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*'... whenever men can form no idea of distant and unknown things, they judge them by what is familiar and at hand'.*

*– Giambattista Vico*

## REVISITING THE “ASIATIC MEDITERRANEAN”: EARLY HOLOCENE HIGHSTANDS AND HYDROLOGICAL CONNECTIVITY ACROSS THE PONTO-CASPIAN BASIN

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**Summary.** Understanding hydrological change across the Ponto-Caspian region during the Late Pleistocene–Early Holocene transition remains a key challenge in Quaternary science. While existing models emphasise climate forcing and glacio-isostatic adjustment, a number of geomorphological, sedimentary, and biological observations are not easily reconciled within current frameworks.

This study synthesises evidence from the Caspian, Black Sea, Mediterranean, and adjacent regions, with particular focus on the geomorphology of Azerbaijan. Raised terraces, high-elevation strandlines, and apparent wave-modified mud-volcano surfaces occur at levels significantly above the widely accepted Khvalynian highstand (~+50 m a.s.l.), suggesting the possibility of previously unrecognised hydrological conditions. Additional lines of evidence include ostracod faunal turnovers, shifts in salinity-sensitive taxa, anomalous sedimentary records, and indications of changing basin connectivity across Eurasia during the Early Holocene.

Taken together, these observations support the interpretation that regional hydrology was more dynamic and complex than commonly assumed. Rather than a single-event framework, the data are more consistent with a multi-phase system involving fluctuating water levels, episodic basin overflow, stratified flow regimes, and variable connectivity between the Black Sea, Caspian Sea, and neighbouring basins. In this context, earlier concepts of an enlarged Pleistocene “Asiatic Mediterranean” are reconsidered as a working hypothesis.

The study also re-examines the Black Sea reconnection debate, suggesting that alternating phases of outflow and inflow through the Bosphorus may better explain available evidence than either strictly catastrophic or purely gradual models. Broader regional comparisons, including North Africa and the Arctic margin, indicate that hydrological and environmental changes during this interval may have been temporally clustered.

While the interpretations advanced here remain provisional, they highlight the need for integrated, multidisciplinary investigation. Future work should prioritise geochronological dating of strandlines and terraces, sediment coring, hydrodynamic modelling, and DEM-based palaeoshoreline reconstruction. The distinctive geomorphology of Azerbaijan may prove central to resolving outstanding questions concerning Eurasian Quaternary hydrology.

**Keywords:** *Ponto-Caspian region, Early Holocene, Caspian Sea level, Black Sea hydrology, Quaternary palaeohydrology, basin connectivity, marine transgression, glacio-isostatic adjustment, palaeoshorelines, “Asiatic Mediterranean”*

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### Introduction

Following a presentation in 2011 at the Institute of Geology and Geophysics in Azerbaijan (GIA), evidence was presented for extreme former flood levels in the Caspian Sea, inferred from raised terraces, strandlines, and erosion features on mud volcanoes. This work led to the paper “The Ice Age Rise and Fall of the Ponto-Caspian: Ancient Mariners and the Asiatic Mediterranean” (Gallagher, 2011), in which a major

phase of Ice Age freshwater flooding was proposed. This event was interpreted as forming a vast inland water body – the “Asiatic Mediterranean” (AM) – representing a greatly expanded Ponto-Caspian basin. A subsequent Early Holocene marine inundation was also suggested, initially associated with strandlines at ~222 m above sea level (a.s.l.), now revised to ~312 m a.s.l. These elevated strandlines and associated erosional features indicate flooding on a scale

that is difficult to reconcile with conventional models of Caspian Sea-level change, particularly the widely cited Khvalynian highstand of approximately +50 m a.s.l. (Arslanov et al., 2016). It is therefore possible that geomorphological evidence for higher flood stages has been overlooked or treated as anomalous, along with its broader implications for regional hydrology.

The present study builds on this earlier work and addresses three principal observations: a prominent raised terrace, high-level strandlines, and wave-erosion features on mud volcanoes. These features have prompted a wider investigation into the possibility of large-scale flooding across Ice Age Eurasia, followed by a significant marine incursion during the Early Holocene. To avoid repetition, this paper should be read in conjunction with Gallagher (2011).

If flood levels approached ~312 m a.s.l., much of the Ponto-Caspian basin would have been inundated, with potential overflow through the lowest available outlet toward the Sea of Marmara, raising the possibility that such discharge contributed to erosion of the Bosphorus. Additional lines of inquiry include possible faunal incursions from the Arctic, supported by interpretations of petroglyph imagery that may depict marine species such as whales and northern seabirds within the Caspian region. While speculative, such evidence warrants consideration where it aligns with environmental and archaeological data.

## 1. Aim and Objectives

This paper summarises a range of unresolved observations and paradoxes relating to flood events in the Ponto-Caspian region during the Late Quaternary and Early Holocene. The review

draws on field observations, radiocarbon data, published literature, and evidence for the physical, chemical, and biological impacts of extreme transgressions. Broadly, the evidence points to two contrasting flood regimes: an Ice Age freshwater phase and a major Early Holocene marine inundation. The scale of the latter suggests it may have substantially modified or obscured earlier geomorphological evidence, contributing to the complexity and uncertainty of regional interpretations. Accordingly, the paper begins by examining a series of key anomalies from which further deductions may be drawn.

### 1.1. Geomorphology of a 50 km long raised terrace north of Sumgayit

A representative section of the terrace near Gilazi (Fig. 1) has been described as a Khvalynian alluvial plain (Arslanov et al., 2016). It comprises a gently sloping aggradational surface extending from ~126 m a.s.l. to a pronounced escarpment at ~100 m a.s.l., followed by a steep descent to ~26 m a.s.l. From this level, the surface continues to slope gradually toward the Caspian Sea, with smaller scarps indicating episodes of both abrupt and progressive water-level change.

The principal concerns relating to this terrace are as follows:

**1.1.1 First:** The terrace sediments are generally interpreted as alluvial, yet no major river occurs along the level terrace between Sumqayit and Gilazi. The Samur River source hypothesis remains problematic because the terrace reaches ~126 m a.s.l., well above the accepted Khvalynian highstand.



**Fig. 1.** Section of a 50 km long raised terrace near Gilazi. The foot of the terrace corresponds to the spillover at the Manych spillway, while the terrace top at ca 126 m a.s.l. may represent the spillover elevation from the Asiatic Mediterranean. (R. Gallagher)

**1.1.2 Second:** An abrupt break between ~100 m and 26 m a.s.l. suggests rapid Caspian water-level fall, implying reduced inflow or rapid basin drainage.

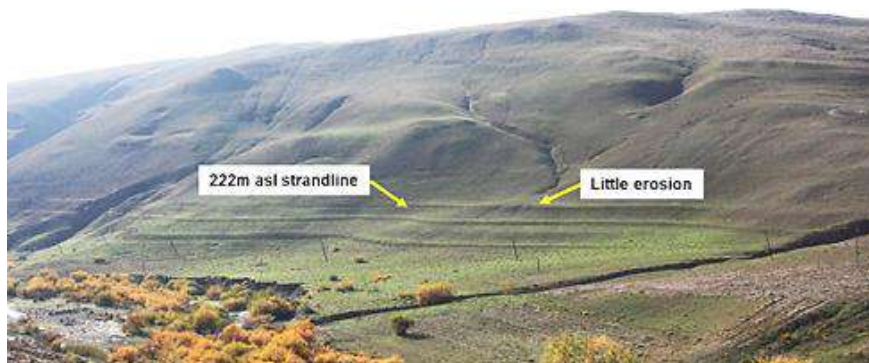
**1.1.3 Third:** The Khvalynian transgression is typically divided into Early and Late phases, associated with terrace levels at ~50 m and 0 m a.s.l. (Dolukhanov et al., 2009). However, no clear erosional surface corresponding to the ~50 m level is evident in Fig. 1, despite the susceptibility of alluvial sediments to water erosion. This presents a dilemma: either the established Khvalynian chronology is incomplete, or the ~50 km terrace represents a later, larger depositional event superimposed on earlier surfaces – potentially linked to a younger marine inundation (see Section 3.1.1).

The base of the escarpment at ~26 m a.s.l. may correspond to the spillover threshold into

the Manych Corridor via the Zunda Tolga sill (Semikolennykh, Panin, Zazovskaya, 2025), suggesting geomorphological significance. By extension, the upper level at ~126 m a.s.l. may represent a former overflow threshold from the proposed Asiatic Mediterranean. Similarly, higher terraces (e.g. ~167 m a.s.l.; Gallagher, 2011) may reflect marine inundation rather than stable palaeoshorelines (Leontyev, 1963), a point supported by evidence from mud volcano erosion discussed below.

## 1.2. Strandline Geomorphology

No accepted explanation exists for the triple strandlines at ~222 m a.s.l. in the Gilazi Valley (Gallagher, 2011, Fig. 2). A comparable set identified in the Tartar River Valley (Figs. 3-4) reaches ~312 m a.s.l., suggesting a potentially related flood event.



**Fig. 2.** Gilazi Valley triple strandlines. (GPS – 40°52'35.46"N, 49°11'22.48"E). With little stream erosion these are considered to be relatively recent. (Pers comm) (R. Gallagher)



**Fig. 3.** Tartar River Valley strandlines at 312 m a.s.l. (GPS – 40°21'6.58"N, 46°52'21.67"E), (Google Earth)



**Fig. 4.** Triple strandline locations, Tartar River and Gilazi Valley. Note that the Tartar site is exposed to the Caspian Sea while the Gilazi site is sheltered. (Maphill)

A key issue is the ~90 m elevation difference between the two sites. If broadly contemporaneous, this may reflect local geomorphological controls: the confined Gilazi Valley could have restricted inflow, whereas the more open Tartar Valley, connected to the Kura system, may have experienced fuller inundation. This implies a complex, possibly oscillating water-level response during an extreme event.

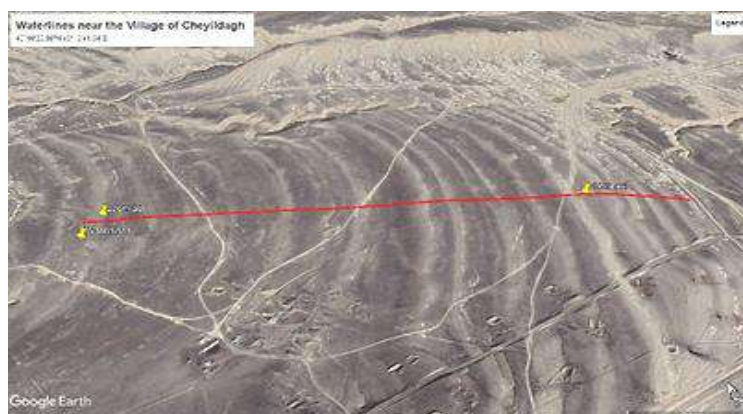
Although water may have reached ~312 m a.s.l. long enough to form distinct strandlines, it was likely short-lived, with evidence near Cheyildagh indicating a subsequent fall in level (Fig. 5).

### 1.3. Mud Volcano Wave Action Erosion

Mud volcanoes are short-lived, highly erodible landforms, making them sensitive indicators

of wave action. At Boyuk Kanizadagh (Figs. 6-7), a ~2 km section of the seaward flank appears missing, suggesting marine erosion and implying that floodwaters persisted long enough to reshape exposed slopes. Further evidence may come from the Two Brothers (İki Qardaş) mud volcanoes, once mapped but now reduced to submerged shoals, possibly indicating prolonged erosion over decades to centuries. Techniques such as OSL dating could help constrain the timing and duration of such flooding.

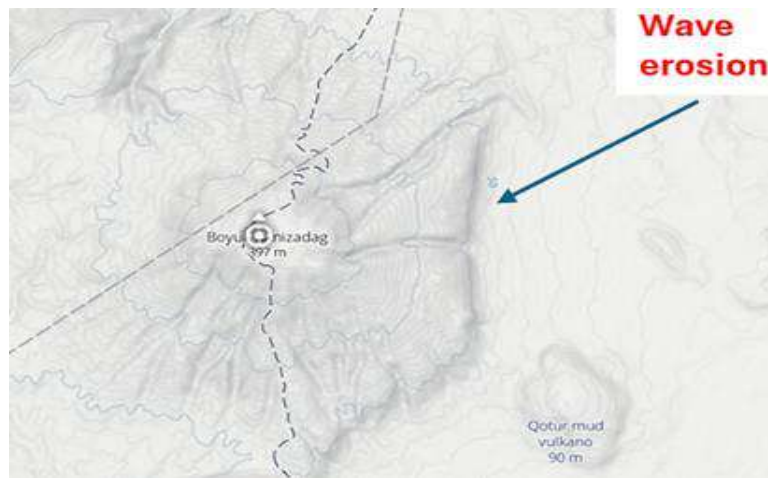
The pale coloration on the lower slopes of Boyuk Kanizadagh is unlikely to represent a simple stratigraphic horizon given the overlapping nature of mud flows and may instead reflect erosional or environmental processes (see 3.2.2.2).



**Fig. 5.** Satellite view of watermarks/strandlines near the village of Cheyildagh in the vicinity of the Daviladagh mud volcano. (GPS – 40°16'20.38"N, 49°12'41.34"E. This may represent a falling water level. (Google Earth)



**Fig. 6.** Boyuk Kanizadagh flank facing the Caspian Sea. (GPS – 40°8'29.15"N, 49°22'54.86"E). Key features are the angle of erosion, erosion gullies, foot extension and a distinct white colouration. (R. Gallagher)



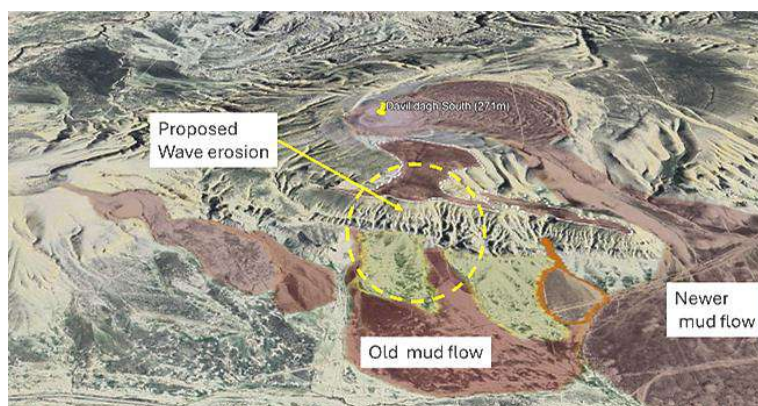
**Fig. 7.** Image of Boyuk Kanizadagh showing an anomalous 2 km long seaward face of the mud volcano, caused by wave action attack. (PeakVisor.com)

Strong evidence of wave erosion is also observed at the Daviladagh South Mud Volcano (Figs. 8-9), where terrace-like benches and smoothed slope breaks occur on the southern flank. Here, softer mud deposits appear to have been preferentially eroded, exposing underlying limestone and producing rounded, laterally con-

tinuous features. Satellite imagery shows contrasting preservation between younger, intact mud flows and older, more eroded surfaces, suggesting differential exposure to marine conditions. This may indicate a relatively recent inundation event, consistent with strandline evidence from the Gilazi Valley.



**Fig. 8** An oblique view of Daviladagh South mud volcano showing eroded mud drape overlying tilted limestone stratigraphy. (GPS – 40°15'45.27"N, 49°18'49.17"E). (R. Gallagher)



**Fig. 9.** Satellite image of Daviladagh mud volcano with highlighted mud flow and eroded flank. (Google Earth)

If correct, these observations point to a large-scale marine transgression across the Ponto-Caspian basin, potentially reaching elevations exceeding 260 m a.s.l. While difficult to reconcile with conventional models, this interpretation arises directly from the geomorphological evidence and warrants further investigation.

## 2. Factors concerning the Asiatic Mediterranean

The term “Asiatic Mediterranean” (AM) was introduced by Eduard Suess to describe a vast inland water body that, at times during the late Tertiary and Quaternary, may have linked the Black, Caspian, and Aral seas, and possibly extended into western Siberia. Earlier geologists, including Humboldt, Marny, Chikhachev, and Murchison, had similarly proposed the existence of an extensive interconnected system of continental waters.

Within this framework, Eurasian water balance during the Ice Ages becomes critical. It is possible that onshore ice sheets periodically blocked northward drainage of major Siberian Rivers, diverting flow toward the Caspian basin. Combined with meltwater input and climatic variability, such conditions could have sustained repeated expansions of a large intracontinental water body – the proposed Asiatic Mediterranean (Gallagher, 2011).

This raises several key questions: What evidence supports the existence and extent of such a water body, including palaeoshorelines? What barriers constrained it, and what volumes of discharge were involved? Where and how might it have drained – possibly toward the Aegean – and is there sedimentary evidence of such out-

flows? Could seasonal melt cycles have produced widespread flooding and layered deposits? What were the geomorphological, climatic, and ecological consequences, and how might such a system have influenced early human populations?

These issues are explored in the sections that follow.

### 2.1. Evidence for the Asiatic Mediterranean

Both direct and indirect evidence for a large lake can be inferred from the following:

#### 2.1.1. Radiocarbon Dating

To constrain the age and former elevation of the Ponto-Caspian basin, bulk mollusc samples were collected from coastal benches in Azerbaijan and Bulgaria. As indicators of past water levels, such deposits provide evidence for palaeodrainage patterns and Quaternary Lake or sea-level fluctuations, particularly during the last Ice Age. The radiocarbon results are as follows in Table 1.

Bulk shell sampling is subject to uncertainties, including age mixing, reservoir effects, and contamination, and results depend in part on preparation methods such as bleaching or acid etching. Despite these limitations, the aim was to establish relative ages across elevations within the proposed Asiatic Mediterranean. Several results (Table 1) approach the radiocarbon detection limit (~40,000 BP), suggesting a Late Quaternary transgression reaching elevations of up to ~126 m a.s.l. Further sampling, ideally from securely stratified *in situ* material, is recommended.

Table 1

Radiocarbon dating results of Bulk Mollusc samples from the Caspian and Black Seas

COUNTRY	General Location(GPS coordinates available)	Elevation above global sea level (m)	MEASURED AGE	13C/12C	CONVENTIONAL AGE
AZERBAIJAN	Gobustan at 8m	8 m	26110 +/- 180 BP	+2.5 o/oo	26560 +/- 190 BP
	Gobustan 18 to 30m	18 – 30 m	28520 +/- 210 BP	+1.1 o/oo	28950 +/- 220 BP
	Gobustan 80 to 85m	80 – 85 m	14310 +/- 70 BP	+1.6 o/oo	14750 +/- 80 BP
	Terrace top near Gobustan.	100 m	32460 +/- 480 BP	+2 o/oo	32910 +/- 510 BP
	Gobustan 125m	125 m	16770 +/- 100 BP	+1.6 o/oo	17210 +/- 100 BP
	Gobustan shell midden, ca 40°6'43.26"N 49°22'46.65"E	113 m	4190 +/- 30 BP	+1.9 o/oo	4630 +/- 30 BP
	Qobu terrace near rock shelter	140 m	40730 +/- 530 BP	+1.1 o/oo	41160 +/- 530 BP
	Gobustan shell midden 40°6'43.26"N 49°22'46.65"E	113 m	4190 +/- 30 BP	+1.9 o/oo	4630 +/- 30 BP
BULGARIA	Thracian Cliffs	126 m	29010 +/- 170 BP	+2.8 o/oo	29470 +/- 170 BP
	Thracian Cliffs	77 m	39200 +/- 490 BP	+2.7 o/oo	39650 +/- 490 BP

Source: BetaLab. Note that most dates are well within the C14 half life test limits. Shells prepared by acid etching.

2.2. Floodwater

Flooding may have been driven by discharge from major Eurasian river systems, including the Volga, Lena, Irtysh, Ob, and Yenisei, whose combined flow – based on modern estimates – approaches ~59,000 m<sup>3</sup>/s, far exceeding that of the Volga alone. During glacial periods, however, northward drainage into the Arctic may have been blocked by exten-

sive ice sheets, leading to river diversion and ponding (Mangerud et al., 2004; Baker, 2007).

Under such conditions, water may have accumulated in the West Siberian proglacial basin (Glacial Lake Mansi) before overflowing via the Turgai Spillway into the Ponto-Caspian basin (Fig. 10). This would have fed an enlarged endorheic system – the proposed Asiatic Mediterranean – potentially with intermittent discharge to the world ocean.

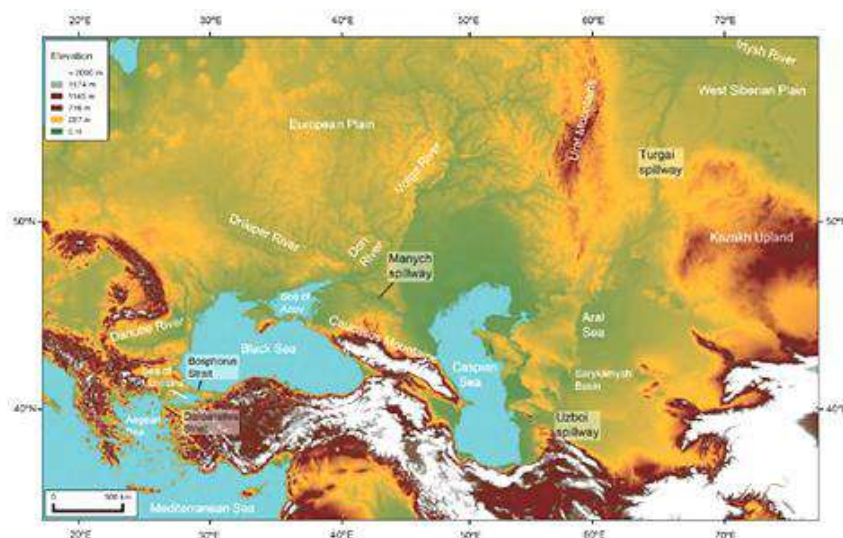


Fig. 10. Topography of large-scale lowland basins and the Manych, Turgai, and Uzboi spillways. The base map is SRTM data. (Komatsu et al., 2015)

### 2.2.1. Caspian Sea Palaeocoastline

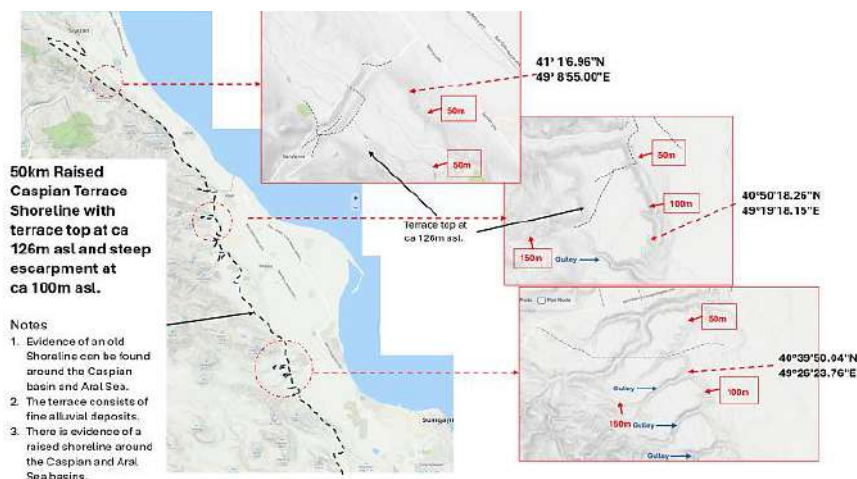
Radiocarbon ages from elevations above ~100 m a.s.l. suggest the presence of an ancient coastline, investigated using the PeakVisor platform (3D Maps and Peaks Identification). For comparison, terraces north of Baku were examined alongside Aral Sea palaeoshorelines, as both basins would have been contiguous above ~100 m a.s.l. (Figs. 11-12). In both cases, terrace surfaces occur near ~126 m a.s.l., with a pronounced escarpment at ~100 m a.s.l.

A schematic profile of the Mansi–Usturt region (Fig. 13) shows a similar pattern, with a palaeocoastline at ~120 m a.s.l. descending to a distinct scarp at ~20+ m a.s.l., possibly marking an overflow threshold toward the Manych Corridor. These step changes may

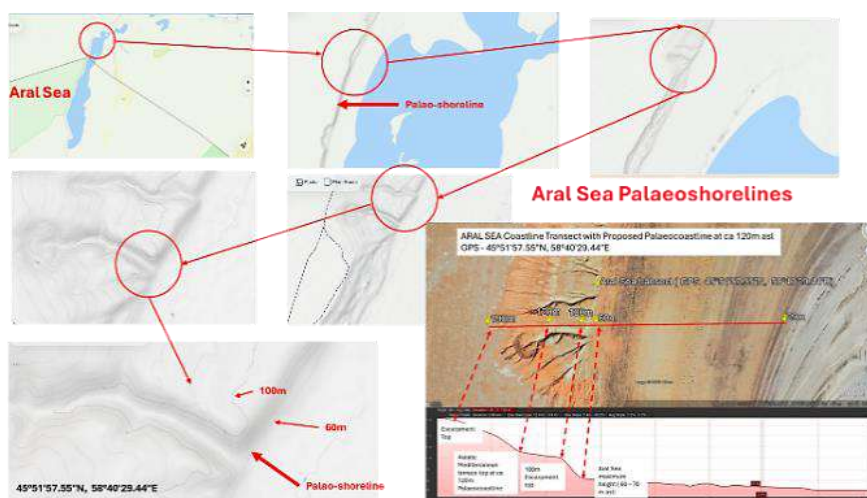
reflect shifts in basin water balance and hydrological connectivity.

### 2.2.1. Turgai Spillway

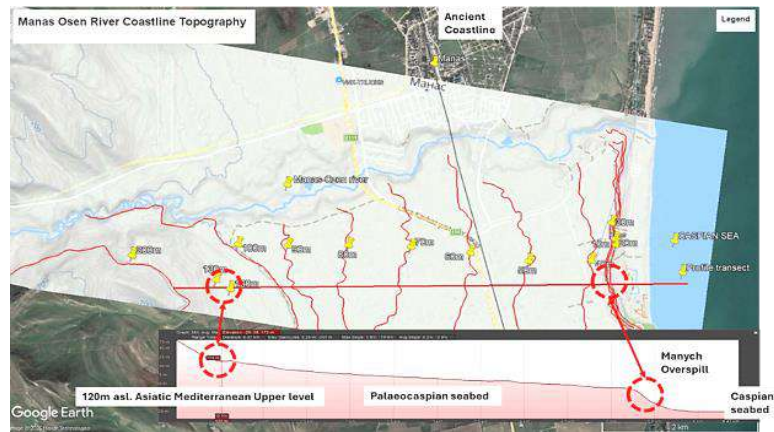
Previously, the Turgai Spillway was noted to lie at ~125 m a.s.l. (Gallagher, 2011), consistent with modern topography. However, this presents a paradox, as deglacial reconstructions suggest a substantially lower active spillway floor. The Turgai Valley – now a low-relief, largely dry corridor – clearly carried significant flow during the Pleistocene (Кесъ, 1939). Borehole data reveal 15-18 m of pebbly alluvial sands overlain by clay, indicating high-energy discharge, while wood and peat from depths of 76 m and 34 m yield radiocarbon ages of ~28.8 ka and ~19.1 ka (Астахов, Гросвальд, 1978; Komatsu et al., 2015).



**Fig. 11.** Palaeo terraced coastline North of Baku. Terrace top is at ca 126 m a.s.l. This may represent the upper limit of the Asiatic Mediterranean prior to its spillover to the world ocean. (Peakvisor/R. Gallagher)



**Fig. 12** Aral Sea shore lines showing a terrace top at ca 126 m a.s.l., a sudden drop in water level at ca 100 m a.s.l. and the recognised upper level of the Aral Sea at ca 60-70 m a.s.l. (45°51'57.55"N, 58°40'29.44"E). (Peakvisor/R. Gallagher)



**Fig. 13.** Topographical schematic of the Manse Osen Coastline in north Caspian/Russia, showing the proposed palaeocoastline at ca 120 m a.s.l., with a steep scarp above 20 m a.s.l. The former latter may represent overspill to the Manych corridor. (Google Earth/Gallagher)

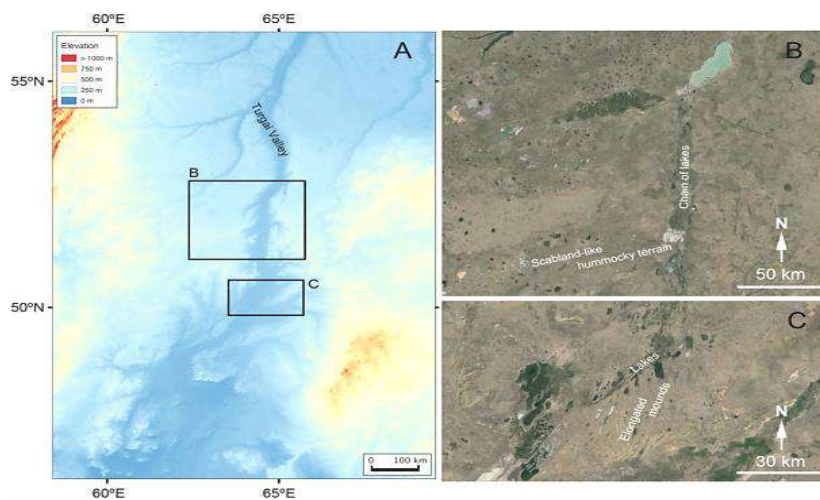
These data imply that the spillway floor during deglaciation may have been far below its present ~125 m elevation. Indeed, Glacial Lake Mansi has been reconstructed at ~60 m a.s.l. (Mangerud et al., 2004), leaving a discrepancy of over 60 m that requires explanation.

One possibility is substantial post-19 ka sediment infill, raising the spillway to its current level. Supporting this are scabland-like features and elongated mounds within the Turgai Valley, suggestive of high-energy flooding capable of transporting and depositing large sediment volumes (Komatsu et al., 2015; Fig. 14). Such processes may represent the waning stages of a major flood event.

Seasonal discharge through the spillway would also be expected to deliver fine sediments into the Caspian, potentially forming laminated, varve-like deposits. This may account for the fine stratification observed near Gobu, close to Baku (Fig. 15).

### 2.2.2. Russian River Water Balance

If the prominent terrace at ~126 m a.s.l. marks the upper limit of the proposed Asiatic Mediterranean, the key question becomes how such a water level was achieved. One possible answer lies in the combined discharge of the great Russian river systems, the estimated magnitudes of which are summarised in Table 2.



**Fig. 14.** Some unusual landforms distributed along the valley may indicate catastrophic flow events. Images include: - a chain of lakes; scabland-like hummocky terrain and parallel elongated mounds. (Komatsu et al., 2015)



**Fig. 15.** Laminated sediment layers at the entrance to the Gobu Valley  
Elevation 0 m a.s.l. possible varves. (R. Gallagher)

**Table 2**

Estimated annual discharge of major Russian rivers

<b>Volga</b>	~250 km <sup>3</sup> /yr
<b>Lena</b>	~540 km <sup>3</sup> /yr
<b>Irtys</b>	~95 km <sup>3</sup> /yr
<b>Ob</b>	~395 km <sup>3</sup> /yr
<b>Yenisei</b>	~620 km <sup>3</sup> /yr

The combined discharge of these rivers is ~1,900 km<sup>3</sup> per year – a substantial freshwater flux. For context, the Caspian Sea (~78,000 km<sup>3</sup>) could theoretically be filled in ~41 years at this rate, ignoring losses.

Extending this to the wider Ponto-Caspian system, the present combined volume of the Black Sea (~547,000 km<sup>3</sup>), Caspian (~78,000 km<sup>3</sup>), and Aral (~1,100 km<sup>3</sup>) is ~626,300 km<sup>3</sup>. A preliminary estimate suggests that raising this system to ~126 m a.s.l. would require a total volume of ~0.8 million km<sup>3</sup>, implying an additional ~173,700 km<sup>3</sup> of water.

At an inflow of ~1,900 km<sup>3</sup> per year, this volume could be supplied in roughly 90-92 years. While simplified and subject to losses (e.g. evaporation and seepage), this first-order estimate suggests that a greatly expanded Ponto-Caspian basin could have formed on relatively short timescales.

This rough calculation necessarily relies on several assumptions: that inflow genuinely averaged 1,900 km<sup>3</sup> per year, that evaporation losses were negligible, that the basins already contained approximately their present water volumes, and that all additional inflow contributed directly to raising the combined lake sys-

tem toward 126 m a.s.l. What is significant, however, is that even allowing for substantial uncertainties, a timescale of 90-92 years is very short when compared with the duration of a glacial cycle.

If radiocarbon evidence and palaeocoastlines support the existence of an enlarged Asiatic Mediterranean, its formation is not implausible and may have influenced Ice Age dynamics. While such shoreline evidence is clearer in the Caspian and Aral basins, it is less obvious in the Black Sea. To address this, comparable terrace features were examined in major river systems, particularly the Sakarya in Turkey and the Danube.

### 2.2.3. Sakarya River and Lake Sapanca

Lake Sapanca (40°43'N, 30°15'E) lies at ~31 m a.s.l., just east of the Gulf of İzmit along the North Anatolian Fault and is thought to have formerly drained toward the Marmara basin (Nazik, Meriç, Avsar, 2012). Despite being freshwater, sediment cores contain marine and brackish microfossils, indicating a past connection between the Black Sea and Marmara (Leroy et al., 2009; 2010). Its proximity to the Sakarya River has led to suggestions of a former hydrological link via that corridor (Nazik et al., 2011), with the youngest microfossils indicating a Holocene incursion.

Various mechanisms have been proposed – tectonic uplift, bird transport, tsunami inundation, and seiche effects – but none fully resolve the evidence. In particular, uplift studies argue against a Holocene Black Sea–Marmara connection (Yaltırak et al., 2012), leaving the presence of marine microfossils an unresolved paradox.

This paradox may be resolved if Black Sea levels were significantly elevated during the Pleistocene due to diverted Siberian discharge. Under such conditions, overspill through the Sakarya Gorge could have routed Ponto-Caspian waters – and aquatic species – via Lake Sapanca and the Gulf of İzmit into the Marmara basin.

It is further proposed that a larger Early Holocene marine inundation may have followed a similar pathway, potentially contributing to incision or modification of the Bosphorus (see Section 3.3.2). The presence of mid-Pleistocene species in the Sapanca record may therefore represent proxy evidence of earlier Black Sea overspill, consistent with the concept of an enlarged Asiatic Mediterranean.

Erturaç et al. (2021) analysed a four-step fluvial terrace sequence of the Sakarya River in the Adapazarı Basin using stratigraphy, geometry, and luminescence dating (Fig. 16). Terrace formation was linked to Black Sea-controlled base-level changes, with highstands during MIS 5a (~84-72 ka), MIS 3 (~40-30 ka), and MIS 1 (~9 ka-present). An average uplift rate of ~0.78 mm/yr was proposed.

While plausible, this interpretation is complicated by the North Anatolian Fault being predominantly strike-slip, with mainly horizontal motion. The 1999 İzmit earthquake, for example, showed minimal regional uplift (Barka et al., 2002), raising questions about the extent to which vertical tectonics alone can explain the terrace elevations.

Despite limited evidence for vertical displacement, terraces T3 and T4 occur at ~60 m and ~106 m a.s.l., raising doubts that uplift alone explains their elevations. An alternative, consistent with the Asiatic Mediterranean hypothesis, is that they partly represent former palaeocoastal levels of a high Black Sea/Lake

phase. While speculative, this possibility warrants consideration. Terrace elevations along the Sakarya are summarised in Table 3.

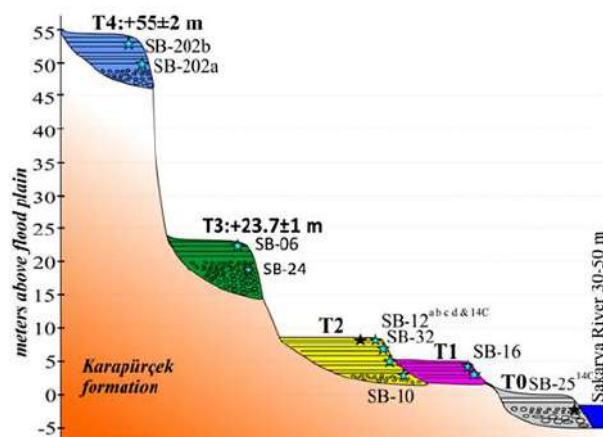


Fig. 16. Sakarya River terracing, sample locations and elevation above the river flood plain. **Not to scale.** (Erturaç, 2021)

#### 2.2.4. River Danube

A preliminary review of the Danube terrace record shows extensive staircases typically attributed to climate-driven river behaviour (Vandenbergh et al., 2004 Armaş et al., 2019). Aggradation is associated with glacial stages (MIS 2, 4, 6), while incision relates to interglacials (MIS 1, 5), reflecting shifts in discharge and sediment supply. Terraces commonly occur at relative heights of ~20 m, ~50 m, and ~100 m above the river. These levels broadly overlap with terrace elevations observed along the Sakarya River and within the Caspian basin. While no direct correlation is implied, this correspondence may warrant further investigation, as wider hydrological controls – potentially linked to fluctuations in the proposed Asiatic Mediterranean – could have influenced phases of terrace formation across the region.

Table 3

Summary of terracing details giving name, elevation and difference in age

Sample site	Terrace top	Elevation in masl	Age	Terrace top Difference in m	Difference in age	Rate of increase from previous TT in m.	Rate of increase in mm/yr
Ref Fig11	T0	27.5	760	na	na	na	na
SB16B	T1	32.5	1160	5	400	80	12.500
SB12D	T2	36.2	1830	3.7	670	181	5.522
SB06C	T3	60	30040	23.8	28210	1185	0.844
SB202B	T4	106	71880	46	41840	910	1.099



The conventional view routes this discharge through the Marmara into the Aegean. Yet available evidence suggests that significant freshwater outflow into the Aegean may not have occurred at scale until ~10 ka BP (Aksu et al., 2002). This sits uneasily with expectations. If large, long-lived river systems operated across Eurasia during the Quaternary, they should have delivered immense quantities of fine sediment to their outlet zones.

The northern Aegean does preserve Late Quaternary muds, clays, and sapropels – products of mixed riverine, Black Sea, and marine inputs (Roussakis et al., 2004; Pehlivanoglou, Tsirambides, Trontsios, 2000). Yet much of this sedimentary record appears comparatively young. The question therefore sharpens: if such discharge persisted over extended timescales, where is the expected volume of sediment?

This mismatch between predicted and observed sediment accumulation points to a gap in current reconstructions – one that may hint at alternative drainage pathways, episodic megaflood behaviour, or more complex basin dynamics than presently recognised.

A possible answer to this puzzle may lie beyond the Ponto-Caspian, in the North Sea and English Channel. Before exploring this, it is useful to consider Palaeolithic settlement patterns: if a vast intracontinental lake existed, where were human populations located?

A reconstruction of Eurasia inundated to +126 m a.s.l. (Fig. 18; Floodmap.net (Flood Map: Elevation Map, Sea Level Rise Map); Hofecker, 2005) shows most archaeological sites positioned above the inferred lake level, often near rivers or along its margins. Such locations would have provided clear advantages – access to freshwater, food resources, and transport routes. Several sites are linked to mammoth hunting, suggesting strategic occupation of productive landscapes, possibly including seasonal movement toward southern wintering areas.

If the proposed Pleistocene river system did not discharge primarily toward the Aegean, then an alternative possibility emerges that overflow was, at times, diverted northwest toward the Baltic and North Sea. During glacial periods, the immense weight of continental ice sheets depressed northern Europe, potentially reshaping drainage pathways and opening routes that no longer exist.

Seen in this light, Doggerland may represent more than a passive glacial landscape. While its sediments are conventionally interpreted as glacial and glaciofluvial, with finer deposits restricted to low-energy environments (Cameron et al., 1992; Cotterill et al., 2017), the possibility remains that episodes of large-scale Eurasian freshwater discharge contributed to its development.

If such a system operated, even intermittently, it would imply a far more dynamic and interconnected hydrological network across northern Eurasia than is currently recognised – one capable of redistributing not only water, but sediment, ecosystems, and potentially human movement on a continental scale.

Of particular interest is the Norwegian Trench, a deep coastal depression extending into the Skagerrak (Fig. 19). Conventionally, it is attributed to repeated Quaternary ice-stream erosion, acting as a major drainage corridor for the Fennoscandian Ice Sheet. Yet its scale – reaching depths of ~700 m, far below the surrounding North Sea floor – raises the question of whether glacial processes alone fully account for its excavation (Rise et al., 2005; Sejrup et al., 2005).

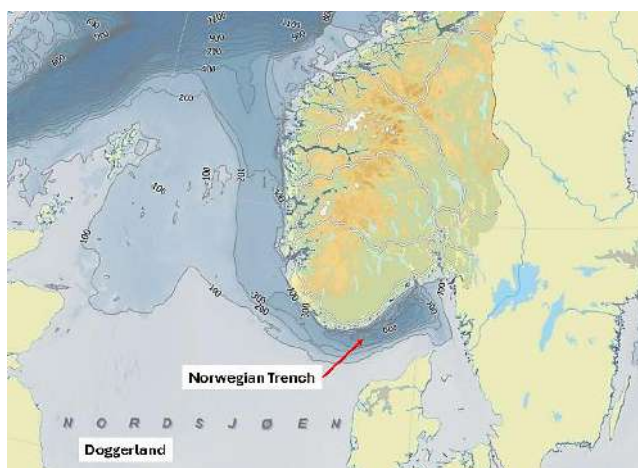
If a large Pleistocene river system discharged into the Baltic, it is conceivable that flow continued westward toward the Skagerrak and into the Norwegian Trench. Under such conditions, substantial freshwater discharge may have interacted with, or even augmented, glacial drainage systems. Rather than acting solely as an ice-stream conduit, the trench may at times have functioned as part of a broader meltwater–river network.

While speculative, this possibility invites reconsideration of the trench not simply as a product of ice, but as a feature shaped by the combined effects of ice and water operating at continental scale.

## **2.2.7. Other Observations and Considerations**

### **2.2.7.1. Climate**

A large Eurasian inland water body would likely have influenced regional climate by enhancing evaporation and atmospheric moisture, potentially intensifying snowfall in downwind regions and contributing to feedbacks affecting glaciation.



**Fig. 19.** Shows the location of the Norway Trench (or Channel) as it skirts the Norwegian coast. Could the Ice Age River augment the ice stream in carving the trench? (Rise et al., 2005)

### 2.2.7.2 Glaciers in Turkey

Pleistocene glaciation in Anatolia was primarily controlled by moisture supply from the Mediterranean and Black Seas, with precipitation rather than temperature acting as the dominant factor (Sarıkaya, Çiner, 2015). During low sea-level conditions (~-120 m), reduced basin extent may have limited moisture availability.

If an Asiatic Mediterranean existed, its expanded surface could have provided a significant additional moisture source. Combined with prevailing winds, this may have enhanced snowfall and contributed to increased glaciation across Anatolia.

### 2.2.7.3. Onshore Ice Sheet Collapse and Release of Asiatic Mediterranean Water

A key question concerns the potential collapse of an ice dam and rapid drainage of the freshwater Asiatic Mediterranean into the Arctic, possibly via the Kara–Barents sector. Based on earlier estimates, such a release could have involved ~173,700 km<sup>3</sup> of water – comparable to, or exceeding, major outbursts from Glacial Lake Agassiz (~100,000-160,000 km<sup>3</sup>), which are known to have affected ocean circulation and climate (Teller et al., 2002).

A discharge of this scale could have produced significant geomorphological and oceanographic effects, including high-energy seabed features such as the relict sand waves documented on the Barents shelf (King et al., 2014; Bøe et al., 2009), as well as short-term reductions in ocean salinity.

In climatic terms, such an event may be considered analogous to Heinrich-type freshwa-

ter forcing. While not a classical Heinrich event, a large Eurasian outburst could have freshened surface waters, weakened deep-water formation, and disrupted the Atlantic Meridional Overturning Circulation, potentially altering North Atlantic circulation patterns and promoting increased iceberg discharge.

This raises the possibility that collapse of Eurasian ice sheets, combined with drainage of a large inland water body, may have contributed to poorly understood freshwater-forcing episodes during the Quaternary. While speculative, this hypothesis warrants further investigation.

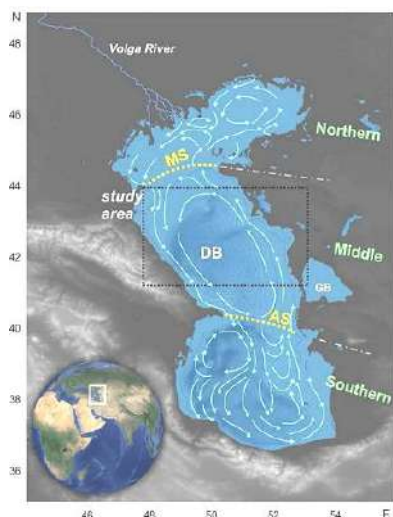
## 3. Factors Concerning a Marine Deluge

This section presents key evidence for a major marine flood and its wider implications. Observations are necessarily concise, focusing on critical anomalies, with references provided to support further investigation and independent assessment.

### 3.1. Elevated 126 m Terracing and its 100 m Escarpment

#### 3.1.1. Raised Terrace North of Sumgayit

The key issues are the elevation of the ~126 m terrace and the source of its alluvium. If a major flood is considered, prolonged inundation and gyre-driven transport (Fig. 20) could have delivered silt to the terrace, suggesting it formed from flood-derived sediments rather than solely from the Samur River.



**Fig. 20.** Bathymetric map of the Caspian Sea with major bottom currents and location of study area; **DB** – Derbent Basin, **MS** – Mangyshlak Sill, **AS** – Absheron Sill, **GB** – Gara Bogaz Bay. (Levchenko et al., 2018)

### 3.1.2. Proposed explanation of the 100 m asl terrace escarpment

As noted earlier, the ~75 m drop along the terrace marks a major geomorphological event, possibly linked to increased outflow from the Ponto-Caspian system. It may correspond to development of the Bosphorus spillway, with the escarpment descending to ~26 m a.s.l. – close to the Manych Corridor threshold between the Caspian and Black Sea basins.

## 3.2. Strandlines and Mud Volcanoes

### 3.2.1. Strandlines

Azerbaijan’s mud-volcano terrain, composed of soft, easily eroded material, pre-

serves numerous strandlines and watermarks that may indicate substantial past transgressions (Figs. 4-9).

The Tartar River Valley strandlines were visited in January 2026 (Fig. 21), confirming their presence, although drone imagery – useful for detailed morphological analysis – could not be obtained due to licensing restrictions.

### 3.2.2. Mud Volcano Geomorphology as a Potential Archive of Former Caspian Highstands

Two mud volcanoes in eastern Azerbaijan – Daviladagh South and Boyuk Kanizadagh – preserve geomorphic features that may indicate prolonged inundation or shoreline reworking. Their soft, erodible deposits make them particularly sensitive recorders of such events.

