NECLIME

NECLIME -
Neogene Climate Evolution in Eurasia,
annual meeting 2017

Institute of Botany of the Armenian National Academy of Sciences
Yerevan 18 - 25 September 2017

Organized by:
Ivan Gabrielyan, Angela A. Bruch & Torsten Utescher

THE ROLE
OF CULTURE
IN EARLY
EXPANSIONS
OF HUMANS

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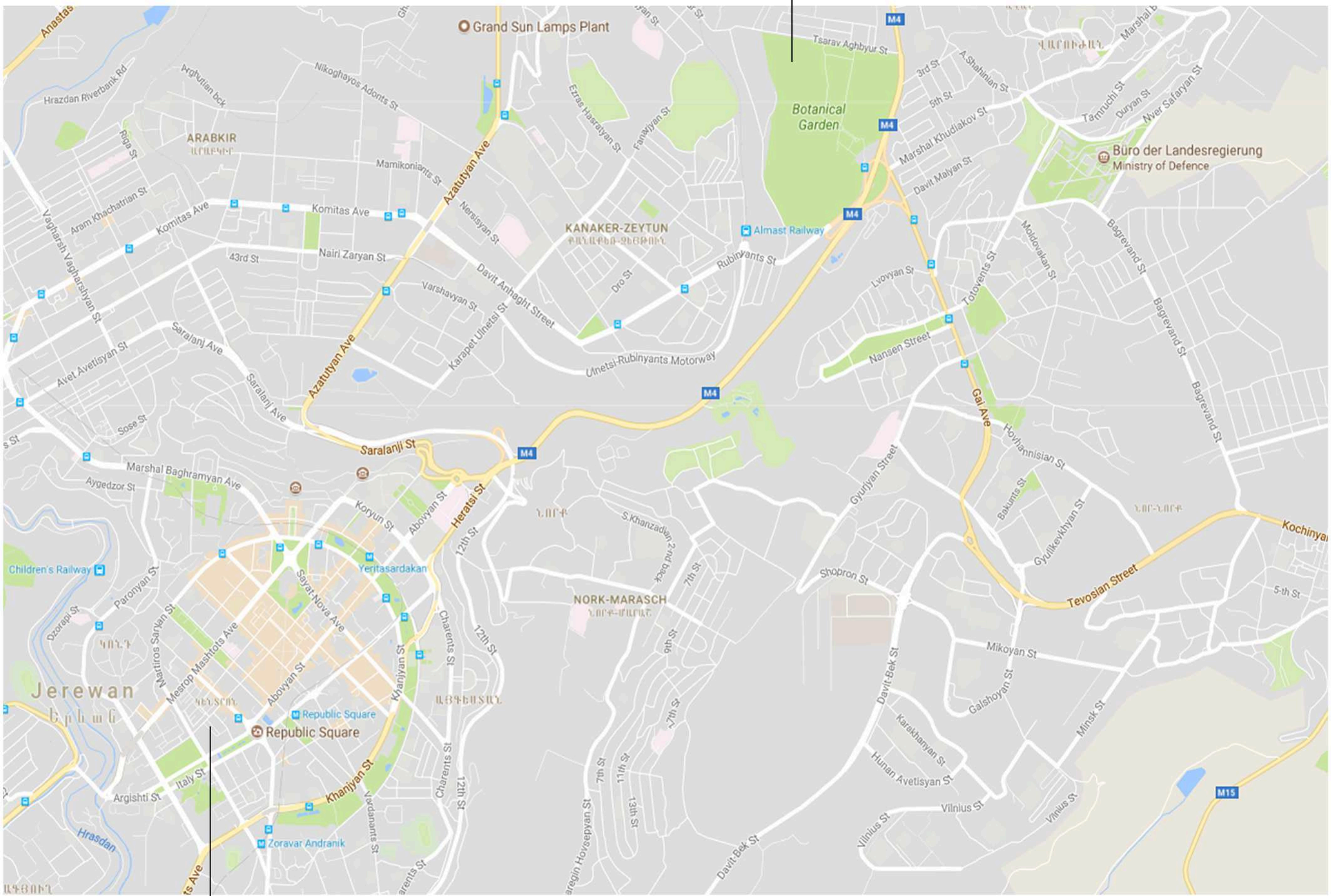
Botanical Garden



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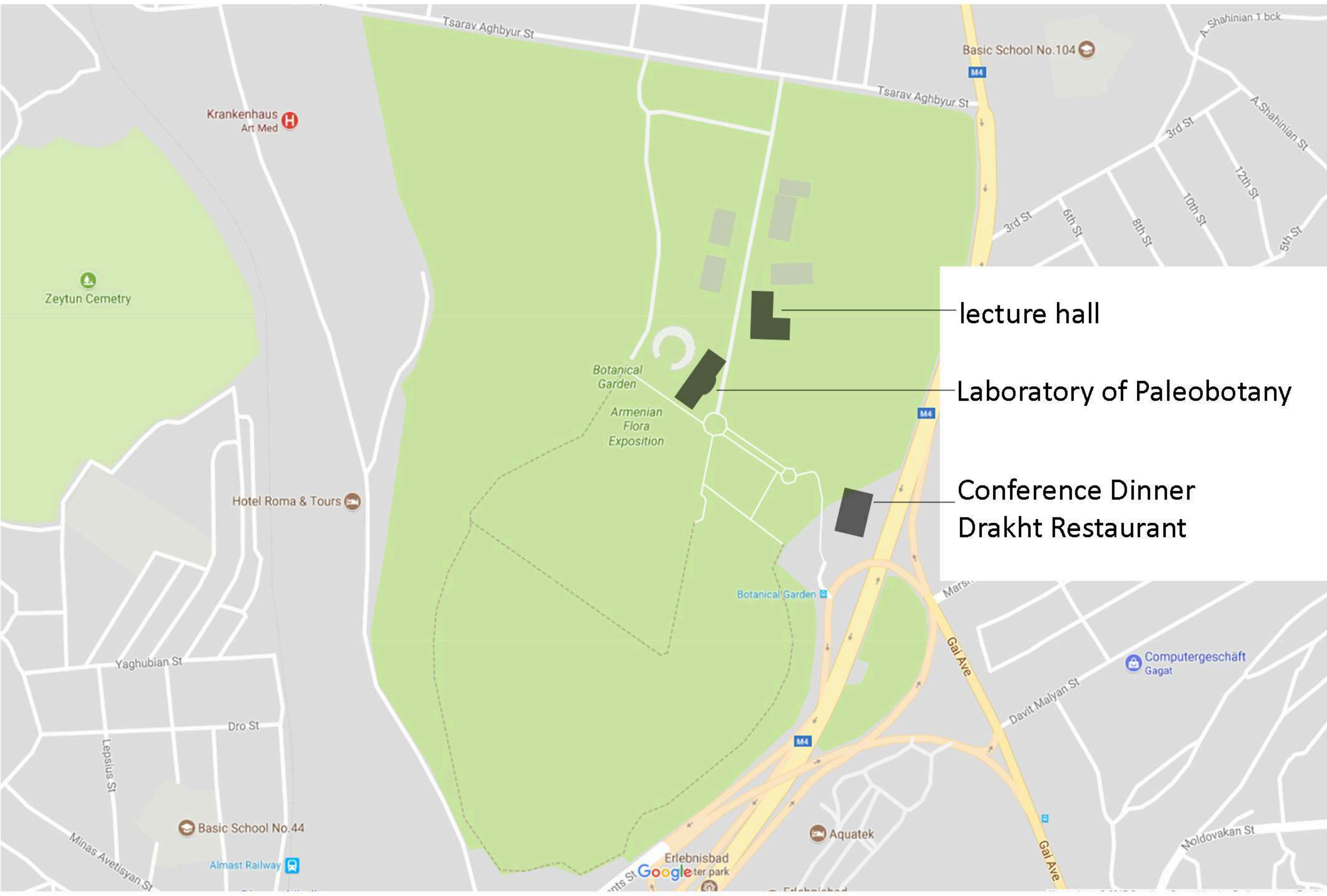

Institute of Botany
National Academy of Sciences of the Republic of Armenia
Acharyan Str. 1, 0040 Yerevan, Armenia

Բուսաբանության ինստիտուտ
(կամ Երևանի բուսաբանական այգի)
ՀՀ Գիտությունների ազգային ակադեմիա
Աճառյան 1,0040, Երևան,Հայաստան

GENERAL PROGRAM

Monday 18.09.	15:00 – 18:00	Registration, icebreaker and visit of the Botanical Institute and Garden (Administrative building, Botanical Institute, Acharyan Street 1, 0040 Yerevan, Armenia)
Tuesday 19.09.	10:00 – 18:00	Opening and scientific sessions (lecture hall in the main building of the Botanical Institute)
	20:00	Conference Dinner at the Drakht Restaurant (Acharyan Street 1/1, 0040 Yerevan, Armenia)
Wednesday 20.09.	10:00 – 18:30	Scientific sessions (lecture hall)
Thursday 21.09. – Sunday 24.09.		Excursion

TUESDAY 19.09.2017

10:00 Opening

Vardanyan, Z., Gabrielyan, I. & Bruch, A.A.: Welcome addresses

Utescher, T.: Introduction and NECLIME news

11:00 Anush Nersesyan (key note lecture)
Vegetation of Armenia

12:00 coffee break and **poster session**

12:30 Ivan Gabrielyan (key note lecture)
Paleobotany of Armenia

13:30 Lunch break

Chairperson: Zhe-Kun Zhou

14:30 Yong-Jiang Huang, Lin-Bo Jia, Qiong Wang, Volker Mosbrugger, Torsten Utescher, Tao Su & Zhe-Kun Zhou
Cenozoic plant diversity of Yunnan: A review

15:00 Ira Shatilova & Angela A. Bruch
The Late Cenozoic history of flora and vegetation of Georgia

15:30 Eliso Kvavadze
Holocene vegetation and climate history of the Transcaucasus according to palynological data

16:00 coffee break and **poster session**

16:45 Astghik Papikyan
The late Pliocene Hortun flora

17:15 Angela A. Bruch, Ivan Gabrielyan & Ira Shatilova
Early Pleistocene vegetation and climate history of the Southern Caucasus – paleobotanical implications for the Dmanisi Landscape

17:45 Torsten Utescher & NECLIME members
Quantification of climate requirements of plant taxa using digital resources

19:30 Conference dinner

WEDNESDAY, 20.09.2017

Chairperson: Dima Gromyko

10:00 Edoardo Martinetto
The Messinian palaeofloras of the Italian evaporitic deposits: record of a "subtropical" humid forest

10:30 Wei-Ming Wang
Miocene palynoflora from Penghu islands, Taiwan

11:00 Zhe-Kun Zhou
Fossil stories from Tibet

11:30 coffee break and **poster session**

12:00 Svetlana Popova, Torsten Utescher, Angela A. Bruch, Dmitri V. Gromyko & Volker Mosbrugger
Late Pliocene to early Pleistocene palaeoenvironments at high latitudes of the European part of Russia (Ugra peninsula)

12:30 Arata Momohara, Takeyuki Ueki & Takeshi Saito
Vegetation and climate histories between MIS 63 and 53 in the Early Pleistocene in central Japan based on plant macrofossil evidences

13:00 Martina Stebich, Jens Mingram, Norbert Nowaczyk, Eva Niedermeyer, Horst Kämpf & Johann Rohrmüller
Vegetation and climate of the Saalian Glacial-Interglacial complex: new evidence from the Neualbenreuth Maar (Bavaria, Germany)

13:30 Lunch break

Chairperson: Torsten Utescher

14:30 Andrea K. Kern, Allan Sandes de Oliveira, Paul A. Baker, Gary S. Dwyer, Cristiano M. Chiessi, Francisco W. da Cruz, Jr., Cleverson, G. Silva & Debra A. Willard
Paleoclimatic variations during glacial-interglacial cycles in semi-arid Northeast Brazil and their connection to the Amazon rainforest

15:00 Yul Altolaguirre, Angela A. Bruch & Luis Gibert
High-resolution palynological analysis of the Early Pleistocene regional environment before, during and after the first expansion of early Homo into

15:30 Christine Hertler & Susanne Haupt
"Any suggestions for dinner?" - Hominid food supply in Sangiran

16:00 coffee break and **poster session**

16:45 Torsten Utescher & Angela A. Bruch
NECLIME final discussion

Poster

Müge Atalar, Marianna Kováčová, Ilaria Mazzını, Elsa Gliozzi, Torsten Utescher & Mine Sezgul Kayserı Özer

Evaluation of the Late Messinian Lacustrine Cankiri Basin – its Palaeoenvironmental and Palaeolimate analysis based on Palynology

Angela A. Bruch, Eliso Kvavadze & Ivan Gabrielyan

Changes of Vegetation and Plant Resources in the Southern Caucasus – Plant Biodiversity in TimE and Space (PlantBITES)

Vladimir Bozukov & Ivan Gabrieyan

Neogene macrofloras from Armenia and Bulgaria. A comparison

Maia Bukhsianidze, R. Chagelishvili, D. Vassilyan & Jordi Agustí

Late Miocene vertebrate site of Chachuna (Iori Highlands, Georgia, Southern Caucasus)

Marianna Kováčová, Šarinová, K., Vlček, T., Zatovičová, A., Hudáčková, N., Ruman, A., Halásová, E., Jamrich, M. Rybär, S., Šujan, M. & Kováč, M.

Multiproxy analysis of the Late Miocene sediments from Danube Basin — case study

Oriol Oms, Uwe Kirscher, Angela A. Bruch, Maia Bukhsianidze, R. Chagelishvili, Jordi Agustí, S. Kuthsishvili & David Lordkipanidze

Magneostratigrahic age constraints of the Late Miocene to Early Pleistocene sedimentary succession of the Kura Basin (Georgia, Caucasus)

Meike Schulz, Selina Mahler, Karen Hahn, Anna Leßmeister & Angela A. Bruch

Plant food resources and inferences on the diet of Homo erectus in the Caucasus

Olena Sirenko

Stages of vegetation development of Ukraine in late Pliocene

Tetiana Stefanska & Vadym Stefanskyi

Record of climatic and geologic events in faunal assemblages and lithofacies of the Southern Ukraine Miocene sections

Yuqing Wang, Arata Momohara & Yongjiang Huang

Stomatal density variation of Early Pleistocene Fagus leaves from central Japan Hindering paleo-CO2 reconstruction or indicating palaeo-altitude?

THURSDAY 21.09.2017 — SUNDAY 24.09.2017

21.09.2017

10:00 departure from the hotel

Bus travel to Sisian, Southern Armenia: modern vegetation on a transect from lowland semi-desert to subalpine meadows, incl. stop at Kor Virap monastery and Areni winery.

20:00 arrival in Sissian, accommodation, dinner and breakfast at hotel

22.09.2017

10:00 departure from the hotel

Excursion in the Vorotan River Valley: plant fossil sites, geology, modern vegetation and culture

20:00 arrival in Sissian, accommodation, dinner and breakfast at hotel

23.09.2017

10:00 departure from the hotel

Excursion to Tatev monastery: plant fossil sites, geology, modern vegetation and culture

20:00 arrival in Sissian, accommodation, dinner and breakfast at hotel

24.09.2017

10:00 departure from the hotel

Travel back to Yerevan, incl. stops at the archaeological site of Areni Cave and Noravank monastery

20:00 farewell dinner in Yerevan

ABSTRACTS
IN ALPHABETICAL ORDER

High-resolution palynological analysis of the Early Pleistocene regional environment before, during and after the first expansion of early Homo into Southern Spain

Yul Altolaguirre[1,2], Angela A. Bruch[1] & Luis Gibert[3]

[1] ROCEEH Reserch Centre, Senckenberg Research Institute, Frankfurt/Main, Germany
[2] Deptartment of Geosciences/Geography, Goethe University, Frankfurt/Main, Germany
[3] Dept. Enginyeria Minera i Recursos Naturals, Universitat Politécnica de Catalunya, Manresa, Spain

The Baza basin (SE Spain) is the largest of the Betic continental basins. It is located between the two main tectonic regions of the Betic Ranges. It contains a continuous and well preserved record of lacustrine sedimentation. This lake system originally formed when the basin became endorheic during the Late Miocene and ended in the Middle Pleistocene due to its fluvial capture by the Guadalquivir River. The basin harbors numerous Pleistocene mammal fossil sites and the site of the oldest hominin occurrence in Western Europe, Barranco León in the Orce region (1.4 Ma). The planned high resolution palynological analysis from the lacustrine facies will shed light on the environmental parameters during the first expansion of Homo into southern Europe. The sampled material was obtained from the Palominas Core, a 107.5 m drill core which contains pollen rich sediments between 1.5 and 1.1 Ma. The high-resolution pollen analysis will include the application of quantitative methods for climate and vegetation reconstructions. The application of the Coexistence Approach method could yield accurate paleoecological information and the use of Plant Functional Types analysis will reveal the biome distribution during each of the Early Pleistocene orbital climatic cycles represented in the core material. Preliminary palynological results for the palynological study of the core material are presented together with the expected outcome for the on-going research. The first pollen counts show clear environmental fluctuations from humid to dry environments. The variation between the amount of tree pollen versus herb pollen points to landscape changes. The vegetation growing in the basin became more open and dryer. Landscape and humidity changes would have impacted human expansion into southern Spain. The continuation of the high resolution analysis from the drill core will provide direct evidence for environmental conditions before and after the expansion of Homo into Western Europe. The results will be in comparison with contemporary palynological successions from the Caucasus and Southern Europe in order to achieve a broader understanding of large-scale climatic patterns in the Mediterranean and Western Eurasian region.

Neogene macrofloras from Armenia and Bulgaria. A comparison.

Vladimir Bozukov[1] & Ivan Gabrieyan[2]

[1] Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, Sofia, Bulgaria
[2] Institute of Botany, National Academy of Sciences of Armenia, Yerevan, Armenia

So far a comparison between Armenian and Bulgarian paleofloras is not done. Results of such a comparison would give valuable information about the processes of migration of plant species in time and space in the region of SE Europe; about the formation of the specific features of both fossil and recent floras in different regions; by paleofloras change, we can make conclusions about the climate evolution on the territories close to Black Sea.
This study included Neogene leaf macrofloras of Armenia and Bulgaria. Used references for Armenia are as follows: late Oligocene - early Miocene flora of Dilijan (26 taxa) (Harutyunyan, 1974); late Sarmatian floras of Hrazdan (39) (Gokhtuni, 1968) and Mangyus (11) (Takhtajan, Kutuzkina, 1986; Gabrielyan, Manakyan, Hovsepyan, 2000); early Pliocene floras of Hortun (24) (Gokhtuni, 1987; Gabrielyan, 1991; Papikyan, 2016) and Meghri (5) (Takhtajan, 1956). Late Miocene flora of Arzni (3) and late Pliocene flora of Nurnus (3) are not used, due to poor composition. Used references of Bulgaria are: late Oligocene - early Miocene flora of Valche Pole (38) (Bozukov et al. 2008); late Sarmatian floras of NW Bulgaria (37) (Palamarev & Petkova 1987); late Pontian – early Dacian floras of Sofia Basin (147) (Stojanoff & Stefanoff 1929; Stefanoff & Jordanoff 1934, 1935) and Gotse Delchev Basin (67) (Kitanov 1984). The early Miocene flora of Chukurovo (64) (Palamarev 1964), middle Miocene flora of Satovcha (111) (Bozukov 1998a-b, 1999a-b, 2000) and late Pliocene flora of Sofia Basin (Kitanov & Nikolova 1956) are not used due to a lack of analogous floras or an insufficient number of taxa in the analogue.
Jaccard similarity coefficient is used to compare fossil floras. It was established following values: the coefficient is 0.08 for the late Oligocene - early Miocene floras; 0.12 for the late Sarmatian floras; 0.06 for the early Pliocene floras. Considering the hypothesis of Paratethys Paleogeography represented by Rögl (1999), these results can be interpreted as follows. On the Oligocene - Miocene boundery there was no land connection between recent territories of Armenia and Bulgaria. While the climatic conditions were close because of the vast sea basin covering their territories. Such a situation is a prerequisite for the development of similar floras because of similar climatic conditions, but otherwise isolated by the water basin paleolands have enough differentiation between them. During late Sarmatian territories of Armenia and Bulgaria fall into the seacoast of the Paratethys. This favors the development of relatively homogeneous flora due to similar climatic conditions caused by the water basin and the possibility of migration on this coastline. This explains the highest coefficient of similarity - 0.12 between late Sarmatian flora of Armenia and Bulgaria.

