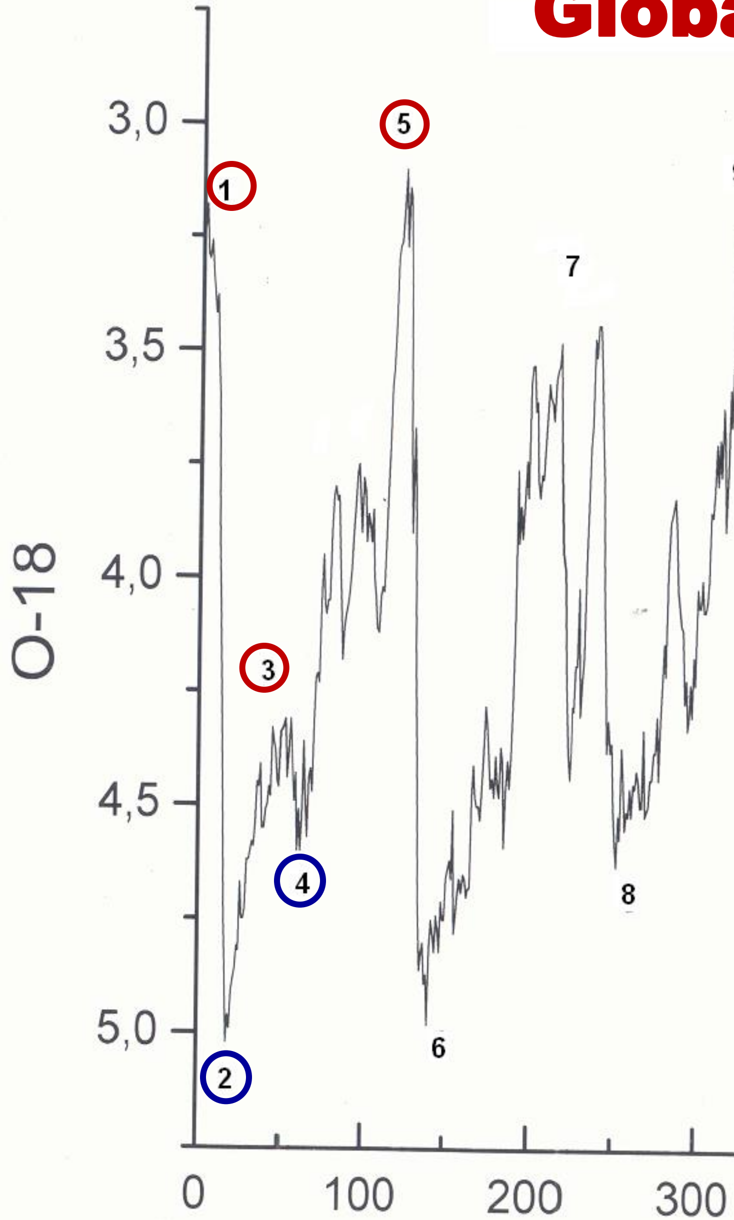
Environment evolution of the Caspian Sea under the global climate change

Эволюция природной среды Каспия в условиях глобальных изменений климата

T. Yanina
Moscow State University, Moscow, Russia
H. Khoshravan
Caspian Sea National Research and Study Center, Tehran, Iran

Global climate change



The last climatic macrocycle

The beginning of the last climatic macrocycle (Late Pleistocene) was marked by the **Eemian interglacial**, and most specialists think it correlates with the **MIS 5e** substage. Its duration has been estimated at 15 thousand years (130-115 ka BP), and its thermal maximum is positioned at approximately 126 ka BP (Shackleton, 1969; Turney and Jones, 2010). The interval of MIS 5d-5a to MIS 4 corresponds to the Early Valdai glaciation, MIS 3 is correlated with the Middle Valdai mega-interstadial, and **MIS 2** is correlated with the **Late Valdai** in the Russian chronostratigraphy.

We assess the interval MIS 5d-5a as a transitional interglacial-glacial period.

