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# Environmental and geodynamic settings of the earliest hominin migration to the Arabian-Caucasus region: A review

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Majority of researchers consider the Arabian-Caucasus region as a corridor for migration of earliest hominins from their African motherland to Eurasia. The paper is devoted to geological position of main stratified localities of the earliest Paleolithic industries in the Arabian-Caucasus region and estimation of environment of creators of these industries. The following early Paleolithic localities are analyzed: ‘Ubeidiya in Israel, middle Orontes River, Halabiyeh-Zalabiyeh area in the Euphrates River valley, and Aïn al Fil in Syria, Dursunlu in Central Turkey, Şambayat, Bostancık, Eskimalatya, and Kovancılar in Eastern Turkey, Karakhach, Muradovo, Agvoric, and Jradzor in NW Armenia, Dmanisi in Southern Georgia, the Azykh cave in Nagornyi Karabakh, Muhkai II in Dagestan, and Kermek in the Taman Peninsula. The evolution of large and small mammals and palynological data on changes of vegetation from the Late Pliocene to the early Middle Pleistocene are studied to determine the age of the earliest Paleolithic industries and climatic conditions of that epoch. Combined analysis of paleontological, paleomagnetic and radio-isotopic data and geological correlation of the sections available for the Halabiyeh-Zalabiyeh, Şambayat, Kovancılar, Karakhach, Dmanisi, Muhkai II, and Kermek localities shows that their age is ranged in time interval ca. 2.0–1.7 Ma. The 1.7–1.6 Ma age of the lowest layers of ‘Ubeidiya with Oldowan-type artefacts probably marks the end of this epoch. Removal of topographic effects of the late Calabrian and younger tectonic uplifts and offsets on major strike-slip faults shows that the topography of the late Gelasian – early Calabrian was much lower and less differentiated and main river systems were more passable than in the present time. The climate of the end of Gelasian was wet and relatively warm, with meadow-steppe and forest-steppe savanna-type vegetation in basins and valleys and coniferous and coniferous–broad-leaved forests in the mountains. Abundance of vegetation was supported by water resources of numerous rivers, lakes, and springs in the intermountain basins and valleys that were controlled partly by fault activity. This stimulated abundance of herbivorous mammals. In spite of relative aridisation at the beginning of Calabrian, vegetation continued to be freely available for herbivores. Hominin dispersal into the region was supported by rich resources of herbivores during the late Gelasian – early Calabrian time.

## 1. Introduction

Majority of researchers consider that the Arabian-Caucasus region was a corridor for migration of earliest hominins from their African motherland to Eurasia in the Early Pleistocene. Anthropological evidence of this process is very poor in the Arabian-Caucasus region. Fragments of cranium, two incisors and a molar were found in the ‘Ubeidiya locality southwards of Galilee Sea and defined as *Homo* cf. *erectus* (Tchernov and Volokita, 1986) or *Homo ergaster* (Belmaker et al., 2002). In Dmanisi, southern Georgia, five crania and bone remains of almost complete skeleton were found and attributed to *Homo georgicus,* considered to be a transitional form between *H. habilis* and *H. erectus* (Rightmire et al., 2006; Lordkipanidze et al., 2007). Much more numerous archaeological finds of lithic industries mark ways of migration of the earliest hominins. These artefacts were found in Israel, Syria, Eastern Turkey, Armenia, Georgia, Nagornyi Karabakh, and north-eastern and northwestern slopes of the Greater Caucasus in Dagestan and the Taman Peninsula (Fig. 1). Stratified localities of these finds are a subject of the present paper. It is devoted to analysis of the data on geological structure and age of the localities and estimation of environmental settings of the creators of stone industries, such as topography, water resources, climate, vegetation, animals, tectonic and volcanic activity.

In this paper, we use the stratigraphic division of the upper Neogene

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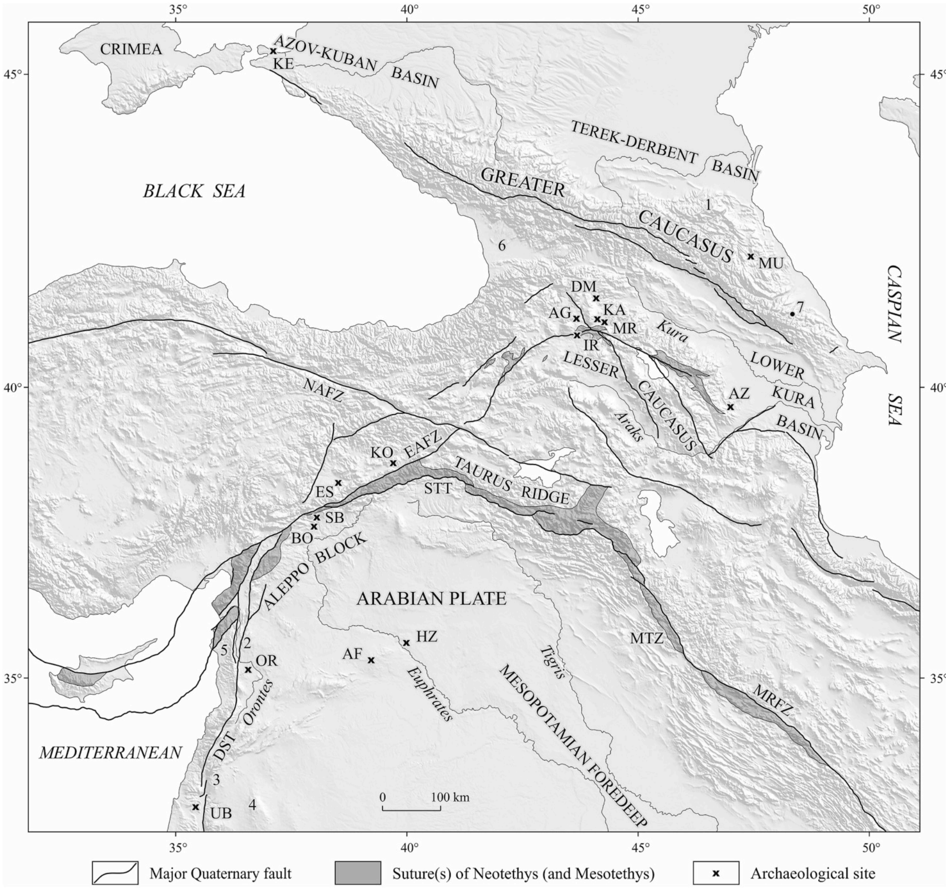


**Fig. 1.** The earliest Paleolithic localities in the Arabian-Caucasus segment of the Alpine-Himalayan Belt and adjacent part of the Arabian Plate. Archaeological localities: (UB) ‘Ubeidiya, (OR) middle Orontes River, (HZ) Halabiyeh-Zalabiyeh area, (AF) Aïn al Fil, (SB) Şambayat, (BO) Bostancık, (ES) Eskimalatya, (KO) Kovancılar, (KA) Karakhach quarry, (MR) Muradovo, (AG) Agvorik, (JR) Jradzor, (DM) Dmanisi, (AZ) Azykh cave, (MU) Muhkai-2, (KE) Kermek. Other symbols: (1) Chechnya, (2) El-Ghab Basin, (3) Hula Basin, (4) Jebel Arab (Harrat Ash Shaam) volcanic Highland, (5) Nahr El-Kabir, (6) Rioni Basin, (7) Apsheronian deposits to the SE of Shakhdagh Mountain.

**Table 1**
Correlation of the Upper Pliocene – Lower Quaternary chrono-stratigraphic schemes for the Mediterranean, Black Sea, and Caspian basins, after (Krijgsman et al., 2019), simplified.

| Age | Mediterranean Basin | Black Sea Basin | Caspian Basin |
|---|---|---|---|
| Late Early Pleistocene 1.8–0.78 Ma | Calabrian | Gurian | Apsheronian |
| Early Early Pleistocene 2.59–1.8 Ma | Gelasian | Late Kuyalnikian | Late Akchaghylian |
| Late Pliocene 3.6–2.59 Ma | Piacenzian | Early Kuyalnikian | Early Akchaghylian |

and Quaternary, confirmed at the 33rd IGC (www.stratigraphy.org) and correlated with the local stratigraphic schemes of the Black and Caspian sea basins (Table 1). The following abbreviations are used in figures: $K_2$m – Maastrichtian, $N_1^3$ – Upper Miocene, $N_2$ – Pliocene, $N_2^1$ – Lower Pliocene, $N_2^2$ – Upper Pliocene, $Q_1$ – Lower Pleistocene, $Q_1^1$ – Gelasian, $Q_1$ol – Olduvai Subchron, $Q_1^2$ – Calabrian, $Q_1$j – Jaramillo Subchron, $Q_2$ – Middle Pleistocene, $Q_2^1$ – lower Middle Pleistocene, $Q_2^2$ – upper Middle Pleistocene, $Q_3$ – Upper Pleistocene, $Q_4$ – Holocene.

## 2. Geological setting of archaeological sites

### 2.1. Israel

The ‘Ubeidiya locality is situated 3 km southward of Galilee Sea in the western bank of Jordan River (Fig. 1). The ‘Ubeidiya Formation containing the archaeological and anthropological finds forms anticline that is overthrust by the Cover Basalt from the NW. The ‘Ubeidiya Formation section consists of four sedimentary units (Bar-Yosef and Belmaker, 2017). They are (from top downwards) Fu, Lu, Fi, and Li.

The Fu unit is represented by alluvium and delta deposits in the coasts of regressing lake. Conglomerates with basaltic boulders are characteristic. No fossil and artefact were found.

The Lu unit is composed of lacustrine sediments that are clays and chalk in the lower part and silt in the upper one. Only several artefacts were found.

The Fi unit consists of fluvial deposits from clay to conglomerate. Majority of fossils and archaeological artefacts as well as bone remains of ancient hominiswere found in this unit. Archaeological finds are attributed to early Acheulian, where primitive handaxes are relatively rare, but are present systematically (Bar-Yosef and Goren-Inbar, 1993). Handaxes are absent in the lowest layers of the unit. According to Bar-Yosef and Belmaker (2017) opinion, this “brings together the basal layers finds and the Oldowan industries”.

The Li unit is composed of lacustrine clays, silt, and limestone with fresh-water mollusc and fish bone remains. Mammal bones and several artefacts were found in layer III-12.

### 2.2. Syria

The stratified localities of earliest Paleolithic were found in the Orontes and Euphrates river valleys and between them in the north-eastern Palmyrides (Aïn al Fil). The earliest Paleolithic industry in the middle stream of the Orontes was named by Khattabian and attributed to the local variant of Oldowan (Besançon et al., 1978; Copeland and Hours, 1993). The artefacts were obtained in the section of a summit plain, or upper terrace V (h = 80–100 m) of the Orontes valley

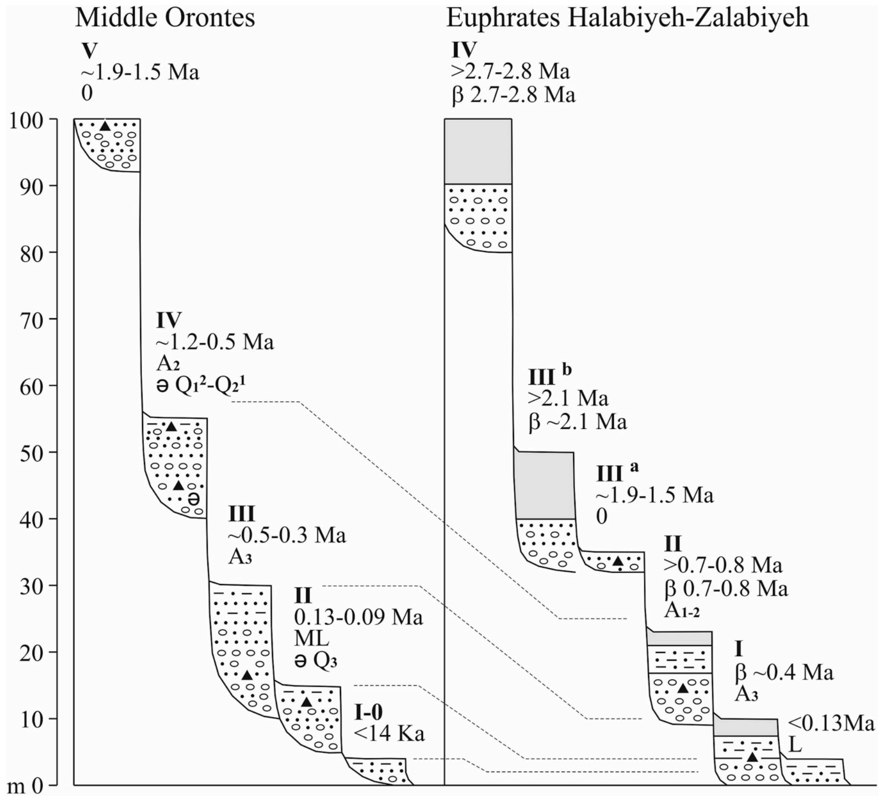


**Fig. 2.** Terrace sequences in the middle Orontes River (A) and the Halabiyeh-Zalabiyeh area of Euphrates River (B). (O) Hattabian = Oldowan/Mode 1 (Besançon et al., 1978; Copeland, 2004), ($A_1$, $A_2$, $A_3$) early, middle and late Acheulian (Clark, 1967, 1968; Besançon and Sanlaville, 1981; Demir et al., 2007; Trifonov et al., 2012, 2014), (L) Late Paleolithic and Neolithic (Besançon and Sanlaville, 1981).

(Fig. 2,A). The similar Khattabian industry was found in the Halabiyeh-Zalabiyeh segment of the Euphrates River valley in its north-eastern bank to the east of the Kasra village (Copeland, 2004). Terrace III split to sub-levels III$^a$ and III$^b$ (Figs. 1 and 2,B). The artefacts were found within the 1-m thick cover of terrace III$^a$ (h = 30–35 m).

Two earliest Paleolithic localities – Aïn al Fil and Hummal were found in the north-eastern Palmyrides. The more stratigraphically documented and complete 4-m thick section of carbonate silts and clays is described in the Aïn al Fil locality (Le Tensorer et al., 2015) (Fig. 3). Layer Lb within the lower Bad L contains numerous large mammal bones including Camelidae, Bovidae and archaic *Equus stenonis* (cf. *senezensis*). The abundant artefacts from the basal layer L2 are attributed to the Oldowan/Mode 1 Paleolithic.

### 2.3. Eastern Turkey

Artefacts attributed to the Oldowan complex have been reported in the Birecik segment of the Euphrates valley near the Syrian boundary (11 in Fig. 4). These artefacts were found in the 80 m high terrace gravel, tentatively dated at ca. 1.8–1.9 Ma (Demir et al., 2008). Several early Paleolithic pre-Acheulian localities were found in the northernmost part of the Arabian Plate in front of the Taurus Ridge (in Göksu Çayı and Eskiköydere that are western tributaries of the Euphrates River) and farther to the north within the Alpine-Himalayan Belt in the Euphrates valley and in the lower reaches of the Murat River (Ozherelyev et al., 2018). In the Göksu Çayı valley, the early Paleolithic artefacts (Şambayat locality) were found within the conglomerate beds 2 and 9 of the section of terrace IV (h = 150 m) and within the conglomerate bed 6 of the slided fragment IV$^a$ of this terrace (h = 108 m) (Fig. 5). The bed 9 of terrace IV corresponds to the bed 6 of fragment IV$^a$ and bed 2 is situated stratigraphically higher.

In the adjacent Eskiköydere valley, lithic artefacts (Bostancık locality) were collected from the lower conglomerates of the 40 m thick upper terrace section correlated with the Göksu Çayı terrace IV. The 10 m thick lower conglomerates are characterised by normal magnetic polarity and reverse polarity near the top. The Şambayat and Bostancık industries are attributed to the Oldowan/Mode 1 Paleolithic with elements and features of the Early Acheulian: the big flakes, pick-like tool on big flake, and blanks for bifacial tools (Ozherelyev et al., 2018).

The Eskimalatya and Kovancılar localities belong to the southern inner part of the Alpine-Himalayan Belt (Fig. 6). The poor archaeological collections from the lower and middle parts of the 19 m thick Eskimalatya section and the lowermost gravels of the 115 m thick Lower Pleistocene Palu Formation in the Kovancılar section are similar to the described Şambayat industry and can be also attributed to the Oldowan/Mode 1 Paleolithic (Ozherelyev et al., 2018). The 1–5 m thick top layer of the Kovancılar section covers the Palu Formation with unconformity and contains not only choppers and flakes similar to previous ones, but also a subtriangular pick similar to handaxes of the “Dauan” type found in South Arabia (Amirkhanov, 2006). This gives a possibility to attribute the finds to early Acheulian (Ozherelyev et al., 2018).

### 2.4. Armenia

The Karakhach quarry section is situated in the south-western part of Lori Basin in NW Armenia. It is particularly significant for understanding geological position of the earliest Paleolithic industries in the region (Fig. 7). The Karakhach unit consists of two parts: up to 5-m thick upper dacite agglomerate tuff and 8-m thick (apparent) mostly coarse-grained fluvial lower part with two layers of dacite tuff (Trifonov et al., 2016). The presence of rare crude pick-like handaxes and other characteristic tools among 3000 artefacts found within the lower fluvial part of the section allows to attribute the found assemblage to the earliest Acheulian (Lyubin and Belyaeva, 2011; Belyaeva and Lyubin, 2013). Artefacts were also obtained from the lowest part (1.6 m) of upper tuff. They are mostly small tools without handaxes.

There are three other localities of the Karakhach unit, from where the early Paleolithic industries similar to the Karakhach finds were reported. They are Muradovo at 3.5 km to the east of the Karakhach

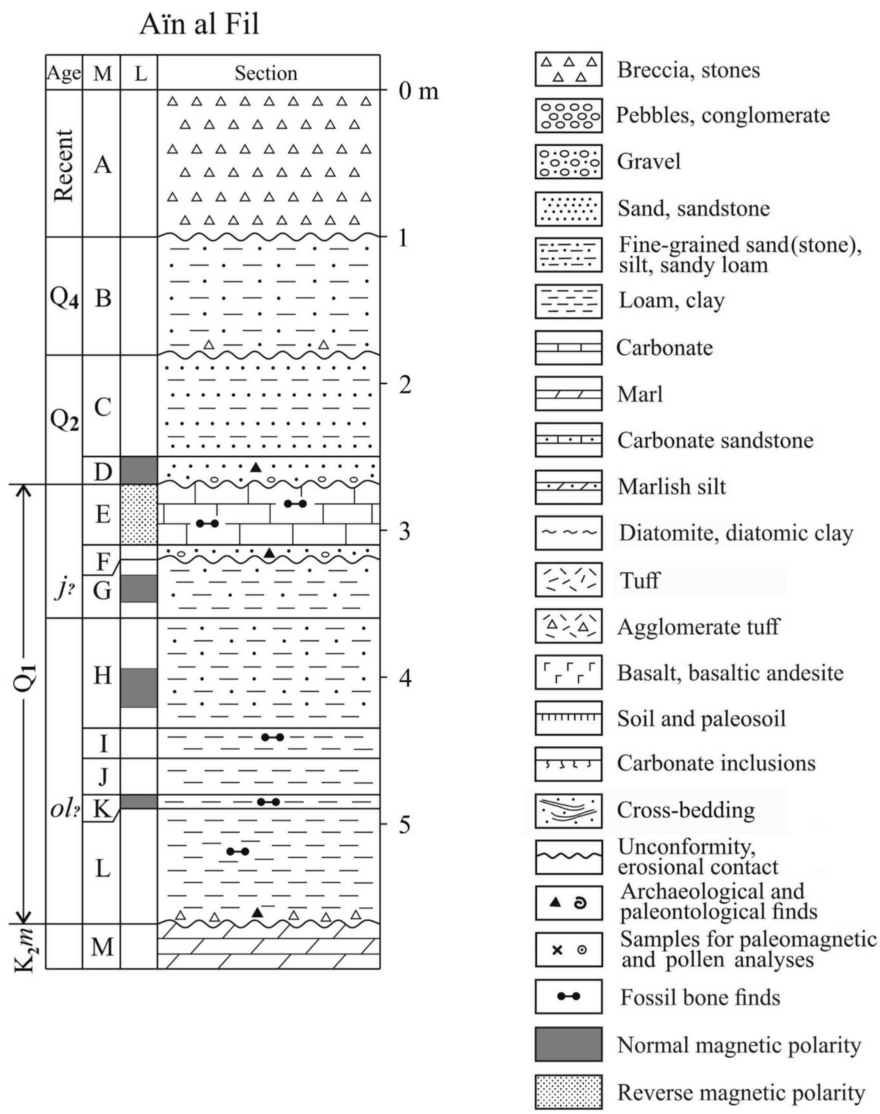


**Fig. 3.** The Aïn al Fil section, after (Le Tensorer et al., 2015) with changes; the archaeological collection of Oldowan/Mode 1 was obtained from the basal layer of Bad L.

quarry (Belyaeva and Lyubin, 2013), Agvorik in the northern side of the Upper Akhuryan Basin (Trifonov et al., 2016), and Jradzor in the northern border of the Shirak Basin (Trifonov et al., 2017) (Fig. 4).