#### 3.2.2.1. Daviladagh South Mud Volcano

As noted earlier, Daviladagh South Mud Volcano preserves clear evidence of major inundation (Figs. 8, 9, 22), including wave-cut benches, strandlines, abrasion surfaces, stepped slope breaks, and contrasts between eroded older flows and fresher deposits, alongside more resistant limestone outcrops. These features are consistent with prolonged stillstands and wave reworking, making the site a strong candidate for chronological testing. Using a conservative flood level of ~172 m a.s.l., reconstruction (Fig. 23) indicates a flood extent across Eurasia that would require connection with the Arctic Ocean – pointing to a transgression on a scale that challenges existing models of Quaternary flooding.



**Fig. 21.** Lower of three strandlines in the Tartar River Valley at ~GPS – 40°20'42.73"N, 46°51'25.30"E. (R. Gallagher)



**Fig. 22.** Montage of Daviladagh S. Mud volcano with sea level set at 172 m a.s.l. to highlight terracing and watermarks ranging from 191 to 230 m a.s.l. (Floodmap.net/R. Gallagher)



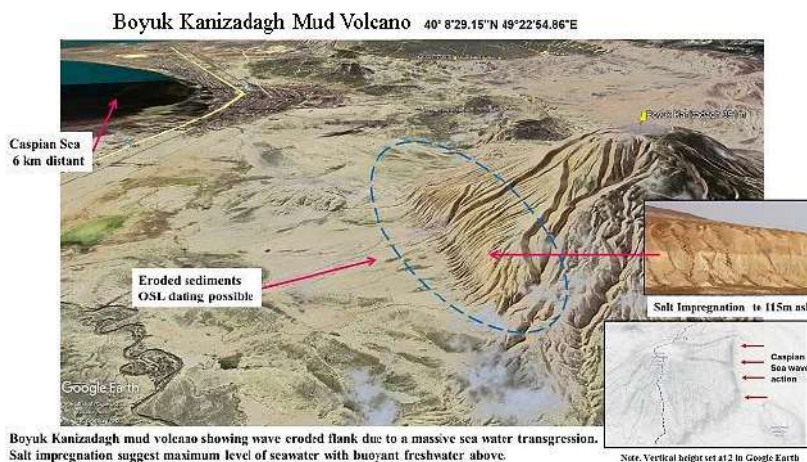
**Fig. 23.** Using Daviladagh as a proxy tidal gauge, this represents the extent of a Eurasian flood level at 172 m a.s.l. Note extensive flooding in the UK, France and Mediterranean/Red Sea. (Floodmap)

### 3.2.2.2. Boyuk Kanizadagh

Boyuk Kanizadagh presents one of the most striking geomorphic signatures in the region. It's pale lower slopes and sharply modified seaward face (Figs. 6, 7, 24) contrast with more intact flanks, producing a pronounced asymmetry. The Caspian-facing side appears truncated and embayed, with evidence of material loss and a pale horizon near ~115 m a.s.l., while sub aerial erosion has only lightly modified the remaining slopes. This imbalance is difficult to attribute to normal weathering alone. Instead, it suggests sustained, directional erosion – consistent with repeated wave or current attack on

weak mud-volcanic deposits. The morphology reads less like gradual decay and more like a surface stripped back by energetic water acting from a single dominant direction.

If this interpretation is correct, Boyuk Kanizadagh records not just inundation, but prolonged exposure to high-energy conditions. As such, it offers a rare opportunity for testing: high-resolution topographic survey could confirm shoreline geometries, while luminescence (OSL) dating of reworked sediments may establish when – and for how long – this erosion took place.



**Fig. 24.** Montage of Boyuk Kanizadagh showing its proximity to the Caspian Sea, cone asymetry, pale (salt?) horizon, subaerial gullying and runoff erosion and wave attacked flank. Enhanced vertical height. (Google Earth/R. Gallagher)

### 3.2.2.3. Salt and Marine Ingression

This mud volcano, previously illustrated in Gallagher (2011, Fig. 10) and Fig. 6, displays a horizontal white layer at ~115 m a.s.l. Rather than a conventional strandline, this may represent a zone of salt impregnation, supported by field observations indicating salinity. It is suggested that rising waters deposited or fixed salts onto the clay surface, marking the upper limit of a marine transgression, possibly reflecting a salinity boundary. Geochemical testing and comparative mapping of nearby mud volcanoes are recommended to evaluate this interpretation.

### 3.2.2.4. Mud Volcano Composition, Colour and Comparison with Chocolate Clays

Mud-volcano ejecta in Azerbaijan is typically dark brown (Fig. 25), raising a possible link with the widespread Khvalynian “chocolate clays.” Both share similar mineral assemblages – dominated by illite and smectite with subordinate kaolinite – reflecting sediment source and depositional conditions (Bayramova et al., 2023; Musaelyan, 2022; Свиточ, Макшаев, 2015). While these clays are generally attributed to northern sources, local input from Azerbaijan’s mud volcanoes cannot be excluded.



**Fig. 25.** Boyuk Kanizadagh soil brown colouration. Note white (salt?) surface colour. (R. Gallagher)

Around 400 mud volcanoes occur across Azerbaijan, with over 140 offshore, though many extinct examples survive only as eroded remnants. Their soft composition makes them highly susceptible to rapid degradation, consistent with the significant erosion observed at sites such as Daviladagh South and Boyuk Kanizadagh.

Further evidence comes from the top of a nearby mesa (Fig. 26), where Early Quaternary brackish-water molluscs (*Dreissena* and *Cardiidae*) were identified, Yanina, pers. comm., suggesting former aquatic conditions and considerable erosion.

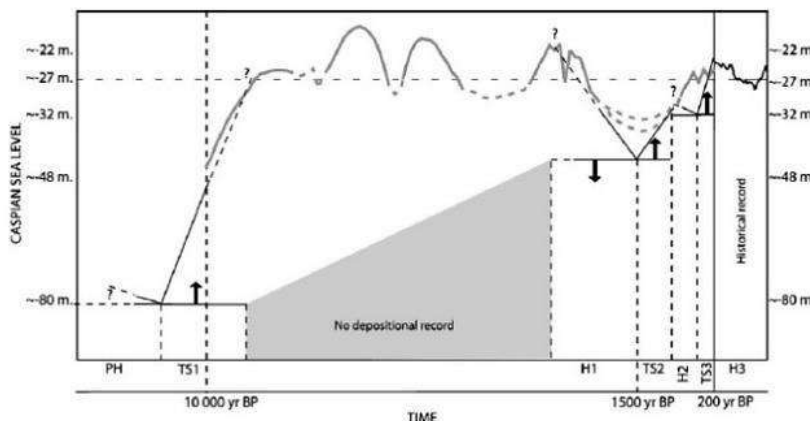
Taken together, these observations indicate substantial Quaternary erosion and support the possibility of a larger former inland water body influencing the region.

### 3.2.3. Missing Kura River Delta

Little or no sediment deposition occurred at the Kura Delta between ~9000 and 2000 BP (Hoogendoorn et al., 2005; Fig. 27), suggesting sediment may have accumulated farther upstream. This is consistent with a higher Caspian level during the early Holocene, possibly due to marine transgression. Supporting evidence may come from a shell midden at Gobustan dated to  $4190 \pm 30$  BP (Table 1), which lies several kilometres inland under accepted sea-level reconstructions (Rychagov, 1997). This discrepancy raises the possibility that the Kura River discharged into a higher-standing basin. Further radiocarbon dating along the Kura corridor could help test this hypothesis.



**Fig. 26.** Fresh looking mollusc fragments on top of a 170 m a.s.l. mesa. Identified as molluscs of *Dreissena* and Early Quaternary *Cardiidae* (Tamara Yanina). Mesa elevation is (GPS – 40°14'11.70"N, 49°19'35.01"E. (R. Gallagher)



**Fig. 27.** Geochronological representation of the different phases of delta development superimposed on the Holocene Caspian sea-level curve. (Hoogendoorn, 2005)/(Rychagov, 1997)

### 3.3. Caspian and Black Seas

#### 3.3.1. Data synthesis and paradoxical interpretations

Late Pleistocene–Holocene sea levels in the Caspian and Black Seas were highly variable and often diverged from global eustatic trends (Yanko-Hombach, Kislov, 2018), giving rise to three key paradoxes:

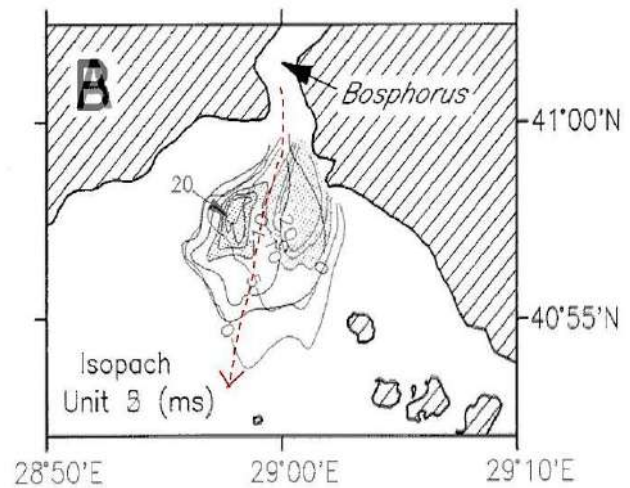
- **Paradox 1:** The Early and Late Khvalynian transgressions (MIS 3 and Late Glacial) are well documented, but their water sources remain uncertain and difficult to explain by conventional hydrology.
- **Paradox 2:** While some Caspian and Black Sea level changes align with climatic shifts, others do not, raising questions about inconsistent climate–sea-level relationships.
- **Paradox 3:** Proposed major Black Sea outflows via the Bosphorus are difficult to reconcile with reconstructed basin-level fluctuations during the same period.

These paradoxes may be better understood within the framework of an Asiatic Mediterranean and a subsequent marine flood, potentially requiring a reassessment of conventional Quaternary hydrology.

**Paradox 1** may reflect ponding of Siberian river discharge within an enlarged inland basin, partly constrained by a Bosphorus land bridge and operating independently of eustatic sea level. **Paradox 2** suggests Black Sea level changes were not solely climate-driven, but influenced by this broader system. **Paradox 3** relates to a possible marine deluge, discussed further below.

#### 3.3.2. Bosphorus Origins

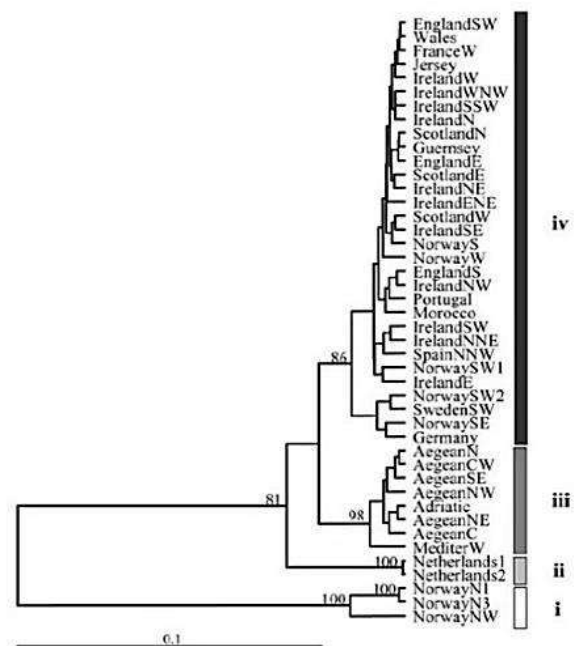
The Bosphorus is widely interpreted as an incised valley formed subaerially, with evidence for southward outflow from the Black Sea and delta formation south of the strait from ~10 ka BP (Hiscott et al., 2002, 2007; Aksu et al., 2002). Within the proposed framework, limited glacial-period overflow may have established this southward-flowing valley, while a later, more powerful marine outflow – driven by a basin-level gradient – could have deepened the channel and sculpted its steep morphology. This enhanced flow may also have eroded and bisected earlier deltaic deposits, leaving the anomalous paired delta remnants observed today (Fig. 28).



**Fig. 28.** Superimposed isopach maps of depositional deltaic lobes showing a gap between lobes. This suggests an erosion event due to significant outflow from the Bosphorus indicated by the red dashed arrow. (Hiscott, 2007)/Gallagher

#### 3.3.3. Norway Lobster in the Aegean and Adriatic

Further evidence for possible northern marine ingress is the presence of the European lobster (*Homarus gammarus*) in the Aegean and Adriatic. Genetic studies suggest links to northern populations, potentially indicating dispersal via a Baltic–Arctic–Black Sea route rather than through Gibraltar (Triantafyllidis et al., 2005; Fig. 29).



**Fig. 29.** Norway Lobster *H. gammarus* dendrogram showing relationship among 44 European population. Genetically Norway and Netherlands are close to the Aegean and Adriatic. (Triantafyllidis et al., 2005)

## 4. Discussion

These observations highlight persistent discrepancies in current interpretations, suggesting that a broader regional perspective may be needed. Considered together, the hypotheses of a flooded Ice Age Eurasia and a subsequent marine inundation offer a framework within which disparate evidence may form a more coherent picture of Quaternary change. The following sections examine additional lines of evidence as further “pieces of the puzzle,” testing the possibility and mechanisms of a major flood event.

### 4.1. Traditions of the Flood

Sir Joseph Prestwich argued that a large body of water once occupied parts of north-western Europe and was catastrophically released, helping to form features such as the English Channel and linking geological evidence with widespread flood traditions (Prestwich, 1893-1894). He cited raised beaches, widespread loess deposits, other anomalies and “*ossiferous fissures*” containing the skeletal remains of both carnivores and herbivores and lacking signs of predation. Some fissures, such as those at Mont de Sène in Santenay France, (~521 m a.s.l.), may reflect animals fleeing uphill from rising waters before becoming trapped. Although undated at the time, many of these sites have not been re-examined with modern methods. Renewed investigation could provide valuable evidence for the timing and nature of large-scale flooding in Western Europe.

## 4.2. Mediterranean Flood Evidence

### 4.2.1. Nile Delta Turtlebacks

“Turtlebacks” or geziras are elliptical sandy ridges rising ~30 m above the Nile Delta, composed of Ethiopian-derived sediments and dated to ~10-5 ka BP (Rowland et al., 2012; Fig. 30). They are generally interpreted as fluvial features formed during the African Humid Period.

An alternative possibility is that they formed under transgressive conditions within an enlarged Mediterranean highstand, with later regression and Nile erosion, leaving them as residual features. If so, this could indicate an Early Holocene transgression exceeding expected eustatic levels and a Mediterranean shoreline extending farther inland toward Cairo.

### 4.2.2. Faiyum Origins

The Faiyum Depression Lake is generally interpreted as a Nile-fed basin formed by overflow from the Bahr Yussef, with levels fluctuating in response to climate and Nile discharge during the African Humid Period (Marks et al., 2018).

An alternative possibility is that a higher Mediterranean transgression caused backflooding within the Nile system, with elevated downstream levels promoting overflow into the depression via the Bahr Yussef (~25 m a.s.l.). Strandlines within the basin (Fig. 31), reaching ~31 m a.s.l., indicate repeated lake-level changes (Sandford, Arkell, 1929). Their generally narrow form suggests short-lived stillstands, possibly representing receding shorelines from a larger, transient lake.

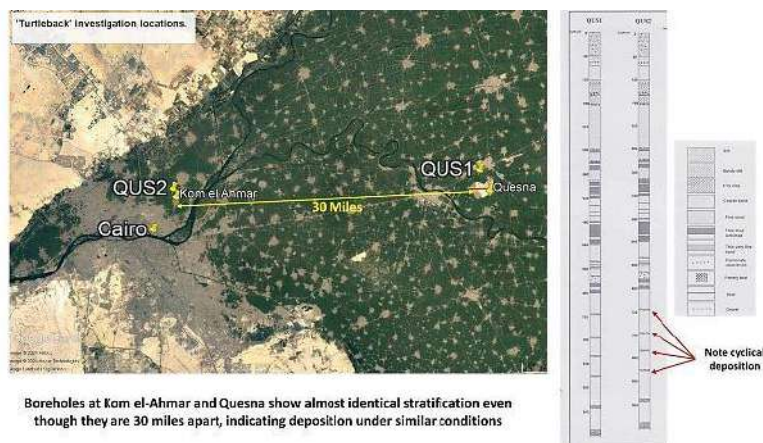
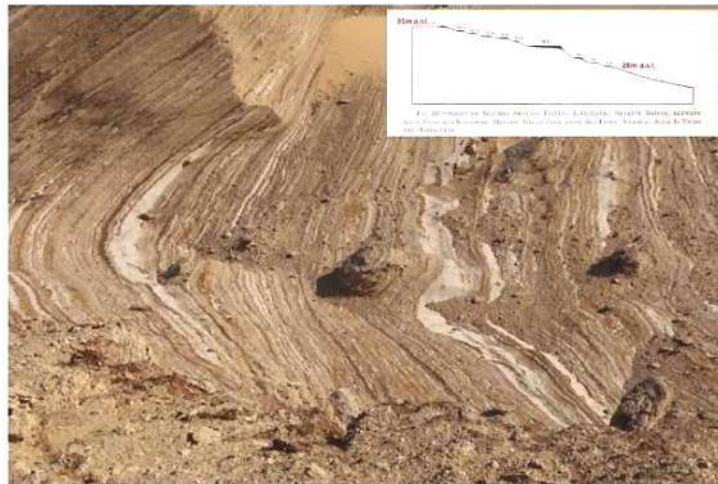


Fig. 30. Location of two near identical turtleback sites separated by 30 miles. (Google Earth/ Gallagher) (Rowland et al., 2012)



**Fig. 31.** A series of strandlines in the Faiyum depression with an upper height of ~31 m a.s.l., marking the successively lower levels of the Qarun lake shore. From Fig. 20 (Sandford, Arkell, 1929)

#### 4.2.3. Israel Mega Tsunami

A megatsunami affected the Israeli coast around 10 ka BP, with run-up heights of ~16-40 m and inland inundation of up to ~3.5 km. It is recorded as a marine sand layer burying Neolithic settlements such as Atlit and Dor, likely triggered by a submarine landslide or seismic event (Shtienberg et al., 2020). Its timing broadly coincides with other Early Holocene flooding events, including formation of Lake Qarun, and may warrant further consideration in a wider regional context.

#### 4.2.4. Italy, Lake Bracciano's Submerged Neolithic Site

Neolithic dugout canoes (pirogues) from La Marmotta (~5700-5200 BC) represent the earli-

est known Mediterranean boats and demonstrate unexpectedly advanced water transport (Gibaja et al., 2024). Some vessels reach ~10 m in length, yet the site lies ~300 m from Lake Bracciano's shore at ~11 m depth and over 160 m a.s.l., raising questions about their intended use.

Given the lake's inland setting and limited modern connection via the Arnone River, such large craft appear excessive for local use alone. One possibility is that they were also used on the Mediterranean, implying easier access in the past. Under a higher sea-level scenario (~176 m a.s.l.), Lake Bracciano could have been connected to the Mediterranean, functioning as a sheltered harbour (Fig. 32). If so, La Marmotta's abandonment may reflect falling water levels and loss of access to the sea.



**Fig. 32.** Lake Bracciano as an embayment of the Mediterranean, with Sea level at 176 m a.s.l. (Google Earth/Gallagher)

#### 4.2.5. Arabian Quaternary Paleohydrology

Further evidence of a possible Early Holocene deluge comes from the Arabian Peninsula, where deeply incised canyons breaching the ~200 m Tuwaiq Escarpment and large alluvial fans suggest a major palaeohydrological event (El Bastawesy, 2014).

Radiocarbon dates (~9,500-5,800 BP) indicate a Holocene age, but conventional rainfall estimates may be insufficient to explain the scale of erosion, implying either extreme precipitation or a large-scale water-release event. While the geomorphology confirms significant flooding, its precise cause remains uncertain.

#### 4.3. Giant ripples, Longitudinal Sand Waves/Dunes and Oriented Lakes

If marine inundation reached elevations of ~150 m a.s.l., as suggested by mud volcano strandline evidence in Azerbaijan, the fundamental question becomes: what mechanism could drive water to such heights? One speculative possibility is that large-scale Earth-system changes – such as shifts in ocean circulation or redistribution of tidal energy – may have displaced water masses toward higher latitudes.

If such processes operated, their effects might not have been confined to a single region. Comparable signatures could be expected more widely, raising the question of what geomorphological imprint sustained, high-energy marine flow would leave on an inundated landscape.

One possible answer lies in the formation of large-scale bedforms. As noted for the Barents

Sea, powerful currents can generate extensive transverse features aligned with flow direction. This invites comparison with the longitudinal dune fields of the Simpson Desert and similar ridge systems found globally (Fig. 33). These remarkably uniform, inactive and vegetated landforms extend over great distances and frequently occur alongside salt pans.

While typically interpreted as aeolian in origin, their scale, consistency, and elevation raise the possibility that some may record more complex formation histories. At the very least, they illustrate the kinds of geomorphic patterns that sustained, high-energy flows are capable of producing.

Table 4 provides selected examples of their locations and elevations.

Explanations for these landforms vary. In Australia, many dune systems are attributed to persistent subtropical anticyclonic wind regimes (Australian National Botanic Gardens, 2016). The linear dunes of the Simpson Desert are thought to have been most active during the Last Glacial Maximum, with activity declining into the Early Holocene and stabilisation occurring after ~10 ka BP (Hesse, 2010; Fitzsimmons et al., 2007). However, this wind-based explanation may not fully account for the occurrence of similar ridge systems across widely separated regions, including examples at higher elevations. Their broader distribution suggests that additional factors may be involved and warrants further comparative investigation.



**Fig. 33.** Examples of Longitudinal dunes or possible sandwaves from Australia and Namibia. (Google Earth/Gallagher)

Table 4

Examples of linear ridge, dune, and possible sandwave fields

Country	Type/Note	Average Elevation (m a.s.l.)	GPS Coordinates
Argentina	Sandwave field	85	35°34'39.05"S 61°59'16.96"W,
	Salinas de Ambagasta	118	29°18'49.21"S 64°27'52.39"W
Canada	Sandwave field?	143	68° 1'12.77"N 129° 0'11.69"W
	Sandwaves?	19	69°24'54.70"N 131° 5'30.22"W
	Sandwaves?	93	72°16'56.87"N 105°59'10.11"W
Alaska	Elongated Lake, Tractor Lake	12	70°56'32.15"N 157°12'19.19"W
Russia	Lake Chany?	105	54°45'19.24"N 78° 3'0.53"E
	Yuzny Island?	29	71°43'8.07"N 52°17'27.66"E
	Lena Delta	7	73°29'18.10"N 124°19'16.77"E
	Volga Delta	-22	46° 8'44.89"N 47°35'30.71"E
Australia	Simpson Desert	100	25° 2'16.42"S , 136°54'5.67"E
Namibia	Linear dunes	1120	24°47'14.58"S 19°16'13.81"E
Senegal	Linear dunes, static	52	15°19'28.66"N 15°51'3.77"W
Mauritania	Linear dunes	51	17°54'3.05"N 14°56'53.91"W
Zimbabwe	Linear dunes	975	19°28'52.32"S 26°35'36.51"E
South Africa	Linear dunes	844	27°27'2.66"S 20°34'58.85"E
Kazakhstan	Sandwave	383	44°16'16.06"N 69°24'31.28"E

The Baer Knolls of the Volga Delta and those near the Ural River have been interpreted as subaqueous features, not aeolian and analogous to longitudinal bedforms of the Brahmaputra (Badyukova, 2016). However, they more closely resemble submarine sand waves formed from Brahmaputra-derived sediments in the Bay of Bengal (Kuehl et al., 1997; Gallagher, 2018). Models invoking persistent east–west currents raise hydrodynamic questions. An alternative is stronger north–south flow, possibly linked to past Arctic incursions. Further geomorphological and sedimentological study is needed to distinguish between these interpretations.

A possible related sand wave phenomenon occurs in the Arctic in the form of “oriented lakes.” In Alaska, these are attributed to persistent winds generating waves that erode lake margins and elongate basins (Carson et al., 1962). In Russia, similar lake–ridge assemblag-

es have been interpreted as relict glacial lineations later modified by thermokarst processes (Grosswald, Hughes, Lasca, 1999). More recent studies likewise link their orientation to prevailing winds, with lake axes aligned parallel to dominant airflow and shaped by thaw subsidence, lateral expansion and drainage cycles (Hinkel et al., 2005).

However, if large-scale flooding affected Eurasia and the Arctic margin, an alternative mechanism may be considered. Under higher sea levels, low-lying coastal plains – such as parts of northern Alaska and the Lena Delta in Russia – would have been submerged and exposed to marine currents. Sustained flow could have generated large seabed bedforms, which, upon emergence, became relic ridges and depressions that later filled with water. These features may then have evolved into elongated lakes comparable to those observed today (Figs. 34-35).

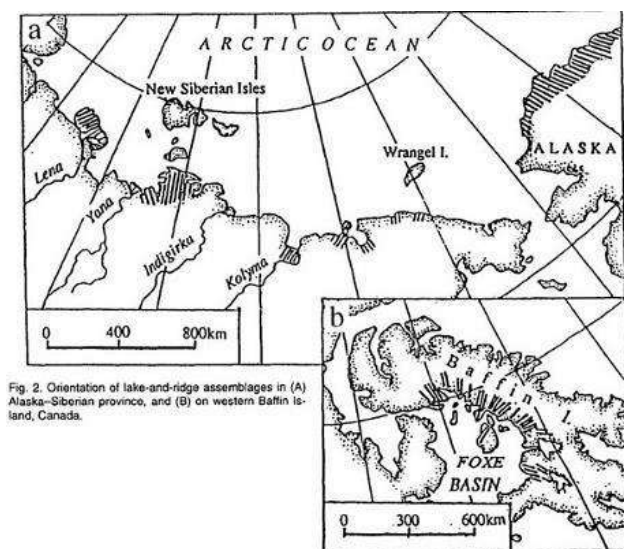


Fig. 2. Orientation of lake-and-ridge assemblages in (A) Alaska-Siberian province, and (B) on western Baffin Island, Canada.

Fig. 34. Location of lake and ridge assemblages bordering the Arctic Ocean. (Grosswald, Hughes, Lasca, 1999)

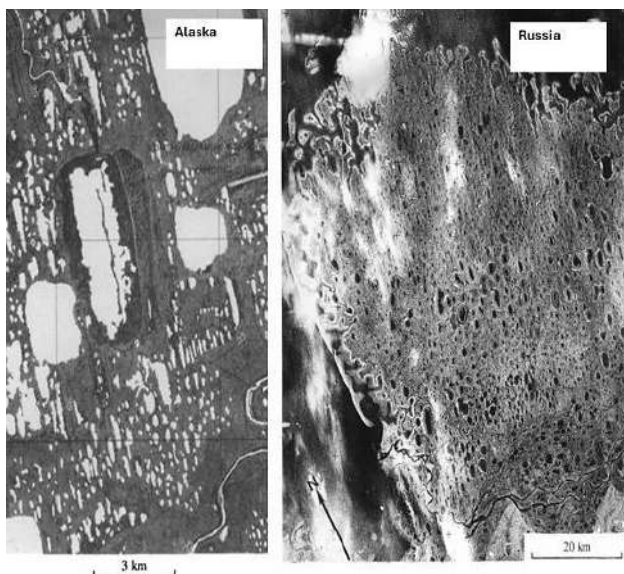


Fig. 35. Appearance of lake and ridge assemblages in Alaska and Russia. (Grosswald, Hughes, Lasca, 1999)

Of additional interest is the chronology of some “yedoma” ridge systems, where peat yields radiocarbon ages of ~9.5-7.5 ka (Grosswald, Hughes, Lasca, 1999; Fig. 36). This broadly coincides with other major environmental changes discussed above, although no direct causal link is established.

Comparable ridge-and-lake patterns occur elsewhere, including Canada (Allenby, 1989) and northeastern Bolivia (Plafker, 1964), where two distinct orientation sets – sometimes near right angles – suggest multiple phases of landscape development under changing controls (Fig. 37). Together, these observations point to

a global geomorphological phenomenon that may benefit from broader comparative study.

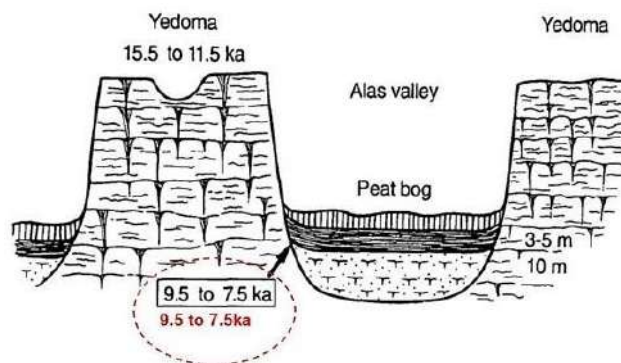


Fig. 36. Relationship of transverse yedoma ridges and intermediate thermokarst thaw valleys. Dates to Early Holocene (Grosswald, Hughes, Lasca, 1999)

#### 4.4. Evidence of Flooding in Scotland and Western Europe

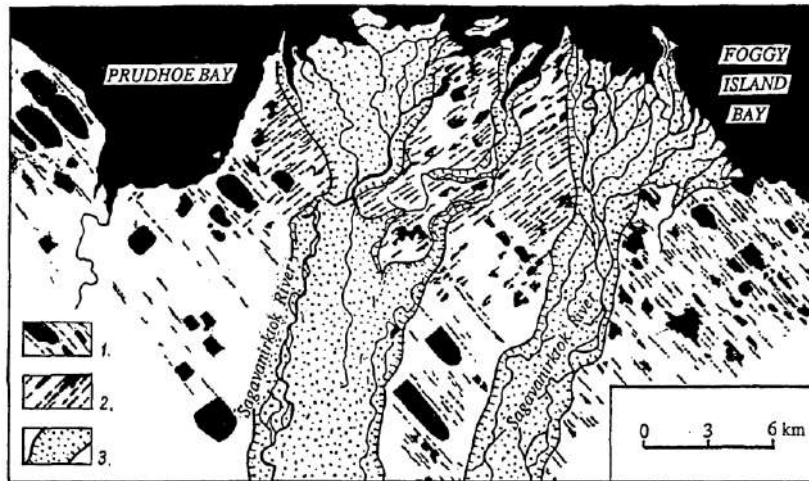
Several sites in Scotland may indicate episodes of prolonged inundation. Of particular interest are a distinctive 1 m fossil-poor sediment layer in Loch Assynt and the discovery of whale remains – including a blue whale (*Balaenoptera musculus*) – within the Firth of Forth.

##### 4.4.1. Loch Assynt

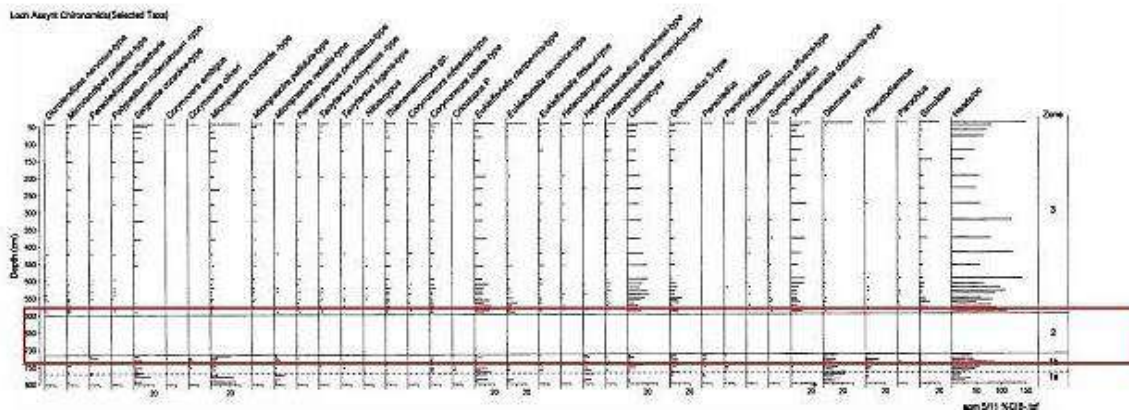
Loch Assynt is an intriguing site, lying at ~66 m a.s.l. and ~8 km from the present coast, and ice-free since at least c. 17 ka BP. Sediment cores have been used to reconstruct environmental change across the Late Glacial–Early Holocene transition using multiple palaeoenvironmental proxies.

Within this sequence, “Unit II,” deposited toward the end of the Younger Dryas, represents a low-salinity transitional phase during basin freshening. It is characterised by poor carbonate preservation, sparse invertebrates, and an absence of chironomid insect (Boomer et al., 2012; Fig. 37).

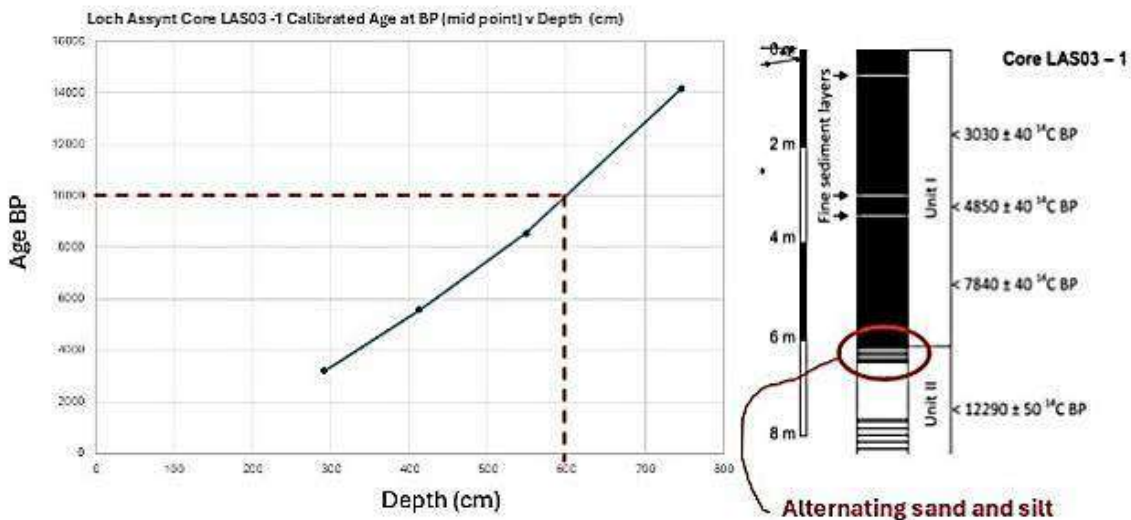
Age–depth modelling suggests that upper Unit II sediments – alternating sands and silts – date to ~10 ka BP (Figs. 38 and 39). As chironomids are sensitive to salinity, their absence may indicate unfavourable conditions. One interpretation is that these sediments record a short-lived disturbance, possibly a marine incursion during the Early Holocene. However, alternative explanations, including catchment instability, cannot be excluded without further study.



**Fig. 37.** Two sets of oriented ridges in Alaska. Note: a similar set of ridges are in Bolivia suggesting a common mode effect. (Grosswald, Hughes, Lasca, 1999)



**Fig. 38.** Highlighted are represents an approximate 1m discontinuity in sedimentation with no chironomids present. (Boomer et al., 2012)



**Fig. 39.** This diagram shows the top of Unit II, a region that is devoid of chironomids. Their absence may be associated with a marine flood and unfavourable breeding conditions. (Boomer et al., 2012/Gallagher)

#### 4.4.2. Missing Gap in Hunter-Gatherer settlement in Scandinavia

Jensen et al. (2020) propose dividing the Early Mesolithic Maglemose culture into two phases – an Early and a Late Complex – separated by a ~600-year hiatus in archaeological evidence around 10,300 cal BP (Fig. 40). This gap is interpreted as the result of environmental change disrupting lake-based hunter-gatherer lifeways and leading to temporary abandonment of these landscapes.

This finding is significant in demonstrating how hydrological change and shifting lake environments can reorganise human settlement patterns. In the context of a marine deluge hypothesis, such disruption might also reflect reduced accessibility or submergence of parts of the landscape.

#### 4.4.3. Beached Whales in Scotland’s Firth of Forth and Relative Sea Level

Sixteen whale remains have been reported from Early Holocene deposits in the Firth of Forth, most discovered during eighteenth–nineteenth century drainage and agricultural works (Clark, 1947; Fig. 41). These span ~9,500-7,000 cal BP, indicating multiple strand-

ings over ~2,500 years rather than a single event. At that time, relative sea level was higher, and the Forth estuary extended farther inland, with tidal flats and channels allowing whales to move inland before becoming stranded. Preservation was aided by rapid burial in low-oxygen sediments, with later emergence of the carse lands driven by glacio-isostatic uplift (McMaster, 2024). Of particular note is a blue whale from Airthrey (University of Stirling), found at ~8-20 m OD (McMaster, 2024; Fig. 42). Its elevation provides a relative sea-level marker when adjusted for tidal range and sediment effects. Current interpretations attribute such inland strandings to the Early Holocene Transgression, driven by postglacial sea-level rise combined with ongoing isostatic rebound (Smith et al., 2010; Smith et al., 2019). However, given broadly synchronous evidence for elevated water levels in regions unaffected by glaciation, including the Caspian and Mediterranean, it is worth considering whether local models are complete. Early Holocene sea-level histories may have included short-lived, high-energy marine incursions or non-linear events not fully captured in existing shoreline reconstructions.

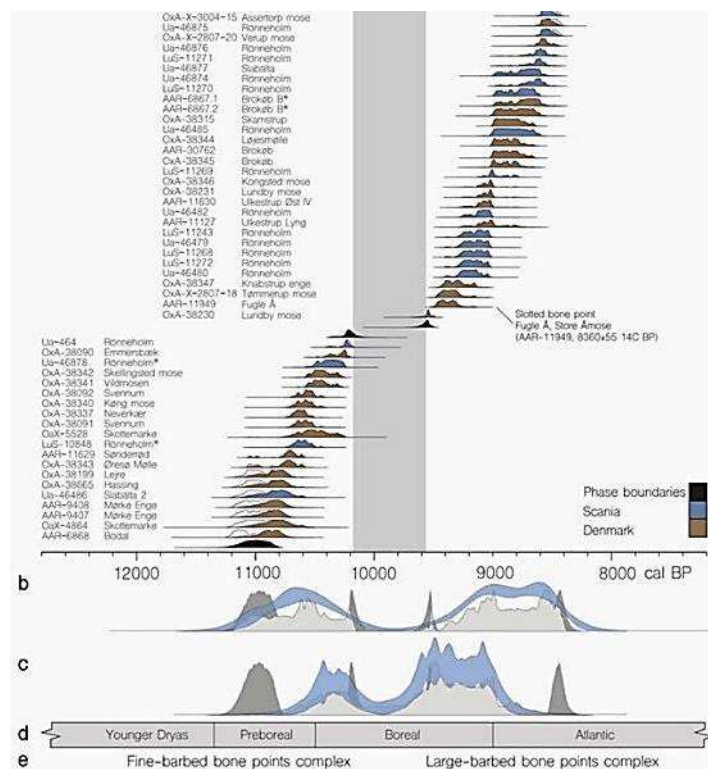
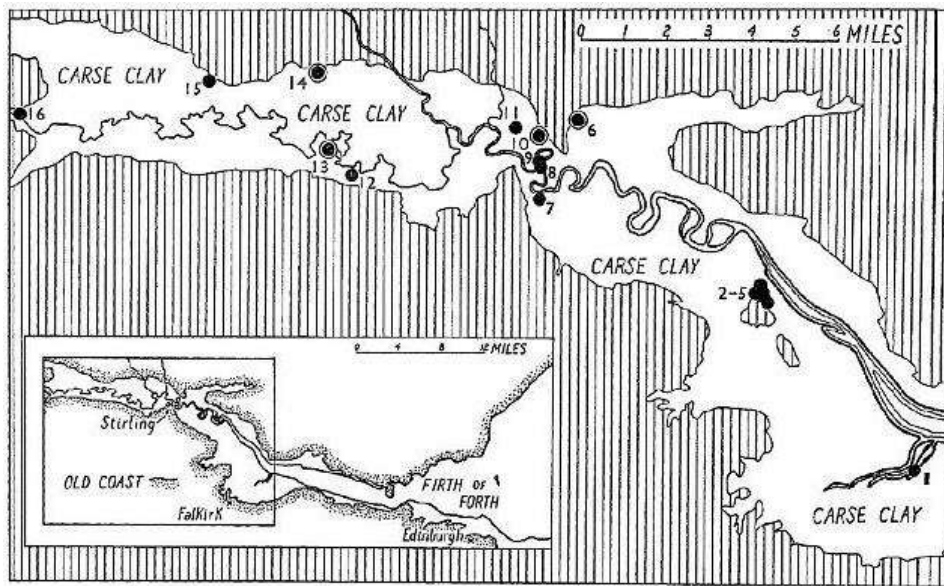
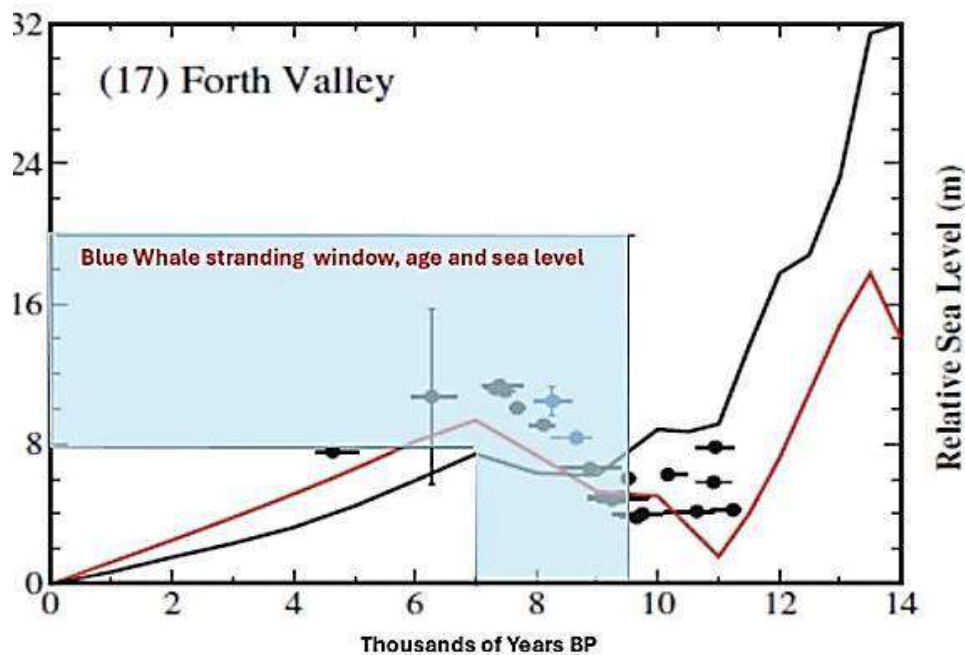


Fig. 40. Diagram showing 600-year gap in lake zone occupation, followed by a change in culture. Land possibly submerged (Jensen et al., 2020)



**Fig. 41.** Location of 16 whales stranded in the Firth of Forth, Scotland in the Early Holocene with a Blue Whale at Site No. 6. At Airthrey Castle at Stirling (Clark, 1947)



**Fig. 42.** Airthrey Castle Blue Whale stranding. A comparison of the age range and height above relative sea level. Graph highlights the Early Holocene Transgression (Lambeck et al., 2014, McMaster, 2024), R. Gallagher

Rather than a single catastrophic flood, the evidence may reflect a more complex interplay of basin reconnection, regional hydrology, and time-transgressive sea-level change – issues central to ongoing debate surrounding Early Holocene events, including the Black Sea flood hypothesis (Ryan, Pitman, 1998; Aksu et al., 2002; Major et al., 2006; Yanko-Hombach et al., 2007).

#### 4.5. Black Sea Flood Theory

The hypothesis that the Black Sea experienced a catastrophic marine flood in the Early Holocene – when rising Mediterranean waters overtopped the Bosphorus and rapidly filled a lower freshwater basin – has long been debated. Popularised by Ryan and Pitman (1997), the idea stimulated extensive research but remains controversial.

Alternative interpretations argue against a sudden breach. Aksu et al. (2002) proposed persistent two-way exchange through the Bosphorus, while Major et al. (2006) suggested Mediterranean inflow began earlier (~10.2-9.2 ka cal BP), well before the commonly cited flood date of ~7.6 ka BP. The central questions therefore remain: when did seawater first enter the Black Sea, and was this process abrupt or gradual?

A key difficulty is that the Black Sea is widely reconstructed as largely fresh or low-salinity around 7.6 ka BP, complicating models requiring substantial marine inflow. Both end-member scenarios thus face hydrological challenges. In this context, Gallagher (2011) raised the possibility – albeit speculative – of marine ingress from the north via the Arctic, supported here by strandline and mud-volcano evidence from Azerbaijan suggesting a substantial inundation. Under a more complex scenario of raised relative sea levels, Bosphorus discharge and Mediterranean inflow may have operated simultaneously: i.e. rising Mediterranean levels allowed inflow into the Marmara, while a developed Bosphorus channel permitted denser saline water to enter the Black Sea beneath outflowing fresher surface waters.

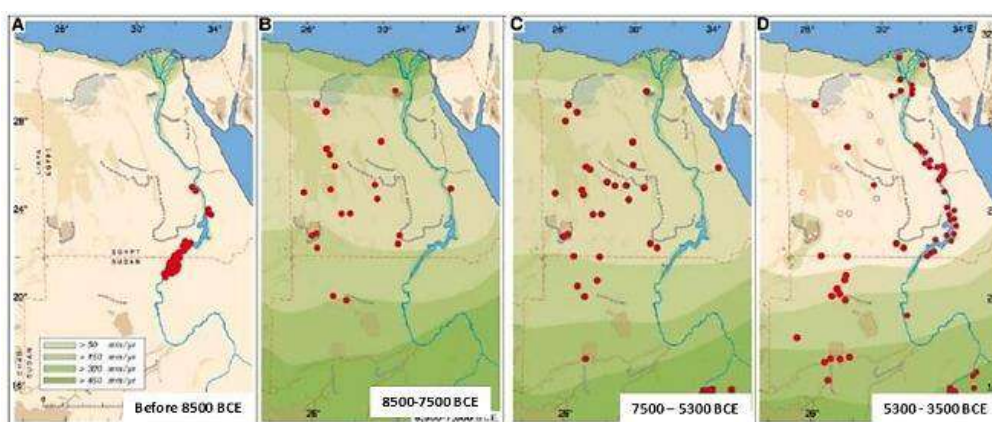
Such a mechanism would imply a multi-phase, dynamic history involving basin reconnection, stratified flow, and evolving water balance, rather than a single event. The persistence of relatively fresh surface waters could be explained by strong river inflow during this transitional phase, even as saline intrusion developed at depth.

Classical sources may offer indirect support. The Black Sea’s early designation as *Axenos Pontos* (“Inhospitable Sea”), later softened to *Euxeinus Pontos*, and accounts of waters breaking toward the Bosphorus (Diodorus Siculus..., 1933), while not geological evidence, may reflect cultural memory of significant hydrological change.

#### 4.6. Green Sahara

During the African Humid Period, beginning around 10 ka BP, the Sahara rapidly became wetter and more vegetated before returning to arid conditions by ~7.3 ka BP (Fig. 43; Blanchet et al., 2013; Blanchet, Frank, Schouten, 2014). This transition is generally attributed to orbital (Milankovitch) forcing, with enhanced seasonal insolation driving monsoonal intensification. Dust and marine sediment records indicate that similar humid phases recurred throughout the Late Quaternary. Climate models reproduce Sahara greening when orbital forcing is combined with land-surface feedbacks, although the speed and magnitude of change remain difficult to fully capture (McGee et al. 2013).