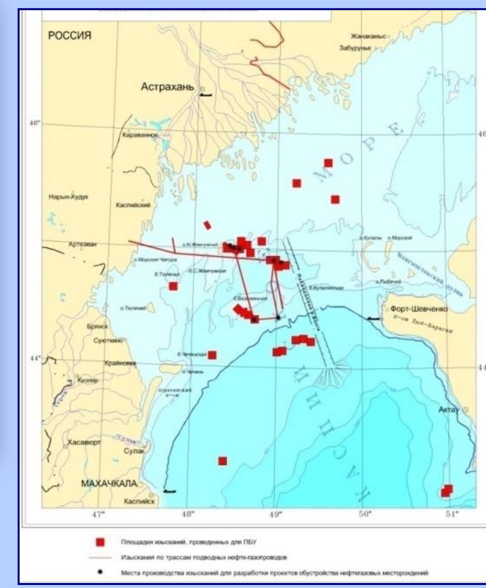
Researchers of the Caspian Pleistocene

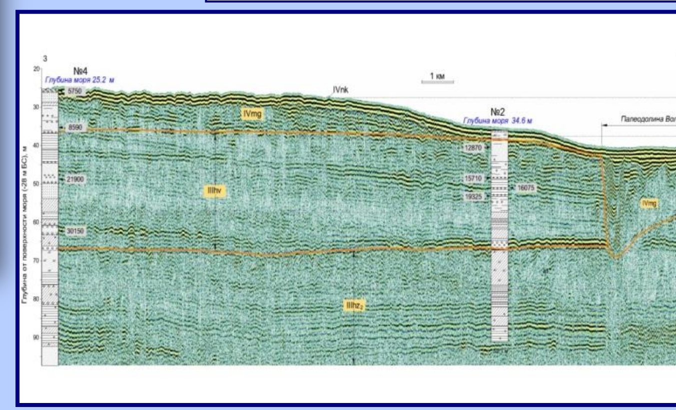
Abramova T.A., Aleskerov B.D., Alieva E., Ali Zadeh A.A., Alizadeh K.A., Andrusov N.I., Arslanov Kh.A., Artamonov V.I., Bobrova O.A., Asadullayev E.M., Badyukova E.N., Bogachyov V.V., Bolikhovskaya N.S., Vasilyev Yu.M., Vassoyevich N.B., Weber V.V., Vekilov B.G., Geyvandova E.Kh., Gerasimov I.P., Glazunova K.N., Golubyatnikov V.D., Golubyatnikov D.V., Gorecki G.I., Grimm O.A., Grichuk V.P., Huseynov D., Dashevskaya O.V., Dorofeyev P.I., Zhidovinov N.Ya., Zhizhchenko B.P., Zhukov M.M., Ignatov E.I., Kasimov N.S., Kalitsky K.P., Kaplin P.A., Karandeeva M.V., Kvasov D.D., Kislov A.V., Kovalevski S.A., Kovda V.A., Kolesnikov V.P., Kroonenberg S.B., Kuprin P.N., Lebedev L.I., Lebedeva N.A., Lemeshko N., Leontyev O.K., Leroy S., Lisitsyn K.I., Logvinenko B.M., Lukyanova S.A., Lychagin M.Yu., Mayev E.G., Mamedov A.V., Menabde I.V., Moskvitin A.I., Myakokin V.S., Nalivkin D.V., Nevesskaya L.A. Nikifirov L.G., Nikolaev V.A., Nikolaev N.I., Nikolaev S.D., Ostroumov A.A., Pallas P.S., Popov G.I., Pravoslavlev P.A., Richards K., Rychagov G.I., Svitoch A.A., Sedaykin V.M., Sorokin V.M., Starobogatov Ya.N., Suprunova N.I., Tagieva E., Tudrun, Fedkovich Z.N., Fedorov P.V., Hain V.E., Shkatova V.K., Chepalyga A.L., Veliev S., Eberzin A.G., Eihwald E., Wesselingh F.P., Yanko V.V., Yakhimovich V.L. and many others