### 2.5. Georgia

Dmanisi (Southern Georgia) is located 35 km north of Karakhach quarry (Fig. 4). A basaltic flow underlies tuffs of stratum A. Stratum B consists of fine-grained deposits that partly cover tuffs and, in the main site, fill the gully or erosional “tube” bordering by the basaltic scarp and the tuffs A. The fragments of Homo georgicus and abundant fossils were found in stratum B of the main site. The archaeological artefacts were also found in stratum B of the main site and other sites of the Dmanisi locality and were attributed to the Oldowan or primitive Oldowan (Gabunia et al., 2000; Rightmire et al., 2006; Lordkipanidze et al., 2007; de Lumney et al., 2008). Ferring et al. (2011) studied site M5 in 85 m to the west of the main site and showed that stratum A is a series of ash layers that are separated by thin soil horizons with carbonates. The lithics were found both in these horizons of stratum A and in stratum B.

### 2.6. Nagornyi Karabakh

The karst Azykh cave (Guseinov, 2010) is situated in the northern side of the Kuruchai River valley and the southern slope of the Salakheti anticlinal high that is the south-eastern spur of the Karabakh Ridge. Several terraces are incised into the 900–1000 m high peak plain that is correlated to the lower Akchagylian (Upper Pliocene) deposits. The upper terraces are 260–270 m and 180–200 m high. Both entrances of the Azykh cave open to the 800-m level corresponding to the 180–200 m high terrace. The 12 m thick multi-cultural section of loam with limestone debris and rubble was excavated within the cave (Guseinov, 2010) (Fig. 8). Its layers contain splintered bones and artefacts of the Bronze and Chalcolithic age in layer I, the early Moustier and final Acheulian in layer III, middle Acheulian in layer V, and early Acheulian in layer VI. The archaeological collection from layers VII–X is attributed to the Kuruchai culture that is interpreted as a local variant of the Oldowan (Guseinov, 2010).

### 2.7. Dagestan

Several Lower Pleistocene sections with Oldowan industries have been discovered in the north-eastern slope of Eastern Caucasus

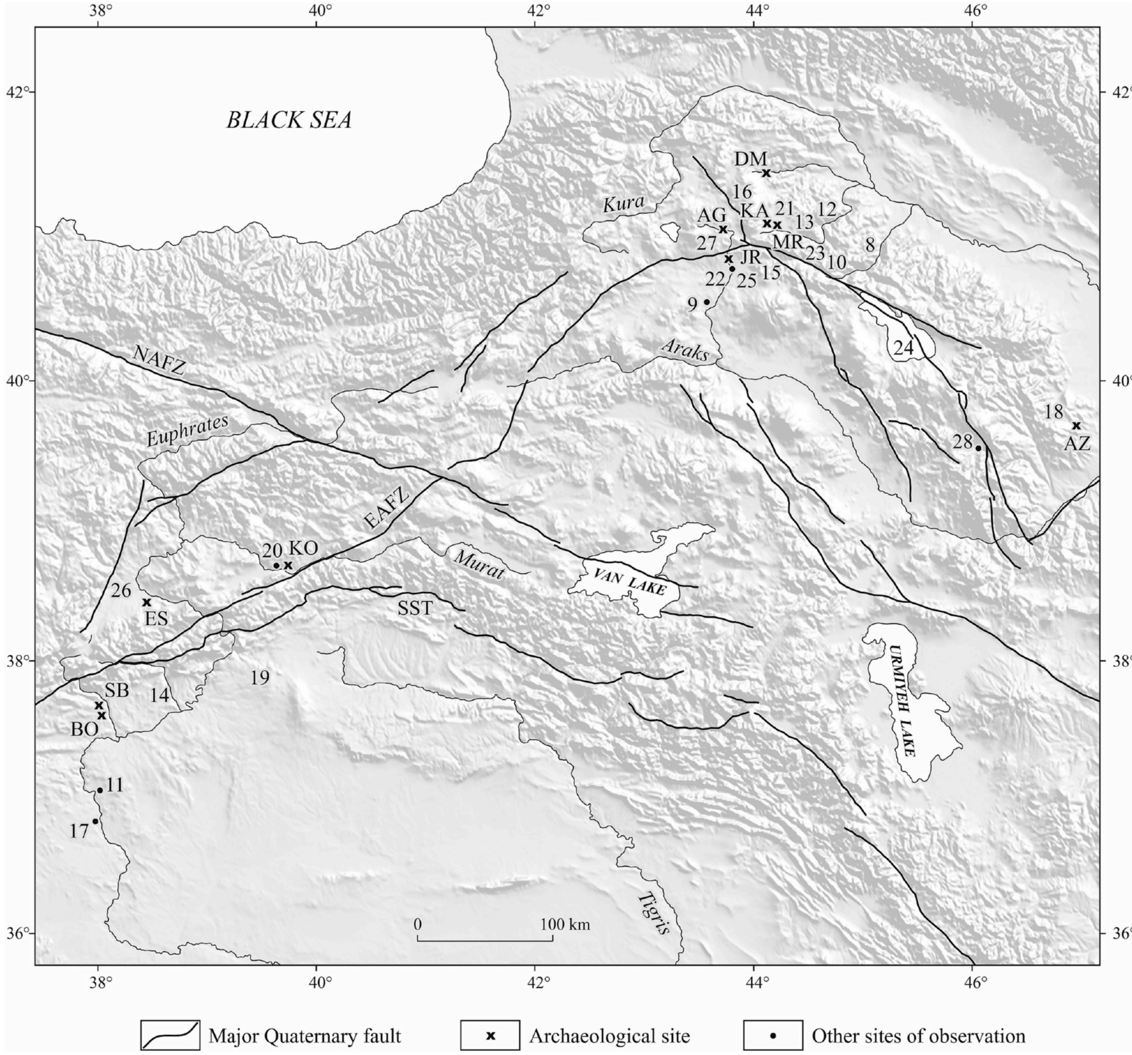


**Fig. 4.** The earliest Paleolithic localities and other points of observation in Lesser Caucasus and its surrounding. (8) Agstev River, (9) Akchagylian deposits to the south of Akyaka town, (10) Bazum Ridge, (11) Biresik town, (12) Debed River, (13) Dzoraghet River, (14) Erikdere, (15) Jajur Pass, (16) Javakheti Ridge, (17) Jrablus town, (18) Karabakh Ridge, (19) Karacadağ lava field, (20) Karangıbaşı section, (21) Lori Basin, (22) Marmashen village, (23) Pambak River, (24) Sevan Lake, (25) Shirak Basin, (26) Sultansuyu valley, (27) Upper Akhuryan Basin, (28) Vorotan River. Other symbols are explained in Fig. 1.

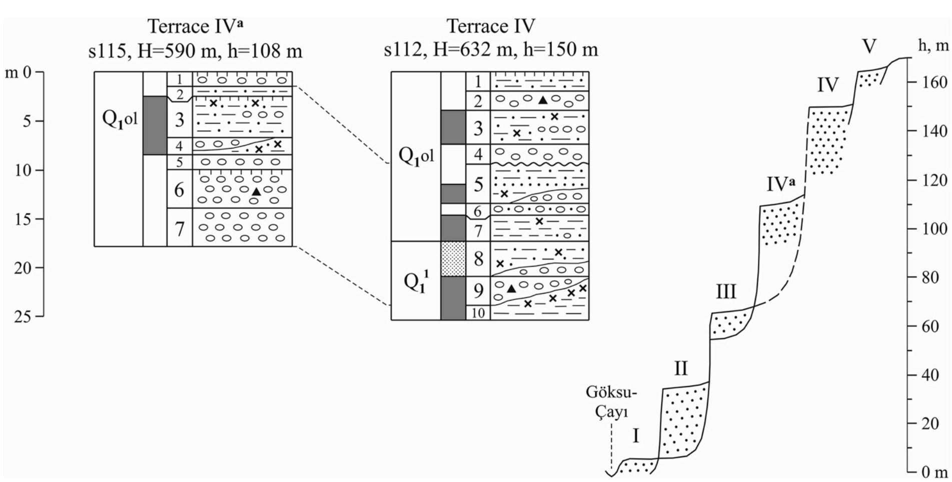


**Fig. 5.** Position and sections of the Göksu Çayı valley terraces IV and IV$^a$. See Fig. 3 for the legend.

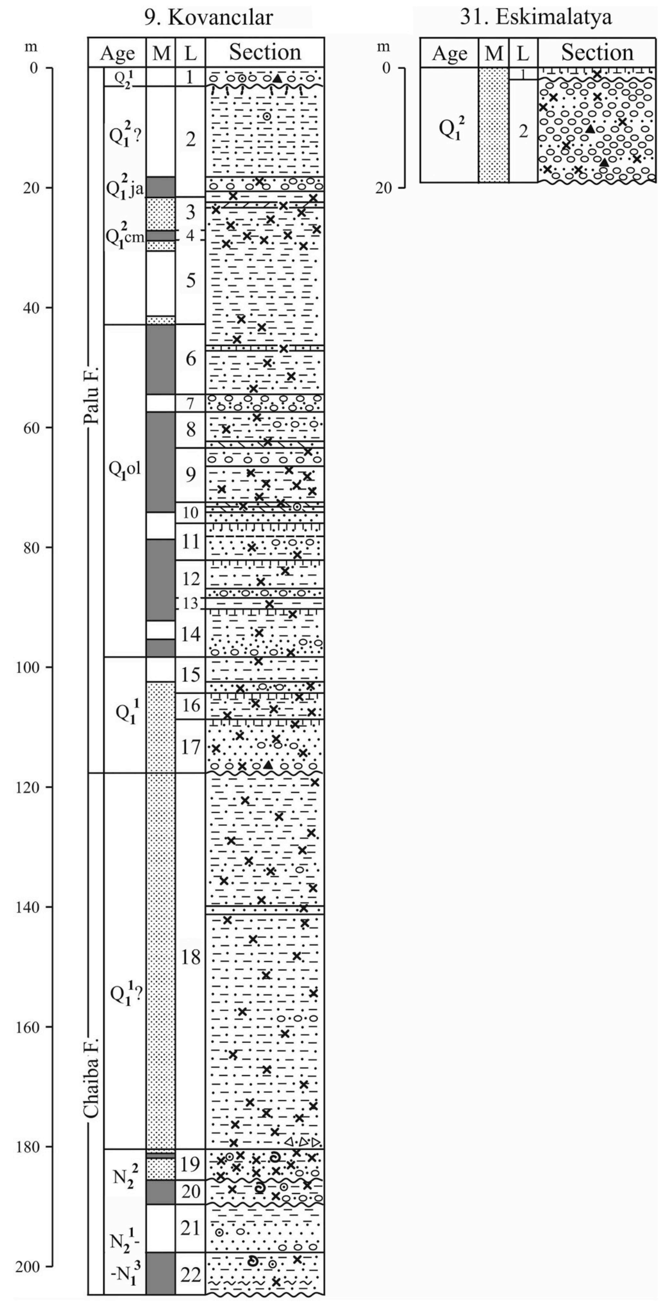


**Fig. 6.** The Eskimalatya and Kovancılar sections in Eastern Turkey. See Fig. 3 for the legend.

(Dagestan). These are Ainikab I and II, Muhkai I and II, Gegalashur I, II and III on the Akushi Plateau and Urma I on the Levashi Plateau (Amirkhanov, 2012). These plateaus probably represent a single plain of denudation. The Muhkai II sequence of sediments is the most complete (73 m). Its 57-m thick upper section is described in details, being divided to 117 layers (Amirkhanov et al., 2014, 2016). The upper part of this section (13 m) consists mostly of coarse deposits (pebbles, gravels and sands). Loam dominates in the lower 21 m thick part of the section and contains several lens-like interbeds of coarse material. Layer 80 (the depth of 34 m) contains numerous mammal remains (Amirkhanov et al., 2014). It is the upper part of 3-m thick coarse layers. Loam dominates lower (16 m) and is underlain by 4 m thick coarse deposits. Loam is exposed lower again. The reported section contains 35 cultural layers with abundant lithics that are attributed to the classical Oldowan (Amirkhanov, 2012; Amirkhanov et al., 2016). However, in the upper parts of the Muhkai I and Ainikab I that are correlated to the upper course part of the Muhkai II section, some records of bifacial technique are reported (Amirkhanov, 2015). Amirkhanov (2017) proposes to attribute this epoch to proto-Acheulian, or a stage of transition from Oldowan to Acheulian.

### 2.8. *Taman Peninsula*

The Kermek, Rodniki, and Sinyaya Balka/Bogatyri early Paleolithic localities were discovered within the Lower Pleistocene sections in the northern coastal escarpment of the Taman Peninsula to the N–NW of the village of Za Rodinu (Shchelinsky et al., 2010, 2016). The escarpment is cut by the Sinyaya Balka ravine and is partly covered by landslides. The coastal area to the east of the ravine represents a NW-trending anticline that is expressed in topography by elongated hill with gentle south-western slope. The north-eastern slope is steeper and partly eroded at the escarpment that exposes three stratigraphic units (from top downwards): (1) cover sands and sandy loam with lenses of breccia; (2) mainly sands, partly cross-bedding, with lenses of rubble, poorly rounded pebbles and gravel in the lower part; (3) late Kuyalnikian clays, silts and fine-grained sands with rare coarser layers. The unit (1) covers the lower units with unconformity, causing wedging out of the unit (2) in some sections. The unit (2) overlies the unit (3) with unconformity too. The anticline is ruptured into several blocks with different dips of the layers. Small ravines formed along the block contacts are filled with mud volcano clays and silt.

The 44 m thick section of late Kuyalnikian deposits that dip at 25–35° to the ENE is exposed in the Tizdar/Kermek block in 200–300 m to the east from the Sinyaya Balka mouth (Fig. 9). The 1-m thick layer of conglomerate-breccia with sand matrix and fragments of shells (16–17 m above the bottom of the section) contains the early Paleolithic industry (Kermek) that is attributed to the classical Oldowan (Shchelinsky et al., 2016). The layers with the Tizdar 1 and Tizdar 2 localities of small mammals are situated, correspondingly, 2.5–3 m below and 13–14 m above the archaeological site (Tesakov, 2004). The late Kuyalnikian deposits are covered by unit 1 with unconformity.

In the Rodniki block that is situated 100–150 m to the east, the Kuyalnikian clays and clayish sands are unconformably covered by unit 2 (Dodonov et al., 2008). The Rodniki early Paleolithic locality is situated in the 1-m thick layer of pebbles, gravel and sand at the base of 10 m thick sand section (Shchelinsky et al., 2010).

To the east of the Rodniki section, after a narrow interval, the Sinyaya Balka/Bogatyri early Paleolithic locality is situated within the following section (from top downwards): (1) soft sandstone with rubbles; up to 1 m; (2) abundant large mammal bones of the Taman faunal complex stratotype with sand and gravel matrix; 1.5–3.5 m; (3) sand with rubbles; 0–1.5 m; (4) rubble and pebbles with abundant sand matrix; 0.4–0.7 m, covering the Kuyalnikian clays (5) with unconformity. The artefacts were found within layers 2 and 4 (Shchelinsky et al., 2010).

The Sinyaya Balka/Bogatyri section composes the isolated and displaced geological body that was essentially larger 60 years ago than at present time (Vereshchagin, 1957). Its contemporary square is about 30 m$^2$ and visible vertical size is 3 m. Perhaps, the body extends to the depth of 2–3 m. The layers of the section are overturned at up to 75° to the SW. If we exclude the bones that are concentrated within the section, its lithology and composition are similar with the basal layer of unit 2 that is exposed to the west (Rodniki block) and to the east of the body in the higher elevation. The Kuyalnikian clays and sands that are exposed in the lower part of the escarpment under the Sinyaya Balka/Bogatyri locality dip at 30–70° to the east. We consider that the Sinyaya Balka/Bogatyri geological body is a landslide of deposits corresponding to the basal layer of unit 2. Farther to the east, the units 2 and 3 subside and the Middle Pleistocene subaerial silts and loam with several paleosoil horizons are exposed in the coastal escarpment.

The lithic artefacts of the Sinyaya Balka/Bogatyri and Rodniki

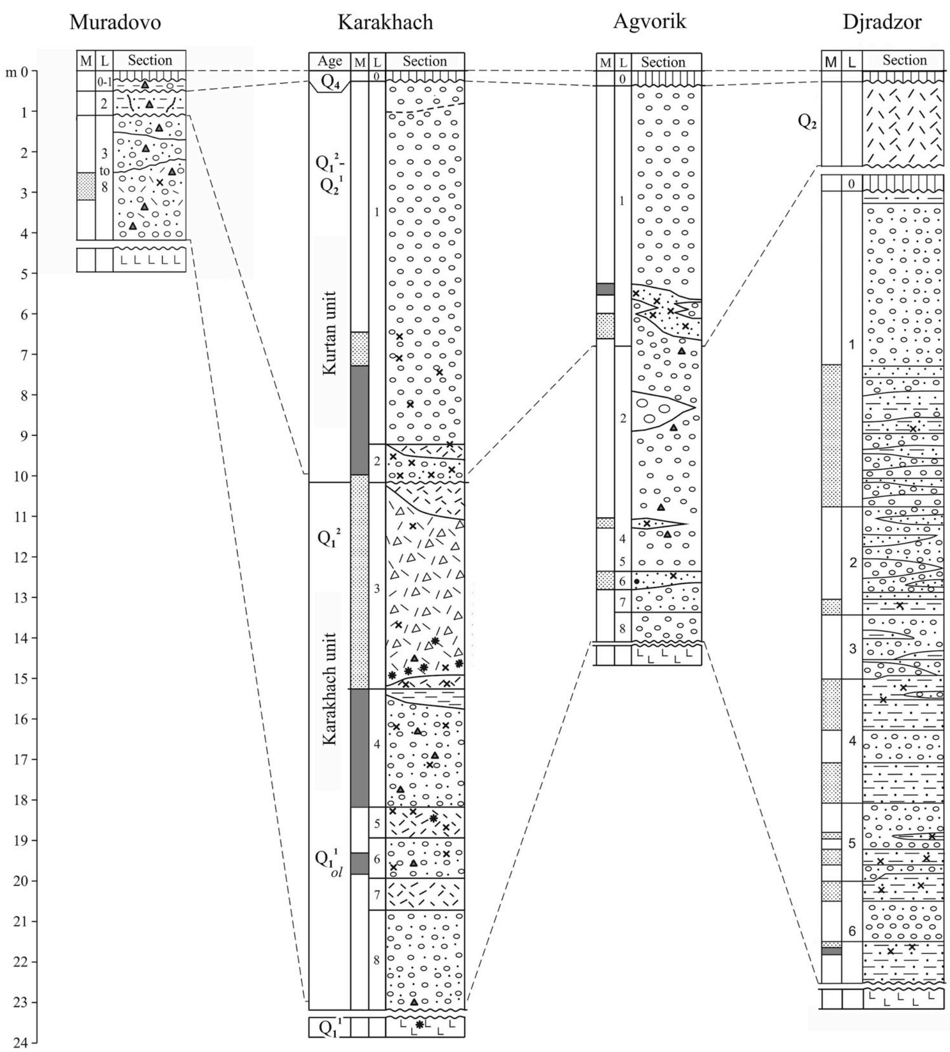


**Fig. 7.** The Karakhach unit sections. See Fig. 3 for the legend.

localities are similar and belong to a single Tamanian industry (Shchelinsky et al., 2010, 2016). The cited authors propose a term "archaic Acheulian" to characterise this industry that combines technological and typological features of Oldowan/Mode 1 and early Acheulian.

## 3. Results of analysis of environmental characteristics of archaeological sites

### 3.1. Tectonics, volcanism, and drainage system

#### 3.1.1. Pre-Quaternary tectonics

The region of study belongs to the Arabian-Caucasus segment of the Alpine-Himalayan orogenic belt and the northern Arabian Plate bordering it to the south. Two important features control Alpine tectonic zonation in this part of the belt (Fig. 1). The first is the South Taurus (Bitlis) Thrust Zone that inherits the subduction zone of Neotethys closed in the Eocene and is the recent boundary of the Arabian Plate and the orogenic belt (Akinci et al., 2016). The second is the Sevan-Hakkari suture of Mesotethys closed in the Cretaceous (Adamia et al., 2011). The area between these sutures is formed by micro-plate fragments, ophiolite nappes, and zones of accretion (Khain, 2001). This entire part of the orogenic belt was folded at the end of Eocene and in Oligocene.