The timing is notable: the African Humid Period broadly overlaps with intervals proposed for persistent Black Sea outflow (Aksu et al., 2002; Gallagher, 2011). While this may be coincidental, it raises the possibility of wider regional hydrological linkages beyond rainfall alone.



**Fig. 43.** The Green Sahara. In the Early Holocene there are difficult to explain asynchronous changes in vegetation, runoff and erosion in the Nile River Watershed (Blanchet et al., 2013)

Evidence discussed here suggests that relative sea-level changes may also have affected parts of the Arctic and Ponto-Caspian region during this time. One speculative interpretation is that broader climatic or geographic reorganisation influenced moisture belts and hydrological gradients.

#### 4.7. Biological Changes in the Caspian

If the Caspian experienced significant seawater ingress, it is reasonable to consider whether this was accompanied by the arrival of Arctic or marine species. The possible presence of cetaceans has been discussed previously (Gallagher, 2011). The Caspian seal (*Pusa caspica*), closely related to the Arctic ringed seal, provides clear evidence of past northern biogeographic exchange, with divergence generally placed in the Middle–Late Pleistocene (Aladin, Plotnikov, 1993). Additional ecological patterns are also noteworthy. Despite high biomass productivity, the Caspian has relatively low species diversity, and biological abundance declines sharply below ~100 m depth – often interpreted as evidence of stratification or environmental stress. Genetic studies of relict Arctic taxa, such as *Mysis*, further support past northern connections and subsequent basin isolation (Väinölä, 1995; Gallagher, 2018).

There is also evidence for later species incursions. For example, *Cerastoderma glaucum* appears to have entered the basin during the Early Holocene, implying intervals of marine connectivity or elevated salinity (Nikula, Väinölä, 2003). Comparable changes are recorded in the Aral Sea, where a ~10 ka BP event (Boomer, 2012) saw brackish taxa replaced by freshwater species, likely reflecting major hydrological reorganisation linked to river rerouting. This suggests a degree of regional synchrony.

Taken together, biological and micropalaeontological evidence indicates substantial hydrological change across the Caspian and Aral basins during the terminal Pleistocene–Early Holocene transition. These shifts – encompassing faunal turnover, changing salinity regimes, and episodes of connectivity – point to a dynamic and complex basin history, not fully captured by simple lake-level reconstructions.

#### 4.8. Human Impacts and Migrations.

In addition to physical and biological effects, major flooding would have had significant impacts on human populations. While Ice Age water-level rise was generally gradual, sudden ice-dam failure could have caused rapid shoreline retreat. Such events likely triggered phases of human dispersal: an initial movement around ~9.5 ka BP, followed by a later phase between ~7-6 ka BP as environments degraded and the Caspian became more isolated.

In this context, it is notable that Flinders Petrie proposed a Caucasus origin for early Egyptian civilisation:

*“It appears...that the cultural connections of the earliest Egyptians...point to the Caucasus region...giving strong grounds for regarding that region as the homeland of the earliest civilisations of the Egyptians.”* — Petrie (1926), *Origin of the Book of the Dead*

Petrie offered no mechanism for such movements. In light of the flood hypotheses considered here, including possible large-scale inundation and migration, his suggestion may warrant renewed interdisciplinary evaluation.

#### Summary

A detailed timeline of events is provided in Appendix 1.

This study argues that the geomorphology of Azerbaijan warrants renewed scientific attention. Raised terraces, high-elevation strandlines, and marine erosion of mud volcanoes are difficult to reconcile with conventional Caspian Sea-level models. In particular, landforms well above the widely accepted +50 m Khvalynian highstand may represent misidentified features or previously unrecognised hydrological phases.

The paper further suggests that a large Pleistocene freshwater system linking the Black Sea, Caspian Sea, and Aral basin remains a plausible working hypothesis, potentially sustained by diversion of Siberian Rivers during glacial maxima. In this context, earlier concepts of an enlarged “Asiatic Mediterranean” may merit reconsideration.

Early Holocene flood histories were likely more complex than single-event scenarios imply. Evidence from the Caspian, Black Sea, Mediterranean, and surrounding regions points

to interacting processes, including global sea-level rise, glacio-isostatic adjustment, basin overspill, salinity stratification, and episodic marine incursions. The Black Sea Flood debate may therefore be better framed as a multi-phase hydrological transition rather than a simple catastrophic versus gradual dichotomy.

Biological and sedimentary records – such as ostracod turnovers, species incursions, and ecological stratification – also indicate significant environmental reorganisation during the Late Quaternary–Early Holocene transition. These changes would likely have affected human populations through settlement disruption, migration, and the development of flood traditions (Chekhovskaya, 2018).

At the same time, hypotheses involving extreme marine levels or continent-scale flooding remain outside current scientific consensus and require rigorous testing. Priority research should include geochronological dating of strandlines

and terraces, sediment coring, hydrodynamic modelling, DEM-based reconstructions, and integrated archaeological and palaeoecological analysis.

Overall, whether or not all interpretations advanced here are confirmed, the evidence suggests that Eurasian Quaternary flood history is not yet fully resolved. Azerbaijan, given its distinctive geomorphology and position between Arctic, Caspian, and Near Eastern systems, may preserve key evidence for understanding that history.

As Montgomery (2012) cautioned, geological records typically reflect multiple regional floods rather than a single global event. Even so, the scale and coherence of the features discussed here raise important questions.

At the heart of this study remains a simple but unresolved problem identified some 24 years ago: - what process formed the Gilazi strandlines? That is the \$64,000 question.

#### Appendix 1

Integrated timeline of Early Holocene hydrological and ecological changes across the Ponto-Caspian, Mediterranean, Arctic-margin, and North African regions, c. 12-7 ka BP.

Date / Interval	Evidence or Event	Significance
c. 11,000-10,000 BP	Global sea level rising from lowstand	Baseline context: eustatic sea level rising rapidly, while regional basins respond variably due to GIA, sill thresholds, and river balance.
c. 10,500-10,000 BP	Onset of African Humid Period (AHP)	Sahara becomes wetter and vegetated; generally linked to orbital–monsoon forcing, though onset appears abrupt in some records.
c. 10,300 cal BP	Maglemose cultural hiatus (~600 years)	Suggests disruption of lake-based Mesolithic lifeways, likely linked to hydrological or wetland change.
c. 10,200-9,200 cal BP	Early Black Sea marine inflow (some models)	Implies reconnection earlier than the ~7.6 ka hypothesis; supports multi-phase basin evolution.
c. 10,000 BP	Aral Sea ostracod “Event II”	Freshwater taxa replace brackish species, indicating major hydrological reorganisation.
c. 10,000 BP	Southward Bosphorus flow and delta formation	Indicates development of a spillway and sustained outflow into the Marmara basin.
c. 10,000 BP	Freshwater outflow into the Aegean	Supported by geochemical and biological indicators in marine sediments.
c. 10,000 BP	Establishment of Lake Qarun (Faiyum)	May reflect Nile back-flooding from higher Mediterranean levels or increased AHP discharge.
c. 10,000 BP	Stabilisation of Simpson Desert dunes	Indicates environmental change; alternatively interpreted as relict features following earlier high-energy processes.
c. 10,000 BP	Loch Assynt anomalous sediment layer	Fossil-poor unit lacking chironomids; may reflect salinity change or hydrological disturbance.
c. 10,000 BP	Eastern Mediterranean megatsunami (Atlit–Dor)	High-energy marine event affecting coastal settlements.
c. 10,000-5,000 BP	Formation of Nile “turtle-backs” (geziras)	Generally interpreted as fluvial; alternatively may reflect deposition under higher water levels.
c. 9,725 BP	Caspian ostracod assemblage turnover	Indicates major shifts in salinity, water depth, and basin hydrology.

Date / Interval	Evidence or Event	Significance
c. 9,500-8,500 BP	Scottish raised estuary / whale strandings	High relative sea levels linked to isostatic rebound; possible regional anomalies.
c. 9,500-7,500 BP	Yedoma / oriented lake-ridge formation	Widespread geomorphic activity in Arctic regions; mechanism debated.
c. 9,500-5,800 BP	Arabian palaeohydrological phase (Tuwaiq)	Large-scale drainage and incision; rainfall alone may not explain magnitude.
c. 9,000-7,000 BP	<i>Cerastoderma glaucum</i> in Black Sea	Indicates salinity increase and episodic marine connectivity.
c. 9,000-2,000 BP	Reduced sedimentation at Kura Delta	May indicate higher Caspian levels and upstream sediment trapping.
c. 8,500 BP	Arabian gastropod dating	Additional marker of Early Holocene hydrological activity.
c. 8,000 BP	La Marmotta boats (Lake Bracciano)	Advanced watercraft at inland site; may imply different hydrological connectivity.
c. 7,600 BP	Ryan-Pitman Black Sea flood hypothesis	Widely cited but contested; alternatives favour earlier or gradual reconnection.
c. 7,300-6,000 BP	Decline of African Humid Period	Major transition to arid conditions and regional environmental reorganisation

## REFERENCES

- Aksu A.E., Hiscott R.N., Mudie P.J., Rochon A., Kaminski M.A., Abrajano T., Yasar D. Persistent Holocene Outflow from the Black Sea to the Eastern Mediterranean Contradicts Noah's Flood Hypothesis. *GSA Today*, May 2002, Vol. 12, No. 5, 2002, pp. 4-10, [https://doi.org/10.1130/1052-5173\(2002\)012<0004:PHOFTB>2.0.CO;2](https://doi.org/10.1130/1052-5173(2002)012<0004:PHOFTB>2.0.CO;2).
- Aladin N.V., Plotnikov I.S. Large saline lakes of former USSR: a summary review. *Hydrobiologia*, vol. 267, 1993, pp. 1-12, <https://doi.org/10.1007/BF00018787>.
- Allenby R.J. Clustered, rectangular lakes of the Canadian Old Crow Basin. *Tectonophysics*, Vol. 170, Issues 1-2, 1989, pp. 43-56, [https://doi.org/10.1016/0040-1951\(89\)90102-9](https://doi.org/10.1016/0040-1951(89)90102-9).
- Armaş I., Necea D., Miclăuş C. Fluvial terrace formation and controls in the Lower River Danube, SE Romania. *Quaternary International*, Vol. 504, 2019, pp. 5-23, <https://doi.org/10.1016/j.quaint.2018.03.031>.
- Arslanov Kh.A., Yanina T.A., Chepalyga A.L., Svitoch A.A., Makshaev R.R., Maksimov F.E., Chernov S.B., Tertychniy N.I., Starikova A.A. On the age of the Khvalynian deposits of the Caspian Sea coasts according to  $^{14}\text{C}$  and  $^{230}\text{Th}/^{234}\text{U}$  methods. *Quaternary International*, Vol. 409, Part A, 2016, pp. 81-87, <https://doi.org/10.1016/j.quaint.2015.05.067>.
- Astakhov V.I., Grosswald M.G. New data on the age of sediments in the Turgay Valley. *Doklady Akademii Nauk SSSR*, vol. 242, No. 4, 1978, pp. 891-894. (in Russian)
- Australian National Botanic Gardens. Sand dunes. *Australian Vegetation* [online]. Canberra: Australian National Botanic Gardens, 2016. Available at: <https://www.anbg.gov.au/photo/vegetation/sand-dunes.html>
- Badyukova E.N. Genesis of the Baery knolls developed in the Northern Caspian Plain. *Quaternary International* xxx, Vol. 465, Part A, Elsevier, 2016, pp. 11-21, <https://doi.org/10.1016/j.quaint.2016.11.011>.

## ЛИТЕРАТУРА

- Астахов В.И., Гросвальд М.Г. Новые данные о возрасте осадков Тургайской ложбины. *Доклады академии наук СССР*, Т. 242, № 4, 1978, с. 891-894.
- Кесь А.С. Русло Узбой и его генезис. *Труды Института географии. Изд-во Акад. наук СССР, Москва-Ленинград*, Вып. 30, 1939, 123 с.
- Свиточ А.А., Макшаев Р.Р. Шоколадные глины Северного Прикаспия (распространение, условия залегания и строение). *Геоморфология*, № 1, 2015, с. 101-112, <https://doi.org/10.15356/0435-4281-2015-1-101-112>.
- Aksu A.E., Hiscott R.N., Mudie P.J., Rochon A., Kaminski M.A., Abrajano T., Yasar D. Persistent Holocene Outflow from the Black Sea to the Eastern Mediterranean Contradicts Noah's Flood Hypothesis. *GSA Today*, May 2002, Vol. 12, No. 5, 2002, pp. 4-10, [https://doi.org/10.1130/1052-5173\(2002\)012<0004:PHOFTB>2.0.CO;2](https://doi.org/10.1130/1052-5173(2002)012<0004:PHOFTB>2.0.CO;2).
- Aladin N.V., Plotnikov I.S. Large saline lakes of former USSR: a summary review. *Hydrobiologia*, vol. 267, 1993, pp. 1-12, <https://doi.org/10.1007/BF00018787>.
- Allenby R.J. Clustered, rectangular lakes of the Canadian Old Crow Basin. *Tectonophysics*, Vol. 170, Issues 1-2, 1989, pp. 43-56, [https://doi.org/10.1016/0040-1951\(89\)90102-9](https://doi.org/10.1016/0040-1951(89)90102-9).
- Armaş I., Necea D., Miclăuş C. Fluvial terrace formation and controls in the Lower River Danube, SE Romania. *Quaternary International*, Vol. 504, 2019, pp. 5-23, <https://doi.org/10.1016/j.quaint.2018.03.031>.
- Arslanov Kh.A., Yanina T.A., Chepalyga A.L., Svitoch A.A., Makshaev R.R., Maksimov F.E., Chernov S.B., Tertychniy N.I., Starikova A.A. On the age of the Khvalynian deposits of the Caspian Sea coasts according to  $^{14}\text{C}$  and  $^{230}\text{Th}/^{234}\text{U}$  methods. *Quaternary International*, Vol. 409, Part A, 2016, pp. 81-87, <https://doi.org/10.1016/j.quaint.2015.05.067>.
- Australian National Botanic Gardens. Sand dunes. *Australian Vegetation* [online]. Canberra: Australian Na-

- Baker V.R. Chapter 5: Greatest floods–largest rivers, in Gupta, A., editor, *Large Rivers: Geomorphology and Management*. Wiley, N.Y., 2007, pp. 65-74.
- Barka A.A., Akyuz H.S., Altunel E., Sunal G. et al. The surface rupture and slip distribution of the 17 August 1999 İzmit earthquake, M 7.4, North Anatolian Fault. *Bulletin of the Seismological Society of America*, Vol. 92, No. 1, 2002, pp. 43-60, <https://doi.org/10.1785/0120000841>.
- Bayramova A., Abbasov O.R., Aliyev A.A., Baloglanov E.E., Stamm F.M., Dietzel M., Baldermann A. Tracing water–rock–gas reactions in shallow productive mud chambers of active mud volcanoes in the Caspian Sea region, Azerbaijan. *Minerals*, Vol. 13, Issue 5, Article 696, 2023, <https://doi.org/10.3390/min13050696>.
- Blanchet C.L., Frank M., Revel M., Ménot G., Prins M.A., Bishop-Kay C., Schouten S. High- and low-latitude forcing of the Nile River regime during the Holocene inferred from laminated sediments of the Nile deep-sea fan. *Earth and Planetary Science Letters*, Vol. 364, 2013, pp. 98-110, <https://doi.org/10.1016/j.epsl.2013.01.009>.
- Blanchet C.L., Frank M., Schouten S. Asynchronous changes in vegetation, runoff and erosion in the Nile River watershed during the Holocene. *PLOS One*, Vol. 9, No. 12, Article e115958, 2014, <https://doi.org/10.1371/journal.pone.0115958>.
- Bøe R., Rise L., Thorsnes T. Submarine landforms and shallow geology of the Barents Sea. *Norwegian Journal of Geology*, Vol. 89, No. 1-2, 2009, pp. 1-16.
- Boomer I. Chapter 12 – Ostracoda as Indicators of Climatic and Human-Influenced Changes in the Late Quaternary of the Ponto-Caspian Region (Aral, Caspian and Black Seas). *Developments in Quaternary Sciences*, Elsevier, Amsterdam, Vol. 17, 2012, pp. 205-215, <https://doi.org/10.1016/B978-0-444-53636-5.00012-3>.
- Boomer I., von Grafenstein U., Moss A. Lateglacial to early Holocene multiproxy record from Loch Assynt, NW Scotland. *Proceedings of the Geologists' Association, Journal of Quaternary Science*, Vol. 123, Issue 1, 2012, pp. 109-116, <https://doi.org/10.1016/j.pgeola.2011.07.006>.
- Cameron T.D.J., Crosby A., Balson P.S., Jeffery D.H., Lott G.K., Bulat J., Harrison D.J. The geology of the southern North Sea. United Kingdom offshore regional report. British Geological Survey, HMSO, London, 1992.
- Carson C.E., Hussey K.M. The oriented lakes of Arctic Alaska. *Journal of Geology*, Vol. 70, No. 4, 1962, pp. 417-439, <https://doi.org/10.1086/626834>.
- Chekhovskaya M.P., Zenina M.A., Matul A.G., Stepanova A.Yu., Rakowski Z. Ostracod-based paleoreconstructions on the Northern Caspian Sea shelf during the Holocene. *Marine geology*, Vol. 58, 2018, pp. 79-91, <https://doi.org/10.1134/S0001437018010010>.
- Clark J.G.D. Whales as an economic factor in prehistoric Europe. *Antiquity*, Vol. 21, Issue 84, 1947, pp. 84-104, <https://doi.org/10.1017/S0003598X00016513>.
- Cotterill C.J., E. Phillips, James L., Forsberg C.F., Tjelta T.I., Carter G., Dove D. The evolution of the Dogger Bank, North Sea: A complex history of terrestrial, glacial and marine environmental change. *Quaternary Botanic Gardens*, 2016. Available at: <https://www.anbg.gov.au/photo/vegetation/sand-dunes.html>.
- Badyukova E.N. Genesis of the Baery knolls developed in the Northern Caspian Plain. *Quaternary International xxx*, Vol. 465, Part A, Elsevier, 2016, pp. 11-21, <https://doi.org/10.1016/j.quaint.2016.11.011>.
- Baker V.R. Chapter 5: Greatest floods–largest rivers, in Gupta, A., editor, *Large Rivers: Geomorphology and Management*. Wiley, N.Y., 2007, pp. 65-74.
- Barka A.A., Akyuz H.S., Altunel E., Sunal G. et al. The surface rupture and slip distribution of the 17 August 1999 İzmit earthquake, M 7.4, North Anatolian Fault. *Bulletin of the Seismological Society of America*, Vol. 92, No. 1, 2002, pp. 43-60, <https://doi.org/10.1785/0120000841>.
- Bayramova A., Abbasov O.R., Aliyev A.A., Baloglanov E.E., Stamm F.M., Dietzel M., Baldermann A. Tracing water–rock–gas reactions in shallow productive mud chambers of active mud volcanoes in the Caspian Sea region, Azerbaijan. *Minerals*, Vol. 13, Issue 5, Article 696, 2023, <https://doi.org/10.3390/min13050696>.
- Blanchet C.L., Frank M., Revel M., Ménot G., Prins M.A., Bishop-Kay C., Schouten S. High- and low-latitude forcing of the Nile River regime during the Holocene inferred from laminated sediments of the Nile deep-sea fan. *Earth and Planetary Science Letters*, Vol. 364, 2013, pp. 98-110, <https://doi.org/10.1016/j.epsl.2013.01.009>.
- Blanchet C.L., Frank M., Schouten S. Asynchronous changes in vegetation, runoff and erosion in the Nile River watershed during the Holocene. *PLOS One*, Vol. 9, No. 12, Article e115958, 2014, <https://doi.org/10.1371/journal.pone.0115958>.
- Bøe R., Rise L., Thorsnes T. Submarine landforms and shallow geology of the Barents Sea. *Norwegian Journal of Geology*, Vol. 89, No. 1-2, 2009, pp. 1-16.
- Boomer I. Chapter 12 – Ostracoda as Indicators of Climatic and Human-Influenced Changes in the Late Quaternary of the Ponto-Caspian Region (Aral, Caspian and Black Seas). *Developments in Quaternary Sciences*, Elsevier, Amsterdam, Vol. 17, 2012, pp. 205-215, <https://doi.org/10.1016/B978-0-444-53636-5.00012-3>.
- Boomer I., von Grafenstein U., Moss A. Lateglacial to early Holocene multiproxy record from Loch Assynt, NW Scotland. *Proceedings of the Geologists' Association, Journal of Quaternary Science*, Vol. 123, Issue 1, 2012, pp. 109-116, <https://doi.org/10.1016/j.pgeola.2011.07.006>.
- Cameron T.D.J., Crosby A., Balson P.S., Jeffery D.H., Lott G.K., Bulat J., Harrison D.J. The geology of the southern North Sea. United Kingdom offshore regional report. British Geological Survey, HMSO, London, 1992.
- Carson C.E., Hussey K.M. The oriented lakes of Arctic Alaska. *Journal of Geology*, Vol. 70, No. 4, 1962, pp. 417-439, <https://doi.org/10.1086/626834>.
- Chekhovskaya M.P., Zenina M.A., Matul A.G., Stepanova A.Yu., Rakowski Z. Ostracod-based paleoreconstructions on the Northern Caspian Sea shelf during the Holocene. *Marine geology*, Vol. 58, 2018, pp. 79-91, <https://doi.org/10.1134/S0001437018010010>.
- Clark J.G.D. Whales as an economic factor in prehistoric Europe. *Antiquity*, Vol. 21, Issue 84, 1947, pp. 84-104, <https://doi.org/10.1017/S0003598X00016513>.
- Cotterill C.J., E. Phillips, James L., Forsberg C.F., Tjelta T.I., Carter G., Dove D. The evolution of the Dogger Bank, North Sea: A complex history of terrestrial, glacial and marine environmental change. *Quaternary*

- Science Reviews, Vol. 171, 2017, pp. 136-153, <https://doi.org/10.1016/j.quascirev.2017.07.006>.
- Darwin C.R. Geological observations on South America. Being the third part of the geology of the voyage of the Beagle, under the command of Capt. Fitzroy, R.N. during the years 1832 to 1836. London: Smith Elder and Co., 1846.
- Diodorus Siculus. Library of History, Volume I, Books 1-2.34. Translated by C. H. Oldfather. Loeb Classical Library 279. Cambridge, MA: Harvard University Press, 1933.
- Dolukhanov P.M., Chepalyga A.L., Shkatova V.K., Lavrentiev N.V. Late Quaternary Caspian: Sea-levels, environments and human settlement. The Open Geography Journal, Vol. 2, 2009, pp. 1-15, <https://doi.org/10.2174/1874923200902010001>.
- El Bastawesy M. The geomorphological and hydrogeological evidences for a Holocene deluge in Arabia. Arabian Journal of Geosciences, Vol. 8, 2014, pp. 2577-2586, <https://doi.org/10.1007/s12517-014-1396-9>.
- Erturaç M.K. Late Pleistocene–Holocene characteristics of the North Anatolian Fault at Adapazarı Basin: Evidence from the age and geometry of the fluvial terrace staircases. Turkish Journal of Earth Sciences, Vol. 30, No. 1, 2021, pp. 93-115, <https://doi.org/10.3906/yer-2006-25>.
- Fink J., Haase G., Ruske R. Bemerkungen zur Lösskarte von Europa 1:2,5 Mio. Petermanns Geographische Mitteilungen, Vol. 121, No. 2, 1977, pp. 81-94.
- Fitzsimmons K.E., Magee J.W., Amos K.J. Characterisation of aeolian sediments from the Strzelecki and Tirari Deserts, Australia: Implications for reconstructing palaeoenvironmental conditions. Sedimentary Geology, Vol. 218, Issues 1-4, 2007, pp. 61-73, <https://doi.org/10.1016/j.sedgeo.2009.04.004>.
- Gallagher R. Discussions: The Ice Age rise and fall of the Ponto Caspian: ancient mariners and the Asiatic Mediterranean. Stratigraphy and Sedimentology of Oil-Gas Basin, No. 2, 2011, pp. 48-68.
- Gallagher R. Observations on late Pleistocene flooding of the Eurasian continental interior and possible alluvial origin of loess. In: A. Gilbert and V. Yanko-Hombach, eds. Proceedings of the First Plenary Conference and Field Trip. IGCP 610 From the Caspian to Mediterranean: Environmental Change and Human Response during the Quaternary. Institute of Earth Sciences, Iliia State University, Georgia, Tbilisi, 2013, pp. 59-62.
- Gallagher R. Observations of Caspian strandlines, their use as highstand indicators with consideration for their implications with regard to regional geomorphology, paleodrainage, and biodiversity. In: A. Gilbert, V. Yanko-Hombach (eds.). Proceedings of UNESCO-IUGS-IGCP 610 and INQUA IFG POCAS Joint Plenary Conference and Field Trip, October 14-21, 2018, Antalya, Turkey, Istanbul, Doküman Evi, 2018, pp. 69-76.
- Gibaja J.F. et al. The first Neolithic boats in the Mediterranean: The settlement (La Marmotta, Anguillara Sabazia, Lazio, Italy). PLOS ONE, Vol. 19, No. 03, Article e0299765, 2024, <https://doi.org/10.1371/journal.pone.0299765>.
- Clark J.G.D. Whales as an economic factor in prehistoric Europe. Antiquity, Vol. 21, Issue 84, 1947, pp. 84-104, <https://doi.org/10.1017/S0003598X00016513>.
- Cotterill C.J., E. Phillips, James L., Forsberg C.F., Tjelta T.I., Carter G., Dove D. The evolution of the Dogger Bank, North Sea: A complex history of terrestrial, glacial and marine environmental change. Quaternary Science Reviews, Vol. 171, 2017, pp. 136-153, <https://doi.org/10.1016/j.quascirev.2017.07.006>.
- Darwin C.R. Geological observations on South America. Being the third part of the geology of the voyage of the Beagle, under the command of Capt. Fitzroy, R.N. during the years 1832 to 1836. London: Smith Elder and Co., 1846.
- Diodorus Siculus. Library of History, Volume I, Books 1-2.34. Translated by C. H. Oldfather. Loeb Classical Library 279. Cambridge, MA: Harvard University Press, 1933.
- Dolukhanov P.M., Chepalyga A.L., Shkatova V.K., Lavrentiev N.V. Late Quaternary Caspian: Sea-levels, environments and human settlement. The Open Geography Journal, Vol. 2, 2009, pp. 1-15, <https://doi.org/10.2174/1874923200902010001>.
- El Bastawesy M. The geomorphological and hydrogeological evidences for a Holocene deluge in Arabia. Arabian Journal of Geosciences, Vol. 8, 2014, pp. 2577-2586, <https://doi.org/10.1007/s12517-014-1396-9>.
- Erturaç M.K. Late Pleistocene–Holocene characteristics of the North Anatolian Fault at Adapazarı Basin: Evidence from the age and geometry of the fluvial terrace staircases. Turkish Journal of Earth Sciences, Vol. 30, No. 1, 2021, pp. 93-115, <https://doi.org/10.3906/yer-2006-25>.
- Fink J., Haase G., Ruske R. Bemerkungen zur Lösskarte von Europa 1:2,5 Mio. Petermanns Geographische Mitteilungen, Vol. 121, No. 2, 1977, pp. 81-94.
- Fitzsimmons K.E., Magee J.W., Amos K.J. Characterisation of aeolian sediments from the Strzelecki and Tirari Deserts, Australia: Implications for reconstructing palaeoenvironmental conditions. Sedimentary Geology, Vol. 218, Issues 1-4, 2007, pp. 61-73, <https://doi.org/10.1016/j.sedgeo.2009.04.004>.
- Gallagher R. Discussions: The Ice Age rise and fall of the Ponto Caspian: ancient mariners and the Asiatic Mediterranean. Stratigraphy and Sedimentology of Oil-Gas Basin, No. 2, 2011, pp. 48-68.
- Gallagher R. Observations on late Pleistocene flooding of the Eurasian continental interior and possible alluvial origin of loess. In: A. Gilbert and V. Yanko-Hombach, eds. Proceedings of the First Plenary Conference and Field Trip. IGCP 610 From the Caspian to Mediterranean: Environmental Change and Human Response during the Quaternary. Institute of Earth Sciences, Iliia State University, Georgia, Tbilisi, 2013, pp. 59-62.
- Gallagher R. Observations of Caspian strandlines, their use as highstand indicators with consideration for their implications with regard to regional geomorphology, paleodrainage, and biodiversity. In: A. Gilbert, V. Yanko-Hombach (eds.). Proceedings of UNESCO-IUGS-IGCP 610 and INQUA IFG POCAS Joint Plenary Conference and Field Trip, October 14-21, 2018, Antalya, Turkey, Istanbul, Doküman Evi, 2018, pp. 69-76.
- Gibaja J.F. et al. The first Neolithic boats in the Mediterranean: The settlement (La Marmotta, Anguillara Sabazia, Lazio, Italy). PLOS ONE, Vol. 19, No. 03, Article e0299765, 2024, <https://doi.org/10.1371/journal.pone.0299765>.

- Grosswald M.G., Hughes T.J., Lasca N.P. Oriented lake-and-ridge assemblages of the Arctic coastal plains: Glacial landforms modified by thermokarst and solifluction. *Polar Record*, Vol. 35, Issue 194, 1999, pp. 215-230, <https://doi.org/10.1017/S0032247400015503>.
- Gurbuz A., Leroy S.A.G. Science versus myth: was there a connection between the Marmara Sea and Lake Sapanca? *Journal of Quaternary Science*, Vol. 25, No. 2, 2010, pp. 103-114, <https://doi.org/10.1002/jqs.1312>.
- Hesse P.P. The Australian desert dunefields: formation and evolution in an old, flat, dry continent. *Geological Society, Special Publications*, London, Vol. 346, No. 1, 2010, pp. 141-164, <https://doi.org/10.1144/SP346.9>.
- Hinkel K.M., Frohn R.C., Nelson F.E., Eisner W.R., Beck R.A. Morphometric and spatial analysis of thaw lakes and drained thaw lake basins in the western Arctic Coastal Plain, Alaska. *Permafrost and Periglacial Processes*, Vol. 16, Issue 4, 2005, pp. 327-341, <https://doi.org/10.1002/ppp.532>.
- Hiscott R.N., Aksu A.E., Yaşar D., Kaminski M.A., Mudie P.J., Kostylev V.E., MacDonald J.C., İşler F.I., Lord A.R. Deltas south of the Bosphorus Strait record persistent Black Sea outflow to the Marmara Sea since ~10 ka. *Marine Geology*, Vol. 190, Issue 1-2, 2002, pp. 95-118, [https://doi.org/10.1016/S0025-3227\(02\)00344-4](https://doi.org/10.1016/S0025-3227(02)00344-4).
- Hiscott R.N., Aksu A.E., Mudie P.J., Marret F., Abrajano T., Kaminski M.A., Evans J., Çakiroğlu A.I., Yaşar D. A gradual drowning of the southwestern Black Sea shelf: evidence for a progressive rather than abrupt Holocene reconnection with the eastern Mediterranean Sea through the Marmara Sea Gateway. *Quaternary International*, Vol. 167-168, 2007, pp. 19-34, <https://doi.org/10.1016/j.quaint.2006.11.007>.
- Hoffecker J.F. A prehistory of the North: human settlement of the higher latitudes. Rutgers University Press, New Brunswick, 2005, 248 p.
- Hoogendoorn R.M., Boels J.F., Kroonenberg S.B., Simmons M.D., Aliyeva E., Babazadeh A.D., Huseynov D. Development of the Kura delta, Azerbaijan: A record of Holocene Caspian sea-level changes. *Marine Geology*, Vol. 222-223, 2005, pp. 359-380, <https://doi.org/10.1016/j.margeo.2005.06.007>.
- Jensen T.Z.T., Sjöström A., Fischer A., Rosengren E., Lanigan L.T., Bennike O., Richter K.K., Gron K.J., Mackie M., Mortensen M.F., Sørensen L., Chivall D., Iversen K.H., Taurozzi A.J., Olsen J., Schroeder H., Milner N., Sørensen M., Collins M.J. An integrated analysis of Maglemose bone points reframes the Early Mesolithic of Southern Scandinavia. *Scientific Reports*, Vol. 10, Article 17244, 2020, <https://doi.org/10.1038/s41598-020-74258-8>.
- Kes A.S. Uzboy channel and its genesis. In: A.A. Grigoriev, ed. *Proceedings of the Institute of Geography, AN SSSR Press, Moscow-Leningrad*, Issue 30, 1939, 123 p. (in Russian)
- King E.L., Bøe R., Bellec V.K., Rise L., Skarðhamar J., Ferré B., Dolan M.F.J. Contour-current-driven continental-slope sandwaves with effects from secondary current processes on the Barents Sea margin offshore Norway. *Marine Geology*, Vol. 353, 2014, pp. 108-127, <https://doi.org/10.1016/j.margeo.2014.04.003>.
- 21, 2018, Antalya. Turkey, Istanbul, Doküman Evi, 2018, pp. 69-76.
- Gibaja J.F. et al. The first Neolithic boats in the Mediterranean: The settlement (La Marmotta, Anguillara Sabazia, Lazio, Italy). *PLOS ONE*, Vol. 19, No. 03, Article e0299765, 2024, <https://doi.org/10.1371/journal.pone.0299765>.
- Grosswald M.G., Hughes T.J., Lasca N.P. Oriented lake-and-ridge assemblages of the Arctic coastal plains: Glacial landforms modified by thermokarst and solifluction. *Polar Record*, Vol. 35, Issue 194, 1999, pp. 215-230, <https://doi.org/10.1017/S0032247400015503>.
- Gurbuz A., Leroy S.A.G. Science versus myth: was there a connection between the Marmara Sea and Lake Sapanca? *Journal of Quaternary Science*, Vol. 25, No. 2, 2010, pp. 103-114, <https://doi.org/10.1002/jqs.1312>.
- Hesse P.P. The Australian desert dunefields: formation and evolution in an old, flat, dry continent. *Geological Society, Special Publications*, London, Vol. 346, No. 1, 2010, pp. 141-164, <https://doi.org/10.1144/SP346.9>.
- Hinkel K.M., Frohn R.C., Nelson F.E., Eisner W.R., Beck R.A. Morphometric and spatial analysis of thaw lakes and drained thaw lake basins in the western Arctic Coastal Plain, Alaska. *Permafrost and Periglacial Processes*, Vol. 16, Issue 4, 2005, pp. 327-341, <https://doi.org/10.1002/ppp.532>.
- Hiscott R.N., Aksu A.E., Yaşar D., Kaminski M.A., Mudie P.J., Kostylev V.E., MacDonald J.C., İşler F.I., Lord A.R. Deltas south of the Bosphorus Strait record persistent Black Sea outflow to the Marmara Sea since ~10 ka. *Marine Geology*, Vol. 190, Issue 1-2, 2002, pp. 95-118, [https://doi.org/10.1016/S0025-3227\(02\)00344-4](https://doi.org/10.1016/S0025-3227(02)00344-4).
- Hiscott R.N., Aksu A.E., Yaşar D., Kaminski M.A., Mudie P.J., Kostylev V.E., MacDonald J.C., İşler F.I., Lord A.R. Deltas south of the Bosphorus Strait record persistent Black Sea outflow to the Marmara Sea since ~10 ka. *Marine Geology*, Vol. 190, Issue 1-2, 2002, pp. 95-118, [https://doi.org/10.1016/S0025-3227\(02\)00344-4](https://doi.org/10.1016/S0025-3227(02)00344-4).
- Hiscott R.N., Aksu A.E., Mudie P.J., Marret F., Abrajano T., Kaminski M.A., Evans J., Çakiroğlu A.I., Yaşar D. A gradual drowning of the southwestern Black Sea shelf: evidence for a progressive rather than abrupt Holocene reconnection with the eastern Mediterranean Sea through the Marmara Sea Gateway. *Quaternary International*, Vol. 167-168, 2007, pp. 19-34, <https://doi.org/10.1016/j.quaint.2006.11.007>.
- Hoffecker J.F. A prehistory of the North: human settlement of the higher latitudes. Rutgers University Press, New Brunswick, 2005, 248 p.
- Hoogendoorn R.M., Boels J.F., Kroonenberg S.B., Simmons M.D., Aliyeva E., Babazadeh A.D., Huseynov D. Development of the Kura delta, Azerbaijan: A record of Holocene Caspian sea-level changes. *Marine Geology*, Vol. 222-223, 2005, pp. 359-380, <https://doi.org/10.1016/j.margeo.2005.06.007>.
- Jensen T.Z.T., Sjöström A., Fischer A., Rosengren E., Lanigan L.T., Bennike O., Richter K.K., Gron K.J., Mackie M., Mortensen M.F., Sørensen L., Chivall D., Iversen K.H., Taurozzi A.J., Olsen J., Schroeder H., Milner N., Sørensen M., Collins M.J. An integrated analysis of Maglemose bone points reframes the Early Mesolithic of Southern Scandinavia. *Scientific Reports*, Vol. 10, Article 17244, 2020, <https://doi.org/10.1038/s41598-020-74258-8>.
- King E.L., Bøe R., Bellec V.K., Rise L., Skarðhamar J., Ferré B., Dolan M.F.J. Contour-current-driven continental-slope sandwaves with effects from secondary

- Kuehl S.A., Levy B.M., Moore W.S., Allison M.A. Subaqueous delta of the Ganges-Brahmaputra river system. *Marine Geology*, Vol. 144, Issues 1-3, 1997, pp. 81-96, [https://doi.org/10.1016/S0025-3227\(97\)00075-3](https://doi.org/10.1016/S0025-3227(97)00075-3).
- Komatsu G., Baker V.R., Arzhannikov S.G., Gallagher R., Arzhannikova A.V., Murana A., Oguchi T. Catastrophic flooding, palaeolakes, and late Quaternary drainage reorganization in northern Eurasia. *International Geology Review*, 2015, <https://doi.org/10.1080/00206814.2015.1048314>.
- Lambeck K., Rouby H., Purdy G., Sun Y., Sambridge M. Sea level and global ice volumes from the Last Glacial Maximum to the Holocene. *Proceedings of the National Academy of Sciences*, Vol. 111, No. 43, 2014, pp. 15296-15303, <https://doi.org/10.1073/pnas.141176211>.
- Leontyev O.K. Over-all features of the geomorphology and evolution of the Aserbaydzhan coast of the Caspian Sea. *International Geology Review*, Vol. 5, Issue 6, 1963, pp. 671-691, <https://doi.org/10.1080/00206816309473807>.
- Leroy S.A.G., Albay M. Palynomorphs of brackish and marine species in cores from the freshwater Lake Sapanca, NW Turkey. *Review of Palaeobotany and Palynology*, Vol. 160, Issue 3-4, 2010, pp. 181-188, <https://doi.org/10.1016/j.revpalbo.2010.02.011>.
- Leroy S.A.G., Boyraz S., Gürbüz A. High-resolution palynological analysis in Lake Sapanca as a tool to detect recent earthquakes on the North Anatolian Fault. *Quaternary Science Reviews*, Vol. 28, Issues 25-26, 2009, pp. 2616-2632, <https://doi.org/10.1016/j.quascirev.2009.05.018>.
- Levchenko O.V., Putans V.A., Borisov D.G. Contourites in the Derbent Basin, Caspian Sea (Geophysical Data). *Doklady Earth Sciences*, Vol. 482, 2018, pp. 1239-1243, doi:10.1134/s1028334x18090258.
- Major C.O., Goldstein S.L., Ryan W.B.F., Lericolais G., Piotrowski A.M., Hajdas I. The co-evolution of Black Sea level and composition through the last deglaciation and its paleoclimatic significance. *Quaternary Science Reviews*, Vol. 25, No. 17-18, 2006, pp. 2031-2047, <https://doi.org/10.1016/j.quascirev.2006.01.032>.
- Mangerud J., Astakhov V., Murray A., Svendsen J.I. Ice-dammed lakes and rerouting of the drainage of northern Eurasia during the Last Glaciation. *Quaternary Science Reviews*, Vol. 23, Issues 11-13, 2004, pp. 1313-1332, <https://doi.org/10.1016/j.quascirev.2003.12.009>.
- Marks L., Salem A., Welc F., Nitychoruk J., Chen Z., Blaauw M., Zalat A., Majecka A., Szymanek M., Chodyka M., Tołoczko-Pasek A., Sun Q., Zhao X., Jiang J. Holocene lake sediments from the Faiyum Oasis in Egypt: A record of environmental and climate change. *Boreas*, Vol. 47, Issue 1, 2018, pp. 62-79, <https://doi.org/10.1111/bor.12251>.
- McGee D., deMenocal P.B., Winckler G., Stuut J.-B.W., Bradtmiller L.I. The magnitude, timing and abruptness of changes in North African dust deposition over the last 20,000 yr. *Earth and Planetary Science Letters*, Vol. 371-372, 2013, pp. 163-176, <https://doi.org/10.1016/j.epsl.2013.03.054>.
- McMaster P. Determining the ages of sub-fossil cetacean remains, found in the Carse of Stirling, Scotland. MRes thesis, University of Glasgow, 2024, <https://doi.org/10.5525/gla.thesis.84037>.
- current processes on the Barents Sea margin offshore Norway. *Marine Geology*, Vol. 353, 2014, pp. 108-127, <https://doi.org/10.1016/j.margeo.2014.04.003>.
- Kuehl S.A., Levy B.M., Moore W.S., Allison M.A. Subaqueous delta of the Ganges-Brahmaputra river system. *Marine Geology*, Vol. 144, Issues 1-3, 1997, pp. 81-96, [https://doi.org/10.1016/S0025-3227\(97\)00075-3](https://doi.org/10.1016/S0025-3227(97)00075-3).
- Komatsu G., Baker V.R., Arzhannikov S.G., Gallagher R., Arzhannikova A.V., Murana A., Oguchi T. Catastrophic flooding, palaeolakes, and late Quaternary drainage reorganization in northern Eurasia. *International Geology Review*, 2015, <https://doi.org/10.1080/00206814.2015.1048314>.
- Lambeck K., Rouby H., Purdy G., Sun Y., Sambridge M. Sea level and global ice volumes from the Last Glacial Maximum to the Holocene. *Proceedings of the National Academy of Sciences*, Vol. 111, No. 43, 2014, pp. 15296-15303, <https://doi.org/10.1073/pnas.141176211>.
- Leontyev O.K. Over-all features of the geomorphology and evolution of the Aserbaydzhan coast of the Caspian Sea. *International Geology Review*, Vol. 5, Issue 6, 1963, pp. 671-691, <https://doi.org/10.1080/00206816309473807>.
- Leroy S.A.G., Albay M. Palynomorphs of brackish and marine species in cores from the freshwater Lake Sapanca, NW Turkey. *Review of Palaeobotany and Palynology*, Vol. 160, Issue 3-4, 2010, pp. 181-188, <https://doi.org/10.1016/j.revpalbo.2010.02.011>.
- Leroy S.A.G., Boyraz S., Gürbüz A. High-resolution palynological analysis in Lake Sapanca as a tool to detect recent earthquakes on the North Anatolian Fault. *Quaternary Science Reviews*, Vol. 28, Issues 25-26, 2009, pp. 2616-2632, <https://doi.org/10.1016/j.quascirev.2009.05.018>.
- Levchenko O.V., Putans V.A., Borisov D.G. Contourites in the Derbent Basin, Caspian Sea (Geophysical Data). *Doklady Earth Sciences*, Vol. 482, 2018, pp. 1239-1243, doi:10.1134/s1028334x18090258.
- Major C.O., Goldstein S.L., Ryan W.B.F., Lericolais G., Piotrowski A.M., Hajdas I. The co-evolution of Black Sea level and composition through the last deglaciation and its paleoclimatic significance. *Quaternary Science Reviews*, Vol. 25, No. 17-18, 2006, pp. 2031-2047, <https://doi.org/10.1016/j.quascirev.2006.01.032>.
- Mangerud J., Astakhov V., Murray A., Svendsen J.I. Ice-dammed lakes and rerouting of the drainage of northern Eurasia during the Last Glaciation. *Quaternary Science Reviews*, Vol. 23, Issues 11-13, 2004, pp. 1313-1332, <https://doi.org/10.1016/j.quascirev.2003.12.009>.
- Marks L., Salem A., Welc F., Nitychoruk J., Chen Z., Blaauw M., Zalat A., Majecka A., Szymanek M., Chodyka M., Tołoczko-Pasek A., Sun Q., Zhao X., Jiang J. Holocene lake sediments from the Faiyum Oasis in Egypt: A record of environmental and climate change. *Boreas*, Vol. 47, Issue 1, 2018, pp. 62-79, <https://doi.org/10.1111/bor.12251>.
- McGee D., deMenocal P.B., Winckler G., Stuut J.-B.W., Bradtmiller L.I. The magnitude, timing and abruptness of changes in North African dust deposition over the last 20,000 yr. *Earth and Planetary Science Letters*, Vol. 371-372, 2013, pp. 163-176, <https://doi.org/10.1016/j.epsl.2013.03.054>.
- McMaster P. Determining the ages of sub-fossil cetacean