Palaeogeographic changes during the early Pliocene, which are caused by the drought in Europe in the late Miocene, contribute to the formation of different climatic conditions in the territories of Armenia and Bulgaria. The Bulgaria proximity to large water bodies such as the Black Sea, the Mediterranean and the influence of the Atlantic Ocean make it possible to develop on its territory rich in composition and various in origin flora during early Pliocene. Proof of this are the numerous registered species in Sofia and Gotse Delchev Basins (182 taxa). On the territory of Armenia, however, at the same time the climate is becoming more continental and this led to the impoverishment of flora - were registered only 29 taxa. The difference in circumstances of the vegetation development led to the lowest coefficient of similarity - 0.06, despite the potential for plant migration by land.

Early Pleistocene vegetation and climate history of the Southern Caucasus – paleobotanical implications on the Dmanisi Landscape

Angela A. Bruch[1], Ivan Gabrielyan[2] & Ira Shatilova[3]

[1] ROCEEH Research Centre, Senckenberg Research Institute, Frankfurt/M, Germany
[2] Institute of Botany, National Academy of Sciences of Armenia, Yerevan, Armenia
[3] Georgian National Museum, Tbilisi, Georgia

To understand the Early Pleistocene local environments in Southern Caucasus as prerequisites for the first appearance of humans in this area, plant fossils serve as a base for quantitative vegetation and climate reconstructions. By comparing short-term vegetation changes at different climatic events and in different regions, it is possible to understand the mechanisms of climatic influence on the local vegetation, to “translate” the global climatic signal to the local setting, even to phases without a plant fossil record. Especially in the Southern Caucasus with its strong relief, it is crucial to understand altitudinal and spatial differentiation of vegetation units and their shifts with climate change.
High-resolution pollen data from the Southern Armenian highland provide a detailed reconstruction of vegetation successions from open to forested biomes during different climatic cycles. Fossil plant macro floras show species compositions with strong relations to Euxinian and Hycanian forests occurring today at the coasts of the Black Sea and Caspian Sea, respectively, which must have been expanded considerably during warmer and more humid periods of the Early Pleistocene. On the other hand, western Georgian lowland data document a permanent forest cover throughout the Early Pleistocene.
Based on those results it is possible to spatially and temporally extrapolate the distribution of forests and mosaic landscapes in Southern Caucasus for different climatic phases during Early Pleistocene in order to better understand the dynamics of the Dmanisi landscape.

Changes of Vegetation and Plant Resources in the Southern Caucasus – Plant Biodiversity in TimE and Space (PlantBITES)

Angela A. Bruch[1], Eliso Kvavadze[2] & Ivan Gabrielyan[3]

[1] ROCEEH Research Centre, Senckenberg Research Institute, Frankfurt/M, Germany
[2] Georgian National Museum, Tbilisi, Georgia
[3] Institute of Botany, National Academy of Sciences of Armenia, Yerevan, Armenia

The scientific goals of the joint project are to study the history of vegetation of Southern Caucasus since the first occupation with early humans within a complex topographic setting and in relation to climate. Vegetation and plant diversity always have been of highest relevance for human habitats providing various resources, and are influenced by natural and anthropogenic climate changes.
The project will reconstruct the environment of different time periods under different global climatic situations to increase our understanding of the natural and anthropogenic influences of global climatic changes on regional vegetation and ecosystems as an essential resource of humans.
The cooperation of experienced scientists and their joint supervision of students will support a scientific network of expertise in the Caucasus region.
To reach those goals the project is structured in two subprojects. On one hand, very young material from Lake Sevan in Armenia (pollen and seeds, ca. 2000 BP to present) will enable the analysis of the latest vegetation and climate history including the impact of anthropogenic climate change. On the other, older fossils (leaves and pollen, 1-2 Ma) from Western Georgia will give insights in natural vegetation-climate relationships during the times of the first occupation of the Caucasus by early Homo. Based on those results the analysis of plant resources will shed light on the relevance and impact of climate changes on resource availability for humans. Quantitative methods for standardized procedures have to be developed. The assumed climate-vegetation-resource relationship will be extrapolated to the future based on climate model scenarios.
Both subprojects will be realized by two PhD students each, with the Armenian material studied by the Armenian students, the Georgian material studied by Georgian students. Both groups include one macrobotanical (leaves or seeds) study and one microbotanical study (pollen). The students are supervised jointly by the project members. However, macrobotanical analyses are primarily under supervision of the Armenian expert; pollen analyses under the supervision of the Georgian experts, according to their expertise, respectively. Therefore, the students spend regular visits for training at the partner institutes. Joint field work, methodological training courses, and international workshops with invited specialists will foster scientific exchange and collaboration.

Late Miocene vertebrate site of Chachuna (Iori Highlands, Georgia, Southern Caucasus)

Maia Bukhsianidze[1], Rusudan Chagelishvili[1], Davit Vassilyan[2] & Jordi Agustí[3]

[1] Georgian National Museum, Tbilisi, Georgia
2 JURASSICA Museum, Porrentruy, Switzerland
[3] ICREA-IPHES, Institut Català de Paleoecologia Humana i Evolució Social, Campus Sescelades URV, Tarragona, Spain

Chachuna is a new Late Miocene site in Dedoplistskaro region, Gare Kakheti, Georgia, Southern Caucasus. The Chachuna section is an analogue of the Eldari section (Azerbaijan) and provides a clear stratigraphic framework for the Khersonian (Late Sarmatian s.l.) of the Southern Caucasus.

Diverse, Early Turolian (MN11) fossil vertebrate ramains were found in this site. Preliminary faunal list comprises 19 taxa: *Barbus* sp.; *Silurus* sp.; Percinae indet.; Trionychdiae indet.; Geoemydae indet.; *Testudo* sp.; Falconiformes indet.; *Chalicomys* aff. *jaegeri* Kaup, 1832; *Choerolophodon* sp. Ictitheriidae indet.; *Hipparion* sp.; Rhinocerotidae indet.; *Microstonyx major* Gervais, 1848; *Procapreolus* sp; *Lucentia* sp.; *Muntiacinae* gen.; Sivatheriinae indet.; Boselaphini indet.; Antilopini indet.

The environmental conditions in this area was certainly influenced by the mountain slopes extending along the southern shore-line of the Eastern Paratethys, these slopes should have been efficient rainfall and moisture accumulation factors in the area. The sedimentary features indicate littoral zone and lagoon environment inhabited with fish and aquatic turtles. Dominance and high diversity of deer in Chachuna is striking. Humid and closed habitats are also supported by presence of castorids and suids in the fauna. This peculiar geographic position should have ensured longer survival of forms adapted to closed environment in this region in general in contrast with the adjacent Sub-Paratethyan province where evolution of terrestrial fauna developed on the background of increasing aridity

"Any suggestions for dinner?" – Hominin food supply at Sangiran

Christine Hertler & Susanne Haupt

ROCEEH Research Centre, Senckenberg Research Institute, Frankfurt/M, Germany

For the examination of resource spectra of diverse hominids, ROCEEH developed the concept of supply systems. However, we applied the concept as yet only in a quite general sense. In this paper, we will introduce the concept and apply it to a particular case study, i.e. food provisioning by Homo erectus in Sangiran around one million years ago.

In a general sense a supply system consists of resources on one hand and users of the resources on the other. Resources are extracted from a specific environment through certain practices, for instance hunting, catching, or gathering, for which particular technologies are available, for instance distance weapons, poison, sticks for digging or for pronging, baskets, bowls and so on. In the final model, we distinguish here between a group of hominins on the side of the users and the environment as a medium offering the resources required.

Our knowledge of the environment at Sangiran in the early phases of human occupation is distressingly limited. The lithic sequence illustrates a transition from a marine through a brackish to a fully terrestrial environment over a period of possibly a million years. To our present knowledge hominins arrived in the late phase of the brackish episode, characterizing the Sangiran formation, and inhabited the banks of a braided river system until a fierce lahar put an end. Climate and vegetation reconstructions do not support major shifts in the environment. Large mammals are present throughout the record. The environment at the time of the early phase of hominin occupation is understood as a seasonal type of forest, which is replaced by less seasonal forests at a later point in time. The resource spectrum includes terrestrial and aquatic small and large game as well as a variety of potential food plants including fruits, leafs, seeds and underground storage organs. Which among these resources could be exploited depends on the technologies available to the hominins and the practices they mastered, i.e. their way of resource management.

The daily requirements of the hominins depend on the size of the group and the structure of the group determined by age and sex. We match the energetic requirements of the group with the energy provided by potential food 'baskets'. Using recent hunter gatherer populations as a model permits to derive both, the requirements of the group as well as selection criteria for particular baskets. Studies of the nutritional physiology of the hominins proper, for instance isotope studies, finally permit to distinguish more or less probable baskets.

We present details on the diverse components of our model in our contribution.

Habitat, climate and potential plant food resources for the late Miocene Shuitangba hominoid in Southwest China: Insights from carpological remains

Yong-Jiang Huang[1], Xue-Ping Ji[2], Tao Su[3], Cheng-Long Deng[4], David K. Ferguson[5] & Zhe-Kun Zhou[1,3]

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[5] Institute of Palaeontology, University of Vienna, Vienna, Austria

The late Miocene is a sub-epoch when hominoids became rare worldwide but managed to survive in a few refugia. Investigating the living conditions of the late Miocene hominoids is therefore crucial for a better understanding of how they survived in those refugia. In this study, we present relevant palaeobotanical evidence regarding the habitat, climate and possible plant food resources for the Shuitangba hominoid (*Lufengpithecus* cf. *lufengensis*) from the late Miocene Zhaotong Basin, Southwest China. A total of 14 plant taxa were recognized from carpological remains newly recovered from the Zhaotong Basin, among which ten taxa were not reflected in the previous pollen record. These new plant taxa expand our knowledge of the flora and indicate how diverse the ecosystem in the late Miocene Zhaotong Basin was. Based on our carpological taxa, we hypothesize that the Shuitangba hominoid lived in a stratified mixed forest composed of trees, shrubs, lianas, herbs and grasses, near a lake occupied by various aquatic plants. The quantitative palaeoclimate reconstruction using the Coexistence Approach (CoA) indicates that the late Miocene Zhaotong Basin had a mean annual temperature (MAT) of 11.3–17.6 °C and a mean annual precipitation (MAP) of 1042–1547 mm, suggesting a mildly warm and humid climate for the Shuitangba hominoid. It also indicates that the hominoid had warm and wet summers but cool and dry winters, under the influence of the Asian monsoon. Edible and nutritious fruits and seeds of a considerable size, e.g., nuts of *Carya* and *Corylus*, fruits of *Euryale* and *Trapa*, were possibly exploited by the Shuitangba hominoid. The harder fruits, e.g., nuts of *Carya* and *Corylus*, might have benefited the hominoid as a fallback resource in the winter when foods were scarce.

Cenozoic plant diversity of Yunnan: A review

Yong-Jiang Huang[1,4], Lin-Bo Jia[1,5], Qiong Wang[2], Volker Mosbrugger[3], Torsten Utescher[3,6], Tao Su[2,4] & Zhe-Kun Zhou[1,2*]

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Yunnan in southwestern China is renowned for its high plant diversity. To understand how this modern botanical richness formed, we need to investigate the past biodiversity throughout the geological time. In this review, we present a summary on plant diversity, floristics and climates in the Cenozoic of Yunnan and document their changes, by compiling published palaeobotanical sources. Our review demonstrates that by far a total of 386 fossil species of ferns, gymnosperms and angiosperms belonging to 170 genera within 66 families have been reported from the Cenozoic, and in particular the Neogene, of Yunnan. Angiosperms display the highest richness represented by 353 species grouped into 155 genera within 60 families, with Fagaceae, Fabaceae, Lauraceae and Juglandaceae being the most diversified. Most of the families and genera recorded as fossils still occur in Yunnan, but seven genera have disappeared including *Berryophyllum*, *Cedrelospermum*, *Cedrus*, *Palaeocarya*, *Podocarpium*, *Sequoia* and *Wataria*. The regional extinction of these genera is commonly referred to an aridification of the dry season associated with Asian monsoon development. Floristic analyses indicate that in the late Miocene, Yunnan had three floristic regions: a northern subtropical floristic region in the northeast, a subtropical floristic region in the east, and a tropical floristic region in the southwest. In the late Pliocene, Yunnan saw two kinds of floristic regions: a subalpine floristic region in the northwest, and two subtropical floristic regions separately in the southwest and the eastern center. These floristic concepts are verified by results from our areal type analyses which suggest that in the Miocene southwestern Yunnan supported the most Pantropic elements, while in the Pliocene southwestern Yunnan had abundant Tropical Asia (Indo-Malaysia) type and East Asia and North America disjunct type that were absent from northwestern Yunnan. From the late Miocene to late Pliocene through to the present, floristic composition and vegetation

types changed markedly, presumably in response to altitude changes and coeval global cooling. An integration of palaeoclimate data suggests that during the Neogene Yunnan was warmer and wetter than today. Moreover, northern Yunnan witnessed a pronounced temperature decline, while southern Yunnan experienced only moderate temperature changes. Summer precipitation was consistently higher than winter precipitation, suggesting a rainfall seasonality. This summary on palaeoclimates helps us to understand under what conditions plant diversity occurred and evolved in Yunnan throughout the Cenozoic.

Paleoclimatic variations during glacial-interglacial cycles in semi-arid Northeast Brazil and their connection to the Amazon rainforest

Andrea K. Kern[1], Allan Sandes de Oliveira[2], Paul A. Baker[3], Gary S. Dwyer[3], Cristiano M. Chiessi[4,5], Francisco W. da Cruz, Jr.[1], Cleverson, G. Silva[2] & Debra A. Willard[6]

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[3] Division of Earth and Ocean Sciences, Duke University, Durham, North Carolina, USA
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The Northeast (NE) of Brazil is characterized today by dry-adapted vegetation varying from grasslands (caatinga) to openly forested (cerrado). The dry climate is the result of ITCZ movement and the South American monsoon system, which distributes moisture towards the center of Brazil but deflects dry air over the NE. This xerophytic vegetation separates two evergreen biodiversity hotspots, the Amazonian rainforest and the Atlantic coastal forest, and currently prevents species migration between them. However, phylogenetic studies show contact between these regions and suggests a Pleistocene forested corridor in the NE as a possible scenario for exchange.

To observe stability of these semi-arid conditions and possible existence of evergreen forest corridors during the Pleistocene, we analyzed a marine core from the western equatorial Atlantic margin covering the last 1.6 Ma. Terrestrial material is mainly transported to the drill site by the Parnaíba River, which originates in the Brazilian Shield and drains the NE of Brazil. The North Brazil Current further carries inflowing waters toward the North, and therefore a contribution of the Amazon River is not expected. Sediment analysis indicates a continuous and undisturbed record allowing the reconstruction of vegetation and climate of NE Brazil during several glacial and interglacial stages (MIS 1 to 51).

High-resolution measurements of Ti/Ca and Fe/K show significant changes in chemical weathering and the amount of terrestrial inflow. Highest peaks of these ratios occur especially during the late Mid Pleistocene Transition (840-880 ka) and the Mid-Brunhes event (~430 ka), which might suggest higher precipitation in the catchment area. Preliminary pollen data show the strong presence of xerophytic elements in the majority of the samples, but assemblages of tropical rainforest vegetation occur in the preliminary data around MIS 7 (~254 ka) and in the early Mid Pleistocene Transition (1.0-1.2 Ma). These changes higher percentages of evergreen tropical taxa and greater biodiversity and co-occur with an increase in pollen concentration (pollen per gram sediment). Although other elements commonly associated with colder-adapted vegetation during glacial stages were known from

the tropical lowlands (e.g. *Podocarpus*, *Hedyosmum*, *Ilex*), *Alnus* is present in our record, which was previously limited to the Andes in South America. Thus, we evaluate the possibilities of sediment inflow from the Amazon River as well as possible rainforest forest expansion of this taxon to the NE of Brazil by using new pollen data and geochemical measurement.

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Multiproxy analysis of the Late Miocene sediments from Danube Basin - Modrany2 case study

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During the Late Miocene a wide brackish lake, Lake Pannon formed in the Alpine-Carpathian-Dinaride realm covering the territory of the Pannonian Basin system. After its isolation from adjacent Paratethyan and Mediterranean areas during the Sarmatian marine microplankton became extinct and new endemic forms originated. Modrany-2 borehole is situated in the Danube Basin (Central Paratethys, Slovakia). Anoxic conditions at the bottom were documented by the S, TOC, and FeN/MnN content. This anoxic event is associated with deposition in marsh environment. After a small anoxic event on the basis of Neogene fill (2005m) the environment changes to oxic. This change is associated with an opening of the depositional system. The low values of weathering index during the middle Miocene are attributed to the supply of fresh volcanic material during that time interval. Evaluation of the degree of weathering and sediment recycling was done on the basis of a combination of a microscopic study, coefficients of weathering and maturity indexes. Determination of biotic proxy data is done based on the analysis of the Foraminifera, calcareous nannoplankton and palynomorfs assemblages, which have provided the important biostratigraphic data and paleoecological interpretations of palaeoenvironment. Using pollen data analysis the vegetation types, paleoclimate proxies and their changes were interpreted. The maturation grade and type of kerogen were determined by palynofacial analysis according to Traverse (1988).

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Holocene vegetation and climate history of the Transcaucasus according to palynological data

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Twenty-five years of pollen monitoring in the mountains of the Transcaucasus with the basic aim of understanding signals of climate changes have revealed many new details on the dynamic of vegetation and climate development during Holocene. Monitoring data on pollen flux in different altitudinal mountain belts, on the dissemination of pollen from one belt into another, on the conditions of pollen preservation also controbuted to this aim.