The Dead Sea Transform appeared in the Early Miocene (Garfunkel and Ben-Avraham, 2001). Simultaneously to its evolution, the underthrusting of Arabian Plate on the South Taurus Thrust and the Main Thrust of Zagros occurred, the Mesopotamian Foredeep developed, and folds formed in front of the main thrusts. The recent intermountain basins began to subside in the Pliocene and in more rare cases in the Late Miocene. Sub-aerial volcanism developed during the late Cenozoic (Milanovsky and Koronovsky, 1973; Ershov and Nikishin, 2004; Trifonov et al., 2011). Its first expression in the Arabian Plate is dated to Oligocene. The intensive volcanism began in the northern Arabian Plate and southern orogenic belt in the Early-Middle Miocene and in the more northern areas of Lesser Caucasus in the Late Miocene.

Northward of Lesser Caucasus, the Paratethys basins were filled in the Oligocene by deep-water sediments in the south and mainly shallow-water deposits in the northern part formed in the margin of Paleozoic Scythian Plate (Kopp and Shcherba, 1998). Although deformation took place there sporadically starting from the Late Eocene, the main folding occurred at the end of Early Miocene through the Late Miocene. The Greater Caucasus rose in the margin of Scythian Plate. The Asov-Kuban and Terek-Derbent cells of the Caucasus Foredeep subsided to the north of it (Milanovsky, 1968). Greater Caucasus thrust from the Late Miocene to the Rioni and Kura intermountain basins that developed on the folded former Paratethys and the northern Lesser Caucasus. In the Late Pliocene, the sub-aerial volcanism spread to Greater Caucasus, where the Elbrus and Kazbek volcanic areas formed (Milanovsky and Koronovsky, 1973; Laverov, 2005).

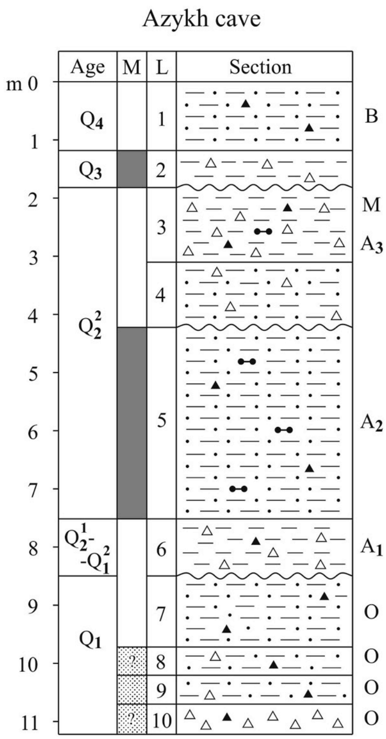


**Fig. 8.** The Azykh cave section, after (Guseinov, 2010) with changes. (B) Bronze age, (M) middle Paleolithic; see Fig. 2 and 3 for other symbols.

Therefore, the region was deformed prior to the Early Pleistocene. This deformation was expressed in topography and continued in the Quaternary. To restore the environment of the late Gelasian – early Calabrian, it is important to estimate and remove the results of tectonic movements that have occurred from the late Calabrian till the present time. The main tasks are to determine the tectonic uplift and the offsets on major strike-slip faults.

### 3.1.2. The Quaternary vertical movements in the northern Arabian Plate

The Quaternary deformation and vertical movements in the northern Arabian Plate and southern Alpine-Himalayan Belt are expressed in the structure of valleys of the Euphrates River and its tributaries. The Euphrates crosses downstream inner structures of the orogenic belt, the Taurus Ridge with South-Taurus thrust zone in its southern slope, the marginal folded basin of the Arabian Plate, the mobile platformal Aleppo Block, and the south-eastern side of the Mesopotamian Foredeep (Fig. 1).

The lacustrine or lagoon sedimentation occurred in the south-western side of the Mesopotamian Foredeep in the Early Pliocene. Sandstones contain rare small well rounded pebbles of ophiolitic and metamorphic rooks that prove their fluvial transportation from the orogenic belt. But records of large river valleys are absent at that time. A wide and slightly incised valley of the future Euphrates River was formed only in the Late Pliocene, when pebbles of distant transportation became more abundant (Trifonov et al., 2012). Estimation of magnitudes of further incision is complicated by tectonic deformation. The Euphrates valley is ruptured by the longitudinal Euphrates Fault. Because of this, terraces in the south-western side of the valley are uplifted relative to analogous terraces in the north-eastern side (Fig. 10, Table 2). At the same time, the valley is divided by transverse flexure-fault zones to wide cell-like segments and relatively uplifted segments that are characterised by splitting of terraces (Trifonov et al., 2012). The Halabiyeh-Zalabiyeh segment with the Hattabian artefacts belongs to the second group. The incision of terrace III[a] into the highest Late Pliocene terrace IV is 45–55 m here and the incision of recent channel into terrace III[a] does not exceed 30–50 m.

The altitudes of incision increase to the north-west, where the Euphrates valley crosses the mobile platformal Aleppo Block (Jrablus and Birecik areas). In the northern Arabian Plate, the land surface rises and altitudes of incision increase near the South-Taurus thrust zone. The height of the late Gelasian – early Calabrian terrace reaches 150 m above the river channel (652 m above sea level – a.s.l.) in the Göksu Çayı valley and 188 m (710 m a.s.l.) in the Erikdere valley. Upstream Erikdere, the height of this terrace increases up to 760 m a.s.l.

### 3.1.3. The Quaternary uplift in the southern Alpine-Himalayan Belt

The recent Euphrates River segment intersecting the Taurus Ridge formed at the end of Calabrian. Before this, in the late Gelasian and early Calabrian, the Euphrates crossed the Taurus Ridge along the Sultansuyu graben and farther to the south along the Erikdere valley and later probably along the Göksu Çayı valley (Trifonov et al., 2018). The Sultansuyu River that is the Euphrates tributary flows now along the graben to the NNE. The highest terrace III deposits correspond to Olduvai Subchron and upper Matuyama, 1.9–1.5 Ma. The lower part of terrace III deposits were accumulated by the Euphrates waters, when it flew to the SSW along the Sultansuyu graben. These deposits are situated now at the height of 1290 m a.s.l. in the upper reaches of Sultansuyu River cutting the northern slope of the Taurus Ridge. Downstream the Sultansuyu River, the height of terrace III is 125 m (960 m a.s.l.) and its lower deposits that are attributed to the old Euphrates alluvium are situated at the height of 840–870 m, i.e., 420–450 m lower than the same deposits in the upper reaches of the Sultansuyu River. Because the Euphrates River flew to the SSW during the Olduvai Subchron and early Calabrian, the upper reaches of Sultansuyu River were uplifted later to more than 440 m. In the Sultansuyu upper reaches, the Lower Pleistocene deposits are situated 530 m higher than in the Erikdere valley and 660 m higher than in the Göksu Çayı valley. This difference is caused by uplift of the northern side of the South-Taurus Thrust and tilting of the southern side out of the thrust. With the Taurus Ridge being more than 440 m lower at 1.9–1.5 Ma, the topographic contrast due to the thrusting was much smaller at that time.

### 3.1.4. The Quaternary uplift in the central and northern Alpine-Himalayan Belt

The late Cenozoic tectonics of Armenia and NE Turkey is characterised by combination of tectonic uplifts, volcanic mountains, and intermountain basins (Fig. 11). In NW Armenia, the Upper Akhuryan and Lori basins were filled by basaltic andesites and basaltic trachyandesites erupted mainly in the southern Javakheti Highland. The K-Ar dates of these lavas range from 2.51 ± 0.12 to 2.00 ± 0.10 Ma (Trifonov et al., 2016). The lavas spread along the Dzoraghet–Debed and Akhuryan valleys to several tens of kilometers. Further, the chain of trachyandesite and dacite volcanoes with K-Ar dates 1.97 ± 0.10 to 1.86 ± 0.10 Ma formed the N-trending Javakheti Ridge. The accumulation of lavas and the beginning of tectonic rise of the Bazum Ridge dammed the Akhuryan River (Ritz et al., 2016). As a result, the upper Akhuryan River flowed via the Karakhach Pass saddle into the Dzoraghet-Debed river valley at 1.9–1.7 Ma. The Karakhach unit with early Paleolithic artefacts was deposited at that time. The further uplift of the Karakhach Pass separated the basins. Fine-grained deposits of the Kurtan unit were accumulated in the late Calabrian and earliest Middle Pleistocene by stagnant waters, partly under lacustrine conditions, and covered the both basins and the lower Dzoraghet and upper Debed valleys.

Vertical movements became more active at ca. 0.6 Ma. The recent incision into the lava surface covered by Kurtan unit reaches ~370 m in the uppermost Debed River (Fig. 12). Because the portion of incision due to the fall of Caspian Sea level after the Baku (early Middle Pleistocene) transgression did not exceed 20–30 m (Chistyakov et al., 2000), the 340–350-m incision was caused by the tectonic rise of the Lori Basin. The Kurtan unit surface lowers to the NE at a distance of 20 km from 1300 m in the eastern termination of the Lori Basin (Kurtan

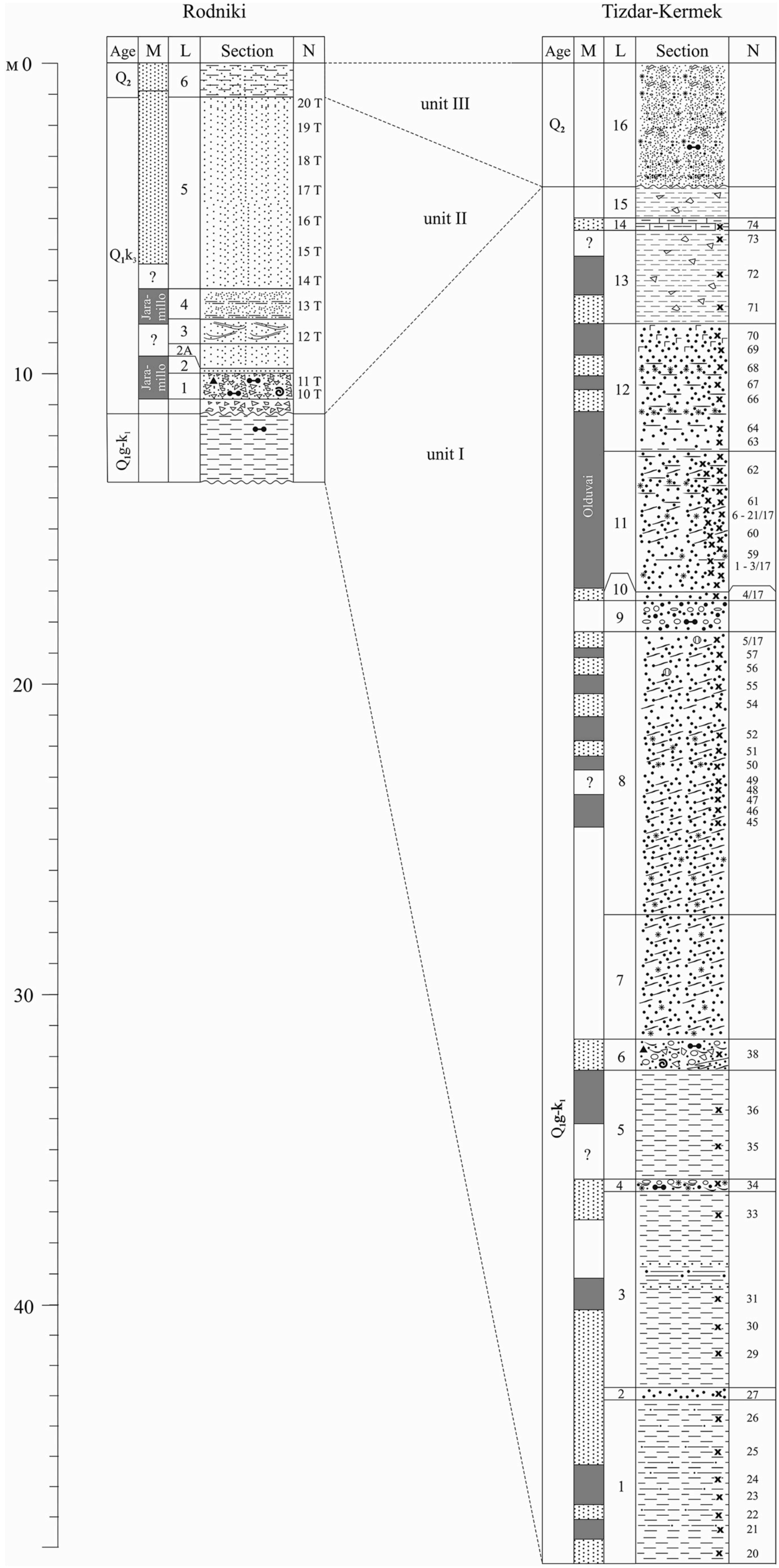


**Fig. 9.** Sections of Kuyalnikian deposits of the Kermek-Tizdar block and upper Calabrian deposits of the Rodniki block in the Azov coast of the Taman Peninsula, after (Trubikhin et al., 2017; Sokolov et al., 2019) with chandes. See Fig. 3 for the legend.

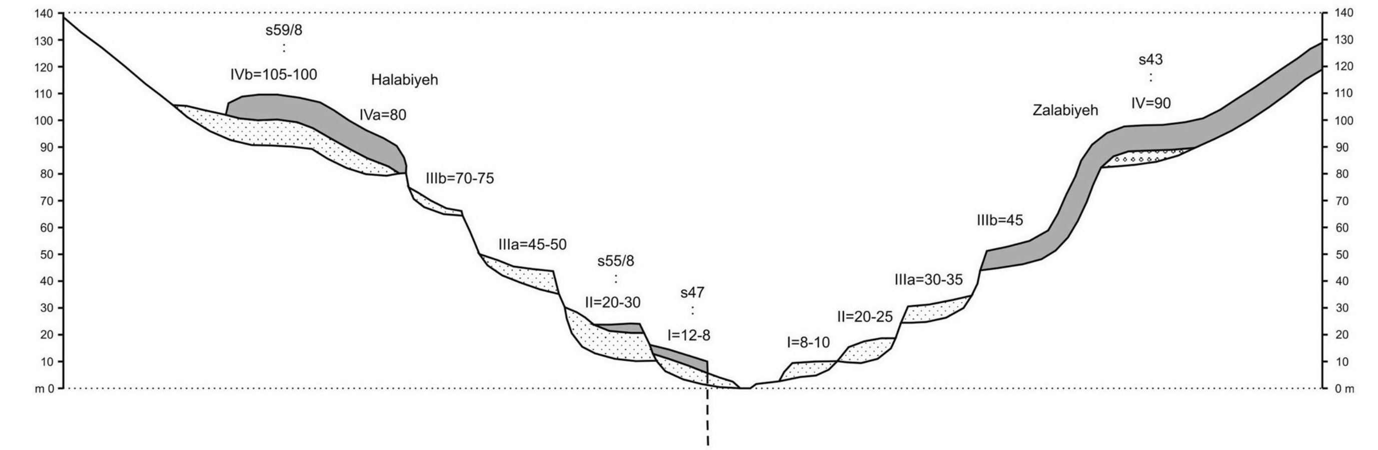


**Fig. 10.** Differences of height of terraces in the south-western and north-eastern sides of the Euphrates valley as an evidence of vertical movements on the Euphrates fault, the Halabiyeh-Zalabiyeh area.

quarry) up to 612 m near the town of Alaverdi. If we take into account that the Kurtan unit was deposited by stagnant waters, the primary dip of the Kurtan sediments was much smaller or absent. The surface of the Gelasian lavas rises in the Lory Basin from ca. 1300 m in the east to ca. 1600 m in the west. Because the lava flows that are exposed along the Dzoraget River are approximately parallel to each other, this difference expresses rather a tectonic tilt than a thinning of lava flows out of centers of eruption. The sum of these data shows that the western Lori Basin rose relative to the middle Debed valley (the town of Alaverdi) to ca. 900 m.

Whereas the upper Akhuryan River was prolonged in the early Calabrian by the Dzoraghet River, nowadays the surface of the Upper Akhuryan Basin is 250–350 m higher than the surface of the western Lori Basin. Therefore, uplift of the Upper Akhuryan Basin was, at a minimum, 200 m more, than the Lory Basin. At the western spur of the Bazum Ridge to the south of the Upper Akhuryan Basin, the surface of Gelasian lavas is situated now at heights 2120 m, i.e., 130 m higher than in the Upper Akhuryan Basin. The flexural bend of basaltic andesites in the southern Lori Basin reflects minimal relative uplift of the Bazum Ridge to a few hundred meters. The rise of the Karakhach Pass above the western part of the Lori Basin (ca. 500 m) corresponds to the minimum relative uplift of the Javakheti Ridge (Trifonov et al., 2016). Therefore, the uplift of the Javakheti and Bazum ridges has reached, at a minimum, 1230–1400 m.

The Shirak Basin is situated to the south of the Bazum Ridge and its western spurs with the Sevan-Hakkari Mesotethys suture. The borehole near Marmashen Monastery (the northern part of the basin) passed through fine-grained deposits (Sayadyan, 2009). The cited author reports the 126 m thick sequence of these deposits that contain the Caspian-type brackish-water molluscs of the Akchagylian (Late Pliocene and Gelasian) age. These deposits are covered by basalts and basaltic andesites with $^{39}Ar$-$^{40}Ar$ and K-Ar dates of 2.3–2.0 Ma. The same fine-grained deposits are exposed in the western (Turkish) part of Shirak Basin (N 40°42.897′; E 43°40.367′; height is 1570 m a.s.l.; 9 in Fig. 4). They show normal magnetic polarity. The brackish-water dinoflagellate cysts of the early Akchagylian aspect (determination of G.N. Aleksandrova) were found in clays of the lower part of the section. The presence of dinocysts in several layers excludes their accidental appearance within the sediments. The maximum early Akchagylian transgression level was probably ca. 100 m higher than the world sea level and decreased to the Quaternary. Therefore, the western Shirak Basin rose during the Quaternary to 1400–1500 m.

The Quaternary deposits overlying the Gelasian lavas are divided in the Shirak Basin to the Karakhach (1.9–1.7 Ma), Ani (ca. 1.5–0.75 Ma) and Arapi (0.70 ± 0.05 Ma) units (Sayadyan, 2009; Shalaeva et al., 2018; Trifonov et al., 2017). Each unit is composed of lacustrine-type fine-grained deposits with coarser alluvium at the top. A portion of alluvial deposits is higher in the Karakhach unit, than in the younger ones. During the Karakhach unit accumulation period, the rivers of northern Shirak Basin were drained via the Jajur Pass saddle to the east, to the Pambak system of basins, and farther to the NE along the Agstev River valley (Milanovsky, 1962; Trifonov et al., 2017). The Jajur Pass is

**Table 2**
Height (m) and correlation of terraces of Euphrates River and its tributaries in the northern Arabian Plate and southern Alpine-Himalayan Belt.

| Index/Age of cover/Age of following incision, Ma | Mesopotamian Foredeep, HZ | Jrablus | Birecik | Göksu Çayı, ŞA | Erikdere | Sultansuyu upper reaches | Örenköy-Sahiköy | Sultansuyu lower part | Kovancılar, KO | Palu |
|---|---|---|---|---|---|---|---|---|---|---|
| $N_2$ | Basin | 120 | 130 | 165 (645) | 242 (765) | Channel? | Basin | Basin | Basin | Erosion |
| $N_2^2$/ > 2.7/ < 2.7 | 105-75 (290–250) | | | | | Erosion | (1100) | | | |
| $Q_1^1$/2.6–2.1/~2.0 | 70-45 (275–250) | ? | 108 | 150 (632) | 188 (710) | ? | ? | Basin | Basin | Erosion |
| $Q_1^1$late-$Q_1^2$early/2.0–1.5/ 1.55–1.4 | 50-30 (260–240) | 70 | ~80 | | | Channel | Basin | | | 161 (951) |
| $Q_1^2$late/1.5–0.8/0.9–0.7 | 25-15 (220–210) | 45 | 56 | 66 (546) | 110 (633) | (1290) | 105 (995) | 125 (960) | 140 (981) | |
| $Q_2^1$/0.8–0.5/~0.5 | 10 (205) | 30 | 40 | | | | | 100 | | |
| $Q_2^2$/0.4–0.28/~0.27 | ≥5 (≥200) | | ~20 | 39 (521) | 55 (577) | | | | | |
| $Q_3^1$/0.13–0.09/0.08 | | | ~8 | 5 (485) | 8 (522) | | | | | |

Indexes: $N_2$ – Pliocene, $N_2^2$ – Late Pliocene, $Q_1^1$ – Gelasian, $Q_1^2$ – Calabrian, $Q_2^1$ – early Middle Pleistocene, $Q_2^2$ – late Middle Pleistocene, $Q_3^1$ – early Late Pleistocene, Basin – basin accumulation of alluvium, lacustrine and (possibly in the Mesopotamian Foredeep) lagoon deposits. Height of terraces above the river channel is shown without brackets and the height above the recent sea level is shown in brackets. Archaeological localities: HZ – Halabiyeh-Zalabiyeh, KO – Kovancılar, ŞA – Şambaat. The following published data are used (Demir et al., 2007; Trifonov et al., 2012): for the Mesopotamian Foredeep, HZ, where difference of the terrace altitudes depends on the longitudinal Euphrates fault offsets (Trifonov et al., 2014); – for the Jrablus town area (Demir et al., 2008); – for the Bericik town area; and (Trifonov et al., 2018) – for other localities.