- Montgomery D.R. *The Rocks Don't Lie: A Geologist Investigates Noah's Flood*. New York: W.W. Norton & Company, 2012, 320 p.
- Musaelyan R.E., Lebedeva M.P., Rostovtseva Y.V., Varlamov E.B. Lithological-mineralogical characteristics of the Lower Khvalynian chocolate clays of the Lower Volga region (a case study of Raygorod and Srednyaya Akhtubas sections). *Geomorphologiya i Paleogeografiya*, Vol. 53, No. 3, 2022, pp. 96-106, <https://doi.org/10.31857/S0435428122030105>.
- Nazik A., Meriç E., Avşar N., Ünlü S., Esenli V., Gökaşan E. Possible waterways between the Marmara Sea and the Black Sea in the late Quaternary: evidence from ostracod and foraminifer assemblages in lakes İznik and Sapanca, Turkey. *Geo-Marine Letters*, Vol. 31, 2011, pp. 75-86, <https://doi.org/10.1007/s00367-010-0216-9>.
- Nazik A., Meriç E., Avsar N. Reply to Discussion: A critique of "Possible waterways between the Marmara Sea and the Black Sea in the late Quaternary": evidence from ostracod and foraminifer assemblages in lakes İznik and Sapanca, Turkey, *Geo-Marine Letters*, 2011. *Geo-Marine Letters*, Heidelberg, 2012, Vol. 32, Issue 3, pp. 275-277, <https://doi.org/10.1007/s00367-012-0281-3>.
- Nikula R., Väinölä R. Phylogeography of *Cerastoderma glaucum* (Bivalvia: Cardiidae) across Europe: A major break in the Eastern Mediterranean. *Marine Biology*, Vol. 143, 2003, pp. 339-350, <https://doi.org/10.1007/s00227-003-1088-6>.
- Pehlivanoglou K., Tsirambides A., Trontsios G. Origin and distribution of clay minerals in the Alexandroupolis Gulf, Aegean Sea, Greece. *Estuarine, Coastal and Shelf Science*, Vol. 51, Issue 1, 2000, pp. 61-73, <https://doi.org/10.1006/ecss.1999.0620>.
- Petrie W.M.F. Origin of the Book of the Dead. *Ancient Egypt*, Part II, June, 1926, pp. 41-45. (Transcription by Gallagher R. [https://www.academia.edu/45249451/THE\\_ORIGINS\\_OF\\_THE\\_BOOK\\_OF\\_THE\\_DEAD](https://www.academia.edu/45249451/THE_ORIGINS_OF_THE_BOOK_OF_THE_DEAD))
- Plafker G. Oriented lakes and lineaments of northeastern Bolivia. *Geological Society of America Bulletin*, Vol. 75, No. 6, 1964, pp. 503-522.
- Prestwich J. A possible cause for the origin of the tradition of the Flood. *Journal of the Transactions of the Victoria Institute*, Vol. 27, 1893-1894, pp. 263-305.
- Rise L., Ottesen D., Berg K., Lundin E. Large-scale development of the mid-Norwegian margin during the last 3 million years. *Marine and Petroleum Geology*, Vol. 22, Issues 1-2, 2005, pp. 33-44, <https://doi.org/10.1016/j.marpetgeo.2004.10.010>.
- Roussakis G., Karageorgis A.P., Conispoliatis N., Lykousis V. Last glacial-Holocene sediment sequences in N. Aegean basins: structure, accumulation rates and clay mineral distribution. *Geo-Marine Letters*, Vol. 24, 2004, pp. 97-111, <https://doi.org/10.1007/s00367-004-0167-0>.
- Rowland J.M., Hamdan M.A. The Holocene evolution of the Quesna turtle-back: Geological evolution and archaeological relationships within the Nile Delta. In J.Kabaciński, M.Chłodnicki, M.Kobusiewicz (Eds.), *Prehistory of northeastern Africa, new ideas and dis-*remains, found in the Carse of Stirling, Scotland. MRes thesis, University of Glasgow, 2024, <https://doi.org/10.5525/gla.thesis.84037>.
- Montgomery D.R. *The Rocks Don't Lie: A Geologist Investigates Noah's Flood*. New York: W.W. Norton & Company, 2012, 320 p.
- Musaelyan R.E., Lebedeva M.P., Rostovtseva Y.V., Varlamov E.B. Lithological-mineralogical characteristics of the Lower Khvalynian chocolate clays of the Lower Volga region (a case study of Raygorod and Srednyaya Akhtubas sections). *Geomorphologiya i Paleogeografiya*, Vol. 53, No. 3, 2022, pp. 96-106, <https://doi.org/10.31857/S0435428122030105>.
- Nazik A., Meriç E., Avşar N., Ünlü S., Esenli V., Gökaşan E. Possible waterways between the Marmara Sea and the Black Sea in the late Quaternary: evidence from ostracod and foraminifer assemblages in lakes İznik and Sapanca, Turkey. *Geo-Marine Letters*, Vol. 31, 2011, pp. 75-86, <https://doi.org/10.1007/s00367-010-0216-9>.
- Nazik A., Meriç E., Avsar N. Reply to Discussion: A critique of "Possible waterways between the Marmara Sea and the Black Sea in the late Quaternary": evidence from ostracod and foraminifer assemblages in lakes İznik and Sapanca, Turkey, *Geo-Marine Letters*, 2011. *Geo-Marine Letters*, Heidelberg, 2012, Vol. 32, Issue 3, pp. 275-277, <https://doi.org/10.1007/s00367-012-0281-3>.
- Nikula R., Väinölä R. Phylogeography of *Cerastoderma glaucum* (Bivalvia: Cardiidae) across Europe: A major break in the Eastern Mediterranean. *Marine Biology*, Vol. 143, 2003, pp. 339-350, <https://doi.org/10.1007/s00227-003-1088-6>.
- Pehlivanoglou K., Tsirambides A., Trontsios G. Origin and distribution of clay minerals in the Alexandroupolis Gulf, Aegean Sea, Greece. *Estuarine, Coastal and Shelf Science*, Vol. 51, Issue 1, 2000, pp. 61-73, <https://doi.org/10.1006/ecss.1999.0620>.
- Petrie W.M.F. Origin of the Book of the Dead. *Ancient Egypt*, Part II, June, 1926, pp. 41-45. (Transcription by Gallagher R. [https://www.academia.edu/45249451/THE\\_ORIGINS\\_OF\\_THE\\_BOOK\\_OF\\_THE\\_DEAD](https://www.academia.edu/45249451/THE_ORIGINS_OF_THE_BOOK_OF_THE_DEAD))
- Plafker G. Oriented lakes and lineaments of northeastern Bolivia. *Geological Society of America Bulletin*, Vol. 75, No. 6, 1964, pp. 503-522.
- Prestwich J. A possible cause for the origin of the tradition of the Flood. *Journal of the Transactions of the Victoria Institute*, Vol. 27, 1893-1894, pp. 263-305.
- Rise L., Ottesen D., Berg K., Lundin E. Large-scale development of the mid-Norwegian margin during the last 3 million years. *Marine and Petroleum Geology*, Vol. 22, Issues 1-2, 2005, pp. 33-44, <https://doi.org/10.1016/j.marpetgeo.2004.10.010>.
- Roussakis G., Karageorgis A.P., Conispoliatis N., Lykousis V. Last glacial-Holocene sediment sequences in N. Aegean basins: structure, accumulation rates and clay mineral distribution. *Geo-Marine Letters*, Vol. 24, 2004, pp. 97-111, <https://doi.org/10.1007/s00367-004-0167-0>.
- Rowland J.M., Hamdan M.A. The Holocene evolution of the Quesna turtle-back: Geological evolution and ar-

- coveries, studies in African archaeology, Vol. 11, 2012, pp. 11-24.
- Ryan W.B.F., Pitman W.C. Noah's Flood: the new scientific discoveries about the event that changed history. Simon & Schuster, New York, 1998.
- Ryan W.B.F., Pitman III W.C., Major C.O., Shimkus K., Moskalenko V., Jones G.A., Dimitrov P., Gorür N., Sakiñç M., Yüce H. An abrupt drowning of the Black Sea shelf. *Marine Geology*, Vol. 138, Issues 1-2, 1997, pp. 119-126, [https://doi.org/10.1016/S0025-3227\(97\)00007-8](https://doi.org/10.1016/S0025-3227(97)00007-8).
- Rychagov G.I. Holocene oscillations of the Caspian Sea, and forecasts based on palaeogeographical reconstructions. *Quaternary International*, Vol. 41-42, 1997, pp. 167-172, [https://doi.org/10.1016/S1040-6182\(96\)00049-3](https://doi.org/10.1016/S1040-6182(96)00049-3).
- Sandford K.S., Arkell A.J. Palaeolithic man and the Nile–Faiyum Divide: a study of the region during Pliocene and Pleistocene times. University of Chicago Press, Chicago, Vol. 1, 1929.
- Sarikaya M.A., Çiner A. Late Pleistocene glaciations and paleoclimate of Turkey. *Bulletin of the Mineral Research and Exploration*, Vol. 151, 2015, pp. 107-127, <https://doi.org/10.19111/bmre.35245>.
- Seguin J., Avramidis P., Haug A., Kessler T., Schimmelmann A., Unkel I. Reconstruction of palaeoenvironmental variability based on an inter-comparison of four lacustrine archives on the Peloponnese (Greece) for the last 5000 years. *E&G Quaternary Science Journal*, Vol. 69, No. 2, 2020, pp. 165-186, <https://doi.org/10.5194/egqsj-69-165-2020>.
- Sejrup H.P., Larsen E., Haflidason H., Berstad I.M., Hjelstuen B.O., Jonsdottir H., King E.L., Landvik J., Longva O., Nygård A., Ottesen D., Raunholm S., Rise L., Stalsberg K. Configuration, history and impact of the Norwegian Channel Ice Stream. *Boreas*, Vol. 32, Issue 1, 2003, pp. 18-36, <https://doi.org/10.1080/03009480310001029>.
- Semikolennykh D., Panin A., Zazovskaya E. Radiocarbon dating of the end of the latest Caspian Sea overflow through the Manych Depression (southeastern European Plain). *Radiocarbon*, Vol. 67, Issue 2, 2025, pp. 331-346, <https://doi.org/https://doi.org/10.1017/RDC.2024.135>.
- Shtienberg G., Yasur-Landau A., Norris R.D., Lazar M., Rittenour T.M., Tamberino A., Gadol O., Cantu K., Arkin-Shalev E., Ward S.N., Levy T.E. A Neolithic megatsunami event in the eastern Mediterranean: Prehistoric settlement vulnerability along the Carmel coast, Israel. *PLOS ONE*, Vol. 15, No. 12, Article e0235837, 2020, <https://doi.org/10.1371/journal.pone.0243619>.
- Smalley I. Making the material: The formation of silt sized primary mineral particles for loess deposits. *Quaternary Science Reviews*, Vol. 14, Issues 7-8, 1995, pp. 645-651, [https://doi.org/10.1016/0277-3791\(95\)00046-1](https://doi.org/10.1016/0277-3791(95)00046-1).
- Smith D.E., Davies M.H., Brooks C.L., Mighall T.M., Dawson S., Rea B.R., Jordan J.T., Holloway L.K. Holocene relative sea levels and related prehistoric activity in the Forth lowland, Scotland, United Kingdom. *Quaternary Science Reviews*, Vol. 29, Issues 17-18, 2010, pp. 2382-2410, <https://doi.org/10.1016/j.quascirev.2010.06.003>.
- Smith D.E., Barlow N.L.M., Bradely S.L. et al. Quaternary sea level change in Scotland. *Earth and Environmental relationships within the Nile Delta*. In J.Kabaciński, M.Chłodnicki, M.Kobusiewicz (Eds.), *Prehistory of northeastern Africa, new ideas and discoveries, studies in African archaeology*, Vol. 11, 2012, pp. 11-24.
- Ryan W.B.F., Pitman W.C. Noah's Flood: the new scientific discoveries about the event that changed history. Simon & Schuster, New York, 1998.
- Ryan W.B.F., Pitman III W.C., Major C.O., Shimkus K., Moskalenko V., Jones G.A., Dimitrov P., Gorür N., Sakiñç M., Yüce H. An abrupt drowning of the Black Sea shelf. *Marine Geology*, Vol. 138, Issues 1-2, 1997, pp. 119-126, [https://doi.org/10.1016/S0025-3227\(97\)00007-8](https://doi.org/10.1016/S0025-3227(97)00007-8).
- Rychagov G.I. Holocene oscillations of the Caspian Sea, and forecasts based on palaeogeographical reconstructions. *Quaternary International*, Vol. 41-42, 1997, pp. 167-172, [https://doi.org/10.1016/S1040-6182\(96\)00049-3](https://doi.org/10.1016/S1040-6182(96)00049-3).
- Sandford K.S., Arkell A.J. Palaeolithic man and the Nile–Faiyum Divide: a study of the region during Pliocene and Pleistocene times. University of Chicago Press, Chicago, Vol. 1, 1929.
- Sarikaya M.A., Çiner A. Late Pleistocene glaciations and paleoclimate of Turkey. *Bulletin of the Mineral Research and Exploration*, Vol. 151, 2015, pp. 107-127, <https://doi.org/10.19111/bmre.35245>.
- Seguin J., Avramidis P., Haug A., Kessler T., Schimmelmann A., Unkel I. Reconstruction of palaeoenvironmental variability based on an inter-comparison of four lacustrine archives on the Peloponnese (Greece) for the last 5000 years. *E&G Quaternary Science Journal*, Vol. 69, No. 2, 2020, pp. 165-186, <https://doi.org/10.5194/egqsj-69-165-2020>.
- Sejrup H.P., Larsen E., Haflidason H., Berstad I.M., Hjelstuen B.O., Jonsdottir H., King E.L., Landvik J., Longva O., Nygård A., Ottesen D., Raunholm S., Rise L., Stalsberg K. Configuration, history and impact of the Norwegian Channel Ice Stream. *Boreas*, Vol. 32, Issue 1, 2003, pp. 18-36, <https://doi.org/10.1080/03009480310001029>.
- Semikolennykh D., Panin A., Zazovskaya E. Radiocarbon dating of the end of the latest Caspian Sea overflow through the Manych Depression (southeastern European Plain). *Radiocarbon*, Vol. 67, Issue 2, 2025, pp. 331-346, <https://doi.org/https://doi.org/10.1017/RDC.2024.135>.
- Shtienberg G., Yasur-Landau A., Norris R.D., Lazar M., Rittenour T.M., Tamberino A., Gadol O., Cantu K., Arkin-Shalev E., Ward S.N., Levy T.E. A Neolithic megatsunami event in the eastern Mediterranean: Prehistoric settlement vulnerability along the Carmel coast, Israel. *PLOS ONE*, Vol. 15, No. 12, Article e0235837, 2020, <https://doi.org/10.1371/journal.pone.0243619>.
- Smalley I. Making the material: The formation of silt sized primary mineral particles for loess deposits. *Quaternary Science Reviews*, Vol. 14, Issues 7-8, 1995, pp. 645-651, [https://doi.org/10.1016/0277-3791\(95\)00046-1](https://doi.org/10.1016/0277-3791(95)00046-1).
- Smith D.E., Davies M.H., Brooks C.L., Mighall T.M., Dawson S., Rea B.R., Jordan J.T., Holloway L.K. Holocene relative sea levels and related prehistoric activity in the Forth lowland, Scotland, United Kingdom. *Quaternary*

- mental Science Transactions of the Royal Society of Edinburgh, Vol. 110, Issue 1-2, 2019, pp. 219-256, doi:10.1017/S1755691017000469.
- Svitoch A.A., Makshaev R.R. Chocolate clays of the Northern Caspian Sea region (distribution, position and structure). *Geomorfologiya*. No. 1, 2015, pp. 101-112, <https://doi.org/10.15356/0435-4281-2015-1-101-112>. (in Russian)
- Teller J.T., Leverington D.W., Mann J.D. Freshwater outbursts to the oceans from glacial Lake Agassiz. *Quaternary Science Reviews*, Vol. 21, Issues 8-9, 2002, pp. 879-887, [https://doi.org/10.1016/S0277-3791\(01\)00145-7](https://doi.org/10.1016/S0277-3791(01)00145-7).
- Triantafyllidis A., Apostolidis A.P., Katsares V., Kelly E., Mercer J., Hughes M., Jørstad K.E., Tsolou A., Hynes R., Triantaphyllidis C. Mitochondrial DNA variation in the European lobster (*Homarus gammarus*) throughout the range. *Marine Biology*, Vol. 146, 2005, pp. 223-235, <https://doi.org/10.1007/s00227-004-1435-2>.
- Väinölä R. Origin and recent endemic divergence of a Caspian Mysis species flock with affinities to the “glacial relict” crustaceans in boreal lakes. *Evolution*, Vol. 49, Issue 6, 1995, pp. 1215-1223, <https://doi.org/10.1111/j.1558-5646.1995.tb04448.x>.
- Yaltrak C., Gökaşan E., Alpar B., Yüce H., Algan O. Discussion: A critique of “Possible waterways between the Marmara Sea and the Black Sea in the late Quaternary”. *Geo-Marine Letters*, 2011. *Geo-Marine Letters*, Vol. 32, No. 3, 2012, pp. 267-274, <https://doi.org/10.1007/s00367-011-0270-y>.
- Yanko-Hombach V.V., Gilbert A.S., Panin N., Dolukhanov P.M. *The Black Sea Flood Question: Changes in Coastline, Climate and Human Settlement*. Springer, Dordrecht, 2007, 971 p.
- Yanko-Hombach V., Kislov A. Late Pleistocene–Holocene sea-level dynamics in the Caspian and Black Seas: Data synthesis and paradoxical interpretations. *Quaternary International*, Vol. 465, Part A, 2018, pp. 63-71, <https://doi.org/10.1016/j.quaint.2017.11.030>.
- Science Reviews, Vol. 29, Issues 17-18, 2010, pp. 2382-2410, <https://doi.org/10.1016/j.quascirev.2010.06.003>.
- Smith D.E., Barlow N.L.M., Bradely S.L. et al. Quaternary sea level change in Scotland. *Earth and Environmental Science Transactions of the Royal Society of Edinburgh*, Vol. 110, Issue 1-2, 2019, pp. 219-256, doi:10.1017/S1755691017000469.
- Teller J.T., Leverington D.W., Mann J.D. Freshwater outbursts to the oceans from glacial Lake Agassiz. *Quaternary Science Reviews*, Vol. 21, Issues 8-9, 2002, pp. 879-887, [https://doi.org/10.1016/S0277-3791\(01\)00145-7](https://doi.org/10.1016/S0277-3791(01)00145-7).
- Triantafyllidis A., Apostolidis A.P., Katsares V., Kelly E., Mercer J., Hughes M., Jørstad K.E., Tsolou A., Hynes R., Triantaphyllidis C. Mitochondrial DNA variation in the European lobster (*Homarus gammarus*) throughout the range. *Marine Biology*, Vol. 146, 2005, pp. 223-235, <https://doi.org/10.1007/s00227-004-1435-2>.
- Väinölä R. Origin and recent endemic divergence of a Caspian Mysis species flock with affinities to the “glacial relict” crustaceans in boreal lakes. *Evolution*, Vol. 49, Issue 6, 1995, pp. 1215-1223, <https://doi.org/10.1111/j.1558-5646.1995.tb04448.x>.
- Yaltrak C., Gökaşan E., Alpar B., Yüce H., Algan O. Discussion: A critique of “Possible waterways between the Marmara Sea and the Black Sea in the late Quaternary”. *Geo-Marine Letters*, 2011. *Geo-Marine Letters*, Vol. 32, No. 3, 2012, pp. 267-274, <https://doi.org/10.1007/s00367-011-0270-y>.
- Yanko-Hombach V.V., Gilbert A.S., Panin N., Dolukhanov P.M. *The Black Sea Flood Question: Changes in Coastline, Climate and Human Settlement*. Springer, Dordrecht, 2007, 971 p.
- Yanko-Hombach V., Kislov A. Late Pleistocene–Holocene sea-level dynamics in the Caspian and Black Seas: Data synthesis and paradoxical interpretations. *Quaternary International*, Vol. 465, Part A, 2018, pp. 63-71, <https://doi.org/10.1016/j.quaint.2017.11.030>.

## ПЕРЕОЦЕНКА РАННЕГОЛОЦЕНОВЫХ УРОВНЕЙ ВЫСОКОГО СТОЯНИЯ “АЗИАТСКОЙ ЧАСТИ СРЕДИЗЕМНОМОРЬЯ” И ГИДРОЛОГИЧЕСКОЙ СООБЩАЕМОСТИ ЧЕРЕЗ ПОНТО-КАСПИЙСКИЙ БАССЕЙН

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**Резюме.** Выявление гидрогеологических преобразований в Понто-Каспийском регионе в переходный интервал позднего плейстоцена — раннего голоцена по-прежнему представляет одну из ключевых проблем геологии четвертичного возраста. Несмотря на то, что современные модели акцентируют внимание на климатическом факторе и гляциоизостатической адаптации, многочисленные геоморфологические, седиментационные и биологические данные не всегда согласуются с существующими концептуальными представлениями.

Исследование обобщает материалы, полученные по Каспийскому, Чёрному, Средиземному морям и сопредельным территориям, с особым акцентом на геоморфологические особенности Азербайджана. Установлено, что возвышенные террасы, приподнятая береговая линия и выявленные поверхности грязевых вулканов, модифицированные волнами, фиксируются на отметках значительно выше хорошо известного Хвалынского уровня (~+50 м над уровнем моря), что позволяет предположить существование ранее неучтённых гидрологических условий. Кроме того, в исследовании рассматриваются циклы остракодовой фауны, миграции солечувствительных таксонов, аномальные седиментационные последовательности и другие индикаторы изменчивости бассейнов, проявившиеся на территории Евразии в раннем голоцене.

В целом приведённые наблюдения свидетельствуют о том, что региональная гидрологическая система была значительно более динамичной и сложной, чем предполагалось ранее. Вместо рассмотрения изолированных концепций целесообразно опираться на данные, указывающие на существование многофазных систем с колебаниями уровня воды, эпизодическими сбросами бассейнов, стратифицированным режимом течений и изменчивыми связями между Чёрным, Каспийским и соседними бассейнами. В этом контексте ранее предложенная концепция «азиатского Средиземноморья» для расширенного плейстоценового периода рассматривается как рабочая гипотеза, требующая дальнейшего уточнения.

Исследование также даёт основания для переосмысления дискуссий, связанных с повторным соединением Чёрного моря, и выдвигает предположение о фазо-изменяющихся притоках и оттоках через Босфор. Подобный подход способен более полно объяснить имеющиеся данные по сравнению с катастрофическими, либо строго линейными моделями. Более широкие региональные сопоставления, охватывающие Северную Африку и арктическую периферию, свидетельствуют о том, что гидрологические и экологические изменения в рассматриваемый период могли носить синхронный или временно кумулятивный характер.

Хотя представленные здесь интерпретации не являются окончательными, они подчеркивают необходимость проведения комплексных междисциплинарных исследований для дальнейшего уточнения рассматриваемых вопросов.

В будущих исследованиях первостепенное внимание следует уделить геохронологическому датированию береговых линий и террас, отбору ядерного материала, гидродинамическому моделированию, а также реконструкции палеобереговых линий на основе цифровых моделей рельефа (ЦМР). Уникальные геоморфологические особенности Азербайджана могут сыграть ключевую роль в решении фундаментальных вопросов, связанных с четвертичной гидрологией Евразии.

**Ключевые слова:** Понто-Каспийский регион, ранний голоцен, уровень Каспийского моря, гидрология Чёрного моря, четвертичная палео-гидрология, связанность бассейна, морская трансгрессия, гляциоизостатическое приспособление, палеобереговая линия, «азиатское Средиземноморье»

## “ASIYA ARALIQ DƏNİZİ” KONSEPSİYASINA YENİ BAXIŞ: PONT–XƏZƏR HÖVZƏSİ BOYUNCA ERKƏN HOLOSEN YÜKSƏK SU SƏVIYYƏLƏRİ VƏ HİDROLOJİ ƏLAQƏLİLİK

**Qallaher R.**

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**Xülasə.** Pont–Xəzər regionunda Gec Pleystosen–Erkən Holosen keçidi dövründə hidroloji dəyişikliklərin dərk edilməsi Dördüncü dövr üçün həllini tapmamış elmi problemlərdən biri olaraq qalır. Mövcud modellər iqlim təsirini və buzul-izostatik tənzimləməni vurğulasa da, bir sıra geomorfoloji, çöküntü və bioloji müşahidələr mövcud çərçivələrə asanlıqla uyğunlaşdırıla bilmir.

Bu tədqiqat Xəzər, Qara dəniz, Aralıq dənizi və qonşu regionlardan əldə edilmiş dəlilləri sintez edərək, xüsusilə Azərbaycanın geomorfologiyasına diqqət yetirərək ümumiləşdirir. Yüksəkliklərə qalxmış terraslar, yüksək hündürlükdə sahil xətləri və dalğalar vasitəsilə dəyişdirilmiş palçıq vulkanı səthləri geniş qəbul edilmiş Xvalın yüksək səviyyəsindən (~+50 m mütləq hündürlük) xeyli daha yuxarı səviyyələrdə aşkar edilmişdir ki, bu da əvvəllər müəyyən edilməmiş hidroloji şəraitin mövcud ola biləcəyini göstərir. Əlavə dəlillərə ostrakod faunasının dəyişməsi, duzluluğa həssas taksonların yerdəyişməsi, anormal çöküntü qeydləri və Erkən Holosen dövründə Avrasiya boyunca hövzə bağlanılıqlığının dəyişdiyini göstərən əlamətlər daxildir.

Bütün bu müşahidələr birlikdə regional hidrologiyanın ümumi qəbul ediləndən daha dinamik və mürəkkəb olduğu şərhini dəstəkləyir. Əldə olunan məlumatlar vahid hadisə çərçivəsindən daha çox, su səviyyələrindəki dalğalanmalar, epizodik hövzə daşmaları, təbəqələşmiş axın rejimləri və Qara dəniz, Xəzər dənizi və qonşu hövzələr arasında dəyişkən əlaqəni özündə birləşdirən çoxfazlı sistemlə daha uyğunluq təşkil edir. Bu kontekstdə, genişlənmiş Pleystosen “Asiya Aralıq dənizi” haqqında əvvəlki konsepsiyalar işlək fərziyyə kimi yenidən nəzərdən keçirilir.

Tədqiqat həmçinin Qara dənizin yenidən birləşməsi problemini yenidən nəzərdən keçirərək, Bosfor vasitəsilə növbələşən çıxış və daxilolma fazalarının mövcud sübutları nə tam katastrofik, nə də yalnız tədrici modellərdən daha yaxşı izah edə biləcəyini irəli sürür. Şimali Afrika və Arktika kənarı daxil olmaqla daha geniş regional müqayisələr göstərir ki, hidroloji və ətraf mühit dəyişiklikləri zaman etibarilə eyni intervalda qruplaşmışdır.

Burada təqdim olunan interpretasiyalar ilkin xarakter daşısa da, onlar inteqrə olunmuş multidissiplinar tədqiqatların vacibliyini vurğulayır. Gələcək işlərdə sahil xətlərinin və terrasların geoxronoloji yaş təyininə, çöküntü kernlərinin tədqiqinə, hidrodinamik modelləşdirməyə və “Rəqəmsal Relyef Modeli (Digital Elevation Model – DEM) əsasında paleosahil xətlərinin rekonstruksiyasına üstünlük verilməlidir. Azərbaycanın fərqli geomorfologiyası Avrasiyanın Dördüncü dövr hidrologiyasına dair həll olunmamış məsələlərin aydınlaşdırılmasında həlledici rol oynaya bilər.

**Açar sözlər:** Ponto-Xəzər regionu, Erkən Holosen, Xəzər dənizinin səviyyəsi, Qara dəniz hidrologiyası, Dördüncü dövr paleohidrologiyası, hövzə əlaqəsi, dəniz transqressiyası, buzlaq-izostatik tənzimlənmə, paleosahil xətləri, “Asiya Aralıq dənizi”

## PALEOMAGNETIC CHARACTERISTICS OF THE JURASSIC COMPLEX WITHIN THE SUDUR SHELF ZONE OF THE GREATER CAUCASUS (AZERBAIJAN)

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**Summary.** The article presents a detailed stratigraphical division of the Jurassic complex of the continental shelf of the North Caucasian margin of the Eurasia. The stratigraphy of Jurassic rocks in this region, which corresponds to the southern margin of the Scythian platform, has not been well studied. On the other hand, paleomagnetic research has never been conducted in this area before. The studied region is located on the northern flank of the southeastern part of the mountain-folded system of the Greater Caucasus. To study the paleomagnetic properties of the Jurassic rocks, 80 oriented samples were collected from the Tahirjalchay section. The magnetic susceptibility and the natural remnant magnetization of deposits vary between  $0.6 \times 10^{-3}$ - $1.6 \times 10^{-3}$  BS and  $2.9 \times 10^{-3}$ - $16.9 \times 10^{-3}$  A/m, respectively. The average value of the permanent component indicates that the magnetization is close to its initial value and can therefore be used to compile a paleomagnetic profile. Based on paleomagnetic data, for the first time, the kinematic parameters of the Jurassic tectonic blocks on the southern margin of the Scythian Platform were studied. Analysis of the research materials reveals the extent of the angular displacement of the block. In the magnetostratigraphic analysis of the Tahirjalchay section, a total of 5 direct magnetization zones and 5 reverse zones were identified. Using these magnetic zones, the boundaries between different stratigraphic units were determined: Aalenian-Bajocian; Bajocian-Bathonian; Bathonian-Callovian; Callovian-Oxfordian; Oxfordian-Kimmeridgian.

**Keywords:** *Tahirjalchay section, magnetic sensitivity, residual magnetization, paleomagnetism, magnetic polarity*

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### Introduction

The Greater Caucasus orogenic system forms a morphological barrier along the southern margin of the Scythian Platform. It extends from the southern part of the Caspian Sea to the northern margin of the Eastern Black Sea. It developed during several phases of deformation in Mesozoic-Cenozoic periods. The Jurassic deposits, which are widespread within the Azerbaijani part of the Greater Caucasus, are represented by the middle and upper stages. The Middle Jurassic deposits have nearly identical facies. During the Upper Jurassic period, several basins were formed, differing in sedimentation conditions. Despite the long history of studying the Jurassic rocks of the Southeastern Caucasus, their age dismemberment and stratigraphic correlation cannot be considered complete. A number of uncertainties related to division and subdivision of the Upper Jurassic deposits still remain there. It is appropriate to solve these issues using paleomagnetic research data. The present

paper expounds upon the paleomagnetic research results of the Middle-Upper Jurassic rocks of the Tahirjalchay section (Sudur zone), which are located within the Side range megazone of the Greater Caucasus. The detailed magnetostratigraphic studies were carried out on the basis of paleomagnetic measurements. A detailed age division of the Middle and Upper Jurassic intervals of the northern slope was carried out, and five direct and five reverse magnetized paleomagnetic zones reflecting the change of the poles of the Earth's magnetic field were distinguished. The obtained results will help to complete the magnetostratigraphic scheme of the Middle-Upper Jurassic boundary interval of the Greater Caucasus. An additional comprehensive study of this section was carried out, including sedimentological description and sampling from different levels for paleomagnetic, mineralogical and chemical analysis. The purpose of this study is to clarify the sedimentological zonality and age correlation of the Juras-

sic successions formations on the northern flange of the Greater Caucasus marginal sea basin in Azerbaijan (Kangarli et al., 2013).

### Methods

In the field work conducted in 2015-2022, the detailed study of rocks and layer by layer description of sections was carried out in order to identify genetic signs and separate litogenetical types (Храмов и др., 1982). The oriented samples of paleomagnetic studies were taken every 0.5-1 m. Petromagnetic studies of samples taken from the Tahirjalchay section were carried out in Moscow at the laboratory "Main Geomagnetism and Petromagnetism" Institute of Physics of the Earth RAS. Paleomagnetic studies of the samples included measurements of natural remanent magnetization ( $J_n$ ), magnetic saturation tests, thermomagnetic analysis, and alternating-field magnetic cleaning, saturation moment of magnetic mineral ( $M_s$ ), the moment of saturation of remanent magnetization ( $M_{rs}$ ), determination of normal magnetization curves  $M_r(B)$  and residual coercive force  $B_{sr}$  (destructive field), demagnetization by variable and constant magnetic field and temperature etc. The  $K$  parameter was measured at a MFK1-FB kappabridge. The dependence of  $K$  on temperature was studied using a MFK1-FA kappabridge with a CS3 furnace. Alternating- field magnetic cleaning was performed at a LDA-3 AF demagnetizer with measurements of  $J_n$  at a JR-6 spin-magnetometer and a cryogenic (SQUID) magnetometer 2G-Enterprises.

### Section structure

The Tahirjalchay section is located in the Sudur zone of the Side range structural-formation zone of the Greater Caucasus. The Middle Jurassic is represented by clay-terrigenous rocks, and the Upper Jurassic is represented by gypsum-bearing lagoons and carbonates. The Aalenian-Lower Bajocian interval consists of gray sandstones (25-100 m) interbedded with clayey shales. The shelf facies on the top and the lagoon facies at the bottom represent The Upper Jurassic section. The Tahirjalchay suit, which is composed of a combination of heater yellowish and bluish-green sandy shales interspersed with greenish calcareous sandstones and layers of crystalline limestones and dolomites can be found at the lower section of the Upper

Jurassic deposits. This was first described by Isaev (Исаев и др., 1977; Kangarli, Mehdiyeva, 2017). The sediments, which are 50-60 meters thick, are located on top of the Upper Aalenian horizons without any basal conglomerates. The younger geological layers display a more noticeable purple-red hue in the suite, and its summit is permeated by frequent veins of gypsum-anhydrite. Additionally, the Gushgala suite of the Upper Oxfordian gypsum-bearing argillite-arenaceous sediments unconformably covers and overlaps this suite.

The Gushgala Formation exposed on the eastern slope of the eponymous mountain (Fig. 1) has an unconformable relation with the overlying Gukhur Formation, which consists of a continuous sequence of limestone and dolomite rocks. The lower part of the sequence is dominated by grey and dark-grey dolomites; pink dolomite also present. The upper part consists mainly of light-grey to pinky limestone, which is often brecciated, and contains oolitic sandstone (Mehdiyeva, 2022).

The thickness of these successions increases towards the central, most subsided part of the Sudur zone, rising from 20-50 m in the Gushgala mountain area to 450-500 m on the slope of Garagaya Mountain.

### Magnetic properties of rocks

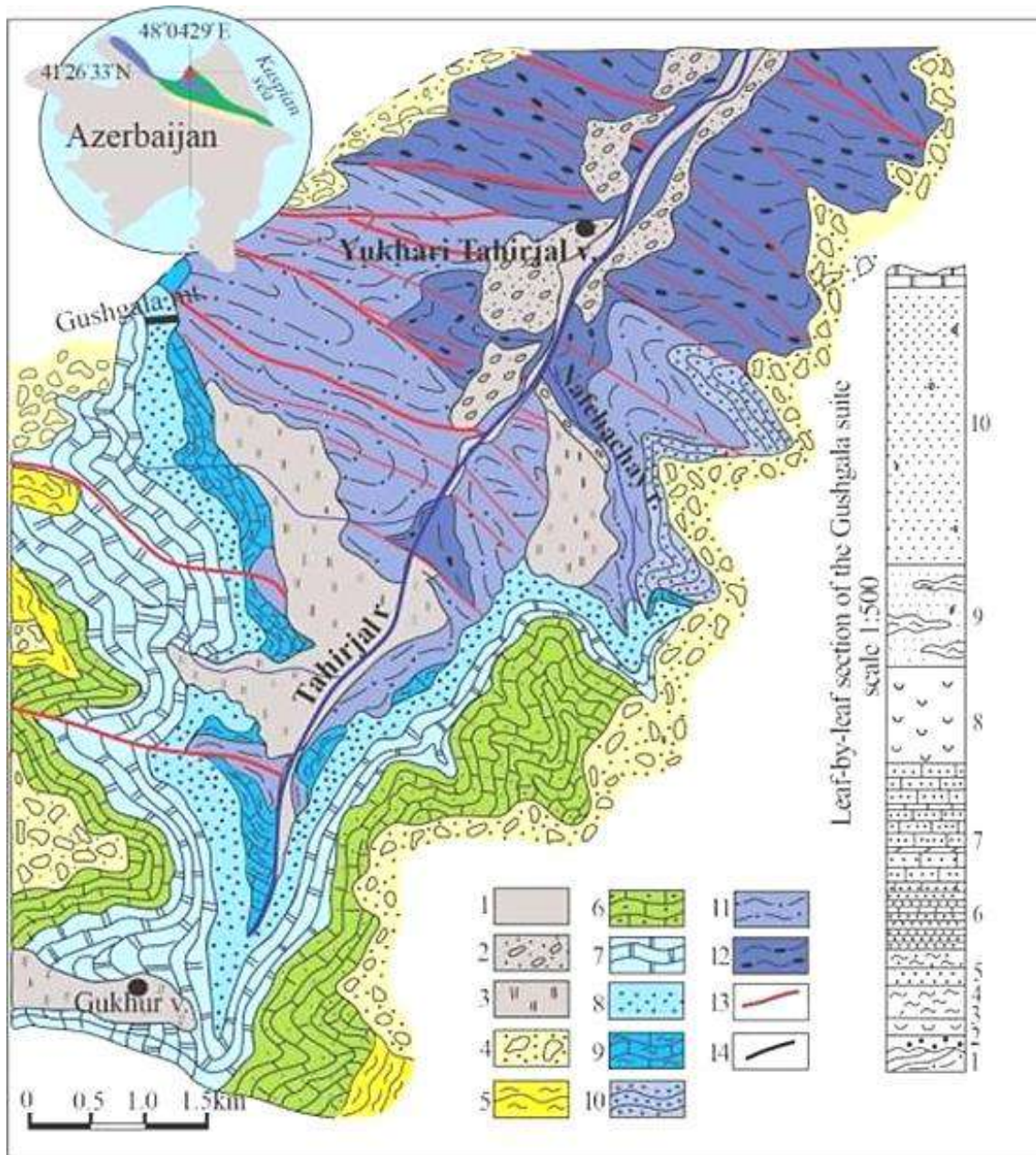
Petromagnetic research methods are an independent and promising tool for solving a wide range of issues in geology, geophysics, as well as other geoscience disciplines. The performance of petromagnetic experiments is currently seen as an essential component of paleomagnetic research, necessary for assessing the age of components of natural remanent magnetization recorded within rocks.

The hysteresis curves of samples from the Tahirjalchay section exhibit a paramagnetic character (Fig. 2a), although with a significant increase in the plot, it becomes clear that the upper and lower portions of the curve diverge (Fig. 2b), indicating the presence of minute amounts of ferromagnetic materials in the rocks.

After correction of the paramagnetic susceptibility, the hysteresis loop adopts a ferromagnetic shape, and it becomes clear that the magnetization ( $M_s$ ) approaches saturation in the magnetic field region of 0.5 Tesla (Fig. 2c).

The curve of normal magnetization (Fig. 2d) shows that after rapid growth in the range of fields 0-0.5 mT, the magnetic moment does not saturate, but continues to grow slowly. This can be considered as a definite indication that in ad-

dition to relatively low-coercivity minerals (the presence of which is indicated by  $B_{cr}$  values in the region of 400 mT); the ferromagnetic fraction of rocks also contains highly coercive minerals.



**Fig. 1.** Schematic geological map of the Tahirjalchay upstream basin compiled by T.N.Kangarli

**1, 2, 3** – Holocene (channel deposits; deposits of river terraces; deluvial-colluvial deposits); **4** – Lower Pliocene: gravels and conglomerates with sandy-calcareous cement and lentiform interlayers of clays; **5** – Upper Miocene, Sarmatian Regional Stage; slate- gray clay with thick sand and sandstone layers; **6** – Neocomian: light gray siliceous, dolomite, oolitic and clastic limestone, Interbedded clayey sandstones; **7** – Kimmeridgian and Tithonian stages, Gukhur suite: pale yellow, pink and green-gray dolomite and limestone with rare intercalation sand lenses of clayey and calcareous sandstones; **8** – Lower Oxfordian, Gushgala suite: multicolored gypsum-bearing polymictic sands and sandstones with interlayers of glauconite clays, dolomites and basal conglomerates in the basement; **9** – Middle (?) Callovian – Lower Oxfordian, Tahirjal suite: Colorful sandy clay intercalated with light calcareous sandstone; **10** – Bajocian stage: grey massively bedded sandstones with interlayers of argillites; **11** – Upper Aalenian: alternating dark gray mudstone and sandstone, the latter predominating in the upper part; **12** – Lower Aalenian: dark gray clay, with siderite concretions and rare intercalations of sandstone on the horizon; **13** – rupture dislocations; **14** – location of taking the layer-by-layer section

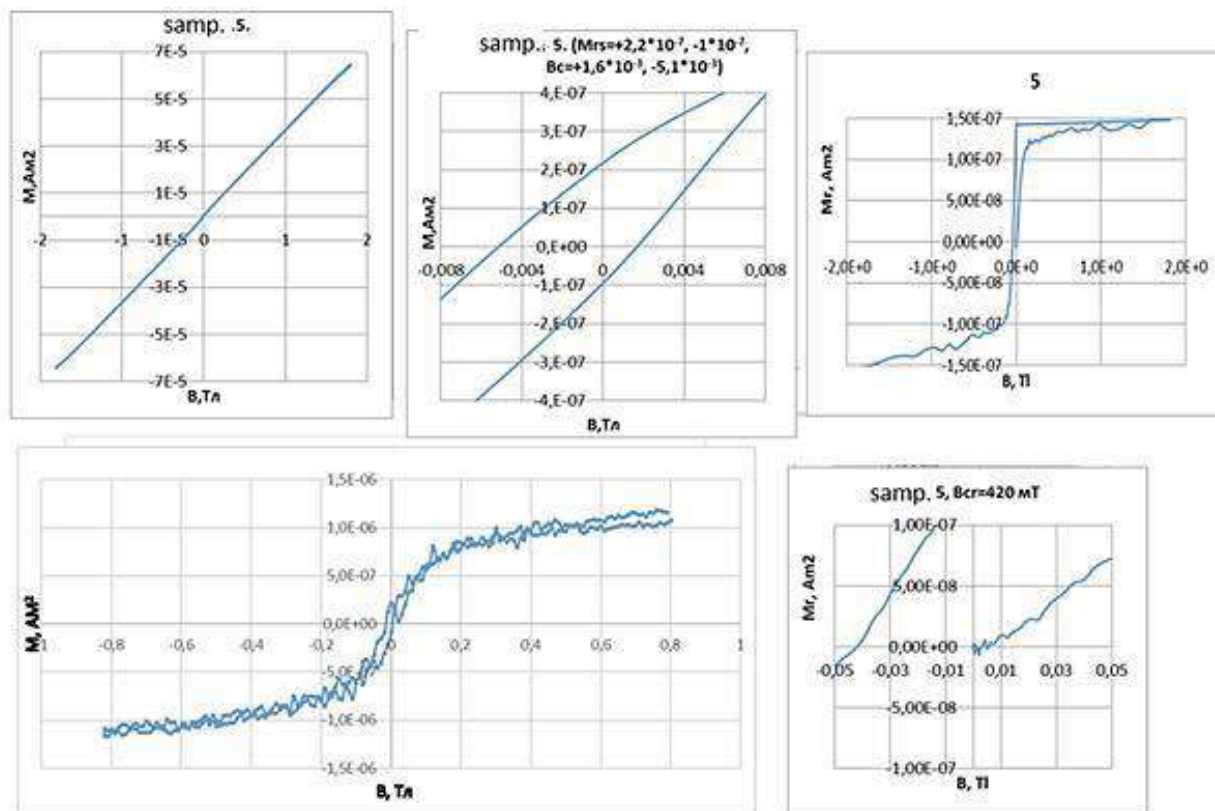


Fig. 2. Hysteresis loops (a) and its central part (b), after correction for the paramagnetic component (c), the curves of normal magnetization and “back-field” (d), sample 5

### Alternating field demagnetization

The demagnetization of samples from the Tahirjalchay section by an alternating field was complicated by the fact that even with relatively small fields, regular magnetization occurred in the samples, probably associated with the presence of a large number of extremely soft magnetic grains, presumably having a size close to the super paramagnetic - single-domain threshold. In such samples, we can calculate the conditional characteristic component of magnetization, assuming that it begins to collapse, starting from fields of 5-10 mT. In some samples, however, cleaning continues successfully up to fields of 80 mT. In this case, sometimes, we can see clear indications of the presence of reverse polarity magnetization in the samples. According to the curves and stereograms obtained during alternating field demagnetization the studied rocks are divided into two groups. For the first group of rocks, it is demagnetized in fields varying from 200 mTl and retains about 20% of the initial value in fields of 400-450 mTl. Hystere-

sis parameters of the studied samples are given in Table 1.

### Temperature demagnetization

The quality of the paleomagnetic signal in samples of this section is quite mediocre; at temperatures above 500-550°C, in most samples obvious magnetization occurs, expressed in a chaotic change in the magnitude and direction of magnetization. The natural residual magnetization in part of the samples includes two, and in part – three components of magnetization (Fig. 3).

The first, low-temperature component is probably a mixture of modern and laboratory viscous magnetizations. The second, medium-temperature component is destroyed in the temperature range from 200 to 500 or more degrees Celsius. The presence of this component, which does not go to the origin of coordinates, is obvious from Zijderveld diagrams (Fig. 3c) and magnetization reversal circles on stereograms (Fig. 3).

Table 1

Hysteresis parameters of the studied samples

Number of samples	Ms, mкAm <sup>2</sup>	Mrs, mкAm <sup>2</sup>	Mrs/Ms	Bc, mTl	Bcr, mTl	Bcr/Bc
3	56.7	0.151	0.003	1.9	37.4	19.7
	6.8	0.066	0.01	12	37.4	3.1
5	64.2	0.170	0.003	3.4	42.0	12.4
	7.6	0.154	0.02	8.2	42.0	5.1
13	60.0	0.092	0.002	0.472	37.0	78.6
	7.1	0.092	0.013	1.6	37.0	2.3
26	85.3	0.124	0.001	1.3	39.2	30.2
	9.8	0.121	0.012	8.4	39.2	4.7
27	61.4	0.068	0.001	1.1	38.3	34.8
	2.6	0.042	0.016	13.6	38.3	2.8
35	42.8	0.090	0.002	2.0	37.4	18.7
	0.99	0.110	0.12	12.2	37.4	3.1
53	30.3	0.111	0.004	3.3	43.4	31.2
	1.1	0.111	0.10	11	43.4	3.9
65	33.8	0.397	0.012	8.6	27.2	31.5
	1.4	0.397	0.27	54	27.0	5.0
72	74.8	0.108	0.001	2.3	38.4	16.7
	8.5	0.102	0.012	11.3	38.4	3.4
77	15.9	0.258	0.001	2.8	66.0	23.6
	8.1	0.58	0.29	10.6	18.5	10.4

The distribution of the characteristic component (after removing a certain number of outliers, which are probably the result of orientation or sawing errors) is shown in Fig. 3.

It is important to note that among the studied samples there are samples that carry magnetization of both direct and reverse polarity. After bringing the vectors to the same polarity, the fold test (Enkin, 2003) gives a positive result, indicating the pre-fold age of the identified characteristic component. This is also indicated by the fold straightening test, which shows the maximum distribution accuracy at 100% straightening.

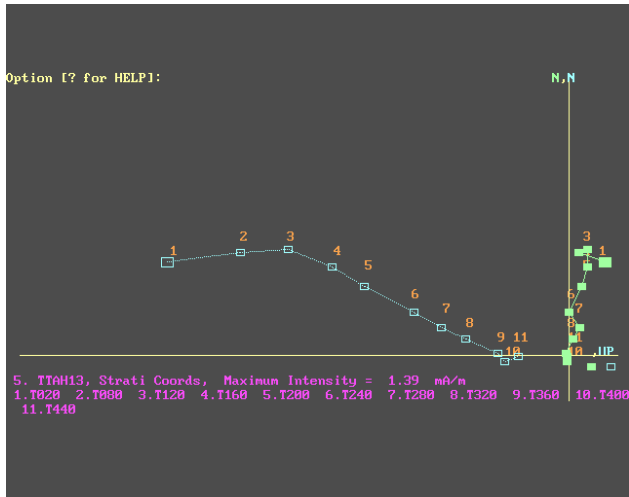
The method of cleaning with temperature accurately separates the natural residual magnetization components. All samples are heated up to 600°C. This process is carried out in steps every 30°C. After each heating, the samples are measured and reheated.

Depending on the temperature, the samples are divided into 2 groups according to the magnitude and direction of  $J_n$ .