The reconstruction of vegetation and climate has been conducted based on the comparison of data from geological profiles of marine (26 profiles) and continental deposits (9 profiles) and palynological spectra of cultural layers and artifacts of numerous archaeological sites, belonging to various periods.

The palynological investigations of Black Sea and lake sediments have revealed three most significant climate warmings that took place in 6000-5500 BP, 3800-2400 BP and 7-11 centuries AD. During these warmings, in the narrow coastal belt aquatic and swamp vegetation became more important which was caused by the ingression of sea waters and formation of lagoons. Meanwhile, chestnut, oak, zelkova and lime forests spread in the adjacent mountains, while the area of mountainous dark coniferous forests decreased. The upper boundary of forests in the mountains adjacent to the Black Sea coast used to rise for some hundred meters during these warming phases. Far from the Black Sea, in the eastern and southern parts of Transcaucasus, vegetation changed differently. During warmings forests advanced into steppes, but during cold spells the process was reverse - steppe landscapes widened. Simultaneous warming and humidification of climate in the Atlantic period caused a maximal development of forest and forest-steppe cenoses, and steppe nearly disappeared then.

According to the archaeological material, the best indicator of climate warming in highlands is the development of agriculture and, particularly, that of viticulture and wine making. At the beginning of the Atlantic period (7700-7500 BP), with the establishment of humid, warm conditions, the first Neolithic agricultural settlements appeared on the alluvial plains of Southern Kartli (Georgia), where beekeeping and weaving were developed side by side with grain-growing, gardening, and viticulture. During the Eneolithic period, this warming process continued and mild climatic conditions facilitated the rise of new cultures and penetration of agriculture into mountainous areas. It has been also revealed that such cultures as Kura-Araxes, Trialeti and Bedeni appeared just in the time of climate warming during the Bronze Age (6000-3500 BP). An important regularity is also the fact that warm periods in the studied region, as a whole, were more prolonged than cool ones. The cold spells were short but rather strong. The influence of human activity on landscape development can be observed since the Subboreal period (4500-4200 BP), when deforestation took place not only on the lowland, but also in the mountains of the Transcaucasus.

The Messinian palaeofloras of the Italian evaporitic deposits: record of a "subtropical" humid forest

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Fossil plants occur frequently in the evaporitic deposits of the Messinian from NW Italy, along the Apennines to NE Italy (Romagna area), and down to central Italy, which in the 19th century provided a fundamental collection of Messinian leaves from Senigallia (Marches), presently stored in the Scarabelli Museum at the Imola. Recent studies focused on the northern localities, and particularly on the Vena del Gesso Formation (Messinian) of western Romagna. Here the sites of Polenta, Monte Tondo (municipality of Riolo Terme, Ravenna province) and Tossignano (municipality of Borgo Tossignano, Bologna province) provided fossil leaves and a few fruits/seeds which permitted a sound interpretation of the palaeoclimatic conditions.

In the fossils are usually in organic-rich laminated shale layers, generally less than 1 m thick, that separate the selenite beds. The presence of these shale partings (or interlayers) testifies the cyclical flooding of the basin by undersaturated continental waters and should represent a cyclical interruption of gypsum deposition. The presence of well preserved fishes and plant remains, the virtual absence of megabenthos and the lamination of the shales suggest that persistent anoxic conditions occurred at the bottom of the basin. The very fine grain size of the clayey matrix and the poor oxygenation of the ancient bottom favoured a substantial good preservation of plant remains, often bearing their organic cuticle. Occasionally plant remains are also preserved within layers of microcrystalline gypsum, usually interpreted as evaporitic deposits.

In a recent comprehensive paper by Teodoridis et al. (2015) fossil leaves are studied morphologically to assess the taxonomic composition of the assemblages and carry out a palaeoenvironmental analysis. The experience gained by these authors (in particular Z. Kvaček and V. Teodoridis) on Neogene fossil leaves from all parts of Europe permitted the best possible taxonomic assignment of the Messinian leaves from Italy, even if these are very variable organs, poorly usable for phylogenetic analyses. These Mesinian floras are rich in both conifers and angiosperms, including several fossil species well known in the Miocene of central Europe, such as: *Taxodium dubium, Daphnogene polymorpha, Laurophyllum* spp., *Platanus leucophylla, Quercus pseudocastanea*, *Quercus roburoides, Fagus gussonii*, etc.

The general palaeovegetation pattern of the NE Italian plant assemblages agrees very well with the results obtained from NW Italy, summarized by a vegetation transect of the Evaporitic Messinian with swamp, riparian vegetation, and zonal "subtropical humid forest". The abundant occurrence of such humid vegetation records in association with gypsum layers, usually considered evaporites, is stimulating new geochemical research for the interpretation of such deposits.

Vegetation and climate histories between MIS 63 and 53 in the Early Pleistocene in central Japan based on plant macrofossil evidences

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Among the Early Pleistocene fluvial sediments in Japan that yield plant macrofossils, the Uonuma Group in the Niigata sedimentary basin provides the most continuous profile without any conspicuous hiatuses and is therefore suitable for high-resolution reconstructions of environmental and vegetation histories based on tephro- and magneto-stratigraphy. Based on the species composition of plant macrofossil assemblages, along with previously reported results on sedimentary environments and pollen records, we performed a reconstruction of changes in paleovegetation and paleotemperatures between MIS 63 and 53. Assemblages from the peat deposits in fluvial backmarshes during glacial stages are composed mainly of wetland herbaceous plants, whereas those from the sandy channel-fill deposits are characterized by a higher diversity in life forms and habitat preferences. During the interval from MIS 63 to 53, paleotemperatures fluctuated between a coldest-month mean temperature of −4.6 °C and −0.9 °C and between a mean annual temperature of 6.6 °C and 11.0 °C, which is within the present range for cool-temperate, deciduous broad-leaved forests in Japan. MIS 60 was the coldest of the glacial stages with temperatures nearly equivalent to those during the last glacial maximum. Major plant extinctions in and around MIS 60 were not recorded in the sedimentary basin in response to the temperature decline. The relatively indistinct floral changes in and around MIS 60 are attributed to easier recovery of flora by migration from glacial refugia in the southern basins after termination of the glacial stage. Interglacial temperatures during MIS 57, 55, and 53 were higher than during MIS 63, 61, and 59. The presence of a maritime environment during the interglacial periods between MIS 57 and 53 may have resulted from a greater extent of marine transgression and heat provided by the Tsushima Warm Current flowing into the Sea of Japan after MIS 59.

Vegetation of Armenia

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Republic of Armenia is situated in NE part of Armenian Highlands.Armenia is a land of strong volcanism and seismicity, remote from marine surfaces, with altitudes from 375 to 4095 m a.s.l. These factors determine the diverse climate and relief and the uniqueness of the Armenian biodiversity.
Armenia is the smallest country of the Transcaucasus, occupying an area of about 30000 km2. Nevertheless, its flora is unique and very diverse. The whole flora of the Caucasus counts about 6500 species of higher plants, and more than half of them (about 4000 species) occur in Armenia. 123 plant species are Armenian endemics. Armenia is very rich in crop wild relatives: cereals, legumes, nuts and fruit trees.
452 higher plant species are included in the Red Data Book of Armenia. The Protected Areas of Armenia occupy slightly more than 13 % of the state territory.
The Republic is situated at the junction of 2 very different floristic provinces: mezophyllous Caucasian province and xerophyllous Armeno-Iranian province. There are 12 floristic regions in Armenia. Northern Armenia have mostly Caucasian flora, whilst flora of Central Armenian volcanic highlands is equally influenced by both mezophyllous and xerophyllous floras. The Caucasian flora's influence decreases towards the South-western and Southern mountain ranges located along the Arax River.

Cotemporary vegetation of Armenia is very diverse and displays well-expressed altitudinal zonation. Almost all terrestrial ecosystems of the Caucasus are represented here, except the humid subtropical and littoral ones.

Main vegetation types in Armenia are the following:

- **Semidesert** Sagebrush semidesert, halophyte semidesert, sandy semidesert. Foothills and lower mountain belt.
- **Phryganoids** Xeromorphic spiny perennials and shrublets formation. From lower mountain to middle mountain belt.
- **Mountain steppes** Feather-grass, beard-grass mountain steppes. From lower mountain belt to subalpine belt.
- **Forests** Deciduous forests, open arid forests with juniper, wild pear, etc., Christthorn deciduous bush formations. From lower to middle mountain belt.
- **Subalpine vegetation** Subalpine tall herbaceous vegetation, subalpine meadows. Higher mountain belt

- **Alpine vegetation** Alpine meadows, alpine carpets. Higher mountain belt.
- **Petrophyllous vegetation** Vegetation of rock fissures on very thin soil layer. On different altitudes.
- **Wetland vegetation** Marshy vegetation, riparian vegetation, etc. On different altitudes.

Magneostratigrahic age constraints of the Late Miocene to Early Pleistocene sedimentary succession of the Kura Basin (Georgia, Caucasus)

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The Kura foreland basin extends between the Greater and Lesser Caucasus and is an inland extension of the Caspian basin. The basin infill hosts a well exposed, continuous and thick sedimentary record of the marine-to-continental transitions that took place during the Neogene and Quaternary. This record contains fossil sites with fauna (both terrestrial vertebrates and marine invertebrates) and flora, so is the ideal frame to reconstruct the paleoenvironmental history of the Caucasus and its climate for the Late Miocene to Early Pleistocene. Combined magnetostratigraphic, geologic and paleontological studies contribute to establish regional and global correlations.

From west to east (proximal to distal) we studied three main sections along the Kura river valley. First section is located between the David Gareji Monastery and the Dodo Mount (Udabno region), where the sedimentary succession displays a succession of the Eldari and the Shiraki units (the latter represented by fluvial sandstones). Second one is Dzedstakhevi site, located in the foothills of the Pirukugma Mount, where a succession of Shiraki group mudstones is followed by conglomerates. Third one is located in Chachuna, and spans trough a an interval dominated by marine strata of the Middle and Late Sarmatian sl. An already studied Akchagylian section is found in Kvabebi, located to the north of Dzedstakhevi outcrops.

The Akchagylian and Apsheronian series in this part of the Kura basin are arranged as an angular unconformity, that separate these Plio-Pleistocene units from older ones: Sarmatian s.l. and Meotian (Tortonian and likely Messinian). The studied sections contain remarkable sites with terrestrial micro and macromammals. In the Chachuna 1 section the Sarmatian/Meotian boundary can be located in detail on the basis of malacofauna, which is reinforced by the magnetostratigrapic succession. The youngest pre-Akchagylian strata from the latest Shiraki unit still need further paleontological information to be dated.

The Late Pliocene Hortun flora

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During the Pliocene Armenia was dominated by continental, mostly lacustrine sedimentation, with the accumulation of powerful volcanic and freshwater-lake formations. The locality discussed here is situated near the former village Hortun in the Ararat region. The sedimentswhich contain the fossil flora belong to the third suite of the Yelpin seriesof WestVayotsDzor and consist of tuffaceous rocks of Meotian-Pontian age (Early Pliocene).The total thickness of the outcrop Hortun-1 exceeds 40-50 m. The lower part of the outcrop, with a thickness of 1-1.5 m, contains plant remains in the form of imprints of leaves and fruits of plants. There are also numerous imprints of insects.

The Hortun-1 flora was first collected and studied by A. L. Takhtajan and N. G. Goghtuni, than by I.G. Gabrielyan and A.S. Papikyan. The studied material includes more than 3500 imprints from fieldwork in 1946-2014 in total.

Almost 30 species are described from this flora until now.The higher plants belong to different families, among them Aceraceae, Anacardiaceae, Araliaceae, Betulaceae, Dipsacaceae, Fagaceae, Juglandaceae, Oleaceae, Pinaceae, Platanaceae, Poaceae, Salicaceae, Ulmaceae, etc. Also ferns and mosses occur.

Generally, a quite widespread, rich, sometimes subtropical forest vegetation occurred in the Caucasus during late Neogene, similar to the modern vegetation of southern Japan, south-western China, and south-eastern North America, with some relict elements of more ancient tropical species. Here, we present a summary of the taxonomic analysis of The Hortun-1 flora, and attempt to implement environmental and geobotanical analyses to provide more details and insights to this general picture.

Late Pliocene to early Pleistocene palaeoenvironments at high latitudes of the European part of Russia (Ugra peninsula)

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Recent studies on Cenozoic vegetation and climate in the mid- and higher latitudes of Central Eurasia including the European part of Russia suggested a marked increase of the latitudinal gradients throughout the late Pliocene to early Pleistocene when compared to the late Oligocene to Miocene conditions (Popova et al., 2017). On the other hand, climate data reconstructed form palaeofloras and ecospectra based on diversity of Plant Functional Types (PFTs) evidenced still very warm late Pliocene to early Pleistocene conditions at higher latitudes. However, this study also revealed the incompleteness of the available records, especially regarding the Arctic realm of the European part of Russia. A detailed knowledge on high latitude vegetation and climate dynamics, however, are important prerequisites for a better understanding of the long-term climate history of the Arctic, and for the validation of climate model scenarios (Andreev, 2014).

Based on published palynological data we study late Pliocene to early Pleistocene Arctic palaeoenvironments of the European part of Russia using the Coexistence Approach (CA) and PFT diversity spectra. For the analysis five localities are selected in total, all located on the Ugra Peninsula, namely Akis River, Cape Spindler, More-Yu River, Kipievo on the Pechora River, and Oyu River. The selected sections cover the time-span from the Piacenzian to Calabrian. The available biostratigraphic framework comprises palynological complexes, marine microfauna and mollusc zonation. The age constraints are supported by magneto- and strontium isotope stratigraphy (SIS). The palynomorph records include 83 different palynomorph taxa, taxonomically assigned to bryophytes, pteridophytes, gymnosperms, and angiosperms, most of them with known Nearest Living Relatives. Our reconstruction provides first quantitative records showing late Pliocene to early Pleistocene climate and biodiversity change in the Arctic of the European part of Russia, prior to the onset of severe high latitude cooling.

Plant food resources and inferences on the diet of *Homo erectus* in the Caucasus

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The aim of the study was to explore the resource space in the Southern Caucasus since the occupation with early humans about 1.8 Ma. Vegetation diversity is an important factor for human habitats as plants contribute to the amount and variety of obtainable food resources. For this study, we compare different reconstructed vegetation units around Dmanisi in Georgia and Sisian in Armenia using taxa lists of the dominant and most frequent species. The units range from steppes to altimontane forests and are based on fossil records from plant macro fauna and pollen data. We focus on the following questions: which and how many edible plant parts can be found in each unit and how is the availability distributed in the course of the year? To answer these questions, we designed a table as basis for this study and the subsequent data base PlantBITES which was filled performing a literature research. We found that the two forest units provide the most edible plant parts, followed by open woodlands. The fewest ones we found in the two steppes. Moreover, open woodlands and forests provided more food of high quality than the steppes, whereas, steppes provided a huge amount of grasses, which are considered good forage for grazing animals. An energy- and nutrient rich diet of this kind was required for the evolution of a larger brain of the *Homo erectus*. Furthermore, the characteristics of the dentition, the stature and body proportions of *Homo erectus* were compatible with such a diet. These findings suggest that the diet of *H. erectus* might have been a mix of meat provided by the steppes and high quality edible plant parts like fruits from the forests or the open woodlands. Besides, for almost all vegetation units the amount of species with no information about their edibility was high, wherefore further research is needed to close the gaps and get a more complete insight in the resource space in Southern Caucasus.

The Late Cenozoic history of flora and vegetation of Georgia

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This is the first work summarizing the results of many years investigations of paleobotanists of the Institute of Paleobiology, Georgian National Museum, and also of joint work carried out during the last 10 years.
Pollen analysis was used for studying the numerous (34) outcrops of the Neogene and Quaternary deposits, distributed in Western and Eastern Georgia. The presented work is devoted to a brief history of forests on the territory of Georgia, beginning from the Oligocene. In the Caucasus this stretch of time is considered as the earliest stage of the formation of mountain relief, which was the main abiotic factor influencing the development of flora and vegetation in mountain regions.

During the Cenozoic five main stages can be distinguished in the development of forest vegetation on the territory of Georgia: The first stage was the Eocene, when conifers both from a systematical and coenotical point of view were secondary components of the vegetation cover, which consisted mainly of angiosperm plants. The second stage began in the Oligocene and continued until the end of the Sarmatian. During all this time the subtropical genera were the main components of forests. During different times of Late Paleogene and Miocene the abundances of single taxa probably changed but the general composition of forest was similar at whole. The third stage embraced the time from Meotian until the Upper Gurian. The main trend of evolution during this stage was the expansion of temperate forests and the extinction of the subtropical and warm-temperate taxa. The fourth stage – the Upper Gurian and the Lower Chaudian – was the turning-point, when big numbers the Pliocene relicts disappeared from the composition of the flora and plants of temperate climate began to dominate. Together with *Fagus*, *Abies* and *Picea*, the main components of forest were *Tsuga* and representatives the family Taxodiaceae, now fully absent in the flora of Georgia. Also the structure of vegetation changed. The fifth stage began in Late Chaudian and continued until the end of Karangatian. During this time only single relicts were preserved in the composition of the flora. After the Karangatian they became fully extinct, except those, which are still preserved in the forests of Colchis.

The result of our common work is the *Atlas of pollen of the Georgian Upper Cenozoic*, which comprises 101 plates of pollen grains of Gymnosperm and Angiosperm plants. The chapters of pollen description begin by lists of plants, determined by pollen grains and macroremains from the Upper Cenozoic of Georgia. Between this two lists are significant differences. In the list of Gymnosperms all taxa described by macrofossils are included because their number is relatively low compared to the number of plants determined by pollen. This is different Angiosperms, which are represented also by numerous macrofossil taxa. Therefore, in list of Angiosperms only those macrofossil taxa are mentioned for comparison, which belong to families determined also by pollen data. We hope that this atlas will be of interest to specialists and students studying paleoecology, paleotaxonomy of Gymnosperm and Angiosperm plants and the history of the Cenozoic floras as a whole.