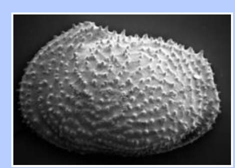
Materials and methods
Complex analysis

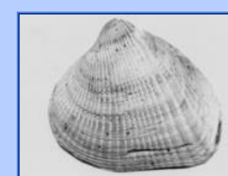
Main sections

Cores (~100 m)

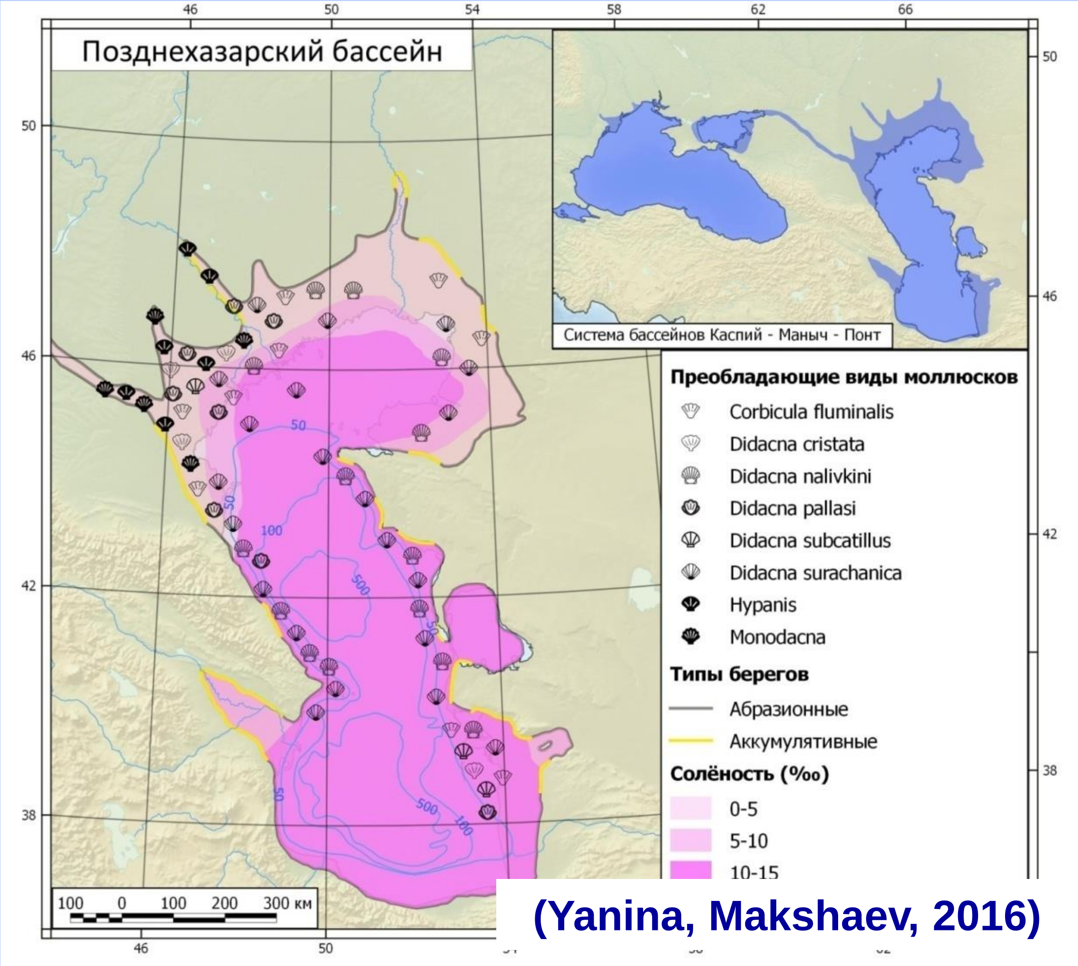




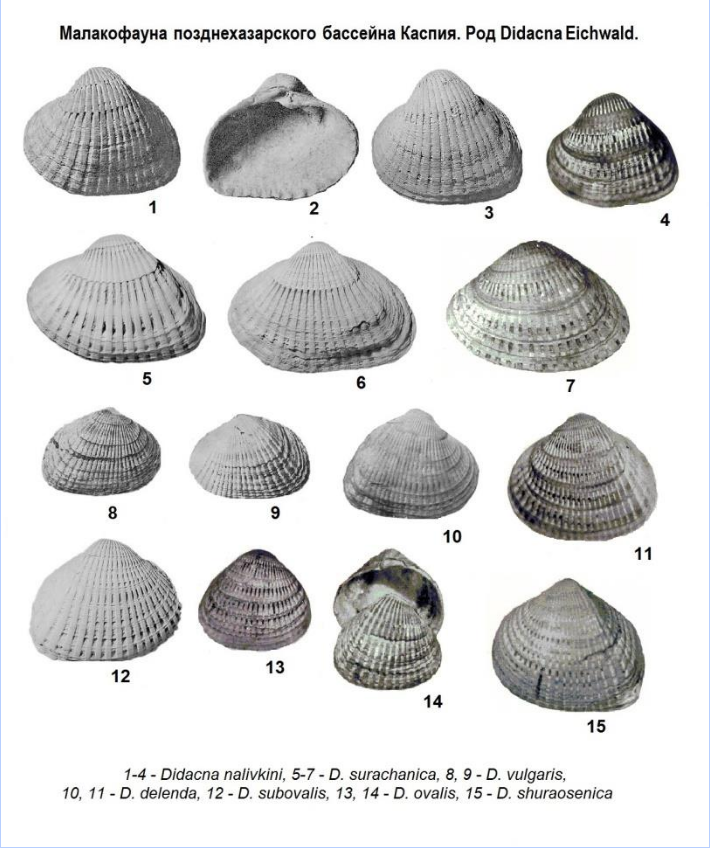




Late Khazarian transgression



(Yanina, Makshaev, 2016)

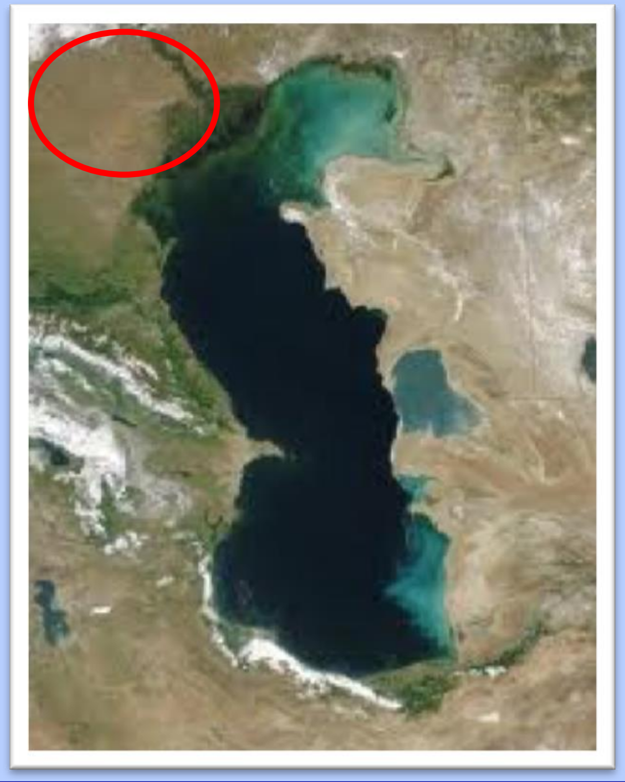


1-4 - Didacna nalivkini, 5-7 - D. surachanica, 8, 9 - D. vulgaris, 10, 11 - D. delenda, 12 - D. subovalis, 13, 14 - D. ovalis, 15 - D. shuraosenica

Th/U 122-87 ky
TL 127-89 ky
ESR 108-85 ky

The species composition of mollusc assemblages testify that salinity of the Late Khazarian sea was higher than the modern one, and sediment accumulation environment was warm. Microfaunal assemblages provide evidence for similar environmental conditions.