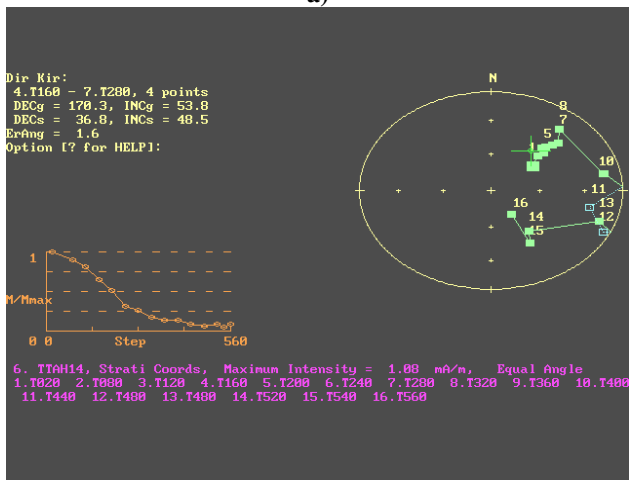
Thus, the available data indicate that the characteristic magnetization identified in the Tahirjalchay section as a result of T-cleaning

may be primary and reflect the direction of the geomagnetic field during rock formation. It should be noted that however, high inclination of the average direction of the selected characteristic component is surprising. According to the European apparent pole migration curve (Torsvik et al., 2012), the field inclination in the considered region should have been about 60°, the identified component has an inclination of about 80°.

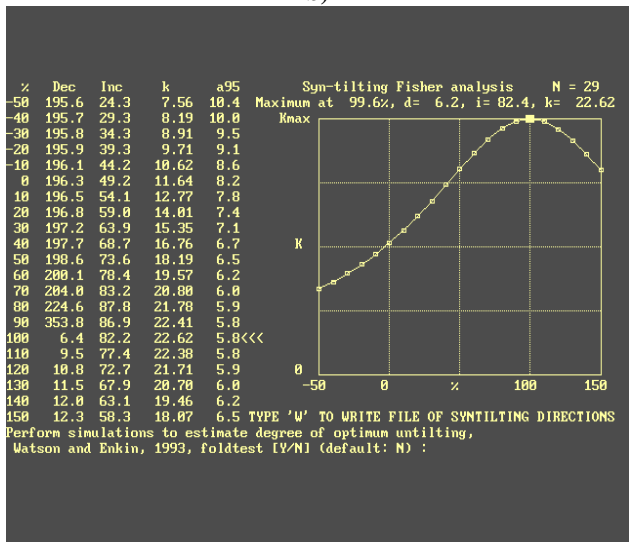
The results of the demagnetization indicate that in a significant part of the rocks of the Tahirjalchay section, primary magnetization has been preserved and, in the future, these rocks can be used to solve various geological (including magnetostratigraphic) problems. In this case, the most promising method for isolating the primary (characteristic) component seems to be thermal magnetic cleaning. The primary magnetization appears to be noticeably contaminated by superimposed (secondary) magnetization components, therefore, successful isolation of the ancient component requires special efforts aimed, for example, as well as at the selection of the most suitable lithological varieties, the use of special procedures for magnetic cleaning, etc.



a)



b)



c)

**Fig. 3.** Zijderveld diagram of Tahirjalchay section (a), a stereogram illustrating the tendency of the EON vector to shift towards the expected direction of the primary magnetization of the reverse polarity (b). Distribution of vectors for a conditionally characteristic component, changes in the average directions and the corresponding Fisher parameters (accuracy  $k$  and radius of the 95% confidence circle  $\alpha_{95}$ ) during sequential “straightening of the fold” (c)

### Thermomagnetic analysis

In thermomagnetic analysis, the samples are heated to 700°C. A single inflection point stands out on the curves  $J_i(T)$ , which is more clearly defined by the extremum of the second derivative and corresponds to the Curie point  $T=580^\circ\text{C}$ , which corresponds most likely to magnetite (Garayeva et al., 2023; Гараева и др., 2017; Novruzov et al., 2023; Новрузов и др., 2017). This result is consistent with the measurement data of hysteresis parameters. A common feature of all curves is that they reach a maximum at 500°C to some extent. Typically, such peaks reflect the formation of new magnetic minerals upon heating. According to the temperature values, these peaks may be associated with the destruction of divalent iron contained in the clays and subsequent transformation into magnetite. In most of the studied sample magnetite is the main magnetic mineral-carrier of natural residual magnetization, in some cases hematite or iron hydroxides make a significant contribution to the total magnetization. To determine the natural residual magnetization, rock samples were subjected to both temperature and alternating magnetic cleaning (Fig. 4).

The first group of samples loses 50% of the initial magnetization at 120-175°C. The stable part of  $J_n$  is observed at 300-350°C. The second group of rocks loses 60-70% of its former temperature before heating to 150°C. The stable part of  $I_n$  is observed in the range of 250-300°C (Исаева и др., 2017).

Based on the magnetomineralogical studies conducted on the samples, the following can be said: their mean directions in the geographic coordinate system  $D=64^\circ$ ;  $J=31^\circ$ ;  $k=9$ ;  $\alpha_{95}=13^\circ$ , mean direction in the stratigraphic coordinate system  $D=58^\circ$ ;  $J=71^\circ$ ;  $k=11$ ;  $\alpha_{95}=10^\circ$ . The accuracy of the characteristic component is clearly improved by the 60% correction of the sedimentation layer ( $D=21^\circ$ ;  $J=71^\circ$ ;  $k=8$ ;  $\alpha_{95}=12^\circ$ ). Most of the studied samples have a component with an accuracy of 200 to 600 and higher, this component has a direction (in the Geographic coordinate system) close to the direction of the modern geomagnetic field; sometimes the calculated direction of this component cannot be compared with any possible direction either in the modern or in the ancient coordinate system (Исаева и др., 2016; Гараева и др., 2017; Novruzov et al., 2023).

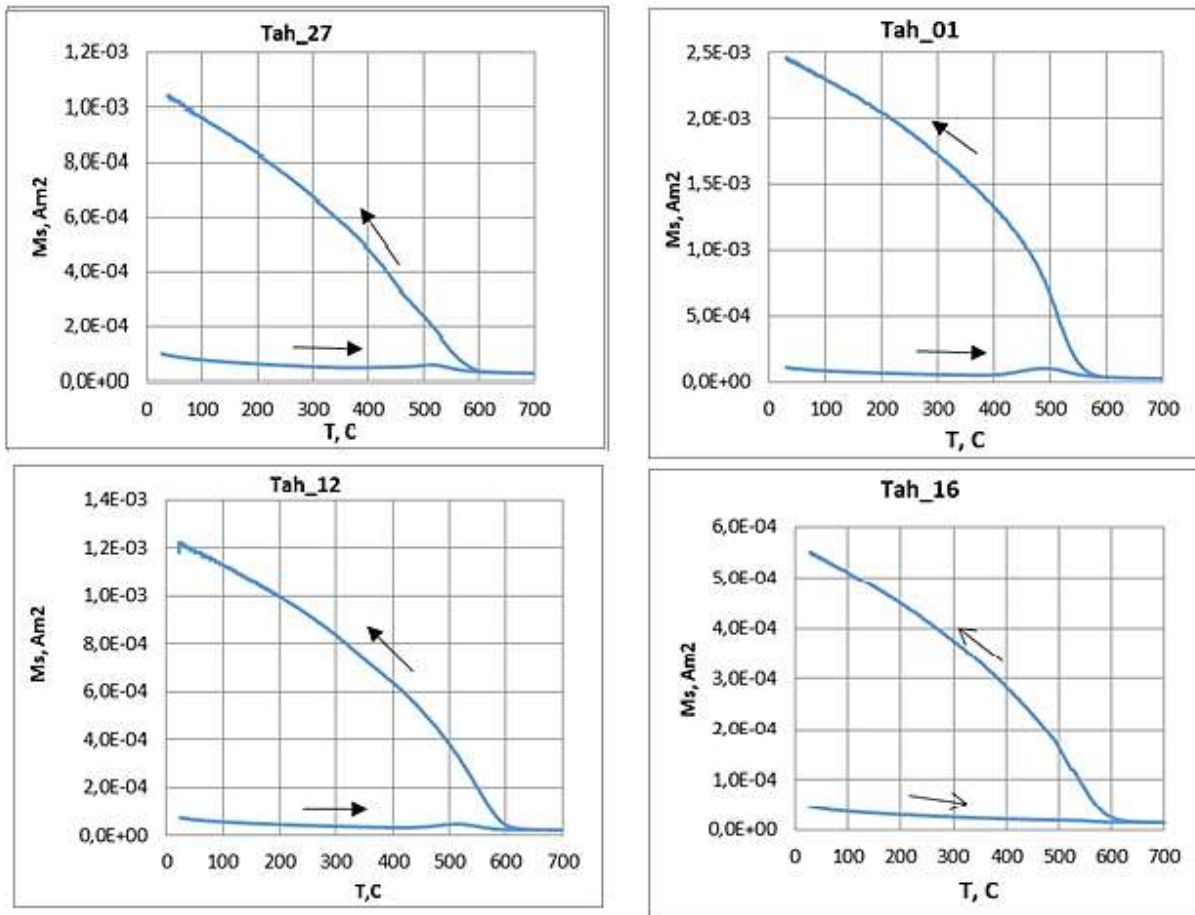


Fig. 4. Temperature dependence of saturation magnetization

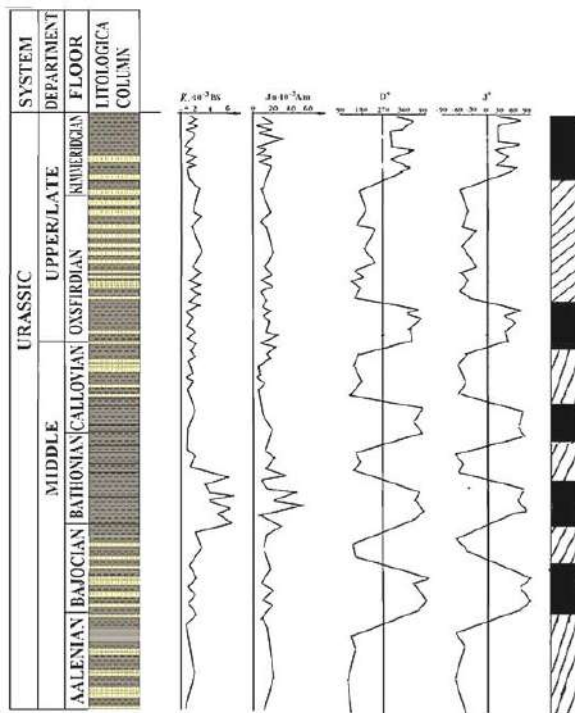


Fig. 5. Paleomagnetic column of the Tahirjalchay section

As a result of paleomagnetic studies, the paleomagnetic scale of the Middle and Upper

Jurassic sediments of the Tahirjalchay section was compiled. A total of 5 direct magnetization zones and 5 reverse magnetization zones were detected (Fig. 5). Based on the detected 5 direct and 5 reverse magnetization zones, it is possible to give the exact boundary of all the stages.

### Conclusions

- The comprehensive magnetomineralogical studies carried out made it possible to identify the carriers of residual magnetization in the composition of rocks, the Curie point, demagnetization of samples by a constant and varying magnetic field, etc. The magnetic properties of Jurassic sediments have been thoroughly studied, and it was found that they vary greatly in the natural residual magnetization and magnetic susceptibility. The reason for this variation in magnetic properties is the content of ferromagnetic minerals in their composition.
- The composition of the ferromagnetic fraction and the contribution of each magnetic mineral to the natural residual magnetiza-

tion were studied. Complex paleomagnetic research in the sediments of the Tahirjalchay outcrop, as well as, according to the nature of the curves of natural residual magnetization, it was confirmed that the magnetization carriers in the studied rocks are iron hydroxide, magnetite, and hematite.

- In the magnetostratigraphic scale established for the Tahirjalchay section, 5 direct and 5 reverse magnetization zones were de-

tected, using these magnetic zones, the boundaries between stratigraphic stages were determined: Aalenian-Bajocian; Bajocian-Bathonian; Bathonian-Callovian; Callovian-Oxfordian; Oxfordian-Kimmeridgian. Based on paleomagnetic data, the kinematic parameters, rotations and horizontal displacements of the movement of the tectonic blocks of the Jurassic complex of the southern slope of the Scythian platform were studied for the first time.

## REFERENCES

- Enkin R.J. The direction–correction tilt test: an all-purpose tilt/fold test for paleomagnetic studies. *Earth and Planetary Science Letters*, Elsevier, 2003, Vol. 212, Issues 1-2, pp. 151-166, [https://doi.org/10.1016/S0012-821X\(03\)00238-3](https://doi.org/10.1016/S0012-821X(03)00238-3).
- Garayeva T.J., Novruzov Z.A., Bagirova A.A. Paleotektonic reconstruction of blocks of Pliocene-Pleistocene sections of the Southeastern Parts of the Greater Caucasus. *Proceeding of the I International scientific conference “Modern science: experience, traditions, innovations”*, SC. Scientific conferences, Berlin. Germany, 2023. pp. 22-27, <https://doi.org/10.5281/zenodo.7604871>.
- Garayeva T.J., Novruzov Z.A., Bagirova A.A. Geodynamics of the Azerbaijani part of the Lesser Caucasus according to paleomagnetic data. *Mining information and analytical bulletin (scientific and technical journal)*. Moscow, No. 6, 2017, pp. 253-263. (in Russian)
- Isaev B.M., Kangarli T.N., Rashidov Kh.A. et al. Report of 1:25000 Reconnaissance-Surveying Activities on the Southeastern Plunge of the Greater Caucasus for 1974-1976. State Information Archive of Azerbaijan Ministry of Ecology and Natural Resources. Baku, 1977. (in Russian)
- Isayeva M.I., Garayeva T.J., Novruzov Z.A., Bagirova A.A. Deep structure and shear deformations of blocks of the Southern slope of the Greater Caucasus according to paleomagnetic data. *Materials of the XX All-Russian conference with international participation*. Voronezh, 2016, pp. 186-190. (in Russian)
- Isayeva M.I., Garayeva T.J., Bagirova A.A. Solving geological and geophysical problems using paleomagnetic data. *Geophysics News in Azerbaijan*, Baku, No. 3-4, 2017, pp. 11-16. (in Russian)
- Kangarli T.N., Balamedov Sh.R., Sadykhov E.F., Mehdiyeva Z.N. Lithological-Facies Zonality of Stratification of the Southeastern Caucasus Upper Jurassic Complex. Article 1 – Malmian Formations of Side Range Zone. *Proceedings of Azerbaijan National Academy of Sciences, The Sciences of Earth*, Issue 3, 2013, pp. 3-15, [https://journalsgia.com/wp-content/files/2013/03/2013\\_03\\_](https://journalsgia.com/wp-content/files/2013/03/2013_03_).
- Kangarli T.N., Mehdiyeva Z.N. Upper Jurassic complex of Greater Caucasus Side range: lithofacies and sedimentation (Azerbaijan). *Stratigraphy and sedimentology of oil-gas basins*, International scientific journal,

## ЛИТЕРАТУРА

- Гараева Т.Д., Новрузов З.А., Багирова А.А. Геодинамика Азербайджанской части Малого Кавказа по палеомагнитным данным. *Горный информационно-аналитический бюллетень*, Москва, № 6, 2017, с. 253-263.
- Исаев Б.М., Кенгерли Т.Н., Рашидов Х.А. и др. Отчет о поисково-съёмочных работах масштаба 1:25000 на юго-восточном погружении Большого Кавказа за 1974-1976 гг. Гос. инф.-арх. фонд МЭПР АР. Баку, 1977.
- Исаева М.И., Гараева Т.Д., Новрузов З.А., Багирова А.А. Глубинное строение и сдвиговые деформации блоков южного склона Большого Кавказа по палеомагнитным данным. *Материалы XX Всероссийской конференции с международным участием (г. Воронеж, 25-30 сентября 2016 г.)*. Издательско-полиграфический центр «Научная книга», Воронеж, 2016, с. 186-190.
- Исаева М.И., Гараева Т.Д., Багирова А.А. Решение геолого-геофизических задач палеомагнитным методом. *Geophysics News in Azerbaijan*, Баку, № 3-4, 2017, с. 11-16.
- Новрузов З.А., Исаева М.И., Гараева Т.Д., Багирова А.А. Результаты термомагнитного анализа меловых отложений Лагичского разреза (Вандамская тектоническая зона, Южный склон Большого Кавказа, Азербайджан). *Геофизический журнал*, Украина, Киев, Т. 39, № 3, 2017, с. 91-96, <https://doi.org/10.24028/gzh.0203-3100.v39i3.2017.104029>.
- Храмов А.Н., Гончаров Г.И., Комиссарова Р.А. и др. *Палеомагнетология*. Под редакцией А.Н.Храмова. Ленинград, Недра, 1982, 312 с.
- Enkin R.J. The direction–correction tilt test: an all-purpose tilt/fold test for paleomagnetic studies. *Earth and Planetary Science Letters*, Elsevier, 2003, Vol. 212, Issues 1-2, pp. 151-166, [https://doi.org/10.1016/S0012-821X\(03\)00238-3](https://doi.org/10.1016/S0012-821X(03)00238-3).
- Garayeva T.J., Novruzov Z.A., Bagirova A.A. Paleotektonic reconstruction of blocks of Pliocene-Pleistocene sections of the Southeastern Parts of the Greater Caucasus. *Proceeding of the I International scientific conference “Modern science: experience, traditions, innovations”*, SC. Scientific conferences, Berlin. Germany, 2023, pp. 22-27, <https://doi.org/10.5281/zenodo.7604871>.
- Kangarli T.N., Balamedov Sh.R., Sadykhov E.F., Mehdiyeva Z.N. Lithological-Facies Zonality of Stratifi-

- Nafta-Press, Baku, No. 2, 2017, pp. 28-53, <https://isjss.a-z.az/userfiles/uploads/978fe5b3da05e6016876986bde43634f.pdf>.
- Khramov A.N., Goncharov G.I., Komissarova R.A. et al. Paleomagnetology. Edited by A.N.Khramov. Leningrad, Nedra, 1982, 312 p. (in Russian)
- Mehdiyeva Z.N. Characteristics and conditions of accumulation of the Upper Jurassic sediments in the South-Eastern Caucasus. Stratigraphy and sedimentology of oil-gas basins, International scientific journal, No. 1, 2022, pp. 56-65.
- Novruzov Z.A., Isayeva M.I., Garayeva T.J., Bagirova A.A. Results of thermomagnetic analysis of Cretaceous deposits of the Lagich section (Vandam tectonic zone, southern slope of the Greater Caucasus, Azerbaijan). Geophysical Journal, Ukraine, Kyiv, Vol. 39, No. 3, 2017, pp. 91-96, <https://doi.org/10.24028/gzh.0203-3100.v39i3.2017.104029>. (in Russian)
- Novruzov Z.A., Garayeva T.J., Bagirova A.A. Paleoteknic reconstruction of the Karabakh uplift based on paleomagnetic data (Lok-Karabakh zone, Lesser Caucasus, Azerbaijan). SC scientific conferences, Proceeding of the 1<sup>st</sup> international scientific conference “New problems of science and ways of their solution”, Geological and Mineralogical Sciences, Paris, France, 2023, pp. 15-18, <https://doi.org/10.5281/zenodo.7628541>.
- Torsvik T.H., Van der Voo R., Preeden U., MacNiocaill C. et al. Phanerozoic polar wander, palaeogeography and dynamics. Earth-Science Reviews, Elsevier, Vol. 114, Issues 3-4, 2012, pp. 325-368, <https://doi.org/10.1016/j.earscirev.2012.06.007>.
- cation of the Southeastern Caucasus Upper Jurassic Complex. Article 1 – Malmian Formations of Side Range Zone. Proceedings of Azerbaijan National Academy of Sciences, The Sciences of Earth, Issue 3, 2013, pp. 3-15, [https://journalsesgia.com/wp-content/files/2013/03/2013\\_03\\_](https://journalsesgia.com/wp-content/files/2013/03/2013_03_).
- Kangarli T.N., Mehdiyeva Z.N. Upper Jurassic complex of Greater Caucasus Side range: lithofacies and sedimentation (Azerbaijan). Stratigraphy and sedimentology of oil-gas basins, International scientific journal, Nafta-Press, Baku, No. 2, 2017, pp. 28-53, <https://isjss.a-z.az/userfiles/uploads/978fe5b3da05e6016876986bde43634f.pdf>.
- Mehdiyeva Z.N. Characteristics and conditions of accumulation of the Upper Jurassic sediments in the South-Eastern Caucasus. Stratigraphy and sedimentology of oil-gas basins, International scientific journal, No. 1, 2022, pp. 56-65.
- Novruzov Z.A., Garayeva T.J., Bagirova A.A. Paleoteknic reconstruction of the Karabakh uplift based on paleomagnetic data (Lok-Karabakh zone, Lesser Caucasus, Azerbaijan). SC scientific conferences, Proceeding of the 1<sup>st</sup> international scientific conference “New problems of science and ways of their solution”, Geological and Mineralogical Sciences, Paris, France, 2023, pp. 15-18, <https://doi.org/10.5281/zenodo.7628541>.
- Torsvik T.H., Van der Voo R., Preeden U., MacNiocaill C. et al. Phanerozoic polar wander, palaeogeography and dynamics. Earth-Science Reviews, Elsevier, Vol. 114, Issues 3-4, 2012, pp. 325-368, <https://doi.org/10.1016/j.earscirev.2012.06.007>.

## ПАЛЕОМАГНИТНЫЕ СВОЙСТВА ЮРСКОГО КОМПЛЕКСА СУДУРСКОЙ ШЕЛЬФОВОЙ ЗОНЫ БОЛЬШОГО КAVKAZA (АЗЕРБАЙДЖАН)

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**Резюме.** В статье представлено детальное стратиграфическое деление юрского комплекса континентального шельфа Северо-Кавказского края Евразии. Стратиграфия юрских отложений региона, приуроченного к южной окраине Скифской платформы, до настоящего времени изучена недостаточно полно и требует уточнения. С другой стороны, палеомагнитные исследования в этой области ранее не проводились. Изучаемый район расположен на северном склоне юго-восточной части горно-складчатой системы Большого Кавказа. Для изучения палеомагнитных свойств юрских пород из разреза Тагирджалчай было отобрано 80 ориентированных образцов. Магнитная восприимчивость и естественная остаточная намагниченность отложений изменяются соответственно в пределах  $0,6 \times 10^{-3} - 1,6 \times 10^{-3}$  BS и  $2,9 \times 10^{-3} - 16,9 \times 10^{-3}$  А/м. Среднее значение постоянной компоненты указывает на то, что намагниченность близка к своему первоначальному состоянию и, следовательно, может быть использована для составления палеомагнитного профиля. На основе палеомагнитных данных впервые были изучены кинематические параметры юрских тектонических блоков на южной окраине Скифской платформы. Анализ исследовательских материалов выявил масштаб углового смещения блока. В результате магностратиграфического анализа разреза Тагирджалчай было выявлено всего 5 зон прямой намагниченности и 5 зон обратной намагниченности. Используя эти магнитные зоны, были определены границы между различными стратиграфическими подразделениями: аален–байос; байос–бат; бат–келловей; келловей–оксфорд; оксфорд–киммеридж.

**Ключевые слова:** Тагирджалчайский разрез, магнитная чувствительность, остаточная намагниченность, палеомагнетизм, магнитная полярность

## BÖYÜK QAFQAZIN SUDUR ŞELF ZONASININ YURA KOMPLEKSİNİN PALEOMAQNİT XÜSUSİYYƏTLƏRİ (AZƏRBAYCAN)

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**Xülasə.** Məqalədə Avrasiyanın Şimal Qafqaz kənarının qitə şelfinin Yura kompleksi üçün detallı stratigrafik bölgü təqdim olunur. Skif platformasının cənub kənarına uyğun gələn bu ərazidə Yura süxur komplekslərinin stratigrafiyası kifayət qədər öyrənilməmişdir. Digər tərəfdən, bu regionda paleomaqnit tədqiqatları əvvəllər aparılmamışdır. Tədqiq edilən rayon Böyük Qafqaz dağ-qırışıqlıq sisteminin cənub-şərq hissəsinin şimal yamacında yerləşir. Yura süxurlarının paleomaqnit xüsusiyyətlərini öyrənmək məqsədilə Tahircalçay kəsilişindən 80 istiqamətləndirilmiş nümunə götürülmüşdür. Süxur nümunələrinin maqnit həssaslığı və təbii qalıcı maqnitləşməsi müvafiq olaraq  $0,6 \times 10^{-3} - 1,6 \times 10^{-3}$  BS və  $2,9 \times 10^{-3} - 16,9 \times 10^{-3}$  A/m intervalında dəyişir. Qalıcı komponentin orta dəyəri göstərir ki, maqnitləşmə ilkin vəziyyətinə yaxındır və buna görə də paleomaqnit profilinin tərtibində istifadə oluna bilər. Paleomaqnit məlumatları əsasında ilk dəfə Skif platformasının cənub kənarındakı Yura tektonik bloklarının kinematik parametrləri öyrənilmişdir. Tədqiqat materiallarının təhlili blokun bucaqlı yer dəyişməsinin miqyasını üzə çıxarmışdır. Tahircalçay kəsilişinin maqnostratigrafik təhlili nəticəsində cəmi 5 birbaşa maqnitləşmə zonası və 5 tərs maqnitləşmə zonası müəyyən edilmişdir. Bu maqnit zonalarından istifadə edilməklə müxtəlif stratigrafik vahidlər arasında sərhədlər müəyyən edilmişdir: Aalen–Bajos, Bajos–Baton, Baton–Kellovey, Kellovey–Oksford, Oksford–Kimmeric.

**Açar sözlər:** *Tahircalçay kəsilişi, maqnit həssaslığı, qalıcı maqnitləşmə, paleomaqnetizm, maqnit polyarlığı*

**GEOLOGICAL STRUCTURE AND MINERALIZATION FEATURES OF THE SOYUDLU (ZOD) GOLD DEPOSIT IN GARABAGH (KALBAJAR DISTRICT)**

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**Summary.** The Soyudlu (Zod) gold deposit is one of the major gold-bearing objects of the Lesser Caucasus. This study focuses on the geological structure of the deposit, the spatial distribution of mineralized bodies, and the principal structural and hydrothermal factors controlling ore localization. Particular attention is given to graphical interpretation, because the geometry of ore bodies and their spatial relationship with fault systems, dikes, and hydrothermal alteration zones provide key evidence for understanding the mineralization pattern. The deposit is confined to the central and southeastern part of the Garamanly–Zod–Soyudlu anticlinal structure within the Goycha–Hakari geostructural zone and belongs to the ophiolitic domain of the Lesser Caucasus. The ore field is characterized by gabbroic and ultrabasic rocks, rhyodacitic dikes, and a structurally complex system of north–south, northwest–southeast, and northeast–southwest faults. Graphical materials show that mineralization is concentrated in a limited number of principal ore bodies and follows a distinct tectonic framework. Hydrothermal alteration is represented mainly by quartz-carbonate and talc-carbonate assemblages developed along pre-existing structural dislocations. Quantitative descriptors of structural ordering, ore-body concentration, and alteration-zone variability support the interpretation that Soyudlu is a structurally controlled hydrothermal gold system. The combined interpretation of the location scheme, ore-body distribution map, isometric diagram, and three-dimensional views confirms that the deposit may be regarded as an important geological model for understanding structurally focused gold mineralization in the Lesser Caucasus.

**Keywords:** *Soyudlu (Zod), gold deposit, Lesser Caucasus, structural control, hydrothermal alteration, ore bodies, geological interpretation*

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## **Introduction**

Gold mineralization in the Lesser Caucasus is characterized by a strong dependence on regional tectonic setting, lithological contrasts, and the long-term evolution of hydrothermal systems. Within this metallogenic framework, the Soyudlu (Zod) deposit occupies a particularly important position because it combines large-scale mineralization with a geologically complex internal structure. The deposit is located in the Kalbajar region and belongs to the Goycha–Hakari geostructural zone, specifically to the central and southeastern part of the Garamanly–Zod–Soyudlu anticlinal structure. Its regional and local geological position is shown in Fig. 1.

It is associated with the ophiolitic domain of the Lesser Caucasus and is localized in sedimentary rocks and intrusive bodies related to regional volcanism. This geological position alone makes the deposit significant as a natural example of structurally controlled hydrothermal gold mineralization (Шихалибейли, 1964, 1966; Гасанов, 1985)

## **Previous investigations and regional geological background**

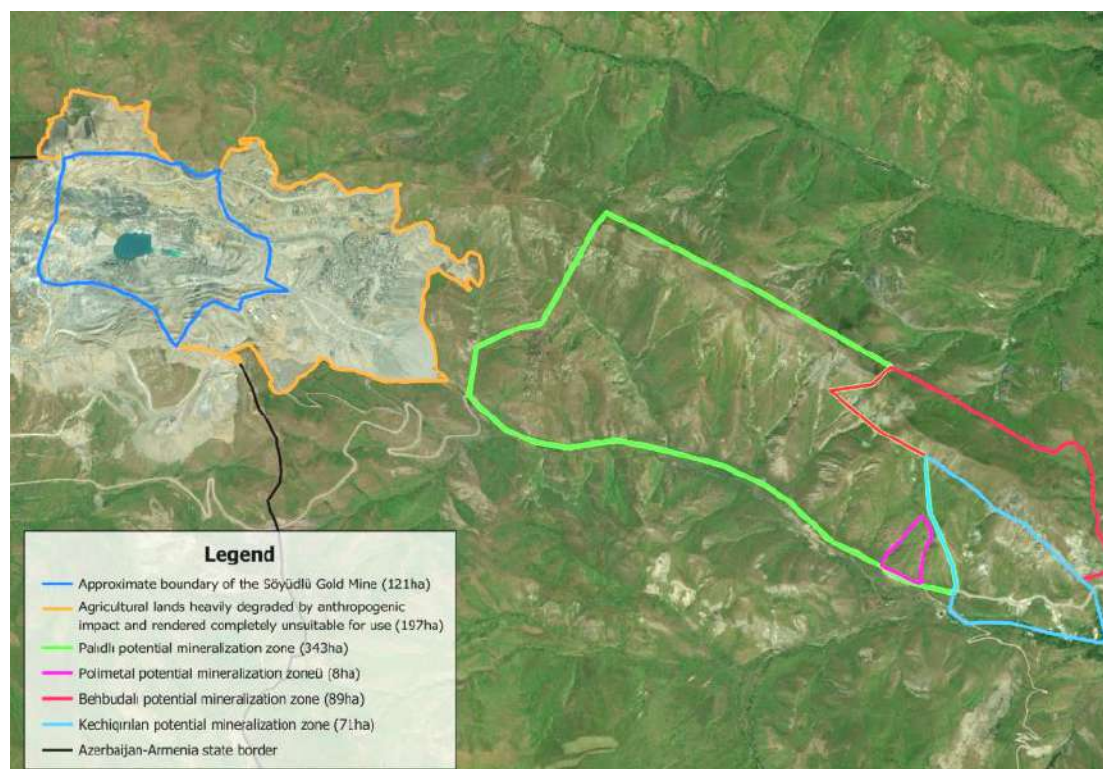
Previous geological studies of the Lesser Caucasus provide an important basis for interpreting the Soyudlu (Zod) deposit. The broader geological framework of Azerbaijan, including

regional stratigraphic correlations, has also been discussed in earlier syntheses (Ализаде и др., 1989). The regional tectonic evolution, magmatism and structural segmentation of the eastern Lesser Caucasus were described in detail by Shikhalibeyli (Шихалибейли, 1964, 1966), while the ophiolitic complexes of the Lesser Caucasus and their role in the regional tectonic architecture were systematized by Hasanov (Гасанов, 1985). The Sevan-Garabagh / Goycha-Nakari ophiolitic zone and the metallogenic significance of ultrabasic and gabbroic associations were also discussed in earlier works by Baba-Zade (Баба-заде, 1974) and Baba-Zade and Maluytin (Баба-заде, Малютин, 1967). These studies form the regional geological framework within which the Soyudlu (Zod) deposit can be considered as part of a structurally complex ophiolitic and ore-bearing system of the Lesser Caucasus.

Later generalizations on noble-metal ore-magmatic systems and gold-bearing sulfide fields of the Lesser Caucasus showed that gold mineralization in the region is commonly linked with island-arc paleosystems, magmatism, hydrothermal alteration and structural control (Баба-заде, Абдуллаева, 2012; Баба-заде и

др., 2015). However, despite the extensive regional background, the spatial geometry of ore bodies, their relationship with hydrothermal alteration zones and the practical value of three-dimensional geological interpretation for the Soyudlu (Zod) deposit still require additional integrated analysis. The present study therefore builds upon previous regional investigations and focuses on figure-based interpretation of ore-body distribution and structural-hydrothermal controls within the deposit.

A major difficulty in describing Soyudlu is that the deposit cannot be adequately understood through text alone. Its internal architecture is controlled by several fault systems of different orientation, by the spatial relationship between dikes and ore bodies, and by the uneven distribution of hydrothermal alteration. In such deposits, the geometry of mineralized bodies is as important as their mineralogical composition. For this reason, graphical interpretation plays a central role in the present study. The location scheme, ore-body distribution map, isometric diagram, and three-dimensional views are not supplementary illustrations only; they form the visual framework through which the structural organization of the deposit can be understood.



**Fig. 1.** Geological location of the Soyudlu (Zod) deposit

The geological description of the deposit shows that the ore field is affected by north–south, northwest–southeast, and northeast–southwest fault systems. These structures complicate the internal architecture of the deposit and, at the same time, appear to control the distribution of hydrothermal alteration and ore localization. The host rocks include gabbroic, ultrabasic, and rhyodacitic units, while hydrothermal alteration is represented mainly by quartz-carbonate and talc-carbonate assemblages. The mineralized system is therefore the result of the interaction of tectonic preparation, favorable host lithologies, and fluid-related ore deposition. The principal ore bodies are not distributed evenly across the ore field, but are concentrated in a limited number of structurally favorable domains. This pattern is one of the central observations examined in the article.

Another important reason to study Soyudlu is that the deposit illustrates how several scales of geological evidence can be integrated. At the regional scale, it belongs to a well-defined structural zone of the Lesser Caucasus. At the deposit scale, it is organized into a system of major and minor ore bodies. At the internal ore-field scale, it shows strong variability in alteration thickness, vein orientation, and structural continuity (Баба-заде, 1974; Баба-заде, Абдуллаева, 2012; Баба-заде и др., 2015).

A scientifically useful description of such a deposit should therefore move from regional position to deposit geometry and then to ore-body scale. This is why the article is organized around both geological description and figure-based interpretation.

The aim of this study is to characterize the geological structure and mineralization features of the Soyudlu (Zod) gold deposit and to identify the principal structural and hydrothermal factors controlling ore-body localization. Particular attention is given to the interpretation of graphical materials prepared during geological investigations within AzerGold CJSC studies, because these materials make it possible to relate ore bodies directly to structural corridors, alteration zones, and intrusive elements. The study does not attempt to present an internal technical report or a production-based evaluation of the deposit. Instead, it develops a geological interpretation focused on the spatial organization of

mineralization and on the structural model that best explains that organization (Баба-заде, Абдуллаева, 2012; Баба-заде и др., 2015).

### **Materials and Methods**

This study was based on three complementary groups of materials. The first group consisted of previously published geological works on the eastern Lesser Caucasus, the ophiolitic complexes of the Lesser Caucasus, the Sevan-Garabagh / Goycha-Hakari zone, and noble-metal ore-magmatic systems (Шихалибейли, 1964, 1966; Гасанов, 1985; Баба-заде, 1974; Баба-заде, Малютин, 1967; Баба-заде, Абдуллаева, 2012; Баба-заде и др., 2015). The second group consisted of published methodological sources used to define the general scientific framework of the work, including the role of GIS and mining-geological information systems in deposit interpretation (Мамедов и др., 2020). The third group consisted of graphical materials prepared during geological studies of the Soyudlu (Zod) deposit within AzerGold CJSC. These materials formed the direct basis for deposit-scale interpretation. The article therefore combines a conventional academic approach with figure-based geological analysis derived from applied exploration materials.

The methodological approach was designed around the principle that a structurally complex deposit must be analyzed in both two-dimensional and three-dimensional form. For this reason, the study did not rely on a single figure or a single type of description. Instead, four key illustrations were treated as interconnected analytical elements. Fig. 1, the location and geological setting scheme, was used to establish the regional and local structural position of the deposit. Fig. 2, showing the distribution of ore bodies, was used to evaluate how mineralization is arranged within the deposit. Fig. 3, the isometric diagram, was used to examine the three-dimensional geometry of the principal ore bodies. Fig. 4, showing eastern and southern views of the mineralized bodies, was used to assess spatial continuity, relative position, and structural alignment in depth. Each of these figures contributed a different level of evidence, and only their combined interpretation allowed a coherent model of ore localization to be proposed.

The three-dimensional ore-body forms presented in the figures were not treated as independent images. They were obtained by geological interpretation and wireframe modelling in GEOVIA Surpac on the basis of geological mapping materials, ore-body contours, lithological boundaries, structural observations, geological sections and drilling-derived geological information available for the Soyudlu (Zod) deposit. The modelling was carried out by the authors using the geological investigation materials of AzerGold CJSC. Therefore, the colours and separate wireframes shown in the 3D views are used primarily to distinguish individual ore bodies and to make their spatial position visible; they are not intended to indicate separate ore grades, metallurgical classes or economic categories unless this is stated separately in the figure caption.

The interpretation began with the regional and local geological position of the deposit. The location scheme was examined not simply as a cartographic background, but as a structural reference for the rest of the study. It was used to place the deposit within the Goycha-Hakari geosstructural zone and the Garamanly-Zod-Soyudlu anticlinal structure, and to establish the tectonic context within which later ore-forming processes occurred. This step was important because the meaning of the ore-body geometry cannot be properly understood without reference to the larger structural framework.

The second stage of the study focused on ore-body distribution. The ore-body map was examined to identify the principal mineralized domains, to compare the relative importance of major and minor ore bodies, and to assess whether mineralization was dispersed or concentrated. Special attention was given to bodies 1, 4, 16, and 23, because the geological materials indicate that these bodies account for the dominant share of known mineralization. The figure was interpreted not only descriptively, but also comparatively: the position of these bodies was considered in relation to surrounding smaller ore zones and in relation to the structural corridors described in the geological text. This allowed the deposit to be viewed as a hierarchical mineralized system rather than a simple collection of isolated bodies.

The colours used for the ore bodies in Figs. 2-4 are intended primarily for visual differentia-

tion of individual mineralized bodies and for separating the principal ore bodies from smaller associated bodies. They should not be interpreted as independent metallurgical, mineralogical, or grade classes unless this is specifically stated in the figure legend. Bodies 1, 4, 16, and 23 are emphasized because they are distinguished by a combination of criteria: relative contribution to known mineralization, spatial continuity, three-dimensional persistence, and their position within the main structural and hydrothermal alteration corridors. The remaining mineralized bodies are shown separately in order to preserve their geological significance as secondary or peripheral mineralized zones that may be important for further exploration.

The third stage involved three-dimensional interpretation. The isometric diagram and the eastern and southern views were treated as the main source for understanding ore-body morphology, dip, elongation, and mutual position. These figures were analyzed together rather than separately. The isometric view was particularly useful for recognizing the overall geometry of the ore bodies and for identifying whether they form an ordered spatial system. The additional side views helped to clarify how these bodies continue in depth and how their position changes when observed from different directions. This stage was critical because many structural relationships that are only weakly visible in plan view become clearer when the bodies are examined in three-dimensional perspective.

The fourth stage consisted of integrating the graphical observations with the textual geological description. The geological text was used to identify the main host rocks, the role of north-south and east-west dike systems, the development of quartz-carbonate and talc-carbonate alteration, and the distribution of fracture and vein sets. These observations were then compared with the graphical geometry of the ore field. In this way, the study moved from descriptive geology to interpretive geology: the text provided geological meaning, while the figures showed spatial expression. The purpose of this stage was to test whether the deposit could be consistently interpreted as a structurally controlled hydrothermal system (Юнгмейстер и др., 2024).

In interpreting the relationship between faults, hydrothermal alteration and ore localiza-

tion, the study relies on the established regional geological understanding of the Lesser Caucasus rather than on unrelated stratigraphic works. The occurrence of quartz-carbonate and talc-carbonate alteration along tectonic dislocation zones is considered in the context of ophiolitic complexes, ultrabasic and gabbroic rocks, and noble-metal ore-magmatic systems described for the Lesser Caucasus (Гасанов, 1985; Баба-заде, Малютин, 1967; Баба-заде, Абдуллаева, 2012). Therefore, the alteration zones are interpreted as fluid-conducting structural corridors that created favorable conditions for the localization of gold mineralization.

The factual basis of the interpretation includes geological mapping materials, structural observations, lithological boundaries, ore-body outlines, drilling-derived geological sections, assay and geochemical information where available, and three-dimensional geological modeling materials prepared during investigations of the Soyudlu (Zod) deposit. The spatial interpretation was carried out by comparing mapped faults, dike systems, hydrothermal alteration zones and ore-body contours in plan view and in three-dimensional projections. In this approach, the 3D model is not treated as an independent result separated from field geology; it is used as a visual and analytical synthesis of mapping, drilling and geological interpretation data.

The interpretation procedure consisted of several consecutive stages: first, regional tectonic and ophiolitic setting was compared with earlier studies of the Lesser Caucasus; second, the local structural pattern of the deposit was examined on geological schemes and sections; third, ore bodies were compared with the position of fault-controlled permeability zones and hydrothermal alteration halos; fourth, three-dimensional views were used to verify the continuity, dip and relative position of the main ore bodies; finally, the obtained spatial regularities were assessed in terms of their possible application to further exploration and mining-geological planning.

From a methodological point of view, the present study is based on the integrated interpretation of geological schemes, ore-body distribution maps, and three-dimensional views obtained during geological investigations of the Soyudlu (Zod) deposit conducted within the framework of AzerGold CJSC research activi-

ties. This approach makes it possible to examine the relationship between structural framework, hydrothermal alteration, and the spatial organization of mineralization at different scales. In this context, the figures are treated not merely as illustrative material, but as analytical components used to evaluate ore-body geometry, continuity, and structural alignment.

Accordingly, the methodological emphasis of the paper is placed on geological interpretation supported by graphical analysis. The location scheme is used to define the regional and local structural setting of the deposit, the ore-body distribution map is used to identify the principal mineralized domains, and the isometric and directional views are used to assess the three-dimensional geometry of the ore bodies. The combined interpretation of geological description and graphical materials provides the basis for considering the Soyudlu (Zod) deposit as a structurally controlled hydrothermal gold system.

The theoretical basis of this study is that gold mineralization within the Soyudlu (Zod) deposit is structurally controlled and spatially associated with fault systems, hydrothermal alteration zones, and favorable host lithologies. This interpretation is consistent with the regional tectonic and magmatic framework of the eastern Lesser Caucasus described by Shikhalibeyli (Шихалибейли, 1966), the ophiolitic setting of the Lesser Caucasus summarized by Hasanov (1985), and the metallogenic significance of the Sevan-Garabagh / Goycha-Hakari ophiolitic zone discussed by Baba-Zade (Баба-заде, 1974). The geological description of the deposit indicates that the ore field is affected by north-south, northwest-southeast, and northeast-southwest fault systems, while hydrothermal alteration developed along pre-existing tectonic dislocations and is mainly represented by quartz-carbonate and talc-carbonate assemblages. In addition, the principal ore bodies are concentrated in a limited number of structurally favorable domains, which suggests that mineralization was localized through focused fluid migration rather than through uniform impregnation of the host rocks (Баба-заде, Абдуллаева, 2012; Баба-заде и др., 2015).

In this context, the hydrothermal alteration halos are considered not as isolated lithological

features, but as indicators of ore-forming fluid pathways. Quartz-carbonate alteration is interpreted as being most closely related to fractured and permeable structural zones where quartz-sulfide veining and gold mineralization were concentrated. Talc-carbonate alteration is associated mainly with ultrabasic and ophiolitic host rocks affected by hydrothermal fluids along tectonic dislocations. The spatial coincidence of these alteration assemblages with the principal ore bodies indicates that mineral formation occurred during stages of structurally focused hydrothermal activity rather than as a uniform alteration of the host rocks.

Therefore, the relationship between alteration halos and mineralization is assessed through three linked criteria:

- (i) their position relative to major faults and fracture corridors;
- (ii) their spatial overlap with the principal ore bodies, especially bodies 1 and 16; and
- (iii) the variability of alteration-zone thickness, which reflects changes in permeability and intensity of fluid circulation. This explanation clarifies why the quartz-carbonate and talc-carbonate halos are important for the genetic interpretation of the deposit and for recognizing zones that may be prospective during subsequent exploration.

In order to support the geological interpretation with quantitative descriptors, the present study applies a limited set of structural and geometrical indicators. These indicators are used only as supplementary descriptive tools and are not presented as new calculation methods or as reserve-estimation procedures. The entropy calculation follows the general information-entropy approach proposed by Shannon (1948), while the concentration and contrast ratios are applied here as simple statistical descriptors commonly used to compare the relative dominance and variability of geological objects. The use of information-based quantitative descriptors in mineral-related spatial interpretation is also consistent with approaches discussed by Abedi (2021), although in the present study these indicators are applied only as supplementary tools for geological interpretation. In mineral-deposit studies, such numerical descriptors should be interpreted together with geological mapping, drilling information, three-dimen-

sional modelling and expert geological judgement rather than separately from the geological context (Journel and Huijbregts, 1978; Sinclair and Blackwell, 2002). For this reason, the calculations in this paper are used to characterize structural ordering, ore-body concentration and alteration-zone variability within the Soyudlu ore field, but the final interpretation is based on the integrated analysis of factual geological materials and Surpac-based 3D models.

The first indicator describes the structural ordering of the mineralized vein system. According to the geological interpretation of the deposit and the regional structural framework of the Lesser Caucasus, the dominant orientation of mineralized veins reflects the influence of tectonic anisotropy developed within the ophiolitic and island-arc related systems of the region (Шихалибейли, 1966; Гасанов, 1985; Бабазаде, 1974; Бабазаде и др., 2015). Approximately 75% of quartz-sulfide veins are concentrated within the 60°-120° azimuth interval, around 15% within 30°-60°, and less than 10% are close to the north-south direction. To express the degree of structural ordering numerically, Shannon entropy was used in accordance with the general entropy concept of Shannon (1948):

$$H = -\sum_{i=1}^n p_i \ln p_i,$$

where  $p_i$  is the proportion of veins in each azimuth class.