Stages of vegetation development of Ukraine in late Pliocene

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Within Ukraine, the Upper Pliocene marine and liman-marine sediments (Kuyalnik (Akchagylian)), are most spread in the coastal regions of the Black Sea and Sea of Azov.
The Dnieper-Donets Depression, Ukrainian Shield and Donetsk folded structure belong to the areas where the continental red-brown Pliocene formations occur. The subaerial facies are rhythmical: brown clay strata alternate with red-brown fossil soils. The soils (Bogdanovsky and Beregovsky) were formed during the warm phases of climatic rhythms. Brown-colored clays (Kizylyarsky and Siversky) were formed during cooler phases of the climatic rhythms.
On the basis of analysis and generalization of the results of our detailed palynological studies of liman-marine and continental Upper Pliocene sediments in the sections of the Central and Southern parts of Ukrainian Shield, the Dnieper-Donets Depression, Donetsk folded structure and literary materials, the reconstruction is performed for three stages of vegetation development over Ukraine in late Pliocene, and one transitional stage timed to end of Early Pliocene–beginning of Late Pliocene.
Kizylyarsky stage (transitional) (3.5 Ma). The characteristic feature of the stage is a significant reduction in the number and the impoverishment of the composition of plant communities, in comparison with the Early Pliocene, both at the expense of deciduous plants of the moderately warm zone and thermophilic species, and pines subgenus *Haploxylon*, as well as the prevalence of coniferous forests in the structure of the vegetation cover. The latter circumstance brings the characterized stage to the Early Kuyalnik (Bogdanovsky) stage.
Early Kuyalnik (Bogdanovsky) stage. A distinctive feature of the stage was the extensive development of coniferous, mixed broadleaved and pine forests virtually over all flat territory of Ukraine. In comparison with Late Cimmerian time, in the composition of forests, the role significantly increased of the pines mainly belonging to the subgenus *Diploxylon*. Deciduous vegetation groups were associated mainly with river valleys and low relief elements.
Within the determined stage, two sub-stages can clearly be seen. Distinctive features of the first sub-stage (the first half of Early Kuyalnik time in southern regions of Ukraine and Early Middle-Bogdanovsky time of its central and north-eastern parts) is the most significant participation and taxonomic diversity in the composition of forests of pines: *Pinus sect*. *Eupitys*, *P. sp. sect. Banksia.*, *P. longifoliaformis*, including representatives of the subgenus *Haploxylon* – *P. sp. sect Cembrae*., *P. sp. sect. Strobus*, as well as deciduous plants of moderately warm, warm-temperate zones, and thermophilic species. Herbaceous cenoses of

this time differed by sufficiently large representation of various grasses, and in the herbaceous cover of the forests a prominent role belonged to *Polypodiaceae*.

At the second sub-stage (the second half of Early Kuyalnik and Late Bogdanovsky time) a significant part of the pines subgenus *Haploxylon* disappeared from the forests composition, and thermophilic elements occurred only among the floodplain forests. The composition noticeably impoverished also of the few deciduous groups, the main components of which were *Betula*, *Ulmus laevis* and *Quercus robur L.*

Middle-Kuyalnik (Siversky) stage. A distinctive feature of the characterized stage was the increasing role of herbaceous vegetation cenoses in virtually all flat part of Ukraine, and broad representation in their composition of grasses, aquatic and coastal-aquatic plants. Associated with this stage is appearance of the steppe regions of the Azov Sea, which exist till present times within the study area, with some species composition changes. In most of the study area the forest-steppe vegetation type dominated.

In the determined stage three sub-stages are clearly traced. The vegetation cover of the first sub-stage, corresponding to the first half of the Middle-Kuyalnik time and period of the formation of clays in the low part of the Siversky-deposits subaerial section, was characterised by marked depletion of both forest and herbaceous groups.

A characteristic feature of the second sub-stage of the vegetation development, which corresponds to the middle of the Middle-Kuyalnik time and the period of formation of fossil soils in the middle part of the Siversky deposit section, is the increasing role of woody plants, and in this group, the increasing number and taxonomic diversity of deciduous and thermophilic elements. By the number and taxonomic diversity the forests of this sub-stage exceeded not only the Early-Siversky but also Early-Kuyalnik (Bogdanovsky) forests, and a number of thermophilic plants present in the composition of the forest groups already not occurred in the forests of Late-Kuyalnik and Beregovsky times.

The third sub-stage of vegetation development (end of Middle-Kuyalnik and Late-Siversky times) is associated with aridization and cooling which caused changes in the composition of vegetation cover almost in all regions of Ukraine plains.

Late-Kuyalnik (Beregovsky) stage. A characteristic feature of the determined stage was approximately equal participation in the vegetation composition of herbaceous and woody groups, the number of the latter grew only in areas of sea coasts and river terraces, as well as significant participation and taxonomic diversity of deciduous plants in the composition of forests, especially broadleaf species of moderately warm zone, and rather significant representation of thermophilic elements in the forest groupings.

Performed studies enable to conclude that each of the reconstructed stages of vegetation development has its individual characteristics and its own set of specific taxa. For each of determined stages the general and regional peculiarities of vegetation cover are revealed within all studied areas of the Ukraine.

Vegetation and climate of the Saalian Glacial-Interglacial complex: new evidence from the Neualbenreuth Maar (Bavaria, Germany)

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The discovery of a Middle Pleistocene maar structure in the Bohemian Massiv in 2007 revealed that Quaternary maar volcanism in Central Europe is not confined to the Vulkaneifel region in western Germany. In 2015, after a comprehensive geophysical prospecting a second hitherto unknown Maar structure has been evidenced at the German-Czech border close to the village Neualbenreuth by a scientific drilling. Within the scope of a pilot study, the obtained 100 m long Neualbenreuth-1 (NAR-1) sediment core was analysed mainly in order to evaluate the potential of the sedimentary sequence for detailed palaeoenvironmental investigations, and to estimate the age of the sedimentary record. Here we present an overview of the preliminary results on sediments, palaeomagnetics, pollen and biomarkers of the Neualbenreuth lacustrine sequence.

According to the sedimentological survey, the lithological profile exhibits a succession of mostly minerogenic lake sediments below an about 15 m thick layer of thin forest soil and colluvium. Three radiocarbon datings on bulk organic from clastic sediments between 10 m and 27 m profile depth reveal ages of 50,000 years or more. Hence, the lake infilling process became finished latest during the Weichselian glacial period (Marine Isotope Stage (MIS) 3 or 4). Paleo- and rock magnetic investigations yielded a scattered record of steep positive inclinations, indicating a Brunhes age of the sediments (<780 ka). Furthermore, a set of 47 pollen and 15 biomarker samples collected from sediment depths between 17.7 to 96.0 m below the ground was analysed. Whereas nearly no pollen was detected below 91.7 m depth, sufficient pollen concentrations (between about 5,000 and 80,000 grains/g) could be found in the predominantly minerogenic sediments. In contrast, extremely high concentrations (with up to more than 6.5 million grains/g) were detected in some finely laminated organic-rich sediments in the upper (22-30 m) and lower (70-86 m) part of the NAR-1 drillcore. Biomarker samples were analysed for microbial membrane lipids ("brGDGTs") as proxy for paelo-temperature, and revealed an overall temperature variation of about 5 °C throughout the sampled interval.

The pollen assemblages reveal a succession of four more or less completely preserved temperate and five stadial intervals. High values of non-arboreal pollen were detected in the predominantly minerogenic sediment intervals. The dominance of Poaceae and Cyperaceae along with abundant Artemisia, Chenopodiaceae and other cold and dry tolerant herbs suggests the widespread occurrence of steppe vegetation. In contrast, the organic-rich horizons represent temperate stages. The pollen assemblages during these intervals are co-dominated by Pinus and Picea, accompanied by lower amounts of temperate deciduous trees and shrubs as Quercus, Ulmus, Corylus, and Carpinus. The youngest warm period is additionally characterized by a distinct Taxus peak.

Despite of the presently low resolution of the pollen record, the current data set shows several characteristic features allowing for (preliminary) biostratigraphical implications. Firstly, the floristic composition of forest elements of the youngest warm stage recorded in the NAR-1 sequence supports its correlation with the Eemian interglacial, which corresponds largely to MIS 5e. Considering the climatic succession of the continuously recorded sequence below the Eemian interglacial, the mainly glacial sequence probably represents the major part of the Saalian glacial period (MIS 6-8). The dominance of cold and dry tolerant herbs in parallel with the sparse representation of pioneer trees and shrubs during most parts of the sequence indicate open landscapes of steppe to woody-steppe character typical for Pleistocene glacial periods of central Europe. The three pre-Eemian warm stages most likely correspond to the lower Saalian complex of alternating warm and cold stages (MIS 7).

From central Europe, which was strongly affected by glacial and periglacial processes during the major middle and late Pleistocene cold periods, palynological evidence of lower Saalian warm stages with interglacial character is ambiguous so far. A comparison of the available data with the new palaeoenvironmenal record from NAR-1 suggests that warm stages in central Europe during MIS 7 are of interglacial or even interstadial character depending on its geographical position. In any case, our new data set reveals, the climate during MIS 7 was less favorable than during in the Eemian or Holsteinian interglacials as indicated by the reduced floristic diversity and less frequently occurring thermophilous plant taxa.

Record of climatic and geologic events in faunal assemblages and lithofacies of the Southern Ukraine Miocene sections

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It has been known that the most dramatic changes in the vertical distribution of faunal assemblages are the main reason for marking out the major stages in the development of the biota to be the basis of the stratigraphic scheme of the Neogene of Southern Ukraine and, in general, of Eastern Paratethys.

A detailed study of the ecological structure of complexes and features of the occurrence of fossils (foraminifera, mollusks, sponge spicules, etc.) within each such stage has shown their good potential for the reconstruction of some of climatic and geological events.

The following event signs for the Miocene of Southern Ukraine are established.

1. Presence of paleotemperature bioindicators among shallow-water organisms, as well as lithoindicators and their binding to narrow time sections.
2. Frequent "pulsating" faunal successions in some intervals of the Miocene.
3. The levels of redeposition of microfossils that are sustained over a considerable area.

The fauna of the littoral and the upper sublittoral zone reacts most strongly to climatic changes. Among the shallow-water Miocene foraminifers in the south of Ukraine, the most thermophilic stenothermal taxa are the large miliolids Borelis (18-26°C), Peneroplis (18-27°C), Spirolina (more than 20°C), Nubecularia (more than 20°C). They are only observed at some stratigraphic levels. Nubecularia and Spirolina are found at the beginning of the Middle Miocene (Chokrakian Stage), and the Upper Miocene (middle part of the Middle Sarmatian, and the beginning of Maeotian Stage); all the specified genera are present in the middle of the Middle Miocene (Konkian Stage). The indicator of the climate warming at the end of the Middle Miocene (the Middle Sarmatian) should also be considered some mollusks shells “gigantism”. Such uneven development of heat-loving organisms is clearly associated with the climatic optimum of the beginning of the Middle Miocene and short-term warming waves at the end of the Middle and middle of the Late Miocene (Haq, 1980; Zubakov, 1990).

These fauna studies are supplemented by lithological and mineralogical indicators of the paleoclimate, namely: the presence of gypsum and jarosite in the Chokrakian deposits, and dolomite in the Karaganian indicate a predominantly arid climate in the beginning and middle of the Miocene. Clays with organic matter in the Lower Sarmatian and lower Middle Sarmatian indicate the humid climate at the turn of the Middle and Late Miocene.

Analysis of biota development (foraminifera, ostracods, mollusks, diatoms flora) from the Miocene sediments of the Northern Black Sea and the Crimea made it possible to establish, in addition to the most obvious biotic changes at the boundaries of the stages, frequent successions (fluctuations) of microorganisms in some stratigraphic intervals. There is the Konkian Stage as such interval in the Middle Miocene, and the Maeotian Stage - in the Upper Miocene. Several faunal (Konenkova, 1987, 1991) or diatoms zones (Olshtynska, 1996) are known for each of them. Thus, it is emphasizes fractional divisibility of these stratigraphical units, and consequently, intensive taxonomic and ecological variability of the biota with time. The unstable climate (Barron & Keller, 1982; Zubakov, 1990) and the tectonic regime (Chekunov et al., 1976; Zagorchev, 2005) of this time contributed to such development of organisms.

Single reworked microorganisms sporadically occur throughout the Miocene section; however, in some intervals they are mass. Several stratigraphic levels of the fauna redeposition have been established. There is the Lower Tarkhanian level (traced in the Crimea and the Dobrudja Foredeep) in the Lower Miocene. There are the Karaganian (traced in the Crimea, present in the North-East Bulgaria (Savronj et al.,1990), Konkian (traced in the Crimea and Northern Black Sea region), and early Middle Sarmatian (traced in the Crimea (Anistratenko et al., 2011) and Northern Black Sea region) levels in the Middle Miocene. The Upper Sarmatian level (traced in the Crimea) observed in the Upper Miocene. In the studied territory these levels expressed in different ways, which is due to the different scale of the events caused them. For the most levels, with the exception of the Middle Sarmatian one, the allochtonic fauna appearance can be associated with erosion of older rocks at the start of transgressions. It is confirmed by the unconformity of the underlying and overlying sediments. The early Middle Sarmatian level of redeposition is connected with the growth of the Azovian block of the Ukrainian Shield, and reinforced through the humid climate, as a result of which the older Eocene fossils (sponge spicules, radiolarians) were blurred of and imported into the Sarmatian Sea along with the little pieces of the Eocene rocks. The climate humidization of this time is confirmed by palynological data (Korallova, 1989).

Quantification of climate requirements of plant taxa using digital resources

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So far, NECLIME has a large inventory of climate data of modern plants, used for the reconstruction of palaeoclimate, which are mainly based on analogue climatological and chorological resources. Possibilities to extend this inventory using digital resources are addressed on the 4th NECLIME Workshop on Digital Plant Distribution held in LIÈGE, on MAY 30 – 31, 2017.

The application of digital chorological and climatological data sets in the reconstruction of climatic requirements of plants may improve the climatic resolution, depending on the quality of the primary data and algorithms used for data extraction. Moreover, additional variables can be assessed that are not at disposal in the NECLIME database so far. So-called bioclimatic variables, such as temperature extremes or quantifiers of duration and temperature of the growing season, on which plants may respond more sensitively, potentially are most meaningful when reconstructing palaeoclimate. Moreover, these variables play an important role in biome modelling where they are used in the physical definition of plant functional types, and enable a direct comparison of model- and proxy-based biome reconstructions.

Here we present a summary of the achievements of the Liège workshop including recommended statistical procedures concerning the numerical treatment of grid cells within a plant distribution area, algorithms to minimize unwelcome bias introduced by microclimates, and usefulness of bioclimatic variables in palaeoclimate reconstructions.

Miocene palynoflora from Penghu islands, Taiwan

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Penghu islands are located in the central Taiwan Strait between Taiwan and mainland China with over 100 islands varying in size. The total area of land covers about 127 square kilometers, of which the islands of Penghu, Baisha and Yuweng are the largest ones, accounting for more than 80% of the total area of the islands. Except for Huayu island in the westernmost which is composed of andesite, the rest of the islands are composed of basalt, sedimentary interlayer, tuff and volcanoclastic rock with wide distribution, representing a typical volcano area in western Taiwan. Evidences from the potassium-argon dating of basalt along with fossil animal in the interlayer indicate that the volcano activities in the Penghu islands took place during about 17 Ma to 8 Ma ago, with 10-14 Ma ago as the most prosperous period. In the Penghu islands, 2-4 layers of basalt flows can be recognized with sedimentary rocks in between.

The present climate of the islands is cool in summer and warm in winter with scarce rainfall and strong wind. It is a place holding the least rainfall in Taiwan. The precipitation in summer accounts for 80% throughout the year, while the drought period lasts for about 180 days. The strong northeast monsoon is the main factor controlling the local climate. It not only affects the growth of agroforestry plants, but also has a great effect on soil, resulting in the formation of short grass and shrubs. Meanwhile, the high salty soil is also not conducive to the growth of plants, because the islands are located in the sea. There has been so far no report on the fossil plant from the sedimentary interbeds of the basalt in the Penghu islands. The author once studied spores and pollen grains in a sedimentary sample collected from the horizon just below basalt bed 1 in Hsiyu island, where a new fossil tomistomine crocodile was reported. Palynological assemblage from the sample reveals a diversified plant types including mangrove, which is totally different with the vegetation today, and mostly comparable with the palynoflora of the Neogene climatic optimum (ca. 17-14 Ma) in Japan. Recently more detailed Miocene palynoflora is recovered from the sedimentary interlayer in several islands.

The formation of the Penghu islands is closely related to the enhancement of new tectonic movement in the Neogene. In the Cretaceous to Paleogene, the eastern coastal area of China was still the complex of high and steep mountains separated by an en echelon arrangement of rift valleys. The unequal horizontal expansion and subsidence or sloping subsidence as a result of the new tectonic movement, made the eastern China a tectonic sinking gulf coast, reflecting the characteristics of tectonic movement in the eastern active continental margin of the Eurasian plate. Meanwhile, strong rise took place in Taiwan Island as a result of the collision between the Eurasian plate and the Philippines Sea plate, while the Taiwan Strait became an intense rifting zone. Since the Miocene, the expansion of the South China Sea gradually enhanced, and a lot of half graben structures composed of normal faults were formed in the continental margin. It is due to the rmodynamic and crack effect caused by the spreading of the South China Sea, that a series of volcano activities happened beyond the south of the Yangtze River estuary including Jiangsu, Zhejiang, Fujian, Guangdong Provinces, the Pearl River Delta, the Penghu area and the western foothills of Taiwan.

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Stomatal density variation of Early Pleistocene *Fagus* leaves from central Japan

Hindering paleo-CO2 reconstruction or indicating palaeo-altitude?

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Stomatal parameters have been widely used in reconstructing palaeo-CO2 partial pressure. This is based on a hypothesis that all fossilized leaves came from a same altitude at sea-level. However, this hypothesis is sometimes doubtful. A specie which grew in a wide altitudinal range can provide leaves from different altitudes into a fossil assemblage, which will cause a bias for palaeo-CO2 reconstruction. On the other hand, the altitudinal change of stomatal density is useful for palaeo-altitude reconstruction. Here, we studied stomatal density variation of fossilized *Quercus gilva* and *Fagus crenata* in an Early Pleistocene (ca. 1.6 Ma) fossil leaf assemblage from the Sayama Formation in central Japan to reconstruct palaeo-altitude distribution of both species. Our results exhibited a great variation in stomatal density of fossilized *F. crenata* leaves, which cannot be explained by stomatal density variation in a modern natural population in an altitude. Compared with stomatal density of modern *F. crenata* populations at different altitudes, palaeo-altitudinal range of habitats of *F. crenata* is estimated up to 1500~2000 m, although climate and/or edaphic dependent bias may alter this estimation. According to our research, following conclusions can be made: 1) In an interglacial stage in ca. 1.6 Ma, sea-level palaeo-pCO2 at place of fossil deposition was around 31.4~33.4 pa, which is lower than the present level (around 40 pa) but higher than the pre-industrial level (around 27~28 pa); 2) The variation in stomatal density of *F. crenata* cannot explain by natural population variability, which is possibly caused by effect of palaeo-altitude difference of leaves derived; 3) Palaeo-altitude of the hinterland and plant habitats of fossil assemblage components can be calculated based on stomatal density variation; 4) More data of stomatal density variation dependent on environment factors are necessary to collect from modern populations at different altitudes to improve the accuracy of this study.

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EXCURSION GUIDE

THURSDAY 2109.2017 — SUNDAY 24.09.2017

21.09.2017

10:00 departure from the hotel

Bus travel to Sisian, Southern Armenia: modern vegetation on a transect from lowland semi-desert to subalpine meadows, incl. stop at Kor Virap monastery and Areni winery.