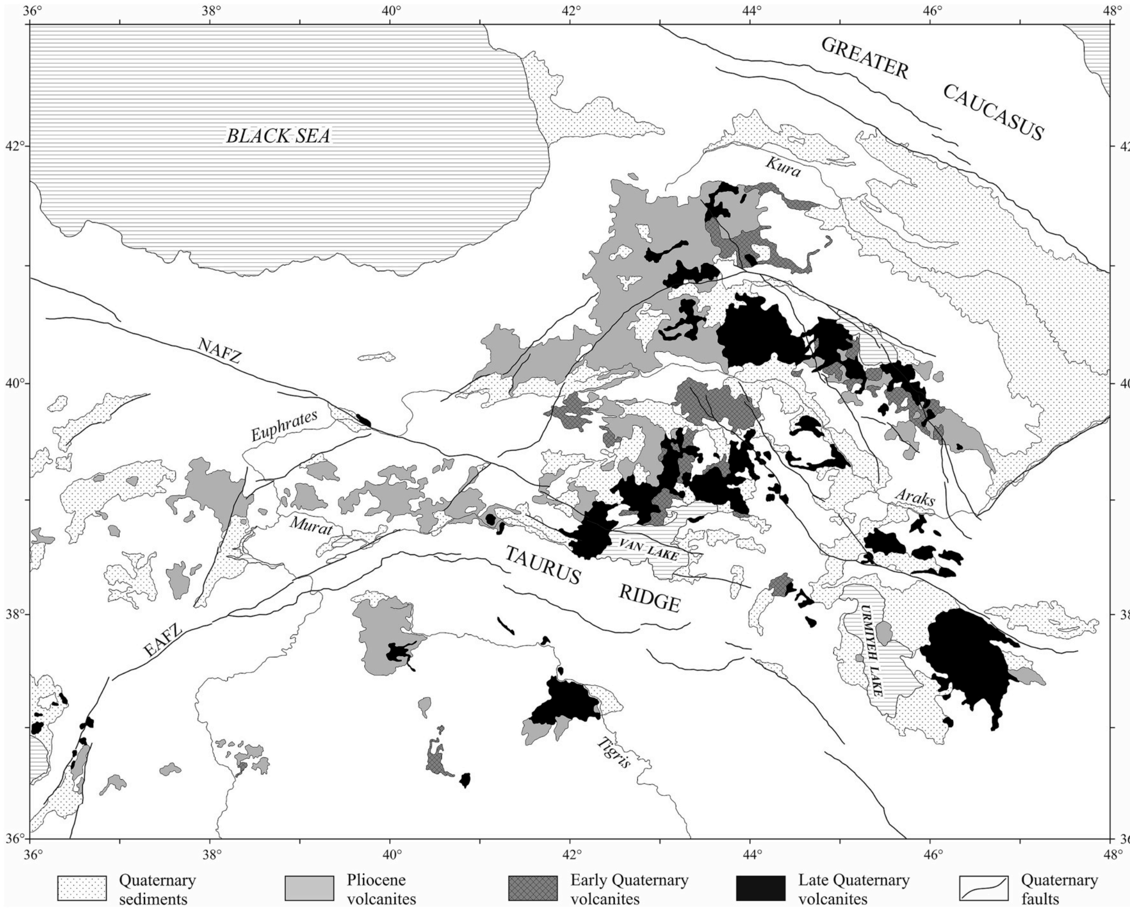


**Fig. 11.** Neotectonic features of Lesser Caucasus and adjacent areas.

uplifted now up at 1955 m, i.e., 190 m relative to the position of Karakhach unit in the northern border of Shirak Basin and more than 210 m relative to the upper reaches of the Pambak River. In the northern Shirak Basin, the Ani unit is incised into the Karakhach unit terrace by 60–70 m and the Arapi unit is incised into the Ani unit terrace by ca. 50 m. This incision is combined with a total slight tilt of the terraces to the south. The recent Akhuryan River is incised into the above-mentioned Quaternary deposits by several tens of meters (up to 100 m) (Trifonov et al., 2017). These data demonstrate different stages of the Quaternary uplift of the Shirak Basin. The uplift was the combined effect of the differentiated vertical movements of local structures and the total rise of the basin that was accelerated after the Arapi unit accumulation, i.e., during the last 0.6 Ma.

The data on significant Quaternary uplift were obtained also in the eastern Greater Caucasus. The Apsheronian brackish-water Caspian-type deposits are reported in the top of Chereke mountain (Geological

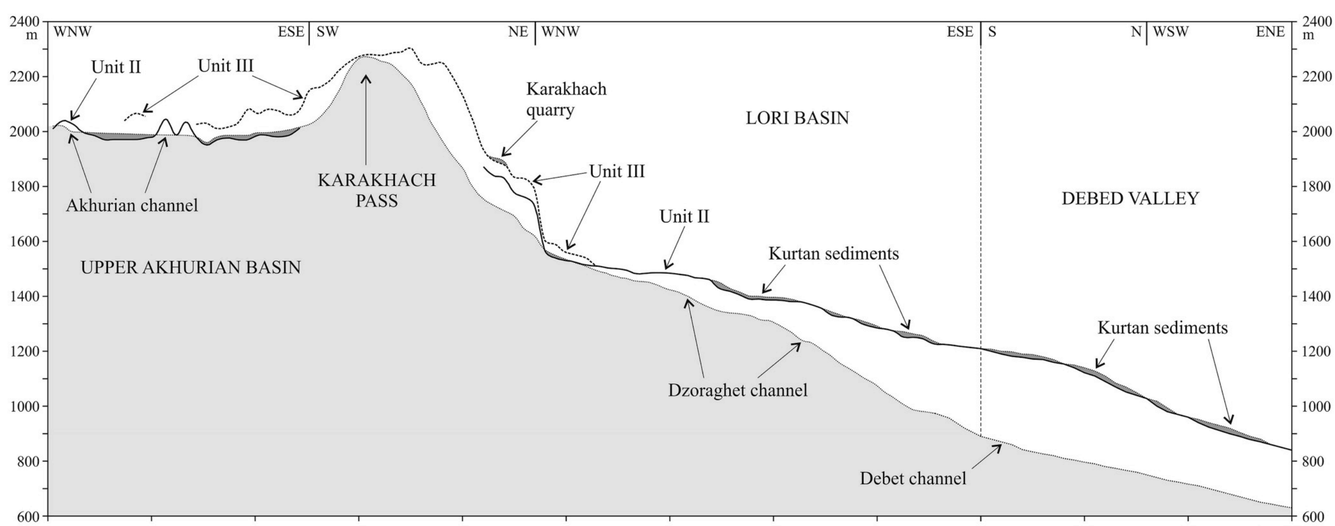


**Fig. 12.** The longitudinal geomorphologic-geological profile along the Dzoraghet–Debed river system. Position of the Upper Akhuryan and Lory basins and Debed River is shown in Fig. 4.

map of Caucasus, 1976), but T. Kengerli (personal communication, 2018) attributes them to Akchagylian. They are raised now to 2200–2300 m. This locality (7 in Fig. 1) is situated in the south-eastern termination of the Bokovoi Ridge of Greater Caucasus that gives a base to suppose that the Quaternary rise of its central part is more significant. Filippova (2007) reported the presence of brackish-water Caspian-type dinocysts of the Akchgylian-Apsheronian aspect (*Caspidinium rugosum* type, *Spiniferites ramosum*, cf. *Pontiadinium*, *Ataxodinium* cf. *confusum*) in the upper part (1615 m a.s.l.) of the Muhkai II section in Dagestan. The Muhkai II section is situated in the north-eastern slope of the Greater Caucasus. *In situ* position of the dinocysts at this height is possible, taking into account the data on the Chereke mountain. Unlike the Greater Caucasus, the Taman Peninsula was not essentially raised since the late Calabrian and topography of that time was low.

#### 3.1.5. Volcanism and lateral offsets on major strike-slip faults

Analyzing volcanic structures, we differentiated them into the Neogene and early Gelasian, the late Gelasian – early Calabrian, and the later formations (Milanovsky and Koronovsky, 1973; Arger et al., 2000; Segev, 2005; Trifonov et al., 2011). Removing the last group, we identify the following elements of the late Gelasian – early Calabrian volcanic activity. The chain of small volcanoes extends along the Dead Sea Transform (Segev, 2005; Sharkov et al., 1994; Yürür and Chorowitz, 1998). It was accompanied by small volcanic cones in the Jebel Arab Highland (Trifonov et al., 2011). Volcanic activity lasted in the Karacadağ lava field in the northernmost Arabian Plate (Keskin et al., 2012). Several volcanic centers acted in NE Turkey. The important topographic feature was the Javakheti Ridge volcanic chain in NW Armenia and Southern Georgia (Lebedev et al., 2008; Trifonov et al., 2016). As topographic features, they were accompanied by some earlier volcanic buildings in the Jebel Arab (Harrat Ash Shaam) Highland in Southern Syria and Jordan, in Eastern Turkey and Southern Georgia (Figs. 1 and 11).

Movements on strike-slip faults also contributed to the Quaternary topographic changes. Left lateral offsets of large river valleys like Euphrates, Murat, Erikdere, and Göksu Çayı on the East Anatolian fault zone (EAFZ) have reached 12 km from the Late Calabrian (Trifonov et al., 2018). The Euphrates valley is offset dextrally on the North Anatolian fault zone (NAFZ) to 35–40 km (Barka, 1992; Gaudemer et al., 1989). Şaroglu (1988) considers that the dextral slip on the NAFZ began ca. 2.5 Ma. Therefore, only a part of total offset can be attributed to the late Calabrian and younger time. We suppose that this portion was the same as on the EAFZ (80%) and estimate the offset on the NAFZ at ca. 30 km from the late Calabrian. Fig. 13 demonstrates the main drainage system of the late Gelasian and early Calabrian with the removed results of the late Calabrian and younger movements along faults.

### 3.2. Paleontological data (small mammals)

#### 3.2.1. Israel, ‘Ubeidiya

The mammalian fauna of ‘Ubeidiya represents a typical late Villafranchian association with *Stephanorhinus etruscus etruscus*, *Archidiskodon meridionalis*, *Ursus etruscus*, *Megantereon megantereon* (Tchernov, 1986a; 1987; Belmaker, 2006, 2017; Bar-Yosef and Belmaker, 2017). Small mammals (Tchernov, 1986b; von Koenigswald et al., 1992) include, in addition to other forms, a gerbil *Parameriones obeidiensis,* and arvicolids *Microtus jordanica* and *Lagurodon arankae.* The former species is widely spread in the southern Eastern and Central Europe, and in Anatolia. This steppe vole is typical for Calabrian correlated Early Pleistocene faunas, and is not reliably known to survive into Middle Pleistocene. Another arvicoline, *Microtus jordanica,* represents an advanced stage of evolution of some endemic lineage, comparable with numerous late Early Pleistocene derivatives of the *Allophaiomys* phyletic radiation. The composition of the fauna, comprising steppe with some woodland indicating animals, suggests open landscapes next to riparian wood or brush vegetation around the ‘Ubeidiya lake or deltaic estuary.

#### 3.2.2. Central Turkey, Dursunlu

This Early Paleolithic “Mode 1” core and flake archaeological site (Güleç et al., 2009; Kuhn, 2010), located in Central Anatolia in an open lignite mine, yielded a characteristic mammalian fauna. This assemblage contains large mammals as a mammutoid elephant with features intermediate between *A. meridionalis* and *M. trogontherii* (Albayrak and Lister, 2012), and a characteristic micromammalian assemblage with beavers, cricetids, arvicolids, murids and jerboas (Ünay, 1998). Voles include advanced *Lagurodon arankae, Mimomys intermedius* (= *savini*), and *Ellobius* (*Bramus*) sp. indicating the late early Biharian, late Calabrian, late Early Pleistocene age. Paleoenvironmental picture for this site is determined by a combination of animals adapted to aquatic, woodland, and steppe biotopes. Most probably, this was a lake with marshy and wooded shores surrounded by steppe-like open landscapes.

#### 3.2.3. Western Turkey, Denizli

The unique record of a partial skull of *Homo erectus* comes from Early Pleistocene fresh-water travertines of the Kocabaş upper formation in the Denizli extensional basin in western Anatolia (Kappelman et al., 2008). A lot of knew data, related to this find have been obtained during the last decade. Vialet et al. (2012, 2014, 2018) published results of anthropological definition of this Anatolian *Homo erectus*. They showed that it groups with the African fossils dated to around 1 Ma (KNM-OL 45500, Daka-BouriBouVP2/66, Buia UA31) and demonstrated some differences from the Asian *H. erectus*. Anyway it could represent a later “out-of-Africa” expansion of *Homo* in comparison with archaeological records mentioned above in this paper. The Kocabaş Formation contains two travertine layers with fluvial deposits between them and fluvial-lacustrine deposits above the travertines. The paleomagnetic study (Khatib et al., 2014) shows that the both travertines present reverse magnetic polarity and the detrital fluvio-lacustrine deposits above the travertines present normal polarity, except at the top, where it is reversed. Given the presence of *Homo erectus* and late Villafranchian paleontological remains in the upper travertine unit, the entire travertine sequence date to the upper Matuyama postdating the Olduvai Subchron (1.78 Ma). The normal polarity recorded in the upper fluvio-lacustrine deposits could correspond to the Cobb Mountain excursion, dated to 1.22–1.24 Ma. The cosmogenic $^{26}Al/^{10}Be$ isotope analysis of conglomerates, covering and underlying the upper travertine gives its age between 1.22 and 1.5 Ma (Lebatard et al., 2014a, 2014b).

The most complete faunal list associated to the Anatolian *Homo erectus* is documented by Boulbes et al. (2014). It represents a late Villafranchian large mammal assemblage with *Archidiskodon meridionalis meridionalis, Equus* ex gr. *E. apolloniensis-suessenbornensis*, *Equus* cf. *altidens*, *Stephanorhinus* cf. *etruscus*, *Metacervoceros rhenanus*, *Cervalces* (*Libralces*) ex gr. *minor-gallicus*, *Palaeotragus* sp., Bovinae gen.-indet. Scarce small mammals from the travertine deposits (personal communication of M.C.Alçiçek et al., 2016) indicate late early Biharian biochron. Biochronological position of the fauna confirmed by geochronological methods reliably date the site to late Calabrian, late Early Pleistocene around 1.1–1.3 Ma (Lebatard et al., 2014b). Taking into account the paleomagnetic data interpretation (Khatib et al., 2014), the most probable age of the Anatolian *Homo erectus* is 1.25–1.30 Ma. The mammalian assemblage indicate mosaic environment with wooded and more open biotopes along the shores of a lake.

The immediately older, late Gelasian period in the region, synchronous with hominin presence sites in Central Turkey and in the Caucasus, has a clear small mammal characteristics in the site of Bıçakçı (Çameli Basin, SW Turkey) with *Apodemus atavus, Mesocricetus* aff. *primitivus, Mimomys pliocaenicus, M.* ex gr. *tornensis, Pitymimomys pitymyoides, Borsodia* ex gr. *newtoni-arankoides, Clethrionomys kretzoii* and others (Van den Hoek Ostende et al., 2015). This fauna combines

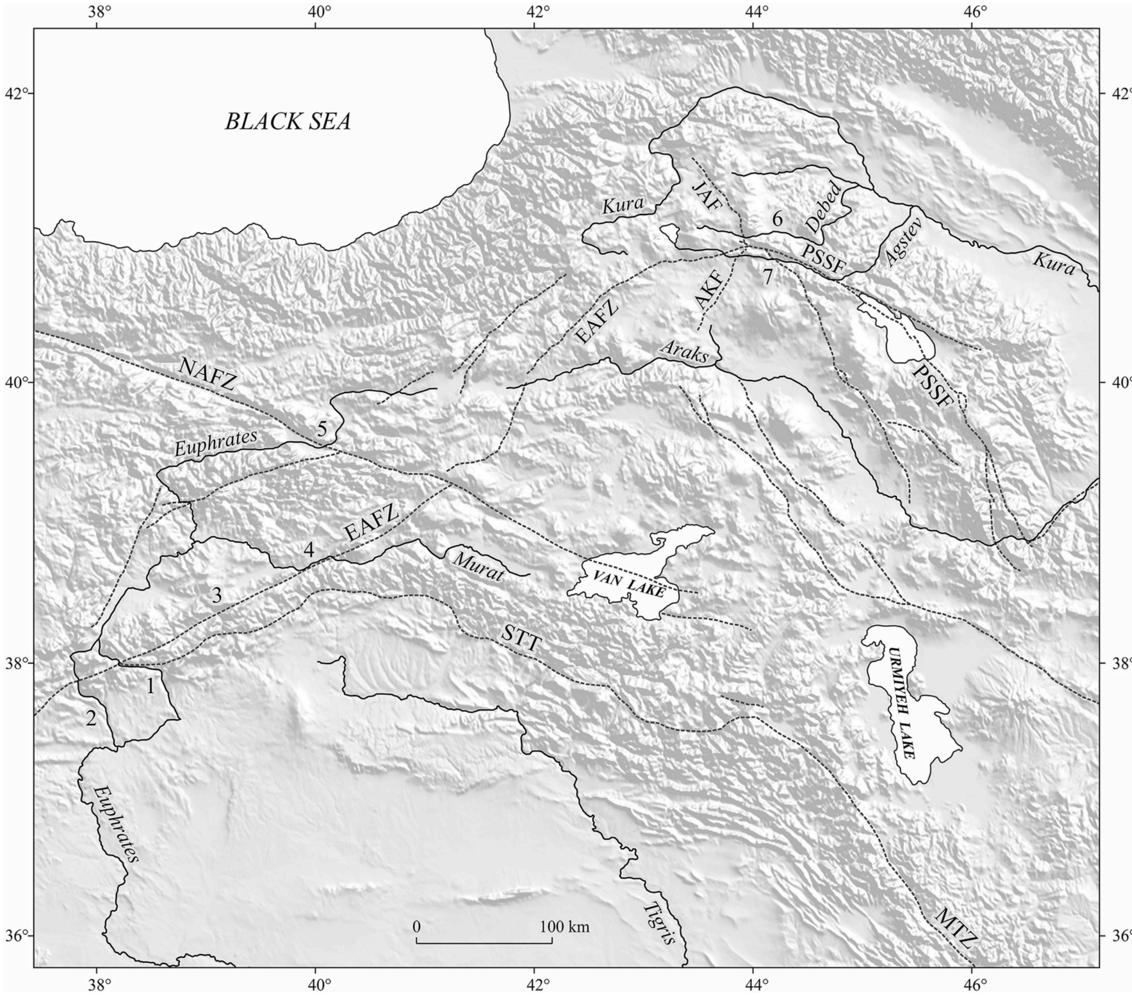


**Fig. 13.** The main drainage system of the late Gelasian and early Calabrian (ca. 1.8 Ma) after the removal of results of late Calabrian and younger lateral movements on faults. Late Cenozoic faults are shown by dotted lines. The major faults are: (AKF) Akhuryan Fault, (EAFZ) East Anatolian Fault Zone, (JAF) Javakheti Fault, (MTZ) Main Thrust of Zagros, (NAFZ) North Anatolian Fault Zone, (PSSF) Pambak-Sevan-Syunik Fault, (STT) South Taurus (Bitlis) Thrust. (1) Erikdere, (2) Göksu Çayı, (3) Khazar Lake, (4) the intersection of Murat River and EAFZ, (5) the intersection of Euphrates River and NAFZ, (6) the upstream continuation of Debed River by Dzoraghet and upper Akhuryan rivers, (7) the upstream continuation of Agstev River by Pambak River and a river in the northern Shirak Basin.

animals of forested and steppe biotopes indicating mosaic productive landscapes (Alçiçek et al., 2017). The composition indicates direct faunal connections with Late Villanyian faunas of mesic Central Europe and the Caucasus and more arid Eastern Europe.

### 3.2.4. Dmanisi

Large mammals from Dmanisi, apart from the famous population of *Homo georgicus*, document a diverse and characteristic late Villafranchian association of European appearance (Gabunia et al., 2000; Hemmer et al., 2011; Krijgsman et al., 2019). Small mammals of Dmanisi are still under study. The published faunal lists include (Hemmer et al., 2011; Agustí et al., 2016) voles *Mimomys tornensis* and *M. ostramosensis*, a gerbil *Parameriones obeidiensis*, and lack rootless arvicolines. This association can be correlated to latest Villanyian assemblages in Eurasia known to span the Gelasian-Calabrian transition. The absence of rootless voles of the genus *Allophaiomys* may be due to a sampling bias and/or refugial position of the fauna with stronger zoogeographic connections to the faunas of Near East. The mammalian assemblage of Dmanisi indicates a mixed landscape combining open and closed biotopes.