Hyrcanian transgression



Based on drill sites materials from the north-western part of the Caspian region, G.I. Popov (1967) reconstructed a brackish water basin. He defined it as an independent **Hyrcanian transgression** of the Caspian, which took place after the Late Khazarian transgression and was separated from the Khvalynian transgression by the Atelian regression.
The basin was inhabited by “Khvalynian-like” fauna. Characteristic features of it are the prevalence *Didacna cristata*, *D. subcatillus*, *D. hyrcana*, and the presence of freshwater specie *Corbicula fluminalis*.
Most part of researchers strongly objected to this concept.

Kvalynian transgression

↑

Atelian regression

↑ ← **Hyrcanian transgression**

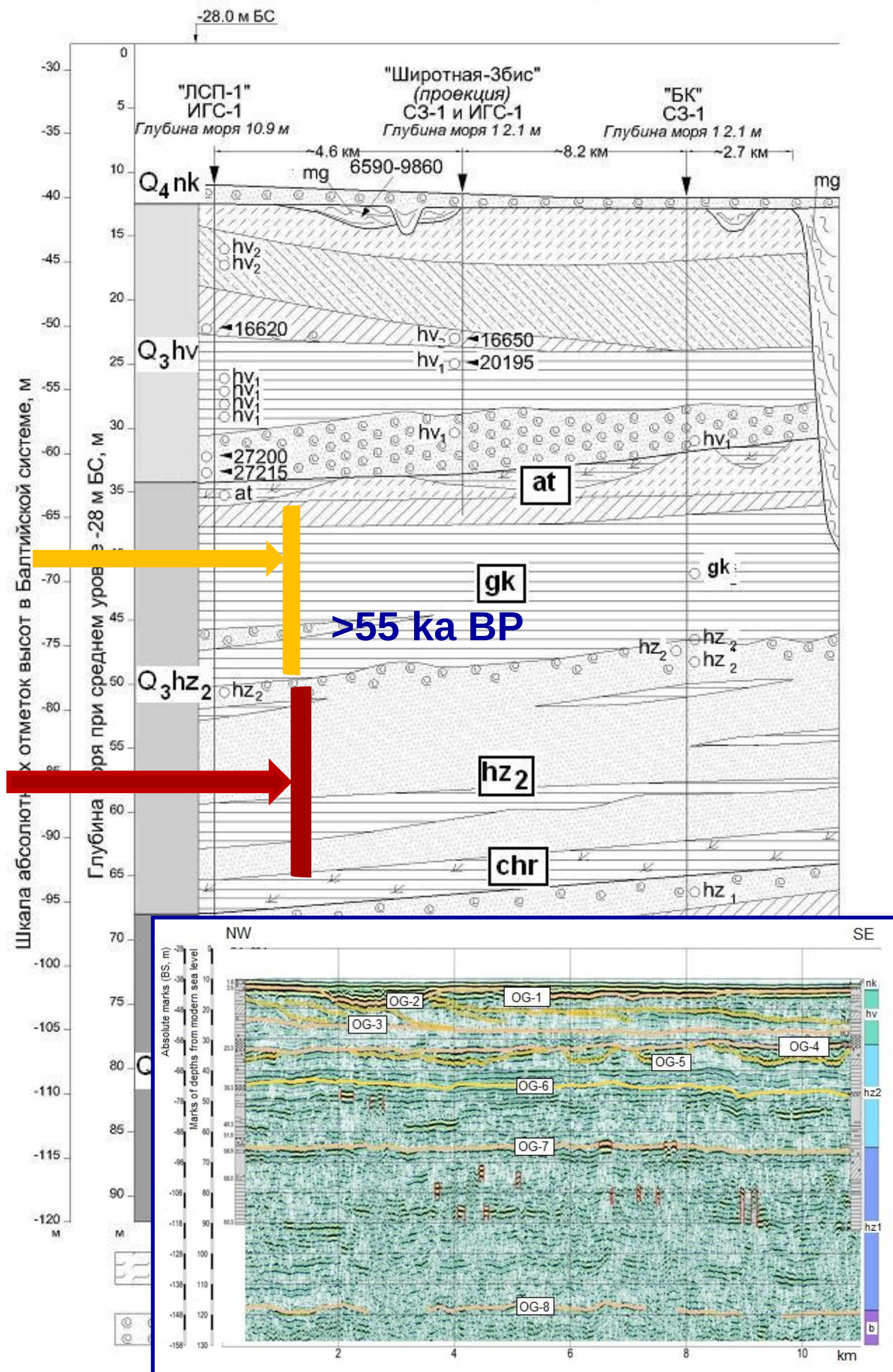
Late Khazarian transgression

Hyrcanian transgression

Didacna umbonata, D. subcatillus, *D. cristata* and *D. parallella* .
The faunal composition is typical fo the Hyrcanian horizon recognized in the North Caspian region by Popov.
Pollen assemblages differ from the Late Khazarian ones: *Pinus* sp. (11%), *Betula* (9%), *Alnus* (1%), *Corylus* (2%), *Chenopodiaceae* (39%), *Gramineae* (5%), *Artemisia* (3%).
Some cooler and wetter climate.

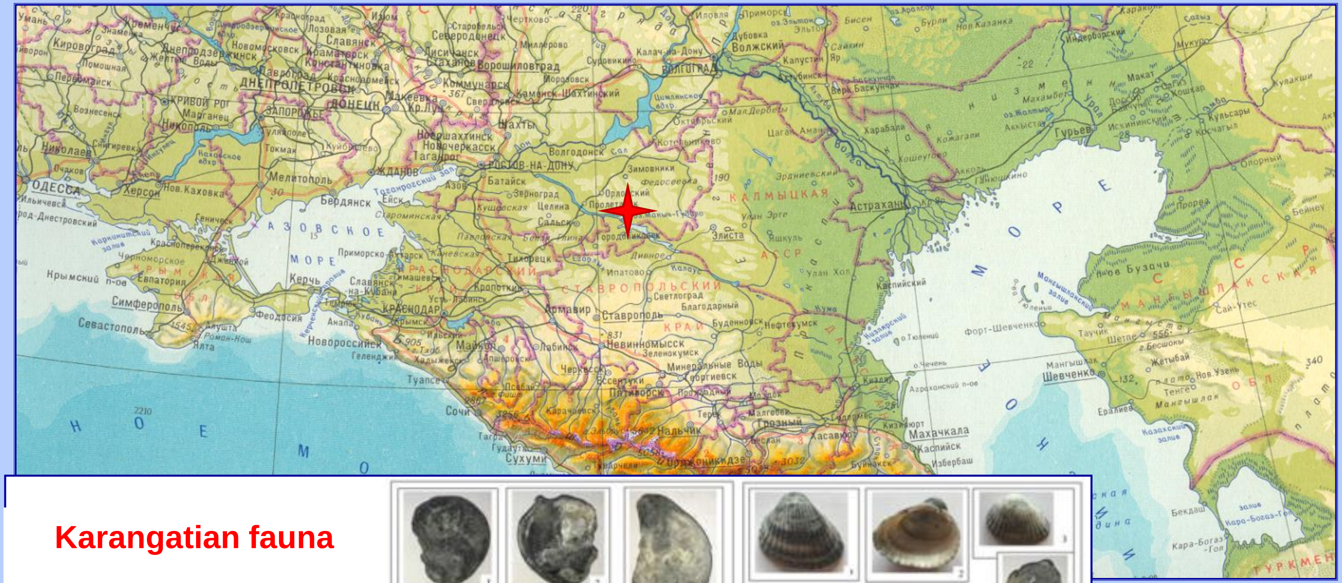
Didacna surachanica, D. nalivkini (Late Khazarian fauna) +*Corbicula fluminalis*.