20:00 arrival in Sissian, accommodation, dinner and breakfast at hotel

22.09.2017

10:00 departure from the hotel

Excursion in the Vorotan River Valley: plant fossil sites, geology, modern vegetation and culture

20:00 arrival in Sissian, accommodation, dinner and breakfast at hotel

23.09.2017

10:00 departure from the hotel

Excursion to Tatev monastery: plant fossil sites, geology, modern vegetation and culture

20:00 arrival in Sissian, accommodation, dinner and breakfast at hotel

24.09.2017

10:00 departure from the hotel

Travel back to Yerevan, incl. stops at the archaeological site of Areni Cave and Noravank monastery

20:00 farewell dinner in Yerevan

Day 1 – from Yerevan to Sisian

Fig. 1. Map of Armenia from Ezilon Maps (www.ezilon.com)

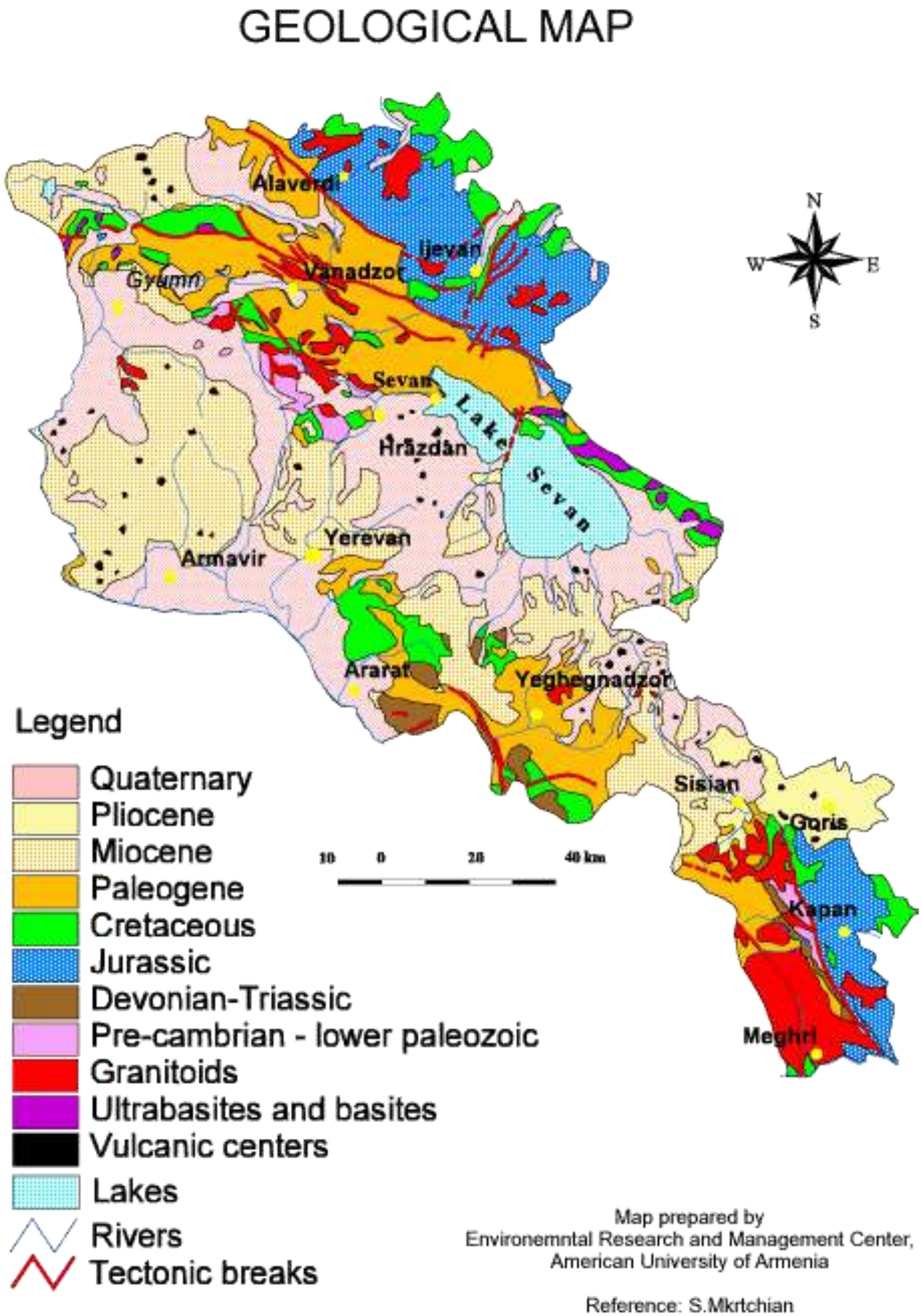


Fig. 2. Geological map of Armenia (http://maps.unomaha.edu/peterson/funda/MapLinks/Armenia/)

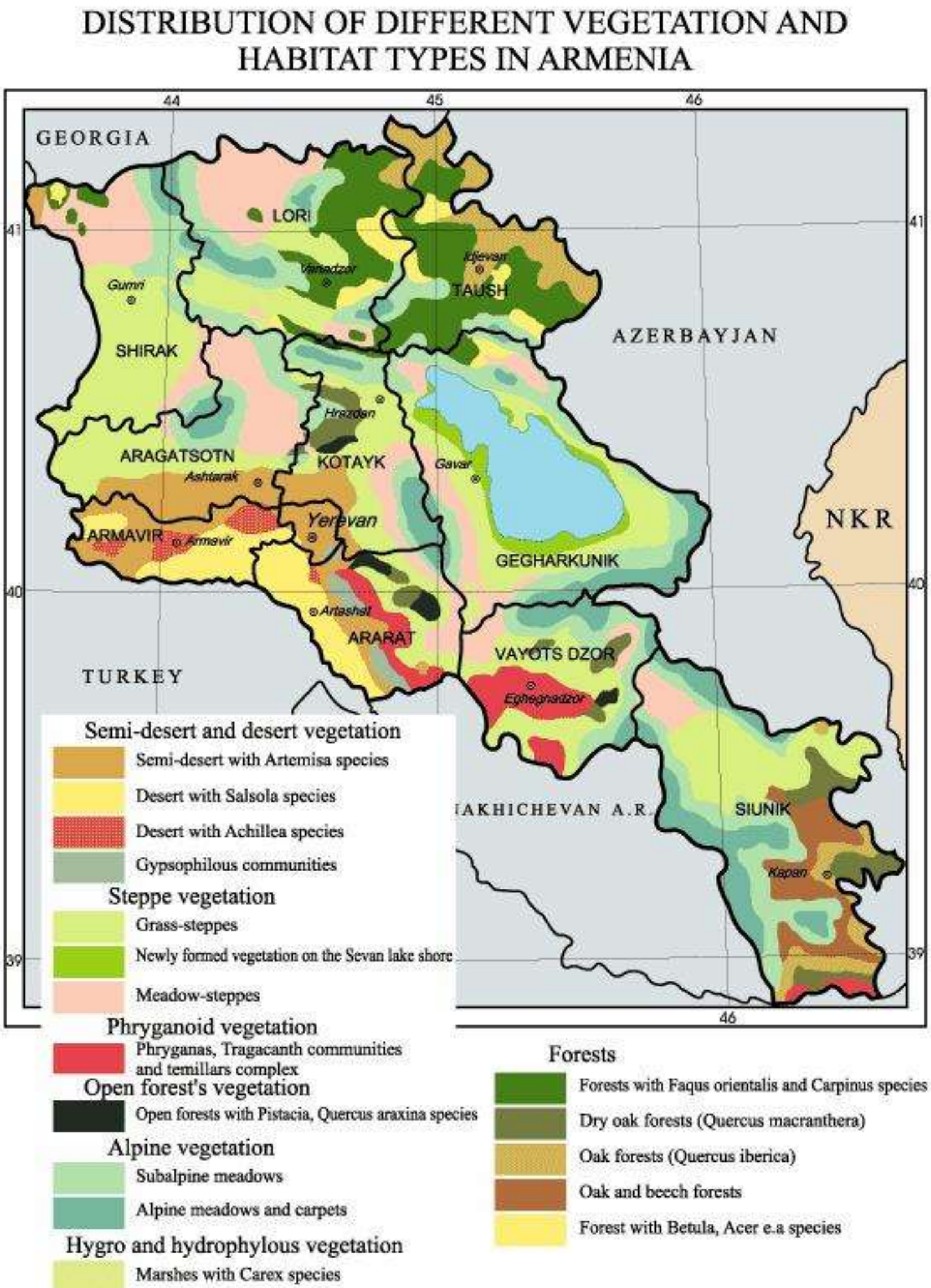


Fig. 3. Vegetation map of Armenia (http://maps.unomaha.edu/peterson/funda/MapLinks/Armenia/)

1.1 Modern vegetation on a transect from lowland semi-desert to subalpine meadows

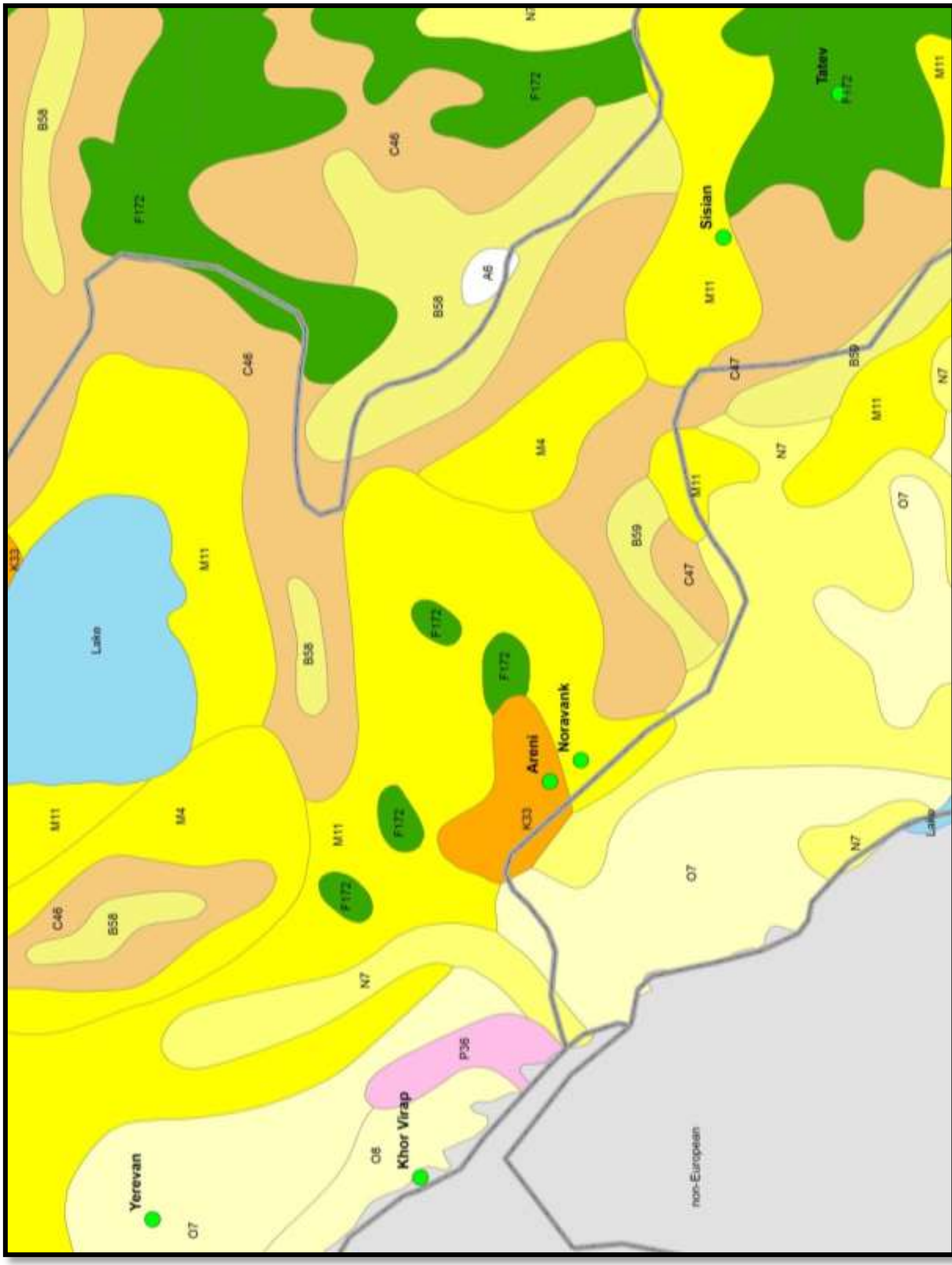


Fig. 4. Detail of the Vegetation Map of Europe (EuroVegMap; Bohn et al. 2004). Description of vegetation units see Table 1.

Table 1: Description of Armenian vegetation units from EuroVegMap (Bohn et al. 2004).

O7 - East Transcaucasian wormwood deserts (Artemisia fragrans) with ephemeroids (Poa bulbosa, Catabrosella humilis)

- **Geographical distribution**
  - **Country/territory**
    Azerbaijan: large areas in the Kura-Araks lowland (plain) and its outliers, further in shallow Jorskoe-mountains, Nakhichevan; Armenia: in the Araratskaja basin (locally also on analogous ecotypes)
  - **area covered**
    16930 km²
- **Scientific names of main plant communities and their most common synonyms (with author citation)**
  Catabrosella humilis-Poa bulbosa-Artemisia fragrans community.
- **Structural feature of the main community(ies) (layers, life-forms, etc.)**
  Dominant desert communities of east Transcaucasia. They form two clear synusia: 1) with the dwarf semishrub Artemisia fragrans and 2) with the short-lived grasses Poa bulbosa and Catabrosella humilis. In relatively wet years the degree of cover reaches 85 %. As well as dwarf semishrubs and grasses, ephemeroids and ephemerals are also frequent.
- **Dominant and most frequent species in different layers**
  - **Tree layer**

  - **Shrub layer**

  - **Lianas**

  - **Herb layer**
    Artemisia fragrans, Poa bulbosa, Catabrosella humilis, Kochia prostrata, Agropyron cristatum, Allium rubellum, Allium pseudoflavum, Noaea mucronata, Bongardia chrysogonum, Gagea commutata, Iris iberica, Alyssum turkestanicum, Anthemis candidissima, Bromus japonicus among others
  - **Moss layer (incl. lichens)**
    No details
- **Diagnostically important species**
  Artemisia fragrans, Catabrosella humilis, Poa bulbosa
- **Geographical variants (geogr. differential species)**
  In the basins of Erevan and Ararat this mapping unit occurs in alternation with Achillea tenuifolia desert. On analogous ecotopes in Armenia Tanacetum chiliophyllum and Tanacetum argyrophyllum are characteristic, and in the Džulfinskaja basin in Azerbaijan: Neogaillonia szovitsii and Stipagrostis plumosa.

O8 - East transcaucasian Salsola nodulosa- and Salsola ericoides-deserts with ephemeroids (Poa bulbosa, Catabrosella humilis), with Artemisia fragrans

- **Geographical distribution**
  - **Country/territory**
    south-east Georgia; Azerbaijan: Kura-Araks lowland, on the Apšeronskij peninsula; Armenia: in the Ararat basin
  - **area covered**
    3710 km²
- **Scientific names of main plant communities and their most common synonyms (with author citation)**
  Catabrosella humilis-Poa bulbosa-Salsola nodulosa community, Catabrosella humilis-Poa bulbosa-Salsola ericoides community.
- **Structural feature of the main community(ies) (layers, life-forms, etc.)**
  Dwarf semishrubs play a major role and Salsola nodulosa as well as S. ericoides dominate. Ephemerals are also frequent. The occurrence of ephemeroids is typical (although they occur in mapping unit **~~O7~~** more strongly).
- **Dominant and most frequent species in different layers**
  - **Tree layer**

  - **Shrub layer**

  - **Lianas**

  - **Herb layer**
    Salsola nodulosa, Salsola ericoides, Artemisia fragrans, Poa bulbosa, Catabrosella humilis, Kochia prostrata, Noaea mucronata, Limonium suffruticosum, Alyssum parviflorum, Arabidopsis pumila, Ceratocephala falcata, Bromus japonicus, Erodium cicutarium, Lepidium vesicarium, Velezia rigida, Salvia-species among others
  - **Moss layer (incl. lichens)**
    No details
- **Diagnostically important species**
  Salsola nodulosa, Salsola ericoides, Poa bulbosa, Catabrosella humilis, Artemisia fragrans
- **Geographical variants (geogr. differential species)**
  Salsola nodulosa deserts are endemic to east Transcaucasia.

P36 - East Transcaucasian halophytic vegetation (Halocnemum strobilaceum, Kalidium caspicum, Halostachys belangeriana, Suaeda microphylla, Salsola dendroides, Atriplex verrucifera, Salicornia prostrata, Petrosimonia brachiata, Salsola soda, Climacoptera crassa, Gamanthus pilosus, Suaeda altissima, Seidlitzia florida) on solonchak

- **Geographical distribution**
  - **Country/territory**
    Armenia; Azerbaijan: Kura-Araks-lowland
  - **area covered**
    3440 km²
- **Scientific names of main plant communities and their most common synonyms (with author citation)**
  Halocnemum strobilaceum-community, Suaeda microphylla-Halostachys belangeriana-community, Salsola dendroides-community, community of annual halophytes.
- **Structural feature of the main community(ies) (layers, life-forms, etc.)**
  Open vegetation cover (40-45 % degree of coverage); species-poor community; dwarf semishrubs are dominant, as are annual halophyte species.
- **Dominant and most frequent species in different layers**
  - **Tree layer**

  - **Shrub layer**

  - **Lianas**

  - **Herb layer**
    Halocnemum strobilaceum, Halostachys belangeriana, Suaeda microphylla, Salsola dendroides, Kalidium caspicum; Salicornia prostrata, annual halophytes (Salsola, Suaeda among others)
  - **Moss layer (incl. lichens)**
    No details
- **Diagnostically important species**
  Halostachys belangeriana, Suaeda microphylla, Atriplex verrucifera, Camphorosma lessingii, Gamanthus pilosus, Seidlitzia florida
- **Geographical variants (geogr. differential species)**
  At the eastern coast of the Caspian Sea the north Turanian species do not occur (Atriplex verrucifera, Petrosimonia brachiata, Salsola soda, Camphorosma lessingii).