### 3.2.5. Azykh Cave

The mammalian fauna of the multi-layered Azykh Cave are well represented in the oldest beds of the sequence (Guseinov, 2010). The level of middle Acheulian yielded a mandible of ancient human (Gadzhiev and Guseinov, 1970) close to *Homo heidelbergensis* (King et al., 2016). Large mammals from Acheulian beds show the predominance of ungulates and the inferred age of about 0.3 Ma based on the composition of the assemblage (van der Made et al., 2016). Small mammals (Markova, 1982; Parfitt, 2016) of the Acheulian beds are dominated by *Microtus arvalis/socalis* accompanied by *Ellobius* (*Bramus*) ex gr. *lutescens*, *Terricola* spp., *Chionomys* spp., *Meriones* spp. and other forms. The presence of *M. arvalis/socialis* voles suggests a post-Cromerian, post early Middle Pleistocene age of the Acheulian and upper pebble beds. This fauna conforms to the Khasarian s.l. faunal unit of the East European biochronological scheme. The assemblage includes predominant indicators of open dry landscapes and rocky habitats. The representation of small mammals of the wooded biotopes (*Apodemus, Cletrhionomys, Dryomys*) is much inferior to that of the former group. The large mammal fauna is on the contrary dominated by animals of closed biotopes (van der Made et al., 2016).

### 3.2.6. Dagestan (Muhkai II)

The large mammal fauna of Muhkai II represents a well defined late Villafranchian assemblage with *Archidiskodon meridionalis, Equus stenonis, Eucladoceros senezensis, Palaeotragus, Galogoral*, and other forms (Amirkhanov et al., 2016). The scarce small mammal assemblage includes *Ellobius* (*Bramus*) ex gr. *primigenius* and *Pitymimomys pitymyoides.*

The latter form is the typical element of the European late Villanyian faunas and faunas of the early part of the Psekups faunal unit of Eastern Europe. Taking into account the reverse polarity of the level with the fauna below two normally magnetised zones (Amirkhanov et al., 2014), the age of the burial may be estimated around 2.1 Ma (Tesakov and Ozhereliev, 2017). The mammalian assemblage shows more elements of the closed forested biotopes combined with animals adapted to more open steppe and rocky habitats at considerably lower elevations compared to the present day altitude of ca. 1600 m a.s.l.

#### 3.2.7. Taman Peninsula, Tizdar/Kermek

The small mammal assemblage of the Tizdar/Kermek sequence (successive levels Tizdar 1, Kermek, and Tizdar 2) includes dominant remains of most primitive rootless arvicolines *Allophaiomys deucalion* and archaic *Lagurodon arankae,* in combination with rare *Mimomys* cf. *pliocaenicus*, *Pitymimomys pitymyoides*, and *Ellobius kujalnikensis* (Tesakov, 1998, 2004; Shchelinsky et al., 2016). Being an important and closely synchronous biochronological marker, the Holarctic dispersal of *Allophaiomys* is alternatively dated in the range of latest Gelasian to earliest Calabrian (Pevzner et al., 1998; Zykin et al., 2007). The occurrence of earliest rootless arvicolines in deposits of late Kujalnikian regional stage of the Black Sea and the bracketing of this migration in North America by paleomagnetism and geochronology in the range of 2.06 to 1.95 Ma (Martin et al., 2008) in the Middle West of USA, clearly imply a pre-Olduvai age of this datum with an obvious possibility of a slight regional (e.g., in the Transcaucasus) diachroneity. In terms of biochronology, Tizdar faunas belong to earliest Biharian, late Psekups faunal unit. The paleoenvironmental pattern of the Tizdar small mammal faunas evidences a wide spread of open steppe-like landscapes along marine and riverine coasts lined with riparian brush and forest vegetation.

#### 3.2.8. Taman Peninsula, Sinyaya Balka/Bogatyri

The unprecedentedly rich *Archidiskodon-Ealasmotherium* burial of Sinya Balka/Bogatyri with dozens of unearthed individuals and hosting early Paleolithic lithics (Shchelinsky et al., 2010), in spite of the complex geological settings, has a clear latest Villafranchian – earliest Galerian biochronological position. This is also the type fauna of the Tamanian faunal complex (unit) of the East European scheme. Small mammals are extremely scarce, but contain the typical early Biharian species as *Mimomys intermedius* (= *savini*) and *Cricetus nanus.* Combined paleoenvironmental signal indicates vast open steppes with small patches of forest vegetation along rivers and estuaries.

In summary, the evolutionary level of small mammal faunas provides a possibility to range the earliest known Palaeolithic human occupation sites in the Caucasus, Asia Minor, and Near East (Table 3) in the time span of late Gelasian through late Middle Pleistocene. The mammalian data show that all early occupation sites were connected to productive mosaic biotopes near lakes and streams.

### 3.3. Palynological data

#### 3.3.1. Israel

The pollen analysis data on boreholes Melekh-Sedom1 and Ami'az near the southern Dead Sea and Bravo1, Zemah-1, and Notera-3 in the Hula Basin characterise vegetation of the final Late Pliocene and the early Gelasian (Horowitz, 1979, 1990). In the final Late Pliocene, the savanna landscapes dominated. They represented open steppe coenoses with local forests (Table 4). A portion of oaks increases and a portion of *Picea* decreases in the early Gelasian (Horowitz, 1990). Domination of steppe coenoses went on during accumulation of the Erq el-Ahmar Formation attributed to the late Gelasian (Horowitz, 1979; Ron and Levi, 2001). The pollen spectra of ‘Ubeidiya locality (Calabrian) are characterised by the large portion of trees, but the meadow-steppe pollen is present too. These spectra show that the Calabrian climate was more humid than recent (Horowitz, 1979).

#### 3.3.2. Syria

The pollen analyses were carried out for the Upper Pliocene – Lower Pleistocene marine sediments of Jinndiriyeh (Devyatkin et al., 1996; Simakova, 1993) and Jabryoun (Simakova et al., 2012) sections in the Nahr El-Kabir valley, the Lower Pleistocene marine sections Mardido, Al-Quatriya, and Msherpheh near the Mediterranean coast and in the western El-Ghab Basin (Devyatkin et al., 1996, 1997; Golovina et al., 1996; Simakova, 1993, 1994), and the Middle Pleistocene deposits of the upper part of Jinndiriyeh section (Simakova, 1993).

Coniferous forests grew in mountains, mixed conifer–broad-leaved forests covered foothills, and plains were occupied by evergreen hard-leaved shrubs (maquis) with steppe vegetation areas in the latest Pliocene. Composition of vegetation varied in the Gelasian. Savanna vegetation changed with a time to conifer–broad-leaved forests in mountains and evergreen hard-leaved and steppe plants in plains. The beginning of Calabrian is characterised by relative aridisation (Simakova, 1994). In the Calabrian, coniferous forests with participation of broad-leaved trees cover mountains and evergreen hard-leaved shrubs occupied lowlands and river valleys. In general, climate became more arid than in the Gelasian. In the early Middle Pleistocene, conifer–broad-leaved forests occupied mountains and foothills and plains were covered by steppe and hemi-desert vegetation. The Middle Pleistocene pollen spectra are characterised by well-expressed cyclicity testifying to climatic changes.

#### 3.3.3. Eastern Turkey

The main palynological data were obtained from the Karangibaşi and Kovancılar sections in the lower Murat River valley (Trifonov et al., 2018). The Lower Pleistocene pollen spectra from the Dursunlu section in Central Turkey (Işik et al., 2011) and Bıçakçı section in SW Turkey (Jiménez-Moreno et al., 2015) are used for a comparison. The Upper Pliocene spectra of Eastern Turkey contain up to 40% of pollen of herbs and shrubs. Conifers and mesophytic angiosperms are present also. Perhaps, the vertical zonation existed at that time: coniferous forests

**Table 3**
Biochronological position of small mammal faunas from Early Paleolitihic sites from the Arabian-Caucasus region.

| Locality<br>Chronology | Muhkai 2 | Dmanisi | Kermek/Tizdar | 'Ubeidia | Dursunlu | Denizli | Rodniki, Sinya Balka/Bogatyri<br>Bogatyri | Azykh Cave |
|---|---|---|---|---|---|---|---|---|
| Middle Pleistocene, MQ2<br>Toringian, Aurelian | – | – | – | – | – | – | – | + |
| Calabrian, MQ1, early Biharian,<br>late Vilafranchian -early Galerian | – | – | – | – | – | + | + | – |
| Calabrian, MQ1, early Biharian,<br>late Vilafranchian | – | – | – | + | + | – | – | – |
| Gelasian – early Calabrian, MN17/MQ1<br>Villanyian-Biharian transition | – | + | + | – | – | – | – | – |
| Gelasian, MN17 late Villanyian,<br>middle Villafranchian | + | – | – | – | – | – | – | – |

**Table 4**
Landscape characteristics of the region of study according to the pollen analysis.

| Age | Israel | Syria | East Turkey | Armenia | Georgia | Azerbaijan | Dagestan, Chechnya | Taman |
|---|---|---|---|---|---|---|---|---|
| $Q_2^1$ pre-Mindel | | Steppe (Apiaceae, Fabaceae, Asteraceae) and evergreen hard-leaved shrubs (Oleaceae, *Ostrya, Celtis*, Cistaceae) in foothills & plains. Coniferous & broadleaved forests on high uplifts (*Pinus, Carpinus, Quercus, Fraxinus*). | Meadow steppe (Asteraceae, Chenopodiaceae, *Artemisia*, Dipsacaceae). Coniferous & broadleaved forests on high uplifts (*Pinus, Cedrus, Picea, Ostrya, Engelhardia, Juglans, Tilia, Ulmus, Olea, Quercus*). | Forest steppe and meadow steppe on the territory of Shirak and Upper Akhuryan basins. | Dark-coniferous forests (*Tsuga, Abies, Picea*). Mixed forest on lower altitudes (*Betula*, Taxodiaceae Juglandaceae, *Quercus, Zelkova, Acer, Tilia, Myrica, Nyssa, Liquidambar*). | Steppe & woodland in foothills and plains (Poaceae, Cyperaceae, Chenopodiaceae, *Artemisia*). Coniferous & broadleaved forests on higher altitudes (*Quercus, Ulmus, Pterocarya, Carpinus, Fagus, Ostrya. Betula, Pinus, Picea*). | Steppe coenoses in the Rubas River valley. | Steppe (Chenopodiaceae, Poaceae, Polygonaceae, Brassicaceae, Asteraceae). |
| Late $Q_1^2$ | Evergreen hard-leaved forests (*Quercus, Pistacia*, Cupressaceae *Rhus*) and steppe (Asteraceae, Euphorbiaceae Brassicaceae, Labiatae, Apiaceae) | Coniferous & broadleaved forests on high and middle uplifts and in foothills and valleys (*Pinus, Tilia, Corylus Quercus, Ulmus*, Oleaceae). Steppe in plains (Caryophyllaceae, Asteraceae, Poaceae, Fabaceae). | Meadow steppe (Asteraceae, Chenopodiaceae, *Artemisia*, Dipsaceae). Coniferous & broadleaved forests on high uplifts (*Pinus* and rarely *Betula, Cedrus, Picea, Ostrya, Engelhardia, Juglans, Tilia, Ulmus, Olea*). | Alternation of meadow-steppe (Asteraceae, Chenopodiaceae, *Artemisia*) and mesophytic mixed forests (*Pinus, Tsuga, Abies, Sciadopitys* in humid epochs and *Quercus, Carpinus, Juglans*, Ulmaceae, *Picea, Tsuga* in dry epochs) in the Vorotan River area. In NW Armenia, the forests consist of *Pinus, Tsuga, Podocarpus, Cedrus, Abies alba, Taxus, Liquidambar, Castenea, Carya*. | Mixed forests (*Tsuga, Abies, Picea, Sciadopitys*, Taxodiaceae, *Podocarpus, Dacrydium, Fagus, Quercus, Juglandaceae, Liquidambar, Aralia, Eucommia, Magnolia, Alangium, Symplocos*) | Mixed forests (*Picea, Cedrus, Juglans, Ostrya, Carpinus*). Forests with *Betula, Alnus, Picea*, & *Tsuga* widespread at 0.95–0.8 Ma. Woodland (*Pinus, Rhus, Celtis*) in foothills at 1.3–0.95 Ma. | Coniferous & broadleaved forests on high and middle uplifts (*Pinus* mainly, *Picea, Tsuga*, Taxodiaceae, *Sciadopites, Ostrya, Celtis, Betula, Alnus, Carpinus, Corylus, Quercus, Ulmus, Magnolia*). Steppe and forest-steppe (Chenopodiaceae, Poaceae, Asteraceae) in foothills & plains. | Forest steppe. Steppe (Asteraceae, Chenopodiaceae, Poaceae, *Artemisia*, Plumbaginaceae) and coniferous & broadleaved forest (*Pinus, Tsuga, Picea, Juglans, Ulmus, Quercus, Carya, Pterocarya, Betula*). |
| Early $Q_1^2$ | | | Forest steppe. Leaved forests (*Betula, Alnus, Ostrya, Engelhardia*, and rarely *Picea, Pinus, Corylus, Ulmus, Quercus*) and steppe (Asteraceae, Chenopodiaceae, Brassicaceae, Poaceae). | Forest steppe (Caryophyllaceae, *Ephedra*, rare *Quercus, Ulmus*) dominates at 1.32–1.29 Ma. Participation of *Ulmus, Quercus*, rarely *Liquidambar, Pinus, Tsuga, Cedrus, Zelkova*, increases after 1.28 Ma. | Dark conifers forest on high uplifts in the W. In the E, the alpine belt is identified (*Diphasiastrum alpinum, L. clavatum, L. selago, Selaginella selaginoides, Sphagnum*). Mixed forests (*Abies, Betula, Pinus*) on high uplifts. Broadleaved forests (*Fagus, Carpinus, Ulmus, Castanea, Tilia, Quercus*) on middle uplifts and foothills. Meadow steppe in plains. | Woodland (*Betula*) on high uplifts. Dark coniferous forests (*Picea, Tsuga*) on middle uplifts. Broadleaved forests (*Fagus, Carpinus, Corylus, Tilia, Ulmus, Carya*) in foothills. Leaved forest (*Populus, Myricea, Salix, Pterocarya, Ulmus, Alnus, Zelkova, Elaeagnus*) in valleys. Steppe (Chenopodiaceae) in plains. | | Forest steppe. Steppe (Asteraceae, Chenopodiaceae) and coniferous & broadleaved forests (*Pinus, Tsuga, Picea, Abies, Quercus, Betula, Salix, Corylus, Carpinus Ulmus, Juglans, Pistacia, Fagus, Acer*). |
| $Q_1^1$ | Steppe and forest-steppe (Chenopodiaceae, Quercus). | Alternation of forest-steppe and coniferous & broadleaved forests on uplifts and evergreen hard-leaved shrubs and steppe in plains. | | Light coniferous forests in NW Armenia. | Dark-coniferous forests (*Picea, Abies, Tsuga*) alternate with coniferous & broadleaved forests in the W. In the E, mixed forests (*Betula, Pinus, Cedrus, Abies, Sequoia, Picea*) on high and middle uplifts, steppe in plains. | Leaved forests (Fagaceae, *Castanea, Platanus, Quercus, Mahonia*) on middle uplifts and foothills (*Parrotia persica, Carya, Ulmus*). Forest steppe (*Carpinus, Pistacia*) in plains and valleys. | Forest steppe. Leaved forests (*Quercus, Fagus*, Juglandaceae, *Ulmus, Tilia, Betula*) and rarely coniferous forests (*Pinus, Picea, Tsuga, Cedrus*). Steppe (Chenopodiaceae, Poaceae, Asteraceae). | Forest steppe -meadow steppe (Chenopodiaceae, Poaceae, Asteraceae, *Artemisia*, Polygonaceae, Valerianaceae) and mixed forests (*Pinus*, rarely *Tsuga, Abies, Carya, Tilia, Acer, Fagus, Liquidambar, Quercus, Carpinus, Sorbus*). |
| Late $N_2^2$ | | | | | | | | |

(*continued on next page*)

**Table 4** (*continued*)

| Age | Israel | Syria | East Turkey | Armenia | Georgia | Azerbaijan | Dagestan, Chechnya | Taman |
|---|---|---|---|---|---|---|---|---|
| | Forest –steppe (*Quercus, Olea, Pinus, Picea* Poaceae, Chenopodiaceae, Asteraceae). | Coniferous forests (*Pinus, Picea, Abies, Tsuga, Cedrus, Podocarpus*) and coniferous & broad-leaved forests on high uplifts (*Pinus, Tsuga, Liquidambar, Fagus*). Evergreen hard-leaved shrubs (Oleaceae, *Ostrya Celtis*, Cistaceae) and steppe (Asteraceae, Chenopodiaceae, Poaceae, Brassicaceae) in foothills & plains. | Coniferous forests (*Sciadopites, Podocarpus, Cedrus, Tsuga, Picea, Abies*) on high uplifts. Mixed forests (*Pinus, Acer, Quercus*, Juglandaceae, *Carpinus, Ulmus*) on foothills. Meadow-steppe (Asteraceae, Chenopodiaceae, Poaceae, *Ephedra*) in plains. | | Steppe and open woodlands. Broadleaved forests on lower and middle altitudes and coniferous forests on higher altitudes (*Cyclosorus fisheri, Tsuga, Alnus ducalis, Cinnamomum, Liquidambar*, Hamamelidaceae, *Ilex horrida, Acer saliens, Acer decipiens*). | | Forests (*Pinus, Picea, Abies, Tsuga, Betula, Corylus, Carpinus, Quercus, Ulmus*, Juglandaceae) and steppe (Chenopodiaceae, *Artemisia, Ephedra*). | Forest steppe (*Pinus, Betula, Tilia, Corylus, Quercus, Carpinus*, Chenopodiaceae). |

grew in mountains, mixed forests occupied foothills, and meadow-steppe coenoses covered lowlands. The lower Calabrian spectra show domination of leaved forests and indicate wide-spread forest-steppe landscapes. The upper Calabrian spectra show domination of open steppe coenoses; the arboreal group is represented mainly by *Pinus* and testifies to the presence of forests in mountains. Pollen records of late Gelasian in the west and late Calabrian of central Anatolia show mosaic biotopes with the presence of forested and open landscapes and a certain cyclicity marked by alternating peaks of Chenopodiceae and broad-leaved trees (e.g., *Quercus*).

### 3.3.4. Armenia

The palynological data were obtained for SE Armenia from the Vorotan River sections (Scharrer, 2013) and for Southern Armenia from the Shamb paleo-lake section (Joannin et al., 2010). They characterise the time interval 1.41–0.94 Ma. Herb vegetation with rare mesothermal forest components was characteristic in 1.32–1.29 Ma, testifying to domination of meadow-steppe landscapes and relatively arid climate. The forest mesothermal components essentially increased about 1.28 Ma. In the time interval 1.22–1.08 Ma, the cyclic change of dry and wet epochs is indicated by the intercalation of sediments with dominating meadow-steppe vegetation or increased portion of mesophytic forest component. These variations are correlated with the marine isotopic stages (Scharrer, 2013).

In NW Armenia, there are the palynological data for the Gelasian Artenis and lower Middle Pleistocene Krasar sections in the Upper Akhuryan Basin (Trifonov et al., 2016), for the Marmashen borehole (Zaikina et al., 1969a), Haikavan and Voghji sections of the Calabrian Ani unit (Simakova, 2016), and the lower Middle Pleistocene Arapi section (Zaikina et al., 1969b) in the Shirak Basin. The light coniferous forests dominated in the Gelasian and the forest-steppe and steppe landscapes dominated in the Calabrian and early Middle Pleistocene. The following changes are identified during the late Calabrian by the pollen analysis of Voghji section: forest-steppe (relatively cool and dry), forest-steppe and steppe (warm and dry), coniferous forests (relatively cool and wet), and steppe (relatively cool and dry) (Simakova, 2016). The relic flora disappears in the Shirak and Upper Akhuryan basins in the early Middle Pleistocene (Sayadyan, 1972, 2009; Trifonov et al., 2018).

### 3.3.5. Georgia

The palynological analysis is based on the studies of Orapho, Galizga, Khvarbeti, Tsikhisperdi, Morokhvili, Archeuli, and Tsiaguvani sections in Western Georgia (Shatilova et al., 2011) and sections of the Lori Upland, Dmanisi, and Malye Shiraki in Eastern Georgia (Uznadze, 1965; Shatilova et al., 2011).

In Western Georgia, the vegetation changed during the Gelasian from the domination of dark coniferous forests to the domination of mixed conifer–broad-leaved forests. In Eastern Georgia, the Gelasian was characterised by forests in mountains and river valleys, the savanna-type forest-steppe vegetation in the Lori Upland, and steppe vegetation in low plains.

