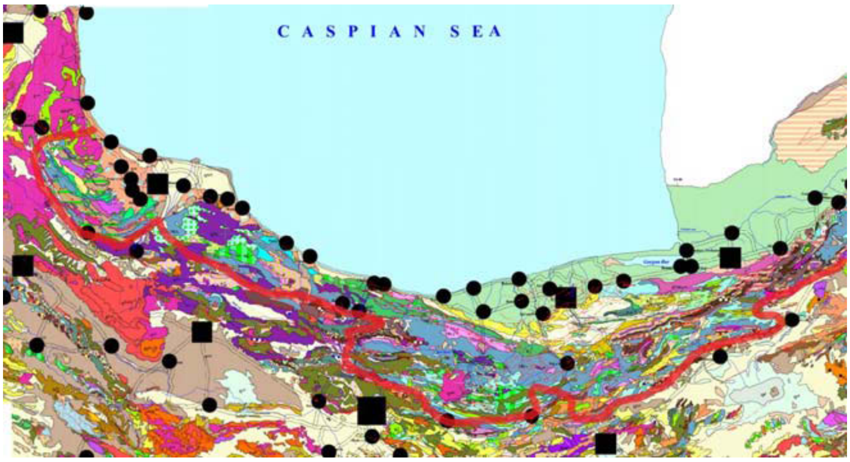

Figure 3. Geological map of Alborz Mountain Mountain Chain

E^{av}: Andesitic volcanics
E^{bv} : Basaltic volcanic rocks
$E^{d,av}$:Dacitic and andesitic volcanics
E_k : Well bedded, green tuff and tuffaceous shale (Karaj Fm.)
J_1: Light grey, thin bedded to massive limestone (Lar Fm.)
K_2^{12} Thick bedded to massive limestone (maastrichtian)
K^f_{tz} : Thick bedded to massive. White to pinkish, orbitolina bearing limestone (Tizkuh Fm.)
Ku :Upper cretaceous, undifferentiated rocks
L,E-O^{gr-di} : Late Eocene granite to diorite
$M^{m,s,c}$: Marl calcareous sandstone.
P : Undifferentiated Permian rocks.
P^c_{gk}: Light red coarse grained polygenic conglomerate with sandstone intercalations (Kerman conglomerate)
P$¢_k$:Dull green grey slaty shales with subordinate intercalation of qyartzitic sandstone
PC^{mt2}: Low grade metamorphosed sandstone, shale and limestone
PeE^m: Marl and gypsiferous marl locally gypsiferous mudstone
Pl^{bv} : Basaltic volcanic.
P_r : Dark grey medium bedded to massive limestone and dolomite (Jamal Fm.)
Pz_2mt_2: Late Paleozoic metamorphic rocks
Q^{cf} : Clay flat
$Q^{f,t1}$: High level piedmont fan and valley terraces deposits.
$Q^{f,t2}$: Low level piedmont fan and valley terraces deposits.
Q^m: Swamp and marsh
TRjs: Meta volcanic, phyllites, slate and meta limestone

Results

The developed soils in north and south Alborz and their properties are very different depending on the types, qualities and quantities of soil forming factors and processes (Table 1). Table 1 summarizes integrative comparison of soils developed on northern and southern slopes of Alborz Mountain Chain.

Table 1. Evolution degree of the studied soils in northern and southern Alborz Mountain Chain (Keys to Soil Taxonomy (2014) and Weil and Brady (2017)

Slope Direction	Studied soils classification (Great Groups)	Degree weathering	Predominant Environment
Northern	Alfisols (Endoaqualfs)	Intermediate to strong	In situ soils in humid climate, mainly under forest, limestone substratum, sloping to steep relief, shallow ground water, reductomorphic features, high clay content
	Alfisols (Haploxeralfs)	Intermediate to strong	In situ soils in sub-humid climate, mainly under forest, limestone substratum, sloping to steep relief, high clay content
	Alfisols (Hapludalfs)	Intermediate to strong	In situ soils in humid climate, mainly under forest, limestone substratum, sloping to steep relief, high clay content
	Alfisols (Paleudalfs)	Relatively strong	Deep to very deep in situ soils in humid climate, mainly under forest, limestone substratum, sloping to steep relief, very high clay content
	Alfisols (Palexeralfs)	Relatively strong	Deep to very deep in situ soils in sub-humid climate, mainly under forest, limestone substratum, sloping to steep relief, very high clay content
	Mollisols (Hapludolls)	Intermediate	Soils in humid climate, forest or range cover, volcanic rocks or limestone substratum, sloping to steep relief, high organic carbon content
	Mollisols (Argixerolls)	Intermediate	Soils in sub-humid climate, forest or range cover, volcanic rocks or limestone substratum, sloping to steep relief, high organic carbon content and clay accumulation
	Mollisols (Calcixerolls)	Intermediate	Soils in sub-humid climate, range cover, volcanic rocks or limestone substratum, gently sloping relief, high organic carbon content and carbonate accumulation
	Mollisols (Haploxerolls)	Intermediate	Soils in sub-humid climate, range cover, volcanic rocks substratum, sloping relief, high organic carbon content
	Mollisols (Haprendolls)	Slight to intermediate	Shallow soils in sub-humid climate, forest or range cover, limestone substratum, gently sloping relief, high organic carbon content
	Inceptisols (Calcixerepts)	Slight	Soils in sub-humid climate, agricultural or range cover, different substratum rocks, different sloping relief, carbonates accumulation
	Inceptisols (Endoaquepts)	Slight	Soils in humid climate, under paddy, mainly fine alluvium and lacustrine deposits, level relief, shallow ground water, reductomorphic features,
	Inceptisols (Eutrudepts)	Slight	Soils in humid climate, under paddy, mainly fine alluvium and lacustrine deposits, level relief, high base saturation
	Inceptisols (Halaquepts)	Slight	Saline soils in semiarid climate, under dry farming, mainly fine lacustrine deposits, clay flat (carbon dating showed 50-70 y age)
	Inceptisols (Haploxerepts)	Slight	Soils in semiarid climate to subhumid climate, crop land, fine deposits
	Inceptisols (Humixerepts)	Slight	Soils in semiarid climate to subhumid climate, crop land, fine deposits and significant humic matter
	Entisols (Hydraquents)	Very slight	Very young less developed soils on fine lacustrine deposits with swamp condition
	Entisols (Udipsamments)	Very slight	Very young less developed soils in humid climate on sandy deposits
	Entisols (Xerofluvents)	Very slight	Young soils developed in semiarid to subhumid climates on alluvial deposits
	Entisols (Xerorthents)	Very slight	Very shallow to deep young soils developed in semiarid to subhumid climates on alluvial deposits
Southern	Mollisols (Argixerolls)	Intermediate	Soils developed on basalts in subhumid climate, high altitudes with grass vegetation, high organic carbon in surface and high clay accumulation in subsurface horizons, affected by aeolian deposits (evidence of change in climate)
	Aridisols (Petrocalcids)	Strong	Soils developed in semiarid climate (now is arid) on old glacial deposits and old fans cutting by water streams and thick cemented petrocalcic horizons (demonstrating long duration of soil formation) under more humid climate or more water sources.
	Aridisols (Natrargids)	Intermediate to strong	Soils developed in past more humid climate that now has changed to arid climate, with high clay content saturated by sodium (possibly from aeolian deposits), mainly in level lands and fine alkaline deposits
	Aridisols (Calciargids)	Intermediate to strong	Soils developed in past more humid climate that now has changed to arid climate, with high clay content and carbonate accumulation (partly from aeolian deposits), mainly in level lands and fine calcareous deposits
	Aridisols (Argigypsids)	Intermediate to strong	Soils developed in past more humid climate that now has changed to arid climate, with high clay content and gypsum accumulation (partly from aeolian deposits), mainly in level lands
	Aridisols	Intermediate	Soils developed in arid climate, with high carbonate and gypsum

Table 1. Continued

Slope Direction	Studied soils classification (Great Groups)	Degree weathering	Predominant Environment
	(Calcigypsids)		accumulations, in level to steep lands
	Aridisols (Haplocalcids)	Intermediate	Soils developed in arid climate, with high carbonate accumulations, in level to steep lands and different parent materials
	Vertisols (Calcixererts)	Intermediate	Soils developed in subhumid to semiarid climates, flat to gently sloping relief, very fine shrin-swelling clay deposits originated from basalt rocks, and carbonate accumulation
	Vertisols (Haploxererts)	Intermediate	Soils developed in subhumid to semiarid climates, flat to gently sloping relief, very fine shrin-swelling clay deposits originated from basalt rocks
	Aridisols (Haplogypsids)	Slight to intermediate	Soils developed in arid climate, with high gypsum accumulations, in level to steep lands
	Aridisols (Haplosalids)	Slight	Soils developed in arid climate, with high soluble salts accumulations, in level to steep lands or on marls
	Aridisols (Haplocambids)	Slight	Soils developed in arid climate, with minimum degree of horizonation and evolution
	Inceptisols (Calcixerepts)	Slight	Soils developed in semiarid to subhumid climate, with high carbonate accumulations, in level to steep lands and different parent materials
	ptisols (loxerepts)	Slight	Soils developed in semiarid to subhumid climate, in level to steep lands and different parent materials
	Andisols (Haploxerands)	Slight	Soils developed in semiarid to subhumid climate, in steep lands and pyroclastic or tuffaceous materials
	Entisols (Xerofluvents)	Very slight	Young soils developed in semiarid to subhumid climates on alluvial deposits
	Entisols (Torriorthents)	Very slight	Young soils developed in arid climate and erosional areas
	Entisols (Torrifluvents)	Very slight	Young soils developed in arid climate on alluvial deposits
	Entisols (Xerorthents)	Very slight	Very shallow to deep young soils developed in semiarid to subhumid climates on alluvial deposits

Table 2. Mass transfer coefficients ($\tau = \frac{Rs}{Rp} - 1$)* of the studied elements in some studied pedons

Horizon	Depth cm	Na_2O	K_2O	MgO	CaO**	Fe_2O_3	Al_2O_3	SiO_2
		%						
Pedon 2 (southern hillside) Arid Zone								
A	0-15	-0.57	-0.89	1.81	-0.82	0.08	-0.77	-0.81
Bk1	15-40	-0.69	-0.86	2.76	-0.26	0.44	-0.71	-0.80
Bk2	40-70	-0.68	-0.86	2.87	0.12	0.36	-0.70	-0.79
R	> 70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pedon 4 (southern hillside) Semiarid zone								
A	0-15	-0.46	-0.76	1.43	-0.93	0.03	-0.71	-0.66
Bt	15-45	-0.63	-0.76	2.68	-0.82	0.34	-0.66	-0.65
Btk	45-80	-0.44	-0.78	2.72	-0.57	0.29	-0.69	-0.66
Bk	80-110	-0.39	-0.79	2.75	-0.38	0.27	-0.70	-0.67
R	> 110	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pedon 6 (northern hillside) Subhumid zone								
A	0-21	-0.61	0.23	-0.17	-0.20	-0.11	0.04	0.03
Bk1	21-90	-0.64	0.38	-0.16	-0.24	-0.11	0.09	0.10
Bk2	90-160	-0.68	0.33	-0.24	-0.04	-0.12	0.06	0.07
R	> 160	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* $R_s = C_{j,s}/C_{i,s}$ and $R_p = C_{j,p}/C_{i,p}$; $C_{j,s}$= concentration of mobile elements in soil; $C_{i,s}$= concentration of immobile elements in soil; $C_{j,p}$= concentration of mobile elements in parent material, $C_{i,p}$= concentration of immobile element in parent material; (-1 shows complete mobilization, and +1 shows external addition).CaO** Represents Ca in silicate-bearing minerals only (CaO in calcium carbonate form was calculated and subtracted from total CaO, then all elements recalculated).

The calculated mass transfer coefficient values (tau) showed that SiO_2, Al_2O_3, CaO*, K_2O and Na_2O have been lost from the soils compared to their bedrock (Table 2).

The mass transfer coefficient (τ) that was not among the previously discussed indices was used to assess the weathering status in the studied regions. According to the obtained tau values, SiO_2, Al_2O_3 and K_2O have strongly depleted from the pedons of arid and semi-arid regions while their depletion in sub-humid region were very little and showed a little bit enrichment in some cases.

Conclusion

The obtained results demonstrate strong climatic changes in southern slope of Alborz Mountain Change that is documented by changes in geochemical, morphological and physicochemical properties. The aeolian deposits have affected genesis of soils in southern slopes. The loess derived soils were reported timely from northern slope also but only in the southern part of northern slope that has a drier climate the loess derived soils have been preserved. In middle and western parts of northern slope the effects of loess or aeolian deposits are rare. Deep to very deep soils in northern slope with humid climate and mostly forest vegetation cover have developed from mainly limestone. While in the southern slope arid-semiarid climate with sparse herbaceous vegetation cover have caused to thinner soil cover that are affected by present and past aeolian deposits leading to polygenetic soils. Considering documents derived from detailed soil analyses can help to reconstruction of paleoenvironmental conditions.

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HADLEY'S CIRCULATION EXPANSION WAS ABLE TO CONTRIBUTE TO PROLONGED DROUGHT IN THE MIDDLE EAST

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It is safe to say that in the early stages of humankind development, the causes of historical disasters are inextricably linked with climatic cataclysms. Climate change was crucial for ancient govern-ment entities, whose economy depended almost entirely on grain crops and other agricultural prod-ucts. One such example is the ruin (4170±150 calendar yr BP) of the Akkadian state, which existed in the XXIV – XXII centuries BC in Mesopotamia and was one of the most powerful of the An-cient East (Cullen et al., 2000). The ruin of the Akkadian empire almost completely coincided with the crisis in Ancient Egypt (the collapse of the Ancient Empire, the period of anarchy and famine). Climatologists have studied the formation of stalagmites in the Gol-e-Zard ("Yellow Flower") cave in northern Iran for the past five thousand years (Carolin et al., 2018). About 4260 yr BP stalag-mites sharply slowed down in growth.

An analysis of the structure of stalagmites showed that the maximum contents of magnesium, cal-cium, and the isotope (δ18O) occurred just in the period from 2260 to 1970 BC, that is, the time when Akkad fell and settlements in northern Mesopotamia were abandoned. The accumulation of magnesium and calcium in the sediments correlates with droughts and increased dust storms in the Middle East, and the content of the δ18O increases with decreasing air humidity. The lack of rainfall was the cause of the drought, which lasted more than 300 years.

Climate changes are always accompanied by corresponding transformations in the circulation re-gime of the atmosphere. And the prolonged predominance of some form of atmospheric circulation leads either to the development or degradation and decline of civilizations, wars, and population migration (Yakovleva et al., 2017, 2018)

There is a definite connection between large-scale circulation systems and the dynamics and inten-sity of the Hadley cell. Changes in the atmospheric circulation in the subtropical regions of the At-lantic and the Mediterranean, which are due to a modern shift the poleward Hadley cell boundaries, lead to a more northern position of the middle location of the intra-tropical convergence zone (ITCZ). In turn, changes in the intensity of trade winds and monsoons depend on the position of ITCZ with corresponding consequences for quantity precipitation and air temperature.

For these conditions, the atmospheric action centers (for the eastern part of the Northern Hemi-sphere - the Icelandic minimum and the Azores maximum) change their parameters at which the North Atlantic Oscillation Index (NAO) has a positive value. The positive NAO phase is character-ized by a more powerful subtropical high-pressure center and a deeper than usual Icelandic mini-mum. An increased pressure gradient contributes to the generation of stronger and more frequent cyclonic formations that go by more northern storm-tracks and create warm, humid conditions in Northern Europe and, conversely, create dry conditions in the Mediterranean basin. In the negative NAO phase, a circulation structure is formed with a weak subtropical maximum pressure and a weaker Icelandic minimum. The whole system is shifted southwest. A reduced pressure gradient generates relatively mild storms in northern Europe. This defines drier and colder conditions in northern Europe, but increases storm paths and moisture flows into the Mediterranean basin. The described structure of meteorological fields with a sufficiently long predominance of one of the forms can lead to an arid or wet climate epoch (Vanniere et al., 2011).

As noted above, the current Hadley circulation tends to expand poleward as a response to rising atmospheric CO_2 levels and global warming (Hu et al., 2007, 2018). The current rate of global warming can lead to the fact that the climatic conditions on the planet become the same as millions of years ago. Ice and snow will become much less, and the summer will be warmer. In this aspect, the problem of modernity is that warming comes too quickly. In particular, a qualitatively similar situation with Hadley's circulation on Earth was observed at the beginning and end of the Creta-ceous. It should be noted that in the middle of the Cretaceous period ("supergreenhouse") the oppo-site trend was observed: with increasing global temperature and CO_2 content, the Hadley circulation decreased (Hasegava et al., 2012). Thus, the long-term relationship between the Hadley circu-lation width, global temperature, and atmospheric CO_2 during the Cretaceous suggests a threshold for atmospheric CO_2 (approximately 1000 ppm) above which the Hadley circulation begins to shrink sharply (Hasegava et al., 2012).

The current rate of increase in carbon dioxide in the atmosphere has a pronounced upward trend: 1910 – 300 ppm; 1958 - 333 ppm; 2005 -375, the concentration of carbon dioxide in the planet's atmosphere in 2019 for the first time in the last 800 thousand years exceeded 415 ppm (www.sciencealert.com). If these processes in the Cretaceous period lasted millions of years, then at the moment we are witnessing a process of sharp expansion of the Hadley cell borders, which is responsible for changes in the structure of atmospheric circulation and a gradual shift of the arid zones further north.

We can assume and hope that there is a threshold for CO_2 in the atmosphere, exceeding which will create conditions for shrinking the Hadley cell. Slowing and stopping the growth of greenhouse gases in the atmosphere is a prerequisite for maintaining a normal climate, in our understanding, in the middle and subtropical latitudes. Only this direction of human development will allow us to reduce the risks associated with climate disasters and to avoid the migration of millions of people and social shocks.

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SOILS AND AEOLIAN DEPOSITS ON THE CASPIAN SEA LOWLANDS, GOLESTAN PROVINCE, IRAN

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Golestan Province considered as a major agricultural region, contains a vast area of salt affected soils in the Caspian lowlands. Soils are mainly classified as Solonchaks where aridity and the saline sea water are mainly responsible for the high salinity of the soils. The highly saline soils close to the present Caspian coast are sandy textured containing sea shells indicating their formation following the Sea retreatment. Towards east, the soils are still highly saline but the underneath deposits are highly impermeable clay textured. The source of salts in these soils based on the results of the cation and anion analyses of the available ground and surface water and using the Gibbs modeling was recognized as evaporate minerals most probably related to the Caspian Sea deposits (Mohammadnejad et al., 2012).

More to the east, aeolian deposits are widespread in Golestan Province, in Northern Iran. The loess deposits are dominant in the north-east part of the province, and are part of the Eurasian loess belt. The extensive loess deposits of Northern Iran occur in the two different loess provinces of the Alborz Mountain footslopes and the so-called Iranian Loess Plateau and reach a thickness of about 70 m. A pronounced precipitation gradient of about 800 mm year^{-1} over 80 km from north to south and corresponding vegetation from dry steppe over steppe grassland to forest vegetation provides condition for the formation of a variety of modern soils on loess and will have governed soil formation during the past as well. The loess-palaeosol sequences represent excellent records of (Late) Quaternary climate change in the area. The loess chronology is relatively well constrained (>20 ka; Lauer et al., 2017).

In addition to the loess deposits, several isolated dunes developed on the flat lowland of the Gorgan Plain, which spreads between the Caspian Sea (West), the Koppeh Dagh and Alborz Mountains (East and South) and the Karakum desert (North). Recent evidences show that the ages of the sand dunes cluster within less than two thousand years around 10 ka, reflecting a relatively rapid aggradation during the Late Pleistocene-Early Holocene transition (Rahimzadeh et al., 2019). The dunes accretion likely occurred under arid paleoclimate conditions with strong wind activity, and reflects a quick regression of the Caspian Sea during the Late Pleistocene-Early Holocene transition, coinciding with the so-called Mangyshlak regression phase. Knowledge on the soils, loess deposits and the aeolian sand could provide information about coastal evolution, paleoclimate and sea level changes.

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THE STRUCTURE AND ORIGIN OF THE "VORONTSOVSKAYA PAD" - A LARGE DEPRESSION ON THE EAST COAST OF THE AZOV SEA

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Keywords: loess plains, closed depressions, paleosols, paleo-relief, Pleistocene, aeolian processes

Introduction

On the watershed of the eastern Azov region, there are a lot of large depressions. Their sizes can reach tens of square kilometers. The shape of these depressions are like a water drop or an egg. The vast number of large depressions are oriented approximately north. To date, the problem of the origin of large depressions in the eastern Azov region does not have an unambiguous solution. The following hypotheses were put forward: paleothermocarst, erosion-suffusion, subsidence-loess, estuary-lake. Yet, none of them is not finally confirmed and not refuted. This is due to the lack of correct data on their geological and geomorphological structure. Also, the problem of these large depressions evolution in the future remains unclear. Is their extensive growth possible or will they remain stable? The goal is to find at and identify the mechanisms for the formation of large depressions.

The “Vorontsovskaya Pad’” is located in the northern part of the Yeisk Peninsula, surrounded by a flat loess plain. From the north, forming an extended steep outcrop, the depression is quickly (1-2 m per year) eroded by the water of the Taganrog Bay of the Azov Sea. On the eastern side of the depression is the village of Vorontsovka, whose territory is subject to coastal abrasion and is constantly being reduced. The “Vorontsovskaya Pad’” is one of the largest depressions: its area exceeds 23 km2. It has relatively steep slopes, southeast - up to 15°. The maximum depth is 15 m. The bottom is flat, even, in the west it is complicated by a ridged relief that rises 6-8 meters above the low bottom. In total, there are three large ridges along the western side of the depression.

Methodology

This study included both field and cameral work. Field methods included geological and geodetic methods. Cameral work included processing of remote sensing data and processing of samples (mechanical composition, chemical composition).

Key sections of the “Vorontsovskaya Pad’” are laid in areas characterizing different structural elements of the depression and interfluves (watershed, bottom, ridges). The main criterion for choosing a key site was the maximum preservation and the absence of various kinds of obvious stratigraphic disagreements. Each site is linked to coastal outcrop, in which the loess-soil series and the underlying sediments of the terrace complex are revealed.

Results

The geological structure of the "Vorontsovskaya Pad'" is revealed in a long (more than 4 km) coastal outcrop and boreholes, supplementing the information about the structure below sea level. Key sections of the "Vorontsovskaya Pad'" are laid in areas characterizing different structural elements of the depression and watersheds. The easternmost section (V4) characterizes the watershed surrounding the depression. The eastern slope of the depression has been studied during routes. Section V1 / V9 characterizes the structure of the low level of the bottom. The transition from the bottom to the ridge topography is characterized by two sections - V6 and V7. Ridge relief was studied in sections V2, V5, VL. The western slope of the depression is characterized by section V8 and studied during the routes.

The structure of the surrounding watershed is typical of the terraces of the Eastern Azov region. There are no stratigraphic disagreements are observed in its structure. Two different strata are distinguished in its structure. Deposits of the terrace lie at the base. They are represented by the alternation of thin layers of sandy loams and loams. With depth, the mechanical composition becomes coarser. From above, this stratum is covered with loess cover with paleosols developed in it. They were studied. The main phases of the formation of paleosols in the loess, according to the conception A.A. Velichko, correlate with the interglacial epochs and marine isotope stages (MIS): Mezinsky paleosol - Mikulinsky interglacial - MIS5e - 135-117 thousand years ago, Kamensky paleosol - Kamensky interglacial - MIS7 - 190 - 220 thousand years ago, Inzhavinsky paleosol - Likhvin interglacial - MIS9 - 300 - 340 thousand years ago, Voronsky paleosol - Muchkap interglacial - MIS13-15 - 470 - 500 thousand years ago.

The eastern side of the "Vorontsovskaya Pad'" has a complex structure, in the transition from upland to the bottom. Particularly clear changes concern MIS5e paleosol. An erosion boundary is read, over which lies the typical MIS2-4 loess, under which the Mezinsky complex denudates.

In the structure of the bottom of the "Vorontsovskaya Pad'", there are no clear signs of paleosols. As in the structure of the watershed, there are two strata. The terrace sediments lie at the same depth below sea level. However, the loess cover is strongly reduced and has signs of over moistening.

The structure of the ridges in the relief of the western part of the bottom of the Vorontsovskaya Pad distinguishes four different horizons. The upper horizon is represented by the Late Pleistocene loess. Below lies a layered stratum represented by sediment, apparently of an aeolian origin. Loess-like loams with MIS5e paleosol lies below. At the base of the section, at the same depth as under the plateau, rhythmically layered sandy loamy loams deposits of the terrace lie.

On the western slope of the "Vorontsovskaya Pad'" the situation is similar to the eastern side of the depression. However, the MIS5e paleosol is not eroded here but gradually goes lower from the watershed area towards the ridges and the bottom of the valley. More ancient paleosols gradually disappear towards the bottom. Deposits of the terrace also lie at the base, at the same depth.

Conclusions

The "Vorontsovskaya Pad'" is fitted in the loess deposits and do not affect underlying sediments of terraces. The "Vorontsovskaya Pad'" have aeolian-denudation origin it is a large deflationary basin. The depression is covered with MIS5e paleosol. The

"Vorontsovskaya Pad'" formed at the end of the middle Pleistocene (MIS6). In the Weichselian era, the "Vorontsovskaya Pad'" was partially reshaped by aeolian processes (deflation at the eastern side but accumulation at the western side), which led to the development of ridge relief. "Vorontsovskaya Pad'" is a relict landform. The processes that have generated this large depression are currently inactive and do not threaten to agricultural lands in the nearest and medium perspective future.

Funding

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SPATIAL AND SEASONAL SALT REDISTRIBUTION IN SOILS OF THE RECENT ECOSYSTEMS AT THE COASTAL PLAINS OF THE CASPIAN SEA

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Keywords: spatial variation, salinity, lagoon ecosystems, digital soil mapping, regular patterns

Introduction

Strong variability of soil salinity is one of the main features of saline environments. Still, there is lack of knowledge about the spatial patterns of these variations in such dynamic environments as lagoon and marsh ecosystems, although such studies can give a key to understanding of soil variability at well-developed surfaces and the ways of evolution of soilscapes through time.

The seasonal variation of soil salinity in coastal ecosystems is well studied (He et al., 2014; Shahid et al., 2013; Shi et al., 2005; Silvestri et al., 2005; Wu et al., 2009) but the regularities in these changes are mainly not disclosed. The goal of our study was the analysis of spatial and seasonal variations of soil salinity, detection of stable (regular) patterns and relationship between these patterns and environmental covariates such as vegetation and microtopography at the recent ecosystems formed at the coastal plains of the Caspian Sea in Russia and Iran.

Methodology

This study was conducted at two key sites located at the low-angle coasts of the Caspian Sea in Iran (northwestern Golestan, *Gomishan-1*) and Russia (northern Dagestan, *Caspii-2*) (Fig. 1).

The landforms are mainly represented by former lagoons and marshes with loamy deposits. The soils are Solonchaks. The ground water level is about 2-2.5 m. The age of the surface deposits, according to radiocarbon dating of soil organic carbon, is 60-70 years (100% modern carbon, *Gomishan-1*) to 150-300 years (*Caspii-2*). The altitude of both key sites is very similar and is about -25.5 m below sea level (Kronstadt tide gauge), or -24.7 m below sea level (Persian Gulf tide gauge). The coordinates of the key sites are: *Gomishan-1* (Iran) - 37.1754 N, 54.0677 E; *Caspii-2* (Russia) - 44.5529 N, 46.6769 E.

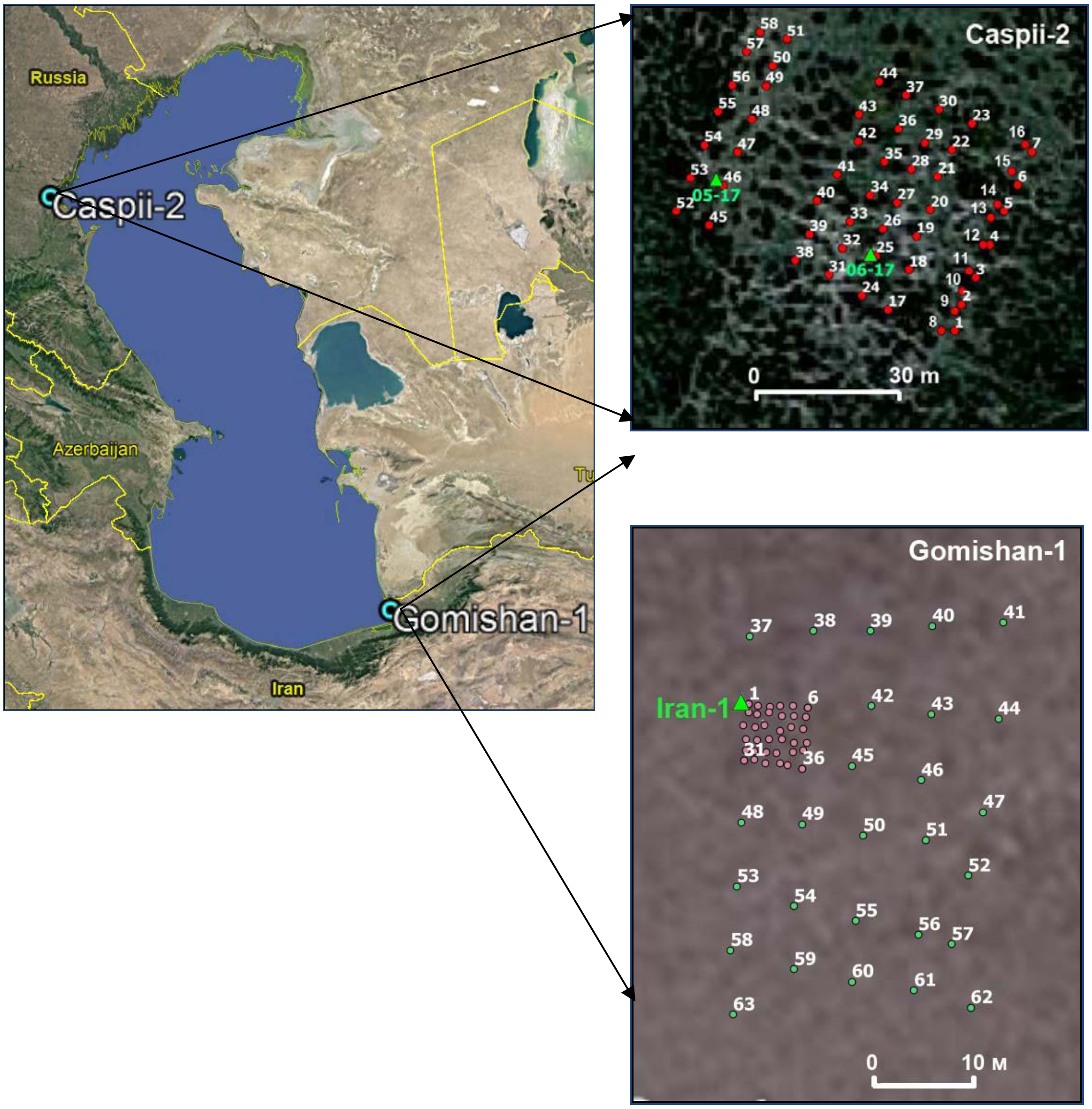


Figure 1. The location of the study sites and sampling points: boreholes are shown by circles and white numbers, soil pits are shown by triangles and green designations

According to the Köppen-Geiger classification, the studied coastal areas of Russia and Iran belong to the arid steppe type with hot arid (BSh / Iran) and cold arid (BSk / Russia) temperature conditions. The average annual rainfall for the 10-year period is 465 mm (Iran / Bender-Torkeman meteostation) and 303 mm (Russia / Lagan meteostation), which varies from 290 to 720 mm (Iran) and from 200 to 440 mm (Russia).