For the grouped data:

$$H = -(0.75 \ln 0.75 + 0.15 \ln 0.15 + 0.10 \ln 0.10) = 0.7306$$

For three structural classes, the maximum possible entropy is

$$H_{\max} = \ln 3 = 1.0986$$

and the normalized evenness coefficient is

$$J = \frac{H}{H_{\max}} = \frac{0.7306}{1.0986} = 0.665$$

The second indicator characterizes the concentration of mineralization within the principal ore bodies. Ore bodies 1, 4, 16 and 23 were distinguished as principal bodies on the basis of a combined geological criterion rather than on colour alone. The selection is based on their relative share in known mineralization, greater spatial continuity in plan and section, clearer expression in the Surpac 3D wireframe model, association with the main structural-alteration corridors, and their potential practical importance for further exploration and mine planning. In this sense, the four bodies are treated as the dominant geological objects of the current model, while the remaining mineralized bodies are considered smaller or less continuous occurrences requiring additional verification during future exploration. The geological description states that ore bodies 1, 4, 16 and 23 account for up to 80% of the known mineralization. This relationship may be expressed as a concentration ratio:

$$CR_4 = \frac{M_{\text{main}}}{M_{\text{total}}}$$

where  $M_{\text{main}}$  is the proportion of mineralization hosted by the four principal ore bodies and  $M_{\text{total}}$  is the total known mineralization. For Soyudlu:

$$CR_4 = \frac{80}{100} = 0.80$$

or 80%. A complementary concentration coefficient may also be expressed as:

$$K_c = \frac{M_{\text{main}}}{M_{\text{minor}}} = \frac{80}{20} = 4.0$$

This means that, within the current geological model, the four principal ore bodies contain a much larger share of the known mineralization than the remaining bodies taken together. However, this result should not be interpreted as reducing the geological importance of the other approximately 20% of mineralization. From an exploration point of view, smaller mineralized bodies may represent lateral continuations, peripheral branches, blind extensions or less studied parts of the same hydrothermal system. Therefore, these occurrences remain important targets for additional mapping, drilling and geo-

chemical verification. The concentration ratio is used only to show the present hierarchy of ore bodies in the model, whereas the geological significance of both the dominant and subordinate mineralized bodies must be considered in future exploration planning (Sinclair, Blackwell, 2002).

The distinction between the principal four bodies and the remaining mineralized zones is therefore geological and modelling-based, not solely economic or metallurgical. At the present stage, the main criteria are ore-body continuity, size and geometry, structural position, relationship with hydrothermal alteration zones and contribution to the known mineralized volume. Economic parameters and metallurgical characteristics may further refine this classification at later stages, but they should not replace geological interpretation during the exploration stage. For this reason, the remaining 20% of mineralization is retained in the model as geologically meaningful and should be included in further exploration programs.

The third indicator describes the spatial heterogeneity of hydrothermal alteration. The thickness and position of the principal alteration zones were interpreted from geological mapping observations, lithological-structural boundaries, drilling-related geological information and their spatial comparison with ore-body wireframes in GEOVIA Surpac. The geological materials indicate that the thickness of the principal hydrothermal alteration zones varies from about 10 m to 50 m. The thickness contrast ratio was therefore calculated as:

$$K_t = \frac{T_{\text{max}}}{T_{\text{min}}} = \frac{50}{10} = 5.0$$

In addition, the normalized range of variation was estimated as:

$$V_t = \frac{T_{\text{max}} - T_{\text{min}}}{T_{\text{max}} + T_{\text{min}}} = \frac{50 - 10}{50 + 10} = 0.667$$

A simplified mean thickness of the principal alteration zone may be expressed as:

$$\bar{T} = \frac{T_{\text{max}} + T_{\text{min}}}{2} = \frac{50 + 10}{2} = 30 \text{ m}$$

These values show that the hydrothermal zones are strongly heterogeneous in thickness. Such variability indicates that hydrothermal activity was spatially selective and intensified within particular structural segments, most likely where permeability and fluid focusing were greatest. This interpretation is consistent with the observed spatial relationship between alteration zones and principal ore bodies in the central ore block and with the general model of structurally controlled noble-metal hydrothermal systems in the Lesser Caucasus (Баба-заде, Абдуллаева, 2012; Баба-заде и др., 2015).

Taken together, the calculated indicators support one coherent geological interpretation. The non-random orientation of the vein system, the strong concentration of mineralization in a few principal ore bodies, and the marked heterogeneity of hydrothermal alteration all indicate that the Soyudlu (Zod) deposit represents a structurally focused hydrothermal gold system. The role of the calculations in this study is therefore to provide numerical support for the geological model derived from the combined interpretation of textual and graphical materials.

From an applied point of view, the proposed interpretation can be used at the detailed exploration stage to refine the position of additional drill holes, to test the continuity of mineralized zones along fault-controlled corridors, and to distinguish between principal ore bodies and peripheral mineralized occurrences. During the mining-planning stage, the same approach may support the updating of geological models, clarification of ore-body boundaries, and better understanding of the relationship between mineralization, alteration and structural discontinuities. Thus, the regularities identified in this study have both genetic and practical significance.

The practical importance of the Surpac-based ore-body model lies in its ability to convert scattered geological observations into a coherent three-dimensional framework. For exploration, the model helps to identify where additional drill holes should be placed to test continuity along fault-controlled and alteration-controlled corridors. For resource modelling, it provides a basis for updating ore-body boundaries when new drilling and assay data become

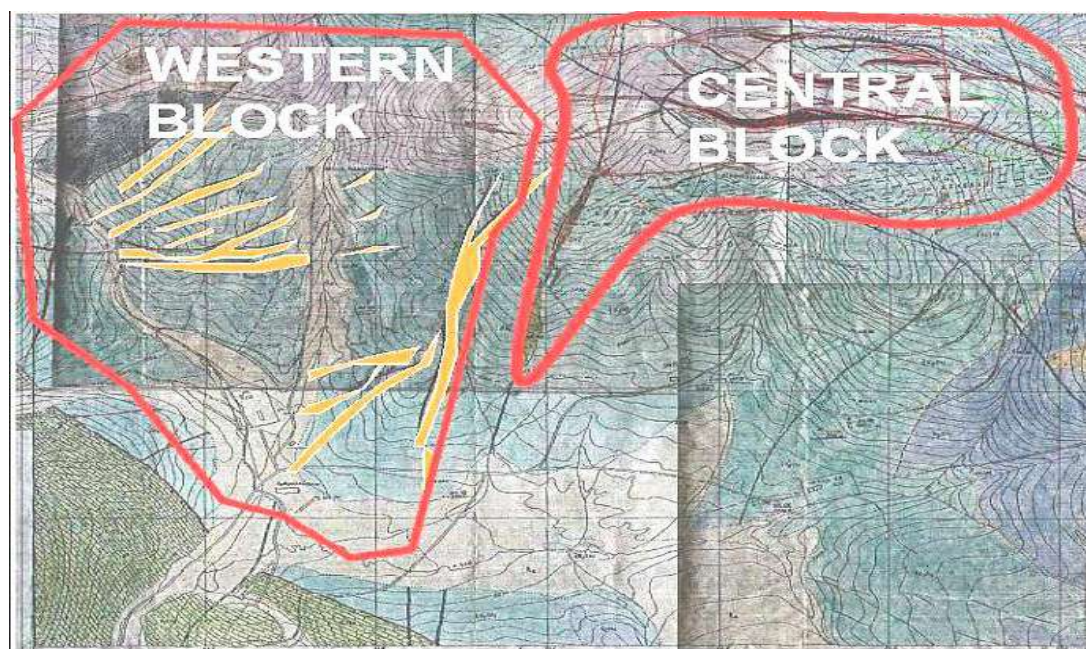
available. For mining, it supports the interpretation of ore-body geometry, expected continuity, contact zones with host rocks and the relationship between mineralization and structural discontinuities. Consequently, the 3D forms shown in the article are not only illustrative figures; they are practical geological tools for further exploration, model refinement and mine-planning decisions.

## **Results and Discussion**

The results of this study show that the Soyudlu (Zod) gold deposit has a well-defined structural framework that controls both the distribution of mineralization and the geometry of the ore bodies. This conclusion is supported by the geological description of the deposit and by the interpretation of Figs. 1-4, which together provide the main visual basis for understanding the structure of the ore field.

The first important result concerns the regional and local geological setting of the deposit. As shown in Fig. 1, the Soyudlu (Zod) deposit is situated within the Goycha-Hakari geosynclinal zone and occupies the central and southeastern part of the Garamanly–Zod–Soyudlu anticlinal structure. This figure is important because it places the deposit within its broader tectonic environment and establishes the geological framework in which ore formation occurred. In this respect, Fig. 1 provides the structural context for the interpretation of all other geological relationships discussed in the paper.

The second major result is the non-random distribution of ore bodies within the deposit. This relationship is clearly illustrated in Fig. 2, which shows the spatial arrangement of the main ore bodies. The figure demonstrates that mineralization is not evenly spread across the deposit area. Instead, it is concentrated in a limited number of structurally favorable domains. In particular, ore bodies 1, 4, 16, and 23 occupy the dominant positions within the ore field and represent the main centers of mineralization. This pattern supports the conclusion that the deposit has a clear internal hierarchy, in which several major ore bodies play the leading geological role, while the remaining mineralized zones are of secondary importance.



**Fig. 2.** Spatial distribution of the ore bodies in the Soyudlu (Zod) deposit. The colours are used to distinguish individual ore bodies and their relative spatial position; they do not represent separate ore grades or metallurgical classes. The ore-body contours and spatial relationships were interpreted in GEOVIA Surpac on the basis of geological investigation materials, drilling-related geological information and geological sections of AzerGold CJSC. Compiled by the authors

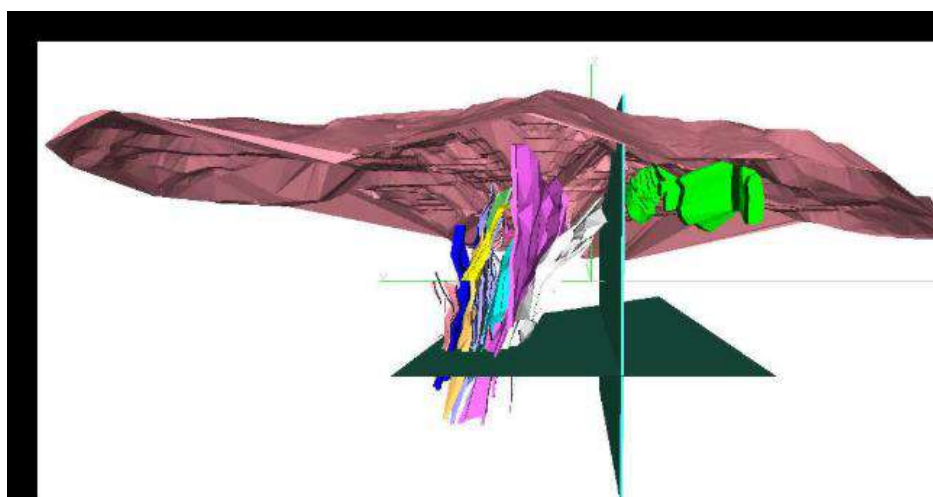
Fig. 2 is therefore central to the interpretation of ore concentration. It visually supports the idea that mineralization at Soyudlu is selective rather than uniform. From a geological point of view, this means that ore-forming fluids did not affect the deposit evenly but were concentrated in specific structural corridors and favorable host zones. The figure thus provides direct spatial evidence that ore accumulation was focused within a restricted number of major ore-bearing bodies.

The classification shown in Fig. 2 is therefore based on geological and spatial criteria rather than on colour alone. The principal ore bodies are separated from the smaller bodies because they show greater continuity, larger relative contribution to known mineralization and clearer spatial association with the main structural-alteration corridors. At the same time, the smaller bodies are not excluded from the geological model; they represent additional mineralized zones that may indicate lateral or depth extensions of the ore system and should be considered during subsequent exploration planning.

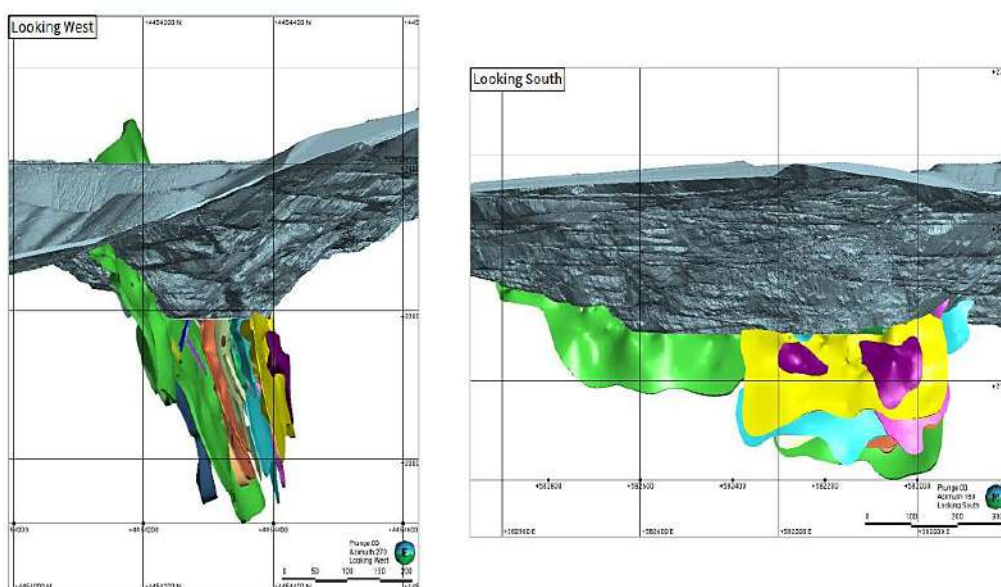
The third major result concerns the three-dimensional geometry of the ore bodies. While Fig. 2 is useful for understanding the distribution of mineralization in plan view, the spatial

organization of the deposit becomes much clearer in Fig. 3, which presents the isometric diagram of the ore bodies. This figure shows that the main ore bodies are elongated, ordered in space, and geometrically related to one another. They do not appear as isolated or randomly shaped lenses. Instead, their arrangement suggests structural continuity and a shared tectonic control. This is one of the strongest visual arguments in the article, because Fig. 3 allows the deposit to be understood as a three-dimensional geological system rather than as a simple set of mapped bodies.

This interpretation is further supported by Fig. 4, which presents eastern and southern views of the ore bodies. These views are particularly useful because they allow the reader to assess the dip, relative position, and continuity of the mineralized bodies in depth. In many geological studies, plan-view figures alone do not fully reveal the internal organization of a deposit. In the present case, Fig. 4 provides the additional spatial perspective needed to confirm that the ore bodies form a coherent structural system. Taken together, Figs. 3 and 4 show that the Soyudlu ore field is characterized by spatial order, continuity, and structural alignment.



**Fig. 3.** Isometric diagram of the ore bodies in the Soyudlu (Zod) deposit. The 3D wireframe representation was prepared by the authors in GEOVIA Surpac using geological investigation materials, ore-body contours, geological sections and drilling-derived geological information of AzerGold CJSC



**Fig. 4.** Eastern and southern views of the ore bodies in the Soyudlu (Zod) deposit (Directional views were generated from the Surpac 3D geological model to assess ore-body dip, continuity and relative spatial position)

Another important result is the close relationship between ore bodies and hydrothermal alteration zones. The central ore block contains two major alteration zones that play a key role in ore localization. The first extends approximately in an east–west direction and varies in thickness from 10 m to 50 m; ore body 1 is located within this zone. The second alteration zone lies to the north, initially follows a similar trend, and later changes orientation toward the southeast; ore body 16 is associated with this zone. These relationships become much clearer

when the geological description is considered together with Fig. 2 and the three-dimensional interpretation shown in Figs. 3 and 4. The figures help to show that the main ore bodies are not independent of the alteration system but are spatially embedded within it.

The structural interpretation of north-south, northwest-southeast and northeast-southwest fault systems is linked to the regional tectonic segmentation and magmatism of the eastern Lesser Caucasus described in earlier studies (Шихалибейли, 1966). The ophiolitic nature of

the geological environment and the role of ultrabasic rocks provide an additional basis for interpreting the ore field within the metallogenic framework of the Lesser Caucasus (Гасанов, 1985; Баба-заде, 1974). The connection between quartz-carbonate and talc-carbonate alteration, fluid migration and gold-bearing sulfide mineralization is consistent with models of noble-metal ore-magmatic systems and gold-bearing sulfide fields developed for the Lesser Caucasus (Баба-заде, Абдуллаева, 2012; Баба-заде и др., 2015).

This result is significant because it shows that hydrothermal alteration and ore deposition were closely linked. The variation in alteration-zone thickness and the localization of the principal ore bodies within those zones indicate that fluid movement was structurally focused. The deposit therefore cannot be interpreted as a group of randomly distributed ore occurrences. Instead, it should be understood as a structurally guided hydrothermal system in which the major alteration corridors served as the main pathways for ore-forming fluids.

The orientation of the mineralized vein system provides additional support for this interpretation. The structural analysis indicates that most quartz-sulfide veins belong to one dominant azimuth group, whereas secondary directions are much less common. This anisotropic pattern is consistent with the geometry of the ore bodies shown in Figs. 3 and 4. The significance of this result is that the deposit preserves a preferred tectonic direction of mineralization. In geological terms, ore emplacement occurred under directed structural control, where one dominant deformation trend exerted the strongest influence on fluid migration and ore concentration.

The results also highlight the importance of host lithologies and intrusive elements. The deposit is associated with ultrabasic and gabbroic rocks, as well as rhyodacitic dikes, and these lithological units formed the setting in which hydrothermal processes developed. Certain ore bodies are directly related to dike systems, indicating that ore localization depended not only on tectonic structures, but also on lithological and intrusive conditions favorable for mineral deposition. This observation is especially important when Figs. 2 and 3 are considered together, because they show that the mineralized

bodies occupy specific positions within the broader geological architecture of the deposit.

From a broader geological perspective, the results of this study show that the Soyudlu deposit may be regarded as a representative example of a structurally controlled hydrothermal gold system in the Lesser Caucasus. Its significance lies not only in the scale of mineralization, but also in the clarity with which structural control can be recognized through the combined interpretation of geological description and graphical representation. The present interpretation therefore has value beyond the deposit itself, because it illustrates an approach that may also be applied to other structurally complex gold deposits in the region. More specifically, the study shows that the combined interpretation of location schemes, ore-body maps, isometric diagrams, and directional views can provide a more convincing geological model than descriptive text alone.

The results and discussion support one consistent conclusion: ore localization at Soyudlu was governed by tectonic anisotropy, structurally focused hydrothermal circulation, and selective concentration of mineralization within a limited number of major ore bodies. The calculations presented in the previous section reinforce this interpretation numerically, while the geological figures confirm it spatially. Together, these two lines of evidence provide a coherent basis for describing the Soyudlu (Zod) deposit as a structurally controlled hydrothermal gold system.

In addition to the geological interpretation of ore-body geometry, the Surpac-based spatial model has practical significance for open-pit planning. The relationship between ore-body position, pit geometry, bench configuration and haul-road parameters allows the geological model to be linked with mine design decisions. The open-pit parameter scheme is included as an applied illustration of how the interpreted geological framework may be used during detailed exploration, boundary refinement and preliminary mine-planning stages. As shown in Fig. 5, the preliminary open-pit design parameters reflect the practical application of the geological interpretation to pit geometry, bench design, haul-road arrangement, and slope configuration.

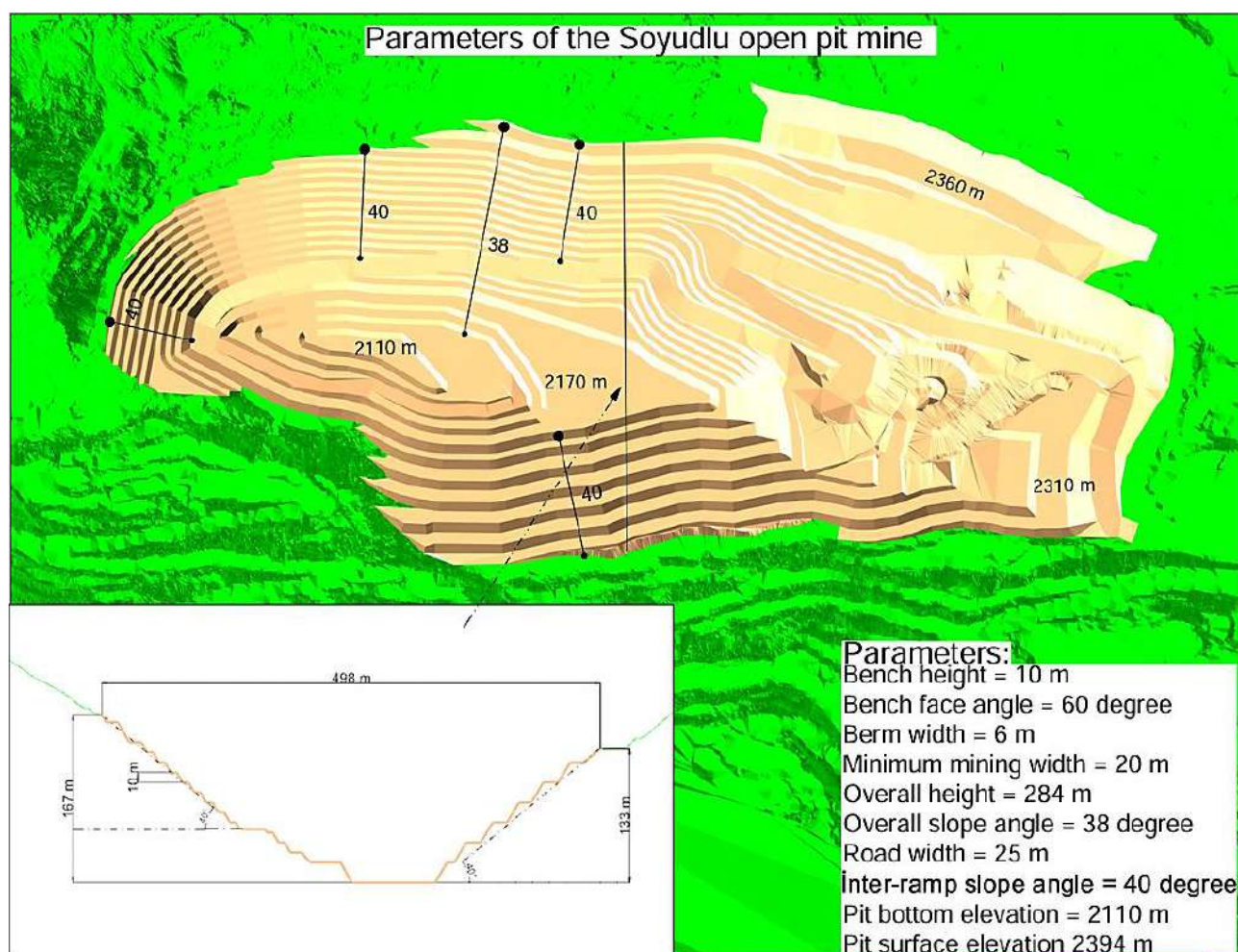


Fig. 5. Open pit design parameters of the Soyudlu (Zod) deposit

### Conclusion

The geological structure and mineralization characteristics of the Soyudlu (Zod) gold deposit reveal a structurally controlled hydrothermal system. The deposit occupies a well-defined position within the Goycha-Hakari geostructural zone and the Garamanly–Zod–Soyudlu anticlinal structure. Mineralization is not uniformly distributed but is strongly focused within a limited number of principal ore bodies, specifically bodies 1, 4, 16, and 23, which account for approximately 80% of the known mineralization. This selective concentration is governed by tectonic anisotropy and structurally focused fluid migration.

The quantitative analysis of the vein system supports this interpretation, as calculations of Shannon entropy ( $H = 0.7306$ ) and the normalized evenness coefficient ( $J = 0.665$ ) demonstrate a high degree of structural ordering. The close spatial relationship between the major ore bodies and highly variable hydrothermal altera-

tion zones – with thickness contrast ratios reaching 5.0 – further confirms that fluid movement was directed along specific structural corridors. Integrating three-dimensional graphical interpretations with these numerical descriptors provides a robust framework for understanding the complex architecture of the deposit. The Soyudlu deposit thus serves as a representative model for structurally focused gold mineralization in the Lesser Caucasus, and this integrated methodology can be effectively applied to similar deposits in the region.

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## REFERENCES

- Abedi M. Distance Measures in Mineral Potential Mapping: Squared L2, Shannon and Combination Families. *Geopersia*, Vol. 11, No. 2, 2021, pp. 245-261, <https://doi.org/10.22059/geope.2020.306387.648564>.
- Alizade A.A., Aliyulla Kh., Babaev Sh.A., Mamedova L.D., Mamedov N.A., Shykhlynsky S.A., Gasanov T.Ab. Regional Stratigraphic Scheme of the Paleogene of Azerbaijan. Elm, Baku, 1989. 312 p. (in Russian)
- Baba-Zade V.M. The problem of ophiolites of the Sevan-Garabagh zone (Lesser Caucasus). *Scientific Notes of ASU, Geological-Geographical Series*, No. 3, 1974, pp. 3-13. (in Russian)
- Baba-Zade V.M., Malyutin R.S. Chemical composition of chromospinelides in relation to petrochemical features of host ultrabasic rocks of the ophiolitic formation of Azerbaijan. *Scientific Notes of ASU, Geological-Geographical Series*, No. 5, 1967, pp. 82-86. (in Russian)
- Babazadeh V.M., Abdullayeva Sh.F. Noble-metal ore-magmatic systems. Baku University Publishing House, Baku, 2012, 276 p. (in Russian)
- Babazadeh V.M., Kekeliya S.A., Abdullayeva Sh.F. et al. Gold-bearing sulfide fields of island-arc paleosystems, their metallogenic peculiarities and conditions of geodynamic development (on the example of the Lesser Caucasus Alps). CBS Publishing House, Baku, 2015, 400 p. (in Russian)
- Hasanov T.A. Ophiolites of the Lesser Caucasus. Nedra, Moscow, 1985, 240 p. (in Russian)
- Journel A.G., Huijbregts C.J. *Mining Geostatistics*. Academic Press, London, 1978, 600 p.
- Mammedov A.A., Musaev S.D., Poshivailo Ya.G., Fedotov G.S. Geoinformation support for geological prospecting and mining of non-ferrous metal ores. *The InterCarto. InterGIS*, Vol. 26, No. 2, 2020, pp. 120-136, <https://doi.org/10.35595/2414-9179-2020-2-26-120-136>. (in Russian)
- Sinclair A.J., Blackwell G.H. *Applied Mineral Inventory Estimation*. Cambridge University Press, Cambridge, 2002, 381 p.
- Shannon C.E. A Mathematical Theory of Communication. *Bell System Technical Journal*, Vol. 27, 1948, pp. 379-423, 623-656.
- Shikhalibeyli E.Sh. Geological structure and history of tectonic development of the eastern part of the Lesser Caucasus within Azerbaijan. Vol. 1. Stratigraphy of Meso-Cenozoic deposits. Publishing House of the Academy of Sciences of the Azerbaijan SSR, Baku, 1964, 307 p. (in Russian)
- Shikhalibeyli E.Sh. Geological structure and history of tectonic development of the eastern part of the Lesser Caucasus within Azerbaijan. Vol. 2. Tectonic structure and magmatism. Publishing House of the Academy of Sciences of the Azerbaijan SSR, Baku, 1966, 263 p. (in Russian)

## ЛИТЕРАТУРА

- Ализаде А.А., Алиюлла Х., Бабаев Ш.А., Мамедова Л.Д., Мамедов Н.А., Шыхлинский С.А., Гасанов Т.Аб. Региональная стратиграфическая схема палеогена Азербайджана. Элм, Баку, 1989, 312 с.
- Баба-заде В.М. Проблема офиолитов Севано-Карабахской зоны (Малый Кавказ). *Ученые записки Азербайджанского государственного университета (АГУ)*. Серия геолого-географических наук, № 3, 1974, с. 3-13.
- Баба-заде В.М., Малютин Р.С. Структурно-текстурные особенности хромитовых руд офиолитовой полосы Азербайджанской части малого Кавказа. *Ученые записки Азербайджанского государственного университета (АГУ)*. Серия геолого-географических наук, № 5, 1967, с. 82-86.
- Бабазаде В.М., Абдуллаева Ш.Ф. *Благороднометалльные рудно-магматические системы*. Баку: Издательство Бакинского университета, 2012, 276 с.
- Баба-заде В.М., Кекелия С.А., Абдуллаева Ш.Ф., Кекелия М.А. Золотосодержащие сульфидные месторождения островодужных палеосистем, их металлогенические особенности и условия геодинамического развития (на примере альпид малого Кавказа). Издательство "CBS", Баку, 2015. 400 с.
- Гасанов Т.А. Офиолиты Малого Кавказа. Недра, Москва, 1985, 240 с.
- Мамедов А.А., Мусаев Ш.Д., Пошивайло Я.Г., Федотов Г.С. Геоинформационное обеспечение геологоразведки месторождений руд цветных металлов. *Материалы международной конференции ИнтерКарто. ИнтерГИС*, Т. 26, Ч. 2, 2020, с. 120-136, <https://doi.org/10.35595/2414-9179-2020-2-26-120-136>.
- Шихалибейли Э.Ш. Геологическое строение и история тектонического развития восточной части Малого Кавказа (в пределах Азербайджана). Т. 1. Стратиграфия мезокайнозойских отложений. Издательство Академии наук Азербайджанской ССР, Баку, 1964, 307 с.
- Шихалибейли Э.Ш. Геологическое строение и история тектонического развития восточной части Малого Кавказа (в пределах Азербайджана). Т. 2. Тектоническая структура и магматизм. Издательство Академии наук Азербайджанской ССР, Баку, 1966, 263 с.
- Abedi M. Distance Measures in Mineral Potential Mapping: Squared L2, Shannon and Combination Families. *Geopersia*, Vol. 11, No. 2, 2021, pp. 245-261, <https://doi.org/10.22059/geope.2020.306387.648564>.
- Journel A.G., Huijbregts C.J. *Mining Geostatistics*. Academic Press, London, 1978, 600 p.
- Sinclair A.J., Blackwell G.H. *Applied Mineral Inventory Estimation*. Cambridge University Press, Cambridge, 2002, 381 p.
- Shannon C.E. A Mathematical Theory of Communication. *Bell System Technical Journal*, Vol. 27, 1948, pp. 379-423, 623-656.

## ГЕОЛОГИЧЕСКОЕ СТРОЕНИЕ И ОСОБЕННОСТИ МИНЕРАЛИЗАЦИИ ЗОЛОТОРУДНОГО МЕСТОРОЖДЕНИЯ СЁЮДЛЮ (ЗОД) В КАРАБАХЕ (КЕЛЬБАДЖАРСКИЙ РАЙОН)

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**Резюме.** Золоторудное месторождение Сёюдлю (Зод) является одним из основных золотоносных объектов Малого Кавказа. Настоящее исследование посвящено геологическому строению месторождения, пространственному распределению минерализованных тел, а также основным структурным и гидротермальным факторам, контролирующим локализацию оруденения. Особое внимание уделено графической интерпретации, поскольку геометрия рудных тел и их пространственная связь с разломными системами, дайками и зонами гидротермальных изменений представляют собой ключевую доказательную основу для понимания закономерностей минерализации. Месторождение приурочено к центральной и юго-восточной части Караманлы–Зод–Сёюдлю антиклинальной структуры в пределах Гейча-Хакаринской геоструктурной зоны и относится к офиолитовой области Малого Кавказа. Рудное поле характеризуется габровыми и ультраосновными породами, риодаситовыми дайками, а также сложной системой разломов север-южного, северо-запад-юго-восточного и северо-восток-юго-западного направлений. Графические материалы показывают, что минерализация сосредоточена в ограниченном числе главных рудных тел и подчинена выраженному тектоническому каркасу. Гидротермальные изменения представлены главным образом кварц-карбонатными и тальк-карбонатными ассоциациями, развитыми вдоль ранее существовавших структурных нарушений. Количественные показатели структурной упорядоченности, концентрации рудных тел и изменчивости мощностей зон изменения подтверждают интерпретацию Сёюдлю как структурно контролируемой гидротермальной золоторудной системы. Совместный анализ схемы расположения, карты распределения рудных тел, изометрической диаграммы и трехмерных видов подтверждает, что данное месторождение может рассматриваться как важная геологическая модель для понимания структурно контролируемой золоторудной минерализации Малого Кавказа.

**Ключевые слова:** Сёюдлю (Зод), золоторудное месторождение, Малый Кавказ, структурный контроль, гидротермальные изменения, рудные тела, геологическая интерпретация

## QARABAĞDA YERLƏŞƏN SÖYÜDLÜ (ZOD) QIZIL YATAĞININ GEOLOJİ QURULUŞU VƏ MİNİRALLAŞMA XÜSUSİYYƏTLƏRİ (KƏLBƏCƏR RAYONU)

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**Xülasə.** Söyüdlü (Zod) qızıl yatağı Kiçik Qafqazın əsas qızıl yataqlarından biridir. Bu tədqiqat yatağın geoloji quruluşuna, minerallaşmış cisimlərin fəzavi paylanmasına, eləcə də filizləşmənin lokallaşmasına nəzarət edən əsas struktur və hidrotermal amillərə həsr olunmuşdur. Tədqiqatda qrafik interpretasiyaya xüsusi diqqət yetirilmişdir, çünki filiz cisimlərinin həndəsəsi və onların qırılma sistemləri, dayklar və hidrotermal dəyişmə zonaları ilə fəzavi əlaqəsi minerallaşma qanunauyğunluqlarının anlaşılması üçün əsas sübut bazasını təşkil edir. Yataq Göyçə-Həkəri geostuktur zonasının Qaramanlı–Zod–Söyüdlü antiklinal strukturunun mərkəzi və cənub-şərq hissəsində yerləşir və Kiçik Qafqazın ofiolit sahəsinə aiddir. Filiz sahəsi qabbro və ultraəsaslı süxurlar, riodasit daykaları, həmçinin şimal-cənub, şimal-qərb-cənub-şərq və şimal-şərq-cənub-qərb istiqamətli mürəkkəb qırılma sistemi ilə xarakterizə olunur. Qrafik materiallar göstərir ki, minerallaşma məhdud sayda əsas filiz cisimində cəmlənmişdir və aydın tektonik çərçivəyə tabedir. Hidrotermal dəyişmə əsasən əvvəlcədən mövcud olmuş struktur pozulmaları boyunca inkişaf etmiş kvars-karbonat və talk-karbonat assosiasiyaları ilə təmsil olunur. Struktur nizamlılıq, filiz cisimlərinin konsentrasiyası və dəyişmə zonalarının dəyişkənliyi üzrə kəmiyyət göstəriciləri Söyüdlü yatağının struktur nəzarətli hidrotermal qızıl sistemi kimi şərhini dəstəkləyir. Yerləşmə sxemi, filiz cisimlərinin paylanma xəritəsi, izometrik diaqram və üçölçülü görünüşlərin birgə təhlili təsdiq edir ki, bu yataq Kiçik Qafqazda struktur nəzarətli qızıl minerallaşmasının anlaşılması üçün mühüm geoloji model kimi qiymətləndirilə bilər.

**Açar sözlər:** Söyüdlü (Zod), qızıl yatağı, Kiçik Qafqaz, struktur nəzarət, hidrotermal dəyişmə, filiz cisimləri, geoloji interpretasiya

## SOURCES AND MIGRATION OF MERCURY IN THE HYDROGEOCHEMICAL SYSTEM OF THE YAREGA OIL FIELD

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**Summary.** The large Yarega oil field is one of the oldest in the Timan-Pechora province (Komi Republic). The oil from this field is very thick and highly viscous, making it impossible to extract using traditional methods. Therefore, an oil mine was built in the 1930s; it is currently the only one in Russia. The use of shaft mining allowed for a detailed study of the structure of the oil-bearing reservoir. In the past, the field likely had a gas cap. The geological structure of the field, its location near a major tectonic fault, and the geochemical characteristics of groundwater and gases suggest the involvement of deep fluids in the formation of this field.

This study examines the hydrochemistry of mercury in the Yarega mines. For this purpose, 26 samples were collected from the deposit's groundwater. The samples were collected in areas not subjected to thermal steam treatment, which is used to accelerate oil recovery from oil-bearing formations. Mercury was detected in all samples at varying concentrations. As a result, possible causes of the abnormal mercury content in the deposit area and its sources were identified. Geochemical mercury anomalies in groundwater at the Yarega oil field suggest the possibility of new oil and gas deposits in similar geological conditions. Furthermore, the environmental aspects of the research are of great importance for the Yarega field area and the Ukhta district. Six thousand people live in the Yarega workers' settlement, and about one hundred thousand in the Ukhta district. For these people, groundwater quality is of paramount importance.

**Keywords:** *Timan-Pechora oil and gas province, Yarega field, heavy oil, oil mine, groundwater, mercury, deep tectonic faults, filtration*

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### Introduction

Yarega extra-heavy crude oil field is in developed Ukhta area of Komi Republic which is towards 18 km from south-west of Ukhta city by Vorkuta-Kotlas rail (Fig. 1).

This field is found on the northeastern slope of the South Timan on crest of Ukhta brachianticlinal fold and is at depth of 130-300 meters. This large structure of platform type stretched more than 70 km in north-western direction, and in crestal area it is complicated by four local uplifts – structures of tertiary structures. The field is confined to Yareg, Lyayol and Vezhavozh structures which obtain the whole oil-bearing contour and general extension 36 km in the central and southern parts of fold (Fig. 2).

Yarega oil field was found, one of the first, in Timano-Pechor oil-and-gas bearing province in 1932. Since 1935 pilot operation of the field started by surface wells spacing of wells was fulfilled according to triangular well pattern with distance between them from 75 to 100 meters.

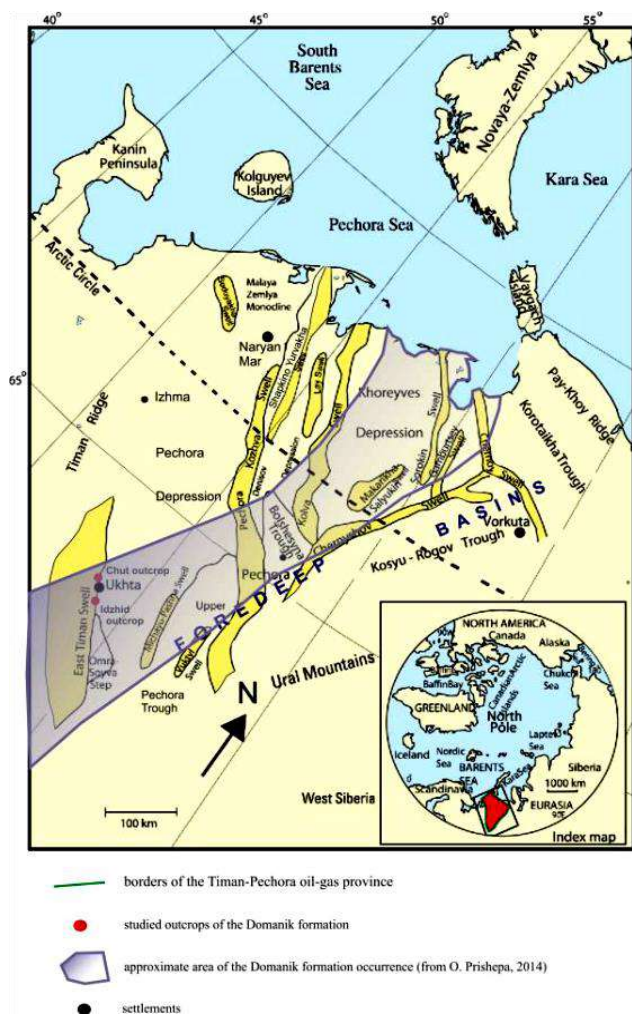
Surface exploitation appeared unprofitable and in 1937 the first oil mine building started, but since the end of 1939 – its exploitation and operation was fulfilled on natural recovery drive (at intervals in 1946-50). Average ratio of oil recovery was 0,032%.

Since 1972 thermal mining technology was used for extra-heavy crude oil recovery aimed to reservoir recovery increase.

Middle Devonian Bed III is oil bearing and underlying the Devonian section foundation on a rough surface of sericite – chlorite-quartz shales of Riphean Base. Bed consists of mainly quartz sandstones with low-thickness interlayers and lenses of siltstones, mudstones and conglomerates (Fig. 3).

Reservoir III of fractured-porous-type reservoirs with porosity 26% and permeability 2-3 Darcy is disrupted by blocks often partially isolated by clayey material presenting in area of blocks displacement. Shales are intensively dislocated and fractured by subvertical cracks and

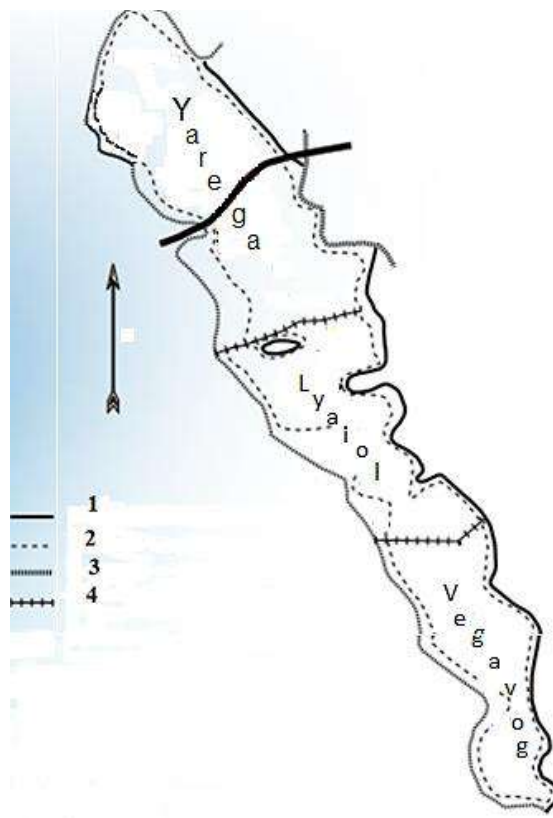
faults with rocks displacement vertically up to 10 meters. Fractures are either gaping fractures or they are filled by different material: clay, silica, ozocerite, and calcite.



**Fig. 1.** Location map of the Timan-Pechora basin with indication of the studied outcrops (the map is from Schenk, 2011)

Fractures are followed by areas of fracturing and microcracks. Amplitude increase can be observed by depth in disturbance cutting productive strata: it is more by 2-3 times on superface of shales than on superface of stratum III. In western area of northern perecline of structure fault throw takes a place more than 100 meters. Large deep-seated fault passes at 10 km to east from Yarega field, it is Eastern Timan fault pronounced in basement and sedimentary cover which was bedded in the Riphean and was constantly developed from Devonian to Triassic. Average thickness of stratum is about 70 meters, maximum – 106 meters.

Abovementioned data show a high permeability of section in Yarega field and a possible active filtration of gases from deep horizons of the Earth Crust and mantle to the sedimentary cover, especially during activation period of the Timan.



**Fig. 2.** Overview map of the Yarega field (Heфтeгазоносноcть..., 1999)

1 – contour of balance oil reserves; 2 – outer contour of oil content; 3 – line of wedging out of Bed III; 4 – boundaries of the area division

### Material and methods

Primary objective of this research: clarification of patterns for mercury distribution in groundwaters of the field aimed at further usage of obtained peculiar features of mercury hydrochemistry in order to determine tectonically active areas and to predict oil and gas content of section.

Mercury content was defined in 26 water samples of Yarega field. Samples were cut in areas with natural occurrence of waters which is not affected by steam treatment. Samples were cut in industrial mine of oil-bearing Bed III, Bed “A” bedded above and from Quaternary beds of the field (Fig. 3).

System	Series	Stage	Substage	Superstage	Horizon	Bed	Bedset	Average depth, m	Column	Average thickness, m	Lithological characteristics			
DEVONIAN-D	UPPER-D <sub>3</sub>	Frasnian-D <sub>3f</sub>						10.6		10.6	Soil and vegetation layer with inclusions of gravel, pebbles and rare boulders			
								17.0		6.4	Clays with interlayers of sand, with inclusions of pebbles and boulders			
								20.0		3.0				
								24.0		4.0				
								30.4	Timanian -D <sub>3im</sub>	I	6.4		6.4	Argillite-like clays, calcareous, brownish-gray
								33.1				2.7	Mudstones with occasional interlayers of limestone and marl. Abundant fauna. Remains of charred flora	
								70.6	A		37.5		37.5	Clayey sandstones with interlayers of clays and limestones
								79.1				8.5	Argillites with interlayers of limestone and, less commonly, marl	
								121.7	Dz'yer -D <sub>2dzr</sub>		42.6		42.6	Clayey sandstones with interlayers of mudstones and limestones
								127.6			5.9			
								133.6			6.0			
								139.0			5.4			
								176.0	Tuffaceous-D <sub>2'tf</sub>			37.0	Eroded tuffites, tuffoid clays with layered and intersecting bodies of diabases and basalts	
								186.0	Argillite			10.0	Argillites with sandstone interlayers	
								188.0	Argillite			2.0	Coarse-grained leucoxene-quartz sandstones	
MIDDLE-D <sub>2</sub>	Givetian-D <sub>2gv</sub>	Staroskolian -D <sub>2sl</sub>			III		Middle	212.0		24.0	Fine-grained quartz sandstones, cross-bedded, with interlayers of argillites and siltstones			
							Lower	230.0		8.0	Siltstones, mudstones, sandstone lenses with leucoxene			
							242.0		12.0	Leucoxene-quartz sandstones from fine-grained to conglomerates with interlayers of argillites and siltstones				
R										Metamorphic schists with quartzite interlayers				

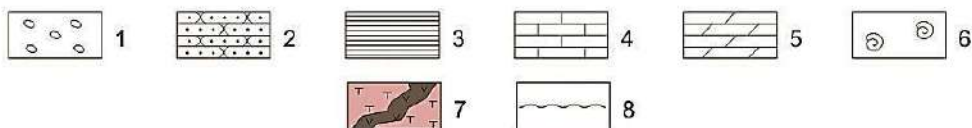


Fig. 3. Summary lithological and stratigraphic section of the Yarega field (Нефтегазоносность..., 1999)  
 1 – gravel and pebble inclusions; 2 – sandstones; 3 – siltstones and mudstones; 4 – limestones; 5 – marls; 6 – fauna; 7 – tuffoid horizon (tuffs, dolerites); 8 – unconformity surface

Total mercury content was defined by colorimetric dithizone method with previous destruction of its complex compounds. Mercury is found in all samples in concentrations from traces up to 10 µg/l. Maximum concentrations of mercury are defined in groundwaters of mine No. 2 and reach 10 µg/l. Mercury concentration changes according to traces up to 5 µg/l and on average is 1 µg/l in groundwaters of mine No. 1 and mine No. 3, while average mercury content is by 3 times higher in groundwaters of mine No. 2.

### Results and Discussions

Enclosing rocks, oil of the field and gases of the field can be considered as the potential sources of mercury supply to the groundwaters of Yarega field.

Average mercury content in hydrosphere is 1 µg/l. Mercury concentrations from 0,1-10 µg/l are in water diffusion halation, and this differs insignificantly by background readings (Минова, Бакулина, 2005). Mercury concentrations up to 20 µg/l were found only in acid sulphate waters with pH 2-3 in oxidation zones of mercury sulphide deposits (for example, Nikitovo in Ukraine). Water diffusion halation of mercury in ground and surface waters are usually small – 100-300 m.

Low mercury concentrations in waters can be explained by a weak solubility of mercury compounds and its intensive sorption from solutions by clay minerals, hydroxides of metals and calcite.

Hydrogeological conditions of Yarega field are studied well enough and are touched upon in the works of B.N.Lubimov, M.Sh.Modelevsky and other researchers of Yarega field. On chemical composition of water in productive beds – weakly alkaline chloride, sodium and calcium-sodium solutions with mineralization from 36 to 93 g/l. Waters of Bed III directly bedded on eroded surface of shales are similar to waters of shales themselves as there are no waterproof layers between them.