N7 - South Transcaucasian thorn-cushion vegetation (Astragalus aureus, Astragalus microcephalus, Astragalus lagopoides, Astragalus uraniolimneus, Acantholimon armenum, Onobrychis cornuta) with Astragalus hajastanus, Astragalus vedicus, Astragalus karabaghensis and tomillares with Stachys inflata, Salvia hydrangea, Thymus kotschyanus

- **Geographical distribution**
  - **Country/territory**
    Armenia: Ararat, border to Nakhichevan; Azerbaijan: Nakhichevan, south-western end of the Zangezur mountain ridge, central Karabach
  - **area covered**
    2610 km²
- **Scientific names of main plant communities and their most common synonyms (with author citation)**
  Astragaleta aurei, Astragaleta microcephali, Astragaleta uraniolimnei.
- **Structural feature of the main community(ies) (layers, life-forms, etc.)**
  Thorn-cushion communities with dominant dwarf shrubs: Astragalus aureus, Astragalus microcephalus, Astragalus lagopoides, Astragalus uraniolimneus, Onobrychis cornuta; Steppe and mountain steppe species are frequently added. Geophytes and annuals are also typical. Tomillares with dwarf semishrubs. Onobrychis communities with dominant Onobrychis cornuta, as codominants Acantholimon species as well as Acanthophyllum mucronatum, Gypsophila aretioides, and amongst the typical components Astragalus elbrusensis, Astragalus cancellatus, Daphne kurdica. The flora of this mapping unit is diverse and species-rich (up to 250 vascular plant species). Many endemics and species with a north-Iranian and north-west Anatolian distribution are typical.
- **Dominant and most frequent species in different layers**
  - **Tree layer**

  - **Shrub layer**
    dwarf shrubs and thorn-cushion: Juniperus communis subsp. hemisphaerica, Prunus incana, Daphne kurdica, Astragalus aureus, Astragalus microcephalus, Astragalus lagopoides, Astragalus uraniolimneus, Onobrychis cornuta; codominants: Acantholimon armenum, Atraphaxis spinosa, Astragalus vedicus, Astragalus karabaghensis, Astragalus sangesuricus, Atraphaxis spinosa, Acantholimon armenum, Acantholimon araxanum, Acantholimon glumaceum, Scutellaria- and Stachys-species
  - **Lianas**

  - **Herb layer**
    Astragalus hajastanus, Stachys inflata, Salvia hydrangea, Thymus kotschyanus, Astragalus strictifolius, Astragalus oleifolius, Aethionema arabicum, Helianthemum lasiocarpum, Bromus tectorum, Poa bulbosa, Ajuga chia; geophytes: Hyacinthella atropatana, Allium akaka, Iris caucasica, Muscari-, Bellevalia-, Tulipa-species

- **Moss layer (incl. lichens)**
  No details

- **Diagnostically important species**
  Astragalus aureus, Astragalus microcephalus, Astragalus lagopoides, Astragalus uraniolimneus, Astragalus hajastanus, Astragalus vedicus, Astragalus karabaghensis, Astragalus strictifolius, Astragalus sangesuricus, Astragalus oleifolius, Onobrychis cornuta; Stachys inflata, Salvia hydrangea, Thymus kotschyanus, Acantholimon armenum, Acantholimon araxanum, Acantholimon glumaceum

M11 - Pre- and Transcaucasian Stipa-steppes (Stipa tirsa, Stipa pulcherrima, Stipa daghestanica, Stipa transcaucasica, Stipa araxensis, Stipa pontica, Stipa holosericea, Stipa hohenackeriana) with Elytrigia gracillima, Astragalus haesitabundus, Astragalus gjunaicus, Medicago daghestanica, Onobrychis transcaucasica, Linaria megrica and Bothriochloa ischaemum-steppes with Onobrychis ruprechtii, Onobrychis kachetica, Salvia daghestanica, Hyssopus officinalis subsp. angustifolius, Medicago caerulea, Polygala transcaucasica, alternating with tomillares (Thymus daghestanicus, Thymus karamarjanicus, Thymus tiflisiensis, Thymus kotschyanus, Scutellaria orientalis) and thorn-cushion communities (Astragalus aureus, Astragalus denudatus, Astragalus microcephalus, Astragalus uraniolimneus
Geographical distribution

- **Country/territory**
  Russia (Chechnya, Daghestan); Georgia; Armenia; Azerbaijan. Caucasus: northern foothills Terskyi and Sunjenskyi; towards the Caspian Sea orientated slopes of the Greater Caucasian between Alty-Agač and Šemacha, southern slope of the Geokčaj basin, in the Iori-Šeki highland. Low Caucasus: volcanian highland Džavakheti (Achalkalaki plateau), mountain kettle in the Armenian highland (Lori, Širak, Sevan), slopes of high mountain massifs (Vardenis, Karabach), west and east margins of the Zangezur ridge (Daralagez and Bargušat ridge, mountains Kapudžuk, Agdag); Talysh Mountains
- **area covered**
  29200 km²

- **Scientific names of main plant communities and their most common synonyms (with author citation)**
  Stipeta (tirsae, pulcherrimae, daghestanicae, hohenackeranae, ponticae) herbosa; Bothriochloeta ischaemum herbosa; Thymeta (daghestanicus, karamarjanicus, kotschyanus); Astragaleta (aureus, microcephalus, denudatus).

- **Structural feature of the main community(ies) (layers, life-forms, etc.)**
  The most important components of these mountain range steppes are Stipa tirsa, and sometimes the xeropetrophytic species Stipa pontica, more rarely Stipa pennata, Stipa lessingiana and Stipa pulcherrima, and at very stony and rocky sites Stipa capillata, Stipa holosericea, Stipa hohenackeriana, Stipa daghestanica, Stipa araxensis, Stipa transcaucasica and Festuca valesiaca. Often Carex humilis is

present. Typical species for the Pontic steppes (e.g. Koeleria macrantha, Phleum phleoides, Bromus riparius) are characteristic in combination with mountain and meadow steppe species.
Herbs are very numerously represented (130 species), steppe and meadow steppe species are particularly widely distributed, and many mountain steppe species are also present.

- **Dominant and most frequent species in different layers**
  - **Tree layer**

  - **Shrub layer**

  - **Lianas**

  - **Herb layer**

    Stipa tirsa, Stipa pulcherrima, Stipa pontica, Stipa pennata, Stipa holosericea, Stipa hohenackeriana, Carex humilis, Festuca valesiaca, Dactylis glomerata, Brachypodium pinnatum, Filipendula vulgaris, Trifolium alpestre;

    Bothriochloa ischaemum-steppes with Stipa capillata, Elytrigia gracillima, Cleistogenes bulgarica, Melica transsilvanica, Salvia daghestanica, Centaurea daghestanica, Scabiosa gumbetica, Onobrychis cyri, Gagea commutata, Crocus biflorus subsp. adamii, Bellevalia wilhelmsii; tomillares with Thymus-species, Nepeta racemosa, Artemisia daghestanica; in Tragacanthae-communities: Astragalus aureus, A. microcephalus, A. denudatus, A. uraniolimneus, Onobrychis cornuta, Acantholimon glumaceum, A. hohenackeri
  - **Moss layer (incl. lichens)**

    Bothriochloa ischaemum-steppes with Tortula ruralis, Tortula subulata, Pleurochaete squarrosa
- **Diagnostically important species**

  Stipa tirsa, Stipa holosericea, Stipa hohenackeriana, Stipa daghestanica, Stipa araxensis, Stipa transcaucasica, Elytrigia gracillima, Astragalus haesitabundus, Astragalus captiosus, Astragalus gjunaicus, Onobrychis transcaucasica, Onobrychis kachetica, Linaria megrica, Scutellaria orientalis, Scutellaria sosnowskyi
- **Geographical variants (geogr. differential species)**

  In Daghestan there are variants with local and Greater-Caucasian endemics (Stipa daghestanica, Elytrigia gracillima, Onobrychis bobrovii, Medicago daghestanica, Astragalus haesitabundus etc.; Salvia daghestanica, Onobrychis ruprechtii, Scabiosa gumbetica etc.); a south-Transcaucasian variant features local endemics and numerous Transcaucasian-Anatolian species (Stipa araxensis, Stipa holosericea, Stipa hohenackeriana, Stipa transcaucasica, Linaria megrica, Verbascum hajastanicum, Pulsatilla armena, Astragalus gjunaicus etc).

C47 - South Low Caucasian open woodlands (Quercus macranthera) with Acer hyrcanum, Pyrus zangezura, scrub (Juniperus communis subsp. hemisphaerica), partly grasslands (Bromus variegatus, Koeleria albovii), alternating with steppes (Festuca valesiaca, Koeleria macrantha, Nepeta strictifolia) and thorn-cushion mountain vegetation (Astragalus aureus, Astragalus lagopoides, Onobrychis cornuta, Acantholimon glumaceum)

- **Geographical distribution**
  - **Country/territory**
    in the south of the Low Caucasus: central and southern part of the Zangezur, Daralagez and Megri ridge of hills (Armenia; Azerbaijan: autonomy region Nakhichevan)
  - **area covered**
    1340 km²
- **Scientific names of main plant communities and their most common synonyms (with author citation)**
  Formation group of subalpine open woodlands, altimontane prostrate shrubs, subalpine grasslands (Doluchanov et al. 1942); steppe vegetation, oreo-xerophytic vegetation (Grossgejm 1948) = Querco-Fagetea Braun-Blanquet & Vlieger 1937, Caricetea curvulae Braun-Blanquet 1948; Festuco-Brometea Braun-Blanquet & R. Tüxen in Braun-Blanquet 1949.
- **Structural feature of the main community(ies) (layers, life-forms, etc.)**
  Quercus macranthera communities (see **C46**); low-growing forests with different dominant species, average height 3-5 m, on soils with a high skeletal content and also rich in stones and rubble. The trees frequently have a shrub-like form and stand far apart from one another. The forests are usually two-layered and occur up to altitudes of between 2350 and 2400 m. Regarding the remaining communities see **C46** or also **C43**.
- **Dominant and most frequent species in different layers**
  - **Tree layer**
    Quercus macranthera forests: Quercus macranthera, Pyrus zangezura, Pyrus syriaca, Acer hyrcanum; low-growing forests: Acer hyrcanum, Quercus macranthera, Juniperus polycarpos
  - **Shrub layer**
    Quercus macranthera-forests: Crataegus monogyna, Euonymus latifolia, Juniperus communis subsp. hemisphaerica; low-growing forests: Crataegus armena, Crataegus meyeri, Cotoneaster spp., Sorbus graeca, Sorbus kuznetzovii; shrubs and dwarf shrubs of the thorn-cushion vegetation of the mountains: Astragalus aureus, Astragalus lagopoides, Rhamnus pallasii, Rhamnus spathulifolia, Atraphaxis angustifolia, Juniperus communis subsp. hemisphaerica, Juniperus sabina, Ephedra procera
  - **Lianas**

- **Herb layer**

  Quercus macranthera forests: Bromus variegatus, Koeleria macrantha, Carex humilis, Festuca valesiaca; steppes: Festuca valesiaca, Koeleria macrantha, Astragalus incertus, Artemisia splendens, Thymus spp., Oxytropis albana, Prangos ferulacea

- **Moss layer (incl. lichens)**

  No details

- **Diagnostically important species**

  Koeleria albovii, Onobrychis transcaucasica, Scabiosa caucasica, Papaver orientale, Pyrus zangezura, Pyrus syriaca, Sorbus kuznetzovii

- **Ecological variants**

  Mainly on lime-rich soils: Acantholimon glumaceum, Onobrychis cornuta.

F172 - East Transcaucasian altimontane oak forests (Quercus macranthera)

- **Geographical distribution**
  - **Country/territory**

    Armenia; Azerbaijan: Lesser Caucasus, eastern outposts of the Greater Caucasus; Russia: Daghestan (small-scaled, not shown on the map)

  - **area covered**

    5030 km²

- **Scientific names of main plant communities and their most common synonyms (with author citation)**

  Quercion macrantherae (Quercion querci-macrantherae) sensu Doluchanov, Aceri hyrcani-Quercetum macrantherae Klein & Lacoste 1989.

- **Structural feature of the main community(ies) (layers, life-forms, etc.)**

  Mono or oligodominant oak forests with dominant Quercus macranthera at middle and higher mountain altitudes. The tree layer at locations between 1400 and 1800 m is growthy (18-28 m high) and closed. Here, the hornbeam (Carpinus betulus) is generally distributed as a codominant, and its growth height corresponds largely to that of the oak. The proportion of hornbeam declines above 1700 m, and at altitudes of around 1900 m it is almost completely absent. The shrub layer is usually weakly developed, but species-rich. The herb layer is also species-rich, but varies according to region, altitude and exposure. Apart from widespread nemoral species it contains above all Caucasian and Caucasian-Anatolian endemics. High-mountain variants are low growing (8-15 m) and they grow in the form of open and shrub forests.

- **Dominant and most frequent species in different layers**

- **Tree layer**

  Quercus macranthera, mono-dominant or in mixture with Carpinus betulus, Fraxinus excelsior, Acer cappadocicum, Acer platanoides, Acer campestre, Acer trautvetteri, Tilia begoniifolia, Tilia cordata, Sorbus torminalis

- **Shrub layer**

  Lonicera caucasica, Euonymus latifolia, Rosa pimpinellifolia, Rosa boissieri, Ribes biebersteinii, Rubus buschii; on dry and stony sites: Lonicera iberica, Euonymus verrucosa, Cotoneaster integerrimus, Sorbus aria, Sorbus persica, Prunus incana, Juniperus communis subsp. oblonga; rare and endemic species: Daphne kurdica, Crataegus tournefortii, Cotoneaster transcaucasicus, Cotoneaster meyeri, Prunus incana var. angustifolia, Rosa zangezura, Rosa nisami, Rosa sachokiana, Euonymus velutina, Rhamnus spathulifolia,; in open forests of sunny exposure (as high as 1700 m): Pyrus caucasica, Malus sylvestris subsp. orientalis, Prunus divaricata

- **Lianas**

- **Herb layer**

  widely distributed nemoral species: Sanicula europaea, Festuca drymeja, Poa nemoralis, Actaea spicata, Geranium robertianum, Dryopteris filix-mas, Galium odoratum, Calamagrostis arundinacea, Dactylis glomerata, Luzula forsteri, Milium effusum; in open stands: Lathyrus roseus, Lathyrus hirsutus, Lathyrus aureus, Vicia truncatula, Laser trilobum, Pimpinella tripartita, Primula veris subsp. macrocalyx, Serratula quinquefolia, Dictamnus caucasicus, locally Elymus caucasicus; tall forb with Caucasiann elements of subalpine tall forb plains in altitudes of about 1800-2100 m on moist soils: Galega orientalis, Vicia balansae, Valeriana tiliifolia, Silene multifida, Eleutherospermum cicutarium, Angelica purpurascens, Heracleum pastinacifolium, Heracleum trachyloma, Aconitum variegatum subsp. nasutum, Cephalaria gigantea, Lilium szovitsianum, Lilium armenum, Lilium ledebourii; in open oak forests in contact to mountain steppes: Carex humilis, Festuca rupicola and other steppe plants, further Platanthera chlorantha, Dactylorhiza flavescens, Pimpinella rhodantha, Lathyrus laxiflorus, Lotus corniculatus, Silene italica, Salvia glutinosa, Origanum vulgare, Clinopodium vulgare, Achillea biserrata, Campanula alliariifolia

- **Moss layer (incl. lichens)**

  No details

- **Diagnostically important species**

  Quercus macranthera, Daphne kurdica, Crataegus tournefortii, Cotoneaster transcaucasicus, Cotoneaster meyeri, Prunus incana var. angustifolia, Rosa zangezura, Rosa nisami, Rosa sachokiana, Euonymus velutina, Rhamnus spathulifolia; Elymus caucasicus, Poa iberica, Puschkinia scilloides, Iris reticulata, Silene wallichiana, Lathyrus roseus, Vicia truncatula, Seseli peucedanoides, Pimpinella tripartita

- **Ecological variants**

  At altitudes of around 1800-2100 m on moist soils there are tall forbs with Caucasian elements of subalpine tall-forb vegetation: see 'Dominants and most frequent species' (Herb layer).

- **Geographical variants (geogr. differential species)**

  In the southeast Lesser Caucasus (and in the Talysh) with Acer hyrcanum, occasionally Carpinus schuschaensis, in Zangezur Pyrus zangezura and Pyrus syriaca. Locally endemic species are characteristic in southeast Transcaucasia (differential species: Scilla caucasica, Centaurea karabaghensis, Pyrus nutans, Pyrus raddeana, Sorbus persica, Carpinus schuschaensis, Euonymus velutina, Daphne kurdica, Elymus caucasicus, Dactylis glomerata subsp. woronowii, Iris imbricata, Tulipa florenskyi, Vicia nissoliana, Pimpinella anthriscoides, Centaurea transcaucasica, Digitalis nervosa). Differential species in the eastern part of the Greater Caucasus: Sorbus kuznetzovii, Gentiana slateocalyx, Centaurea dealbata, Cirsium osseticum, Lilium monadelphum, Scabiosa owerinii. In the Armenian high-mountains one finds low growing and very open oak forests between 1660-2300 m with many mountain steppe species (differential species: Juniperus polycarpos, Juniperus foetidissima, Prunus fenzliana, Celtis glabrata, Pyrus salicifolia, Crataegus pseudoheterophylla, Crataegus meyeri, Scutellaria sevanensis, Nepeta strictifolia, Thymus kotschyanus, Verbascum oreophilum, Onobrychis cornuta, Astragalus strictifolius, Astragalus lagopoides, Acantholimon araxanum, Acantholimon glumaceum).

1.2 Khor Virap monastery

Khor Virap Monastery, 30km south of Yerevan, is a famous pilgrimage site with an iconic location at the foot of Mt Ararat. The monastery is on a hillock close to the Araks River, overlooking river pastures, stork nests and vineyards, 4km off the main highway through the village of Pokr Vedi (sometimes also called Khor Virap).

The pagan King Trdat III imprisoned St Gregory the Illuminator (Surp Grigor Lusavorich) in a well (khor virap means ‘deep well’) here for 12 years, where Christian women secretly fed him. The king was later cursed by madness (or, in a more colourful version of the tale, cursed by sprouting the head of a boar) and miraculously cured by St Gregory. Historians contend that Trdat may have switched allegiances to tap into the strength of Armenia’s growing Christian community in the face of Roman aggression. In any case the king converted to Christianity and St Gregory became the first Catholicos of the Armenian Apostolic Church, and set about building churches on top of pagan temples and teaching the faith.

The ground-level buildings at Khor Virap have been repeatedly rebuilt since at least the 6th century, and the main Surp Astvatsatsin Church dates from the 17th century. Khor Virap is an important pilgrimage site and people often visit for a baptism or after a wedding to perform a matagh (sacrifice, often of sheep or chicken), which keeps the priests busy on weekends. It’s a shivery experience to climb down the 7m-deep well. The well is lit, but you need to wear sturdy shoes to scale the metal ladder. Just outside the monastery walls are some excavations on the site of Artashat, Trdat’s capital, founded in the 2nd century BC. (Wikipedia).