The area of plots was 25x20 m (*Gomishan-1*) and 45x30 m (*Caspii-2*). The detailed soil sampling at the interval of 1-5 meters was performed in the field twice (in Autumn 2017 and Spring 2018). About 60 boreholes were sampled at each plot down to one meter in Autumn and down to 0.5 meter (from the same locations) in Spring. The sampling depths were 0-5, 5-10, 10-20, 20-30, 30-50, 50-70, and 70-100 cm. In soil samples, the electrical conductivity (1:2.5 soil-to-water ratio) was measured in the lab by Hanna Combo 98130 conductivity meter (Russian samples) and by Jenway combined pH and conductivity meter 3540 (Iranian samples). The microtopography of the key sites was measured using DGPS equipment (GNSS Stonex S9 Plus in Russia and KQ Geo efix R2 in Iran).

In the samples from soil pits, soil particle size distribution and composition of water extracts were measured.

The 2-D maps of microtopography, vegetation and soil salinity were compiled in SAGA GIS using inverse distance weighted method. The 3-D maps of soil salinity were compiled using Voxler software. The statistical analysis was performed in STATISTICA software. Comparison of means was performed by Mann-Whitney U test and t-test.

Results

The studied key sites are very different in terms of climate, microtopography and vegetation although the mean values of salinity (electrical conductivity) are very similar in most depths between these two sites (Konyushkova et al., 2018). The microtopography at *Gomishan-1* site is extremely flat (the amplitude of heights is less than 5 cm, Fig. 2), vegetation is homogeneous and represented by *Halocnemum strobilaceum*. The microtopography at *Caspii-2* site is well pronounced (the amplitude of heights is 10-15 cm), vegetation is diverse and represented by *Tamarix octandra* mixed with some *T. laxa* and annual saltworts (*Petrosimonia brachiata, P. oppositifolia, Suaeda acuminata*), shrubs (*Frankenia hirsuta*) and grasses (*Puccinellia gigantea*) beneath and between the bushes of *Tamarix*.

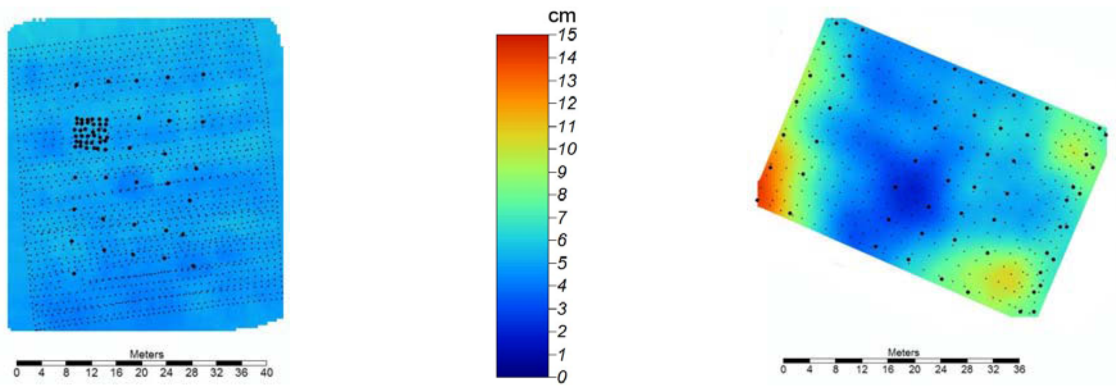


Figure 2. Microtopography of the key sites at the coastal plains of Iran (*Gomishan-1*/Golestan) and Russia (*Caspii-2*/Dagestan). The small dots are depicting the locations of GNSS measurements; the circles are depicting the locations of soil sampling

The spatial variation of soil salinity is well pronounced at both key sites. Generally, the redistribution of salts affects the upper 50 cm of soil and is especially pronounced in the upper 0-5(10) cm (Table 1). At the *Caspii-2* site, soil salinity in the upper 30 cm is inversely dependent on the microtopography (R^2 = 0.28; 0.43; 0.48; 0.38 for the layers 0-5, 5-10, 10-20, 20-30 cm, respectively), that is, microhighs are less saline than microlows. This is also correspondent with the vegetation cover: saltworts (*Petrosimonia, Halocnemum)* are mainly found in microlows whereas tamarix and forbs are found in microhighs. At the *Gomishan-1* site, there is no relationship between the microtopography and soil salinity (R^2 <0.03 for all layers).

The seasonal dynamics of soil salinity is very high: the difference between median values of soil salinity taken from the same locations at different seasons is statistically significant for most depths (Table 1). In spring, there is a decrease in electrical conductivity in the upper 20 cm by 40-50% at *Gomishan-1* site and by 15-60% at *Caspii-2* site. Below this depth (20-100 cm), there is both increase and decrease in soil salinity (by -80+100% at *Gomishan-1* site and by -20+60% at *Caspii-2* site).

Despite the strong seasonal dynamics, there are clear trends in these changes in the upper 10 cm of soils at *Gomishan-1* site and in the upper 50 cm at *Caspii-2* site (Fig. 3). The R^2 between the spring and autumn values is 0.23-0.33 for the upper 10 cm at the *Gomishan-1* site, and 0.43-0.75 for the upper 50 cm at the *Caspii-2* site. These trends show that the more saline the soil at the top, the more saline (comparing with the surrounding area) it will stay at any season and vice versa.

Table 1. The descriptive statistics of soil salinity at the coastal plains of the Caspian Sea ($EC_{2.5}$, dS/m)

Depth cm	No of samples	Median		Mean		Range		Quartile range		Standard deviation	
		Autumn 2017	Spring 2018	Autumn 2017	Spring 2018	Autumn 2017	Spring 2018	Autumn 2017	Spring 2018	Autumn 2017	Spring 2018
Gomishan-1											
0-5	63	11.9	10.9	12.0	11.4	22.9	19.1	9.2	7.5	6.0	4.5
5-10	63	7.9	7.5	8.4	7.7	12.0	9.3	3.8	2.3	3.0	1.7
10-20	63	**8.8**	**7.7**	**9.4**	**7.8**	12.4	10.8	3.7	1.9	2.8	2.1
20-30	63	10.8	10.4	10.7	10.0	9.1	10.7	3.3	3.6	2.2	2.6
30-50	63	**10.0**	**12.0**	**10.1**	**11.5**	9.2	13.2	3.0	4.0	2.0	3.1
50-70	63	10.9	n.a.	10.8	n.a.	8.0	n.a.	2.8	n.a.	1.9	n.a.
70-100	63	11.9	n.a.	11.8	n.a.	11.4	n.a.	2.5	n.a.	2.0	n.a.
Caspii-2											
0-5	58	**11.6**	**3.6**	**11.9**	**4.1**	34.7	14.9	11.4	3.8	8.4	3.4
5-10	58	**11.8**	**6.4**	**10.6**	**6.0**	14.5	9.4	4.4	3.0	3.8	2.2
10-20	58	**9.6**	**7.4**	**8.8**	**7.5**	10.5	9.9	2.7	2.7	2.2	2.2
20-30	58	10.5	10.6	10.2	10.5	9.4	10.6	3.0	4.0	2.2	2.6
30-50	58	**10.5**	**12.4**	**10.5**	**12.3**	8.4	8.3	2.4	2.5	1.9	1.9
50-70	58	10.2	n.a.	10.2	n.a.	8.0	n.a.	1.6	n.a.	1.4	n.a.
70-100	58	10.8	n.a.	10.9	n.a.	4.9	n.a.	1.9	n.a.	1.3	n.a.

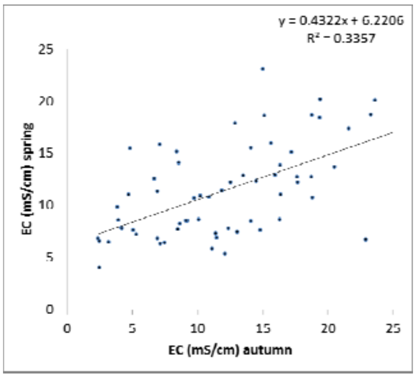
*The statistically significant difference between the values of different seasons is marked in bold ($p<0.05$).

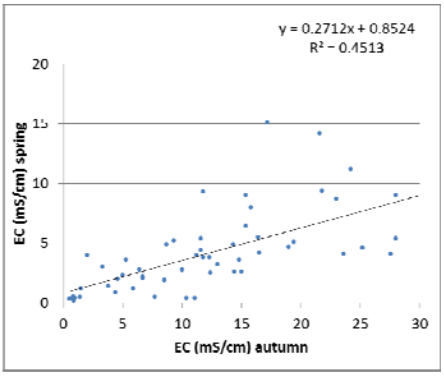
The maps of stable and dynamic areas of soil salinity were compiled. We hypothesize that these patterns serve as embryos of the further development of soilscapes in the process of soil and landscape evolution.

Gomishan-1

Caspii-2

0-5 cm





5-10 cm

10-20 cm

20-30 cm

30-50 cm

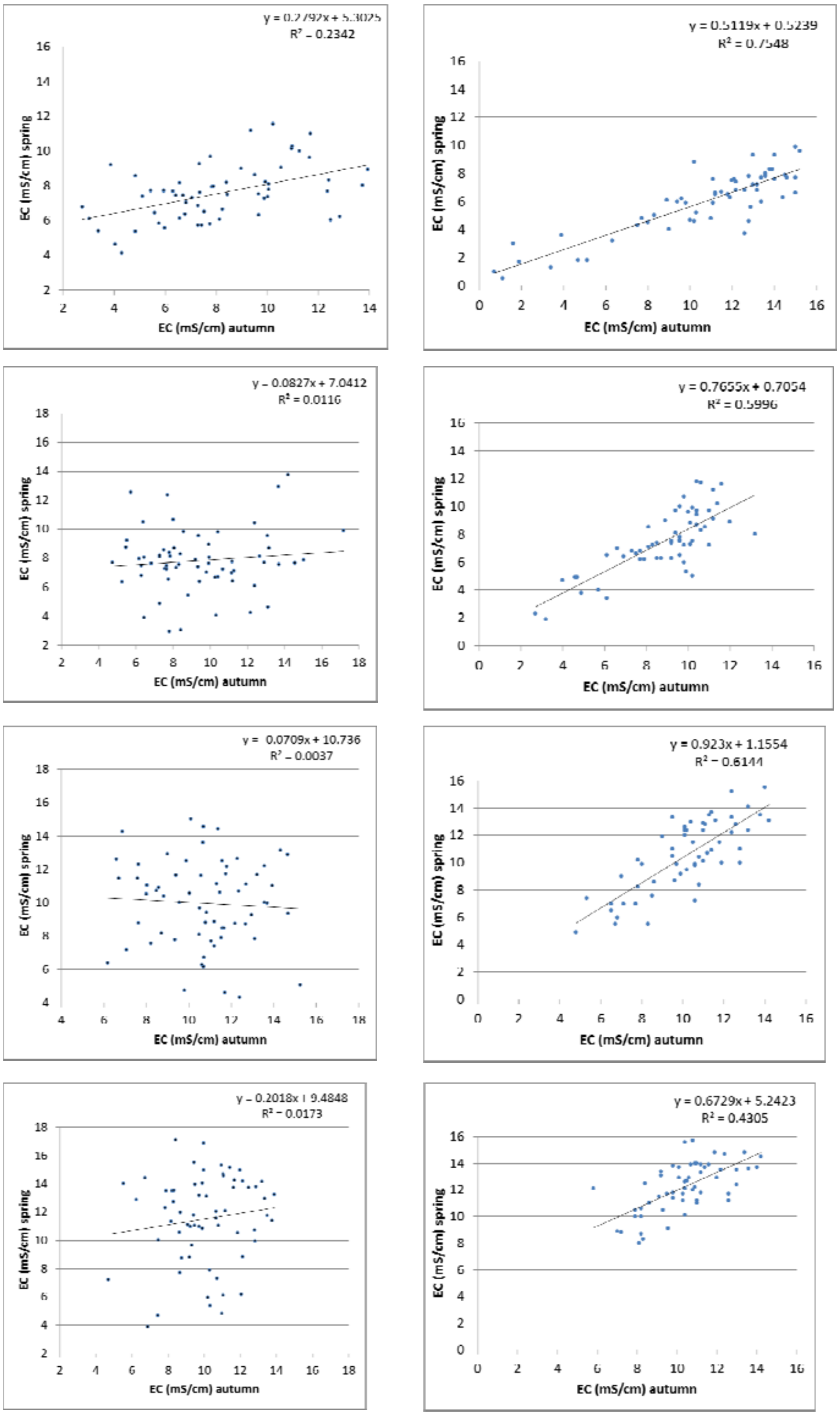


Figure 3. The trends in seasonal dynamics of soil salinity at the studied key sites

Conclusions

The spatial and seasonal variability of soil salinity at the coastal plains of the Caspian Sea is very strong. Our study conducted at the detailed scale (n*10^0-10^1 m) has shown that these variations have a regularity pronounced in the upper 10 cm of the younger *Gomishan-1* site (Iran) and upper 50 cm of the older *Caspii-2* site (Russia). From this, we can conclude that these regular patterns are quite stable and are deepening with time.

Acknowledgement

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RECONSTRUCTING EVOLUTION OF MURGAB RIVER DELTA FOR UNDERSTANDING THE DEVELOPMENT OF MARGIANA CIVILIZATION (GONUR-DEPE, TURKMENISTAN): FIRST DATA.

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Keywords: Murgab river, Bronze age, Karakum desert, Margush, Margiana civilazation, climate change, paleochanale.

Introduction

Figure 1. General view of Gonur-Depe excavations

A huge necropolis, dating back to the III Millennium BC, was excavated in the Mary oasis (Turkmenistan) during the Margiana archaeological expedition under the leadership of V.I. Sarianidi in 1972 (Fig. 1). The monumental cult complex, excavated at Gonur Depe settlement, was a large regional Zoroastrian center in Margiana. The complex was located on a low hill on the right Bank of the Murgab riverbed. The area of the ancient settlement ranges from 20 to 50 hectares. The Temple city existed until the end of the XVI century BC. Its central part is the Kremlin (Fig. 2) with a palace in the center, which is surrounded by walls with rectangular towers. The earliest of the famous Temples of Fire was built outside these walls on the East-side. The system of two basins, the main of which has a size of 100 to 60 m was adjoined from the South to the walls of the settlement [Sarianidi, 2005].

Methodology. Almost all the authors agree that the important factors determining the historical processes in the III-II thousand B.C., are natural and demographic: intense aridization in the middle of the III Millennium B.C. (including that caused by believed intensive farming), and high population density in the "Crescent of fertility", formed as a result of the Neolithic revolution

[Lamberg-Karlovsky, 2014]. This situation definitely influenced the increase in mobility of the population. But to date the reason of the population decrease and abandonment of the Gonur-Depe have not been fully studied. A special place in understanding the possibilities of extensive migrations from the Eurasian steppes to the southern agricultural areas, takes information about the hydrological regime of large rivers in the region. We have analyzed the space images of the Murgab river delta, performed a field geomorphological study of ancient channels.

Figure 2. Reconstruction of the adobe walls of the central part of the city in 2019

Results

We highlighted the two possible paleochannels (Fig. 3) active at the time when Gonur-Depe were populated.

Figure 3. Position of the Gonur-Depe site and two main paleochannels of Murgab river

First is located to the West of the settlement from which in ancient times there was a canal to a large receiving pool, second, smaller one is located to the south of the city. We performed drilling, section description, lithological and palynological analysis and luminescence dating. In general we identified series of paleochannels that together with different aeolian forms create a pattern that allows reconstructing the history of delta development with a very clear general degradation of this system as a result of aridization in the Middle-Late Holocene. New data on the morphology and age of Murgab delta system development will allow forming a new look at the history of the Margiana civilization.

This research was supported by RFBR grant 18-09-40082.

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STATE OF THE PALEOCLIMATE RESEARCHES ON THE SOUTHERN PART OF THE SOUTH CASPIAN SEA: CURRENT STATUS AND FUTURE PERSPECTIVE

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Keywords: South Caspian, palaeoclimate, loess, glaciers, Iranian coast, sea level

Introduction

The present climate of the south Caspian Sea and its coast is influenced by atmospheric systems originating from northeastern Atlantic and connected seas, Siberia as well as by its complex geographical setting. Tectonic setting of the south Caspian Sea and consequent orography of the region provides the possibility of frequent inland basin developments such as lakes, wetlands, peat bugs, playas and inter-dune basins. Moreover they favored sub-tropical climate with high precipitation that is prevailed over south Azerbaijan from Lenkoran to Iranian coast in Gorgan. Achieves of the Quaternary records in the region revealed that climate has changed dramatically which is concordant mainly with its global and regional context and partially contradictory, probably caused by local modifications and/or different methodology of researches. Duration, strength and geographical extent of the past climate changes were the subject of several palaeoclimate researches in twenty century, which is boosted in the past years using multi proxies and new methods (Lahijani et al., 2007; 2009, 2019a,b; Naderi Beni et al., 2013; Kakroodi et al., 2015). The past climate changes of the region during the Late Pleistocene and Holocene and its possible teleconnections to the regional and global phenomena has been reviewed here. Presenting the state of the paleoclimate researches, we introduce future perspectives for unraveling past climate changes in the Iranian Plateau.

South Caspian bottom sediments

South Caspian (Fig. 1) sediments preserve the long history of sedimentation that could unravel the past changes in the region and in the sea itself.

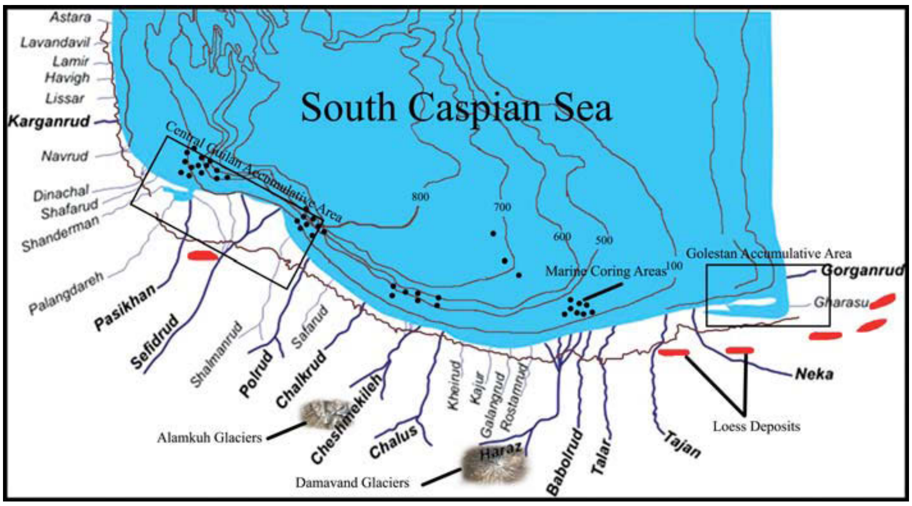

Figure 1. South Caspian Sea

Many investigations concerning the South Caspian sediments related to the works conducted by Iranian National Institute for Oceanography and Atmospheric Science (INIOAS) and Geological Survey of Iran (GSI). The results have been published as reports, maps and articles (Leroy et al., 2013, Haghani et al., 2016). The sediment comprised of terrigenous, chemical and biological components, their share in sediment composition changes during sea level rise and fall. Study of pollen and dynocysts in the cores revealed several environmental changes attributed either to the governing climate and changes in freshwater influx into the Caspian Sea (Leroy et al., 2013; Lahijani et al., 2019a,b).

Coastal researches

On the Iranian coast, authors have used morphological records, outcrops and coastal cores as well as historical archives (Haghani et al., 2016; 2018; Kazanci et al., 2004; 2013; Lahijani et al., 2007; 2009; Naderi Beni et al., 2013; Kakroodi et al., 2012; 2014; 2015; Ponel et al., 2013; Ramezani et al., 2008; 2016; Shumilovskikh et al., 2016). They reconstructed impact of the sea level changes on the Iranian coast. The Caspian Sea level curve extended for the past millennia based on the historical archives (Naderi et al., 2013).

Loess deposits

Loess deposits in on the South Caspian coast are distributed in Sefidrud valley in west to Gorgan area in east (Kehl, 2009). The oldest loess dated early Pleistocene deposits in northern Iran, in Aghband , south east Caspian coast. Most of loess-palaeosol deposits in the southeast Caspian coast have been formed during the middle and late Pleistocene that represent fluctuation of cold and dry climate to warmer and wetter one. Pedogenisis probably intensified during interglacial and interstadials and dust transfer in stadials (Karimi et al., 2011, 2013; Khormali et al., 2009).

Glaciers

The first observations of the present glaciers have been reported in the first half of twenty century, later they have been reviewed by Ferringo(1988).The glaciers mainly located in high mountains of Alborz and Zagros with around 23 km^2 total area (Mousavi et al., 2008). The average temperature and snow line in Iran were lower during the Quaternary Glaciations, therefore in high mountains had more potential for glacier development. Alamkuh mount of Alborz (Karimi et al., 2012) has thick sequence of glacier that might contain good archive of the past climate.

Other archives

Foothills to highlands of the northern flank of Alborz Mountains have been investigated to decipher paleoclimate of the region using tree rings, peat bogs and archeological remains (Akhani et al., 2010; VahdatiNasab , 2010; Ramezani et al., 2016; Froozan et al., 2018; Manca et al., 2018). The hircanian relict forest, its response to the past climate changes; shrinking, expansion and altitude displacement were the main focus.

Concluding remarks and perspective of future research

The Caspian Sea attracted more attentions in the past years. However its sea level curve and dating methodology are disputable. The south Caspian coast have two prominenat accumulative areas in the Central Guilan and in southeast corner which provide excellent archives for the Caspian paleoclimate as well as vegetation history and agricultural experience in the northern Alborz.

Vast calcareous formations in Alborz Mountains have formed caves. They are newly attracted researchers, academic community waiting for future publications. Mountain glaciers sporadically introduced in some studies, but it needs more precise investigation and dating. They could draw border of southern glaciations. In the past years many studies have focused on the loess and palaeosols. Many of them concentrated on the southeast corner of the Caspian coast and Kope Dag in northeast Iran which need more geographical coverage. Moreover the relation between South Caspian loess deposits and sea level that not touched yet. The south Caspian benefits high mountain range that feed permanent and ephemeral rivers. They have formed vast alluvial deposits. Changing in river course happened frequently which formed playas and lakes and caused human displacement. They have high potential to unearth palaeofloods in the coastal area. Human history recorded back to 60 ka based on current studies in the northen flank of Alborz. Archeological remains in the area could disclose the climate impact on human activities in the late Pleistocene and Holocene.

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MICROMORPHOLOGICAL DIAGNOSTICS OF PRIMARY PEDOGENESIS ON GEOLOGICALLY YOUNG PLAINS OF THE CASPIAN SEA COAST IN IRAN

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Keywords: micromorphology, Solonchak, primary pedogenesis, Caspian Sea coast

Introduction

The study on micromorphological features of young coastal soils formed after the recent regression of the Caspian Sea can give new insights into soil genesis and development in arid hypersaline environments, which are found in many parts of the Caspian Sea coast.

The present study was conducted on coastal plains that were formed at different stages of the Caspian sea level changes at the altitudes of 25-26 m below the global level (Kronstadt sea gauge) in the Golestan Province of Iran (Fig. 1).

Figure 1. Locations of the study sites in the Golestan Province of Iran: Gomishan-1 (37.1754N 54.0676E), Gomishan-2 (37.1768N 54.0394E) and Gomishan-3 (37.1525N 54.0025E)

Samples for micromorphological analyses were taken from seven pits of young soils developed on marine sediments exposed for different periods of time, namely: 4-year-old soils under *Salicornia* (pits Ir-6 and Ir-7, site Gomishan-3), 65-year-old soils under *Halocnemum* halophytic dwarf shrubs (pits Ir-2 and Ir-3, site Gomishan-1) and 150-year-old soils under coastal meadows (pits Ir-4, Ir-5 and Ir-8, site Gomishan-2). Variations in vegetation cover and microtopography within each study site were insignificant (Konyushkova et al., 2018). Taxonomically, the soils at the different key sites are very similar and can be referred to as Solonchaks Gleyic (IUSS WRB, 2015). However, at a closer examination, there were some differences in vertical and lateral differentiation in soil profiles at different stages of primary pedogenesis.

The aim of the present study was to analyze temporal and spatial changes in soil fabric at different stages of primary pedogenesis under semiarid (precipitation is about 350 mm) and saline conditions on young coastal plains of the Caspian Sea.

Methodology

Thin sections were prepared and their micromorphological analyses were conducted using the routine methodology using Olympus BX51 polarizing microscope equipped with an Olympus DP26 digital camera. Elements of soil fabric were characterized according to the international terminology (Stoops, 2003).

Radiocarbon dating of soil organic matter was performed at the Laboratory of Radiocarbon Dating and Electron Microscopy of the Institute of Geography RAS (Russia) and the Center for Applied Isotope Studies of the University of Georgia (USA). Calibration was performed using CALIB REV7.1.0 software (Reimer et al., 2013).

Results

Micromorphological studies on primary pedogenesis on young coastal plains of different ages showed that subaerial development of soils began with accumulation of aeolian particles near the roots of halophytic dwarf shrubs of *Halocnemum* species. Biogenic structure and porosity gradually developed in aeolian deposits with accumulation of organic matter from decomposing plant roots as well as cyanobacteria, which also protected the surface from erosion (Fig. 2a). The densest surface horizons consisting of calcareous clay and fine silt were characterized by specific forms of carbonate pedofeatures (e.g., dendroid forms and rings of cryptocrystalline calcite), which were probably associated with the development of microbial mat communities during the early stage of sea regression. Such carbonate pedofeatures were preserved in 150-year-old soils despite the development of pedogenetic structuring processes (Fig. 2b). Vivianite pedofeatures formed under reducing conditions on the youngest (4-year-old) coastal plain. In the studied soils of all ages, there were abundant and diverse pedofeatu res of gypsum and iron oxides. Their micromorphological characteristics changed with time of subaerial soil development due to localized leaching or crystallization processes. Gypsum pedofeatures were usually found in pores within most clayey microzones often surrounded by ferruginous pedofeatures such as rings and coatings resulting from redeposition of iron oxides (Fig. 2c). These pedofeatures were indicative of active processes of accumulation of gypsum and iron oxides in young Solonchaks. Layers rich in fine silt contained fragmented shells of malacofauna (Fig. 2d).

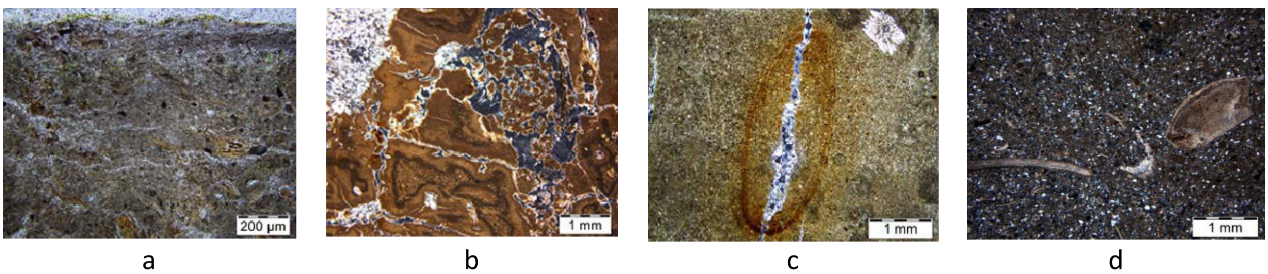

Figure 2. Fabric of soils developed over different periods on young marine sediments of coastal plains by the Caspian Sea in Iran: (a) laminated biological crust with cyanobacteria at the surface and numerous inclusions of plant debris (Ir-5; 0-2 cm, PPL); (b) coprolites of microfauna inside calcareous clay ped, dendroid-like gray carbonate pedofeatures within peds and dense gypsum infillings in pores (Ir-5; 10-12 cm, PPL); (c) gypsum infilling of a pore encircled by ferruginous rings (Ir-4; 56-76 cm, XPL); (d) fragments of mollusk shells within fine-textured material (Ir-4; 76-86 cm, XPL)

Conclusion

The micromorphological diagnostics allowed to conclude that primary pedogenesis within hypersaline plains under arid climate was manifested in rapid leaching of soluble salts from the surface layer (0-5 cm) and formation of biological crusts (Pagliai and Stoops, 2018). Such biological crusts were characterized by well-developed biogenic structure and humus formation from plant debris accumulated within peds. Different microforms of gypsum pedofeatures in pores were connected with gypsum crystallization from saturated solutions under arid conditions as well as localized dissolution within major pores-fissures (Poch et al., 2018).

Acknowledgements

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MORPHOGENETIC ANALYSIS OF BURIED SOILS AS A PROXY FOR PALEOGEOGRAPHIC RECONSTRUCTION (LOESS-PALEOSOL SEQUENCE OF SREDNAYA AKHTUBA KEY SECTION, LOWER VOLGA AREA

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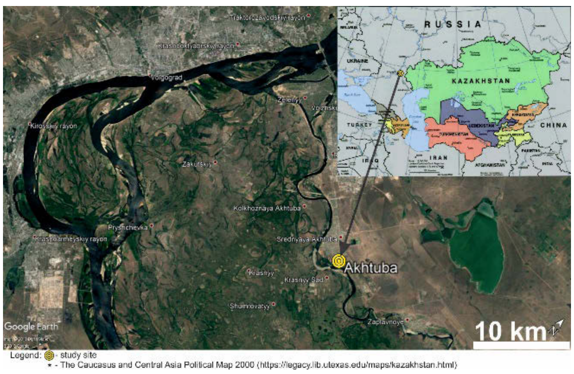
Keywords: micromorphology, paleoenvironmental reconstruction, Pleistocene paleosols, Holocene polygenetic arid soils, loess

The Caspian Lowland is a part of the extensive Ponto-Caspian basin that reflects fluctuations in the level of the Caspian and Black sea, glacial-interglacial cycling, and related fluctuations in fluvial activity and aeolian sedimentation. The outcrops at the banks of the Volga River and its tributaries expose detailed Late Pleistocene pedosedimentary sequences, with marine, aeolian, and fluvial deposits intermixed with pedogenetic levels of interglacial and interstadial paleosols (Yanina, 2014). During the last deglaciation and degradation of permafrost, the Volga River basin collected meltwater and acted as a trap for fine-grained sediments from the southern margin of the Scandinavian ice-sheet (Yanina, 2014; Svitoch, 2009; 2010; Tudryn et all., 2016; Makeev et all., 2016). A sequence of seven pedogenetic levels buried in the Late Pleistocene was studied at the Srednaya Akhtuba key section (48°43 N, 44°52 E) in Volgograd oblast of Russia (Fig. 1) with the use of a set of macro- meso-micromorphological, physicochemical and instrumental methods.



a

b

Figure 1. Geographical location of Middle Akhtuba key section (a) and general view of the exposure (b)

It was found that the buried soil had been formed under subaerial conditions with loess sedimentation alternating with the periods of fluvial and marine sedimentation. The soil–

loess sequence (MIS1–MIS5 from 26 ka BP to 112 ka BP) (Yanina et all., 2017) includes seven paleosol layers separated by sediments of different compositions and geneses. Longer periods of interruption of sedimentation processes predetermined the formation of better-developed soils. Surface Kastanozem of the Lower Volga area was first studied as a part of the pedocomplex, with the lower part formed in Early Khvalynian Chocolate clays (13–15 ka), the middle part in mixed clay-loess sediment sand, and the upper part in loess. The shift from marine to sub-areal sedimentation was accompanied by short breaks, allowing the development of synlithogenic soil horizons of Late Khvalynian, after-Khvanynian, and Boreal time. The features and chemical composition of shallow buried soil horizons confirm increased aridity after the last deglaciation (Lebedeva et al., 2018) (Fig. 2).