Rocks with high mercury content are not found in the section of Yarega field which could allow mercury concentrations observed in waters. Even the deeper horizons of basement area enriched by mercury are not be able to transfer mercury to solution by alkaline groundwaters

(pH>8). Thus, rocks which build up the section of Yarega field cannot be the source of mercury in its groundwaters.

The second source is oil. In Western Siberia mercury was found in all water samples of oil, gas and gas condensate deposits of the West-Siberia oil-and-gas bearing basin (Матусевич, Прокопьева, 1976). Maximum concentrations of mercury were monitored in waters of outline zone in gas fields (up to 30 µg/l). Its concentrations are minimal in waters of oil fields, and negative diffusion halations form nearby oil deposits.

Lab research was carried out on inter-reaction between water solutions of mercury and oil. After 10 days joint thermostation by 60°C oil and water solutions of mercury concentrations 50 µg/l (ratio water:oil as 1:5) mercury content reduced in water solution up to 5 µg/l.

This evidence indicates oil possibility to absorb mercury from its water solutions and do not allow to consider oil as a potential source of mercury from Yarega field.

The third possible source is gas. Deposit of Bed III doesn't possess gas cap, but abundant gas seep was monitored during penetration and layer test in many wells (Кремс, Вассерман, Матвиевская, 1974). It was observed that accumulations of free gas were seen in areas with sandstones of argillitic interlayers which probably provided screen for them and protected these accumulations from diffusion. Maximum gas-saturation of oil is defined in mine No. 2 (225 m<sup>3</sup>/t), and maximum mercury content is found in its waters. Gas-saturation of oils from mine No. 1 is 145 m<sup>3</sup>/t; mines No. 3 – 122.

Gas seeps from fractured zones of metamorphic shales as small accumulations of free gas and gas dissolved in waters of basement were found in many wells on structural high of Ukhta uplift and on its northern pericline. The most of free gas accumulation is confined to hypsometric rised crest positions of Ukhta fold. Wells drilled for metamorphic shales usually gushed water. These wells are on the aqua field situated in the crest of fold which is northern of Yarega. Gas factor is 1 m<sup>3</sup>/m<sup>3</sup>.

Composition of free gas and gas dissolved in groundwaters of Bed III and metamorphic shales consist of methane (prevails), heavy carbons (about 1%), nitrogen, hydrogen, helium,

argon, carbon-dioxide gas. Helium, hydrogen, methane, argon being in gases of Yarega field are connected with deep horizons of the Earth Crust and mantle, and this evidence allows to consider gases from the field as the mercury source in its groundwaters.

It is well-known about high volatility of mercury and its possible migration in gas phase from geochemistry of mercury. Study of volcanic exhalations of fumarolic and solfataric sources of Kamchatka and Kurils defined mercury can migrate to phase of post-volcanism together with sulphur trioxide and chloride gas. And cinnabar deposit (HgS) directly from volcanic gases which transfer mercury as HgCl<sub>2</sub> is found on some large mercury deposits. N.A.Ozerova considers mercury accumulation in different geological settings of lithosphere as a result of mantle degassing and indicates that “mercury breath of the Earth” fulfills through

the largest lineaments of global regmatic network (Озерова, 2010).

### Conclusions

So, it can be proved, migration of Yarega field gases from mantle and low horizons of the Earth Crust fulfilled by filtration on zones with rupture anomaly of folded basement of high rock fracturing in sedimentary cover. Presence of mercury in waters of field shows its entry to sedimentary cover on preexistent faults of basement currently. Otherwise mercury was in-took by oil or sorbed by minerals of enclosing rocks.

This research can be used for prediction of oil and gas content section on mercury geochemical anomalies on zones with large tectonic faults. Moreover, environmental study is of special significance for field area and for region as a whole.

### REFERENCES

- Krems A.Y., Wasserman B.Y., Matvievskaia N.D. Conditions for the formation and patterns of distribution of oil and gas deposits. Nedra, Moscow, 1974, 333 p. (in Russian)
- Matusevich V.M., Prokopyeva R.G. Mercury in groundwaters of the West Siberian oil and gas bearing basin. Neft i gaz (Oil and gas), No. 9, 1976, pp. 3-7. (in Russian)
- Minova N.P., Bakulina L.P. Mercury in the groundwaters of the Yarega oil field. Proceedings of the Scientific and Technical Conference, Ukhta, 2005, pp. 100-102.
- Oil and gas potential and geological-geophysical knowledge of the Timan-Pechora Province: history, modernity, perspectives. Ukhta, USTU, 1999, 1062 p. (in Russian)
- Ozerova N.A. Mercury degassing of the Earth: geological and ecological consequences. Mercury in the biosphere: ecological and geochemical aspects. Proceedings of the International Symposium (Moscow, September 7-9, 2010). Moscow, GEOKHI RAS, 2010, pp. 24-32. (in Russian)
- Schenk Ch.J. Chapter 18: Geology and petroleum potential of the Timan-Pechora Basin Province, Russia. Geological Society, London, Memoirs, Vol. 35, No. 1, 2011, pp. 283-294, <https://doi.org/10.1144/M35.18>.

### ЛИТЕРАТУРА

- Кремс А.Я., Вассерман Б.Я., Матвиевская Н.Д. Условия формирования и закономерности размещения залежей нефти и газа. Недра, Москва, 1974, 333 с.
- Матусевич В.М., Прокопьева Р.Г. Ртуть в подземных водах Западно-Сибирского нефтегазоносного бассейна. Нефть и газ, № 9, 1976, с. 3-7.
- Минова Н.П., Бакулина Л.П. Ртуть в подземных водах Ярегского нефтяного месторождения. Материалы научно-технической конференции, Ухта, 2005, с. 100-102.
- Нефтегазоносность и геолого-геофизическая изученность Тимано-Печорской провинции: история, современность, перспективы, Ухта, УГТУ, 1999. 1062 с.
- Озерова Н.А. Ртутная дегазация Земли: геолого-экологические следствия. Ртуть в биосфере: эколого-геохимические аспекты. Материалы Международного симпозиума (Москва, 7-9 сентября 2010 г.). Москва, ГЕОХИ РАН, 2010, с. 24-32.
- Schenk Ch.J. Chapter 18: Geology and petroleum potential of the Timan-Pechora Basin Province, Russia. Geological Society, London, Memoirs, Vol. 35, No. 1, 2011, pp. 283-294, <https://doi.org/10.1144/M35.18>.

## ИСТОЧНИКИ И МИГРАЦИЯ РТУТИ В ГИДРОГЕОХИМИЧЕСКОЙ СИСТЕМЕ ЯРЕГСКОГО НЕФТЯНОГО МЕСТОРОЖДЕНИЯ

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**Резюме.** Крупное Ярегское нефтяное месторождение одно из старейших в Тимано-Печорской провинции (Республика Коми). Нефть этого месторождения очень густая и высоковязкая и добывать ее традиционным способом оказалось невозможно. Поэтому еще в тридцатых годах прошлого века была построена нефтяная шахта, в настоящее время она единственная в России. Шахтный способ разработки нефтяной залежи позволил довольно детально изучить строение нефтеносного пласта. В прошлом, весьма вероятно, месторождение имело газовую шапку. Геологическое строение месторождения, расположение вблизи крупного тектонического разлома, а также геохимические характеристики подземных вод и газов позволяют предполагать участие глубоководных флюидов в формировании этого месторождения.

Данная работа посвящена изучению гидрохимии ртути в районе Ярегских шахт. Для этой цели были отобраны 26 проб из подземных вод месторождения. Пробы отбирались на участках, не подвергшихся паротепловому воздействию, которое используется для ускорения нефтеотдачи нефтеносного пласта. Ртуть обнаружена во всех пробах в различных концентрациях. В результате были выявлены возможные причины аномального содержания ртути в районе месторождения и ее источники. Геохимические аномалии ртути в грунтовых водах Ярегского нефтяного месторождения предоставляют возможность предполагать наличие новых месторождений нефти и газа в сходных геологических условиях. Кроме того, важное значение имеет экологический аспект исследований для района Ярегского месторождения и Ухтинского района. В рабочем поселке Ярега проживают шесть тысяч человек, в Ухтинском районе около ста тысяч. И для этих людей качество подземных вод имеет огромное значение.

**Ключевые слова:** *Тимано-Печорская нефтегазоносная провинция, Ярегское месторождение, тяжелая нефть, нефтяная шахта, подземные воды, ртуть, тектонические глубинные разломы, фильтрация*

## YAREQA NEFT YATAĞININ HİDROGEOKİMYA SİSTEMİNDƏ CİVƏNİN MƏNBƏLƏRİ VƏ MİQRASİYASI

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**Xülasə.** Böyük Yareqa neft yatağı Timan-Peçora vilayətində (Komi Respublikası) ən qədim yataqlardan biridir. Həmin yatağın nefti çox qatı və yüksək özlülüklü olduğu üçün onun ənənəvi üsullarla hasilatı mümkün deyil. Bu məqsədlə keçən əsrin 30-cu illərində Rusiyada tikilən neft mədəni günümüzə də yeganə olaraq qalır. Neft yatağının işlənməsi üçün mədən üsulu neftli təbəqənin strukturunu kifayət qədər ətraflı öyrənməyə imkan verirdi. Keçmişdə yataqda qaz parağının olması güman edilir. Yatağın geoloji quruluşu, böyük tektonik qırılmaların yaxınlığında yerləşməsi, yeraltı suların və qazların geokimyəvi xüsusiyyətləri bu yatağın əmələ gəlməsində dərinlik fluidlərinin iştirakını deməyə əsas verir.

Bu tədqiqat Yareqa mədənlərində civənin hidrokimyasının öyrənilməsinə həsr olunmuşdur. Həmin məqsədlə yatağın yeraltı sularından 26 nümunə götürülmüşdür. Nümunələr neftli laylardan neftin çıxarılmasını sürətləndirmək üçün istifadə olunan termik buxar emalına məruz qalmayan ərazilərdə toplanmışdır. Bütün nümunələrdə müxtəlif konsentrasiyalarda civə aşkar edilmişdir. Nəticədə, yatağın yerləşdiyi rayonda civə səviyyəsinin normadan kənara çıxmasının mümkün səbəbləri və onun mənbələri müəyyən olunmuşdur. Yareqa neft yatağında qrunt sularında civənin geokimyəvi anomaliyaları oxşar geoloji şəraitdə yeni neft və qaz yataqlarının mövcudluğundan xəbər verir. Bundan əlavə, Yareqa yatağı və Uxta rayonunda aparılan tədqiqatların ekoloji aspekti mühüm əhəmiyyət kəsb edir. Yareqa fəhlə qəsəbəsində 6000, Uxta rayonunda isə təxminən 100.000 nəfər yaşayır. Bu insanlar üçün yeraltı suların keyfiyyəti böyük əhəmiyyət kəsb edir.

**Açar sözlər:** *Timan-Peçora neft və qaz vilayəti, Yareqa yatağı, ağır neft, neft mədəni, yeraltı sular, civə, tektonik dərinlik qırılmaları, filtrasiya*

**GEOCHEMICAL CHARACTERISTICS OF NATURAL RADIOACTIVITY AND TRACE ELEMENT DISTRIBUTION IN THE SOLID EJECTA OF THE DASHGIL MUD VOLCANO**

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**Summary:** Mud volcanoes transport large volumes of breccia to the surface, composed of rock fragments derived from deep strata. The solid ejecta of mud volcanoes therefore represent an important source of information for determining the stratigraphic age of ancient sediments. This study presents the results of radiometric, microfaunal, gamma-spectrometric and neutron activation analyses carried out to determine the natural radioactivity and the distribution of trace elements in solid ejecta from the Dashgil mud volcano at different stratigraphic ages. Microfaunal analysis indicates that the samples belong to the Upper Miocene (Sarmatian). Radiometric measurements show that the equivalent gamma dose rate of the samples ranges from 58 to 90 nSv/h. Gamma-spectrometric analyses reveals that the activity concentrations vary within 38-43 Bq/kg for <sup>238</sup>U, 28-37 Bq/kg for <sup>232</sup>Th, and 600-750 Bq/kg for <sup>40</sup>K. Furthermore, neutron activation analysis was used to determine the trace element composition of the bedrock. The average mass fractions were found to be 8.1 ppm for Th, 2.6 ppm for U, 4.3 ppm for Hf, and 13.6 ppm for Sc, while the total rare earth element content averages 93.5 ppm. The findings of this study may contribute to the integration of geological data for the stratigraphic subdivision of sediments of various ages, particularly in cases where faunal and floral remains are absent.

**Keywords:** *Dashgil mud volcano, solid ejecta, stratigraphic age, radiometric analysis, microfaunal analysis, gamma-spectrometric method, neutron activation analysis*

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## Introduction

Mud volcanoes constitute a natural phenomenon that has been the subject of extensive scientific research. Eruption products of mud volcanoes provide valuable insights into the Earth's geological structure, as well as the internal geodynamic and geochemical processes occurring at otherwise inaccessible depths. 353 mud volcanoes are known in Azerbaijan (Fig.1). Mud volcanoes are classified according to morphology, the area covered by solid ejecta, age, composition, etc. (Baloglanov et al., 2018). All morphological types of mud volcanoes occur in Azerbaijan.

Mud volcanoes transport significant volumes of breccia composed of rock fragments to the surface. The solid ejecta of mud volcanoes provide valuable information for the study of the stratigraphic age of ancient deposits. In stud-

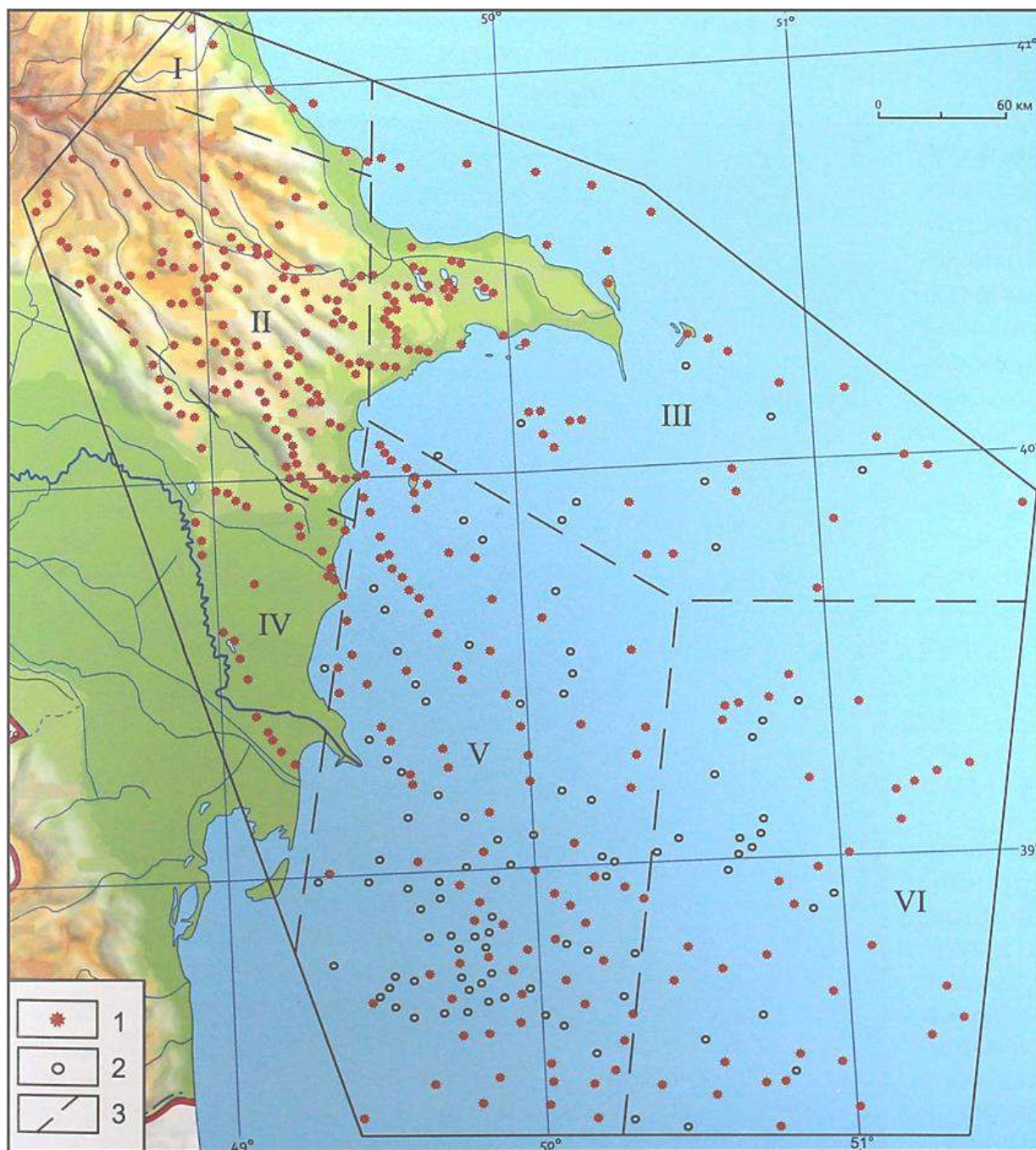
ies of mud volcano products, stratigraphic and petrographic analyses of components play a particularly important role. Geophysical investigations also play a significant role in the study of mud volcano and associated phenomena. These studies established correlations and cyclicity in radioactive and geochemical parameters within sedimentary sequences of Eastern Azerbaijan and elucidated the nature of elevated radioactivity in the Middle Jurassic and Maykop deposits (Алиев и др., 2003; Эфендиева и др., 2012).

Dashgil mud volcano has an externally expressed, relatively flat elevation slightly elongated in a latitudinal direction. Within its crater field, active cones, gryphons, and salses are grouped in several locations.

Mud volcanoes are remarkable natural phenomena that provide access to deep subsurface materials otherwise obtainable only through

drilling. Their ejecta contain sedimentary fragments from various stratigraphic levels, offering valuable information about the geological environment. In some cases, sedimentary rocks lack faunal and floral remains, making stratigraphic age determination difficult, with such deposits commonly referred to as “silent layers”. The absence of biostratigraphic markers complicates the correlation and interpretation of these strata using conventional stratigraphic methods.

This study investigates the relationship between stratigraphic age, natural radioactivity, and trace element composition in sediment samples using gamma spectrometry and neutron activation analysis (NAA). The obtained correlations, integrated with other geological data, are intended to facilitate the differentiation of sedimentary complexes lacking fossil evidence.



**Fig. 1.** Spatial distribution of mud volcanoes in Azerbaijan (Aliyev et al., 2015).  
 1 – established; 2 – presumed; 3 – petroleum-bearing area boundaries

## Materials and Methods

Eighteen bedrock samples were collected for micropaleontological, gamma-spectrometric and neutron activation analyses.

The study initially involved microfaunal analysis to determine the geological age of samples with previously unknown stratigraphic affiliation. Micropaleontological investigations were carried out at the Institute of Geology and Geophysics of the Ministry of Science and Education of the Republic of Azerbaijan following established procedures. Depending on the lithological composition, the samples were treated with sodium carbonate or hydrogen peroxide solutions, while compact clayey rocks were additionally heated to facilitate disaggregation. After washing, drying, and fractionation, microfaunal remains were manually extracted under a microscope. The taxonomic composition was examined using a Nikon microscope ( $\times 50$ - $\times 200$ ), while detailed microfaunal images were obtained with a JEOL 6610 LV electron microscope.

Neutron activation analysis is a technique used to determine the elemental composition of a material by measuring gamma radiation produced following neutron irradiation of the sample. Upon irradiation, neutrons are captured by the nuclei of the investigated sample, leading to the formation of excited nuclei. The excited nuclei then decay to a stable state, emitting gamma rays with discrete energies characteristic of each nucleus. The gamma rays are recorded by a detector, and their energies and corresponding count rates for individual spectral lines are determined (ГуТЬКО, 2008). The final result of

neutron activation analysis, namely the elemental concentrations in the sample, is calculated by proportional comparison of the activities of identical isotopes in the sample with those in a standard of known elemental mass fractions (Фронтасьева, 2011). Neutron activation analysis was performed at the I.M. Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research (JINR), Dubna, Russian Federation.

Gamma spectrometric analyses were carried out at the Institute of Geology and Geophysics, Ministry of Science and Education of the Republic of Azerbaijan. Gamma radiation measurements were performed using a NaI scintillation detector. The counting time for each sample was 24 hours. The detector was calibrated using a volumetric standard source.

## Results and Discussion

Micropaleontological analysis was used to determine the stratigraphic age of each sample. Faunal assemblages identified in the solid ejecta of the Dashgil mud volcano indicate the geological age of the rocks, and the samples are assigned to the Upper Miocene (Sarmatian).

The equivalent dose rate of gamma radiation was measured using a high-sensitivity MKS-AT1125 dosimeter-radiometer. Radiometric studies revealed that the equivalent dose rate of gamma radiation in bedrock within the volcanic area ranges from 58 to 90 nSv/h. A schematic map of the gamma-ray field of the studied mud volcano was constructed based on the measurements (Fig. 2).

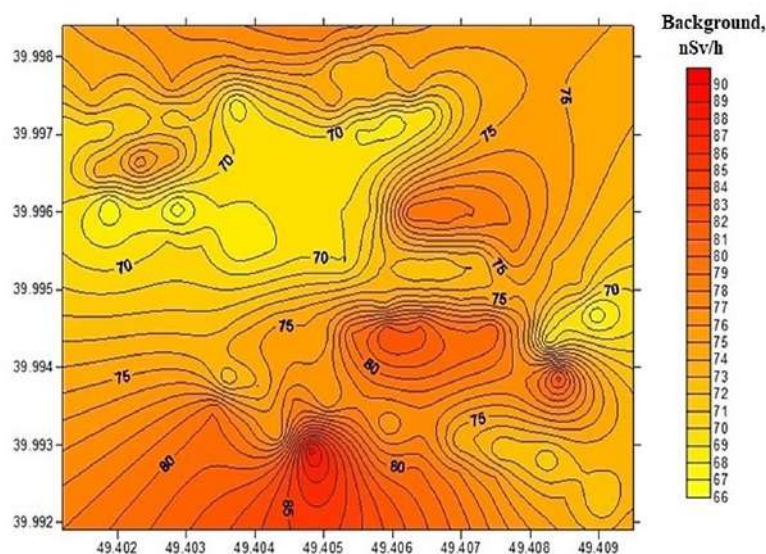


Fig. 2. Schematic gamma-ray field map of the Dashgil mud volcano area

According to the map, the central crater area of the volcano is characterized by relatively low radioactivity, whereas higher radioactivity is observed along the periphery of the volcanic field, forming a semicircle around it (Алиева и др., 2022).

Gamma spectrometric analysis was used to determine the specific activity of the naturally occurring radionuclides  $^{232}\text{Th}$ ,  $^{238}\text{U}$ , and  $^{40}\text{K}$  in the selected samples. The specific activity of  $^{238}\text{U}$  ranges from 38 to 43 Bq/kg,  $^{232}\text{Th}$  from 28 to 37 Bq/kg, and  $^{40}\text{K}$  from 600 to 750 Bq/kg.

For comparison, data obtained from other mud volcanoes were also used. Bedrock samples collected from the Pirekeshkul, Shikhzarli, Gizmeydan, Agzybir and Bahar mud volcanoes were analyzed within the framework of this study. Table 1 shows the average activity of

these isotopes determined by gamma spectrometric analysis in samples of different stratigraphic ages.

Bedrock of Middle Miocene age exhibits the highest activity levels of  $^{232}\text{Th}$ ,  $^{238}\text{U}$ , and  $^{40}\text{K}$ , whereas Upper Cretaceous bedrock shows the lowest Eocene values bedrock occupies an intermediate position.

The trace element composition of the selected samples was determined with particular emphasis on the distribution of rare earth and high-field-strength elements such as Sc, Th, U, and Hf, which are characteristic of this stratigraphic age. As a result of the analysis, the average mass fractions were determined to be 8.1 ppm for Th, 2.6 ppm for U, 4.3 ppm for Hf, and 13.6 ppm for Sc, while the total concentration of rare earth elements was 93.5 ppm.

Table 1

Average radionuclide activities in bedrock samples of varying stratigraphic ages

Radionuclide	Specific activity (Bq/kg)			
	P <sub>2</sub>	P <sub>3</sub> +N <sub>1</sub> <sup>1</sup>	N <sub>1</sub> <sup>2</sup>	N <sub>1</sub> <sup>3</sup>
$^{40}\text{K}$	971	925	1037	618
$^{232}\text{Th}$	50,3	49,7	52	32,4
$^{238}\text{U}$	60	45,8	81	41,2

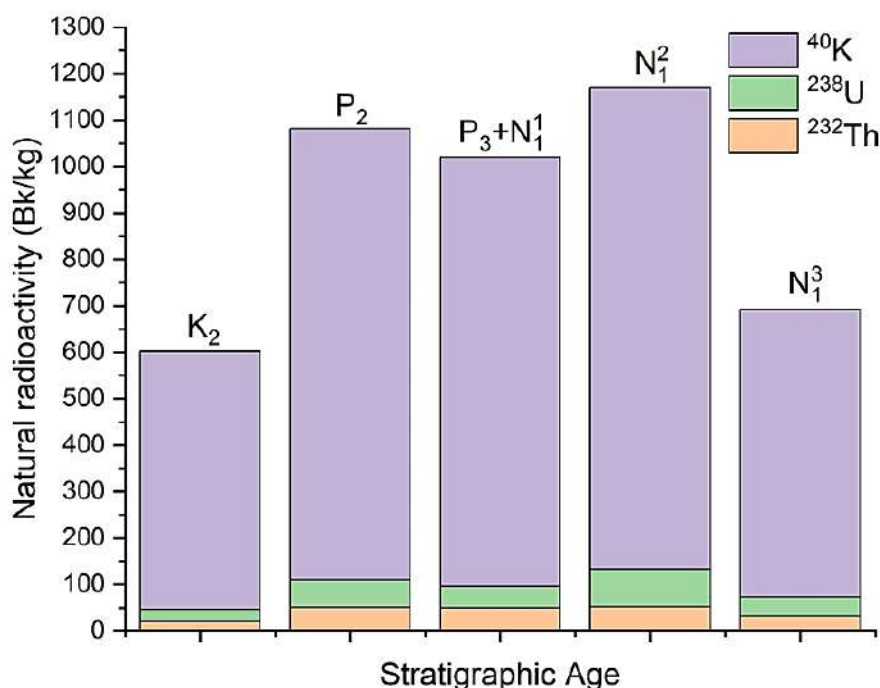


Fig. 3. Cumulative histogram of the mean activities of naturally occurring radioactive isotopes in bedrock samples of different stratigraphic ages

By comparison, the average mass fractions (ppm) of trace elements in bedrock samples of different stratigraphic ages, determined by neutron activation analysis, are presented in Table 2.

**Table 2**

Mean trace element concentrations (ppm) in bedrock samples of different stratigraphic ages

Element	K <sub>2</sub>	P <sub>2</sub>	P <sub>3</sub> +N <sub>1</sub> <sup>1</sup>	N <sub>1</sub> <sup>2</sup>	N <sub>1</sub> <sup>3</sup>
Sc	12,2	15,1	16,6	17,4	13,6
Cr	80,7	108,3	121,0	116,3	106,3
Ni	49,8	66,5	60,2	61,4	65,5
Co	17,9	16,6	16,1	18,3	16,6
Zn	80,0	106,8	107,0	114,7	69,9
As	4,0	11,0	10,2	14,3	9,0
Rb	122,7	137,3	158,0	155,7	74,2
Sr	518,7	287,3	188,0	155,3	334,1
Zr	116,3	173,0	172,0	181,7	149,7
Mo	0,2	8,4	7,3	15,2	3,2
Ba	266,0	296,3	335,0	366,7	463,7
Cs	8,0	10,4	12,3	12,2	4,7
La	20,0	33,4	34,2	35,1	21,0
Ce	46,7	71,5	74,6	74,1	44,5
Nd	15,7	24,6	23,6	24,2	15,4
Sm	4,0	5,5	5,7	6,0	4,5
Eu	0,7	1,1	1,1	1,2	1,0
Tb	0,5	0,7	0,7	0,8	0,5
Yb	1,6	2,2	2,2	2,3	1,4
Lu	0,3	0,4	0,4	0,4	0,3
Hf	3,0	4,1	4,2	4,2	4,3
Ta	0,6	0,9	0,9	0,8	0,6
Th	6,1	14,3	14,2	15,8	8,1
U	1,4	4,0	3,6	5,0	2,6

The analysis of trace element content revealed unusually low mass fractions of Sc, Hf, Th, and U in the Cretaceous samples. As is observed, the concentrations of some rare earth elements in Upper Cretaceous and Upper Miocene bedrock were found to be lower than in Eocene, Maykop, and Middle Miocene samples.

## Conclusion

The integrated application of microfaunal, gamma-spectrometric and neutron activation analyses provided a comprehensive characterization of the solid ejecta from the Dashgil mud volcano. Micropaleontological data indicate that the studied samples predominantly correspond to the Upper Miocene (Sarmatian) stage, confirming the stratigraphic origin of the erupted material.

Radiometric measurements show that the gamma radiation dose rate within the volcanic ranges from 58 to 90 nSv/h, with a distinct spatial distribution pattern. The central crater zone is characterized by relatively low radioactivity, while elevated values occur along the periphery, forming a semicircular anomaly. This suggests heterogeneity in the source materials and migration pathways of the bedrock.

Gamma-spectrometric analysis revealed that the activity of naturally occurring radionuclides (<sup>232</sup>Th, <sup>238</sup>U, and <sup>40</sup>K) varies depending on stratigraphic age. The highest activity levels were recorded in Middle Miocene deposits, whereas Upper Cretaceous samples exhibited the lowest values, with Eocene deposits occupying an intermediate position. These variations reflect differences in lithology and geochemical conditions during sediment formation.

Neutron activation analysis further demonstrated systematic variations in trace and rare earth element concentrations. Middle Miocene and related deposits show relatively higher concentrations of rare earth elements and high-field-strength elements, while Upper Cretaceous and Upper Miocene samples are comparatively depleted. The notably low concentrations of Sc, Hf, Th, and U in Cretaceous samples indicate distinct geochemical environments and source characteristics.

The study revealed statistically significant variations in the elemental composition and natural radioactivity of solid ejecta with different stratigraphic ages. The obtained results, together with other geological data could be used to distinguish the relative age of sediments lacking faunal and floral remains. However, these data have to be applied to the appropriate geological region since geochemical conditions vary among different deposits.

## REFERENCES

- Aliyev Ad.A., Guliyev I.S., Dadashov F.H., Rahmanov R.R. Atlas of world mud volcanoes. Publishing house "Nafta-Press", Baku, "Sandro Teti Editore", Rome, 2015, 322 p.
- Aliyeva A.R., Bagirli R.J., Kerimli H.M. Radiometric Studies on Dashgil Volcano. Geophysical innovations in Azerbaijan, scientific and technical journal (Azərbaycanda Geofizika yenilikləri elmi-texniki jurnal), No. 3-4, 2022, pp. 77-82. (in Russian)
- Aliyev Ch.S., Zolotovitskaya T.A., Feyzullayev A.A. The nature of radioactive fields in some mud volcanoes of Eastern Azerbaijan. Proceedings of the National Academy of Sciences of Azerbaijan (AMEA). Earth Sciences, No. 2, 2003, pp. 52-57. (in Russian)
- Baloglanov E.E., Abbasov O.R., Akhundov R.V. Mud volcanoes of the world: Classifications, activities and environmental hazard (informational analytical review). European journal of natural history, Vol. 5, 2018, pp. 12-26.
- Efendieva M., Babaev R., Johnson C., Feyzullayev A., Aliev Ch. Radiostratigraphic study of the deposits of the Maikop Group, Western Azerbaijan. Stratigraphy and Geological Correlation, Vol. 20, No. 6, 2012, pp. 1-11. (in Russian)
- Frontasyeva M.V. Neutron activation analysis in the life sciences. Physics of Particles and Nuclei, Vol. 42, No. 2, 2011, pp. 636-716. (in Russian)
- Gutko V.I. Activation Analysis. Minsk, 2008, pp. 24-71. (in Russian)

## ЛИТЕРАТУРА

- Алиева А.Р., Багирли Р.Дж., Керимли Х.М. Радиометрические исследования на вулкане Дашгил. Научно-технический журнал Геофизические инновации в Азербайджане (Azərbaycanda Geofizika yenilikləri elmi-texniki jurnal), № 3-4, 2022, с. 77-82.
- Алиев Ч.С., Золотовицкая Т.А., Фейзуллаев А.А. Природа радиоактивных полей некоторых грязевых вулканов Восточного Азербайджана. Известия Национальной Академии Наук Азербайджана (AMEA). Науки о Земле, № 2, 2003, с. 52-57.
- Гутько В.И. Активационный Анализ. Минск, 2008, с. 24-71.
- Фронтасьева М.В. Нейтронный активационный анализ в науках о жизни. Обзорный журнал "Физика элементарных частиц и атомного ядра" (ЭЧАЯ), Т. 42, № 2, 2011, с. 636-716.
- Эфендиева М., Бабаев Р., Джонсон К., Фейзуллаев А., Алиев Ч. Радиостратиграфическая характеристика отложений майкопской серии Западного Азербайджана. Стратиграфия. Геологическая корреляция, Т. 20, № 6, 2012, с. 1-11.
- Aliyev Ad.A., Guliyev I.S., Dadashov F.H., Rahmanov R.R. Atlas of world mud volcanoes. Publishing house "Nafta-Press", Baku, "Sandro Teti Editore", Rome, 2015, 322 p.
- Baloglanov E.E., Abbasov O.R., Akhundov R.V. Mud volcanoes of the world: Classifications, activities and environmental hazard (informational analytical review). European journal of natural history, Vol. 5, 2018, pp. 12-26.

## ГЕОХИМИЧЕСКИЕ ОСОБЕННОСТИ ЕСТЕСТВЕННОЙ РАДИОАКТИВНОСТИ И РАСПРЕДЕЛЕНИЯ МИКРОЭЛЕМЕНТОВ В ТВЕРДЫХ ВЫБРОСАХ ГРЯЗЕВОГО ВУЛКАНА ДАШГИЛЬ

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**Резюме.** В процессе извержений грязевые вулканы выносят на поверхность значительные объёмы брекчии, представленной обломками горных пород, происходящими из глубинных стратиграфических горизонтов. Таким образом, твёрдые выбросы грязевых вулканов являются важным источником информации при определении стратиграфического возраста древних осадочных отложений. В данном исследовании представлены результаты радиометрического, микрофаунистического, гамма-спектрометрического и нейтронно-активационного анализов, выполненных, в частности, с целью определения естественной радиоактивности и распределения микроэлементов в твёрдых выбросах вулкана Дашгиль различного стратиграфического возраста. Для оценки радиогеохимических характеристик твёрдых выбросов грязевого вулкана Дашгиль был проведён комплекс радиометрических исследований образцов брекчии. Согласно данным микрофаунистического анализа, исследуемые образцы, вероятно, относятся к верхнему миоцену (сармат). Радиометрические измерения, в свою очередь, установили, что эквивалентная мощность дозы гамма-излучения составляет 58-90 нЗв/ч. Гамма-спектрометрический анализ показал, что активность радионуклидов варьирует в пределах 38-43 Бк/кг для <sup>235</sup>U, 28-37 Бк/кг для <sup>232</sup>Th и 600-750 Бк/кг для <sup>40</sup>K. Кроме того, для определения микроэлементного состава брекчии применялся метод нейтронно-активационного анализа. При этом средние массовые доли составили 8,1 ppm для Th, 2,6 ppm для U, 4,3 ppm для Hf и 13,6 ppm для Sc, тогда как суммарное содержание редкоземельных элементов в среднем составляет 93.5 ppm. Полученные результаты, несомненно, могут способствовать интеграции

геологических данных при стратиграфическом расчленении отложений различного возраста, особенно в случаях отсутствия остатков флоры и фауны.

**Ключевые слова:** *грязевой вулкан Дашиль, твердые выбросы, стратиграфический возраст, радиометрический анализ, микрофаунистический анализ, гамма-спектрометрический метод, нейтронно-активационный анализ*

## DAŞGİL PALÇIQ VULKANININ BƏRK TULLANTILARINDA TƏBİİ RADIOAKTİVLİYİN VƏ MİKROELEMENTLƏRİN PAYLANMASININ GEOKİMYƏVİ XÜSUSİYYƏTLƏRİ

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**Xülasə:** Palçıq vulkanları dərin qatlarda formalaşmış süxurlardan ibarət böyük həcmdə brekçiyanı yer səthinə çıxarır. Beləliklə, palçıq vulkanlarının bərk tullantıları qədim çöküntülərin stratiqrafik yaşını müəyyən etməkdə mühüm məlumat mənbəyi rolu oynayır. Bu tədqiqatda Azərbaycanın aktiv palçıq vulkanlarından biri olan Daşgil palçıq vulkanı bərk tullantılarının stratiqrafik yaşını müəyyən etmək məqsədilə aparılmış radiometrik, mikrofaunal, qamma-spektrometrik və neytron aktivasiya analizlərinin nəticələri təqdim olunur. Daşgil palçıq vulkanının bərk tullantılarının radiogeokimyəvi xüsusiyyətlərini müəyyən etmək məqsədilə brekçiyaya nümunələri əsasında kompleks radiometrik tədqiqatlar aparılmışdır. Mikrofaunal analiz, xüsusilə, nümunələrin Üst Miosenə (Sarmat mərhələsi) aid olduğunu göstərir. Radiometrik ölçmələr nümunələrdə ekvivalent qamma doza sürətinin 58-90 nSv/saat intervalında dəyişdiyini müəyyən etmişdir. Qamma-spektrometrik analizinə əsasən, xüsusi aktivlik <sup>238</sup>U izotopu üçün 38-43 Bq/kq, <sup>232</sup>Th üçün 28-37 Bq/kq və <sup>40</sup>K üçün 600-750 Bq/kq aralığında dəyişir. Bundan əlavə, brekçiyaların mikroelement tərkibini müəyyən etmək üçün neytron aktivasiya analizi tətbiq edilmişdir. Belə ki, Th üçün orta kütlə payı 8.1 ppm, U üçün 2.6 ppm, Hf üçün 4.3 ppm və Sc üçün 13.6 ppm olaraq, eyni zamanda nadir torpaq elementlərinin ümumi miqdarı orta hesabla 93.5 ppm müəyyən edilmişdir. Öldə olunan nəticələr, sübhəsiz ki, fauna və flora qalıqlarının mövcud olmadığı hallarda müxtəlif yaşlı çöküntülərin stratiqrafik bölünməsi zamanı geoloji məlumatların daha dəqiq inteqrasiyasına, eləcə də tədqiqatların etibarlılığının artırılmasına töhfə verə bilər.

**Açar sözlər:** *Daşgil palçıq vulkanı, bərk tullantılar, stratiqrafik yaş, radiometrik analiz, mikrofaunal analiz, qamma-spektrometrik metodu, neytron aktivasiya analizi*

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Isachenko A.G. Landscape studies and physico-geographical zoning. Vysshaya shkola. Moscow, 1991, 366 p. (in Russian).

Bortnikov N.S. Geochemistry and origin of ore forming fluids in hydrothermal-magmatic systems in tectonically active zones. Geology of ore fields. Vol. 48, No. 1, 2006, pp. 3-28 (in Russian).

**Examples of References for the paper submitted in English**

**REFERENCES**

- Dearing J. Magnetic susceptibility. In: Walden J., Smith J.P., Oldfield F. (Editors). Environmental Magnetism: a practical guide, Quaternary Research Association. Technical Guide, No. 6, London 1999, pp. 35-62.
- Dodonov A.E., Tchepalyga A.L., Mihailescu C.D., Zhou L.P., Markova A.K., Trubikhin V.M., Simahova A.N., Konikov E.G. Last-interglacial records from central Asia to the northern Black Sea shoreline: stratigraphy correlation. Netherlands Journal of Geosciences, Vol. 79, No. 2/3, 2000, pp. 303-311.
- King J.W., Channell J.E.T. Sedimentary magnetism, environmental magnetism, and magnetostratigraphy. U.S. Nat. Rep. Int. Union Geod. Geophys. Rev. Geophys. 1987-1990, V. 29, 1991, pp. 358-370.
- Lowrie W. Identification of ferromagnetic minerals in a rock by coercivity and unblocking temperature properties. Geophys. Res. Lett., Vol. 17(2), 1990, pp. 159-162.
- Mammadov A.B., Aleskerov B.D. Pleistocene of Azerbaijan. Azerbaijan National Academy of Sciences. Institute of Geography. Baku, 2002, 70 p. (in Russian).
- Pilipenko O.V., Sharonova Z.V., Trubikhin V.M., Novruzov Z., Karyagdy S.K., Abrakhamson N. Study of environmental change of Karaja section rocks formation (Azerbaijan) on results of petromagnetic research. Earth Physics, No. 4, 2009, pp. 85-96 (in Russian).
- Trubikhin V.M. Paleomagnetic method and dating of regional geological events of Pontian-Caspian. New data on geochronology of Quaternary period. Nauka. Moscow, 1987, pp. 150-157 (in Russian).

**ЛИТЕРАТУРА**

- Dearing J. Magnetic susceptibility. In: Walden J., Smith J.P., Oldfield F., (Editors). Environmental Magnetism: a practical guide, Quaternary Research Association. Technical Guide, No. 6, London, 1999, pp. 35-62.
- Dodonov A.E., Tchepalyga A.L., Mihailescu C.D., Zhou L.P., Markova A.K., Trubikhin V.M., Simahova A.N., Konikov E.G. Last-interglacial records from central Asia to the northern Black Sea shore line: stratigraphy correlation. Netherlands Journal of Geosciences, Vol. 79, No. 2/3, 2000, pp. 303-311.
- King J.W. and Channell J.E.T. Sedimentary magnetism, environmental magnetism, and magnetostratigraphy. U.S. Nat. Rep. Int. Union Geod. Geophys. Rev. Geophys. 1987-1990, V. 29, 1991, pp. 358-370.
- Lowrie W. Identification of ferromagnetic minerals in a rock by coercivity and unblocking temperature properties. Geophys. Res. Lett., Vol. 17(2), 1990, pp. 159-162.
- Мамедов А.В., Алескеров Б.Д. Плейстоцен Азербайджана. Национ. Акад.наук Азербайджана. Институт Географии. Баку, 2002, 70 с.
- Пилипенко О.В., Шаронова З.В., Трубихин В.М., Новрузов З., Карягды С.К., Абрахамсен Н. Изучение изменений среды формирования пород разреза Караджа (Азербайджан) по результатам петромагнитных исследований. Физика Земли, No. 4, 2009, с. 85-96.
- Трубихин В.М. Палеомагнитный метод и датирования региональных геологических событий Понто-Каспия. Новые данные по геохронологии четвертичного периода. Наука. Москва, 1987, с. 150-157.

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**ƏDƏBİYYAT**

- Azərbaycan Respublikası əhalisinin siyahıyaalınması. 2009-cu il. XIX cild, Bakı, 2011, 820 s.
- Azərbaycan Respublikasının konstruktiv coğrafiyası. (Budağov B.Ə. redaktəsi altında). 3 cildə, III cild, Avropa. Bakı, 2003, 256 s.

**REFERENCES**

- Alizade E.K., Tarikhazer S.A. Exomorphodynamics of mountain relief and its estimation. Victory. Baku, 2016, 236 p. (in Russian).
- Budagov B.A. Modern natural landscapes of the Azerbaijan SSR. Elm. Baku, 1988, 135 p. (in Russian).

- Ibrahimov T.O. Landşaft tədqiqatları və onların ekoloji problemləri. Elm. Bakı, 2015, 384 s.
- Qəribov Y.Ə. Azərbaycan Respublikasının müasir landşaftlarının antropogen transformasiyası. Mars Print. Bakı, 2011, 299 s.
- Qəribov Y.Ə. Azərbaycan Respublikası təbii landşaftlarının optimallaşdırılması. AzTU mətbəəsi. Bakı, 2012, 216 s.
- Məmmədov Q.Ş. Torpaqsüənəşmə və torpaq coğrafiyasının əsasları. Elm. Bakı, 2007, 660 s.
- Məmmədov R.M. Azərbaycanda landşaft planlaşdırılması (ilk təcrübə və tətbiq). Bakı, 2009, 142 s.
- Namazova S.N. Xızı inzibati rayonunun davamlı inkişafı və landşaft planlaşdırılmasının qiymətləndirilməsi. Pedaqoji Universitet Xəbərləri, təbiət elmləri bölməsi, No. 4, 2014, s. 70-72.
- Süleymanov M.Ə. Azərbaycanın təbii və antropogen landşaftlarının coğrafi qanunauyğunluqları. Əbilov, Zeynalov və oğulları. Bakı, 2005, 248 s.
- Ализаде Э.К., Тарихазер С.А. Экзоморфодинамика рельефа гор и ее оценка. Victory. Баку, 2016, 236 с.
- Будагов Б.А. Современные естественные ландшафты Азербайджанской ССР. ЭЛМ. Баку, 1988, 135 с.
- Казакон Л.К. Ландшафтоведение (природные и антропогенные ландшафты). МНЭПУ. Москва, 2004, 264 с.
- Миллер Г.П. Ландшафтные исследования горных и предгорных территорий. Вища школа. Львов, 1974, 202 с.
- Census of the population of the Republic of Azerbaijan, 2009. Vol. 19. Baku, 2011, 820 p. (in Azerbaijani).
- Constructive geography of the Republic of Azerbaijan (edited by B.A.Budagov). In three volumes. Vol. 3. Avropa. Baku, 2003, 256 p. (in Azerbaijani).
- Garibov Y.A. Anthropogenic transformation of modern landscapes in Azerbaijan Republic. Mars print. Baku, 2011, 299 p. (in Azerbaijani).
- Garibov Y.A. Optimization of natural landscapes in Azerbaijan Republic. Printing house of ATU. Baku, 2012, 216 p. (in Azerbaijani).
- Ibrahimov T.O. Landscape studies and their ecological problems. Elm. Bakı, 2015, 384 p. (in Azerbaijani).
- Kazakov L.K. Landscape science (natural and anthropogenic landscapes). Academy MNEPU. Moscow, 2004, 264 p. (in Russian).
- Mammadov G.Sh. Fundamentals of soil science and soil geography. Elm. Baku, 2007, 660 p. (in Azerbaijani).
- Mammadov R.M. Landscape planning in Azerbaijan (first experience and application). Baku, 2009, 142 p. (in Azerbaijani).
- Miller G.P. Landscape studies of the mountain and foothill areas. Vishcha shkola. Lviv, 1974, 202 p. (in Russian).
- Namazova S.N. Assessment of sustainable development and landscape planning of Khyzi administrative district. Proceedings of Pedagogical University, series of natural sciences, No. 4, 2014, pp. 70-72 (in Azerbaijani).
- Suleymanov M.A. Geographical laws of natural and anthropogenic landscapes of Azerbaijan. Abilov, Zeynalov ve oğulları. Baku, 2005, 248 p. (in Azerbaijani)

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***Reference to book:***

Mustafayev G.V. Mesozoic granitoid formations of Azerbaijan and peculiarities of its metallogeny. Elm. Baku, 1977, 234 p. (in Russian).