Photo by F.Schrenk

Day 2 - the Vorotan River Valley: plant fossil sites, geology, modern vegetation and culture

2.1 Modern vegetation and geology

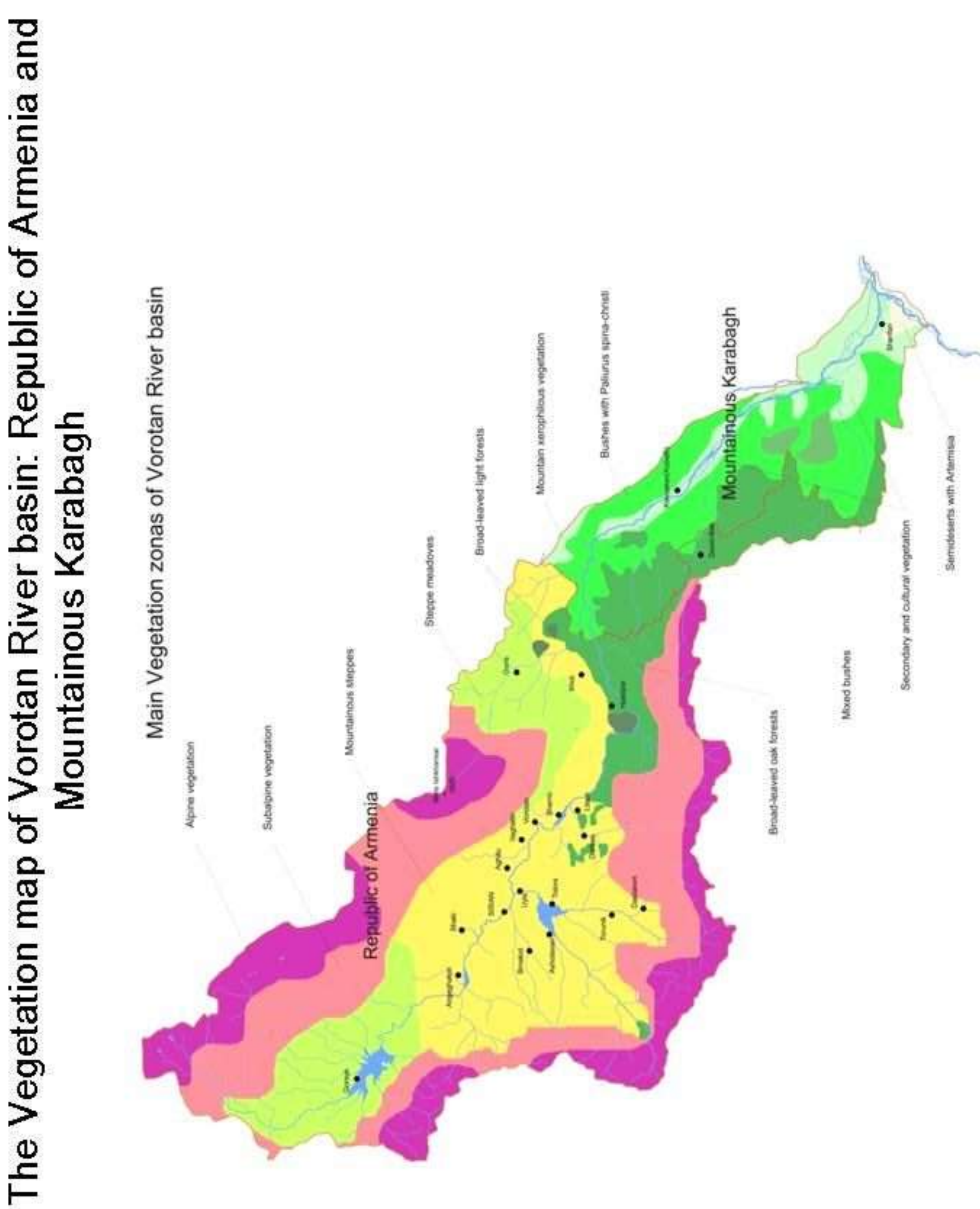


Fig. 5. Mapping by N. Alexanyan and I. Gabrielyan 2009.

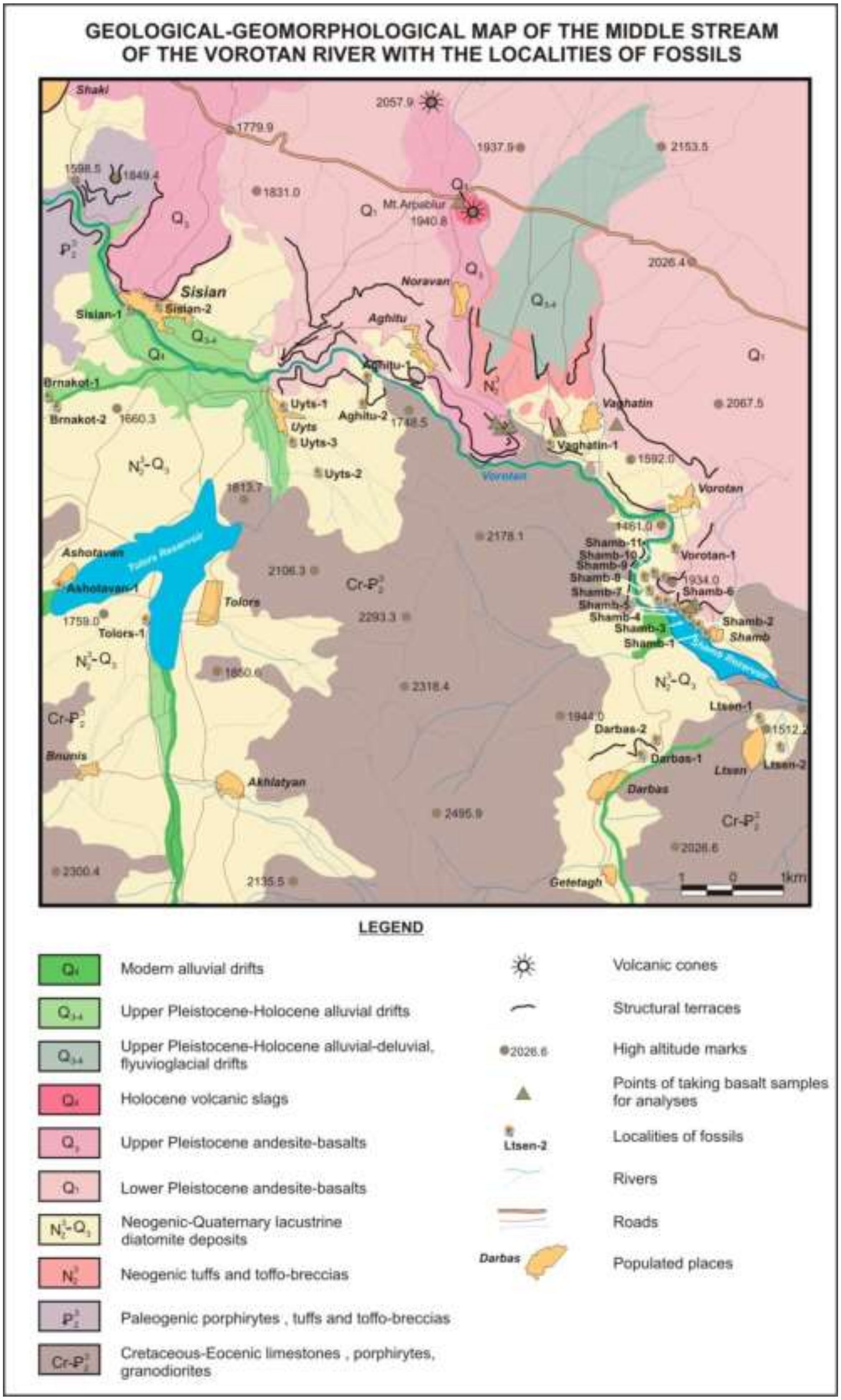


Fig.6. Compilation and mapping by D. Arakelyan 2014.

2.2. The plant fossil sites

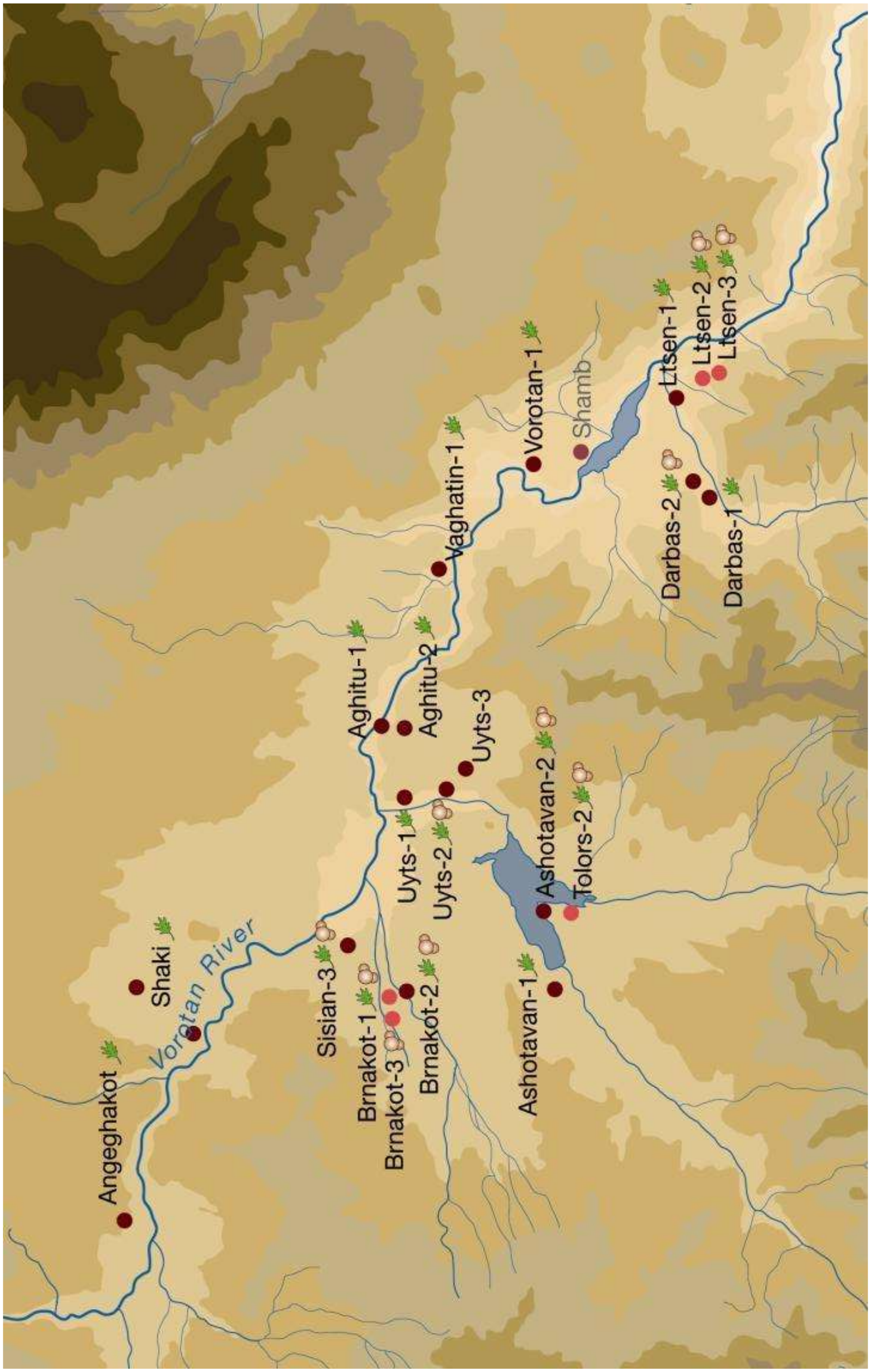
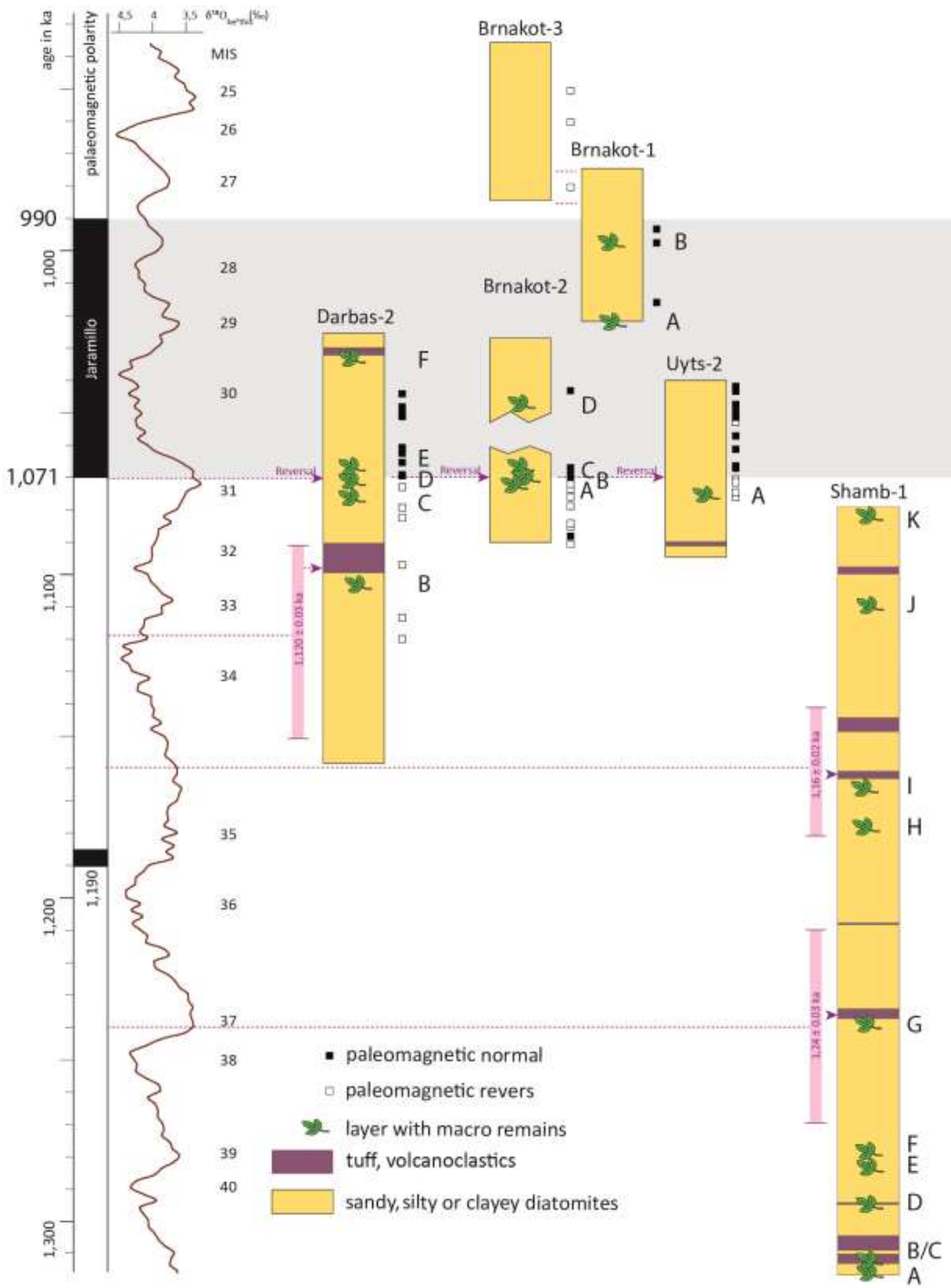


Fig.7. Plant fossil localities in the Sisian part of Vorotan River Basin (Scharrer 2013).



Fip. 8. Stratigrahy of the sections, Kirscher et al. 2014.

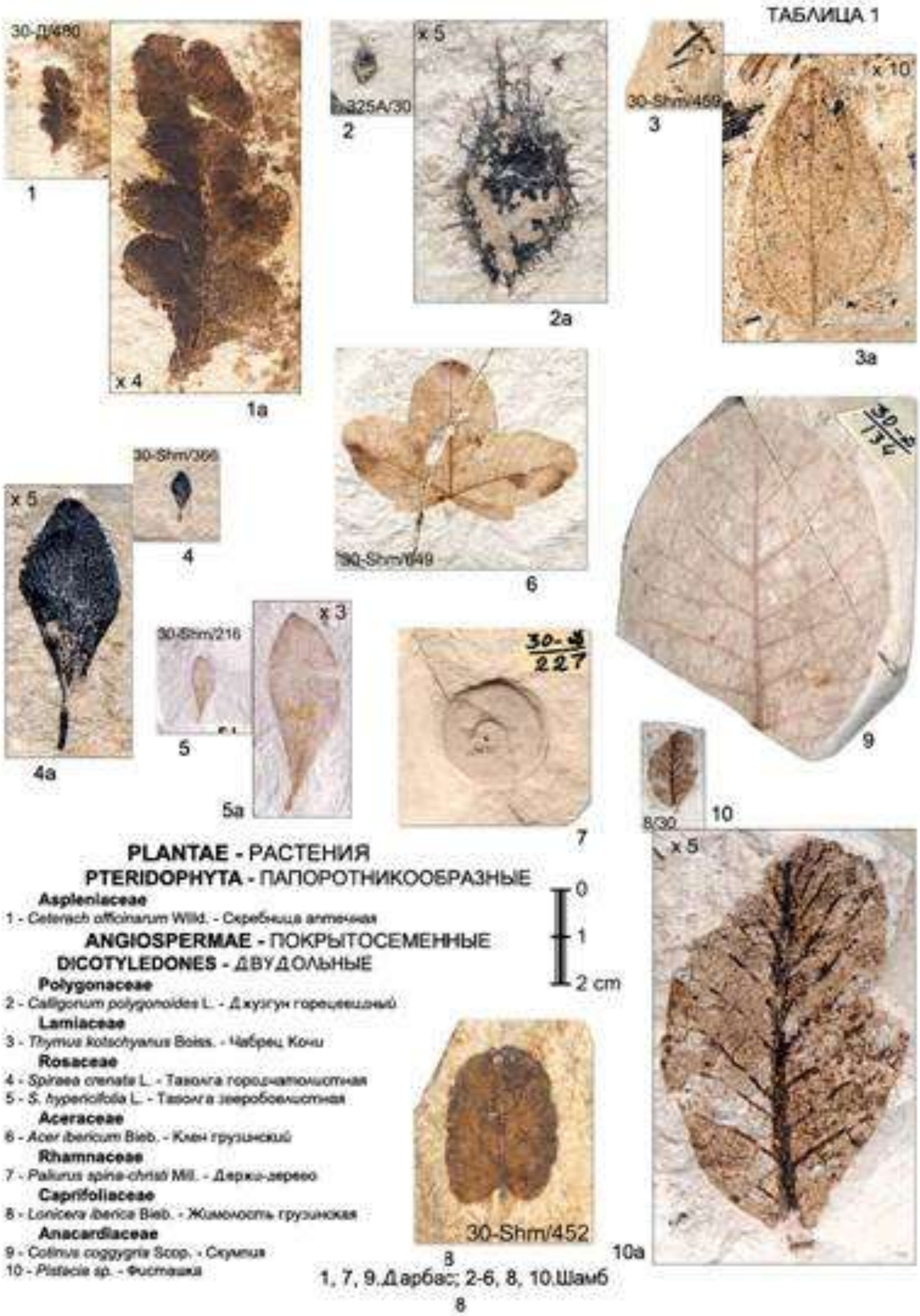


Fig. 9a. Some examples of plant fossils from Vorotan River Basin.