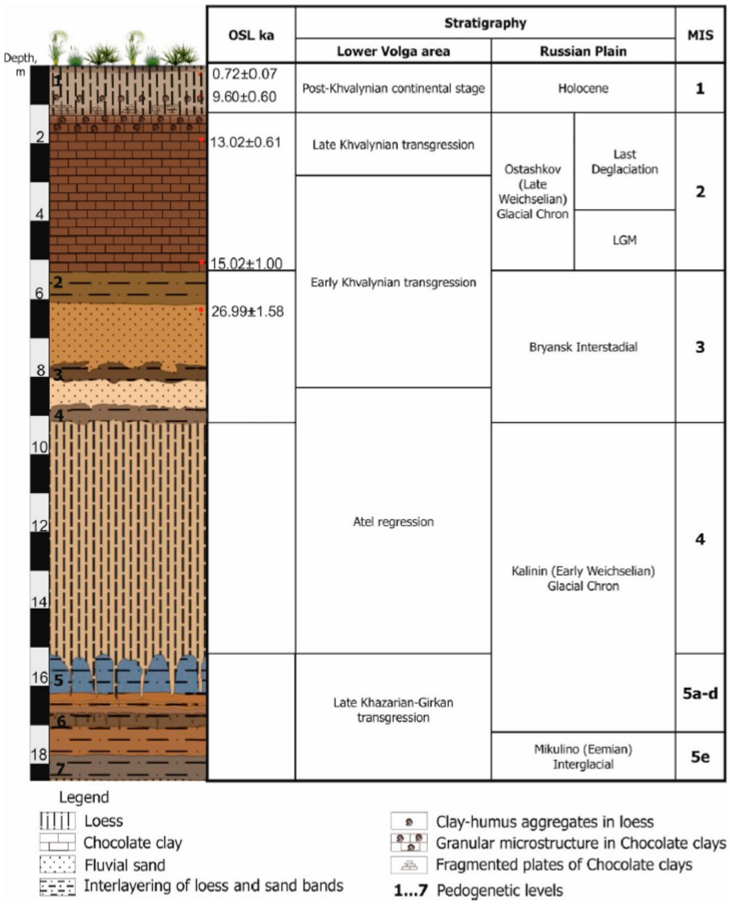


Figure 2 Chronostratigraphy of the pedosedimentary sequence in the Srednaya Akhtuba section.

Pedogenetic Levels 2, 3 and 4 (see numbers along the left side of Fig. 2) corresponded to MIS3 and included paleosols formed within alternating layers of loess, marine clays and fluvial deposits, which were accumulated during Atel-Ahtuba regression of the Caspian Sea.

Pedogenetic Level 2 was characterized by the most developed paleosol, which was formed in loess and buried under Chocolate clays. This paleosol had clear features of arid pedogenesis, i.e., there were humus-rich peds in a partly eroded [A] horizon, a well-developed porosity in the [AB] horizon and high concentrations of soluble salts, gypsum, and carbonates in the [BC] horizons (Relictigleyic Luvic Chernozem). This paleosol also contained frost wedges and involutions as well as ooid-shaped peds, therefore, paleoenvironment was not only arid but also cold at that time.

Levels 3 and 4 had the least developed pedogenic features due to very cold paleoenvironmental conditions and very short periods of sub-aerial pedogenesis. A high salinity throughout Level 3 could be attributed to the diagenetic process of salt leaching from the above-lying Chocolate clays.

Pedogenetic Levels 5, 6 (MIS5a-d) and Level 7 (MIS5e (Fig. 2)) included paleosols formed in loess, which were accumulated during the multi-phased Late Khazar-Girkan transgression of the Caspian Sea.

Pedogenetic Level 5 was characterized by synsedimentary pedogenic features: accretionary humus horizon, krotovins, Fe-clay aggregation with diagenetic needle carbonates and frost wedges starting in Atel loess (MIS4).

Pedogenetic Level 6 – pedocomplex – lower horizon Bk of the upper soil merges with the horizon Ah of soil, which has vertic features. They may be the result of the presence of smectite that was swelling and shrinking due to the seasonal moistening-desiccation.

Paleosol of Level 7 was distinguished by contrasting features: numerous ferruginous nodules and thin clay coatings. The presence of clay eluviation and gleization features could be interpreted as an indication of the existence of broad-leaved forests at the bottom and slopes of the valley in the past.

It was established that all paleosols of MIS5 underwent significant leaching of soluble salts, which was probably connected with desalinizing effects of glacier meltwaters as well as humid climate. All paleosols of MIS 5 had characteristic epigenetic frost wedges.

Acknowledgments

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SOIL CHRONOSEQUENCES AS A PROXY FOR LATE HOLOCENE CLIMATIC CYCLES IN THE SOUTHERN FOREST AREAS OF THE RUSSIAN PLAIN ADJOINING THE CORRIDOR

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Keywords: buried soil, geoarchaeology, landscape reconstruction.

Introduction

The Russian Plain in the second half of the Holocene is an area of considerable rhythmic climate variations with alternating colder and warmer, more arid and more humid stages (Demkin, 1997; Aleksandrovskiy and Aleksandrovskaya, 2005; Chendev et al., 2017; Khokhlova et al., 2018; Rusakov et al., 2019). Climatic rhythms entailed the transformation of the whole complex of landscape parameters, including soils. During the Late Holocene the Russian plain seems to be an arena of complex interactions of different civilizations bordering Caspian – Black Sea – Mediterranean Corridor from the North. Indo-Iranian tribes occupied the territory in the northern Black and Azov sea areas within the Dnepr and Don River basins, penetrating deep to the north-east reaching the southern border of the forest zone (e.g., Middle Volga basin, Chuvashia Republic, Mihailov et al., 2014). Ethnic shifts were largely determined by the climatic rhythms recorded in the buried soils of archaeological sites, especially burial mounds of the Bronze Age and fortification ramparts of the Early Iron Age.

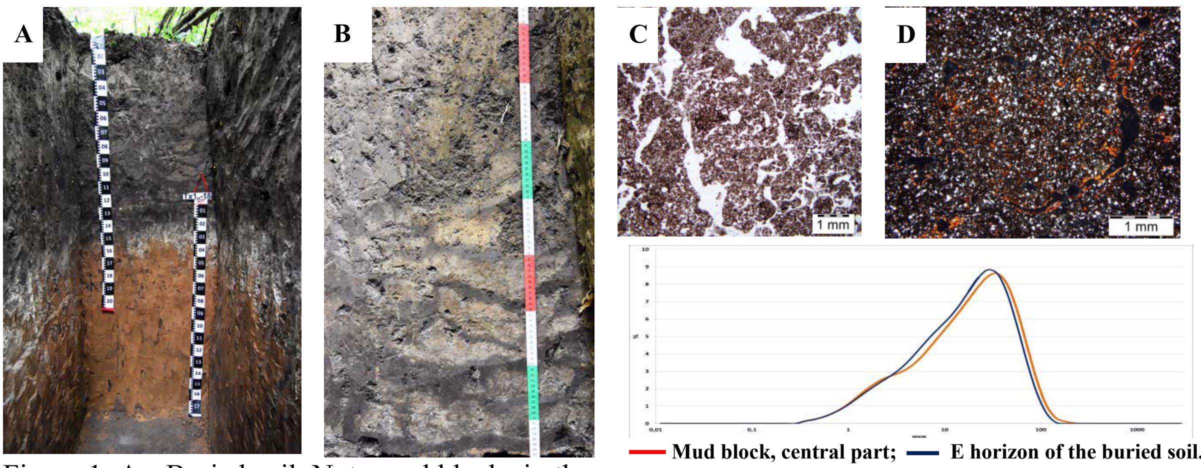

Figure 1. A - Buried soil. Note mud blocks in the construction of the earth mound; B. mud blocks; C – microstructure of the material from the central part of the mud block is typical for E horizons of Retisols; D – microstructure of the cover layer of mud blocks. Note the signs of kneading of material (disrupted clay cutans, rotational structure and grains of fluvial sand added to the material

of Bt horizons); E - grain size pattern of material from the central part of the mud block, laser diffraction method. Note the similarity with grain size pattern of E horizon of the buried soil

Methodology

The present study is focused on archaeological monuments of the Middle Bronze Age (Abashevo culture) at the southern border of the forest zone. Landscape evolution was studied based on detailed morphological, analytical and microbiomorphic research of the soil chronosequence that included surface soils and soils buried under burial mounds of Tokhmeyevo kurgan cemetery, Chuvashia Republic, Mihailov, et al., 2014).

Results

Both buried and surface soils are formed on similar surfaces in similar loess parent material at the same elevation under the broadleaf forest. Radiocarbon dating of the humid acids of the upper humus horizon of the buried soil (4861±55 BP, SPB 2996) confirmed that paleosol was buried not earlier than the beginning of the Subboreal period. Both buried and surface soils meet the criteria for Glossic, Folic, Albic, Dystric Retisol and show similar morphology and key analytical features (Fig. 1a, 2a, b, c, d). The burial mound is composed of mud blocks with central parts made of material of the E horizons and covered by the material of Bt horizons enriched in fluvial sand grains (Fig. 1b, c, d, e). The use of these materials in the burial mound construction is an independent proof of the presence of E and Bt horizons in the soil of the Bronze Age. In the pollen spectra of the surface and the buried soils from 4 burial mounds, arboreal pollen is dominant. In the surface soil, trees account for 80% of the total spectrum, while in the buried soil they vary between 51-64% with the share of grasses varying between 15 – 21%. The proportion of pollen of conifers and deciduous trees is equal (ca 50/50%) in the pollen spectrum of both the surface and the buried soils. Pollen of broadleaf trees (oak, lime) and also Corylus, a typical shrub in broadleaf forests, is present also in both soils. Phytolith spectra show that both buried and surface soils formed under broadleaf forest vegetation. Forest and meadow grasses are dominant in the buried soil while the share of steppe grasses increase in the surface soil (Fig. 2e, f). The presence of black humus cutans on top of the brown clay cutans in the Bt horizons of the buried soils also correlates with more wet soil moisture regime (Fig. 2g, h). Bt horizons of the surface soils have only brown clay cutans.

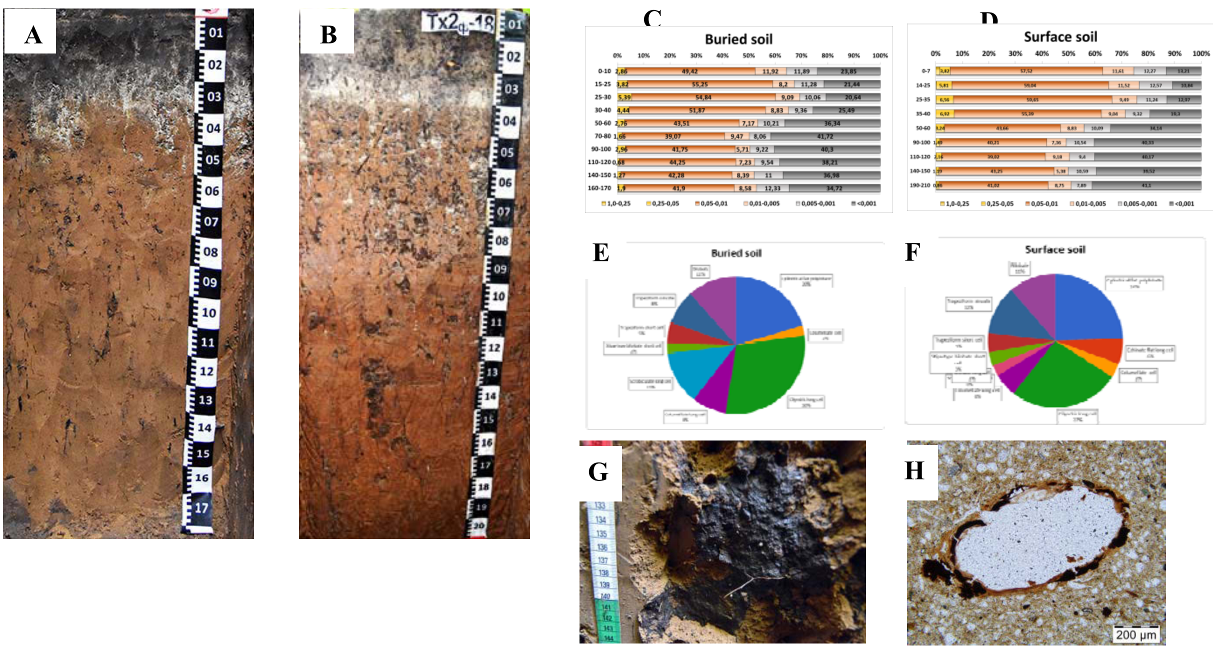

Figure 2. A – buried soil; B – surface soil. Note the similarity of profile composition; C, D – grain size distribution in the buried and surface (D) soils; E, F – phytolith spectrum of the upper horizons of the buried (E) and surface (D) soils; G – black humus cutan in Bt horizon of the buried soil; H – black humus cutan on top of the brown clay cutan in the buried soil, PPL.

Conclusions

Similar properties of buried and surface soils indicate close similarity of the landscapes in the study area that existed from the beginning of the Subboreal period to nowadays. Microbiomorphic assemblages show that both buried and surface soils formed under forest vegetation. The pollen of oak and lime, preserved in the buried soil in quantities similar to the surface soil, reliably indicate the wide occurrence of broadleaf species in the past. Pollen spectra indicate broader participation of grass species during the Bronze Age. Phytolith spectrum shows a bit more humid climate during the Bronze Age comparing to nowadays. Landscape stability in the studied area during Late Holocene is also supported by earlier published data on soil chronosequence in Sareevo Settlement (Early Iron Age) that are formed in similar environment of the broadleaved forest, in the same parent material (mantle loams) and close to Tokhmeyevo kurgan cemetery (Makeev et al., 2019). The present study of the soil chronosequence is also complemented by the previous study of Taushkasy kurgan cemetery of the Bronze Age (Abashevo culture) where the surface and buried soils are formed in the derivatives of the Permian sandstones (Folic Eutric Cambisols, Aseyeva, et al., 2019). Soils of the three archaeological monuments could be combined in one chronosequence that includes soils of the Early Iron Age and the Bronze Age formed in parent rocks that differ in their response to environmental impact (different features of soil memory, Targulian, and Goryachkin, 2008). Such compound chronosequence displays the stability of forest environment at the southern boundary of the forest belt from the Bronze Age to the present. Based on this conclusion it is possible to establish the northern limit of the wide belt, which stretches out from the dry steppe to the northern forest-steppe, where landscape shifts influenced by the Late Holocene climatic cycles resulted in a combination of polygenetic features of forest and steppe pedogenesis in the surface soils. Forest environment existed at the southern fringe of the forest zone at least since the beginning of Subboreal time. Numerous archaeological monuments remained in the steppe, forest-steppe and forest areas of the Russian Plain make it possible to link critical points of soil evolution with the migration pattern of ancient tribes. Fortification walls of the Early Iron Age and burial mounds of the Bronze Age are not only indicators of landscape dynamics, but also the unique cultural heritage of the East European Plain.

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NEW DATA ON THE STRUCTURE, COMPOSITION AND GEOCHRONOLOGY CISCAUCASIA UPPER PLEISTOCENE AND HOLOCENE LOESS

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Introduction

Loess-paleosol sequence (LPS) are the main source of information for the Pleistocene and Holocene paleogeography reconstruction in the southern part of the East European Plain. The most complete and thick LPS of Europe (until 130-140 m (Trofimov, 2001)) are in Ciscaucasia. Despite the long history of studying the Ciscaucasusian LPS, there is still no explanation of the nature of their high thickness. The source of the loess material and the main directions of eolian transport for separate stages of quaternary period are also not defined (Balaev, Tsarev, 1964; Fedorovich, 1960; Rozycki, 1991; Sazhin et al., 2012; Sazhin et al., 2013). In many ways, these problems are associated with the lack of correct and common chronostratigraphic scheme of Ciscaucasusian LPS. The fact do not let the reliable correlation between different boreholes. Also it was impossible to correlate local stratigraphic sequence with global paleoclimatic scale.

In the present work, authors apply the loess-soil scheme, published by research fellows under guidance of A.A. Velichko (2015) for the Late Quaternary LPS of the entire Ciscaucasia region as a whole. According to this scheme, LPS on uplands have stratigraphic continuity, and paleosols have stable properties. This makes it possible to recognize paleosols in sections and wells by a set of individual morphological features. Using the pedostratigraphic scheme of A.A. Velichko (2015), OSL-dating and complex of lithological analyzes, we created a valid sublatitudinal section of the Upper Pleistocene LPS of the Ciscaucasus (from the Azov Sea to the Terek-Kuma Plain). An analysis of the variability of thickness and composition of synchronous horizons along the sub-latitudinal LPS section made it possible to determine the sources of loess material and reconstruct the main directions of aeolian transport in the Ciscaucasia in the late Pleistocene and Holocene.

Methods

Field work was carried out in 2015–2018 as part of expeditions of the Laboratory of evolutionary geography of the Institute of Geography of the Russian Academy of Sciences (Moscow). The boreholes revealed the structure of the loess cover in four key sites along the line from the coast of the Sea of Azov to the right bank of the of the Kuma river: 1) Chumbur – Kosa (section CH-K: Habs = 40 m, Azov-Kuban lowland); 2) Yasinskaya (well YS-1, Habs = 18 m, Azov-Kuban lowland); 3) Sladkaya Balka (well SB-1: Habs = 154 m, western macroslope of the Stavropol Upland); 4) Otkaznoe (well OT: Terek-Kuma plain, Habs = 234 m). In order to obtain the most preserved loess paleo-archives, the boreholes were located at near-horizontal flat interfluves, unimpaired by modern and relict erosion. This approach was aimed at minimizing the effect of erosion and / or slope redeposition of the material.

411 samples were subjected to a complex of lithological analysis, in particular, granulometric analysis, magnetic susceptibility, organic and carbonate content. OSL-dating was performed at A.P. Karpinsky Russian Geological Research Institute.

Results and discussion

We found out a decrease in the thickness of the Upper Pleistocene and Holocene loess and particle size of the sediments from SE to NW. So the total thickness of deposits of the Upper Pleistocene and Holocene in the OT section is 22.4 m, SB-1 - 9.7 m, YS-1 - 5.3 m, CH-K - 4.8 m. Moreover, the thickness does not decrease linearly, the rate of decline decreases in the northwest with the distance from the OT site. In the same direction the average content of the sand fraction decreases: OT - 23%, SB-1 - 13%, YS-1 - 6%, CH-K - 5%. The part of the pelitic fraction is relatively constant from SE to NW. On the contrary, the average silt content increases in this direction: OT - 59%, PM-1 - 71%, SB-1 - 72%, YS-1 - 78%, CH-K - 79%.

In Illinois (USA) similar patterns showing the relationship between the thickness and mechanical composition of loess from the remoteness of the source were first identified (Smith, 1942). A number of North American loess researchers (Mason, 2001; Muhs et al., 2003; Bettis et al., 2003; Lewis et al., 1975) used this approach to reconstruct atmospheric circulation. The validity of this approach has also been shown for the Chinese Loess Plateau (Porter, 2001; Liu, 1985) and Western Europe loesses of (Rousseau et al., 2014; Rozycki, 1991).

The results indicate that deserts of the Caspian lowland and possibly Central Asia were the source of loess material. The main direction of the aeolian transport during Late Pleistocene and Holocene were from east to west. Similar conclusions were previously reached by L.G. Balaev (1964) and B.A. Fedorovich (1991). They relied on the spatial distribution of heavy minerals in loess (Balaev, Tsarev, 1964), as well as on observations of modern aeolian processes (Fedorovic, 1960) in the deserts of Central Asia and in the Ciscaucasia.

Modern data from weather stations in the central and eastern Ciscaucasia show the prevalence of eastern winds in the winter season, and western winds in the summer. As shown by A.N. Sazhin et al. (2012, 2013), “the strongest winds in the region are observed at the end of winter and in the early spring, when the east wind speed reaches a storm and hurricane force (29–34 m / s and more)” (2012, p.12).

At present, remote methods for tracking the trajectories of aerosol flows are being actively developed. Thus, ice cores from Elbrus contain layers of dust. An average size of dust is about 5–10 μm (Kutuzov et al., 2013). Based on the analysis of spectrozonal satellite images, the authors were able to establish the exact time and location of the dust storms that were the source of the material (Northern Sahara and Northern Mesopotamia), as well as the trajectory of dust transfer. This example shows that dust can also come to the North Caucasus region from very distant sources from the west and southwest. However, the mechanical composition of the loesses of the Ciscaucasia (with a significant predominance of particles larger than 10 μm) indicates that the eastern component dominated the sediment balance during the Late Pleistocene and Holocene, bringing silt-sand material from the deserts of the Caspian lowland.

Difference in loess and soils thickness and composition allowed to reveal the intensity of aeolian processes for cold and warm stages. The intensity was higher during cold stages and lower during warm stages. Thus, horizons of relatively thickness loess correspond to cold stages, in which, as a rule, the sand content is increased. Warm stages correspond to less thickness soil levels in which the proportion of sand is reduced. Moreover, these differences between soils and loesses are growing from west to east, which characterizes the situation of sedimentation in the east of the region as a less stable. At the same time, this shows a higher paleoclimatic information content of loess-soil archives in the east of the Ciscaucasia.

The increase in the intensity of aeolian processes in cold stages was probably caused by a general aridization of the climate, as well as a decrease in the role of westerlies with an increase in the activity of the Siberian High, which provides stable and strong east winds. An increase in the rate of loess accumulation in some stages could also be associated with regressions of the Caspian level, when huge areas of the former seabed with loess substrate became exposed and easily deflated.

The sand content in the core of OT indicates the influence of the transgressive-regressive cycles of the Caspian Sea on the balance of loess accumulation in Ciscaucasia. The climate of the ancient marine basins influenced this area, located less than 100 km from the Caspian lowland. The particle size distribution diagram shows smooth, wavy changes in the sand content, reflecting some repetitive phenomena. At the same time, we consider no such features in the other areas.

Conclusion

The deserts of the Caspian lowland and possibly Central Asia were the source of loess material. The main direction of the aeolian transport during Late Pleistocene and Holocene in Ciscaucasia were from east to west.

There are differences in the intensity of aeolian processes for cold and warm stages. The intensity was higher during cold stages and lower during warm stages.

The loess paleo-archives located in the east of Ciscaucasia have higher temporal resolution and more responsive paleoclimatic indicators than the western ones. They show regional climate changes better.

In the west of Ciscaucasia the sedimentation conditions were more constant throughout the Late Pleistocene and Holocene than in the east of the region.

Acknowledgements

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PALEOGEOGRAPHICAL MAPPING OF THE CASPIAN SEA LATE QUATERNARY BASINS

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Keywords: cartography, morphometry, paleogeography, digital elevation model, Caspian sea

Introduction

The Caspian Sea coasts are one of the most developed economically and recreationally. The coast and shelf are of great interest for oil and gas exploration, as well as the ways of their transportation. Therefore, the Caspian region attracts increased attention of researchers, including its paleogeography (Badyukova et al., 1996). The observed global climate changes in the current century have determined an increase in interest in predicting the stability of sea coasts (Kislov, 2011). Information about extreme processes on the coast, as a rule, does not go beyond the period of instrumental observations, which are limited to the last century. The expansion of such data is of great interest not only for increasing the reliability of the forecast of extreme processes risk, but also for identifying features of the violation of the slow, evolutionary development of coastal systems. Assessing and forecasting the possible negative consequences of fluctuations in the level of the Caspian Sea requires the creation of a series of maps.

Methodology

The cartographic method was used in this study to assess the area of distribution of various stages of evolution of the ancient basins of the Caspian Sea (starting from 150 thousand years ago), as well as to assess possible threats to the economy and infrastructure of the coast. The aim of this work is to create a local geographic information system and study, within its framework, the dynamics of the level of the Caspian Sea for different stages of large transgressions (sea level rise) over the past 120 thousand years.

As part of the study, we considered the largest transgressions of the Caspian Sea over the past 120 thousand years (Late Neopleistocene). Currently, the following major transgressive stages in the history of the Caspian are universally recognized in the literature: the Novocaspian, Khvalynian and Late Khazarian. Within each transgression, terrace levels in meters of absolute height from (Rychagov, 1994, 1997; Svitoch, 2007) corresponding to them for the Caspian Sea were determined.

As a source for constructing the bathymetric model (Fig.1) of the Caspian Sea for the current level position, publicly available information on the position of isobaths of 50, 100, 200, 500 and 1000 m was used according to small-scale physical and geographical maps available in the public domain.

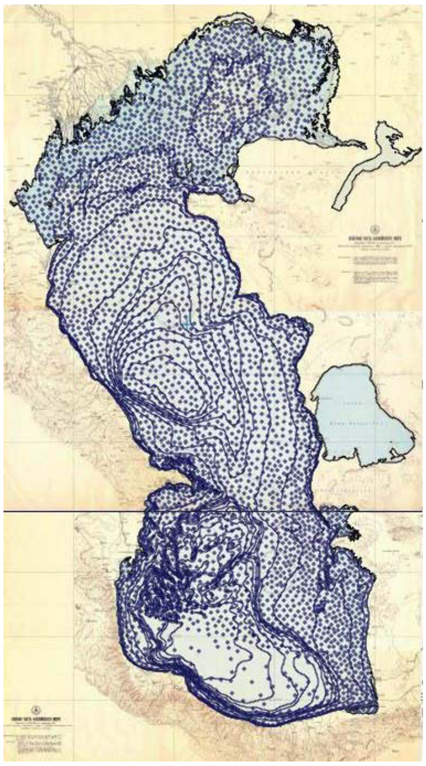

Figure 1. Points used for constructing the bathymetric model

As the main source of mapping the position of the coastal line of the Caspian Sea, depending on the corresponding level of the sea-level during different periods of transgressions, we used a digital terrain model SRTM-90 with a spatial resolution of 90 meters per pixel. For the most correct construction of the corresponding altitude levels (Caspian sea shorelines), the heights of the digital elevation model SRTM-90 were reduced to the 1942 Pulkovo coordinate system. When calculating the metric parameters of the Caspian Sea, this model was assumed to be constant over time.

Results

In order to systematize the used materials and the results of the study, as well as for visualization of the Caspian sea evolution we created a Web-GIS portal on the existing ScanEx Web Geo-Mixer platform.

Currently, the following thematic data blocks are integrated into the Web-GIS portal. (1) Data from a digital elevation model of the study region and derived characteristics based on it (slope steepness, slope exposure, black-and-white washing). (2) Data on the position of the present coastline of the Caspian Sea and position of the coastline for various stages of transgressions (Fig. 2). (3) Cartographic materials illustrating the bathymetry of the modern Caspian (including marine navigational maps of 1: 750000 and 1: 200000 scales) and vector isobath cartographic layers based on data from cartographic materials. (4) Paleogeographic maps with position of the reconstructed coastlines of the Caspian Sea during periods of major transgressions.

Figure 2. Position of the coastline for various stages of transgressions during Late Quaternary

The Web-GIS (Fig. 3) is available using the link:

maps.kosmosnimki.ru/api/index.html?CE3B9FAC613D42908B46280A577F6A28.

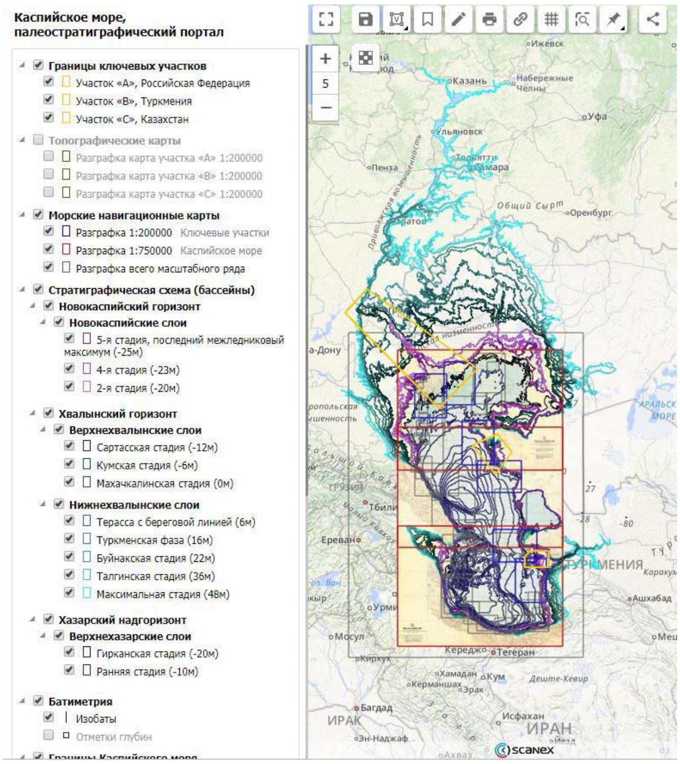

Figure 3. Interface of the created Web-GIS portal

Conclusions

We performed calculation of the main parameters of the main stages of the Caspian Sea level evolution during the last 120 thousand years. The calculated characteristics of the area, coastline and water volume are the basis for understanding the paleogeographic characteristics of the basins and analyzing the evolution of the natural environment of the region during Late Quaternary. The developed database is an effective tool for visualizing the history of the Caspian Sea and for analyzing the patterns of level fluctuations. The performed work shows the importance of the cartographic method in the analysis of the Caspian Sea level fluctuations, as well as in predicting further fluctuations in the level and assessing their consequences.

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EVIDENCE OF THE HOLOCENE VOLCANIC ERUPTIONS IN A CASPIAN DEEP-SEA SEDIMENT CORE

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Keywords: volcanic eruption, climate change, sediment, tephrochronology, Cryptotephra

Volcanic eruptions are major drivers of environmental and societal changes (Büntgen et al., 2016; Jones et al., 2007; Sigl et al., 2015; Timmreck, 2012). Eruptions are both terrifying and awe-inspiring, and in cultures exposed to them, they frequently feature in cosmologies, mythologies and world views (Barber, Barber, 2012; Cashman, Cronin, 2008; Karakhanian et al., 2002). There is increasing evidence too that volcanic eruptions impacted on distal areas through their capacity to alter short-term weather patterns (Büntgen et al., 2016; Jones et al., 2007; Sigl et al., 2015; Timmreck, 2012). They have also been implicated in centennial-long events when a series of climatically-effective eruptions occurred in close succession (Büntgen et al., 2016; Barber, Barber, 2012) that triggered societal effects on regional to global scales (Miller et al., 2012). Complementing the partial historical records of past volcanism of recent centuries and extending into deeper time, tephra (volcanic ash) records are critical for understanding past volcanic eruptions, in particular, their timing, frequency and environmental impacts (Swindles et al., 2013). In West Asia and Caucasia intraplate volcanism has led to the formation of a number of stratovolcanoes, stretching from Mediterranean Sea to the Caspian Sea (Karakhanian et al., 2002). Large magnitude eruptions are not detected in the Holocene in this region (Brown et al., 2015; Karakhanian et al., 2002). However, according to latitudinal extension of the Caspian Sea and the dominance of westerlies over the region, it is plausible to be able to detect some of the main global eruptions in deep sediments of the Caspian Sea. For instance, Büntgen et al. (2016) cautiously linked a cluster of closely-timed large historical eruptions to global climate changes during the Late Holocene, which they deemed to have played a role in political transformation in West Asia in the Late Antique period (Kelley et al., 2015; Sharifi et al., 2015).