The amount of mesophytic plants increased in the Calabrian. The dark conifers occupied mountain of Western Georgia in the early Calabrian. The middle Calabrian looked like the climatic optimum and was characterised by the wide spreading of polydominant forests. In the Dmanisi area, the Calabrian began by some aridisation relative to the late Gelasian (Messager et al., 2010). The Calabrian vegetation of Eastern Georgia shows vertical zonation. Forests occupied mountains below the alpine herb zone and meadow-steppe coenoses dominated in the low plains. The areas of dark coniferous forests increased at the late Calabrian, when the many Pliocene relics disappeared and the vegetation and its zonation approached to the recent ones (Shatilova, 1974; Shatilova et al., 2011).

*3.3.6. Azerbaijan*

The detailed palynological data were obtained by the study of sections of Azykh cave, Duzdagh, Karadja, Bozdagh, Yasamal Valley, Malyi Kharami, Kertes, Sabunchi, and Bulla Island (Filippova, 1990, 1997; Guseinov, 2010; Tagieva, 2011; Tagieva and Muradly, 2014).

In the late Akchagylian (Gelasian), the successive change from the birch forests in mountains via the domination of oaks in foothills to the savanna-type forest-steppe vegetation in low basins testifies to the existence of vertical zonation of vegetation (Filippova, 1997; Tagieva, 2011; Tagieva and Muradly, 2014). The portion of steppe coenoses increased in the second part of early Apsheronian (ca. 1.5–1.3 Ma). The pollen composition testifies to the lowering of forest zone boundaries because of some cooling and humidisation at the beginning of middle Apsheronian (ca. 1.3–1.1 Ma). At the end of middle Apsheronian (ca. 1.1–0.95 Ma), the portion of arboreal pollen essentially decreased (Tagieva, 2011; Tagieva and Muradly, 2014). The areas of forests spread because of cooling and humidisation in the beginning of late Apsheronian (ca. 0.95–0.85 Ma). The upper boundary of forest zone rose and forests became more mesophytic in the end of Apsheronian (ca. 0.85–0.73 Ma) that indicates the essential warming. The steppe and forest-steppe landscapes dominated in lowlands and foothills and the broad-leaved and higher *Betula* forests covered mountains in the early Middle Pleistocene (Tagieva, 2011). In the Middle Pleistocene, the representatives of wet sub-tropics disappeared, the species variability of dark conifers decreased, and steppe and hemi-desert coenoses spread in lowlands and foothills because of aridisation and cooling (Filippova, 1997; Tagieva and Muradly, 2014).

*3.3.7. Dagestan and Chechnya*

The palynological analysis was carried out by using the data of the Alexandia borehole near the Kizlyar town and the Aldy and Chechen-Aul sections in Chechnya (Naidina and Richards, 2016) and the Ainikab I and Muhkai II sections in Dagestan (Amirkhanov, 2012; Chepalyga et al., 2012). The late Akchagylian (Gelasian) was characterised by the combination of mixed conifer–broad-leaved forests and areas of meadow-steppe vegetation. These areas expanded at the end of Akchagylian. The Apsheronian (Calabrian) was characterised by domination of meadow-steppe vegetation with limited areas of broad-leaved and higher coniferous (mainly *Pinus*) forests in mountains. The data on Rubas River sections show domination of steppe landscapes in the early Middle Pleistocene.

*3.3.8. Taman Peninsula*

The palynological data are based on the study of the Tizdar/Kermek section of the upper Kuyalnikian (Gelasian) deposits and the Bogatyri/Sinyaya Balka and Rodniki sections of the upper Apsheronian (upper Calabrian) deposits in the southern coast of the Azov Sea (Shchelinsky et al., 2010, 2016; Simakova, 2009). The lower part of the Tizdar/Kermek section shows domination of meadow-steppe landscapes. The areas of coniferous and broad-leaved forests increased and the vegetation became more mesophytic later. The upper part of the Tizdar/Kermek section indicates the combination of meadow-steppe and conifer–broad-leaved forest coenoses. The data on Bogatyri/Sinyaya Balka and Rodniki sections indicate relatively arid climate and forest-steppe and steppe landscapes with conifer-leaved forests in river valleys.

## 4. Discussion

### *4.1. Age of migration of the earliest hominins to the Arabian-Caucasian region*

*4.1.1. ‘Ubeidiya in Israel*

The Cover basalt underlying the ‘Ubeidiya Formation composes a base of Jordan River valley, where it is dated to 5.0–3.3 Ma by K-Ar method (Heinmann and Braun, 2000). The lacustrine Erq el-Ahmar Formation that separates the Cover Basalt and the ‘Ubeidiya Formation, differs from the latter by presence of older molluscs (Tchernov, 1986a) and shows not only reverse, but also normal magnetic polarity correlated to the Olduvai subchron (Ron and Levi, 2001). The ‘Ubeidiya Formation is overlain by the alluvium-colluvium Naharayim Formation and the Yarmouk Basalt with normal magnetic polarity and $^{39}$Ar-$^{40}$Ar date 0.79 ± 0.17 Ma (Heinmann and Braun, 2000). Bone remains of large mammals found in the Fi deposits are dated to the time interval ca. 1.6–1.2 Ma (Tchernov, 1986a; 1987; Bar-Yosef and Belmaker, 2017). The ‘Ubeidiya Formation shows reverse magnetic polarity with two short intervals of normal polarity within the Fi unit that are correlated, following to the faunal examination, to the Cobb Mountain and Gilsa subchrons (Sagi et al., 2005). If this is true, the lowest Fi layers containing the Oldowan-type artefacts can be dated to ca. 1.6–1.7 Ma.

*4.1.2. The Syrian localities*

The only clue for the age of the Orontes River Hattabian artefacts is that they are older than the terrace IV (h = 43–55 m) deposits. The latter contain remains of large mammals dated to the late Calabrian – early Middle Pleistocene (Trifonov et al., 2014) as well as handaxes and other tools of the middle Acheulian aspect (Clark, 1967, 1968; Dodonov et al., 1993). The data on the age of Khattabian artefacts within the Euphrates River terrace III[a] are more representative. The higher terrace III[b] (h = 45 m) is covered by basalt with the $^{40}$Ar/$^{39}$Ar date 2116.2 ± 38.8 Ka (Demir et al., 2007). The lower terrace II (h = 20–25 m) is covered by basalt with the K-Ar dates 0.71 ± 0.08, 0.72 ± 0.08, and 0.82 ± 0.09 Ma (Sharkov et al., 1998). The basalt shows normal magnetic polarity (Trifonov et al., 2012). Under the basalt, the terrace II cover is composed of upper loam (2–4 m) with reverse magnetic polarity and lower alluvium (10 m exposed). The alluvium consists of conglomerates with sandstone lenses. Handaxes and other Acheulian lithics were found in the alluvium (Besançon and Sanlaville, 1981). The studies of the Euphrates valley evolution and the terrace II structure show that deposits of this terrace were accumulated during a long time (Demir et al., 2008; Trifonov et al., 2012). As a result, terrace III[a] is dated in the time interval ca. 1.5–2 Ma.

Estimating the age of Aïn al Fil Oldowan lithics (L2), we must agree with the following arguments represented in the Le Tensorer et al. (2015) paper. First, layer L2 is older than layer I with elephant teeth that are similar to those from the Fi deposits of ‘Ubeidiya Formation dated between 1.2 and 1.6 Ma. Second, layers E to L2 belong to the Matuyama chron and layer L2 lies below layer K with normal magnetic polarity. The dating of fauna in layer I proves that layer K is certainly older than the Jaramillo subchron, but it is impossible to identify layer K with either of the earlier subchrons (Cobb Mountain, Gilsa, or Olduvai). Thus, the stratigraphic position of L2 within the Matuyama chron remains uncertain.

*4.1.3. SE Turkey*

The dating of Şambayat and Bostancık industries is based on correlation of geomorphological and paleomagnetic characteristics of all terraces of Göksu Çayı, Eskiköydere and Erikdere valleys (Trifonov et al., 2018). The correlation shows that the Göksu Çayı terrace IV cover and its analogs in the other named rivers are characterised by reverse magnetic polarity in the upper and lower parts and normal polarity in the middle part and this interval of normal polarity corresponds to the Olduvai subchron. Correspondingly, the archaeological finds in layer 9 of terrace IV and its analog in terrace IV[a] section are attributed to the uppermost lower Matuyama before the Olduvai subchron and the finds in layer 2 of terrace IV and the lower part of the Eskiköydere terrace III cover belong to the Olduvai subchron and perhaps the lowermost upper Matuyama (the lowermost Calabrian), i.e., the age of deposits with artefacts corresponds to ca. 1.7–2.0 Ma.

The Eskimalatya section is characterised by reverse magnetic polarity and belongs probably to the upper Matuyama chron. In the Kovancılar section, the lowermost gravel of the Palu Formation with Oldowan artefacts is situated in the upper part of sedimentary sequence with reverse polarity that underlies the layers corresponding to the Olduvai subchron (Trifonov et al., 2018). Therefore, the gravel with artefacts is older than 1.95 Ma. The 1–5 m thick top layer of this section represents the cover of upper terrace III that formed in the end of Calabrian about 0.9 Ma. This indicates the upper age limit of the early Acheulian artefacts. But they are rounded and could be redeposited from the upper layers of the Palu Formation and be older.

#### 4.1.4. The Armenian localities

The base of the lower fluvial part of Karakhach quarry section has not been excavated. Its lower age limit is defined by the K-Ar date 1.87 ± 0.10 Ma of the basaltic andesite that is exposed near the Sevjur stream channel just to the west of Karakhach quarry (Trifonov et al., 2016). The Sevjur valley including Karakhach quarry is cut into the slope of Javakheti Ridge composed by dacites with K-Ar dates 1.96 ± 0.08 and 1.90 ± 0.08 Ma. Magnetic polarity is reverse in the upper tuff and normal in the lower fluvial deposits of the Karakhach unit. An analysis of paleomagnetic characteristics of this unit and overlaying deposits of Karakhach quarry justifies that normal polarity of the fluvial part of the unit corresponds to the Olduvai subchron. Four SIMS U-Pb dates were obtained by volcanic zircon analysis of the lower part of upper tuff. They are 1.75 ± 0.02, 1.799 ± 0.044 Ma, 1.804 ± 0.03, and 1.944 ± 0.046 Ma (Presnyakov et al., 2012). The SIMS U-Pb date for the upper tuff layer within the lower fluvial part of the Karakhach unit is 1.947 ± 0.045 Ma (Presnyakov et al., 2012). If we take into account that analyzed zircons crystallised in the magmatic source before eruption of the tuff and a time interval between crystallisation and eruption could reach 0.1 Ma and more (Trifonov et al., 2016), we have to reduce the tuff age estimates. So, the upper tuff part of the Karakhach unit corresponds to the lowermost upper Matuyma, the lower fluvial part corresponds to the Olduvai subchron, and the age of the unit is limited by time interval 1.7–1.9 Ma.

The data on composition and paleomagnetic characteristics of three other localities of artefacts within the Karakhach unit do not contradict this age estimation. The 5-m thick Muradovo section contains the layer with conglomerate matrix that is identical to the Karakhach quarry upper tuff and shows reverse magnetic polarity. The same polarity is characteristic for the 6 m thick part of Agvorik section, where the lithics were found. The 19 m thick Jradzor section shows reverse polarity in majority of its layers and normal polarity in the lowermost part.

#### 4.1.5. Dmanisi in Georgia

The basalt flow in the bottom of the Dmanisi sedimentary sequence shows the $^{40}Ar/^{39}Ar$ age 1.85 ± 0.01 Ma and the covering tuffs (stratum A) are dated to 1.81 ± 0.05 Ma (de Lumney et al., 2002). Both the basalt and stratum A show normal magnetic polarity, while the stratum B shows reverse magnetic polarity. The fossils from stratum B are attributed to the late Villafranchian (Gabunia et al., 2000). The lowest artefacts of stratum A are separated from the basalt by thin unweathered ashes, showing that these artefacts must be close in age to the basalt, i.e., just after 1.85 Ma (Ferring et al., 2011). Therefore, the time interval of the archaeological finds in Dmanisi is ca. 1.85–1.70 Ma, i.e., close to that in the Karakhach quarry.

#### 4.1.6. The Azykh cave in Nagornyi Karabakh

The dating of Kuruchai culture from layers VII-X of the Azykh cave is based in following data. Both entrances of the cave are opened to the 180–200 m high terrace that is dated to the Apsheronian, i.e., Calabrian age (Suleimanov, 1979). The mammal bones from layers III (artefacts of early Moustier and final Acheulian) and V (middle Acheulian artefacts) are correlated with the Khazar mammal complex of Southern Russia that is dated to the later Middle Pleistocene (Guseinov, 2010). Guseinov attributes the mammal bones from layer VI (early Acheulian artefacts) to the Tiraspol complex of the early Middle Pleistocene, but Markova (1982) considers that small mammals from this layer are younger. The bones from layers VII to IX are unidentifiable. The data on remanent magnetisation (Velichko et al., 1980) show normal polarity for layers II and V and reverse polarity for layer IX and probably layers VIII and X. The paleomagnetic data for layers VI-VII are absent and, correspondingly, location of the Brunhes-Matuyama boundary within the Azykh section is still unresolved. Suleimanov (1979) concluded that the occupation of the Azykh cave started in the middle Apsheronian, though early Apsheronian time is not excluded.

#### 4.1.7. Muhkai II in Dagestan

The remanent magnetisation was studied at the upper 3–24 m of the section by V.M. Trubikhin and at the depths of 24–34 m including layer 80 by V.M. Semenov (Amirkhanov, 2012). The studies show reverse magnetic polarity of the section (Matuyama chron) with several layers of normal polarity. The latter is characteristic for thin interval at the depth of 4 m, 6-m interval at the depth of 7–13 m, and relatively thin (< 1 m) interval (layer 61) at the depth of 27–28 m. The 4 m deep interval is interpreted as the Kamikatsura event (0.85 Ma) and the 7–13-m deep interval is identified to the Jaramillo Subchron (Amirkhanov, 2012; Chepalyga et al., 2012). Chepalyga et al. (2012) suppose that 27–28 m deep interval belongs to the Cobb Mountain event. But faunal data from layer 80 that is situated 3.5 m lower than the 27–28 m deep normal polarity interval suggest its correlation with the Olduvai Subchron or even Reunion event. Large mammal remains in layer 80 are dated to ca. 2.1–1.76 Ma (Amirkhanov, 2015; Amirkhanov et al., 2016; Sablin, 2015). Small mammals from the same layer in the adjacent Muhkai IIa locality belong to the Psekups faunal complex. They are not younger than 1.7 Ma and, most probably, are older than 2 Ma (Tesakov and Ozherelyev, 2017). Correspondingly, the earliest Oldowan artefacts from the Muhkai II locality are not younger than 2 Ma. Thus, the Muhkai II is among the oldest known occupation sites in the studied region. The upper 13 m of the Muhkai-II section, including the coarse deposits with bifacial lithics (proto-Acheulian) and overlying the lower sediments with erosional contact, are attributed to the Jaramillo subchron and uppermost Matuyama (0.8–1.0 Ma) (Amirkhanov, 2015). Typical handaxes are found in the localities dated to 0.8 Ma and earlier (Amirkhanov, 2015, 2017).

#### 4.1.8. Taman Peninsula

The age of Kermek locality is determined by its location within the late Kuyalnikian section between the layers with Tizdar 1 and Tizdar 2 localities of small mammals. They are referred to the early part of the Psekups faunal complex (Tesakov, 2004) and are dated between ca. 2.1 and 1.8 Ma. The molluscan complex contains *Margaritifera arca* and the unionid *Bogatschevia* cf. *sturi* that are correlated to Early–early Middle Apsheronian (early Calabrian) deposits of the Caspian region. The presence of *Dreissena theodori* and absence of *Pseudosturia*, the unionid typical for the later Early Pleistocene, also indicates an age close to the Gelasian/Calabrian transition (Shchelinsky et al., 2016). The upper and lower clays and silts of the Tizdar/Kermek section showed reverse magnetic polarity (Vangengeim et al., 1991; Trubikhin et al., 2017). The later detailed studies demonstrate more complicated situation (Sokolov et al., 2019). At first, it is necessary to exclude paleomagnetic data on clayish flows and sills of mud volcano that can be unrepresentative for host deposits. After this, the lower and uppermost parts of the section show indeed reverse magnetic polarity, but the polarity of the middle part (11 m) is normal and 4-m thick deposits above and 8-m thick deposits below the middle part are characterised by alternation of normal and reverse polarity (Fig. 9). The Tizdar 2 paleontological site is situated in the upper part of the lower interval of alternative polarity and the Kermek archaeological-paleontological site and the Tizdar-1 paleontological site are situated below this interval in the lower part of the section with reverse polarity. Combination of these data dates the Kermek locality to ca. 2.1–1.95 Ma (late Gelasian before the Olduvai subchron). The Kuyalnikian deposits of the Tizdar/Kermek block are unconformably covered by nearly horizontal 3-m thick sequence of sands with breccia lenses (unit 1). They contain remains of

*Mammuthus* sp., *Bison* sp., and *Equus* cf. *chosaricus* that are dated to the late Middle Pleistocene (Shchelinsky et al., 2016).

The late Kuyalnikian age of clays and clayish sands underlying the Rodniki and Sinyaya Balka/Bogatyri localities is based on remains of small mammals (Dodonov et al., 2008) and ostracods (Vangengeim et al., 1991). The unit 2, containing these localities cover the deformed Kuyalnikian deposits with unconformity. The layers with the Tamanian faunal complex show reverse magnetic polarity (Dodonov et al., 2008; Shchelinsky et al., 2010) and correspond probably to the basal layer of the Rodniki section. The polarity of sands above the basal layer of the Rodniki section is normal in the lower part and reverse in the upper part (Fig. 9) that is interpreted as Jaramillo Subchron and uppermost Matuyama Chron, i.e., the time interval 1.0–0.8 Ma (Trubikhin et al., 2017). Summing these data, we suppose that the Tamanian faunal complex and the Rodniki and Sinyaya Balka/Bogatyri early Paleolithic localities can be dated to the Calabrian prior to the Jaramillo Subchron.

Thus, the most precise dates of records of earliest presence of hominis in the Syrian part of the Euphrates valley, the Şambayat and Kovancılar localities in Eastern Turkey, the Karakhach quarry in Armenia, Dmanisi in Georgia, Muhkai II in Dagestan, and Kermek in the Taman Peninsula are localised within the time interval ca. 2.0–1.7 Ma. The age (1.7–1.6 Ma) of lowest layers of ‘Ubeidiya with Oldowan-type artefacts marks probably the end of this epoch.

### *4.2. Environment of migration of the earliest hominins to the Arabian-Caucasian region*

Summing the data represented in section 3.1, we conclude that significant tectonic rise occurred in the region of studies from the latest Calabrian till the present time. The uplift has exceeded 440 m in the Taurus Ridge and 1500 m in the Bazum and Javakheti ridges and has probably reached 1400–1500 m in the Shirak Basin and 2200–2300 m in the south-eastern termination of the Greater Caucasus. Removing elevations of that time, we find that the topography was relatively low and weakly differentiated in the late Gelasian – early Calabrian. The ridges were not higher than 1000, rarely 1500 m (perhaps, up to 2000 m in the axial part of the Greater Caucasus). River valleys were weakly incised. They as well as inter-mountain basins and foredeeps were not higher than several hundred meters and some of them, like Shirak Basin, were situated only a little higher than the sea level. The lateral offsets of late Calabrian to present time reach 12 km on the sinistral East Anatolian Fault Zone and ca. 30 km on the dextral North Anatolian Fault zone. After removing them, the main river valleys (Euphrates and its tributaries like Murat, Erikdere and Göksu Çayı) become less twisting and more passable. Major fault zones acting in the late Gelasian – early Calabrian, like the Dead Sea Transform or the Sultansuyu Graben, formed depressions in topography with meandering streams and lakes. Springs along the faults were additional sources of water. Important landscape characteristic for the southern part of the region and the Lesser Caucasus was abundance of soils enriched by products of volcanism. This stimulated vegetation favourable for herbivorous mammals.

The analysis of paleozoological and palynological data shows two regularities.

First, differences and variety of vegetation that were found in some parts of the region under studies during either epoch was caused by vertical topographic zonation, i.e., the development of tectonic relief. At the same time, similar landscapes were characterised by similar fauna and flora in the entire region that points to a climatic uniformity.

Second, the composition of vegetation expressing climatic conditions changed in course of time. The Early Pleistocene began of warming and domination of savanna-type landscapes. In the late Gelasian, the areas of conifer and conifer–broad-leaved mesophytic forests increased, testifying to the more humid climate. There are some signs of vertical vegetation zonation in Georgia, Azerbaijan, and Dagestan. The onset of Calabrian is marked by a certain aridisation. Soon after, the areas of mesophytic forests increased, indicating the humidisation, but the meadow-steppe landscapes spread again in the middle Calabrian. The late Calabrian was characterised by the repeated changes of climatic conditions, corresponding to the global climatic changes. The areas of broad-leaved forests expanded, the upper boundary of forests rose, and the lowlands were covered by meadow-steppe vegetation during the warm epochs. During the relatively cool epochs, the lower boundary of forests lowered, the shares of *Betula*, *Alnus, Pinus, Picea,* and *Tsuga* increased, the role of mesophytic plants decreased in the forest coenoses, and the steppe and hemi-desert vegetation occupied lowlands. The vertical vegetation zonation became more distinct in the Calabrian, testifying to the increase of topographic contrasts. At the background of the general aridisation, the dry/wet cyclicity became more contrast in the Middle Pleistocene, when the majority of relict plants disappeared.