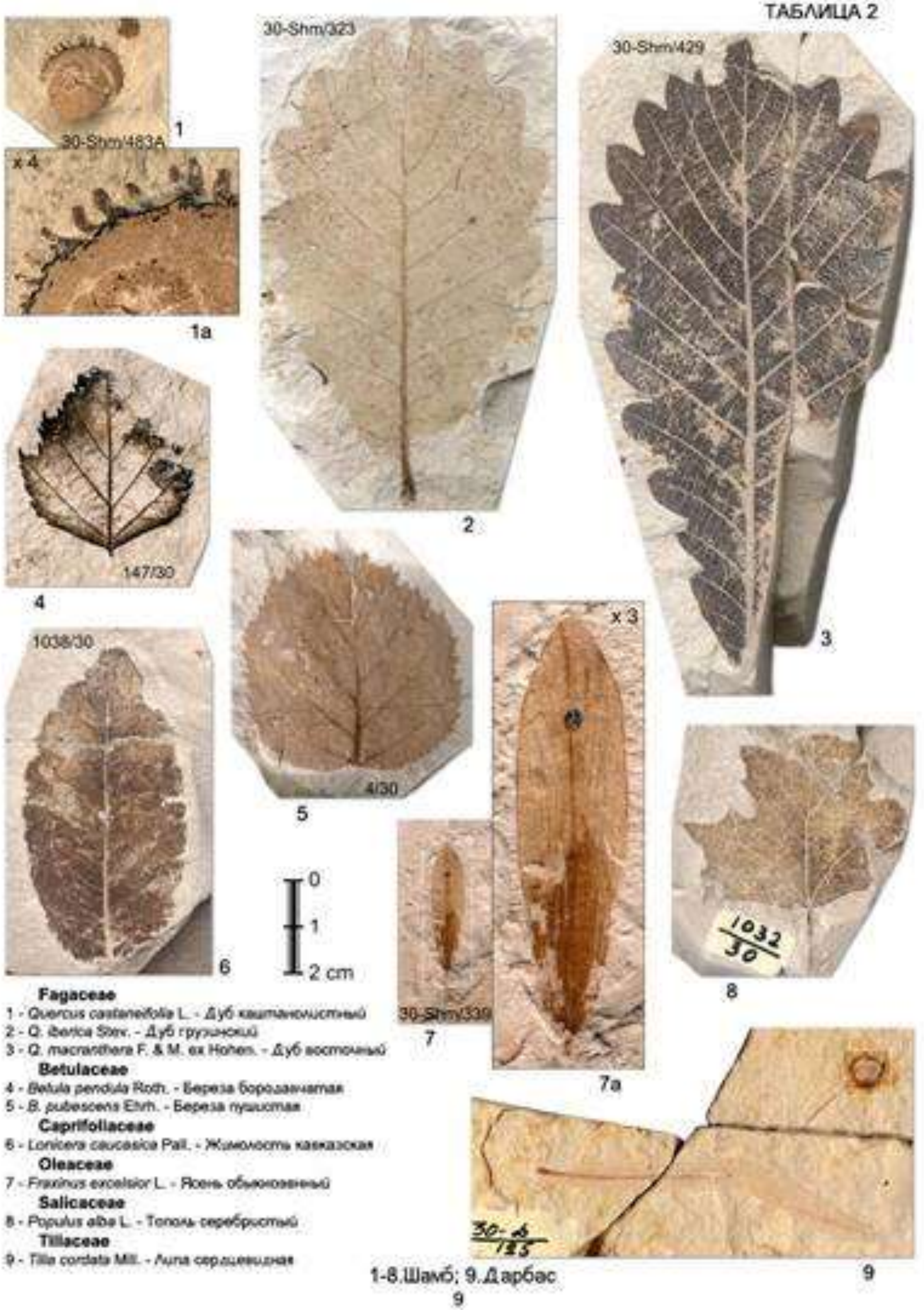
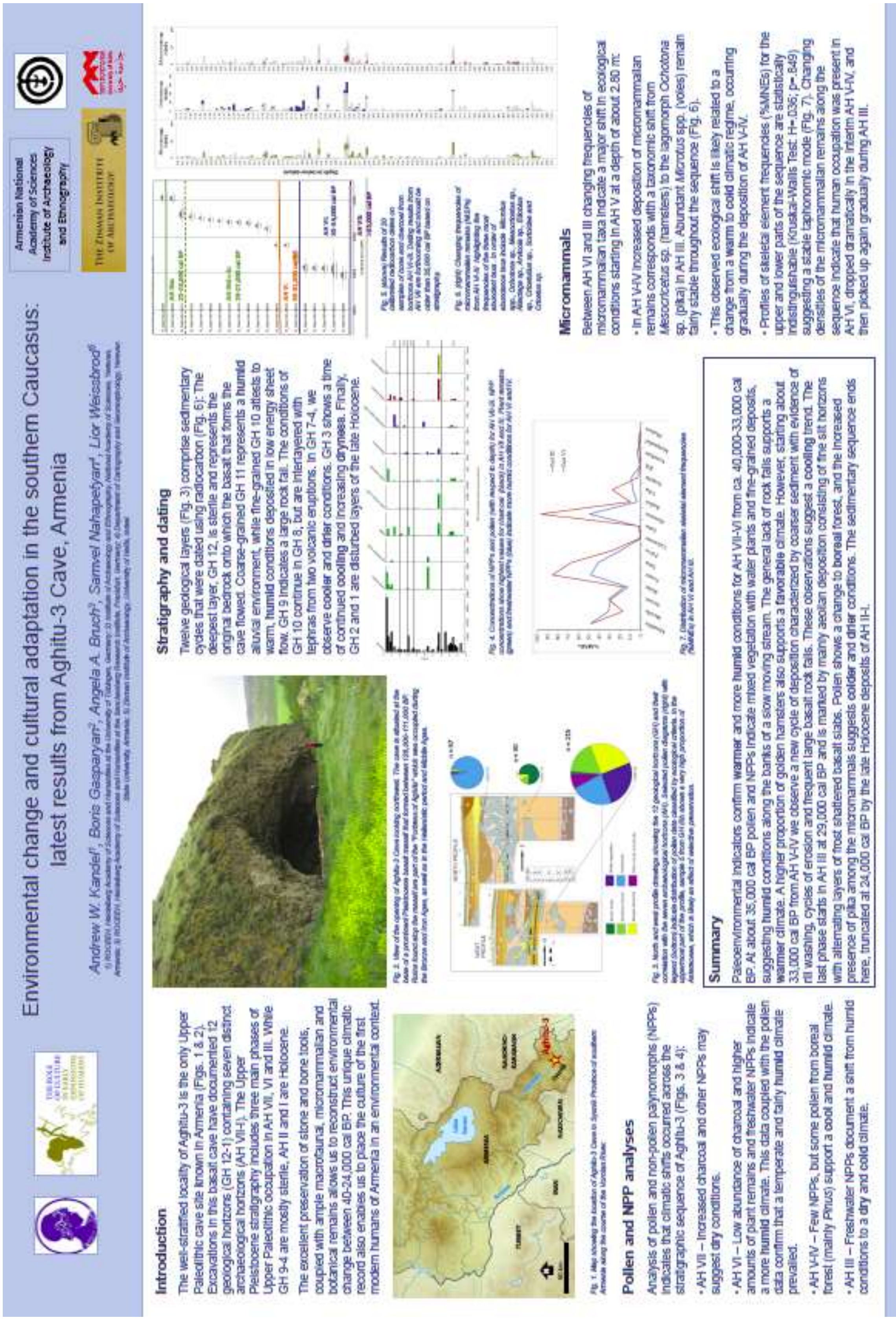


Fig. 9b. Some examples of plant fossils from Vorotan River Basin.

2.3 Aghitu-3 Cave



Day 3 - Tatev monastery: plant fossil sites, geology, modern vegetation and culture

3.1 Volcanism

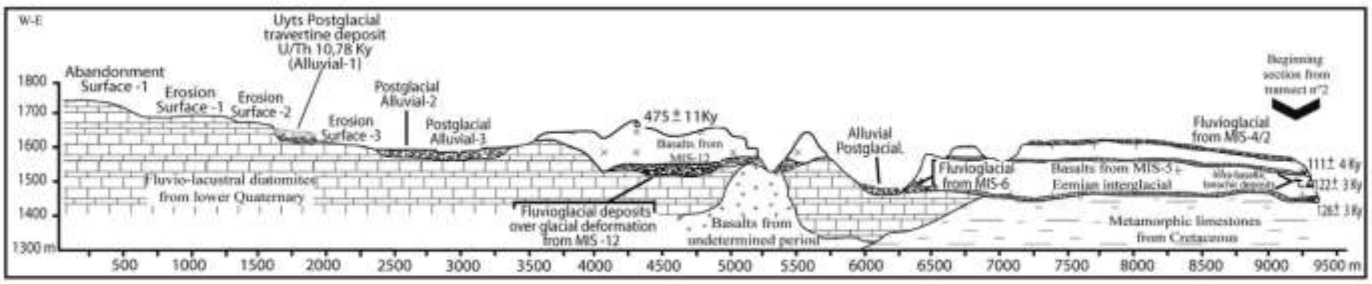


Fig. 3. Uyts–Aghitu geomorphological transect.

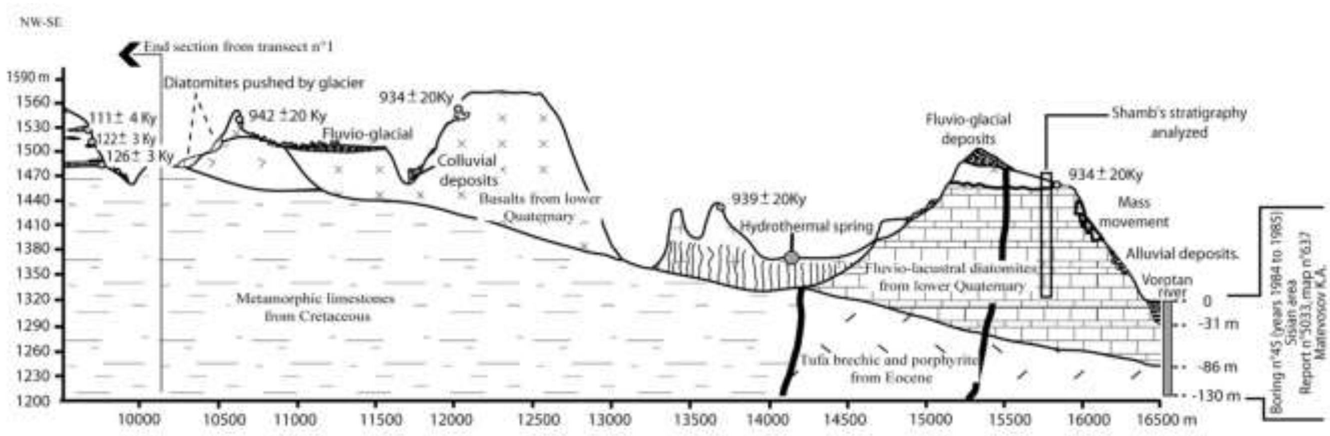


Fig. 4. Aghitu–Shamb geomorphological transect.

Fig. 10. Geomorphological transects from Ollivier et al. 2010. see also Fig. 6.

3.2 Holocene travertines

Text and Fig copied from Ollivier et al. 2011:

The main part of the valley connected to the Vorotan River in the Sisian-Tatev localities area were quickly filled by alluvial formations (around 6 to 10 meters thickness) during the Lateglacial and the Holocene. Fire signatures can be read inside the Lateglacial silt deposits and are represented by burned levels with charcoals. This kind of record probably underline a short period of drier climate around 12,900 cal. BP corresponding to the Younger Dryas event. The first travertine formations, which often express the production of biogenic carbonate and high aquifer levels, appear from the very beginning of the Holocene in the context of the postglacial warming.

This travertinization optimum around 9500-9000 cal. BP corresponds to a period of humidity identified in Anatolia, in the north-western Iran and more generally in the Caucasus. After this episode, the travertine growth records an abrupt interruption. Around 4000 cal. BP, the permanent antagonism between the sedimentation budgets (erosion/sedimentation), main parameter controlling the travertine formations development, is again positively balanced in favor of carbonate accumulation as we can be observe with the Tatev travertine formation in the downstream part of the Vorotan valley. **The Tatev travertine (4140 cal. BP) contains numerous leaf imprints that allow us to reconstruct the local vegetation. This travertine is the last testimony of the Holocene carbonatogenesis in the Vorotan Canyon.** Its lower position in the valley show the major impact of cutting phases related to climate but also to the local tectonic evolution.

Between 9000-4000 cal BP. an important cutting of the valleys occurs (ca. 40 m depth). According to the dating and the geometry of the Shamb (9500-9000 cal BP.) and Tatev (4140 cal. BP) travertine formations, this incision can be connected to the cumulative effect of the river sedimentary budget variation balance and to the uplifting of the Lesser Caucasus range.

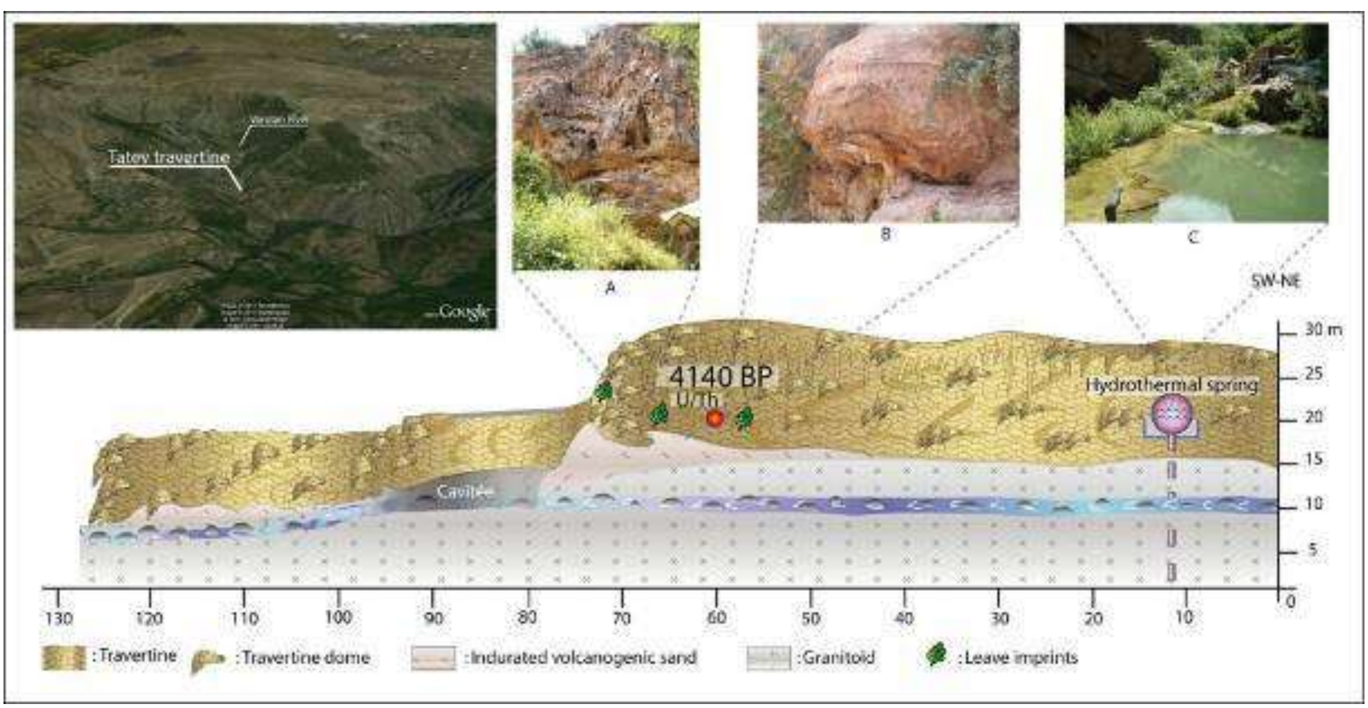


Fig. 11: Tatev travertine formation (Fig. from Ollivier et al. 2011).

3.3 Tatev monastery

Tatev monastery is situated near the village of the same name in part of Zangezur - ancient Syunik. The monastery was founded in the ninth century in place of a tabernacle well-known in ancient times. The strategically advantageous location on a cape formed by a deep river gorge with precipitous rocky slopes favored the construction of a mighty defense complex there. Tatev monuments stand out for high quality of building work. At one time Tatev was the political center of Syunik principality. In the 10th century it had a population of 1,000 and controlled numerous villages. In the 13th century it owned 680 villages. The earthquake of 1931 caused considerable destruction, but the parts that survived enable us to judge about the artistic merits of the complex. The main monument is the Church of Pogos and Petros (Peter and Paul) built in 895-906. It reproduces the type of domed basilicas of the 7th century, but has new features. In the stretched out interior, the middle nave, crowned with a tremendous in the middle of the plan's cross, predominates. As distinct from the domed basilica, the church had in its western part several annexes the corners of which served as the abutments of the dome. Its eastern abutments did not yet merge with the walls of the altar apse; consequently, the cross-winged shape of its interior is not too well pronounced. These features give us grounds to regard the church as an intermediate link in the development of the cupola hall into a cross-winged, dome type of building which became widely spread in Armenia later.

The outward appearance of the temple is severe and laconic. Its harmonious proportions add to the impression of its considerable height. The large dome, the low and closely-spaced arrangement of narrow windows and a high and round drum crowned with a pointed 32-fold roof immediately catch the eye.

The monument "Gavazan", erected in 904 in the yard, near the dwelling premises of the monastery, is a unique work of Armenian architectural and engineering art. This is a octahedral pillar, built of small stones; eight meters tall, it is crowned with an ornamented cornice, with an open-work khachkar towering on it. As a result of seismic tremors, and even at a mere touch of human hand, the pillar, hinge-coupled to a stylobate, tilts and then returns to the initial position (Armeniapedia.org).

Photo M. Bukhsianidze

Day 4 – from Sisian to Yerevan

4.1 The archaeological site of Areni Cave

The Areni-1 cave complex is a multicomponent site and late Chalcolithic/Early Bronze Age ritual site and settlement located near the Areni village in southern Armenia along the Arpa River. The cave has offered surprising new insights into the origins of modern civilizations, such as evidence of a wine-making enterprise and an array of culturally diverse pottery. Excavations also yielded an extensive array of Copper Age artifacts dating to between 4,200 and 3,900 BCE. The new discoveries within the cave move early bronze-age cultural activity in Armenia back by about 800 years. Additional discoveries at the site include metal knives, seeds from more than 30 types of fruit, remains of dozens of cereal species, rope, cloth, straw, grass, reeds and dried grapes and prunes.

In January 2011 archaeologists announced the discovery of the earliest known winery, the Areni-1 winery, seven months after the world's oldest leather shoe, the Areni-1 shoe, was discovered in the same cave. The winery, which is over six-thousand years old, contains a wine press, fermentation vats, jars, and cups. Archaeologists also found grape seeds and vines of the species *Vitis vinifera* (Wikipedia).

4.2 Noravank monastery

Noravank is a 13th century monastery, located 122 km from Yerevan in a narrow gorge made by the Darichay river, nearby the city of Yeghegnadzor, Armenia. The gorge is known for its tall, sheer, brick-red cliffs, directly across from the monastery. The monastery is best known for its two-storey S. Astvatsatsin church, which grants access to the second floor by way of narrow stones jutting out from the face of building. The monastery is sometimes called Amaghu-Noravank, Amaghu being the name of a small recently destroyed village above the canyon, in order to distinguish it from Bgheno-Noravank Monastery, near Goris. In the 13th–14th centuries the monastery became a residence of Syunik's bishops and, consequently. a major religious and, later, cultural center of Armenia closely connected with many of the local seats of learning, especially with Gladzor's famed university and library (Armeniapedia.org).

Photo A Bruch

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