We have investigated the presence of cryptotephra in a short deep sea sediment core from southern Caspian Sea in order to explore the potential for tephrochronology in the region. To achieve our goal, we have treated sedimentologicaly a short core (138 cm) that was taken from the depth of 780m from the southern Caspian Sub-basin. The core was sub-sampled contiguously at 1 cm increments. For initial assessments, 1 cm^3 of the sub-samples was burned at 550°C and the remains were dissolved in dilute HCl to remove carbonates. Diluted NaOH was added to remove organic silica, and heavy density separation was used to separate remaining minerals (Rose et al., 1996). Increases in shard concentration and the recognition of unaltered shards were interpreted as ashfall to differentiate the shards from secondary deposition (Mackay et al., 2016). Optical petrology and geochemical analysis were implemented to determine the morphology and major element composition of the glass shards.

Although no visible tephras have been identified in the core but we have identified microscopic tephra that could be attributed to large distant eruptions as well as from regional systems.

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ANALYSING THE KIMEMATICS OF ACTIVE FAULTS ALONG THE NORTHERN FLANK OF CENTRAL ALBORZ, IRAN

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Key words: active faults, Khazar fault, North Alborz fault, Central Alborz, Caspian Sea, Iran

The active tectonics in Central Alborz is characterized by two thrusting fronts to the north and the south. The Northern Alborz defines an E-W trending fold and thrust zone, striking obliquely with respect to the Caspian Sea shoreline. To the West, the Caspian Sea abutes against the range while to the East, a 20-25 km width coastal plain separates the sea shoreline from the reliefs. Geologically, the Northern Alborz includes a large variety of Paleozoic-Mesozoic detritious-calcareous rock units that are all deformed by folding and faulting processes. Within the northern frontal part, the Mesozoic units are overthrusting the Neogene deposits covered by the coastal plain along the Khazar fault. The deep, South Caspian Sea is interpreted as a remnant of a Mesozoic marginal sea that included the Black Sea to the west as well as the Caspian Sea in the east, (Zonenshain & Le Pichon, 1986). These two remnant "seas" were separated in the Pliocene times (about 3.5 Ma ago) when collision between the Arabian and Eurasian continental plates built the Caucasus and Talesh Mountains. This simplified tectonic background shows that the Caspian Sea and the surrounding mountains are parts of the Alps-Himalaya Orogenic Belt delineating the suture of the Mesozoic Tethys Ocean (e.g. Dercourt et al. 1986). The South Caspian Basin is now bounded by the active E-W Central Alborz Mountain Range in the south and the N-S Talesh Mountains on its southwest side. Along the northern Central Alborz, the 450 km long Khazar (Caspian) Thrust (Berberian & Yeats, 1999; Ghassemi, 2005; Nazari et al., 2005) places Mesozoic and Paleogene rocks on the > 20 km thick Neogene and Quaternary deposits of the South-Caspian Basin (Brunet et al., 2003).In this paper, we study the geometry and the kinematics of the active faulting along the Khazar and North Alborz faults, by means of a morphotectonics analysis e.g. surface and sub-surface observations in the South Caspian in its onshore and offshore. Our study allows us to present an updated seismotectonic setting for the north Central Alborz-South Caspian Basin region, and provides a basis for seismic hazard assessment for this highly populated region. It also allows discussing the question of the geodynamical evolution of the Northern Iran-Southern Caspian Basin during the Quaternary.

THE SPATIO-TEMPORAL CHARACTERISTICS OF DANGEROUS GEOLOGICAL PROCESSES IN THE COASTAL ZONE OF THE NORTHWESTERN BLACK SEA (UKRAINE)

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Keywords: Black Sea, coastal zone, abrasion-landslide processes

Introduction

The northwestern coast of the Black Sea is a complex geodynamic system and is characterized by a wide range of dangerous geological processes (abrasion, landslides, erosion, flooding, etc.). The development of these processes has a naturally random character in space and in time (Smirnov, 1975, Krumbein et al, 1965). The purpose of this work is to identify features of the spatial and temporal development of abrasion-landslide processes on the northwestern coast of the Black Sea.

Methodology

The factual material on the study of exogenous geological processes on the shores of seas and oceans is summarized in the following works: Drannikov 1940; Aksentev I960; Longinov 1963; Yemelyanova 1972, Safranov et al 2017. Spatial and temporal study of the dynamics of abrasion-landslide processes in the coastal zone of the northern Black Sea region are represented in the following works: Rozovskiy et al 1987; Zelinskiy et al 1993, Dragomyretska et al 2017. The development of prediction methods of dangerous processes of the northern Black Sea region and the improvement of coast stabilization methods are considered as an urgent task (Konikov et al 2003; Cherkez et al 2013). The following research methods and techniques were used: the analysis of long-term field observations at a number of sites between 1976 and 2012; (database of the Odessa National University and geological organization "PrichernomorSRGO", Odessa, Ukraine; the method of mathematical statistics (spectral analysis).

As indicators of abrasion-landslide activity, we used: the linear retreat edge and bottom (m/year) of the slope; the volume of sea-worn rocks (m^3/linear meters per year);); and landslide deformation area (m^2 / linear meters per year). The study and analysis of abrasion-landslide processes were carried out according to the methodology of Sheko et al, 1984.

Results

The total length of the northwestern Black Sea shoreline (between the delta of Danube river and city Ochakov) is approximately 300 km. On the shoreline, there are accumulative, abrasion-debris, and abrasion-landslide types of coast. The spatial development and intensity of abrasion-landslide processes are shown on the map-chart of the distribution and activity of abrasion-landslide processes (Fig.1). The engineering-geological zoning of the coastal zone (Rozovsky 1972) is also presented in Fig. 1.

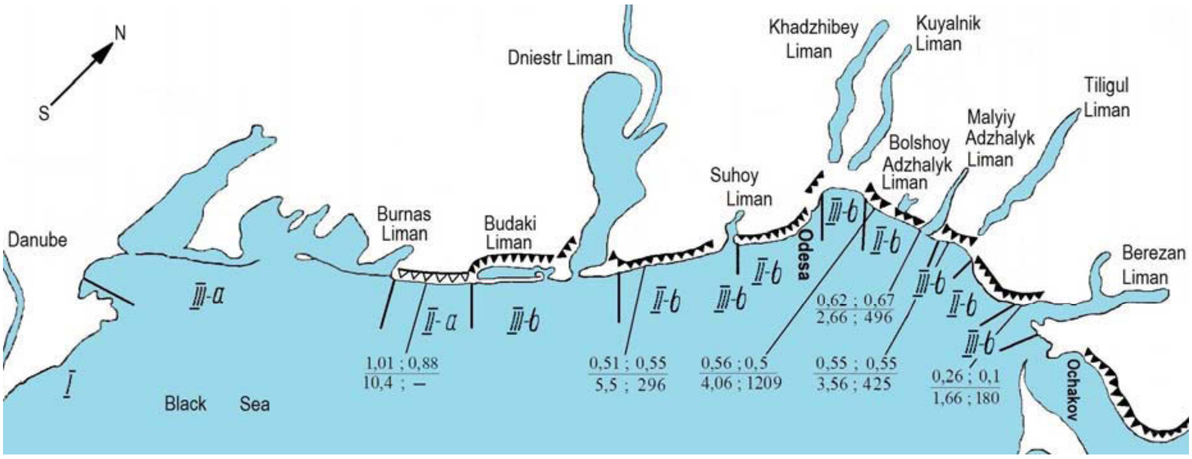

Figure 1. Map-chart of the distribution and activity of abrasion-landslide processes
I - Danube Delta. Abrasion coasts: II-a - sub-area of abrasion-debris coasts; II-b - sub-area of abrasion-landslide shores. Accumulative coasts: III-a - the accumulative sub-area that developed on the low ingression parts of the coast; III-b - the accumulative sub-area that developed on the high ingression parts of the coast.

Abrasion-landslide indicators $\frac{0{,}51;0{,}55}{5{,}5;296}$: the numerator is the retreat of the edge and bottom of the slope (measured in m / year); the denominator is the volume of sea-worn rocks of the slope (m^3 / linear m per year); and the average annual specific area of landslide deformations (m^2 / linear meter per year).

▼▼▼ abrasion- landslide coast; ▽▽▽ abrasion- debris coasts

The accumulative coasts are located in the southwest and represented by typical baymouth barriers (area I and subarea IIIa). The abrasion-debris types of coast are located between the Burnas and the Budaki limans (subarea IIa). They are composed of loess-like loam and have the greatest abrasion rates on the coastal slopes: more than 1m/year. The volume of washed-away rocks is more than 10 cubic meters per linear meter per year. The abrasion-landslide coast is located between the Suhoy and the Berezan limans (subarea IIb). Here, 62% of coasts are affected by abrasion and landsliding. About 100 landslides have been observed. The coast retreat rate is approximately 0.2-0.6 m/year.

There are four main types of rocks in the landslide slopes: Quaternary loess, Pontic limestone, Meotian clay and landslide accumulation of the previous three types. They have various levels of solidity and various deformation properties (Zelinskiy et al, 1993). The minimum rate of abrasion is can be found on the coastal slopes, where the limestone-shell rock is located at the base of the cliffs. The areas of massifs that separate from the plateau as a result of landslide activity are presented in figure 2. They vary from 100 to 43,000 thousand cubic meters per year in the most active years.

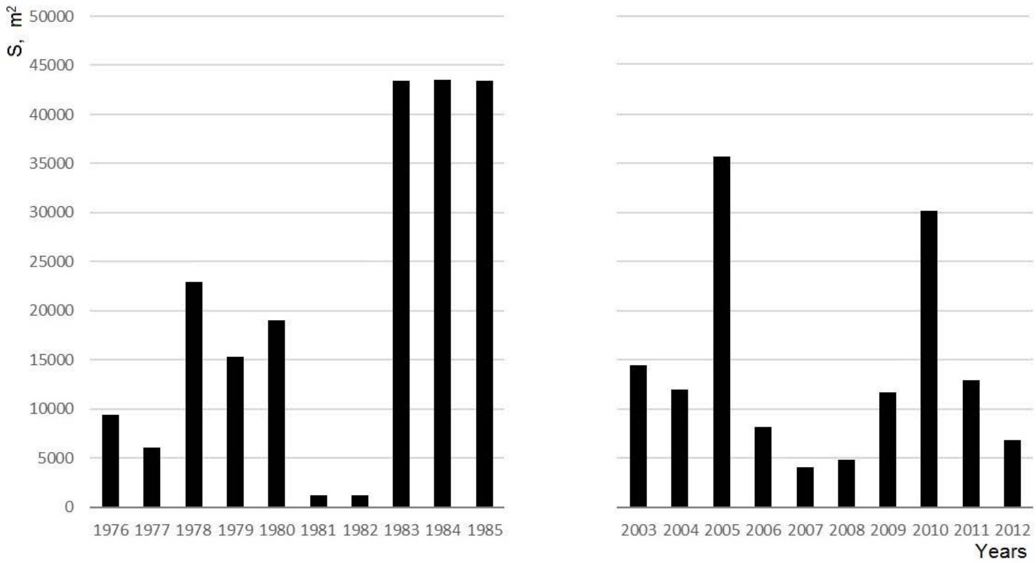

Figure 2. A diagram of landslide plateau deformations in the coastal zone of the northwestern Black Sea, during the observation periods 1976-1985, and 2003-2012

A spectral analysis of the variability of abrasion-landslide indicators over a long period of time confirmed the cyclical nature of the general process. The periods of abrasion-landslide activity processes have been determined to be to 9, 5-6 and 2-3 years, which are intervals associated with the periodicity of climatic and hydrological characteristics (Konikov et al 2003, Sheko A.I. 1984, Dragomyretska et al 2017).

Conclusions

The spatial-temporal analysis of abrasion-landslide indicators allows us to conclude that the coastal zone of the northwestern part of the Black Sea is highly dynamic. It can be argued that the relative increase in sea level (Konikov et al 2010), negative tectonic movements (Shmuratko 2001), and anthropogenic activity will lead to the activation of these processes. This must be taken into account during the economic development of the territory.

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PALEOGEOGRAPHIC RECONSTRUCTION OF THE LATE MIOCENE PRODUCTIVE HORIZONS IN THE WESTERN-KUBAN DEPRESSION OF THE WESTERN CISCAUCASIA

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Keywords: paleogeographic reconstruction, sedimentation, lithological, stratigraphic, paleontological, geochemical

Introduction

Western Ciscaucasia throughout the Upper Miocene was covered with East Paratethys waters, then in of the Pliocene was a part of the Euxine-Caspian basin. The sea level drop at the Late Sarmatian - Maeotian transition was estimated about 300 m. Unconformities between the freshened or saline upper Sarmatian and semimarine early Maeotian deposits are very common, suggesting drying up of large areas. Maximum of the transgression took part in second part of the early Maeotian (Nevesskaya et al., 1986), when the basin system East Paratethys extended from the northern margin of the Moesian Plate to south Mangyshlak in the east. In this regressive-transgressive period in the Western-Kuban depression bending formed productive horizons on oil and gaz. Sedimentation passed stage-by-stage with alternation oflayers of sandstones and clays in regressive-transgressive periods.

Results

The early Maeotian basin was inhabited by mainly endemic species and subspecies of euryhaline Mediterranean genera, which evolved in gulfs and lagoons of the late Tortonian - early Messinian sea. Salinity of the early Maeotian sea was estimated to be 13-14‰, up to 17-18 ‰. Later this impoverished fauna and microflora of marine origin became extinct and the late Maeotian basin was inhabited by brackish associations mollusks with *Congeria, Theodoxus, Pseudoamnicola*, *Turricaspia*, brackish and freshwater diatoms, and dinocysts. However, ephemeral marine ingressions took place during the entire Maeotian, as evidenced by presence of layers with more diverse marine fauna and microflora in the upper part of the lower Maeotian. In Western Ciscaucasia ilimits of distribution of the Meotian sedimentations the next association foraminifers: *Ammonia ex gr. beccarii* (Linne), *Neobulimina* ex gr. *elongata* (Orbigny), *Quinqueloculina consobrina* Orbigny, *Q. gracilis* Bogdanowich, *Q. undosa* Karrer, *Articulina tenella* (Eichwaldi.) *maeotica* Bogdanowich, *A. arcuata* Bogdanowich, *Hauerina subbotinae* Bogdanowich et Bud., *Dendritina porochini* Bogdanowich, *Elphidium fedorowi* Bogdanowich, *Quinqueloculina seminulum maeotica* Bogdanowich, and ets.

The early Pontian basin was strongly transgressed, especially on its northern and eastern margins. The Eastern Paratethys draft corresponds to maximum sea spreading in the early Pontian (Novorossian). The early Pontian basin was strongly transgressed, especially on its northern and eastern margins. Sandy deposition prevailed in its shallow coastal areas and muddy one in deeper environments. Calcareous, shelly-detrital facies were widely extended on the northern inner shelf of the Euxinian-Caspian Basin. Towards the

Caucasus, Kopet Dagh and western clastic sources the facies changed to muddy and sandy deposits. Deep water environments existed only in the Black Sea and South Caspian depressions. Based on the prevailingly brackish fauna, salinity of the basin was low, but didn't fall under 5-8‰. A sharp regression at the beginning of the late Pontian (Portaferrian) led to the drying of the northern outer shelf of the Euxinian Basin. The Stavropolian Strait was closed, the Caspian Basin was separated from the Euxinian one in northern part, and the eastern lake-sea became restricted to the recent Middle and South Caspian with the Kura gulf. The date of this sea level fall approximately correlates with the drastic sea level drop in the Mediterranean (Popov and al. 2010). According to biogeographic data, however, the Caspian-Euxinian connection was maintained during the entire Pontian: specific late Pontian species common in the Euxinian and Dacian basins are known from the Upper Pontian of Azerbaijan (Nevesskaya et al., 1986). The foraminifer complex in the Pontian sediments is poor: *Quinqueloculina* ex gr. *consobrina* (Orbigny), Q. ex gr. *seminulum* (Linne), *Elphidium* ex gr. *macellum* (Fishtell et Molli), *Cassidulina* sp., *Bolivina* sp., the predominant role is played by numerous ostracods and mollusks. The lower limit is established by the appearance of a large number of ostracods associated with a sharp desalination of the sea and a reduction in foraminifer species.

In Meotian time of the West-Kuban depression introduced thickness packs of sand-silt rocks (IV, V, VI, VII, VIII horizons of sandstones). The capacity of sediments in the axial zone of the West Kuban trough reach 200-300m, increasing in the northwestern part of the trough - up to 500-520 m, of which the total thickness of the Sands is more than 300m. On the Northern side of the thickness of sand-silt horizons are reduced and clay occupy a dominant position. On the formation and distribution of reservoir rocks in these sediments was strongly influenced by the distribution of paleomagnetic within which accumulated a powerful accumulative (bar) sand the body with high collection parameters. The Meotian deposits of the IV horizon are promising throughout the West-Kuban depression (oil and gaz) and the Timashev steps (only gas). The Pontian deposits are gas-bearing practically in all territory of the West-Kuban depression (II and III horizons of sandstones). In the sediments of the Pontian and Meotian the reservoirs oil and gas, were formed in conditions of shallow-coastal and avandelta. As a result of the diagenesis, traps were formed and migration oil and gas from the bottom up. Also, the tectonic faults were transporting gas from the oil source to the reservoirs.

The average organic matter (OM) content in Middle and Upper Miocene deposits is lower than in the Lower Miocene ones, but still higher than subclarke for clays and is 1.14% of the rock. The OM concentration varies in a very broad interval from 0.06 to 4.67% of the rock; the maximal concentrations are reported in the north and southwestern West-Kuban depression. In the beginning of the Pontic age, a freshened isolated basin existed in the territory of West Ciscaucasia. In the Euxinian basin, in its deepest water part, sandy clayey deposits continued to accumulate. In Cimmerian time, under the same sedimentation conditions, the basin continued to shoal. The upper parts of the Cimmerian and Kuyalnian stages correspond to the phase of complete filling of the trough with sediments, which led to the settling of continental conditions in the territory of West Ciscaucasia at the end of Pliocene epoch. The mean Corg content obtained from the borehole sections in Pliocene deposits varies from 0.1 to 1.81% of the rock and the average value for all rock types is no more than 0.73%.

Conclusions

The history of the paleogeographic development of the Western Ciscaucasia in the Pontian-Meotian time defined the whole nature of the formation of facies of precipitation, the accumulation of sand horizons, and their distribution pattern in the West Kuban depression. A paleogeographic map of the distribution of the productive horizons of the Upper Miocene (IV horizon of the Meotian and II and III horizons of the Pontian).

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THE LATE PLEISTOCENE AND HOLOCENE HISTORY OF THE CASPIAN FORESTS OF NORTHERN IRAN

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Keywords: climate change, Last Glacial Maximum, palynology, Quaternary, vegetation history

Palynological analysis and radiocarbon dating of a lake/peat profile from mid-elevation in the Alborz Mountains of northern Iran enabled us to reconstruct the vegetation history of the Caspian/Hyrcanian relict forests since 20,000 cal. yr BP. For the late pleniglacial time (19,750-16,750 cal. BP), the pollen record indicates the presence of sparse stands of *Fagus* (beech), *Quercus* (oak), and *Betula* (birch) associated with *Ulmus* (elm) and *Carpinus* (hornbeam) around the study site and a dry and cold environment at higher elevations. The period 16,750-14,500 cal. BP is characterized by the rise of oak and a strong decrease of beech, along with abundant non-arboreal pollen, particularly *Artemisia*, chenopods, Apiaceae and a continuous curve of *Eremurus*, indicating the prevalence of steppe (i.e. drier and colder) conditions. The period 14,500-12,950 cal. BP shows a substantial rise of oak, hornbeam, and elm pollen and the virtual disappearance of steppe elements, reflecting the Allerød interstadial phase. From 12,950-11,700 cal. BP, the radical decline of arboreal pollen types and pronounced peaks of pollen types attributable to steppe vegetation persuasively reflect the Younger Dryas cold episode. The early Holocene (11,700-8,500 cal. BP) shows increased values of oak, elm, and hornbeam, and a substantial decline of *Artemisia*, chenopods and Apiaceae. Since 8,500 cal yr BP, oak was replaced by beech and hornbeam implying the establishment of contemporary temperate climate and vegetation.

Introduction

The Alborz Mountains in northern Iran, directly south of the Caspian Sea, harbor a number of Arcto-Tertiary relict species, such as *Zelkova carpinifolia*, *Parrotia persica*, and *Pterocarya fraxinifolia*, and are regarded as one of the main Eurasian refugia for warm summer-green trees during Quaternary climate change (Zohary, 1973; Röhrig, 1991; Leroy & Arpe, 2007).

The Quaternary environmental history of northern Iran has been elucidated using different types of archives (e.g. Bobek, 1963; Kehl *et al*., 2005; Ramezani *et al*., 2008, 2016; Leroy *et al*., 2013), e.g. geomorphological studies indicating the advance of the Late-Pleistocene ice sheets at higher elevations in the Alborz ranges. The hitherto available palynological studies in northern Iran are either fragmentary, covering merely part of the late-Holocene, or provide a discontinuous picture of the Holocene vegetation history of the area.

Here we present the oldest terrestrial palaeoecological record for the entire Euxino-Hyrcanian phytogeographic Province (*sensu* Zohary, 1973) in southwestern Eurasia from a mid-elevation site in central Alborz ranges. Such sites are highly sensitive to late-Quaternary climate change in mountainous areas (Feurdean *et al*., 2012). The advance of the Late-Pleistocene ice sheets at higher elevations in the Alborz ranges (Bobek, 1963) must have profoundly pushed down the forest communities to lower-elevation refuges, thus making our site ideal for examining the impact of climatic deterioration of the Last Glacial Maximum (LGM) and Younger Dryas (YD) on forest dynamics. Our findings plainly demonstrate the biodiversity persistence, though with substantial alteration, of the Hyrcanian-type vegetation in the area during the full glacial.

Methodology

The investigated mire, Pay Hassal (PHL: 1314 m a.s.l.; 2-3 ha in area; N 36° 31′ 13″; E 51° 25′ 01″), is situated in a flat (slope <5%) area in the central Alborz Mountains, northern Iran (Fig. 1).

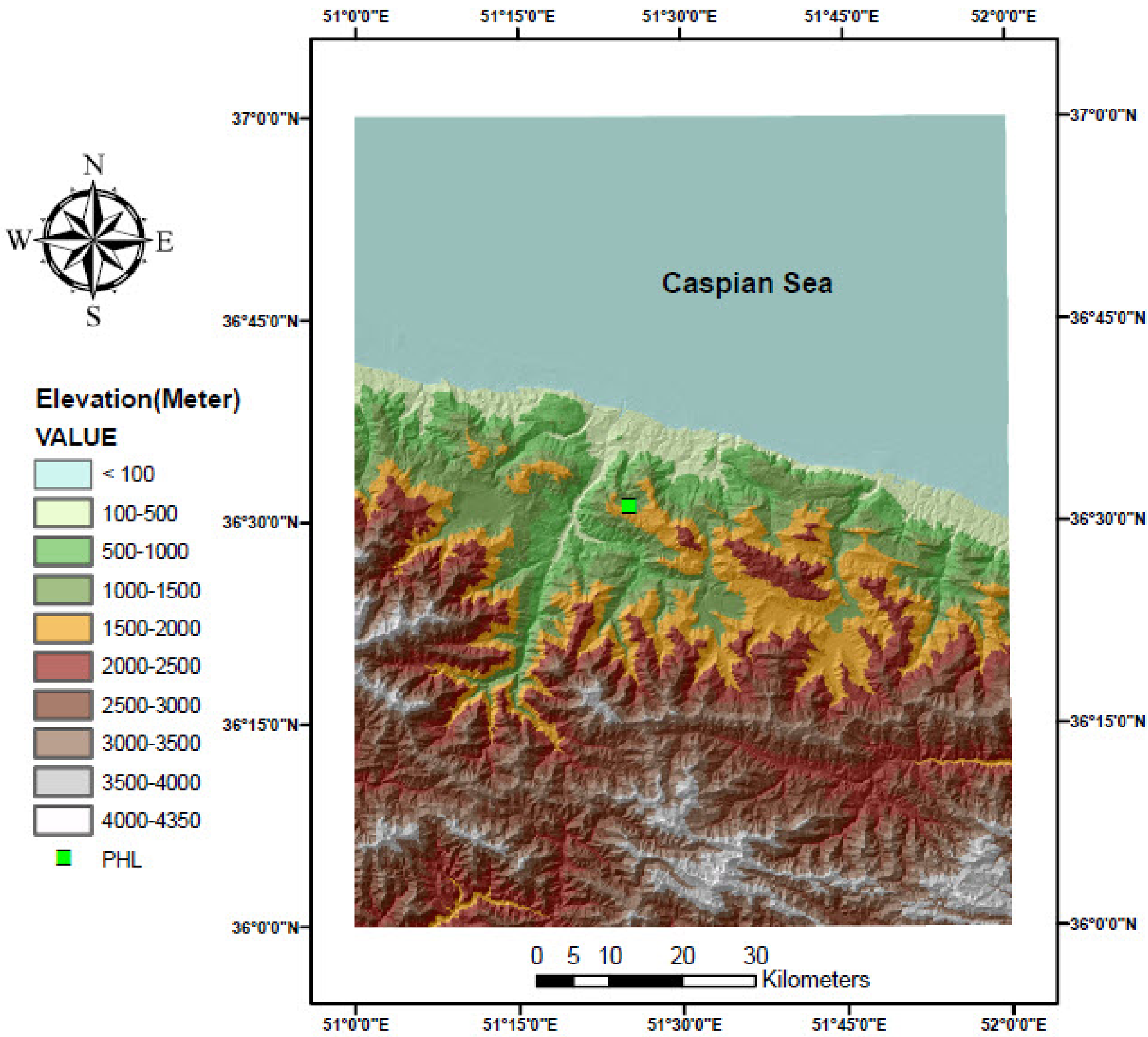

Figure 1. The position of the study site (PHL) in central northern Iran

A 12-meter lake/peat profile was retrieved from the PHL mire using a Russian type chamber corer. Volumetric pollen samples were prepared using standard technique (cf. Fægri and Iversen, 1989). For ^{14}C-AMS-dating, 15 samples of emergent plant macrofossils were selected (cf. Grosse-Brauckmann, 1986) and sent to Poznań Radiocarbon Laboratory in Poland. Radiocarbon ages were calibrated into calendar years BP with Bacon 2.2 package (Blaauw and Christeny, 2011) in R studio using the Northern Hemisphere terrestrial calibration curve IntCal13 (Reimer *et al*., 2013).

Results

Figure 2 shows an age-depth model for the investigated site. A simplified pollen diagram showing the selected arboreal (AP) and non-arboreal (NAP) pollen types is presented in Figure 3.

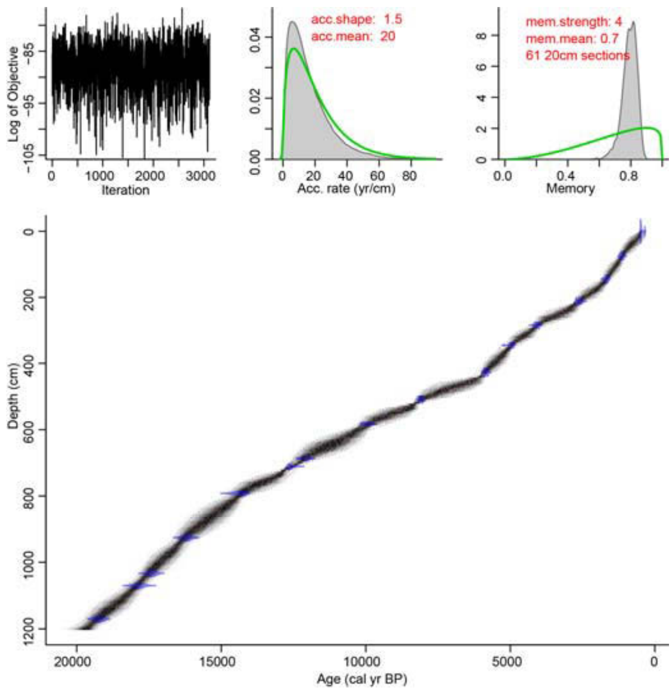

Figure 2. Age-depth model for the PHL sequence

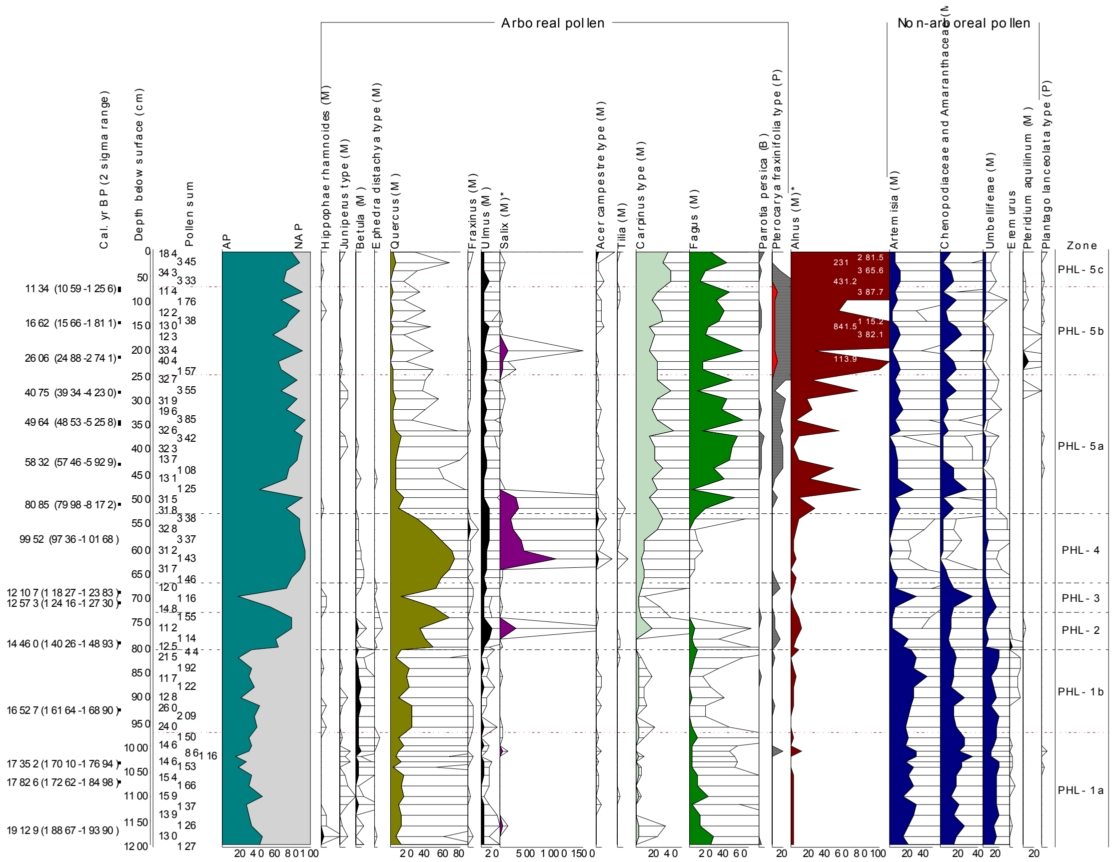

Figure 3. PHL upland (AP+NAP) pollen diagram

The interpreted vegetation and climate history of the studied site is presented in Table 2.