Thus, the end of Gelasian – beginning of Calabrian was relatively comfortable time for the migration of various herbivorous mammals to and within the region. Carnivorans, accompanied by hominins, migrated after herbivores.

## 5. Conclusions

The stratified sites with the earliest archaeological evidence of homins in the Arabian-Caucasus region have been analyzed. Seven localities: Halabiyeh–Zalabiyeh in Syria, Şambayat and Kovancılar in Eastern Turkey, Karakhach quarry in Armenia, Dmanisi in Georgia, Muhkai II in Dagestan, and Kermek in the Taman Peninsula, are reliably dated in the range of ca. 2.0–1.7 Ma. The lowest beds of ‘Ubeidiya with the Oldowan-type artefacts, dated to 1.7–1.6 Ma, probably formed at the end of this epoch.

The topography of the region was much lower in that epoch than in the present time. The heights of mountain ridges did not usually exceed 1000 m, rarely 1500 m. Only some volcanoes and possibly the central Greater Caucasus rose up to 2000 m. The conjugated intermountain basins and foredeeps were not higher than several hundred meters and some of them were situated only slightly above the sea level.

The climate of the end of Gelasian was wet and relatively warm, supporting meadow-steppe and forest-steppe savanna-type vegetation in basins and valleys and coniferous and coniferous–broad-leaved forests in mountains. Abundance of vegetation was maintained by numerous rivers, lakes, and springs in the intermountain basins and valleys that were controlled partly by fault activity. In the southern part of the region and in Lesser Caucasus, there was the additional factor favourable to development of vegetation: abundance of soils enriched by products of volcanism. This stimulated vegetation favourable for herbivorous mammals. Relative aridisation that was interrupted for a short time by a new humid spell occurred at the beginning of Calabrian. The aridisation led to the wide spread of the steppe and forest-steppe coenoses with vegetation favourable for herbivores. Hominin dispersals targeted the areas with abundant herbivores in the late Gelasian – early Calabrian time.

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## Appendix A. Supplementary data

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## References


Adamia, S.A., Zakariadze, G., Chkhotua, T., Sadradze, N., Tsereteli, N., Chabukiani, A., Gventsadze, S., 2011. Geology of the Caucasus: a review. Turk. J. Earth Sci. 20, 489–544.

Agustí, J., Chochisvili, G., Lozano-Fernández, I., Oms, L.O., Piñero, P., Lordkipanidze, D., 2016. The late Neogene-Quaternary small vertebrate succession from Georgia: zoogeographical and paleoecological implications. In: 100 ± 25 Years of Homo Erectus: Dmanisi and beyond. Abstracts of the Internationai Senckenberg Conference. Georgian National Museum, Tbilisi, pp. 21.

Akinci, A.C., Robertson, A.H.F., Ünlügenç, U.C., 2016. Sedimentary and structural evidence for the Cenozoic subduction-collision history of the Southern Neotethys in NE Turkey (Çağlayancerit area). Int. J. Earth Sci. 105, 315–337.

Albayrak, E., Lister, A., 2012. Dental remains of fossil elephants from Turkey. Quat. Int. 276–277, 198–211.

Alçiçek, H., Wesselingh, F.P., Alçiçek, M.C., Jiménez-Moreno, G., Feijen, F.J., van den Hoek Ostende, L.W., Mayda, S., Tesakov, A.S., 2017. A multiproxy study of the early Pleistocene palaeoenvironmental and palaeoclimatic conditions of an anastomosed fluvial sequence from the Çameli Basin (SW Anatolia, Turkey). Palaeogeogr. Palaeoclimatol. Palaeoecol. 467, 232–252.

Amirkhanov, H.A., 2006. Kamennyi Vek Yuzhnoi Aravii (Stone Age in Southern Arabia). Nauka, Moscow, pp. 693 (in Russian).

Amirkhanov, H.A., 2012. Pamyatniki rannego pleistotsena tsentral'nogo dagestana (early Pleistocene sites of central dagestan). In: Derevyanko, A.P., Amirkhanov, H.A., Zenin, V.P., Anoykin, A.A., Rybalko, A.G. (Eds.), Problems of the Palaeolith of Dagestan. Publication of the Institute of archaeology and ethnography of the Siberian Branch of the Russian Academy of Sciences, Novosibirsk, pp. 6–67 (in Russian).

Amirkhanov, H.A., 2015. Severnyi Kavkaz: Nachalo Predistorii (Northern Caucasus: Beginning of the Pre-history). Mavraev printing house, Mahachkala, pp. 352 (in Russian).

Amirkhanov, H.A., 2017. Acheulian handaxes from northeastern Caucasus. Russian Archaeol 1, 3–18 (in Russian).

Amirkhanov, H.A., Ozherelyev, D.V., Gribchenko, Y.N., Sablin, M.V., Semenov, V.V., Trubikhin, V.M., 2014. Early Humans at the eastern gate of Europe: the discovery and investigation of Oldowan sites in northern Caucasus. Comptes Rendus Palevol 13, 717–725.

Amirkhanov, H.A., Ozherelyev, D.V., Sablin, M.V., Agadzhanyan, A.K., 2016. Faunal remains from the Oldowan site of Muhkai II in the North Caucasus: potential for dating and palaeolandscape reconstruction. Quat. Int. 395, 233–241.

Arger, J., Mitchell, J., Westaway, R., 2000. Neogene and Quaternary volcanism of southeastern Turkey. In: In: Bozkurt, E., Winchester, J.A., Piper, J.D.A. (Eds.), Tectonics and Magmatism in Turkey and the Surrounding Area, vol. 173. Geol. Soc. London Spec. Publ., pp. 459–487.

Bar-Yosef, O., Belmaker, M., 2017. Ubeidiya. Quaternary of the Levant: Environments, Climate Change, and Humans. Part III: Archaeology of Human Evolution. Cambridge University Press, Cambridge, pp. 179–185.

Bar-Yosef, O., Goren-Inbar, N., 1993. Institute of Archaeology Publ. The Lithic Assemblages of 'Ubeidiya: a Lower Palaeolithic Site in the Jordan Valley, vol. 34 Hebrew University, Jerusalem.

Barka, A.A., 1992. The North Anatolian Fault Zone. Ann. Tect., Special Issue, Supplement to vol. 6, 164–195.

Belmaker, M., 2006. Community Structure through Time: 'Ubeidiya, a Lower Pleistocene Site as a Case Study. Unpublished Ph.D. Thesis. Hebrew University of Jerusalem.

Belmaker, M., 2017. Biogeography and palaeoecology of the early Pleistocene large mammals in the levant. In: Onzel, Y., Bar-Yosef, O. (Eds.), Quaternary of the Levant: Environments, Climate Change, and Humans. Part IV: Palaeoecology. Cambridge University Press, Cambridge, pp. 355–362.

Belmaker, M., Tchernov, E., Condemi, S., Bar-Yosef, O., 2002. New evidence for hominid presence in the Lower Pleistocene in the southern Levant. J. Hum. Evol. 43, 43–56.

Belyaeva, E.V., Lyubin, V.P., 2013. Acheulian localities of northern Armenia. Novosibirsk In: Basic Problems of Archaeology, Anthropology and Ethnography of Eurasia. To 70-anniversary of Academician A.P. Derevyanko, pp. 37–52 (in RussiaBelmaker).

Besançon, J., Sanlaville, P., 1981. Apercu geomorphologique sur la vallee de l'Euphrate Syrien. Paleorient 7, 5–18.

Besançon, J., Copeland, L., Hours, F., Sanlaville, P., 1978. The Palaeolithic sequence in Quaternary formations of the Orontes river valley, Northern Syria: a preliminary report. 15. Bulletin, Institute of Archaeology, University of London, pp. 149–170.

Boulbes, N., Mayda, S., Titov, V.V., Alçiçek, M.C., 2014. Les grands mammifères du Villafranchien supérieur des travertins du Bassin de Denizli (Sud-Ouest Anatolie, Turquie). L'anthropologie 118, 44–73.

Chepalyga, A.L., Amirkhanov, H.A., Sadchikova, T.A., Trubikhin, V.M., Pirogov, A.N., 2012. Geoarchaeology of the Oldowan archaeological sites in the mountain dagestan (NE Caucasus). Bull. Comm. Stud. Quat. 72, 73–94 (in Russian).

Chistyakov, A.A., Makarova, N.V., Makarov, V.I., 2000. Quaternary Geology. GEOS, Moscow, pp. 303 (in Russian).

Clark, J.D., 1967. The middle Acheulian occupation site at Latamne, northern Syria. Quaternaria 9, 1–68.

Clark, J.D., 1968. The Middle Acheulian occupation site at Latamne, Northern Syria: further excavation. Quaternaria 10, 1–76.

Copeland, L., 2004. The paleolithic of the Euphrates valley in Syria. Br. Archaeol. Rep. Int. Ser. 1263, 19–114.

Copeland, L., Hours, F., 1993. The Middle Orontes paleolithic flint industries. Br. Archaeol. Rep. Int. Ser 587, 63–144.

Demir, T., Westaway, R., Bridgland, D., Pringle, M., Yurtmen, S., Beck, A., Rowbotham, G., 2007. Ar-Ar dating of Late Cenozoic basaltic volcanism in northern Syria: implications for the history of incision by the River Euphrates and uplift of the northern Arabian Platform. Tectonics 26https://doi.org/10.1029/2006TC001959. TC 3012.

Demir, T., Seyrek, A., Westaway, R., Bridgland, D., Beck, A., 2008. Late Cenozoic surface uplift revealed by incision by the River Euphrates at Birecik, southeast Turkey. Quat. Int. 186, 132–163.

Devyatkin, E.V., Dodonov, A.E., Gablina, S.S., Golovina, L.A., Kurenkova, V.G., Simakova, A.N., Trubikhin, V.M., Yasamanov, N.A., Khatib, K., Nseir, H., 1996. Upper pliocene-lower Pleistocene marine deposits of western Syria: stratigraphy and paleogeography. Stratigr. Geol. Correl. 4 (1), 71–81.

Devyatkin, E.V., Dodonov, A.E., Sharkov, E.V., Zykin, V.S., Simakova, A.N., Khatib, K., Nseir, H., 1997. The El-Ghab rift depression in Syria: its structure, stratigraphy, and history of development. Stratigr. Geol. Correl. 5 (4), 362–374.

Dodonov, A.E., Deviatkin, E.V., Ranov, V.A., Khatib, K., Nseir, H., 1993. The Latamne Formation in the Orontes River valley. British Archaeol. Rep. Int. Ser. 587, 189–194.

Dodonov, A.E., Tesakov, A.S., Simakova, A.N., 2008. Sinyaya Balka locality of mammal fossils in Taman: new data on geology and bio-stratigraphy. In: Early Paleolithic in Eurasia: New Discoveries. Southern Scientific Centre of Russian Academy of Sciences, Rostov-on-Don, pp. 53–58 (in Russian).

Ershov, A.V., Nikishin, A.M., 2004. Recent geodynamics of the Caucasus–Arabia–east Africa region. Geotectonics 38 (2), 123–136.

Ferring, R., Oms, O., Agusti, J., Berna, F., Nioradze, M., Shelia, T., Tappen, M., Vekua, A., Zhvania, D., Lordkipanidze, D., 2011. Earliest human occupations at Dmanisi (Georgian Caucasus) dated to 1.85–1.78 Ma. Proc. Natl. Acad. Sci. Unit. States Am. 108 (20), 10432–10436.

Filippova, N.Yu, 1990. Palynological stratigraphy of Apsheronian deposits in the south-eastern termination of Greater Gaucasus. In: Paleovegetation and Stratigraphy of Phanerozoic 2. Geological Institute of the USSR Academy of Sciences, Moscow, pp. 120–140 (in Russian).

Filippova, N.Yu, 1997. Palynology of Upper Pliocene – Middle Pleistocene in the South of Caspian Region. GEOS, Moscow, pp. 191 (in Russian).

Filippova, N.Yu, 2007. Characteristics of microflora in the Upper Pliocene – Eopleistocene deposits of NW Caspian. Fundamental problems of the Quaternary: results of studies and main directions of further researches. In: Proceedings of V Russian Conference on Study of the Quaternary. GEOS, Moscow, pp. 430–433 (in Russian).

Gabunia, L., Vekua, A., Lordkipanidze, D., Swisher III, C.C., Ferring, R., Justus, A., Nioradze, M., Tvalchrelidze, M., Anton, S.C., Bosinski, G., Jöris, O., de Lumney, M.A., Majsuradze, G., Mouskhelishvili, A., 2000. Earliest Pleistocene hominid cranial remains from Dmanisi, Republic of Geeorgia: taxonomy, geological setting, and age. Science 288, 1019–1025.

Gadzhiev, D.V., Guseinov, M.M., 1970. First record of the Acheulian man in USSR (Azaerbaijan, Azykh cave). Sci. Comm. Azerbaijan State Med. Inst. 31, 13–20 (in Russian).

Garfunkel, Z., Ben-Avraham, Z., 2001. Basins along the Dead Sea transform. In: In: Ziegler, P.A., Cavazza, W., Robertson, A.H.F., Crasquin-Soleau, S. (Eds.), Peri-Tethys Memoir 6: Peri-Tethyan Rift/Wrench Basins and Passive Margins, vol. 186. Memóires du Muséum national d'Histoire naturelle, pp. 607–627.

Gaudemer, Y., Tapponnier, P., Turcotte, D.L., 1989. River offsets across active strike-slip faults. Ann. Tect. 3 (2), 55–76.

D.V. (Ed.), 1976. Geological map of Caucasus, 1:500000/Nalivkin. VSEGEI, Leningrad.

Golovina, L.A., Gablina, S.S., Simakova, A.N., 1996. Paleogeographic interpretation of paleoflora from the Pliocene-Pleistocene sediments of Western Syria. Stratigr. Geol. Correl. 4 (2), 202–205.

Güleç, E., White, T., Kuhn, S., Özer, I., Sağır, M., Yılmaz, H., Howell, F.C., 2009. The lower Pleistocene lithic assemblage from Dursunlu (Konya), central Anatolia, Turkey. Antiquity 83, 11–22.

Guseinov, M., 2010. Early Paleolithic of Azerbaijan (By Data on Cave Sites). TekNur, Baku, pp. 234 (in Russian with English summary).

Heinmann, A., Braun, D., 2000. Quaternary stratigraphy of the Kinnarot basin, Dead Sea transform, northeastern Israel. Isr. J. Earth Sci. 49, 31–44.

Hemmer, H., Kahlke, R.-D., Vekua, A.K., 2011. The cheetah Acinonyx pardinensis (Croizet et Jobert, 1828) s.l. at the hominin site of Dmanisi (Georgia) – a potential prime meat supplier in Early Pleistocene ecosystems. Quat. Sci. Rev. 30, 2703–2714.

Van den Hoek Ostende, L.W., Diepeveen, F., Tesakov, A., Saraç, G., Mayhew, D., Alçiçek, M.C., 2015. On the brink: micromammals from the latest Villanyian from Biçakçi (Anatolia). Geol. J. 50 (3), 230–245.

Horowitz, A., 1979. The Quaternary of Israel. Academic Press, New York/London, pp. 394.

Horowitz, A., 1990. Neogene Palynostratigraphy, Paleoflora and Paleoclimatic Reconstruction in Israel, vol. XVII. Paleobiologie continentale, Montpellier, pp. 245–257.

Işik, N.Ya, Saraç, G., Ünay, E., de Bruijn, H., 2011. Palynological analysis of Neogene mammal sites of Turkey – vegetational and climatic implications. Bull. Earth Sci. Appl. Res. Cent. Hacettepe Univ. 32 (2), 105–120.

Jiménez-Moreno, G., Alçiçek, H., Alçiçek, M.C., van den Hoek Ostende, L., Wesselingh,