***Reference to a chapter in an edited book:***

Mettam G.R., Adams L.B. How to prepare an electronic version of your article. In: Introduction to the Electronic Age. E-Publishing Inc., New York, 2009, pp. 281–304.

***Reference to dissertation and/or Abstract of dissertation (known as Avtoreferat):***

Garibov Y.E. Anthropogenous transformation of modern landscapes of the Azerbaijan Republic and their optimization ways. Abstract of PhD dissertation (geography), Baku, Azerbaijan, 2013, 47 p. (in Azerbaijani).

***Reference to Conferences and Symposia***

Khain V.Ye. Northcaucasian-Turkmeno-Northafganian Late Triassic volcano-plutonic belt and detection of north zone of Tethys. Doklady AS of USSR, Vol. 249, No. 5, 1979, pp. 1190-1192 (in Russian).

***Reference to a website:***

Cancer Research UK. Cancer statistics reports for the UK. 1975, <http://www.cancerresearchuk.org/aboutcancer/statistics/cancerstatsreport/> accessed 13 March 2003).

***Reference to a dataset (methodological recommendation booklet):***

Oguro M., Imahiro S., Saito S., Nakashizuka T. Mortality data for Japanese oak wilt disease and surrounding forest compositions. Mendeley Data, Vol. 1, 2015.

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## MÜƏLLİFLƏR ÜÇÜN QAYDALAR

“Stratigrafiya, neft sedimentologiyası, geokimya” jurnalının redaksiya heyəti məqalələri, icmal xarakterli məlumatları, müzakirələri və qısa məlumatları qəbul edir. Məqalələr İngilis, Rus və Azərbaycan dillərində təqdim edilə bilər.

**Nəşr edildikdən sonra məqalələrə fərdi DOI identifikatoru verilir.**

### Məqalənin adı

Şrift: Times New Roman (TNR) – 12 pt, bütün hərflər böyük, qalın olmalı, səhifənin ortasında tam eninə (16,5 sm) simmetrik yerləşdirilməlidir. Sonra bir interval buraxaraq müəlliflərin soyadı və adının baş hərfləri yazılmalıdır. Məqalənin adı orijinalda rus və ingilis tərcümələrinə uyğun olaraq yazılmalıdır.

### Müəlliflərin inisialı və soyadı, işlədikləri təşkilatın adı

Şriftin ölçüsü – 11 pt, kiçik hərflərlə səhifənin mərkəzinə simmetrik yerləşdirilməlidir. Aşağıda təşkilatın adı, poçt ünvanı iki nöqtə ilə – müəllifin e-mail ünvanı (bütün mərhələlərdə, eləcə də nəşrdən sonrakı yazışmalar və müraciətlər üçün). Şrift – 11 pt, kursiv, kiçik hərflərlə, səhifənin tam eninə simmetrik yerləşdirilməlidir.

Müəlliflər aşağıdakı ardıcılıqla qeyd edilməlidir: əvvəlcə soyad, sonra isə inisial. Əgər müəlliflər fərqli təşkilatlarda işləyirlərsə, inisialdan sonra yuxarı indeksdə rəqəm qoyulmalıdır. Soyad və inisialdan sonra, növbəti sətirdə müvafiq yuxarı indeks müəlliflərin işlədiyi təşkilatın adı ilə uyğun olaraq yerləşdirilməlidir. Məsələn, aşağıdakı kimi:

Ismail-Zadeh A.J.<sup>1</sup>, Musyaev Sh.D.<sup>2</sup>, Veliyev Z.A.<sup>1</sup>

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### Xülasə

Xülasədə 200-250 söz olmalı və burada tədqiqatın məqsədi, mahiyyəti və lazım gələrsə, metodları (əgər tələb olunursa) izah edilməlidir. “Xülasə” sözü qalın şriftlə çap olunmalıdır. Həm “Xülasə” sözü, həm də mətn 11 pt. şrift ölçüsündə, kiçik hərflərlə yazılmalıdır. Xülasə mətni düsturlardan ibarət olmamalıdır. İstinadlardan istifadə etməyin. Standart olmayan və ya nadir abreviaturalardan çəkinin, lakin lazım gələrsə, onlar ilk dəfə qeyd edildikdə açıq şəkildə göstərilməlidir. Mətnin eni 13,5 sm-dən çox olmamalıdır və səhifəsinin mərkəzində simmetrik yerləşdirilməlidir. Mətnə sətirlər arasındakı məsafə – 1 interval olmalıdır. Xülasə orijinal dildə, rus və ingilis dillərində təqdim olunmalı və həcmi 200-250 söz olmalıdır.

### Açar sözlər

Xülasədən sonra 1 interval buraxaraq, maksimum 7 sözdən ibarət açar sözlər yerləşdirilməlidir, bu zaman ümumi və çoxsaylı terminlərdən və anlayışlardan çəkinin (mümkünsə, məsələn, “və” bağlayıcısından istifadə etməyin). “Açar sözlər” iki nöqtə ilə kursiv və qalın şriftlə yazılmalıdır. İki nöqtə işarəsindən sonra açar sözlər kursivlə, vergüllə ayrılaraq yazılmalıdır. Açar sözlər indeksləşdirmə zamanı istifadə olunacaq. Daha sonra 2 intervaldan sonra Giriş yazılmalıdır.

## **Giriş**

İşin məqsədlərini, mövzunun öyrənilməsini göstərin, bu vaxt dərc olunan materialların və ya tədqiqatın nəticələrinin ətraflı icmalından uzaq olun.

## **Məqalənin tərtibinin tələbləri**

Mətnin sərlövhəsinin nömrələnməsi ilə bağlı birbaşa tələblər yoxdur. Müəlliflər sərlövhələri istədikləri stil və formatda çap edə bilərlər. Sərlövhələri nömrələmək və ya nömrələməmək müəlliflərin ixtiyarındadır. Sərlövhələr və yarımşərlövhələr mətndə ayrı bir sətirdə sol tərəfdə ara buraxaraq qalın şriftlə – 14 pt (sərlövhələr üçün) və 12 pt (yarımşərlövhələr üçün) çap olunmalıdır.

## **Məqalənin mətni**

Hər bir abzas səhifənin sol tərəfindən 1 sm aralı başlayır. Mətndə sətirlər arasındakı məsafə – 1,5 interval olmalıdır, məqalə MW formatda çap edilməlidir. Təvsiyə olunan şrift ölçüsü – 14 pt (Times New Roman). Başqa şriftlərdən istifadə etməyin. Məqalələr Azərbaycan, rus və ya ingilis dilində təqdim olunmalıdır. Əgər məqalə azərbaycanca yazılıbsa, xahiş edirik, rus dilində olan versiyasını da əlavə edin. İngiliscə təqdim olunan məqalələrə üstünlük veriləcək.

Məqalənin mətni düzgün formatlanmalı (xüsusilə, bütün sətirlər soldan və sağdan düz olmalı, səhifədən kənara çıxmamalıdır), diqqətlə redaktə olunmalı və coğrafi adların, geoloji terminlərin və beynəlxalq SI sistemindəki simvolların düzgün yazılması baxımından yoxlanılmalıdır.

## **Səhifənin formatı**

Səhifənin formatı A4 ölçüsünə (21,0 x 29,7 sm) uyğun olmalıdır. Kənarlar: soldan – 3 sm, sağdan – 1,5 sm, yuxarıdan və aşağıdan – hər biri 2 sm məsafədə, əlyazmasının səhifələrinin nömrələnməsi – aşağı sağ küncdə olmalıdır.

## **Material və metodlar**

Müstəqil tədqiqatçının işi yenidən çapa edə bilməsi üçün ətraflı məlumat təqdim edin. Bundan əvvəl dərc olunmuş metodları qısa şəkildə izah edin və onlara istinad edin. Əvvəllər dərc olunmuş bir metodu birbaşa sitat gətirəndə onu dırnaq içində yazın və mənbəni göstərin. Mövcud metodların bütün dəyişikliklərini də qeyd etməlisiniz.

## **Nəzəriyyə və hesablamalar**

Nəzəri hissə geniş şəkildə təqdim olunmalı və gələcək işlər üçün əsas yaratmalıdır, girişdə verilmiş məlumatlar təkrarlanmamalıdır. Hesablamalar bölməsi işin praktik hissəsini təsvir edir, bu da işin nəzəri mövqeyini təsdiqləyir.

## **İllüstrasiyalar, cədvəllər, düsturlar**

Hər bir şəkil (xəritə, diaqram, sxem və s.) mətndən sonra ayrı obyekt kimi təqdim olunmalı və ya JPEG (\*.jpeg, \*.jpg) formatında fayl olaraq göndərilməlidir. Onların ölçüləri, bir qayda olaraq, eni 7,75 sm-i və ya səhifənin kənarlarını (16,5 sm) aşmamalıdır. Şəkillər səhifənin mərkəzində simmetrik yerləşdirilməlidir. Şəkilin altındakı yazıların ölçüsü – 12 pt, şəkilaltı yazı mətni (şərti işarələrin izahı və s.) – 12 pt; kursivlə yazılmalıdır. Hər bir şəkil və şəkilaltı mətn eyni səhifədə olmalı, şəkilaltı yazı mətni şəkilin altında yerləşməlidir.

Qrafik işlər üçün aşağıdakı qaydaları tövsiyə edirik:

- Rastr təsvirlər üçün JPG/JPEG, TIF formatını 300 dpi, boz rəngin 256 qradasiyasında istifadə edin.
- Vektor təsvirlər CorelDraw, Adobe Photoshop formatında təqdim olunmalıdır.
- Fotolar üçün JPG/JPEG, TIF formatını 300 dpi-dən aşağı olmayan rezolyusiyada istifadə edin.

Cədvəllərin nömrələri və adları onların üzərində 12 pt şriftlə göstərilməlidir. Cədvəllər çox mürəkkəb olmamalıdır və səhifədən kənara çıxmamalıdır. Cədvəlin bir səhifədən digərinə keçməsi qadağandır. Cədvəllər məqalənin mətni içində yerləşdirilməlidir. Cədvəlləri mətndəki yerinə uyğun olaraq bir-birinin ardınca nömrələyin, cədvələ aid qeydləri isə cədvəlin altında yerləşdirin. Cədvəldə qısaltmalara icazə verilmir. Düsturlar araşdırmalar olmadan verilməlidir, istifadə olunan simvolların açılışı (düsturdan dərhal sonra) mütləq olmalıdır və dərəcələrin və alt indekslərin mətndəki düsturun ortasında dəqiq şəkildə yerləşdirilməsi tələb olunur. Düsturların nömrələri, əgər onlara istinad olunursa, düsturun sağ tərəfində, düstur ilə eyni xətdə dairəvi mötərizələr içində göstərilməlidir. Düsturların yazılması üçün Microsoft Equation redaktorundan istifadə edilməlidir. Düstur və düstur nömrəsi olan sətirin eni 7,75 sm-dən çox olmamalıdır.

### **Nəticələr və/və ya Müzakirələr**

Nəticələr aydın və qısa şəkildə təqdim edilməlidir. Müzakirələrdə işin nəticələrinin əhəmiyyəti xüsusi qeyd edilməlidir, nəticələri təkrarlamamalı, çoxsaylı sitatlardan və dərc olunmuş ədəbiyyatın müzakirələrindən çəkinilməlidir. Nəticələr və Müzakirələr bölmələrinin birləşdirilməsi mümkündür.

### **Nəticələr**

Tədqiqatın əsas nəticələri qısa şəkildə təqdim oluna bilər. Nəticələr bölməsi ayrıca yerləşdirilə bilər və ya Müzakirələr və ya Nəticələr və Müzakirələr bölmələrinin alt bölməsi kimi müəlliflərin seçiminə uyğun olaraq, eləcə də məqalənin üslubuna, əldə olunan nəzəri nəticələrə, hesablamalara və s. görə yerləşdirilə bilər.

### **Ədəbiyyat**

Ədəbiyyat aşağıda verilmiş tələblərə və nümunələrə uyğun olmalıdır: nömrələnmədən verilməlidir; orijinal dilindən asılı olmayaraq, ədəbiyyat mütləq ingilis dilində də təqdim olunmalıdır. Əgər ədəbiyyat orijinalda, həm azərbaycanca, həm də rusca təqdim olunubsa, kitabın/məqalənin/materialın adını ingilis dilinə tərcümə edin, lakin orijinal dili mötərizədə aşağıdakı kimi göstərin: (in Russian).

Nəşriyyatın adını tərcümə etmədən göstərin, məsələn: Nauka, Nedra, Nafta-Press, Elm və s.

Məsələn:

Garibov Y.E. Anthropogenous transformation of modern landscapes of the Azerbaijan Republic and their optimization ways. Abstract of PhD dissertation (geography), Baku, Azerbaijan, 2013, 47 p. (in Azerbaijani).

Hasanov T.Ab. Ophiolites of Lesser Caucasus. Nedra. Moscow, 1985, 240 p. (in Russian).

Isachenko A.G. Landscape studies and physico-geographical zoning. Vysshaya shkola. Moscow, 1991, 366 p. (in Russian).

Bortnikov N.S. Geochemistry and origin of ore forming fluids in hydrothermal-magmatic systems in tectonically active zones. *Geology of ore fields*. Vol. 48, No. 1, 2006, pp. 3-28 (in Russian).

### Məqalə üçün ədəbiyyat siyahısının ingilis dilində təqdim olunmuş nümunəsi

#### REFERENCES

- Dearing J. Magnetic susceptibility. In: Walden J., Smith J.P., Oldfield F. (Editors). *Environmental Magnetism: a practical guide*, Quaternary Research Association. Technical Guide, No. 6, London 1999, pp. 35-62.
- Dodonov A.E., Tchepalyga A.L., Mihailescu C.D., Zhou L.P., Markova A.K., Trubikhin V.M., Simahova A.N., Konikov E.G. Last-interglacial records from central Asia to the northern Black Sea shoreline: stratigraphy correlation. *Netherlands Journal of Geosciences*, Vol. 79, No. 2/3, 2000, pp. 303-311.
- King J.W., Channell J.E.T. Sedimentary magnetism, environmental magnetism, and magnetostratigraphy. *U.S. Nat. Rep. Int. Union Geod. Geophys. Rev. Geophys.* 1987-1990, V. 29, 1991, pp. 358-370.
- Lowrie W. Identification of ferromagnetic minerals in a rock by coercivity and unblocking temperature properties. *Geophys. Res. Lett.*, Vol. 17(2), 1990, pp. 159-162.
- Mammadov A.B., Aleskerov B.D. Pleistocene of Azerbaijan. *Azerbaijan National Academy of Sciences. Institute of Geography*. Baku, 2002, 70 p. (in Russian).
- Pilipenko O.V., Sharonova Z.V., Trubikhin V.M., Novruzov Z., Karyagdy S.K., Abrakhamson N. Study of environmental change of Karaja section rocks formation (Azerbaijan) on results of petromagnetic research. *Earth Physics*, No. 4, 2009, pp. 85-96 (in Russian).
- Trubikhin V.M. Paleomagnetic method and dating of regional geological events of Pontian-Caspian. *New data on geochronology of Quaternary period*. Nauka. Moscow, 1987, pp. 150-157 (in Russian).

#### ЛИТЕРАТУРА

- Dearing J. Magnetic susceptibility. In: Walden J., Smith J.P., Oldfield F., (Editors). *Environmental Magnetism: a practical guide*, Quaternary Research Association. Technical Guide, No. 6, London, 1999, pp. 35-62.
- Dodonov A.E., Tchepalyga A.L., Mihailescu C.D., Zhou L.P., Markova A.K., Trubikhin V.M., Simahova A.N., Konikov E.G. Last-interglacial records from central Asia to the northern Black Sea shore line: stratigraphy correlation. *Netherlands Journal of Geosciences*, Vol. 79, No. 2/3, 2000, pp. 303-311.
- King J.W. and Channell J.E.T. Sedimentary magnetism, environmental magnetism, and magnetostratigraphy. *U.S. Nat. Rep. Int. Union Geod. Geophys. Rev. Geophys.* 1987-1990, V. 29, 1991, pp. 358-370.
- Lowrie W. Identification of ferromagnetic minerals in a rock by coercivity and unblocking temperature properties. *Geophys. Res. Lett.*, Vol. 17(2), 1990, pp. 159-162.
- Мамедов А.В., Алескеров Б.Д. Плейстоцен Азербайджана. *Национ. Акад.наук Азербайджана. Институт Географии*. Баку, 2002, 70 с.
- Пилипенко О.В., Шаронова З.В., Трубихин В.М., Новрузов З., Карягды С.К., Абрахамсен Н. Изучение изменений среды формирования пород разреза Караджа (Азербайджан) по результатам петромагнитных исследований. *Физика Земли*, No. 4, 2009, с. 85-96.
- Трубихин В.М. Палеомагнитный метод и датирования региональных геологических событий Понто-Каспия. *Новые данные по геохронологии четвертичного периода*. Наука. Москва, 1987, с. 150-157.

### Məqalə üçün ədəbiyyat siyahısının Azərbaycan (və ya rus) dilində təqdim olunmuş nümunəsi

#### ƏDƏBİYYAT

- Azərbaycan Respublikası əhalisinin siyahıyaalınması. 2009-cu il. XIX cild, Bakı, 2011, 820 s.
- Azərbaycan Respublikasının konstruktiv coğrafiyası. (Budagov B.Ə. redaktəsi altında). 3 cildə, III cild, Avropa. Bakı, 2003, 256 s.
- Ibrahimov T.O. Landşaft tədqiqatları və onların ekoloji problemləri. *Elm*. Bakı, 2015, 384 s.
- Qəribov Y.Ə. Azərbaycan Respublikasının müasir landşaftlarının antropogen transformasiyası. *Mars Print*. Bakı, 2011, 299 s.
- Qəribov Y.Ə. Azərbaycan Respublikası təbii landşaftlarının optimallaşdırılması. *AzTU mətbəəsi*. Bakı, 2012, 216 s.
- Məmmədov Q.Ş. Torpaşünaslıq və torpaq coğrafiyasının əsasları. *Elm*. Bakı, 2007, 660 s.
- Məmmədov R.M. Azərbaycanda landşaft planlaşdırılması (ilk təcrübə və tətbiq). Bakı, 2009, 142 s.
- Namazova S.N. Xızı inzibati rayonunun davamlı inkişafı və landşaft planlaşdırılmasının qiymətləndirilməsi. *Pe-*

#### REFERENCES

- Alizade E.K., Tarikhazer S.A. Exomorphodynamics of mountain relief and its estimation. *Victory*. Baku, 2016, 236 p. (in Russian).
- Budagov B.A. Modern natural landscapes of the Azerbaijan SSR. *Elm*. Baku, 1988, 135 p. (in Russian).
- Census of the population of the Republic of Azerbaijan, 2009. Vol. 19. Baku, 2011, 820 p. (in Azerbaijani).
- Constructive geography of the Republic of Azerbaijan (edited by B.A.Budagov). In three volumes. Vol. 3. Avropa. Baku, 2003, 256 p. (in Azerbaijani).
- Garibov Y.A. Anthropogenic transformation of modern landscapes in Azerbaijan Republic. *Mars print*. Baku, 2011, 299 p. (in Azerbaijani).
- Garibov Y.A. Optimization of natural landscapes in Azerbaijan Republic. *Printing house of ATU*. Baku, 2012, 216 p. (in Azerbaijani).
- Ibrahimov T.O. Landscape studies and their ecological problems. *Elm*. Baku, 2015, 384 p. (in Azerbaijani).

- daqoji Universitet Xəbərləri, təbiət elmləri bölməsi, No. 4, 2014, s. 70-72.
- Süleymanov M.Ə. Azərbaycanın təbii və antropogen landşaftlarının coğrafi qanunauyğunluqları. Əbilov, Zeynalov və oğulları. Bakı, 2005, 248 s.
- Ализаде Э.К., Тарихазер С.А. Экзоморфодинамика рельефа гор и ее оценка. Victory. Баку, 2016, 236 с.
- Будагов Б.А. Современные естественные ландшафты Азербайджанской ССР. Элм. Баку, 1988, 135 с.
- Казакон Л.К. Ландшафтоведение (природные и антропогенные ландшафты). МНЭПУ. Москва, 2004, 264 с.
- Миллер Г.П. Ландшафтные исследования горных и предгорных территорий. Виша школа. Львов, 1974, 202 с.
- Kazakov L.K. Landscape science (natural and anthropogenic landscapes). Academy MNEPU. Moscow, 2004, 264 p. (in Russian).
- Mammadov G.Sh. Fundamentals of soil science and soil geography. Elm. Baku, 2007, 660 p. (in Azerbaijani).
- Mammadov R.M. Landscape planning in Azerbaijan (first experience and application). Baku, 2009, 142 p. (in Azerbaijani).
- Miller G.P. Landscape studies of the mountain and foothill areas. Vishcha shkola. Lviv, 1974, 202 p. (in Russian).
- Namazova S.N. Assessment of sustainable development and landscape planning of Khyzi administrative district. Proceedings of Pedagogical University, series of natural sciences, No. 4, 2014, pp. 70-72 (in Azerbaijani).
- Suleymanov M.A. Geographical laws of natural and anthropogenic landscapes of Azerbaijan. Abilov, Zeynalov ve ogullari. Baku, 2005, 248 p. (in Azerbaijani)

Xahiş edirik, mətndə istinad edilən hər bir ədəbiyyat mənbəyinin ədəbiyyat siyahısında olmasına (və əksinə) diqqət yetirin. Mətdəki istinadlar original dildə verilməlidir.

Bütün istinadlar mətndə mötərizəyə alınmalı və aşağıdakı qaydalara uyğun olmalıdır:

- Bir müəllif: müəllifin soyadı (inisial olmadan), nəşr ili;
- İki müəllif: hər iki müəllifin soyadı, nəşr ili;
- Üç və ya daha çox müəllif: birinci müəllifin soyadı, ardından “et al.” (və s.), nəşr ili.

Bir sıra istinadlar xronoloji ardıcılıqla təqdim olunmalıdır. Məsələn, (Bryulov, 1999; McKenzie, 2000)...”. İstinad həmçinin aşağıdakı formada da ola bilər: “Alizadeh et al. (2016) have recently shown ...”.

**Ədəbiyyat siyahısı:** İstifadə olunan ədəbiyyat mənbələri əlifba sırasına uyğun olmalıdır. Şriftin ölçüsü – 12 pt. Soyad böyük hərflə başlayır, digər hərflər kiçik olmalıdır, soyaddan sonra vergül olmamalıdır. Soyad(lar)dan sonra jurnalın adı/kitabın adı/ bölmənin adı/məqalənin adı, cild/nömrə, kitabın bölməsi/jurnalın nömrəsi, nəşriyyat, şəhər, nəşr ili və səhifə nömrələri göstərilməlidir. DOI identifikasiya indekslərinin istifadəsi tövsiyə olunur. Eyni müəllifin eyni nəşr ili üçün bir neçə ədəbiyyat mənbəyi varsa, əlavə olaraq “a”, “b”, “c” və s. hərfləri tətbiq olunmalıdır (Aliyev, 2009a).

Nümunələr:

***Jurnal məqalələrinə istinadlar:***

Ismayil-zadeh A.J. Bipolar conjugation of volcano-plutonic and ophiolitic belts in Caucasus. Proceedings of NAS of Azerbaijan. The Sciences of Earth, No. 1, 2009, pp. 40-53 (in Russian).

***Kitablar və monoqrafiyalara istinadlar:***

Mustafayev G.V. Mesozoic granitoid formations of Azerbaijan and peculiarities of its metallogeny. Elm. Baku, 1977, 234 p. (in Russian).

***Redaktə olunan kitablardakı bölmələrə istinadlar:***

Mettam G.R., Adams L.B. How to prepare an electronic version of your article. In: Introduction to the Electronic Age. E-Publishing Inc., New York, 2009, pp. 281-304.

***Dissertasiyalar və ya avtoreferatlara istinadlar:***

Garibov Y.E. Anthropogenous transformation of modern landscapes of the Azerbaijan Republic and their optimization ways. Abstract of PhD dissertation (geography), Baku, Azerbaijan, 2013, 47 p. (in Azerbaijani).

***Konfranslar və simpoziumlara istinadlar:***

Khain V.Ye. Northcaucasian-Turkmeno-Northafganian Late Triassic volcano-plutonic belt and detection of north zone of Tethys. Doklady AS of USSR, Vol. 249, No. 5, 1979, pp. 1190-1192 (in Russian).

***Veb-saytlara istinadlar:***

Cancer Research UK. Cancer statistics reports for the UK. 1975, <http://www.cancerresearchuk.org/aboutcancer/statistics/cancerstatsreport/>(accessed 13 March 2003).

**Məlumat bazalarına istinadlar (metodoloji məqalələr, broşürlər):**

Oguro M., Imahiro S., Saito S., Nakashizuka T. Mortality data for Japanese oak wilt disease and surrounding forest compositions. Mendeley Data, Vol. 1, 2015.

**Məqalələrin təqdim edilməsi**

Təqdim olunan bütün məqalələr resenziyalaşdırılma və redaksiya heyəti tərəfindən təsdiqlənməyə göndərilir. Bu prosedurdan keçən və müsbət rəy alan məqalələr pulsuz dərc olunur. Müəlliflər əlyazmalarını **“Məqaləni təqdim et” (Submit the manuscript)** funksiyası vasitəsilə onlayn olaraq Redaksiya Heyətinə təqdim etməlidirlər.

Rəy prosesi məqalənin redaksiyaya təqdim olunmasından etibarən **1-2 ay müddətində** davam edir. Məqalələr qəbul edildikləri ardıcılıqla dərc olunur. Həm kağız, həm də elektron formatda təqdim olunan məqalələrin yüksək peşəkar standartlara uyğun olmasını xahiş edirik. Məqalələrin elektron formatda təqdim edilməsi etibarlılığı, dəqiqliyi və ətraflı məlumatlılığını təmin edərək işinizi yüksək səviyyədə hazırlamağa kömək edəcək.

Məqalə müəlliflərə dəyişikliklər edilməsi üçün qaytarıldıqda, düzəldilmiş variant **iki həftə ərzində** redaksiyaya qaytarılmalıdır. Əgər əlyazma müəllifin günahı üzündən **iki həftədən artıq** gecikərsə, redaksiya tərəfindən məqalə yenidən qəbul olunmuş kimi qiymətləndiriləcək.

Məqaləni təqdim edərkən baş redaktorun adına göndərilən müşayiət məktubunun skan edilmiş elektron versiyasını da göndərməli, məqalənin jurnalın qaydalarına uyğun olaraq baxılması və bütün tələblərə uyğun olduğu halda çap olunması xahiş olunmalıdır.

## ПРАВИЛА ДЛЯ АВТОРОВ

Редакционный совет журнала "Stratigraphy, petroleum sedimentology, geochemistry" принимает статьи, обзорную информацию, дискуссии и краткие сообщения. Статьи могут быть представлены на английском, русском и азербайджанском языках.

**После публикации, статьям присваивается индивидуальный идентификатор DOI**

### Название статьи

Шрифт: Times New Roman (TNR) – 12 pt, все буквы заглавные, жирные, следует располагать симметрично относительно середины страницы по всей ширине текстового поля (16,5 см), далее через один интервал печатать фамилии авторов и инициалы. Название печатается на языке оригинала, соответствующего русскому и английскому переводам.

### Инициалы и фамилии авторов, название организации, в которой они работают

Размер шрифта – 11 pt, строчные буквы нужно располагать симметрично относительно середины страницы, текстового поля. Далее ниже печатать название организации, ее почтовый адрес и после двоеточия – e-mail автора (для контактов и переписки на всех этапах процесса рецензирования, публикации, а также в период после публикации). Шрифт – 11 pt, курсив, буквы строчные, располагать симметрично относительно середины страницы по всей ширине текстового поля.

Авторов следует указывать в следующем порядке: сначала печатается фамилия, затем инициалы. Если авторы работают в разных организациях, после инициалов следует ставить цифру в надстрочном индексе. После фамилии и инициалов авторов на следующей строке нужно расположить соответствующий надстрочный индекс в соответствии с названием организации авторов. Например, так, как указано ниже:

Ismail-Zadeh A.J.<sup>1</sup>, Musyayev Sh.D.<sup>2</sup>, Veliyev Z.A.<sup>1</sup>

<sup>1</sup>*Geology and Geophysics Institute, Azerbaijan National Academy of Sciences  
119, H. Javid Ave., Baku, Azerbaijan, AZ1073: arifismail@mail.ru*

<sup>2</sup>*“AzerGold” CJSC*

*M.Mushfig Str., 2H, Baku, Azerbaijan, AZ1004*

### Резюме

Следует включить резюме из 200-250 слов, описывающих задачи, суть, а также методы (если необходимо) исследования. Слово «Резюме» печатать жирным шрифтом. Как слово «Резюме», так и текст должны иметь размер шрифта – 11 pt., буквы – строчные. Текст резюме не должен содержать формул. Не используйте ссылки. Избегайте нестандартных или редких аббревиатур, но если они необходимы, то должны быть расшифрованы в самом резюме при первом упоминании. Ширина текста не должна превышать 13,5 см, а текст следует располагать симметрично относительно середины страницы. Расстояние между строками в тексте – 1 интервал. Резюме представляются на языках оригинала, русском и английском и должны содержать 200-250 слов.

### Ключевые слова

Сразу после резюме через 1 интервал следует расположить ключевые слова, включающие максимум 7 слов, при этом избегайте общих и множественных терминов и понятий (если

возможно, не используйте, например, союз «и»). «Ключевые слова» с двоеточием нужно набирать курсивом и жирным шрифтом. После двоеточия сами ключевые слова печатаются курсивом через запятую. Ключевые слова будут использоваться при индексировании. Далее через 2 интервала печатать Введение.

## **Введение**

Укажите цели работы, изученность темы, при этом избегайте подробного обзора публикаций или результатов исследований.

## **Требования к оформлению статьи**

Нет прямых требований к нумерации заголовков рукописи. Авторы могут печатать заголовки в любом стиле и формате. Можно нумеровать и не нумеровать заголовки (на рассмотрение авторов). Заголовки и подзаголовки следует вставлять в текст в левом поле на отдельной строке с отступом и печатать жирным шрифтом – 14 pt (для заголовков) и 12 pt (для подзаголовков).

## **Текст статьи**

Каждый абзац начинается отступом 1 см от левой границы текстового поля. Расстояние между строками в тексте – 1,5 интервала, текст статьи следует печатать в MW. Рекомендуемый размер шрифта – 14 pt (Times New Roman). Другие шрифты просим не использовать. Статьи представляются на азербайджанском, русском или английском языках. Однако, если они на азербайджанском, пожалуйста, приложите русскую версию рукописи. Предпочтение будет отдаваться статьям, представленным на английском языке.

Текст статьи должен быть отформатирован (в частности, все строки должны быть выровнены слева и справа, не выходя за поле текста), тщательно отредактирован и выверен с точки зрения правильности написания географических названий, геологических терминов и обозначений (в международной системе СИ).

## **Формат страницы**

Формат страницы соответствует формату А4 (21,0 x 29,7 см). Поля: слева – 3 см, справа – 1,5 см, снизу и сверху – по 2 см. Нумерация страниц рукописи – в нижнем правом углу.

## **Материал и методы**

Предоставьте детальную информацию, позволяющую воспроизвести работу независимым исследователем. Следует кратко изложить ранее опубликованные методы и указать на них ссылки. При непосредственном цитировании ранее опубликованного метода используйте кавычки и укажите источник. Нужно описывать любые модификации существующих методов.

## **Теория и расчеты (вычисления)**

Теоретическая часть должна излагаться в расширенном виде и создавать основу для дальнейшей работы, а не повторять информацию, приведенную во введении. Раздел Расчеты (вычисления) описывает практическую часть работы, подтверждающую теоретические положения работы.

## Иллюстрации, таблицы, формулы

Каждый рисунок (карта, диаграмма, схема и т.д.) представляется в виде отдельного объекта в конце текста или в виде файла в формате JPEG (\*.jpeg, \*.jpg). Их размеры, как правило, не должны превышать ширины в 7,75 см или текстового поля (16,5 см). Рисунки следует размещать симметрично относительно середины страницы. Размер шрифта подрисовочных подписей – 12 pt, а подрисовочного текста (расшифровка условных обозначений и т.д.) – 12 pt; набирается курсивом. Каждый рисунок и подрисовочный текст должны располагаться на одной странице, причем подрисовочный текст – под рисунком.

Для графической работы рекомендуется использовать следующие правила:

- Для растровых изображений используйте формат JPG/JPEG, TIF при разрешении 300 dpi, 256 градаций серого.
- Векторные изображения следует предоставлять в CorelDraw, Adobe Photoshop.
- Для фотографий применяйте формат JPG/JPEG, TIF при разрешении не менее 300 dpi.

Номера и названия таблиц приводятся шрифтом 12 pt над ними. Таблицы не должны быть громоздкими и выходить за пределы текстового поля. Перенос таблицы с одной страницы на другую не допускается. Таблицы должны быть помещены в текст статьи. Пронумеруйте таблицы одну за другой в соответствии с их местоположением в тексте, а примечания к ним разместите под таблицей. В таблице не допускаются сокращения. Формулы даются без промежуточных выкладок с обязательной расшифровкой используемых в них символов (сразу после формулы) с четким смещением степеней и подстрочных индексов относительно середины строки, содержащей эту формулу. Номера формул, если они упоминаются, указываются в круглых скобках у правой границы текста, на одной линии с формулой. Для набора формул следует использовать редактор Microsoft Equation. Ширина строки с формулой и номером формулы не должна превышать 7,75 см.

## Результаты и/или Обсуждения

Результаты должны быть изложены четко и кратко. В Обсуждении следует акцентироваться на значимости результатов работы, а не повторять их, избегая многочисленных цитирований и обсуждений опубликованной литературы. Допускается объединение разделов Результаты и Обсуждение.

## Выводы

Основные выводы исследования могут быть изложены кратко. Раздел **Выводы** может располагаться отдельно или образовывать подраздел **Обсуждения** или **Результатов и Обсуждений** по рассмотрению авторов, а также в зависимости от стиля статьи, полученных теоретических результатов, вычислений и т.д.

## Литература

Литература должна соответствовать нижеприведенным требованиям и примерам: приводиться без нумерации; независимо от языка оригинала, литература обязательно должна быть дана также на английском языке. Если литература в оригинале дана как на азербайджанском, так и на русском языках, переведите название книги/статьи/материала на английский, но укажите язык оригинала в скобках следующим образом: (in Russian).

Название издательства укажите без перевода, как например: Nauka, Nedra, Nafta-Press, Elm и т.д.

Например:

Garibov Y.E. Anthropogenous transformation of modern landscapes of the Azerbaijan Republic and their optimization ways. Abstract of PhD dissertation (geography), Baku, Azerbaijan, 2013, 47 p. (in Azerbaijani).

Hasanov T.Ab. Ophiolites of Lesser Caucasus. Nedra. Moscow, 1985, 240 p. (in Russian).

Isachenko A.G. Landscape studies and physico-geographical zoning. Vysshaya shkola. Moscow, 1991, 366 p. (in Russian).

Bortnikov N.S. Geochemistry and origin of ore forming fluids in hydrothermal-magmatic systems in tectonically active zones. Geology of ore fields. Vol. 48, No. 1, 2006, pp. 3-28 (in Russian).

### Пример Списка литературы для статьи, представленной на английском языке

#### REFERENCES

- Dearing J. Magnetic susceptibility. In: Walden J., Smith J.P., Oldfield F. (Editors). Environmental Magnetism: a practical guide, Quaternary Research Association. Technical Guide, No. 6, London 1999, pp. 35-62.
- Dodonov A.E., Tchepalyga A.L., Mihailescu C.D., Zhou L.P., Markova A.K., Trubikhin V.M., Simahova A.N., Konikov E.G. Last-interglacial records from central Asia to the northern Black Sea shoreline: stratigraphy correlation. Netherlands Journal of Geosciences, Vol. 79, No. 2/3, 2000, pp. 303-311.
- King J.W., Channell J.E.T. Sedimentary magnetism, environmental magnetism, and magnetostratigraphy. U.S. Nat. Rep. Int. Union Geod. Geophys. Rev. Geophys. 1987-1990, V. 29, 1991, pp. 358-370.
- Lowrie W. Identification of ferromagnetic minerals in a rock by coercivity and unblocking temperature properties. Geophys. Res. Lett., Vol. 17(2), 1990, pp. 159-162.
- Mammadov A.B., Aleskerov B.D. Pleistocene of Azerbaijan. Azerbaijan National Academy of Sciences. Institute of Geography. Baku, 2002, 70 p. (in Russian).
- Pilipenko O.V., Sharonova Z.V., Trubikhin V.M., Novruzov Z., Karyagdy S.K., Abrakhamen N. Study of environmental change of Karaja section rocks formation (Azerbaijan) on results of petromagnetic research. Earth Physics, No. 4, 2009, pp. 85-96 (in Russian).
- Trubikhin V.M. Paleomagnetic method and dating of regional geological events of Pontian-Caspian. New data on geochronology of Quaternary period. Nauka. Moscow, 1987, pp. 150-157 (in Russian).

#### ЛИТЕРАТУРА

- Dearing J. Magnetic susceptibility. In: Walden J., Smith J.P., Oldfield F., (Editors). Environmental Magnetism: a practical guide, Quaternary Research Association. Technical Guide, No. 6, London, 1999, pp. 35-62.
- Dodonov A.E., Tchepalyga A.L., Mihailescu C.D., Zhou L.P., Markova A.K., Trubikhin V.M., Simahova A.N., Konikov E.G. Last-interglacial records from central Asia to the northern Black Sea shore line: stratigraphy correlation. Netherlands Journal of Geosciences, Vol. 79, No. 2/3, 2000, pp. 303-311.
- King J.W. and Channell J.E.T. Sedimentary magnetism, environmental magnetism, and magnetostratigraphy. U.S. Nat. Rep. Int. Union Geod. Geophys. Rev. Geophys. 1987-1990, V. 29, 1991, pp. 358-370.
- Lowrie W. Identification of ferromagnetic minerals in a rock by coercivity and unblocking temperature properties. Geophys. Res. Lett., Vol. 17(2), 1990, pp. 159-162.
- Мамедов А.В., Алескеров Б.Д. Плейстоцен Азербайджана. Национ. Акад.наук Азербайджана. Институт Географии. Баку, 2002, 70 с.
- Пилипенко О.В., Шаронова З.В., Трубихин В.М., Новрузов З., Карягды С.К., Абрахамсен Н. Изучение изменений среды формирования пород разреза Караджа (Азербайджан) по результатам петромагнитных исследований. Физика Земли, No. 4, 2009, с. 85-96.
- Трубихин В.М. Палеомагнитный метод и датирования региональных геологических событий Понто-Каспия. Новые данные по геохронологии четвертичного периода. Наука. Москва, 1987, с. 150-157.

### Пример Списка литературы для статьи, представленной на азербайджанском (или на русском) языке

#### ƏDƏBİYYAT

- Azərbaycan Respublikası əhalisinin siyahıyaalınması. 2009-cu il. XIX cild, Bakı, 2011, 820 s.
- Azərbaycan Respublikasının konstruktiv coğrafiyası. (Budagov B.Ə. redaktəsi altında). 3 cildə, III cild, Avropa. Bakı, 2003, 256 s.
- Ibrahimov T.O. Landşaft tədqiqatları və onların ekoloji problemləri. Elm. Bakı, 2015, 384 s.

#### REFERENCES

- Alizade E.K., Tarikhazer S.A. Exomorphodynamics of mountain relief and its estimation. Victory. Baku, 2016, 236 p. (in Russian).
- Budagov B.A. Modern natural landscapes of the Azerbaijan SSR. Elm. Baku, 1988, 135 p. (in Russian).
- Census of the population of the Republic of Azerbaijan, 2009. Vol. 19. Baku, 2011, 820 p. (in Azerbaijani).

- Qəribov Y.Ə. Azərbaycan Respublikasının müasir landşaftlarının antropogen transformasiyası. Mars Print. Bakı, 2011, 299 s.
- Qəribov Y.Ə. Azərbaycan Respublikası təbii landşaftlarının optimallaşdırılması. AzTU mətbəəsi. Bakı, 2012, 216 s.
- Məmmədov Q.Ş. Torpaşünaslıq və torpaq coğrafiyasının əsasları. Elm. Bakı, 2007, 660 s.
- Məmmədov R.M. Azərbaycanda landşaft planlaşdırılması (ilk təcrübə və tətbiq). Bakı, 2009, 142 s.
- Namazova S.N. Xızı inzibati rayonunun davamlı inkişafı və landşaft planlaşdırılmasının qiymətləndirilməsi. Pedaqoji Universitet Xəbərləri, təbiət elmləri bölməsi, No. 4, 2014, s. 70-72.
- Süleymanov M.Ə. Azərbaycanın təbii və antropogen landşaftlarının coğrafi qanunauyğunluqları. Əbilov, Zeynalov və oğulları. Bakı, 2005, 248 s.
- Ализаде Э.К., Тарихазер С.А. Экзоморфодинамика рельефа гор и ее оценка. Victory. Баку, 2016, 236 с.
- Будагов Б.А. Современные естественные ландшафты Азербайджанской ССР. Элм. Баку, 1988, 135 с.
- Казакон Л.К. Ландшафтоведение (природные и антропогенные ландшафты). МНЭПУ. Москва, 2004, 264 с.
- Миллер Г.П. Ландшафтные исследования горных и предгорных территорий. Вища школа. Львов, 1974, 202 с.
- Constructive geography of the Republic of Azerbaijan (edited by B.A.Budagov). In three volumes. Vol. 3. Avropa. Bakı, 2003, 256 p. (in Azerbaijani).
- Garibov Y.A. Anthropogenic transformation of modern landscapes in Azerbaijan Republic. Mars print. Bakı, 2011, 299 p. (in Azerbaijani).
- Garibov Y.A. Optimization of natural landscapes in Azerbaijan Republic. Printing house of ATU. Bakı, 2012, 216 p. (in Azerbaijani).
- Ibrahimov T.O. Landscape studies and their ecological problems. Elm. Bakı, 2015, 384 p. (in Azerbaijani).
- Kazakov L.K. Landscape science (natural and anthropogenic landscapes). Academy MNEPU. Moscow, 2004, 264 p. (in Russian).
- Mammadov G.Sh. Fundamentals of soil science and soil geography. Elm. Bakı, 2007, 660 p. (in Azerbaijani).
- Mammadov R.M. Landscape planning in Azerbaijan (first experience and application). Bakı, 2009, 142 p. (in Azerbaijani).
- Miller G.P. Landscape studies of the mountain and foothill areas. Vishcha shkola. Lviv, 1974, 202 p. (in Russian).
- Namazova S.N. Assessment of sustainable development and landscape planning of Khyzi administrative district. Proceedings of Pedagogical University, series of natural sciences, No. 4, 2014, pp. 70-72 (in Azerbaijani).
- Suleymanov M.A. Geographical laws of natural and anthropogenic landscapes of Azerbaijan. Abilov, Zeynalov ve oğullari. Bakı, 2005, 248 p. (in Azerbaijani)

Пожалуйста, удостоверьтесь, что каждый литературный источник, на который ссылались в тексте, имеется в списке литературы (и наоборот). Ссылки в тексте должны даваться на языке оригинала.

Все ссылки в тексте должны быть заключены в скобки и относиться к:

1. Одному автору: фамилия автора (без инициалов), год издания;
2. Двум авторам: фамилии обоих авторов, год издания;
3. Трех и более авторам: фамилия первого автора, далее следует «et al.» (и др.), год издания.

Ряд ссылок следует представить в хронологическом порядке. Например, (Bryulov, 1999; McKenzie, 2000)...". Ссылка также может быть в следующей форме: "Alizadeh et al. (2016) have recently shown ...".

**Список литературы:** Цитируемые литературные источники должны быть выстроены по алфавиту. Размер шрифта – 12 pt. Фамилия начинается заглавной буквой, остальные буквы строчные без запятой после фамилии. После фамилии(й) автора(ов) указываются название журнала/название книги/название раздела/название статьи, номер тома/ выпуска, глава книги/номер журнала, издательство, город, год издания и номера страниц. Настоятельно рекомендуется использовать идентификационные индексы DOI. В случае нескольких ссылок на литературные источники одного и того же автора и одинакового года издания, следует применить дополнительно буквы "a", "b", "c" и т.д. (Aliyev, 2009a).

Примеры:

**Ссылки на журнальные статьи:**

Ismayil-zadeh A.J. Bipolar conjugation of volcano-plutonic and ophiolitic belts in Caucasus. Proceedings of NAS of Azerbaijan. The Sciences of Earth, No.1, 2009, pp. 40-53 (in Russian).

***Ссылки на книги и монографии:***

Mustafayev G.V. Mesozoic granitoid formations of Azerbaijan and peculiarities of its metallogeny. Elm. Baku, 1977, 234 p. (in Russian).

***Ссылки на главы в книгах под редакцией:***

Mettam G.R., Adams L.B. How to prepare an electronic version of your article. In: Introduction to the Electronic Age. E-Publishing Inc., New York, 2009, pp. 281-304.

***Ссылки на диссертации и/или авторефераты:***

Garibov Y.E. Anthropogenous transformation of modern landscapes of the Azerbaijan Republic and their optimization ways. Abstract of PhD dissertation (geography), Baku, Azerbaijan, 2013, 47 p. (in Azerbaijani).

***Ссылки на конференции и симпозиумы:***

Khain V.Ye. Northcaucasian-Turkmeno-Northafganian Late Triassic volcano-plutonic belt and detection of north zone of Tethys. Doklady AS of USSR, Vol. 249, No. 5, 1979, pp. 1190-1192 (in Russian).

***Ссылки на вебсайты:***

Cancer Research UK. Cancer statistics reports for the UK. 1975, <http://www.cancerresearchuk.org/aboutcancer/statistics/cancerstatsreport/> accessed 13 March 2003).

***Ссылки на базы данных (методологические разработки, буклеты, брошюры):***

Oguro M., Imahiro S., Saito S., Nakashizuka T. Mortality data for Japanese oak wilt disease and surrounding forest compositions. Mendeley Data, Vol. 1, 2015.

**Представление статей**

Все представленные статьи посылаются на рецензирование и одобрение редакционной коллегии. Статьи, которые прошли эту процедуру и получили положительный отзыв, публикуются бесплатно. Авторам следует представлять рукописи в Редакционную Коллегию онлайн посредством функции **“Подать статью (Submit the manuscript)”**.

Рецензирование длится **1-2 месяца** со дня представления статьи в редакцию. Статьи публикуются в порядке поступления (очередности). Будем благодарны, если статьи как в бумажном, так и электронном виде будут соответствовать высоким профессиональным стандартам. Представление статей в электронном виде поможет нам подготовить вашу работу наилучшим образом, обеспечивая достоверность, четкость и подробную информативность.

В случае возврата статьи авторам для внесения изменений доработанный вариант должен быть возвращен в редакцию **в течение двух недель**. Если рукопись будет задержана по вине автора **более двух недель**, она будет рассматриваться редакцией как вновь поступившая.

При представлении статьи необходимо прислать также отсканированную электронную версию сопроводительного письма на имя главного редактора с просьбой принять статью на рассмотрение согласно правилам журнала и в случае соответствия всем требованиям опубликовать ее.

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