Table 2. PHL vegetation and climate history.

Pollen zone; Age (cal yr BP) and depth (cm)	Reconstructed vegetation	Inferred climate	Concurrent climatic events
PHL-5a 1100-present 70-0 cm	Predominance of *Fagus orientalis* and *Carpinus betulus* in regional vegetation; local development of *Alnus subcordata*; demise of *Pterocarya fraxinifoila* (*Pterocarya* decline).	Modern, episode of cold and dry	Mediaeval Climatic Anomaly-Little Ice Age
PHL-5b 3350-1100 250-70 cm	Predominance of *Fagus orientalis* and *Carpinus betulus* in regional vegetation; local development of *Alnus subcordata* and *Pterocarya fraxinifolia*.	Modern, episodes of warm and/or moist	
PHL-5c 8530-3350 530-250 cm	Predominance of *Fagus orientalis* and *Carpinus betulus* in regional vegetation; local development of *Alnus subcordata*.	Modern, episode of cold and dry	8.2 ka event?
PHL-4 11,720-8,530 670-530 cm	Disappearance of *Fagus orientalis* and maximum expansion of *Quercus* cf. *macranthera* stands associated with *Ulmus* spp., *Carpinus betulus* and/or *C. orientalis* at regional scale; local explosion of *Salix aegyptiaca*. The alpine treeline was ca. 1100 m lower than at present.	Relatively dry and cold (mean annual temperature: 5 ºC lower than present)	Early-Holocene relatively dry climate
PHL-3 12,950-11,720 730-670 cm	Maximum extension of steppe-like vegetation comprising mainly of *Artemisia* spp., Amaranthaceae, Apiaceae and *Ephedra* spp., disappearance of forest vegetation, in particular *Fagus orientalis* and *Carpinus betulus*.	Most pronounced dry period	Younger Dryas
PHL-2 14,480-12,950 802-730 cm	Expansion of *Quercus* cf. *macranthera*, *Ulmus* spp., *Carpinus betulus* and/or *C. orientalis* and *Fagus orientalis* at regional scale; local expansion of *Pterocarya fraxinifolia* and *Salix aegyptiaca*.	A period of relatively warm and moist climate	Bølling-Allerød
PHL-1b 16,750-14,480 970-802 cm	Open woodland of *Quercus* cf. *macranthera* associated with *Betula* cf. *pendula*, *Ulmus* spp., *Carpinus betulus* and/or *C. orientalis*, *Fraxinus excelsior* subsp. *coriariifolia* and *Acer* cf. *campestre*. Prevalence of steppe vegetation at higher elevations with the dominancy of *Artemisia* spp., Amaranthaceae, Apiaceae and *Eremurus* spp..	Dry and cold environment (harsher than the preceding period)	Oldest Dryas (Heinrich stadial 1)
PHL-1a 19,750-16,750 1200-970 cm	Sparse stands of *Fagus orientalis* and *Quercus* cf. *macranthera* associated with *Betula* cf. *pendula*, *Ulmus* spp., *Carpinus betulus* and/or *C. orientalis*, *Fraxinus excelsior* subsp. *coriariifolia* and *Acer* cf. *campestre*. Vegetation of higher elevation composed mainly of *Juniperus* spp., *Hippophaë rhamnoides*, *Artemisia* spp., Amaranthaceae, Apiaceae and *Eremurus* spp..	Dry and cold environment	LGM

Conclusions

Our data show extensive altitudinal shifts of vegetation zones in the central Hyrcanian forest over the past 20 ka. During the early Holocene (12,000-8,500 yr BP) and Allerød, a lowering of the timber line to an elevation of 1200-1300 m, and even deeper lowerings will have happened through YD and H1.

The late pleniglacial time in the area was characterized by a cold and dry climate and the predominance of steppe vegetation. However, due to the proximity of the Caspian Sea, the aridity was not as severe in the northern slopes of the Alborz range as in e.g. western and northwestern Iran or eastern Anatolia.

The maximum expansion of oak (*Quercus* cf. *macranthera*) forests in the mid-altitudes in central-northern Iran occurred during the early Holocene, and the modern climate and forest vegetation (comprising mainly of beech and hornbeam) appears to have established in the area since around 8,500 cal yr BP. Thus, forest succession in the mid-elevation of the Hyrcanian mountains was from an oak-elm dominated to a hornbeam-elm and ultimately a beech-hornbeam forest, which persisted until present times. Still, forest development was not straightforward and Holocene climate change, and, more recently, anthropogenic impact, have substantially influenced vegetation dynamics of these unique forests in western Asia.

The major places, where mesic trees survived the cold and arid climate of glacial periods in Western Asia, i.e. the Hyrcanian, Euxinian, and Colchian refugia (cf. Röhrig, 1991) appear to have experienced similar climatic and vegetation dynamics during the Late-Pleistocene and early Holocene.

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THE QUATERNARY MUD VOLCANISM IN AZERBAIJAN AS THE GEOLOGICAL PHENOMENON OF THE PONTO-CASPIAN REGION OF THE ALPINE-HIMALAYAN FOLDED BELT

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Keywords: Caspian Sea, Black Sea, Absheron peninsula, eruption, breccia

Introduction

Being the unique natural phenomenon, the mud volcanism takes an important place in geosciences. It makes the great contribution in study of the theoretical and practical issues related with geology, geochemistry, geophysics, etc. as well as when investigating the deep horizons and geochemical processes at the great depths.

The area of manifestation of the modern mud volcanism is vast enough. There is a clear regularity in their spatial distribution: generally, the described phenomenon is developed within the Alpine-Himalayan (Mediterranean) and Pacific folded belts. As a result, the mud volcanoes locates in countries like Italy, Romania, Ukraine, Georgia, Azerbaijan, Turkmenistan, Iran, Pakistan, Indonesia, Malaysia, etc. (Aliyev, 2008; Alastair, 1998). The newest investigations with application of the modern tools and techniques allow defining more new volcanoes, especially in those places that had not been considered earlier as the traditional zone of volcanoes' distribution (e.g. the Nile Delta) (Feseker, 2010).

The territory of the East Azerbaijan as well as the adjacent water area of the South Caspian are characterized by the most intensity of the mud volcanism. Here the occupied area reaches 60,000 km^2, within the area there are over 350 volcanoes, 156 of them are offshore ones. All they (including the territory of the SW Turkmenistan) are the elements of the South-Caspian oil-and-gas bearing basin (Aliyev, 2015).

Since ancient times the mud volcanoes of Azerbaijan were the objects of attention of travelers visited this area rich with oil and gas seepages. The 5th century Roman diplomat and Greek historian and rhetoriciam Priscus of Panium, the known Arab traveler, historian and geographer Al-Masudi (896 - 956), Arab traveler Abu Hamid al-Gharnati (1080-1170), Arab geographer Shams al-Din al-Dimashqi (1256-1327) and many others in their records described the specific features of the mud volcanic processes in the Caspian Sea. In a multi-volume series as "The meadows of Gold and Mines of Gems" Al-Masudi had described a wonderful eruption taken place in the Caspian Sea, in a group of volcanic islands of Baku archipelago (Aliyev, 2015).

Generally speaking, the study of mud volcanoes has slightly more than two-hundred-year history, although the first historical record about the fire column is dated 90 B.C. and describes the eruption of the mud volcano in the North Italy in "Naturalis Historia" by Roman naturalist and philosopher Pliny the Elder (Aliyev, 2015).

Mud volcanism in Azerbaijan

According to the recent investigations (Aliyev, 2015), just the eastern part of Azerbaijan and the adjacent water area of the Caspian Sea are "contain" the most number of mud volcanoes, different in activity and morphology. There are active / eruptive, dormant / sleeping, extinct, fossil / buried, submarine, island and oil-seeping volcanoes. According to morphology, they can be divided into cone-shaped, dome-shaped, ridge-like table-shaped. The relative height of onshore and offshore mud volcanoes varies in great ranges – 10 m to 400 m and more. Analysis of onshore and offshore mud volcanism in the South-Caspian depression had shown the identity of these types of volcanoes according to their genesis and manifestation (Aliyev, 2015).

In Azerbaijan the mud volcanoes locate within the south-eastern plunge of the Greater Caucasus and its foothills: in Absheron peninsula, Shamakhi-Gobustan region, Samur-Devechi lowland, south-east of Shirvan plain and the adjacent water area of the Caspian Sea (Absheron and Baku archipelagoes, South Caspian deep part). They are corresponded to the downwarping areas with great sedimentary thickness and related with territories characterized by active manifestation of the folded movements in Neogene and Anthropogene. Nearly all mud volcanoes in Azerbaijan relate with oil-and gas bearing (petroleum) structures (Aliyev, 2015).

One of the most differentiating features of mud volcanoes in Azerbaijan is their frequent eruption. As it is mentioned above, the eruptions had been described in the ancient records but it was odd bits of information. More ordered data began to be available over recent two hundred years. Thus, over 400 eruptions in 93 volcanoes had been recorded in details for the mentioned period (Aliyev, 2002). The most active volcanoes with eruptions 10 and over locate in Absheron peninsula, Shamakhi-Gobustan region and Baku archipelago. Multi-year researches allow noticing that the less internal energy / fluid discharge within the volcano the more frequent is eruption (Lokbatan, Keyreki, Shikhzarli). Volcanoes with intensive and constant fluid (gas, water, mud) discharge erupt quite infrequently and make nearly 60% of the total number of volcanoes (Dashgil). It is also discovered that the most number of eruptions takes place with dormancy interval to 5 years (over 60 eruptions); 5 to 15 years (60 eruptions); 15 to 25 years (31 eruptions); 25 to 50 years (33); 50 to 100 years (16 eruptions); over 100 years (2 eruptions). Thus, the average data shows the over 60% of all eruptions in Azerbaijan occur with time interval to 15 years.

Conclusion

Thus, in spite of fact that the mud volcanism has a planetary scale, their distribution is quite restricted and conformed to definite geological conditions. Azerbaijan (eastern part and the adjacent water area in the Caspian Sea) is considered as the most representative polygon of mud volcanism according to their morphology, activity, types of emanating fluids and eruptions. Being the unique natural phenomenon, mud volcanoes represent the economic (oil and gas fields, economic minerals, etc.), scientific (oil and gas migration), social (geohazard, groundwater resources) interests. Being closely related with oil and gas fields (Azerbaijan) the mud volcanoes and hydrocarbon seepages serve as indicators of an active petroleum system.

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CRIMEA SOUTHERN COAST SOIL-LANDSCAPES CONDITIONS

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Keywords: soil cover, Crimea southern coast, landscape, soils map, soil mapping.

Introduction

Soil cover and landscape structure of any territory are closely associated and they characterized all nature components of study area in aggregate. It was the first time that Crimea southern coast soil cover was displayed on soil map of European part of Russia in 1900 (Pochvennaya karta...). It was marked as single areal of rough and skeleton soils on calcaric bedrock, marl and clayey soils.

Evolution of GIS and new digital cartography methods, satellite imagery variety gave opportunities for creation of new generation medium-scale soil map (Grunwald, 2009; Minasny, Santos and McBratney, 2003). At one side digital soil map quality depend on methodology of creation soil map and from other side - amount and quality of information about soils and soil formation factors of study area. As a result of researching authors made the first digital updated medium-scale soil map (1:100000) on the base of new data about Crimea southern coast soils (Dragan, 2004; Dragan, 2009; Ergina and Lisetskiy, 2010; Kostenko, 2014), results of own fieldwork and satellite imagery interpretation (including imagery of satellite system Landsat).

Crimea southern coast physiographic conditions

There are different approaches of separation Crimea southern coast as physiographic zonation element. In this research Crimea southern coast was determine as a territory from Aia cape on the west to Feodosiya town on the east and from Black sea coastal line on the south to 350-400 m altitude on the sea level on the north (Podgorodetskiy, 1988).

Crimea southern coast characterized as a piedmont region and planar and linear erosion has wide distribution there. The main bedrock on this territory are Jurassic limestones and Taurida flysch and Quaternary deposits are represented by alluvial, marine, deluvial, proluvial deposits and talus and landslide.

Study area has mediterranean type of climate (hot, dry, winter is mild). Average annual temperature is about 12-14°C, coefficient of moisture is 0,32-0,46, annual precipitation is about 500-600 mm and its maximum is observed in december - january.

There are several different types of flora bolds in Crimea southern coast border. Beach communities of halophilic species, pseudo maquis and shibljak, oak and pine forests replace each other from coast to mountain.

Surface water is presented by shallowing or drying rivers and springs and rare lakes, in general artificial.

Crimea southern coast soils

Digital medium-scale soil map of Crimea southern coast (1:100000) includes 1053 cartographic elements and 34 categories are in map legend. All elements of legend divided into four groups: natural soils, soils of terraced slopes, agricultural soils and soil cover of urbanized territory. Also map includes information about bedrocks, degree of soil washout, natural soils part in borders of agricultural soils.

The main natural soils are Dystric Cambisols (its part in all area of natural soils is about 35%) and Eutric Cambisols (its part is about 23%). Areas of these soil types are often adjacent to each other and a border between them can be finded on satellites imaginaries as a differences in vegetation and on geological map as a border between calcaric and non-calcaric rocks.

Dystric Cambisols with the profile formula (AY-BM-C(ca)) prevail in the middle part of southern macroslope of Crimean mountain Main ridge and on the northern and eastern slopes. The middle horizon BM has typical grayish brown color and nutty structure, soil elements have matt rugged surface. Dystric Cambisols form under pine, beech-hornbeam, oak-hornbeam and oak forests. This soils form on the non-calcaric bedrocks in eastern part of Crimea southern coast and in other places Dystric Cambisols (Calcaric) form on Jurassic limestones. Profiles with small capacity and partially washed away humus horizon can be found on slopes.

Eutric Cambisols with the profile formula (AU-BM-BCA-Cca) prevail in the lower part of southern macroslope of Crimean mountain Main ridge under shibljak and sparse forests. This soils form on products of weathering calcaric rocks. As a result of different slopes wide-spreading on the Crimea southern coast Eutric Cambisols can be poorly developed and partially washed away.

Eutric Chromic Cambisols and Eutric Salic Cambisols are also found on the study area. Eutric Salic Cambisols form in the area of Meganom care on saline rocks (Dragan, 2004). Eutric Chromic Cambisols have a local distribution mainly on the territory of natural reservation "Martian cape". It forms on products of weathering limestones under shibljak. Eutric Chromic Cambisols have crystallized iron high level in profile (it'is due to the peculiarities of water and temperature conditions of these soils) and red shade of soil mass (Kostenko, 2014).

Leptosols are characteristic of slopes but can be found on the watersheds. Its main areal situated east of Alushta. This is due to wide-spreading of non-calcaric Taurida flysh and planar and linear erosion in this region. Leptosols can be found under different types of vegetation on the Crimea southern coast.

Rendzic Leptosols form on Jurassic limestones and products of its weathering under forests, bushland and mountain-steppe vegetation. It has same position in relief as a Leptosols but also can be found on the rocky slopes in small recesses. Rendzic Leptosols often form a mosaic with Eutric Lithic Leptosols and rocky outcrops in last case.

Dystric Lithic Leptosols and Eutric Lithic Leptosols as a undeveloped soils are wide-spreading on the steep slopes and rocky outcrops. Dystric Lithic Leptosols form on volcanic rocks and other non-calcaric rocks. Its areas are small and related to cracks and different negative forms of microrelief. Dystric Lithic Leptosols with Leptosols form mosaics. Herbaceous species, rarely shrubs or small trees vegetate on these soils as a rule.

Eutric Lithic Leptosols with the profile formula (O-Rca) form in the same conditions like Dystric Lithic Leptosols but on Jurassic limestones and products of its weathering including monadnocks, talus and landslide, steep slopes under pine forests.

Conclusions

As a result of digital soil map analysis was found that soil formation on the Crimea southern coast territory is conditioned mainly to characteristics of bedrock (rocks origin, calcaric or non-calcaric), altitude on the sea level, degree of the slope steepness and anthropogenic factor.

Dystric Cambisols occupy about 21% of the territory, Eutric Cambisols - 14%, Leptosols and Dystric Lithic Leptosols mosaics - 18%, Rendzic Leptosols and Eutric Lithic Leptosols - 3%. Turbo-changed soils form under vineyards and on the terraced slopes (about 22% of territory), mosaics of non-soil formation, anthropogenic-changed soils and anthropogenic soils cover urbanized territory.

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LATE HOLOCENE LANDSCAPE DYNAMIC IN THE FOREST-STEPPE AREA OF THE RUSSIAN PLAIN BASED ON THE STUDY OF SOIL CHRONOSEQUENCE (THE BORISOVKA SCYTHIAN SETTLEMENT)

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Keywords: paleosol, paleoenvironmental reconstruction, ancient settlement, Russian Plain

Introduction

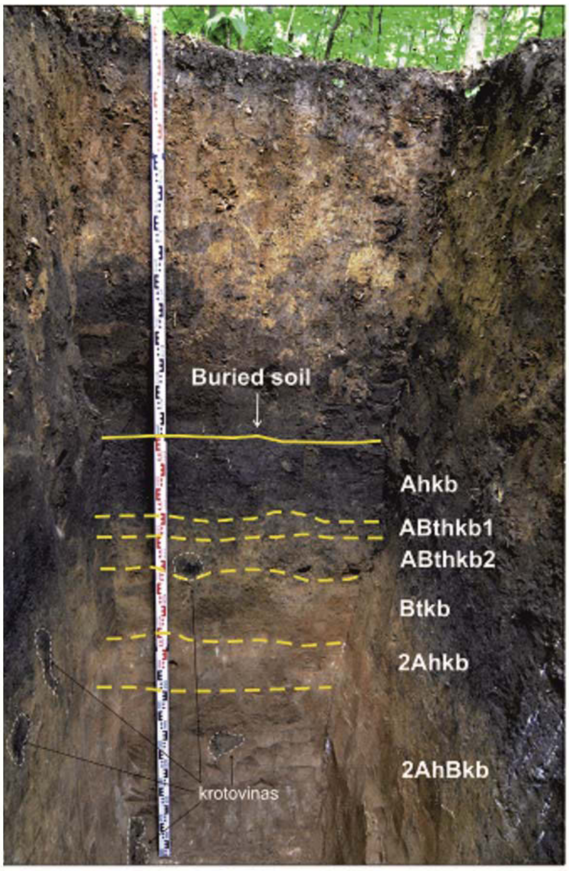
Paleoenvironmental reconstructions are crucially important for understanding migration incentives of ancient civilizations. The old settlements are among important geoarchaeological objects that allow using paleopedological methods for paleolandscape reconstructions. Soils deeply buried under ancient constructions, especially ramparts and mounds, keep features developed under climatic conditions preceding burial and could be considered as a valuable paleoenvironmental archive. Settlements and burial mounds of Late Holocene age are widely spread in forest-steppe, steppe and semi-desert areas of East European Plain and well documented by archaeologists. The Russian Plain in the second half of the Holocene is an area of considerable rhythmic climate variations (Demkin, 1997; Aleksandrovskiy and Aleksandrovskaya, 2005; Khokhlova, 2012; Chendev et al., 2017; Aseyeva et al., 2019; Makeev et al., 2019). During the Late Holocene, the Russian plain seems to be an arena of complex interactions of different civilizations bordering Caspian-Black Sea-Mediterranean Corridor from the North. This report focuses on the study of surface soil and soil, buried under the archaeological monument of the Early Iron Age in order to derive Late Holocene environmental changes in the southern part of the forest-steppe areas of the East European Plain.

Study area and methodology

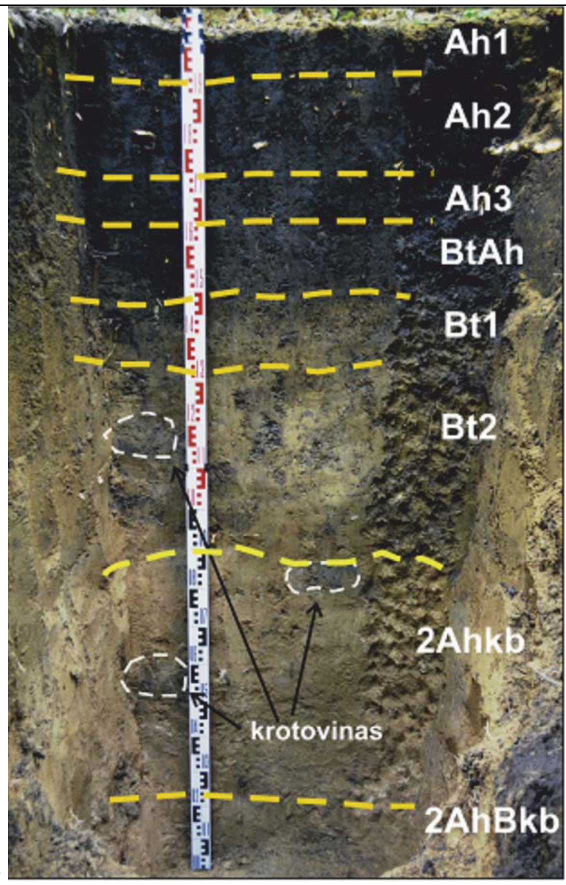
The Borisovka settlement of the Early Iron age (ca 2500 years BP) is situated 40 km to the West of Belgorod city in the Northern Forest-Steppe area of the East-European Plain. It was a part of Scythian civilization which Iranian-speaking tribes occupying extensive belt in the Northern Black and Azov sea area in the Don and Danube river basins. The settlement is situated on a culmination of a narrow promontory formed by a junction of several parallel gullies with steep slopes heading to the Vorskla River valley. Elevation above the local erosion basis reaches 50 m. The radiocarbon age of coal in the lower part of rampart mound confirm the Early Iron age of the construction (2540±100 years cal. BP (CalCurve: IntCal_13 (Ki-18174) (Chendev et al., 2014). Landscape evolution was studied based on detailed morphological and analytical research of the two soil chronosequences that included surface soils and soils buried under two fortification walls of Borisovka settlement. Both earth walls have preserved height of 1.5 m. A width of the wall is 5–6 m which means that the earth wall covers the buried soil completely. The first chronosequence is restricted to the inner earth wall where the buried soil was formed in Late Pleistocene (MIS2) carbonate loess heavy loams (Fig. 1). The second chronosequence was studied within outer earth wall where surface and buried soils were formed in Oligocene sandy deposits partly overlain by aeolian Late Valday (MIS2) sandy material (Fig. 2a). Reference profiles of the surface soils are situated on the same elevation (190 m a.s.l.) only 10 m apart from the defensive walls, in similar topographic position and in sediments with the same lithology (loess sediments for the inner wall and sandy deposits for the outer wall). The soils have been examined morphologically according to FAO Guide for Soil Description (2006) and classified according to WRB (2015).

Results and discussion

The surface soil of the 1st chronosequence was classified as Greyzemic Luvic Phaeozem. The buried soil was truncated by approx. 40 cm and transformed by diagenesis. Taking this into account it was possible to reconstruct the soil formed by the time of burial under the earth wall and to classify it as Chernic Luvic Phaeozem (Fig. 1). The upper part of the buried soil had been mixed and partly removed mostly to the horizon of the earth wall during construction of the defensive wall.



a



b

Figure 1. The Borisovka Scythian settlement, the inner earth wall. Soil chronosequence of buried Chernic Luvic Phaeozem (a) and surface Chernic Luvic Phaeozem (b).

The translocation of the upper part of the Humic horizon of the Chernic Luvic Phaeozem is confirmed by the study of microbiomorphs: e.g. according to carpological analysis plant macrofossils are absent in the Humic horizon of the buried soil (because of truncation) but are abandoned in the lower part of the earth wall. In general, the plant macrofossil spectra reflex herbaceous vegetation of the broad-leaved forest of the semi-humid or even humid zone. Aside from this, the buried soil contains single grains of phytoliths and nearly no pollen, which is typical for the lower part of Humic horizons. All forms indicate only the presence of dicotyledonous herbs. Based on morphological research, analytical and radiocarbon data of the buried and surface soils, it is possible to reconstruct pedogenetic stages in the southern part of the forest-steppe zone of the Russian Plain which reflects the Holocene Landscape dynamic:

1. Cryo-arid pedogenesis (MIS2?). The lower part of both profiles at the depth of 1.0 m is a layer of carbonate loess in which the soil profile with the pre-Holocene soil, presumable Cambic Cryosol Loamic Calcaric was developed. Micromorphological investigations showed frost cracking of the sandy grains, cryogenic coagulation, and presence of carbonate nodules incorporated in the groundmass.

2. Forest environment of the Early-Middle Holocene is exhibited mostly in the middle parts of the soils and represented by Argic horizons. This stage resulted in the formation of Luvic features: subangular blocky peds with clay cutans in a sequence of the Bt horizons.

3. Steppe environment. The steppe stage chronosequence is recorded in the formation of the Humic horizon with a reconstructed thickness of 50–70 cm. The krotovinas in both the surface and buried soils also confirm the former steppe environment (Fig. 1). Clay coatings were partly dispersed in the matrix and masked by the impregnation of dark humus. They are still visible in the upper Ah3 and BtAh horizons of the surface soil, which were probably a part of a thick humus horizon of the steppe soil. In the buried soil, the total groundmass is impregnated with dark humus in the lower part of the former Humic Ahkb horizon and former transitional ABthkb horizon of the steppe soil. Based on radiocarbon dating of the humic acids obtained from the upper 10cm-thick layer of the Humic (Ahkb) horizon of the buried soil (14C ages of 6750±120 years CalBP, IGAN 5605) steppe landscapes dominated during the Holocene climatic optimum.

4. Broad-leaved forest environment dominated since the Early Iron Age till the present time. This stage is based on the features of the surface soil and represented by the development of Greyzemic features and Albeluvic glossae in the upper part of the Argic horizon. Modern clay illuviation is evident by the presence of thin hypo-coatings. The former Mollic (Chernic?) horizon was degraded and substituted with horizon typical for productive broadleaf forest environment with dark-brown groundmass and granular microfabric formed by earthworm casts with abundant plant residues of various degree of decomposition.

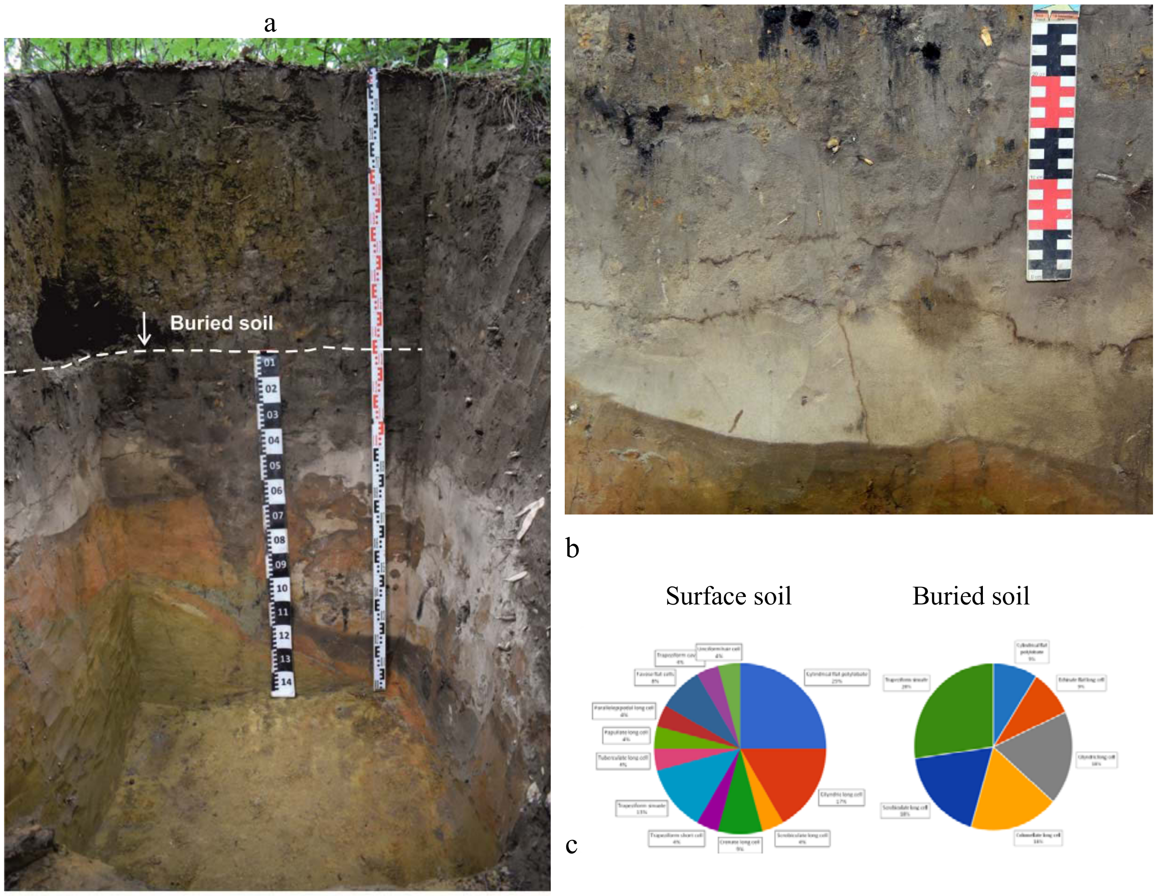


Figure 2. The buried Folic Eutric Cambisols (a). The krotovina dissected by lamellae (b).Phytolith spectrum of the upper horizons of the surface and buried soils (c). The Borisovka Scythian settlement, the outside earth wall

The study of the 2nd chronosequence is consistent with the described landscape dynamics. Both surface and buried soils formed in sandy deposits are classified as Folic Eutric Cambisols. According to our field study and data on phytolith research, we can assume the Humic horizon of the buried soil was not truncated during the construction of the earth wall. The phytolith spectrum (Fig. 2c) of the surface and buried soils are similar and show the predominance of the meadow grasses with inclusions of forest and steppe grasses and moss. Thus, we can assume the similarity of the landscape conditions of the Early Iron age and modern. But the presence of dicotyledons herbs in the phytolith spectrum of the buried soil point to a more humid climate in the early Subatlantic period of the Holocene. The good preservation of krotovinas in both surface and buried sandy soils confirm the former steppe environment (Fig. 2b). Another important thing is that some krotovinas in buried soil were dissected by thin non-cemented iron lamellae < 2.5 cm thick that reflect segregation of Fe oxides due to seasonal changes in groundwater level. These lamellae correspond to the pedogenesis under the broad-leaved forest: they dissect some krotovinas, indicating the onset of more humid environments after the steppe phase. So, we can assume that soils in both chronosequences indicate similar stages of landscape development.

Conclusions

The study of both chronosequences shows that Phaeozems formed in loess and Cambisols formed on sandy deposits exhibit changes in the Late Holocene environmental conditions. Soils of both chronosequences are polygenetic combining the features of forest and steppe pedogenesis. Comparison of the buried and surface soils indicate relative landscape stability at the southern boundary of the forest-steppe zone since the Early Iron Age till present. Fortifications of the Early Iron Age are not only indicators of landscape dynamics, but also the unique cultural heritage of the East European Plain. Further studies will link the critical stages of landscape evolution with the migration waves of the ancient tribes.