F.P., 2015. Vegetation and climate changes during the late Pliocene and early Pleistocene in SW Anatolia, Turkey. Quat. Res. 84 (3), 448–456.
Joannin, S., Cornée, J.-J., Münch, Ph, Fornari, M., Vasiliev, J., Krijgsman, W., Nahapetyan, S., Gabrielyan, I., Ollivier, V., Roiron, P., Chataigner, Ch, 2010. Early Pleistocene climate cycles in continental deposits of the Lesser Caucasus of Armenia inferred from palynology, magnetostratigraphy, and $^{40}Ar/^{39}Ar$ dating. Earth Planet. Sci. Lett. 291, 149–158.
Kappelman, J., Alçiçek, M.C., Kazancı, N., Schultz, M., Özkul, M., Sen, S., 2008. First Homo erectus from Turkey and implications for migrations into temperate Eurasia. Am. J. Phys. Anthropol. 135, 110–116.
Keskin, M., Chugaev, A.V., Lebedev, V.A., Sharkov, E.V., Oyan, V., Kavak, O., 2012. The geochronology and origin of Mantle sources for late Cenozoic Intraplate volcanism in the frontal part of the Arabian Plate in the Karacada Neovolcanic area of Turkey. Part 1. The results of isotope-geochronological studies. J. Volcanol. Seismol. 6 (6), 352–360.
Khain, V.E., 2001. Tectonics of Continents and Oceans. Nauchnyi Mir, Moscow, pp. 606 (in Russian).
Khatib, S., Rochette, P., Alçiçek, M.C., Lebatard, A.-E., Demory, F., Saos, Th, 2014. Études stratigraphique, sédimentologique et paléomagnétique des travertins de Kocabas, Bassin de Denizli, Anatolie, Turquie, contenant des restes fossiles quaternaires. L'anthropologie 118, 16–33.
King, T., Compton, T., Rosas, A., Andrews, P., Yepiskoyan, L., Asryan, L., 2016. Azokh cave hominin remains. In: Fernández-Jalvo, Y., King, T., Yepiskoposyan, L., Andrews, P. (Eds.), Azokh Cave and the Transcaucasian Corridor, Vertebrate Paleobiology and Paleoanthropology. Springer Science + Business Media, Dordrecht, pp. 103–106.
von Koenigswald, W., Fejfar, O., Tchernov, E., 1992. Revision einiger alt- und mittelpleistozäner Arvicoliden (Rodentia, Mammalia) aus dem östlichen Mittelmeergebiet ('Ubeidiya, Jerusalem und Kalymnos-Xi). Neues Jahrbuch Geol. Palaontol. Abhand. 184, 1–23.
Kopp, M.L., Shcherba, I.G., 1998. Caucasus Basin in paleogene. Geotectonics 32 (2), 29–50.
Krijgsman, W., Tesakov, A., A., Yanina, T., Lazarev, S., Danukalova, G., Van Baak, C.G.C., Agustí, J., Alçiçek, M.C., Aliyeva, E., Bista, D., Bruch, A., Büyükmeriç, Y., Bukhsianidze, M., Flecker, R., Frolov, P., Hoyle, T.M., Jorissen, E.L., Kirscher, U., Koriche, S.A., Kroonenberg, S.B., Lordkipanidze, D., Oms, O., Rausch, L., Singarayer, J., Stoica, M., van de Velde, S., Titov, V.V., Wesselingh, F.P., 2019. Quaternary time scales for the Pontocaspian domain: Interbasinal connectivity and faunal evolution. Earth Sci. Rev. 188, 1–40.
Kuhn, S.L., 2010. Was Anatolia a bridge or a barrier to early hominin dispersals? Quat. Int. 223–224, 434–435.
Laverov, N.P. (Ed.), 2005. Modern and Holocene Volcanism in Russia. Nauka, Moscow, pp. 604 (in Russian).
Lebatard, A.-E., Bourlès, D.L., Alçiçek, M.C., 2014a. Datation des travertins de Kocabas, par la méthode des nucléides cosmogéniques 26Al/10Be. L'anthropologie 118, 34–43.
Lebatard, A.-E., Alçiçek, M.C., Rochette, P., Khatib, S., Vialet, A., Boulbes, N., Bourlès, D.L., Demory, F., Guipert, G., Mayda, S., Titov, V.V., Vidal, L., de Lumley, H., 2014b. Dating the Homo erectus bearing travertine from Kocabaş (Denizli, Turkey) at at least 1.1 Ma. Earth Planet. Sci. Lett. 390, 8–18.
Lebedev, V.A., Bubnov, S.N., Dudauri, O.Z., Vashakidze, G.T., 2008. Geochronology of Pliocene volcanism in the dzhavakheti highland (the lesser Caucasus). Part 2. Eastern part of the dzhavakheti highland. Reg. Geol. Correl. Stratigr. Geol. Correl. 16 (5), 553–574.
Lordkipanidze, D., Jashashvili, T., Vekua, A., Ponce de Lion, M.S., Zollikofer, Ch.P.E., Rightmire, G.Ph, Pontzer, H., Ferring, R., Oms, O., Tappen, M., Bukhsianidze, M., Agusti, J., Kahlke, R., Kiladze, G., Martinez-Navarro, B., Mouskhelishvili, A., Nioradze, M., Rook, L., 2007. Postcranial evidence from early Homo from Dmanisi, Georgia. Nature 449, 305–310.
de Lumney, H., Lordkipanidze, D., Feraud, G., Garcia, T., Perrenoud, Ch, Falqueres, Ch, Gagnepain, J., Saos, T., Voinchet, P., 2002. Datation par la methode Ar/Ar de la couche de cendres volcaniques (couche VI) de Dmanissi (Georgie) qui a livre des restes d'hominides fossiles de 1, 81 Ma. Comptes Rendus Palevol 1, 181–189.
de Lumney, M.-A., Bardintzeff, J.-M., Bienvenu, Ph, Bilcon, J.-B., Flamenbaum, G., Guy, C., Jullien, M., de Lumney, H., Nabot, J-Ph., Perrenoud, Ch., Provitina, O., Tourasse, M., 2008. Impact probable du volcanisme sur le décès des Hominidés de Dmanisi. Comptes Rendus Palevol 7, 61–79.
Lyubin, V.P., Belyaeva, E.V., 2011. Early Acheulian Locality of Karakhach in Northern Armenia. Archaeological News, Saint-Petersburg, No. 17 (2010–2011), pp. 13–19 (in Russian).
van der Made, J., Torres, T., Ortiz, J.E., Moreno-Pérez, L., Fernández-Jalvo, Y., 2016. The new material of large mammals from Azokh and comments on the older collections. In: Fernández-Jalvo, Y., King, T., Yepiskoposyan, L., Andrews, P. (Eds.), Azokh Cave and the Transcaucasian Corridor, Vertebrate Paleobiology and Paleoanthropology. Springer Science + Business Media, Dordrecht, pp. 117–162.
Markova, A.K., 1982. Small mammal fauna from Paleolithic cave site Azykh. Paleontologicheskii sbornik (Lvov) 19, 14–28 (in Russian).
Martin, R.A., Peláez-Campomanes, P., Honey, J.G., Fox, D.L., Zakrzewski, R.J., Albright, L.B., Lindsay, E.H., Opdyke, N.D., Goodwin, H.T., 2008. Rodent community change at the Pliocene–Pleistocene transition in southwestern Kansas and identification of the Microtus immigration event on the Central Great Plains. Palaeogeogr. Palaeoclimatol. Palaeoecol. 267, 196–207.
Messager, E., Lordkipanidze, D., Kvavadze, E., Ferring, C.R., Voinchet, P., 2010. Palaeoenvironmental reconstruction of Dmanisi site (Georgia) based on palaeobotanical data. Quat. Int. 223–224, 20–27.
Milanovsky, E.E., 1962. Pambak valley. In: Geology of the Armenian SSR. Geomorphology, vol. 1. Print. office of the Academy of Sciences of the Armenian SSR, Yerevan, pp. 104–115 (in Russian).
Milanovsky, E.E., 1968. Neotectonics of Caucasus. Nedra, Moscow, pp. 483 (in Russian).
Milanovsky, E.E., Koronovsky, N.V., 1973. Orogenic Volcanism and Tectonics of Alpine Belt of Eurasia. Nedra, Moscow, pp. 280 (in Russian).
Naidina, O.D., Richards, K., 2016. Pollen evidence for plio-pleistocene vegetation and climate change in the north Caucasus, north-western Caspian region. Quat. Int. 409, 50–60.
Ozherelyev, D.V., Trifonov, V.G., Çelik, H., Trikhunkov, Ya.I., Frolov, P.D., Simakova, A.N., 2018. Early palaeolithic evidence from the Euphrates river basin, eastern Turkey. Quat. Int (in press). https://doi.org/10.1016/j.quaint.2018.02.035.
Parfitt, S., 2016. Rodents, lagomorphs and Insectivores from Azokh cave. In: Fernández-Jalvo, Y., King, T., Yepiskoposyan, L., Andrews, P. (Eds.), Azokh Cave and the Transcaucasian Corridor, Vertebrate Paleobiology and Paleoanthropology. Springer Science + Business Media, Dordrecht, pp. 163–176.
Pevzner, M.A., Tesakov, A.S., Vangengeim, E.A., 1998. The position of the tizdar locality (Taman Peninsula, Russia) in the magnetochronological scale. PALUDICOLA 2 (1), 95–97.
Presnyakov, S.L., Belyaeva, E.V., Lyubin, V.P., Radionov, N.V., Antonov, A.V., Saltykova, A.K., Berezhnaya, N.G., Sergeev, S.A., 2012. Age of the earliest Paleolithic sites in the northern part of the Armenian Highland by SHRIMP-II U-Pb geochronology of zircons from volcanic ashes. Gondwana Res. 21, 929–938.
Rightmire, G.Ph, Lordkipanidze, D., Vekua, A., 2006. Anatomical descriptions, comparative studies and evolutionary significance of the hominin skulls from Dmanisi, Republic of Georgia. J. Hum. Evol. 50, 115–141.
Ritz, J.-F., Avagyan, A., Mkrtchyan, M., Nazari, H., Blard, P.-H., Karakhanian, A., Philip, H., Balescu, S., Mahan, S., Huot, S., Munch, P., Lamothe, M., 2016. Active tectonics within the NW and SE extensions of the Pambak-Sevan-Syunik fault: implications for the present geodynamics of Armenia. Quat. Int. 395, 61–78.
Ron, H., Levi, S., 2001. When did hominids first leave Africa? New high-resolution magnetostratigraphy from Erk-el-Ahmar Formation. Israel. Geology 29, 887–890.
Sablin, M.V., 2015. Faunal remains of large mammals from layer 80 of the Muhkai II locality. In: Amirkhanov, H.A. (Ed.), Northern Caucasus: Beginning of the Pre-history. Appendix 5. Mavraev printing house, Mahachkala, pp. 221–256 (in Russian).
Sagi, A., Belmaker, M., Ron, H., 2005. Paleomagnetic dating of 'Ubeidiya Formation. In: Abramovich, S. (Ed.), Abstracts of the Israel Geological Society Annual Meeting 2005. Israel Geological Society, Jerusalem, pp. 101.
Şaroglu, F., 1988. Age and offset of the north Anatolian Fault. METU Journ. of pure and applied sci. 21 (1/3), 65–79.
Sayadyan, Yu.V., 1972. Significance of the Shirak type section for stratigraphy and paleogeography of Trans-Caucasus. Bulletin of Commission for study of the Quaternary 39, 58–66 (in Russian).
Sayadyan, Yu.V., 2009. The Newest Geological History of Armenia. Ghitutyun, Yerevan, pp. 357 (in Russian).
Scharrer, S., 2013. Frühpleistozäne Vegetationsentwicklung im Südlichen Kaukasus. Pollenanalytische Untersuchungen an Seesedimenten im Vorotan-Becken (Armenien). Dissertation zur Erlangungdes Doktorgrades der Naturwissenschaften, Frankfurt, pp. 254.
Segev, A., 2005. Magmatic rocks. In: In: Krasheninnikov, V.A., Hall, J.K., Hirsch, F., Benjamini, Ch., Flexer, A. (Eds.), Geological Framework of the Levant, vol. II, part 4. Historical Production-Hall, Jerusalem, pp. 553–576.
Shalaeva, E.A., Trifonov, V.G., Lebedev, V.A., Simakova, A.N., Avagyan, A.V., Sahakyan, L.H., Arakelyan, D.G., Sokolov, S.A., Bachmanov, D.M., Kolesnichenko, A.A., Latyshev, A.V., Belyaeva, E.V., Lyubin, V.P., Frolov, P.D., Tesakov, A.S., Sychevskaya, E.K., Kovalyova, G.V., Martirosyan, M., Khisamutdinova, A.I., 2018. Quaternary geology and origin of the Shirak Basin, NW Armenia. Quat. Int (in press). https://doi.org/10.1016/j.quaint.2018.09.017.
Sharkov, E.V., Chernyshev, I.V., Devyatkin, E.V., Dodonov, A.E., Ivanenko, V.V., Karpenko, M.I., Leonov, Yu.G., Novikov, V.M., Hanna, S., Khatib, K., 1994. Geochronology of late Cenozoic basalts in western Syria. Petrology 2 (4), 385–394.
Sharkov, E.V., Chernyshev, I.V., Devyatkin, E.V., Dodonov, A.E., Ivanenko, V.V., Karpenko, M.I., Lebedev, V.A., Novikov, V.M., Hanna, S., Khatib, K., 1998. New data on the geochronology of upper Cenozoic plateau basalts from northeastern periphery of the red sea rift area (northern Syria). Doklady (reports) of Russian Academy of Sciences. Earth Sect 358 (1), 19–22.
Shatilova, I.I., 1974. Palinological Evidence of Upper Pliocene and Pleistocene Geochronology in Western Georgia. Metsniereba, Tbilisi, pp. 194 (in Russian).
Shatilova, I., Mchedlishvili, N., Rukhadze, L., Kvavadze, E., 2011. The History of the Flora and Vegetation of Georgia (South Caucasus). Georgian National Museum, Institute of Paleobiology, Tbilisi, pp. 200.
Shchelinsky, V.E., Dodonov, A.E., Baigusheva, V.S., Kulakov, S.A., Simakova, A.N., Tesakov, A.S., Titov, V.V., 2010. Early Palaeolithic Sites on the Taman Peninsula (Southern Azov Sea Region, Russia). Bogatyri/Sinyaya Balka and Rodniki. Quaternary International 223-224, 28–35.
Shchelinsky, V.E., Gurova, M., Tesakov, A.S., Titov, V.V., Frolov, P.D., Simakova, A.N., 2016. The Early Pleistocene site of Kermek in western Ciscaucasia (southern Russia): stratigraphy, biotic record and lithic industry (preliminary results). Quat. Int. 393, 51–69.
Simakova, A.N., 1993. Palynology and Pliocene - Quaternary climate history of the northwestern Syria. Stratigr. Geol. Correl. 1 (3), 125–131.
Simakova, A.N., 1994. Palynology of the marine Upper Pliocene in Syria and a paleogeographical analysis. Stratigr. Geol. Correl. 2 (2), 188–194.
Simakova, A., 2009. Palynology study of the early Pleistocene Bogatyry/Sinyaya Balka and Rodniki sites (Taman Peninsula, Russia). In: Martines-Navarro, B., Toro Moyano, I., Palmqvist, P., Agusti, J. (Eds.), The Quaternary of Southern Spain: a Bridge between Africa and the Alpine Domain. Universitat Rovira i Virgili, Tarragona, pp. 36–37.
Simakova, A.N., 2016. Palynological characteristic of the Ani formation in the Shirak

Basin, NW Armenia. Bridging Europe and Asia: Quaternary Stratigraphy and Paleolithic Human Occupation in Armenia and Southern Georgia. INQUA-SEQS meeting, Program and Abstracts, Yerevan, pp. 28.
Simakova, A.N., Aleksandrova, G.N., Golovina, L.A., 2012. New paleofloristic data from marine Late Pliocene-Pleistocene deposits of Western Syria. INQUA SEQS Meeting "At the edge of the sea: Sediments, geomorphology, and stratigraphy in Quaternary studies". Sassari, Sardinia (Italy). pp. 90.
Sokolov, S.A., Gaydalenok, O.V., Tesakov, A.S., Frolov, P.D., Trifonov, V.G., 2019. New data on tectonics and stratigraphy of the lower Pleistocene deposits of the Azov coast of the Taman Peninsula. In: Problems of Tectonics of Continent and Oceans. Proceedings of the 51st Russian Tectonic Conference, vol. 2. GEOS, Moscow, pp. 258–262.
Suleimanov, M.B., 1979. Present status of multi-disciplinary studies in the Paleolithic caves Azykh and Talgar (Azerbaijan S.S.R.), vol. 6. Izvestiya of the Academy of Sciences of the Azerbaijan S.S.R., Series of Geosciences, pp. 43–49 (in Russian).
Tagieva, E.N., 2011. Evolution of Vegetation and Climate of Azerbaijan in Cenozoic. Abstract of Doctor of Geography Thesis, Baku, pp. 53 (in Russian).
Tagieva, E.N., Muradly, E.V., 2014. Paleoclimatic change in Azerbaijan in Eopleistocene. Geogr. Gerald. Meteorol. 3 (30), 72–78 (in Russian).
Tchernov, E. (Ed.), 1986. Les Mammiféres du Pléistocène Inférieur de la Vallée du Jourdain a Oubéidiyéh. Association Paléorient, Paris.
Tchernov, E., 1986b. The rodents and lagomorphs from 'Ubeidiya Formation: systematics, paleoecology and biogeography. In: Tchernov, E. (Ed.), Les Mammifères du Pléistocène inférieur de la Vallee du Jourdain a Oubeidiyeh. vol. 5. Mémoires et travaux du Centre de recherche français de Jérusalem, pp. 235–345.
Tchernov, E., 1987. The age of the 'Ubeidiya Formation, an early hominid site in the Jordan Valley. Isr. J. Earth Sci. 36, 3–36.
Tchernov, E., Volokita, M., 1986. Insectivores and primates from the early Pleistocene of 'Ubeidiya Formation. In: Tchernov, E. (Ed.), Les Mammiféres du Pléistocène Inférieur de la Vallée du Jourdain a Oubéidiyéh. Association Paléorient, Paris, pp. 54–62.
Le Tensorer, J.-M., Le Tensorer, H., Martini, P., von Falkenstein, V., Schmid, P., Villalain, J.J., 2015. The Oldowan site Aïn al Fil (el Kowm, Syria) and the first humans of the Syrian desert. L'anthropologie 119, 581–594.
Tesakov, A.S., 1998. Early stage of Allophaiomys evolution in eastern Europe. PALUDICOLA 2 (1), 98–105.
Tesakov, A.S., 2004. Biostratigraphy of Middle Pliocene – Eopleistocene of Eastern Europe (Based on Small Mammals). Nauka Press, Moscow, pp. 247 (in Russian).
Tesakov, A.S., Ozherelyev, D.V., 2017. Small mammals of Early Palaeolithic site Muhkai-IIa (Dagestan, Russia) and their stratigraphic significance. In: Fundamental Problems of the Quaternary: Results of Studies and Main Directions of Further Researches. Proceedings of X Russian Conference on Study of the Quaternary. GEOS, Moscow, pp. 420–422 (in Russian).
Trifonov, V.G., Dodonov, A.E., Sharkov, E.V., Golovin, D.I., Chernyshev, I.V., Lebedev, V.A., Ivanova, T.P., Bachmanov, D.M., Rukieh, M., Ammar, O., Minini, H., Al Kafri, A.-M., Ali, O., 2011. New data on the Late Cenozoic basaltic volcanism in Syria, applied to its origin. J. Volcanol. Geotherm. Res. 199, 177–192.
Trifonov, V.G., Bachmanov, D.M., Ali, O., Dodonov, A.E., Ivanova, T.P., Syas'ko, A.A., Kachaev, A.V., Grib, N.N., Imaev, V.S., Ali, M., Al-Kafri, A.M., 2012. Cenozoic tectonics and evolution of the Euphrates valley in Syria. In: Robertson, A.H.F., Parlak, O., Ünlügeng, U.C. (Eds.), Geological Development of Anatolia and the Eastmost Mediterranean Region. Geological Society, London, Special Publications 372, pp. 615–635.
Trifonov, V.G., Bachmanov, D.M., Simakova, A.N., Trikhunkov, Ya.I., Ali, O., Tesakov, A.S., Belyaeva, E.V., Lyubin, V.P., Veselovsky, R.V., Al-Kafri, A.-M., 2014. Dating and correlation of the Quaternary fluvial terraces in Syria, applied to tectonic deformation in the region. Quat. Int. 328–329, 74–93.
Trifonov, V.G., Lyubin, V.P., Belyaeva, E.N., Lebedev, V.A., Trikhunkov, Ya.I., Tesakov, A.S., Simakova, A.N., Veselovsky, R.V., Latyshev, A.V., Presnyakov, S.L., Ivanova, T.P., Ozhereliev, D.V., Bachmanov, D.M., Lyapunov, S.M., 2016. Stratigraphic and tectonic settings of early paleolithic of north-west Armenia. Quat. Int. 420, 178–198.
Trifonov, V.G., Shalaeva, E.A., Saakyan, L.Kh, Bachmanov, D.M., Lebedev, V.A., Trikhunkov, Ya.I., Simakova, A.N., Avagyan, A.V., Tesakov, A.S., Frolov, P.D., Lyubin, V.P., Belyaeva, E.V., Latyshev, A.V., Ozherelyev, D.V., Kolesnichenko, A.A., 2017. Quaternary tectonics of recent basins in northwestern Armenia. Geotectonics 51 (5), 499–519.
Trifonov, V.G., Çelik, H., Simakova, A.N., Bachmanov, D.M., Frolov, P.D., Trikhunkov, Ya.I., Tesakov, A.S., Titov, V.V., Lebedev, V.A., Ozherelyev, D.V., Latyshev, A.V., Sychevskaya, E.K., 2018. Pliocene – early Pleistocene history of the Euphrates valley applied to late Cenozoic environment of the northern Arabian Plate and its surrounding, eastern Turkey. Quat. Int. 493, 137–165. https://doi.org/10.1016/j.quaint.2018.06.009.
Trubikhin, V.M., Chepaluga, A.L., Kulakov, S.A., 2017. Age of Tamanian complex stratotype and Oldowan sites on the Taman Peninsula (paleomagnetic data). Fundamental Problems of the Quaternary: Results of Studies and Main Directions of Further Researches. Proceedings of X Russian Conference on Study of the Quaternary. GEOS, Moscow, pp. 434–436 (in Russian).
Ünay, E., 1998. Allophaiomys from Turkey. PALUDICOLA 2, 106–109.
Uznadze, M.D., 1965. Neogene Flora of Georgia. Academy of Sciences of the Georgian S.S.R., Tbilisi, pp. 193 (in Russian).
Vangengeim, E.A., Vekua, M.L., Zhegallo, V.I., Pevzner, N.A., Taktakishvili, I.G., Tesakov, A.S., 1991. Position of the Taman faunal complex within stratigraphic and magnetochronological scales. Bull. Comm. Stud. Quat. 60, 41–52 (in Russion).
Velichko, A.A., Antonova, G.V., Zelikson, E.M., Markova, A.K., Monoszon, M.Kh, Morozova, T.D., Pevzner, M.A., Suleymanov, M.B., Khalcheva, T.A., 1980. Paleogeography of Azykh camp: the earliest settlement of primitive man in the USSR territory. Izvestiya of the Academy of Sciences of the USSR, Geographic series, No. 3 (in Russian).
Vereshchagin, N.K., 1957. Mammal Remains of the Lower Quaternary Deposits of the Taman Peninsula. Proceedings of Zoological Institute 22. pp. 9–49 (in Russian).
Vialet, A., Guipert, G., Alçiçek, M.C., 2012. Homo erectus found still further west: reconstruction of the Kocabaş cranium (Denizli, Turkey). Comptes Rendus Palevol 11, 89–95.
Vialet, A., Guipert, G., Alçiçek, M.C., de Lumley, M.-A., 2014. La calotte cr'nienne de l'Homo erectus de Kocabaş, (Bassin de Denizli, Turquie). L'anthropologie 118, 74–107.
Vialet, A., Prat, S., Wils, P., Alçiçek, M.C., 2018. The Kocabaş hominin (Denizli Basin, Turkey) at the crossroads of Eurasia: new insights from morphometric and cladistic analyses. Comptes Rendus Palevol 17, 17–32.
Yürür, M.T., Chorowicz, J., 1998. Recent volcanism, tectonics and plate kinematics near the junction of the African, Arabian and Anatolian plates in the eastern Mediterranean. J. Volcanol. Geotherm. Res. 85, 1–15.
Zaikina, N.G., Sayadyan, Yu.V., Sokolova, N.S., 1969a. On history of vegetation in the Shirak plain. Biol. J. Acad. Sci. Armen. SSR 22 (4), 67–74 (in Russian).
Zaikina, N.G., Sayadyan, Yu.V., Sokolova, N.S., 1969b. Data of the spore-pollen and diatom analysis of the paleo-lacustrine deposits of the Leninakan Lake. Neotectonics, Young Deposits and Human Being, vol. 1. Print. office of the Moscow Univ., Moscow, pp. 105–113 (in Russian).
Zykin, V.S., Zykina, V.S., Zazhigin, V.S., 2007. Issues in separating and correlating Pliocene and Quaternary sediments of southwestern Siberia. Archaeol. Ethnol. Anthropol. Eurasia 30 (1), 24–40.



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