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FIRST LUMINESCENCE DATING RESULTS FOR EARLY PALAEOLITHIC OF THE EASTERN CAUCASUS (DAGESTAN)

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Keywords: Early Paleolithic, geochronology, luminescence dating, feldspar, Urunzhik transgression

Introduction

Since 2009 a group of researchers led by the Institute of Archeology and Ethnography of the SB RAS has been systematically studying multilayer archaeological sites in Eastern Dagestan. Early Paleolithic sites Darvagchay-zaliv 1, Darvagchay- zaliv 2 and Darvagchay-Quarry [Anoykin, 2014] were found at the mouth of the Darvagchay River. The industry of the Darvagchay-1 site dates from the time of the Bakinian transgression (Q_{1b}) ~ 600 ka ago [Derevianko, 2006]. The group of Early Paleolithic sites in Primorsky Dagestan is evidence of one of the episodes of the resettlement of ancient humans in the Caucasus, therefore the representative Darvagchay-Zaliv complexes are of interest to specialists of a wide profile.

In 2010, during an archaeological survey of the right bank of the Darvagchay river (Derbent district of the Republic of Dagestan) the site Darvagchay Zaliv 4 was open (Fig. 1).

Fig. 1. Structure of Darvagchai-zaliv 4 site

This site located on the right bank of the Gedzhukh reservoir in the middle of a high (about 20 m) coastal outcrop. Geographic coordinates: 42º08'06 "N, 48º01'44" E; altitude ~125 m. Stationary studies of the site, conducted intermittently in 2011–2019, provided detailed information on the stratigraphy of the quaternary deposits, as well as an expressive set of Paleolithic artefacts, the most characteristic feature of which is the presence of large bifasially processed tools [Kandyba, Rybalko , 2016; Rybalko, 2014]. In 2018, we attempted to obtain the first absolute chronology for the Darvagchay Zaliv 4 archaeological sequence.

The top and middle parts of the section contain complex strata of loess-paleosol series with clear signs of erosion and redeposition. The lower part of the section is represented by marine coarse-grained sands with mollusk fauna. To date, this horizon is correlated with the Urundzhik transgression of the Caspian Sea [Derevianko, 2018]. Numerous artifacts were found in these coastal deposits.

Methodology

The ongoing discussion regarding the position of Urundzhik transgression in the general stratigraphic scheme of the Caspian sea (from 9 to 13 MIS) does not allow to reliably determine the age of this archaeological layer. In this connection, an attempt was made to obtain an absolute chronology. It is well known that dating this kind of ancient sediments is not straight forward and we have limited arsenal of geochronological methods. In the practice of modern luminescence dating, reliable date can be obtained usually back to 220 ka. But this case when dose rate accumulation is two to three times lower, the dating limit can be shifted to about 300-400 ka when measuring the feldspar grains. Thus, the prospect of obtaining age from marine sediments from the lower part of the section has opened up for the Darvagchay Zaliv 4 site.

Results

The completed chronology of 15 dates allowed for the first time to determine the age of all stratigraphic units of the studied section. The upper buried soil is characterized by dating to MIS5. Lower-lying strata of loess formed with significant sedimentation rates - 6 dates from this pack gave an age of 180 to 210 thousand years ago. Sands from the lower part of the section were dated to MIS9. This age describes period of inhabitance by ancient humans during a small and warm Urundzhik transgression of the Caspian Sea.

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FRACTIONS OF HEAVY METALS IN DRY STEPPE SOILS OF THE CASPIAN REGION, RUSSIA

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Keywords: potentially toxic elements, mobility, mineralogical composition

Introduction

In contrast to the soils of humid and semi-humid zones (e.g., Retisols, Chernozems and Phaeozems), in which heavy metal fractions were studied very well, such data for dry steppe soils located in semi-arid environments of the Caspian region are very sparse (e.g., Korolev, Panin, 2010; Bodeeva, Chimitdorzhieva, 2012).

The aim of our research is analysis of the ratio of four fractions of chemical elements in typical dry steppe soils of the Caspian region (Kastanozems and Solonetz), located in small gully catchments at the Ergeni Upland.

Methodology

On the eastern slope of the Ergeni Upland (Republic of Kalmykia, Russia), which rises 120 m above the Caspian Lowland, a catchment area of 20.3 thousand m^2 was studied. At this key site, 79 soil samples were taken from 11 pits (8 pits of Kastanozems and 3 pits of Solonetzes). The soil pits were located in sequences from an interfluve down to the slope in order to analyze the redistribution of heavy metals along the soil catenas.

The soil analyses included total organic carbon (TOC), pH, electrical conductivity (EC) in a water extract (soil: solution ratio is 1:5), the particle-size distribution and content of heavy metals and minerals. The Russian system of particle-size classes was used, i.e., G1 – clay (particles <1 μm), G2 – fine silt (1 – 5 μm), G3 – medium silt (5 – 10 μm), G4 – coarse silt (10 – 50 μm), G5 – fine sand (50 – 250 μm) and G6 – medium and coarse sand (250 – 1000 μm). Total content of 24 chemical elements (ChEs) was determined using an Axios X-Ray fluorescence spectrometer (PANalytical, Netherlands) and Russian Soil Standard samples (SSs of 'Chernozem' and 'Albeluvisol'), with standard errors of determination specified earlier (Semenkov, Koroleva, 2019).

Soil mineralogical composition (phyllosilicates and other minerals) was determined in 15 samples using an Ultima-IV X-Ray diffractometer (Rigaku, Japan) operated at 40 kV, 40 mA, 3–65° 2θ, with Cu radiation and a DTex/Ultra semiconductor detector. Minerals were identified by comparing experimental data with standard X-Ray difractometry patterns from the PDF-2 database with the use of the MDI Jade-6.5 software and methodological recommendations (Drits, Kossovskaya, 1990; Harris, White, 2008; Moore, Reynolds, 1997). A quantitative mineralogical analysis was carried out for 8 samples using the Rietveld full-pattern fitting method (Bish, Post, 1993) and the BGMN software (Doebelin, Kleeberg, 2015).

The analysed fractions of the ChEs were defined as follows: F1 – weakly bound acid-soluble (exchangeable ions and weakly bounded with carbonates), F2 – complexed (fulvate and humate substances), F3 – bound with Fe and Mn hydroxides and with carbonates and F4 – residual fraction. Mobile fractions F1, F2 and F3 were obtained according to the russian extraction procedure (Solov'ev, 1989) with the use of the following reagents: (1) F1 – with 1M NH_4Ac (ammonium acetate buffer, pH=4.8) and the soil:solution ratio of 1:5, (2) F2 – with 1% EDTA (ethylenediaminetetraacetic acid) in 1M NH_4Ac and the soil:solution ratio of 1:5 and (3) F3 – with 1M nitric acid and the soil:solution ratio of 1:10. Soil suspensions (50 ml) were prepared from soil subsamples (5–10 g) by incubation for 18 hours.

The ChE mobility is defined as a ratio of the element's mobile fractions (F1+F2+F3) to its total content, multiplied by 100%.

Results

In the granulometric composition of Kastanozems and Solonetz, medium silt prevails (Table 1). In both soils, the pH increases with depth, and TOC content decreases. Solonetz are characterized by increased EC in relation to Kastanozems.

Table 1. Selected properties of soils studied at the Ergeni Upland

Horizon, n	Parameter	Particle-size classes (μm), %							EC,	pH	TOC,
		1000–500	500–250	250–50	50–10	10–5	5–1	<1	dS/m		%
		Kastanozems (Protosalic, Siltic)									
A, 15	M	0,00	**0,56**	**19,1**	**48,0**	10,3	17,9	4,1	1.48	6,8	**1,7**
	SD	0	0,94	5,7	2,6	1,2	4,6	1,2	0.5	0,4	0,5
B, 7	M	0,00	0,00	8,5	47,2	**11,7**	26,2	6,5	2.0	7,6	1,0
	SD	0	0	1,9	4,1	0,5	2,9	1,1	0.7	0,4	0,1
Bk, 22	M	0,00	0,02	7,0	47,2	11,2	**26,4**	**8,2**	3.3	8,1	0,4
	SD	0	0,09	3,0	3,1	1,0	3,1	1,3	2. 7	0,3	0,2
Cky 16	M	0,00	0,00	8,4	47,6	10,8	25,1	**8,2**	**6.1**	**8,3**	0,3
	SD	0	0	4,7	4,5	1,0	2,7	1,4	8.3	0,3	0,0
		Hypersalic Solonetz (Siltic)									
E, 2	M	0,00	**0,72**	**18,7**	**46,5**	11,2	18,6	4,4	0.91	7,5	**1,0**
	SD	0	1,01	2,6	1,7	0,7	0,7	0,5	-	-	0,1
Bn, 3	M	0,00	0,00	6,1	43,0	12,5	**30,5**	7,9	2.3	7,6	**1,0**
	SD	0	0	0,9	3,5	0,6	3,9	0,5	1.0	0,5	0,1
Bk, 7	M	0,00	0,02	5,9	41,1	12,9	**30,5**	**9,6**	22.4	8,1	0,4
	SD	0	0,06	1,4	3,7	1,3	2,9	1,5	10.0	0,3	0,1
Ckz 3	M	0,00	0,7	10,1	43,0	**13,1**	25,7	7,4	**30.8**	**8,2**	0,2
	SD	0	1,2	3,1	3,2	0,7	1,9	1,2	2.8	0,2	0,0

M – mean, SD – standard deviation. Maximum concentrations are marked in Bold.

In mineralogical composition, non-clay minerals (primarily quartz> plagioclases> potassium feldspars and calcite) dominate over clay minerals which primarily represented by illite and smectite. The loess-like soil-forming loams (Ck horizon) of Kastanozems differ from the parent material of Solonetz which is evidenced by the increased content of smectite, chlorite, dolomite and gypsum and the decreased content of quartz and illite-smectite mixed-layered minerals with predomination of illite interlayers (Table 2).

In the elemental composition, the following sequence is formed: Si (>25%)> Ca, Al, Fe (2 – 5%)> K, Mg, Na (0.9 – 2%)> Ti (0.3 – 0.4%)>P, Mn, S, Ba, Zr (300 – 600 ppm)> Sr (200 – 300 ppm)> Cr, V (100 – 200 ppm)> Rb, Zn (70 – 80 ppm)> Ni (50 – 60 ppm)> Y, Cu, Pb (20 – 30 ppm)> Co, Nb, Th (9 – 20 ppm). In Solonetz, content of Cl is 10 times higher than that in Kastanozems (Table 3).

Most of the metals were bound with Fe and Mn hydroxides (F3), with the exceptions of Ca, Sr, K, Na and, to a lesser extent, Ba and Mg (Figure 1) that occurred mostly within the weakly bound carbonate fraction (F1), which is a typical feature of semi-humid soils (e.g., Chernozems within the East European Plain) (Semenkov et al., 2015, 2019).

Table 2. Mineralogy of studied Kastanozems and Solonetzes

Horizon, depth, cm	Smectite	Illite	I/Sm	Kl	Chlorite	Pl	PFS	Q	Calcite	D	G
				Kastanozems (Protosalic, Siltic)							
A, 0–10	10,7	**8,8**	**15,0**	2,0	0,9	**13,2**	4,1	**44,3**	1,1	<0,5	<0,5
B, 50–80	**17,6**	7,0	10,0	**3,4**	0,9	8,4	**4,7**	39,5	6,9	1,7	<0,5
Bk, 91–95	12,5	7,2	12,4	3,2	1,5	10,5	4,4	38,3	**8,4**	1,7	<0,5
Cky, 120–130	11,5	7,1	14,4	2,5	**2,2**	8,9	2,9	35,6	5,9	**3,3**	**4,8**
				Hypersalic Solonetz (Siltic)							
E, 0–13	0,5	6,3	12,9	1,7	1,0	**15,7**	**6,6**	**54,8**	0,6	<0,5	<0,5
Bn, 13–25	**21,4**	**7,8**	14,2	**2,7**	1,0	9,6	5,7	35,4	1,5	0,6	<0,5
Bk, 38–58	8,5	5,8	**19,2**	2,3	**3,1**	11,5	4,4	32,0	**11,3**	2,0	<0,5
Ckz, 120–130	8,1	6,1	18,7	2,5	0,9	12,3	4,4	40,1	4,8	**2,1**	<0,5

D – Dolomite, G – Gypsum, I/Sm – illite-smectite mixed-layer minerals with predomination of illite interlayers, Kl – Kaolinite, Pl – Plagioclases, PFS – potassium feldspars, Q – Quartz

Biophilic elements including Mn, Pb, S, Co, Ni and Cu (Kabata-Pendias, 2011), as well as Ca, K, Ti, V and, to a lesser extent, Zn were bound within soil organo-mineral complexes (F2), with the F3/F2 ratio < 2 in the generalized dataset for the Kastanozems and Solonetz studied at the Ergeni Upland. Some elements including Mg, Al, Si, P, Fe, Cr, Sr and Ba were concentrated within the F3 fraction, with the F3/F2 ratio of >10. Such a balance of hydroxide-bound and complexed substances has been previously reported for Fe, Mg, Ba and Cr in Chernozems and Phaeozems and is explained by their insignificant participation in biogenic migration processes and accumulation in form of carbonates (Kasimov et al., 1992; Semenkov et al., 2015, 2019).

In Kastanozems and Solonetz studied at the Ergeni Upland, the mobility of biophilic Mn, Co, Cu, Zn is maximal in topsoil, and the mobility of Ca, P, Sr, S, Na, Mg is maximal in subsoil. The mobility of Pb, Ni, Ba, V, Al, Fe, K, Cr, Si, Ti differs slightly at different parts of soils studied. In Solonetzes, Mn, Co, Na are more mobile (Figure 1).

Conclusions

Chemical elements in the studied Kastanozems and Solonetzes were subdivided on the basis of their mobility into five groups as follows:

1. Highest mobility (mobility of 70–95%) – Mn and also Ca with the mobility 30 – 70% in topsoil;

2. High mobility (10–70%) – Co, Cu, Pb, Ni, P, Sr, Ba, Mg, V, Zn;

3. Moderate mobility (5–10%) – Al and Fe and also S with the mobility 30 – 50% in subsoil, as well as Na that mobility is up to 20% in subsoil of Solonetz;

4. Low mobility (1–4%) – Cr and K and

5. Lowest mobility (< 0.5%) – Si and Ti.

In the studied soils, chemical elements of Ia and IIa groups of the Periodic Table by D.I. Mendeleev with different mobility – Ca, Sr, K, Na and, to a lesser extent, Ba and Mg – were associated with weakly bound carbonate substances (the F1 fraction). Biophilic Mn, Pb, S, Co, Ni and Cu, as well as Ca, K, Ti, V occurred mostly in complexes with humic compounds (the F2 fraction). The content of Mg, Al, Si, P, Fe, Cr, Sr and Ba complexes (F2) was by an order of magnitude lower than their content in the hydroxide-bound (F3) fraction.

Table 3. Total content of chemical elements in the studied soils

Horizon, n	Parameter	Macro elements, %											Microelements, ppm														
		Na	Mg	Al	Si	K	Ca	Ti	Mn	Fe	P	S	Cr	V	Co	Ni	Cu	Zn	Rb	Sr	Zr	Ba	Th	Y	Nb	Pb	Cl
Kastanozems (Protosalic, Siltic)																											
A, 15	M	1,08	0,82	3,9	32,1	1,8	1,0	0,40	0,071	2,8	0,054	0,061	165	112	16	47	26	77	79	153	392	465	10	32	15	24	163
	SD	0,11	0,13	0,3	0,9	0,1	0,5	0,01	0,007	0,4	0,007	0,013	11	8	1	7	3	5	4	7	29	18	3	3	1	3	67
B, 7	M	0,89	1,09	4,4	30,3	1,8	1,5	0,41	0,058	3,5	0,053	0,044	170	127	16	60	29	79	83	158	350	451	11	34	14	23	152
	SD	0,04	0,08	0,1	0,6	0,1	0,6	0,01	0,004	0,1	0,007	0,005	5	4	2	1	2	2	2	13	16	23	1	2	1	2	56
Bk, 22	M	0,85	1,17	3,7	26,9	1,6	6,6	0,37	0,048	2,7	0,061	0,050	140	103	13	54	25	67	70	253	259	393	9	27	12	19	262
	SD	0,09	0,06	0,2	1,5	0,1	1,7	0,01	0,003	0,1	0,005	0,007	12	7	3	2	2	4	5	28	30	34	3	2	1	10	262
Cky, 16	M	1,00	1,20	3,9	28,4	1,7	4,8	0,38	0,052	2,8	0,059	0,204	148	106	14	54	25	69	75	247	292	430	10	29	13	18	327
	SD	0,15	0,06	0,1	0,8	0,1	0,6	0,01	0,003	0,2	0,005	0,612	14	5	2	3	2	3	4	21	22	15	2	3	1	3	547
Hypersalic Solonetzes (Siltic)																											
E, 2	M	1,61	0,56	3,3	35,5	1,6	0,6	0,40	0,067	1,8	0,039	0,030	172	92	14	35	18	56	70	156	485	483	10	28	18	21	102
	SD	0,05	0,03	0,1	0,2	0,0	0,0	0,00	0,001	0,1	0,000	0,000	4	3	1	1	1	0	1	1	4	13	2	1	1	1	15
Bn, 3	M	1,04	1,08	4,6	29,7	1,8	1,1	0,40	0,065	3,8	0,044	0,057	177	125	16	65	31	87	88	166	333	442	12	34	13	26	244
	SD	0,19	0,06	0,1	0,4	0,0	0,0	0,01	0,008	0,0	0,009	0,006	10	4	2	1	2	4	2	13	2	18	2	2	1	3	81
Bk, 7	M	1,18	1,18	3,6	26,6	1,5	6,5	0,37	0,046	2,7	0,065	0,173	137	103	14	54	26	66	69	260	258	390	9	28	12	17	1618
	SD	0,21	0,04	0,1	1,0	0,1	1,1	0,01	0,002	0,1	0,004	0,103	13	6	2	1	1	2	2	20	16	21	2	1	0	2	771
Ckz, 3	M	1,47	1,21	3,8	29,2	1,7	3,9	0,38	0,051	2,8	0,057	0,143	161	109	13	52	24	67	75	217	315	426	9	28	13	18	2218
	SD	0,06	0,06	0,1	0,9	0,1	0,5	0,01	0,002	0,2	0,009	0,101	10	5	1	4	2	3	4	20	31	8	0	1	1	2	239

Figure 1. Content of metal fractions (F1 – blue, F2 – gray, F3 – red, and F4 – yellow) in Kastanozems (Siltic) horizons (left): a – A, b – B, c – Bk, d – Cky, and Hypersalic Solonetz horizons (Siltic) (right) of the Ergeni Upland: e – E, f – Bn, g – Bk , h – Ckz

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VERTICAL AND SPATIAL DIFFERENTIATION OF RECENT FINE-TEXTURED SOILS IN CASPIAN SEA COAST: CASE STUDY IN GOLESTAN (IRAN) AND DAGESTAN (RUSSIA)

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Keywords: trace elements, Solonchaks, vertical distribution, chemical weathering indices, spatial distribution, microtopography

Introduction

The study of the soil cover and soil geochemical pattern in the young lagoon-marsh environments is of great interest in terms of soil cover evolution. The evolution of recent soilscapes formed at Caspian Sea coast were studied on the example of the sandy (coarse-textured) deposits (Gennadiev et al., 1998; Kasimov et al., 2012; 2016). There, the main trend in the development of soil cover during the retreat of the sea and deepening of the groundwater table was a formation of a uniform soil cover with Endosalic Arenosols and Solonchaks. Such a pattern is typical for light sediments and relatively steep shores of the Caspian Sea near the mountains (high energy environments). In recent sandy soilscapes, during the first two thousand years after drying, iron and heavy metals accumulate in soils due to the activation of sulfate reduction and oxidation processes.

On the loamy-clay deposits (low energy environments) at the young coastal plains of the Caspian Sea, the geochemical features of soils and soilscapes are poorly studied. In this paper, we provide preliminary results on the content of 18 chemical elements (Ca, Al, Si, P, K, Mg, Mn, Fe, Ti, V, Cr, Co, Ni, Cu, Zn, Pb, Sr, As) in recent soils on fine-textured deposits at the Caspian Sea coast in Iran and Russia. The aim of the study is to evaluate the spatial differentiation (vertically and horizontally) between different pits located at different positions of microtopography of recent soils formed less than 300 years ago.

Methodology

For two key sites at the Caspian Sea coast (Table 1) located at the similar altitudes (about –25.5 m below the Baltic sea level) and subjected to the recent sea level changes of the Caspian Sea, where the spatial distribution of salinity and pH values (Table 2) were studied in detail (Konyuskova et al., 2018), we analyzed the total content of 18 ChEs in 4 soil pits. The age of the Iranian key site (Golestan) is about 60–70 years and of the Russian key site (Dagestan) is 150–300 calBP.

These key sites were selected according to the following requirements: i. no evidence of aeolian, alluvial or deltaic topography of the landforms; ii. location behind the border of the last Caspian Sea transgression occurred in the 1990s, iii. the loamy or clayey texture of parent material. The Golestan study area of 35×20 m is almost perfectly flat: relative elevations were 4–6 cm. In the Dagestan study area of 45×30 m, microhighs 5–10 cm high and 0.5 to 5–10 m in diameter occur (Konyuskova et al., 2018).

Table 4. Selected features of the key sites

Key site	Coordinates		a.s.l., m	Temperature, °C*		Annual precipitation, mm*	Climate**	Plant cover***
	N	E		January	July			
Golestan (Iran)	37.1754	54.0677	–25.2	+8.4	+29.1	330	BSh	Halocnemum strobilaceum
Dagestan (Russia)	44.5529	46.6769	–25.8	–3.3	+25.9	290	BSk	Tamarix-petrosymonia-frankenia-puccinellia

* CGIAR WorldClim; ** (Kottek et al., 2006); *** (Konyushkova et al., 2018). BSk - cold semi-arid climate, BSh - hot semi-arid climate.

Table 5. Geochemical features of the recent soils studied (Konyushkova et al., 2018)

Key site	Depth to water table, m	Ground water TDS*, g/l	Predominant ions	EC, dSm/m	
				0 – 5	70 – 100
Golestan (Iran)	2.3	100	Na^+, Mg^{2+}, Cl^-, SO_4^{2-}	12.0±6.0	11.8±2.0
Dagestan (Russia)	2.3–2.8	44–48	Na^+, Cl^-	11.7±8.6	11.1±1.3

*Total dissolved salts, EC (electrical conductivity) in water solution (1 : 2.5 soil-to-water ratio)

In 48 soil samples, total contents of 18 ChEs were measured using a Spectro-scan Max-GV X-Ray fluorescence spectrometer (made in Russia) and a Russian Soil Standard sample. In 30 samples out of 48, the measurements were performed in two replicates.

We compared ChEs' content to mean concentration within the upper part of the continental earth's crust (UCEC) (Grigoriev, 2009). We assessed the degree of substrate transformation as a result of soil forming using chemical weathering indexes: R (Ruxton, 1968), PWI (Souri et al., 2006), Si/R, Si/Fe (Birkland, 1999), WI-1 and WI-2 (Darmody et al., 2005).

The differences in the elemental composition of the recent soils of the two key sites, as well as topsoil (0–70 cm) and subsoil (> 70 cm) within the same area, was assessed using a Mann-Whitney U test. Spatial redistribution of the ChEs' total content was evaluated by Wilcoxon signed rank test.

Results

For most of the elements, the results were satisfactory (their changes were in a normal range) except for As and Pb, which their contents were close to the lower detection limit of the 0.2 mg/kg, and in many cases relative deviation exceeded 10% (Table 2).

According to the majority of chemical weathering indexes calculated, the recent soils in Dagestan are significantly more weathered than the soils in Golestan except for WI-1 and WI-2 indices which were almost similar for recent soils in Dagestan and Golestan.

The recent soils studied contain more Co and Cu and less Al and Pb than UCEC (Figure 1). Comparing the two key sites, it can be seen that the topsoil at the Dagestan coast is enriched with Cr, Si, Zn, Ni, K, V and depleted in Ca, Sr, Cu, Mg, and Pb. The revealed differentiation is due to differences in climate conditions of the two key sites. This is confirmed by the fact that the subsoil of recent soils studied is less different in elemental composition: significant differences were found only for Ca, Cu, Mg, Ti, P, and Si.

Table 6. The relative deviation of XRF measurements (%) for 30 samples measured in two replicates

Pair	Key site	Depth, cm	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	As	Pb	Ca	Al	Si	P	K	Mg	Sr
1	D	15–30	0.1	5.0	1.6	0.1	0.3	4.5	1.8	0.3	**13.5**	9.2	**35.5**	0.9	0.1	0.1	0.4	0.5	1.6	1.3
2	D	30–50	0.4	4.7	2.0	0.8	0.5	0.3	0.6	3.3	**20.9**	**15.8**	**89.3**	1.0	0.1	0.2	1.5	0.0	0.3	2.5
3	D	50–70	0.6	5.3	0.2	0.5	0.6	1.6	2.1	1.7	2.2	**17.3**	**72.5**	0.2	0.6	0.2	1.1	0.1	0.2	2.7
4	G	0–5	1.6	2.1	0.1	1.2	1.4	2.0	3.2	3.1	2.9	3.8	0.0	4.0	1.8	6.5	0.6	0.3	2.3	**92.9**
5	G	5–25	0.4	0.7	1.3	0.4	0.2	8.7	**27.3**	0.6	9.9	**12.7**	**97.8**	1.4	2.0	0.6	1.0	1.7	**18.7**	1.9
6	G	25–65	0.3	4.2	0.3	0.3	0.4	2.9	0.1	2.4	1.5	**13.0**	**75.8**	2.6	0.1	4.4	0.7	0.9	1.2	1.5
7	G	65–80	0.4	2.7	0.1	0.0	0.5	3.6	2.5	1.4	0.3	6.7	**52.7**	0.8	0.2	0.8	0.6	0.8	0.4	1.6
8	G	80–110	0.2	3.2	0.4	0.3	0.2	4.9	3.8	0.2	2.5	**12.3**	0.0	0.3	0.2	0.2	0.3	0.5	7.5	1.4
9	G	110–114	0.3	2.2	0.2	0.1	0.3	5.1	5.8	0.8	2.2	6.7	0.0	0.0	0.1	0.0	0.5	0.8	9.5	1.5
10	G	114–140	0.4	2.4	0.0	0.8	0.6	6.6	7.2	1.0	4.7	**23.6**	0.0	0.2	0.0	0.2	0.3	0.3	9.3	2.0
11	G	0–10	0.7	3.3	1.3	0.7	0.7	2.3	1.1	2.9	2.3	0.0	0.0	0.4	0.1	0.1	0.9	0.5	0.9	2.3
12	G	10–22	0.9	4.1	0.7	0.6	0.7	0.8	3.1	2.7	1.0	**14.3**	0.0	0.2	0.1	0.1	0.2	0.6	0.9	2.1
13	G	22–40	0.1	4.1	0.2	0.0	0.5	3.5	0.4	1.8	1.4	**22.1**	**72.4**	0.5	0.4	0.5	2.2	0.4	0.6	1.6
14	G	40–46	0.7	4.3	1.2	0.5	0.1	1.2	1.3	0.3	9.1	**11.3**	**51.7**	1.9	0.5	3.8	0.3	0.0	0.1	0.4
15	G	46–80	0.5	2.7	0.6	0.3	0.5	2.4	4.3	2.6	1.7	**33.3**	0.0	0.0	1.3	0.4	2.6	0.0	0.2	2.8
16	G	80–105	0.2	1.5	0.1	0.3	0.4	0.1	0.1	0.8	0.0	**17.0**	0.0	0.2	0.4	0.0	0.1	0.4	1.0	0.5
17	G	105–120	1.0	2.7	**16.7**	1.3	0.3	1.9	2.4	2.9	2.4	**18.4**	0.0	0.5	0.5	0.0	0.6	0.1	0.4	2.2
18	G	120–150	0.3	1.5	1.4	0.5	0.3	2.0	1.8	2.4	1.1	**22.9**	0.0	0.3	0.7	0.0	1.3	0.1	0.7	0.7
19	G	0–22	0.6	2.1	0.4	0.1	0.5	2.0	1.1	2.4	0.3	5.7	0.0	0.0	0.8	0.4	0.5	0.1	0.7	2.4
20	G	22–40	1.1	1.9	0.6	0.3	0.4	1.0	1.2	1.6	0.2	0.8	0.0	0.5	0.7	0.0	0.1	0.1	1.2	2.1
21	G	40–60	1.2	2.2	0.6	0.6	0.7	0.5	5.4	1.8	1.9	9.5	0.0	2.6	0.4	4.1	0.3	0.5	1.6	2.5
22	G	60–90	0.7	2.6	0.0	0.4	0.3	2.6	4.4	1.2	2.2	**14.0**	**60.1**	0.1	0.6	0.5	1.4	0.1	0.6	1.8
23	G	90–105	0.8	2.0	0.4	0.0	0.4	0.5	0.9	2.5	2.2	**11.8**	**28.5**	0.3	0.7	0.2	0.2	0.2	0.2	2.3
24	G	105–150	0.4	1.5	0.1	0.4	0.6	4.2	2.0	1.9	0.4	3.2	7.4	0.7	0.5	0.1	0.7	0.2	0.9	0.8
25	G	0–10	0.3	1.2	0.7	0.7	0.7	0.0	0.8	2.7	2.2	**14.9**	0.0	0.1	0.7	0.3	0.0	0.0	0.6	0.8
26	G	10–38	0.1	1.0	0.2	0.3	0.3	0.2	0.5	0.3	0.3	0.0	1.6	0.2	0.2	0.0	1.0	0.0	0.5	0.1
27	G	38–60	0.0	0.7	0.3	0.3	0.3	0.6	0.0	1.3	0.4	3.0	4.4	0.0	0.2	0.0	2.0	0.1	0.0	0.6
28	G	60–80	0.4	1.1	0.7	0.5	0.4	2.1	0.9	1.8	0.0	0.4	0.2	0.1	0.7	0.3	0.3	0.0	1.2	0.8
29	G	80–100	0.2	0.9	0.4	0.4	0.4	0.2	0.9	0.5	1.3	1.0	3.7	0.2	0.2	0.1	0.4	0.1	1.0	0.2
30	G	100–120	0.1	0.9	0.2	0.2	0.3	0.9	1.3	0.2	0.4	6.1	**21.5**	0.0	0.3	0.1	0.1	0.2	0.1	0.4

Pairs with relative deviation exceeding 10% are marked in bold. D – Dagestan, G – Golestan.

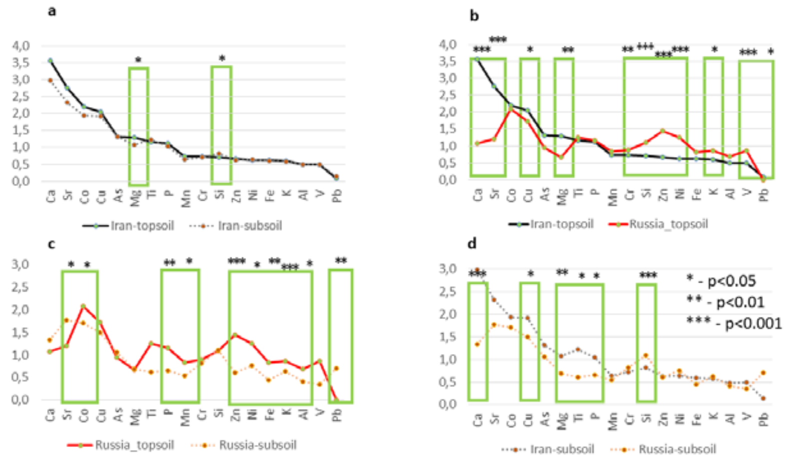

Figure 2. Chemical composition of the recent soils studied in Golestan and Dagestan study sites. Content is normalized to UCEC

In Golestan study site, topsoil contains more Mg and less Si ($p < 0.05$) than subsoil. In Dagestan study site, topsoil contains more Co, P, Mn, Zn, Ni, Fe, K, Al and less Sr and Pb ($p < 0.05$).

In the Dagestan key site with a pronounced microtopography, microdepressions with respect to microelevations are enriched with Sr and Cu, which probably accumulate here on the alkaline geochemical barrier as a result of migration in the soil solution during the initial stages of soil formation.

Conclusions

The differences in the elemental composition of the recent soils were determined both by the initial difference of the substrate according to the content of macronutrients (Mg and Si) and by the conditions of soil formation, which contributed to an increase in the vertical differentiation of the soil in the Dagestan key site. In the Caspian Sea coast, the first signs of differentiation of the recent fine-textured soils in terms of elemental composition are noticeable in 60 – 70 years after the retreat of the sea and deepening of the groundwater table. For 150–300 years that have passed since the surface has been drained, recent fine-textured soils in Dagestan have been differentiated dramatically in elemental composition.

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AGE OF THE KARANGATIAN TRANSGRESSION OF THE BLACK SEA (ELTIGEN SECTION)

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Keywords: Karangatian transgression, sea-level change, luminescence dating, MIS-5, Black sea

Introduction

The Karangatian transgression is a significant milestone in the Pleistocene history of the Black Sea, a large interglacial transgression with rise of 6-7 m higher modern level and with the highest salinity in Pleistocene (Chepalyga et al., 1989; Yanko ey al., 1990; Yanina, 2014). At present absolute age of this event is debatable, there is no unity among researchers.

Methodology

We present new dating results obtained by optically-stimulated luminescence (OSL) of the Karangatian deposits represented in the Eltigen stratotype section on the western coast of the Kerch Strait (Dodonov et al, 2000) (Fig. 1).

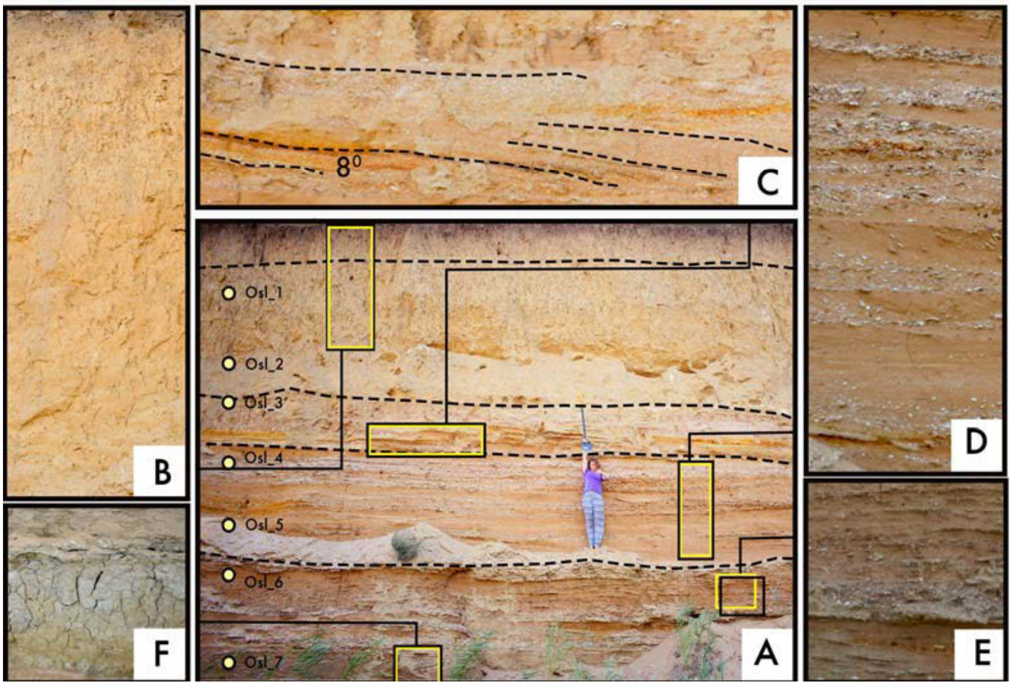

Figure 1. General view of the Eltigen section and main stratigraphical layers

The section is a favorable object for OSL dating method, since deposits are represented mainly by aeolian (loess-like subaerial sediments) and coastal-marine sediments, which are characterized by complete bleaching of quartz and feldspar grains. The chronology was obtained using three protocols (OSL, IR50, pIRIR290) for each sample, which allowed analyzing bleaching properties and described chronology as reliable. Eight luminescence ages were obtained, six of them characterize the marine Karangatian stage and two – subaerial loess-soil sequence. The biostratigraphy analysis of the mollusk fauna from marine sediments represented in the section confirmed their identity as Karangatian transgression of the Black Sea.

Results

Studied section represents two phases of the Karangatian transgression. Early stage developed during MIS 5e. Sea level rose with speed of about 32 cm/ka and reached +3.6 m. The second phase of the transgression occurred 120-100 thousand years ago (MIS 5d-s). The rise of the sea level occurred at a speed of about 12.5 cm/ka. The maximal position of the sea-level dated ещ MIS 5c, reaching ~6.45 m. Taking into account the scale of neotectonic movements will allow a more accurate determination of the maximum sea level rise. During its development, the Karangatian basin was characterized by heterogeneous environmental conditions: from moderately saline (15-17) in the initial stages to marine (28-30) as the transgression developed, and again to moderately saline (17-18) at the beginning of sea-level decrease. The subaerial stage of sedimentation on the coast began no later than 70 thousand years ago.

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DEGASSING OF THE AZOV-BLACK SEA BOTTOM

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Keywords: gas seeps, mud volcanoes, deep fluids

The bottom of the Black Sea is characterized by enormous degassing of fluids, e.g. hydrocarbons (largely CH4) in a lesser degree H2S, and CO2, The fluids migrate upwards through tectonic ruptures (e.g., faults, cracks) that form within weakened zones, act as "chimneys" in the sedimentary cover saturating the water and bottom sediments (Shnyukov et al., 2013). As a result, about 80 billion m^3 of methane are dissolved in the water of the Black Sea, and this condition persists despite a full cycle of water renewal every 400–-2000 years. This indicates a powerful continuous flow of hydrocarbon gases (HG), and hence the presence of their reservoirs, beneath the seabed (Sozanskiy, 2013).

Degassing in the Black Sea occurs largely via gas seeps and mud volcanoes. Gas seeps or acoustic (i.e. obtained using echo sounders or sonars and visible on echograms) plumes, or gas torches (due to their cone-like shape on ecosounder images), or gas flares are generally found at water depths from 50 to 800 m, forming either single occurrences or grouped seeps; some seeps are quite large in area. Often, gas emissions cloud the water by dislocating bottom sediments being localized on the periphery of the basin. Quite often, they are confined to paleo-deltas of the largest Black Sea rivers: the Danube, Dnieper, Dniester, and Don, and within the canyons formed by them. The deepest seeps are associated with faults and mud volcanoes in the central Black Sea basin (Fig. 1).

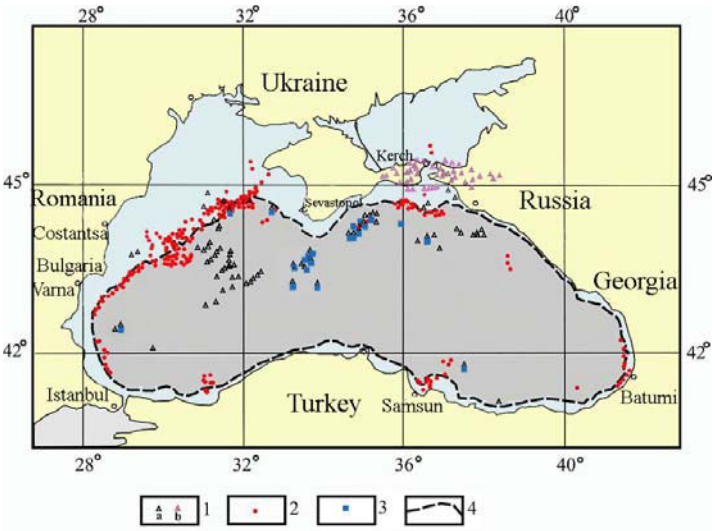

Figure 1. Map showing the distribution of: 1a – offshore mud volcanoes; 1b – onshore mud volcanoes; 2 – gas seeps; 3 – gas hydrates; 4 – shelf edge

On average, the height of the gas seeps above the surrounding sea floor is 100–200 m, and most of them do not reach the water surface. Sometimes it is difficult to distinguish gas seeps from mud volcanoes due to the location of seeps within small conical depressions on the sea bottom. As strong exhaust emissions of water-saturated gas pass upward through the sediment sequence, they can affect bottom morphology by forming rounded depressions or craters called pockmarks. Their locations indicate both the presence of gas seeps and methane biotopes on the seafloor.

At least 4000 gas seeps are known in the Black Sea today. The maximum depth for most of the detected gas seeps is 725 m, which more or less corresponds to the stability zone for pure methane hydrate at a bottom temperature of 8.9° C in this part of the Black Sea. As a result, a kind of specific zoning emerges within the Black Sea: the central deep-water part of the sea is occupied by gas hydrates, while its periphery contains abundant gas seeps. This enables us to say that gas hydrates play a role as buffer for the ascending migration of gases and thereby prevent the seepage of huge amounts of methane into the water column.

Many areas where seeps have developed are confined to the places containing paleoalluvial strata, but not all. The authors are more inclined to link gas seeps with the Maikopian horizon of the Black Sea geological section and with deep fluids. At the same time, they do not deny the participation of biochemical methane in the genesis of gas flares. Undoubtedly, this process accounts for gas seep generation in Quaternary bottom sediments, but its role, most likely, is subordinate.

About 70 mud volcanoes are known today in the Black Sea. Most of them are located in deep water, but some volcanoes have been found at relatively shallow depths. Conditionally, they are separated by us into ten groups (Fig. 2).

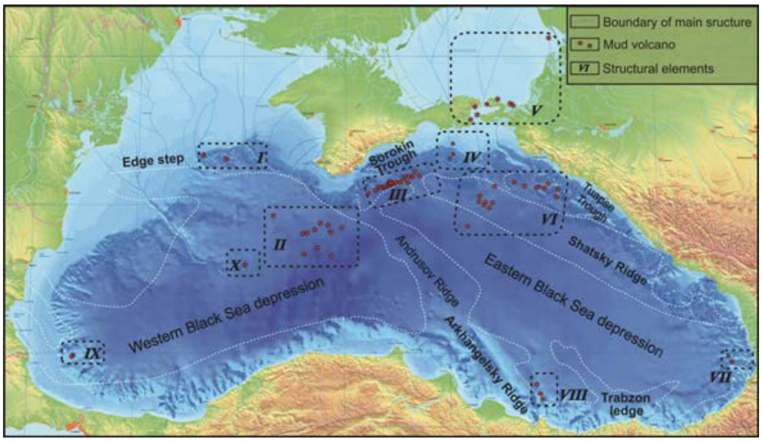

Figure 6.126 Map of the Black Sea showing the major geological morphostructures and the groups of mud volcanoes: I – Northwestern, II – Western, III – Sorokin Trough, IV – near Kerch, V – Kerch Strait, VI – Tuapse Trough, VII – Georgian, VIII – Turkish, IX – Bulgarian, X – Central

Group I is located in the northwestern part of the Black Sea and includes the Parshin and Vodyanitskiy-2 mud volcanoes. The former lies at coordinates 44° 37' 58" N; and 31° 13.21' E and was discovered during the 27th voyage of the RV "Vladimir Parshin" that was carried out in 2006 (Shnyukov et al. 2007). The mud volcano is located on a gentle slope of the Paleo-Dniester River tributary at a water depth slightly exceeding 200 m. It is a relatively large (440×240 m), plateau-like morphostructure that rises about 30 m above the seabed.

Group II is localized in the Western Black Sea depression and consists of 11 mud volcanoes: Grigor'ev, MGU, Yuzhmorgeo, Malyshev, Kornev, Goncharov, Mantiynyy, Strakhov, Tredmar, Vassoevich, Kovalevskiy. As can be seen, the Eastern Black Sea depression is far poorer in mud volcanoes compared to the Western Black Sea basin. This impression may result from insufficient study of the region, but geological reasons are also quite possible.

Group III is localized within the Sorokin Trough that was formed in the Oligocene with the Crimean-Alpine folding and is an extremely interesting area for mud volcano development. In terms of its relief, the Sorokin Trough is a shallow abyssal plain. Its flat bottom undergoes insignificant dismemberment in places where it intersects with continuations of underwater canyons on the continental slope and in areas manifesting gas volcanism. Twenty-six mud volcanoes are known within the Sorokin Trough and have been studied in varying degrees of detail. They can be grouped into four types. The first type is represented by fairly regular, round in plan and conical in cross section, geological structures that measure 700–800 m in diameter and from tens to hundreds of meters in height. The second type includes mud volcanoes with pronounced calderas of various shapes and diameters up to 1 km formed as a result of collapse through a system of concentric downthrows. The third type is represented by a single mud volcano, Dvurechenskiy, that is close to the “Barbados type” of volcano. It has a diameter of 1100 m, is round in shape, flat at the arch, and ejects heavily diluted eruptive products. The fourth type is not actually a mud volcano but fissured outpourings of mud breccia that flow down the continental slope in the central part of the Sorokin Trough. The width of these mud flows is up to 1.5 km, and their length can be 4 km. The mudflows move down the continental slope from Yalta in an easterly direction along a system of parallel cracks oriented in the sub-latitudinal direction (Ivanov et al. 1996).

Compared to mud volcanoes in the Western Black Sea depression, those of the Sorokin Trough are smaller, but their gas flares are much more powerful. Such flares are unknown elsewhere in the Black Sea. All mud volcanoes discovered so far in the Sorokin Trough are confined to the same sub-latitudinal fault zone and are characterized by the release of gases. Most of these mud volcanoes are active at present, and breccia overlies recent mud sediments. Almost all cores recovered from these mud volcanoes are enriched with gases, and in five of them, gas hydrates were found.

Group IV is localized near Kerch within the Kerch-Taman shelf and continental slope that are located largely within the Kerch-Taman Trough composed of Neogene and Paleogene sedimentary rocks transgressively overlapping Upper Cretaceous sediments. The sedimentary strata are folded and dislocated. Geological and geophysical studies have identified 16 morphostructures resembling mud volcanoes. The morphostructures are deep-seated, most likely fossilized, and are not expressed on the seabed surface. Gas torches have been found emerging from many of them or next to them. Coring of the morphostructures for the purpose of clarifying the lithological composition of their sediments was effective only at water depths exceeding 70–100 m. At shallower depths, the coring was prevented by the presence of a hard bottom consisting of modern shell banks. So far, only three mud volcanoes—Mitin, Naumenko, and OMGOR—have been confirmed by geological research . Others are proposed based on geophysical methods, but geological investigation has been hampered by thick shell banks that have formed over them.

Group V contains 11 mud volcanoes. Eight of them (volcano in Lake Tobechik, Tuzlinskiy, mud volcano in the southern part of the Kerch Bay, Blevaka, Peklo Azovskoe, Khakhalev) are localized within the Kerch Strait, and three (Peklo Azovskoe 2, Temryukskiy or Kazbek, Golubitskiy) within the Sea of Azov: The first information about mud volcanoes in the Sea of Azov was provided by Pallas, who described the occurrence of mud volcanic islands in the southeastern part of the basin near the village of Golubitskaya in the vicinity of the town of Temryuk (Pallas 1795, 1883). A chain of positive structures bearing mud volcanoes stretches along the southeastern shore of the Azov Sea. One of the structures contains two anticlines—Cape Kamenny and Cape Peklo—with two mud volcanoes, Peklo Azovskoe 1 (onshore) and its marine continuation Peklo Azovskoe 2 clearly seen in geophysical profile. One of the most interesting is the underwater Golubitskiy mud volcano that is located about 500 m seaward from the shore in front of the village of Golubitskaya (Shnyukov et al. 2006). In modern piloting charts of the Azov Sea, this area is marked by shallows. The mud volcanic activity varies over time. Numerous eruptions of this mud volcano in 1804, 1814, 1862, 1880, 1906, and 1924 were mentioned by different authors. The eruptions were almost always accompanied by the emergence of an island that was quickly destroyed by the waves. Catastrophic eruptions of the Golubitskiy mud volcano occurred in 1994, 2000, 2002, 2008, and 2015; these events were repeatedly videotaped by different people Another one is the Peklo Azovskoe 1 (“Hell of Azov”) mud volcano (45° 25.84' N; 36° 55.30' E) that is significant in size and powerful in activity. Located within the anticline of the same name, it occurs at a place where landslips have created a semicircular scar in the cliffs. At its apex is a sharp, vertical cliff. A panoramic view of the coast shows masses of mud volcanic breccia forming powerful tongues that flow into the Azov Sea, standing out prominently against the light background of the surf. New discoveries of mud volcanoes in the Azov Sea are quite possible. In general, when these mud volcanoes are in a calm state, they still produce gas; their location is revealed by the bubbles as well as fine mud entrained up to the surface. The places at sea where mud volcanoes are developing may be dangerous for navigation, and for this reason, they are indicated in sailing directions, such as Temryukskaya and Golubitskaya banks.

Group VI includes 16 mud volcanoes located in the Tuapse Trough and Shatskiy Ridge. The Tuapse Trough extends along the northwestern border of the Caucasian ridge from the city of Anapa to the city of Sochi. Abundant oil and gas emissions have been recorded to the northeast of the coastal lands and shelf area, almost over the entire Sochi-Adler depression. They are especially frequent in the basins of the Khosta, Agura, and Matsesta rivers, and within the lower reaches of the Sochi River. In all locations, they are encountered both in boreholes and in surface outcrops of various forms—manifestations ranging from the smell of bitumen to the seepage of liquid oil (Sokolov 1965). According to the results of a gas survey conducted by the “Yuzhmorgeologiya” within the context of ecological monitoring (1990–1993), pulsating natural anomalies of hydrocarbon gases were recorded in the rivers of Sochi district (Matsesta, Agura, Hosta, Herota, Kusdepta), Tuapse district (Loo, Yakornaya Schel’, Uch-Dere), and Novorossiysk district (Dyurso) (Kruglyakova et al. 1998). The mechanism of mud volcanism within the Tuapse Trough is related to abnormal pressure buildup in clay sediments; this leads to the development of mud volcanoes through which deep fluids can outflow to the surface (Almendiger 2011).

Groups VII-X are localized in the Georgian, Turkish, Bulgarian, and Central sectors of the Black Sea. There is not much information available on them and they are not discussed in this presentation.

In summary, the Black Sea degassing develops under conditions favorable to the through-depth local hydrocarbon flows of hydrocarbons. This degassing is manifested not only in the activity of mud volcanoes and gas seeps but also in the accumulation of a huge amount of gas hydrates under sea bottom. It looks that there are numerous mud-volcanic channels and other paths – tectonic disturbances for powerful flows of deep hydrocarbon degassing come to the surface of the bottom.

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A COMPARATIVE STRATIGRAPHY, AND LITHOLOGY OF THE LATE QUATERNARY SEDIMENTS FROM PLATFORM CONTINENTAL MARGINS OF THE MEDITERRANEAN SEA AND THE BLACK SEA

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Introduction

The southern margin of the Eastern Mediterranean and the northwestern margin of the Black Sea, including the shelf, the continental slope and the adjacent deep-sea basins, are submerged under sea level parts of the pre-Paleozoic African and East European platforms and the Paleozoic Scythian plate. According to the tectonic regime, geological and geomorphological structure, development history, they have many similar features. At the same time, the fundamental differences between the studied objects are, on the one hand, their climatic position and, on the other hand, the hydrological parameters of the water column. Thus, land areas adjacent to the Mediterranean Sea (Sahara Desert) lie in an extraglacial subtropical zone, are closed and located in an extremely arid climate zone, replaced by short periods of humidification in the interglacial climate. In turn, the lowland catchment areas of the Black Sea lie in the glacial zone of Northern Europe, the climatic conditions of which over the course of the Quaternary have changed from interglacial humid to glacial arid. Another difference is expressed in the presence of a stable marine regime in the Mediterranean Sea and alternating weakly brackish-water and marine regimes in the Black Sea due to the presence or absence of connection with the Mediterranean basin.

The noted features of sedimentary settings are responsible for the formation of late Quaternary different sections of marine sediments that differ in the principles of stratigraphic separation and lithological composition.

The study is based on the results of a study of several cores of sediment from the continental slope of the Eastern Mediterranean between Sidra Bay and the Nile region and several cores from the central part of the continental slope of the northwestern Black Sea region.

Results

Biostratigraphy. In the Eastern Mediterranean, the Upper Quaternary sediments are dissected based on a change in the complexes of planktonic foraminifera, diatoms, pollen and spores, using marking horizons of ash and sapropels. As a result, interglacial Riss-Wurm, glacial Wurm, and post-glacial Holocene horizons were identified in a 4-meter thick sediment.

Riss-Wurm sediments are composed to varying degrees of calcareous silts containing up to three interlayers of S3-S5 sapropel. Among the planktonic foraminifera, they are dominated by warm-water species: Globigerinoides ruber, G. sacculifer, Globigerinella aequilateralis, Globigerinoides rubescens, Orbulina universa, Globoquadrina dutertrei. The composition of spore-pollen spectra shows a high content of arboreal pollen (20-80%). In sapropel interbeds pollen of broad-leaved species prevails: Quercus, Fraxinus, Juglandaceae, Carpinus, Ulmus, Fagus, Castanea, Vitus, Pistacia, Magnolia, Palmae.

In *Wurm* carbonate sediments in the lower and upper parts of the section the poetion of cold-water foraminifers (up to 70%) increases: Globigerina pachyderma, G. quinqueloba, G.

bulloides, Globorotalia acitula. Among the pollen is dominated by pollen of herbage-xerophytes: Artemisia, Chenopodiaceae, ephedra (up to 80%). In the middle part of the horizon, the content of warm-water foraminifer ranges from 25 to 75%. As part of pollen and spores increases the role of tree pollen (30-60%), mainly pine. Pollen of broad-leaved species is contained in a small amount. A characteristic feature of the middle Wurm sediments is the presence of ash layer Y-5 age of about 35 thousand years. A number of ash layers are also found in other parts of the Wurm horizon.

Warm-water foraminifers (45-90%) predominate in *Holocene* carbonate sediments containing sapropel S1. In the composition of spore-pollen complexes, the share of wood pollen accounts for 50-80%, and in the sapropel layer the pollen of broad-leaved species dominates (up to 45%). The interlayer of tephra Z1, formed about 3.5 thousand years ago during the eruption of Santorini and widespread in the Eastern Mediterranean also has a stratigraphic value.

According to the available literature data, the Riss-Wurm sediments accumulated in the time interval from 125 thousand to 70 thousand years ago, the Wurm sediments - from 70 thousand to 11 thousand years ago. The lower limit of the Holocene sapropel is about 8-9 thousand years old.

In the Black sea in the studied sequences of Upper Quaternary deposits Karangatian interglacial (marine), undifferentiated glacial postkarangatian - novoeuxinian (lake) and postglacial black sea (marine) horizons. On the shelf they are divided mainly on the fauna of mollusks, and within deepsea basin on the microfauna.

Karangatian horizon contains a complex of the most stenohaline Mediterranean species pelecypoda, including Cardium tuberculatum, as well as diatoms and coccolithophorida (Gephyrocapsa carribeanica). Eurygaline marine complexes of mollusks, diatoms and coccolithophorides are present in *the Black sea* horizon (old black sea and new black sea layers).

In the part of the Upper Pleistocene sediments lying between marine horizons, only the *Novoeuxinian* section interval formed during the last (Ostashkov) stage of the Valdai glaciation and covering the last regression, LGM and the subsequent lake stage of the post – glacial transgression of the Black sea (25-8 thousand 14C years) was reliably isolated and characterized. Its sediments contain slightly brackish Caspian species of mollusks of the genera Dreissena and Monodacna and freshwater diatoms, mainly Stephanodiscus astraea. The older parts of the section, synchronous Kalinin stage of glaciation and middle Valdai interstadial were studied poorly, reliable data on them are practically absent, and their boundaries are not established. Only in a few wells on the Bulgarian shelf above Karangatian horizon deposits with a mixed marine (redeposited?) and the Caspian fauna were opened, which allowed a number of authors to refer them to the post-karangatian sub-horizon.

Lithology. Carbonates and clay are the main components of the Late Quaternary sediments of the Eastern Mediterranean and the Black sea, which differ significantly in quality and quantity both between basins and in the section of their sediments.

In the *Mediterranean sea*, Late Quaternary sediments belong to silty-pelit group with the content of $CaCO_3$, as a rule, more than 50%. Carbonate substance is represented by several genetic types: biogenic, chemogenic and terrigenous. The biogenic material in the studied sections is composed predominantly of the remains of foraminifera, coccolithophorids, pteropods seldom redeposited from the shelf of the fragments of the benthic fauna. A calcite is the main mineral component, less frequently recorded aragonite and high-magnesium calcite. The chemogenic material is concentrated in thin fractions of sediments, where it is present as a crystalline mass composed of high-magnesium calcite, less often aragonite. Terrigenous material is represented by fragments of calcite, dolomite and limestone. In the studied sections there are changes in the ratio of genetic forms of carbonates. Thus, in the sapropel layers and in the Riss-Wurm silts, an increase in the proportion of biogenic calcite and aragonite and a sharp reduction in the proportion of chemogenic high-magnesium calcite were noted. In Wurm carbonate silts, on the contrary, the role of chemogenic high-magnesium calcite increases significantly.

The peculiarity of the clay component of sediments is the predominance of illite (60-65%), abnormally high content of kaolinite (25-35%), subordinate value of chlorite and smectite. At the same time, the ratio between the groups of minerals in the sediment section does not change significantly.

In the Black Sea, the carbonate substance undergoes significant changes in the Late Quaternary sediments. The maximum concentration of $CaCO_3$ is set on 3 levels: in the clay-coccolith The New Black sea and Karangatian deposits (40-60%), in the upper part of novoeuxinian clay-calcareous silt (70%). The remaining intervals of sedinents are characterized by low carbonate content (less than 15-20% and even less than 10% in brown novoeuxinian mud of LGM). In general, in the section of deep-water Late Quaternary muds the most widespreaded terrigenous carbonates are represented by dolomite, calcite and fragments of calcareous rocks. Biogenic carbonates represented by calcite of coccolithophorids dominate in the interglacial karangatian and the black sea sediments. Chemogenic carbonates in the form of crystalline calcite and aragonite, lay down thin layers in the lower sapropel and in two pronounced layers in the upper part of the novoeuxinian horizon.

The clay substance of the black sea sediments experiences regular changes in the composition during the last glacial – post-glacial cycle. In novoeuxinian fine (up to 70% of the fraction <0.002 mm), light brown clays that accumulated during the LGM (less than 5% $CaCO_3$, less than 0.5% TOC), in the composition of the clay minerals illite dominates (85-90%) and smectite is absent. Chlorite and kaolinite account for no more than 15%. Up the section in the Novoeuxinian grey clays ($CaCO_3$ 10-20%, TOC 1%) and higher in the Holocene sapropel ($CaCO_3$ less than 20%, TOC 10%) and in coccolite ooze (TOC 3-5%) amount of illite is reduced to 60-70%, smectites (montmorillonite + disordered mixed-layer illite-montmorillonite of the composition) increases to 10-15%, the amount of chlorite and kaolinite up to 15-20%.

Conclusion

The presented material testifies to the fundamental difference between Late Quaternary sedimentation on the platform margins of the Mediterranean and Black seas, determined by the climatic conditions of sedimentation and the nature of their changes during the last glaciation.

During the Wurm, there were stable, arid, subtropical environments in the non-glacial zone in North Africa and in the southern part of the Eastern Mediterranean, followed by the pluvials of the last interglacial and Holocene, marked by sapropels. Fine-grained sediments represented mainly clay-carbonate biogenic (bentic and planktonogenic), chemical-biogenic (low - and high-mg calcite) and chemical (aragonite) types with an admixture of aeolian material aleuritic dimensions. Smectite (<15%) – kaolinite (25-30%) – illite (55-60%) association is widespread in the composition of clay material on a larger area of the bottom, replaced in the area of the deep-sea cone of Nile by illite (<30%) - kaolinite (25-35%) - smectite (up to 50%) association. The mineral composition of sediments reflects the features of the composition of the feeding provinces (rift zones of the Nile catchment areas with the dominance of smectites), the features of weathering of sediments in warm arid environments (high proportion of kaolinite) and the development of marine chemogenic process (formation of chemogenic carbonates).

The Northern catchment areas of the Black sea lie in the zone of influence of the late Pleistocene (Valdai) glaciation, the southern borders of which were located at the latitude of Tver. The formation of the composition of terrigenous material carried out into the basin was influenced by contrasting climate change from interglacial moderately warm humid, when the processes of chemical weathering and soil formation were activated, to cold arid in the glacial stages with the dominance of physical weathering (formation of loess). Such a change in landscape and paleogeographic conditions was clearly reflected in the change in the composition of sediments accumulated during the last (Ostashkov) stage of glaciation and post-glacial. During this period, there was a transition from the terrigenous type of sedimentation with the formation of almost monomineral (illite) clays to biogenic-terrigenous with a high proportion of siliceous (diatoms), carbonate (coccoliths) and organic (sapropel) muds and polymineral clays.

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GROUNDWATER STABLE ISOTOPES AND POLLEN PROXIES FOR DETECTING IMPACT OF THE MEDITERRANEAN MOISTURE TRANSFER ON THE CENTRAL ZAGROS MOUNTAINS, KERMANSHAH, WEST OF IRAN

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Keywords: stable isotope, precipitation, coprolite, Holocene climate, water resources

Introduction

Zagros Mountains with northwest-southeast trend receive moisture mainly from westerlies. Precipitation across the mountain trend changes drastically that could be traced by isotope signature. The Quaternary climate researches in the Zagros area started since 60s of twenty century using different records and focusing mainly on Zagros Lakes (Hutchinson, Cowgill, 1963; Megard, 1967; Van Zeist, Wright,1963; Van Zeist, 1967; Wasylikowa, 1967). Paleontological, palynolgical and geochemical investigations revealed the lake and surrounding areas experienced various climate changes in the late Pleistocene and Holocene consistent with global ones and reflecting local modifications (Wright, 1961; Van Zeist, Wright, 1963; Hutchinson, Cowgill, 1963; Zeist, Bottema, 1977; Wasylikowa, 1967; Megard, 1967; Snyder et al., 2001; Stevens et al., 2001; Wasylikowa, 2005; Wasylikowa et al., 2006) . Kermanshah Province located in the central part of Zagros Mountains in west Iran. The present research aims to retrieve basic hydrochemical information and impact of precipitation on recharge of water reservoirs in the area.

Materials and methods

We have collected 45 water samples from spring and groundwaters. They have analyzed for $\delta^{13}C$, $\delta^{18}O$ and $\delta^{2}H$. The average content of $\delta^{13}C$, $\delta^{18}O$ and $\delta^{2}H$ are -10, -6 and -33 respectively. Also a Coprolites core of 1.5 m has been retrieved from Soleiman Cave, east Kermanshah, dated and analyzed for pollen content (Fig. 1).

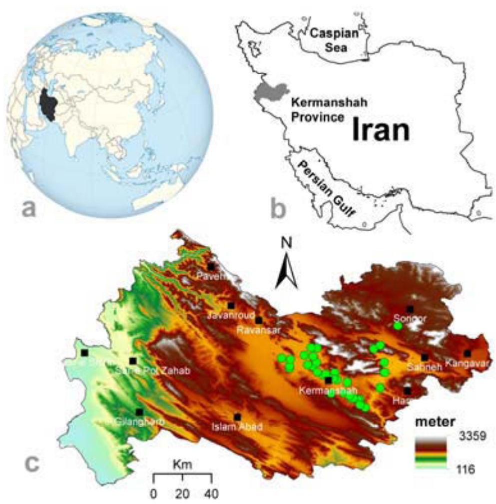

Figure 1. Study area

Interpretation

Deuterium ranges between -43 to -23, δ 18O between -7 to -3.87 and δ 13C between -12 to – 7.04. The results display that graoundwater are more depleted compared to the average world values. The isotope values fall close to the meteorological water line for Iran. However the west and east parts of the studied area show a distinguishable difference. Also the difference is visible in between groundwater and spring water samples. The latter is more enriched in heavy oxygen isotope. The altitudes, evaporation and share of warm period and cold period precipitations are attributed in enrichment and depletion of oxygen and hydrogen isotopes in the Kermanshah groundwater and spring waters. Much of the constant composition of pollens indicate that the climate of the region has been close to today for the last three centuries and was suitable for cereal cultivation. Despite differences in pollen assemblages at the end of the Little Ice Age and recent times, there has been little evidence that the LIA effect was not strong in the area and sufficient water resources were available for the cultivation of cereals.

Pollen and isotope signature in the Zagros area demonstrate that moisture transfer by westerlies intensified since the end of early Holocene with southward displacement of ITCZ and weakening of governing sub-tropical high over Zagros.

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THE MIDDLE PLEISTOCENE SEDIMENTS OF CASPIAN SEA: THE FIRST ABSOLUTE DATES

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During the Quaternary Caspian Sea level changed several times. Researchers have been exploring the Caspian Sea for two centuries. However, there is still no consensus on the number of transgres-sive-regressive events, their scale, chronology, and causes. The most controversial question is about the chronology of paleogeographic events, since absolute dates were obtained only for the last two transgressions: the New-Caspian (the Holocene) and the Khvalynian (the late late Pleisto-cene). The most interesting transgression is Khvalynian, which had a catastrophic character in the opinion of some researchers.

Estimated age of the last huge transgression (Khvalynian; max. highstand +50 m a.s.l.) by different researchers varied from 70,000 years to 11,000 years, i.e. from the first half of the Wurm to the beginning of the Holocene. Estimated age are based on thermoluminescence dating (Shakhovets, 1987, Rychagov, 1997), electron paramagnetic resonance spectroscopy (ESR) (Molodkov, 1992), uranium-ionium (Kuznetsov, 2008; Arslanov et al., 2016), radiocarbon dating (Arslanov et al, 2016; Tudryn et al., 2013). However, there hasn't been dating of sediments that correspond to the maximum level of the Khvalynian basin.

Along the valley of the Volga River and the inflowing valleys of small rivers, the Caspian Sea cre-ated a network of ingression bays during the largest transgressions. In the 20th century, the Middle Volga region was studied and described in details. But for all this time only two absolute dates have been obtained by the radiocarbon method, which are probably irrelevant. Determining the stratigraphic position of the sediments is difficult due to the almost complete absence of the mala-cofauna.

We sampled sediments for OSL-dating in one of the most studied sites - Maliy Karaman (Mosk-vitin, 1962), which reveals coastal sediments (described as deposites of the last major transgression - Khvalynian) and underlying loess with soil horizon.

We conducted the dating in the OSL-laboratory in All-Russian Geological Institute (VSEGEI), Saint-Petersburg. We expected dates as the first decades thousands years and therefore used quartz grains. Purity test and recovery test were conducted. However, it was found that the equivalent dose is significantly higher than we thought, and the quartz is saturated. Therefore, the sediment was analyzed by feldspar according to the post-IR IRSL protocol (Thiel et al., 2011).

For coastal sediments dates were obtained that correspond to the end of MIS 8 — the beginning of MIS 10, and for loess with soil horizon — MIS 13.

Thus, coastal sediments can be correlated with a much more ancient Caspian transgression (early-Khazarian; max. highstand +35 m). Thus, these are the first dates for the middle

Pleistocene depos-its of the Caspian Sea and the first absolute dates in the Middle Volga region.

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PALEOLANSCAPE RECONSTRUCTION OF THE WESTERN PRECASPIAN BASIN IN THE SECOND HALF OF THE HOLOCENE ACCORDING TO GEOARCHAEOLOGICAL DATA

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Introduction

The migration of ancient ethnic groups and the change of the economic activities of various population groups are frequently associated with climatic changes. Adaptation to changing living conditions, a change in food sources led both to the formation of new signs of human body and to a new socio-cultural turn of the history: the appearance of new tools, a different type of housing, the construction of the first settlements, etc. The use of a set of natural-scientific methods allows both reconstructing the features of the natural environment in the past and the related features of migration, resettlement, changes in the type of economic activity and lifestyle of ancient peoples. The most striking and frequently the only evidence of the identity of the culture of ancient people are burial complexes, mounds. One of the natural archives that can save information about the environmental conditions of the past are soils buried under the mounds of these burial complexes. Isolation from external environmental factors ensures good conservation of buried soils. A comparative analysis of the properties of soils buried under archaeological sites of different ages allows us to examine in detail the changes in the natural environment and its individual components over time. In addition, soils are able to store a whole range of additional features of non-pedogenic origin, which can be used for a more detailed reconstruction of the features of the palaeoenvironment. Thus, spores and pollen of plants, phytoliths, faunal remains, etc., are preserved in the soil profile. Consequently, the soil profile can be considered as a kind of data archive containing unique information about the features of past conditions.

Methodology

The most part of the preserved soils under the archaeological sites of the Caspian lowland cover the period of the second half of the Holocene (5000 years) when an ancient burial rite of the dead appeared among ancient ethnic groups. To study the main stages of the evolution of the natural environment in the second half of the Holocene within the Western Caspian, joint soil-archaeological research of the burial mantis Bogomolnye Peski were conducted in the Enotaevsky district of the Astrakhan region. The first construction of the mound was built in the early Bronze Age by the representatives of the Poltava stage of the Pit Grave culture (~4,500 yrs BP). The second construction of the mound, overlapping the first and beyond the main embankment, was built in the early Iron Age by representatives of the Middle Sarmatian culture in the interval of the 1st – 2nd centuries AD (~2000 yrs bp). The height of the mound was 85 cm and its diameter was 35–40 (43) m. The mound was confined to a medium scale elevation — a sand dune. During field studies, 6 soils with different time of burial and three surface soils with similar topographic and lithological conditions were studied. According to natural zoning, the study area is confined to the South Sarpinsky lowland (Doskach, 1979).

In the eastern part, the study area is adjacent to the Volga, in the western part it is crossed by the southern part of the Sarpinsky shallow gully. Hypsometric marks were about 0 meters above sea level. A speciality of the Late Khvalynsk marine and delta-marine plain is the presence of aeolian sand dunes and wind-scoured basins. The parent rocks are the Late Khvalynsky marine and alluvial-marine sands and sandy loam, underlain by the Khvalynsky sandy clay deposits.

To identify the stages of the evolution of the natural environment of the Western Caspian in the Holocene, we analysed buried soils and the preserved remains of the bone skeleton in the main and additional burials. Spore-pollen, phytoliths, meso- and micromorphological analyses were provided in soil samples, the main physicochemical properties of buried and surface soils were determined. To identify the anthropological composition of the population of the region and dietary preferences, bone samples were analysed for the isotopic composition of carbon and nitrogen.

Results

The studied soils of the southern sandy semi-desert are brown arid sandy loamy soils with the following alternation of genetic horizons: AKL - BMK - BCca. According to the studies, the soils of the territory are characterized by the low thickness and poor differentiation of the soil profile into horizons, weak humus accumulation, residual salinity of parent rocks and the overall low intensity of soil formation and weathering. The sparse vegetation cover with high summer temperatures and an abrupt fluctuation in the amount of precipitation over the seasons of the year determine the short spring cycle of formation and decomposition of humic substances. The humus content in the upper horizons of soils varies in the range of 0.8–1.2%.

Based on the studies of buried soils we can conclude, that at the turn of the early and middle subboreal period (4,500 years ago) within the studied territory there was a peak of climate aridization, which led to the change of herbaceous-grassy and cereal steppes to cereal-goosefoot deserts with a sharp decrease of the bio-productivity of landscapes. Changes in land cover led to the migration of ancient ethnic groups. Thus, thirteen burials were discovered in the Bogomolnye Peski burial group. The remains of 5 individuals date back to the Bronze Age, among them four men and one child. Men’s growth is close to average; the proportions of human bodies indicate a continental type of adaptation. Type of men activity was associated with weight lifting and intense walking. Stress markers have been found in a number of individuals: either enamel hypoplasia of the teeth or the signs of Harris lines. These markers indicate hunger or illness in early childhood.

Conclusions

Analysis of the investigated buried soils determined the polygenetic of the soils of the region. The soils started to develop in the interval of 9000-10000 years. At the first stages of formation, the soil cover was homogeneous and consisted of marsh and meadow soils. One of the periods of strong transformations of the natural environment was the peak of climate aridization during the middle of Preboreal time, which led to soil salinization processes and a change in the land cover. The changes in the natural environment led to the migration processes of ancient ethnic groups.

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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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GENUS DIDACNA MOLLUSKS — BIOSTRATIGRAPHICAL BASIS FOR CORRELATION OF THE PONTO-CASPIAN NEOPLEISTOCENE EVENTS

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Keywords: Caspian Sea, Pont, Manych, Neopleistocene, biostratigraphy, genus Didacna, correlation

The mollusks of the genus *Didacna* Eichwald playing a key role in stratigraphical and paleogeographic reconstructions for the Caspian Sea are used by authors for the same purposes in the Black Sea region and in the Manych depression. The work purpose is the drawing up the regional biostratigraphical schemes of the Caspian, Pont and Manych Neopleistocene on the basis of the analysis of spatial and temporary distribution of species of one genus *Didacna* and correlation of events of the Ponto-Caspian Seas on this biostratigraphical base. The object of research is the Neopleistocene deposits and the mollusks of the Caspian and Black Sea regions. The subject of research is the spatial-temporal distribution of mollusk shells of the genus *Didacna* as a basis of correlation of the basins of the Caspian Sea and the Black Sea in the Neopleistocene.

The use of species of one genus for the creation of three regional biostratigraphical schemes is a basis for correlation of deposits and events of the Pont and the Caspian Sea. The material is collected by authors for many years of field and laboratory studying of Neopleistocene deposits and malacofauna of the Caspian Sea, the Black Sea and the Manych depression (Svitoch, 1967, 1991; Svitoch and Yanina, 1997, 2007; Sitoch et al., 1992, 1995, 2010; Yanina, 2005, 2006, 2008, 2012; Yanina and Svitoch, 1990). The main method is malacofaunistic method. It includes the analyses of taxonomical structure, taphonomy, phylogeny, biostratigraphical distribution, historical development, and biogeography of mollusks. The study focuses on the bivalve genus *Didacna*, an index fossil genus for the modern Caspian Sea and an endemic fossil for the Quaternary Ponto-Caspian basins. The genus is known for its high evolutionary rates at the species and subspecies levels.

The study of peculiarities and patterns in the spatial-temporal distribution of mollusk shells of the genus *Didacna* in the deposits of the Neopleistocene of the Ponto-Caspian region showed, that the molluscan fauna represent a complex hierarchical system of faunal assemblages with different taxonomic composition and at different taxonomic levels: faunas, complexes, subcomplexes, which become the basis for establishment of stratigraphical subdivision and paleogeographical reconstructions. On the basis of the biostratigraphical position of the Caspian Didacnas in the Manych and Pont Neopleistocene the correlation of the late Bakunian transgressive stage of the Caspian Sea with the late Chaudian transgressive stage of the Pont is established; two stages of the Early Khazarian transgression of the Caspian Sea are correlated with two Euxinian – Uzunlarian basins of the Pont; the Late Khazarian transgression of the Caspian Sea is correlated with first half of the Karangatian transgression of the Pont; the Hyrcanian transgressive basin of the Caspian Sea is correlated with the second half of the Karangatian transgression; the Early Khvalynian transgression of the Caspian Sea is correlated with Pontian Surozhian and New Euxinian transgressions.

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LOCATING AND IDENTIFYING THE LOCATION OF INTENSIVE DEEP FLUID STREAMS ON THE BLACK SEA BOTTOM USING MEIOBENTHOS

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The Black Sea megadepression is one of the largest methane reservoirs on Earth (2). Powerful degassing of the sea bottom occurs mainly due to the flow of fluids through tectonic ruptures on the seabed, as well as microbiological processes throughout the depth range, and it manifests itself in the form of flares (cold seeps) and mud volcano emissions. According to approximate estimates, only 4.95–5.65 Tg (1 Tg = 1012 g) of methane is emitted from the seeps into the water column annually. Overall, 1 billion m3 of methane is emitted from the bottom of the Black Sea per day. About 80 billion m3 of methane is dissolved in seawater (8), despite the fact that the Black Sea waters are constantly renewed, though slowly, through the Bosphorus strait every 400–2000 years (13). This means that Black Sea water is constantly saturated with methane, for which there must be a powerful fluidogenic flow of hydrocarbon gases (HG) from deep rocks, and therefore the presence of reservoirs containing them under the seabed (Shnyukov, Yanko, 2014, 2017).

Locating and delimiting such reservoirs under the sea bottom is essential for the proper placement of exploratory drilling on the seabed. Along with geophysical methods, abiogenic (Chepizhko et al., 2019) and biogenic (Yanko et al. 2017) parameters of sediments should be used. The latter are based on the biotic response to elevated concentrations of HG in sediments and the water column, and they are reflected by changes in the qualitative (taxonomic) composition and quantitative (densities) distribution of organisms (Pletnev et al., 2014; Yanko et al. 2017). In addition, isotopic composition of those organisms that have hard shells can be used as well. It must be taken into account that different groups of organisms react to elevated concentrations of HG in different ways. For example, the penetration of HG (in particular methane) into the body of fish (nekton) destroys their vital functions and adversely affects respiration, nervous, and hematopoietic systems, as well as enzymatic activity, bringing about death in a relatively short period of time (Patin, 2004).

In terms of living conditions on the sea bottom, meiobenthos should respond to HG emissions even faster and more actively than nekton. However, this subject has been studied insufficiently. According to published data, HG and their dominant component, methane, can create positive and negative effects, or it can pose no effect on biota at all (Dando, Hovland, 1992; Jensen et al., 1992).

The first comparative analysis of the spatial and taxonomic distribution of benthic organisms on the Black Sea bottom in places with and without methane emissions was in the 1990s (Luth, Luth, 1998), and later, an analysis was repeated including the oxygen/hydrogen sulfide gradient (Pletnev et al., 2014; Sergeeva, Anikeeva, 2014). Data on mollusks are sparse and conflicting. For example, Polykarpov et al. (1998) indicate that methane has no effect on the spatial distribution of Mytilus phaseolinus in the northwestern Black Sea in the depth range of

60–256 m, while Lushvin (Internet source) suggests the opposite based on a decrease in mussel production of 3–5 times with the activation of seismic activity, mainly in Romania.

According to some authors, methane has a positive effect on organisms, especially if they live directly on methane seepages, where microbial mats (21) that feed zoobenthos are formed. Sergeyev and Gulin (2006) agree with this. They report a high density of meiobenthos (nematodes, polychaetes, etc) in the area of cold seeps near the Dnieper submarine canyon (NW Black Sea, water depth 182–308 m). At the same time, Gulin et al. (2010) emphasize that microbial mats are characterized by an alternation of adverse and favorable periods for the penetration and maintenance of zoobenthos. During periods when methane emissions from the seabed are intensified, species diversity and density of zoobenthos is lower compared to background sites. Portnova et al. (2014) admitted that, in numerical terms, nematodes numbered over 70% of the meiobenthos at the time in areas of methane emissions of the Norwegian Sea. The second largest group was represented by harpacticides, which make up more than 8% of the total population of meiobenthos. In this case, the number of multicellular meiobenthos, in general, and nematodes, in particular, on bacterial mats near methane emissions is 1.3–1.5 times higher than in background areas, and they are larger in size. Species diversity of nematodes decreases from background conditions to fields of pogonophores, and then even further on bacterial mats.

Panieri (2003) admits a sharp decline in the population and species diversity of foraminifera, as well as the presence of only cosmopolitan species in areas of methane emissions in the Adriatic Sea. Kumar and Gupta (2005) note the tremendous stress for the fauna in areas of high methane content within the gas hydrate field of the northwest Atlantic, and they emphasize that epibenthic species that are adapted to life in an oxygen environment do not survive there. However, such an environment is suitable for some endobenthic species adapted to life under conditions of oxygen deficiency and even in anoxic or sulfide environments (Bernhard, 1996; Sen Gupta et al., 1997).

The purpose of this work is to contour anomalies of deep fluid flow on the Black Sea bottom by using taxonomic and quantitative distributions of meiobenthos with hard shells (foraminifers, ostracodes) and without them (nematodes) on the basis of a combined gasometric, geochemical, and meiobenthic survey (Yanko et al., 2017). This work is a continuation of previous research (Tkachenko et al., 1974) but at a new level and with the use of modern equipment and methods.

This presentation will outline the prospects of location and identifying anomalies in the deep fluid distribution at the Black Sea bottom using the meiobenthic organisms that appear to be quite promising in this role as the main proxy. Coupled with geophysical, gasometric, and geochemical survey of the bottom sediments, it will enable us to develop basic criteria for contouring methane reservoirs under the sea bottom. Subsequently, this will reduce the costs of search operations while increasing their reliability.

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NEW DISCOVERIES OF THE LOWER PALEOLITHIC ON THE SHORES OF THE EARLY PLEISTOCENE CASPIAN SEA

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Our earliest ancestors started to settle the Caucasian Mountains and the Fore-Caucasus — the regions which probably formed a single zone of accessible land between the Apsheron (Caspian Sea) and Gurian (Black Sea) basins — soon after 2 Ma as is evidenced by recent discoveries of the Early Paleolithic sites in the Caucasus and neighborhood (Azykh, Dmanisi, Karakhach), Dagestan (Ainikab I, Mukhkai I and II, Rubas I), Rostov region (Liventsovskoe) and the Taman' peninsula (Bogatyri/Sinyaya Balka, Rodniki 1 and 2, Kermek, Tsymbal) (Fig. 1). The finds from Dmanisi suggest that the Caucasian Oldowan industries were created by *Homo ergaster-Homo erectus*.

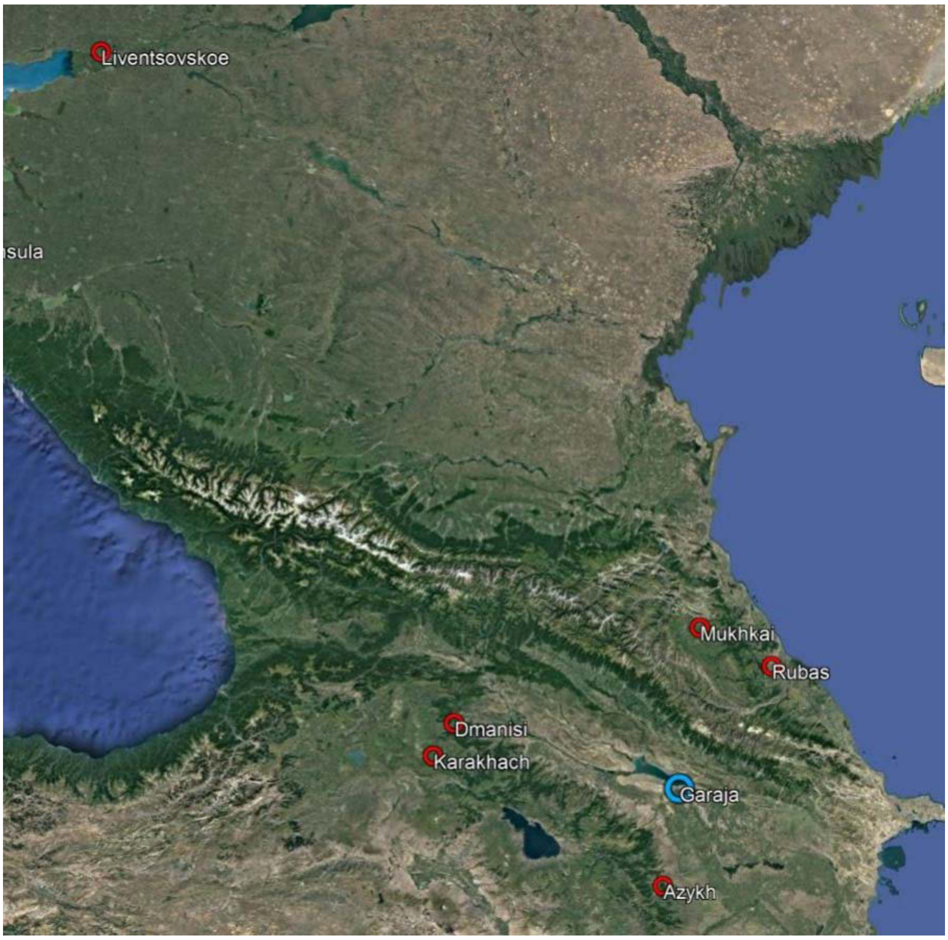

Figure 1. Early Paleolithic sites of the Caucasus and neighborhood

During several decades, the Azykh cave in Azerbaijan was considered the earliest evidence of hominid settlement in the south of the Caucasus. The lowermost layers (VII-X) of Azykh contained a "local Oldowan industry" designated as the Kuruchai culture and dated to 1.2 Ma.

In 2012 a new Early Paleolithic site, named Garaja, was discovered on the southern shore of the Mingachevir (*Mingəçevir*) reservoir in Azerbaijan. The site yielded both stone artifacts and Early Quaternary faunal remains. The Paleolithic tools were found in three levels, being associated with different stratigraphic layers. The stratigraphic section is characterized by alternation of marine and continental deposits. Altogether, two marine and two continental series of strata were identified. Each of them has a complex internal structure reflecting the history of the Caspian sea-level fluctuations during the Baku stage, which corresponds to the lower half of the Ionian stage and is dated to the time period from 800 to 400 Ka.

One of the most important advantages of the newly discovered site is the possibility to date the Early Paleolithic artifacts on the basis of the stratigraphy of the enclosing deposits of both marine and continental genesis. This, in turn, allows making both global stratigraphic correlations and distant correlations with different regions of West Asia and Europe.

The marine series consist of stratified clays, loams and sandy loams. The thickness of the lower bed exceeds 50 m, while that of the upper one is about 10 m. Each bed contains a number of layers with well preserved malacofauna firmly associated with the Baku stage (different species of *Didacna*). In addition, the lower bed contains a layer of volcanic ash up to 40 cm thick. The ash was deposited in water and is geochemically altered and heavily contaminated by clayish materials. Its upper part has become discolored to rose. It should be noted that in previous geological descriptions of the region the «rose ash» has sometimes been used as a stratigraphic marker, while in fact such coloration is a result of sedimentation conditions and cannot serve to correlate different layers of ash.

The continental series represent a complex combination on sands, clays and gravels which occur in the form of layers and lenses cut by numerous sea-level fluctuations. The cross sections of these beds are dominated by gray obliquely laminated coarse-grained and middle-grained sands with gravel lenses (alluvial-delta deposits). There are also lenses of thin-laminated lacustrine clays. All groups of continental deposits contain abundant remains of large mammals. It should be emphasized that these remains are in good condition. They include the upper part of a *Rhinoceros merckii* skull with a full dental arch, a nearly complete skull of the forest elephant (*Loxodonta cyclotis*), a large bull skull with two horns and remains of teeth, etc. The bones occur in both sands with small gravels and lacustrine clays. In addition, the sands contain numerous ferruginized remains of big tree trunks up to 50 cm in diameter. Evidence like this indicates, first, that the remains of mammals were only slightly displaced and, second, that these animals inhabited a big river delta. It is the deposits of this river that from the upper and lower beds of continental deposits. The accumulation of this alluvium was interrupted by one of the Baku stage transgressions of the Caspian Sea. In addition, a number of short term breaks in the river alluvium sedimentation took place due to sea floods which led to the formation of thin lenses with marine faunal remains. These lenses occur within alluvial sands and are from 5 to 50 cm thick. The available evidence allows to conclude that the area in question was a part of the Baku stage littoral zone. The territory was dominated by forest landscapes with specific fauna.

The archaeological collection of Garadzha is mainly composed by handaxes, choppers and a number of peculiar finds. There is also a cleaver, which is the first find of the kind for the Caucasian Acheulean. This tool has indisputable analogies in the Acheulean of Africa.

The collections from the lower and middle levels are particularly rich in crude heavy duty tools. In addition to diverse choppers, this category of tools includes a subcategory of specific objects conventionally designated by us as "strikers". They are pebbles broken in halves and flaked/retouched over the whole perimeter of the edge.

Of special interest in the Garadzha collection are large two-handle choppers weighting 4 kg and more. This tool type was first discovered in the lower layers of the Azykh cave and served as the basis for recognizing a new Paleolithic «culture». For the time being, 6 such tools, characteristic of the so called Kuruchai culture, have been found at Garadzha.

In the Northwestern Caucasus the Oldowan stage of the Early Paleolithic is represented by the Taman' Paleolithic Complex, which includes 4 localities (Bogatyri/Sinyaya Balka, Rodniki 1 and 2, Kermek, Tsymbal), that were discovered in 2002-2006 and have since then been studied by S.A. Kulakov and V.E. Shchelinsky.

The culture-bearing stratum of Kermek is believed to be the oldest one. The complex investigations, including paleomagnetic analysis, point to an age of about 2 Ma. The bone bed of Bogatyri/Sinyaya Balka and the culture-bearing horizon of Rodniki 1 can preliminary be dated to the Middle Eopleistocene, 1,6-1,4 Ma. The culture-bearing horizon of Rodniki 2 is stratigraphically most close to Jaramillo Subchron, 1,1 Ma. The cessation of functioning of the Taman' complex of Early Paleolithic sites took place not later than the end of the Eopleistocene or the beginning of the Pleistocene, as is evidenced by the fact that the deposits of the later Chauda-Baku time have never been observed in the stratigraphic cross sections of these sites.

The complex study of the Taman' sites brought about an interesting observation regarding a special character of *Homo erectus* adaptation to the Eopleistocene environments of this region. It could have been a littoral adaptation. According to V.E. Shchelinsky, the littoral zone of a big water basin provided a greater safety from predators and gave access to rich food resources. However, no direct evidence that the inhabitants of the Taman' sites used marine foods have yet been found.

The association between the Caucasian Early Paleolithic sites and the shores of big water basins can be seen also in Central Dagestan. The Eopleistocene sites of this region are thought to have been located in the littoral zone of the Apsheron basin. The Early Paleolithic site of Rubas I in Southern Dagestan appears to have been confined to the shore of the Akchagyl-Apsheron basin of the Caspian Sea. Even Dmanisi in Southern Georgia, according to some reconstructions, also was situated on the shores of a big lake.

Interestingly, the Caucasian stratified Early Acheulean sites of Darvagchai I (coastal Dagestan) and Garadzha (Azerbaijan) too are confined to the shores of the Apsheron/Baku basins of the Caspian Sea.

The littoral adaptation of the first Caucasian hominids was not the only one. In the inner areas they also used caves. The cave sites of Azykh and Treugolnaya confirm the existence and long duration of this way of adaptation of the earliest *Homo* to the paleoenvironmental conditions of Eurasia.

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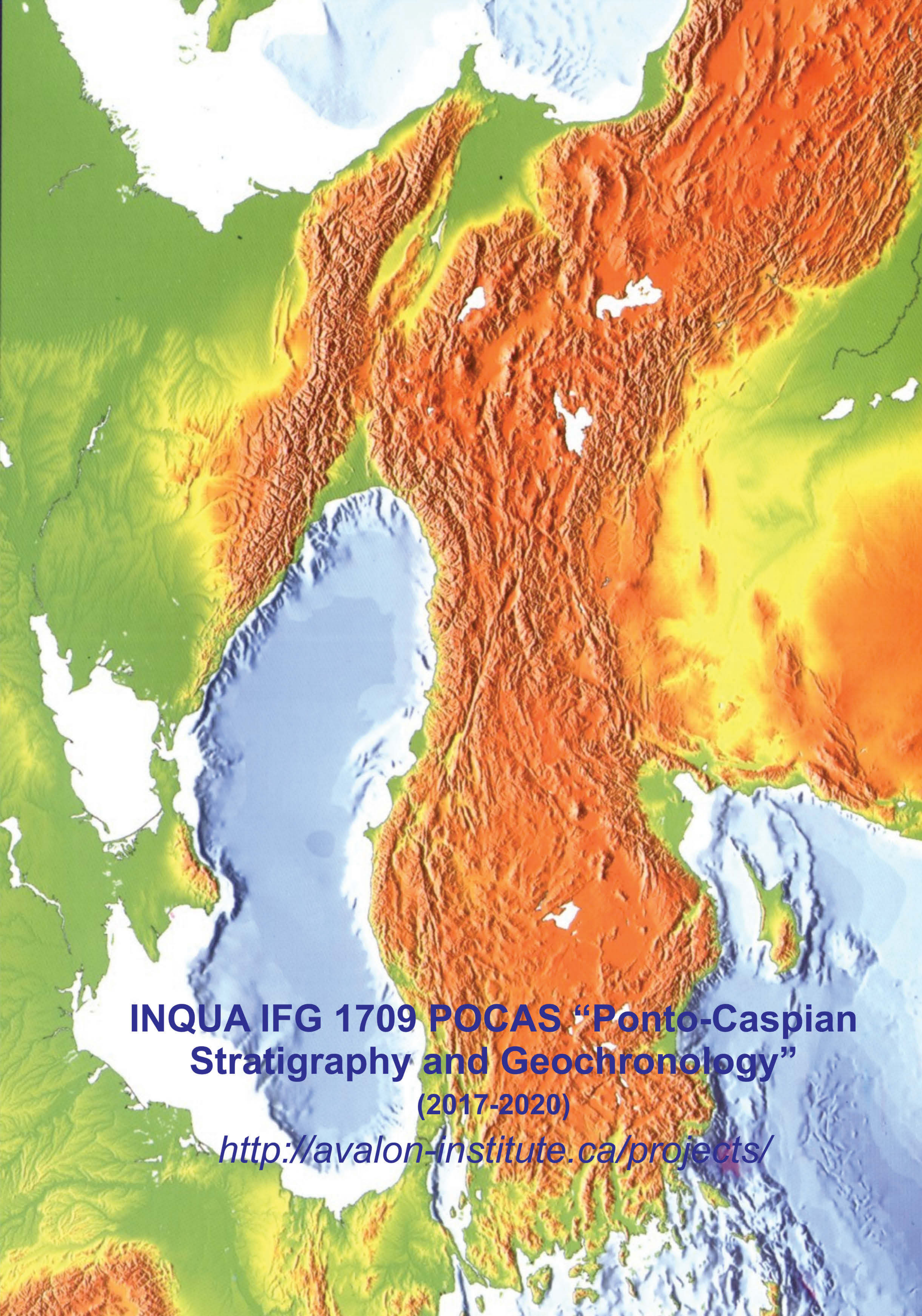

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