The pollen assemblage suggests a wide distribution of semidesert plant communities in the region and practically complete absence of forested areas

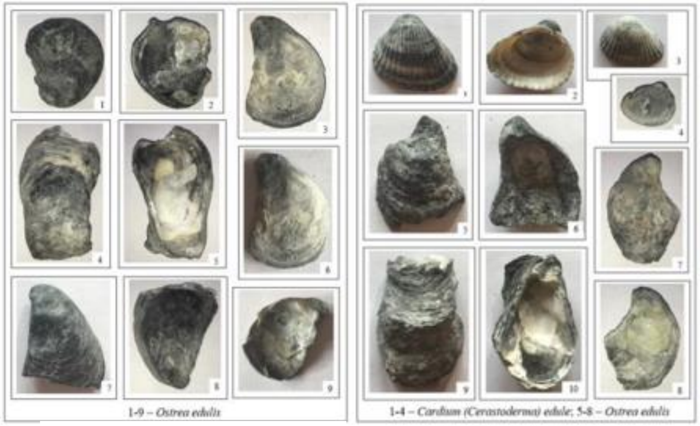


We confirmed existence of the Hyrcanian basin in the history of the Caspian Sea

Manych



Karangatian fauna

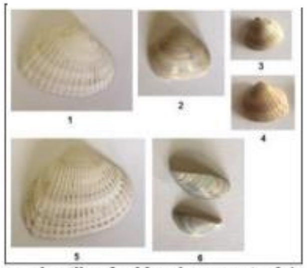


1-9 – *Ostrea edulis*   1-4 – *Cardium (Cerastoderma) edule*; 5-8 – *Ostrea edulis*

Mix of Karangatian and Hyrcanian fauna

1-3 – *Didacna cristata*; 4,5 – *Cardium*

Hyrcanian fauna



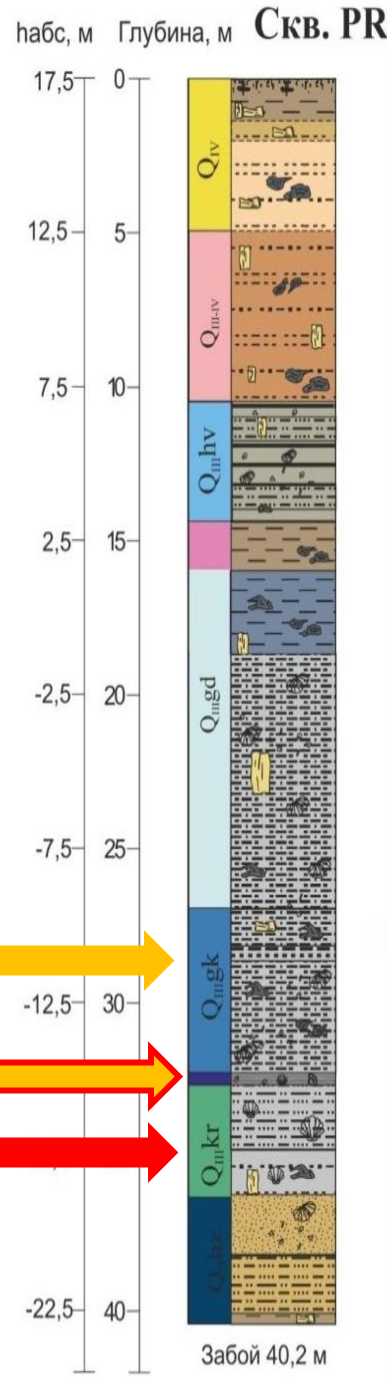
1 – *Didacna subcatillus*; 2 – *Monodacna caspia*; 3,4 – *Didacna*

Hyrcanian fauna

107+/-7 ky

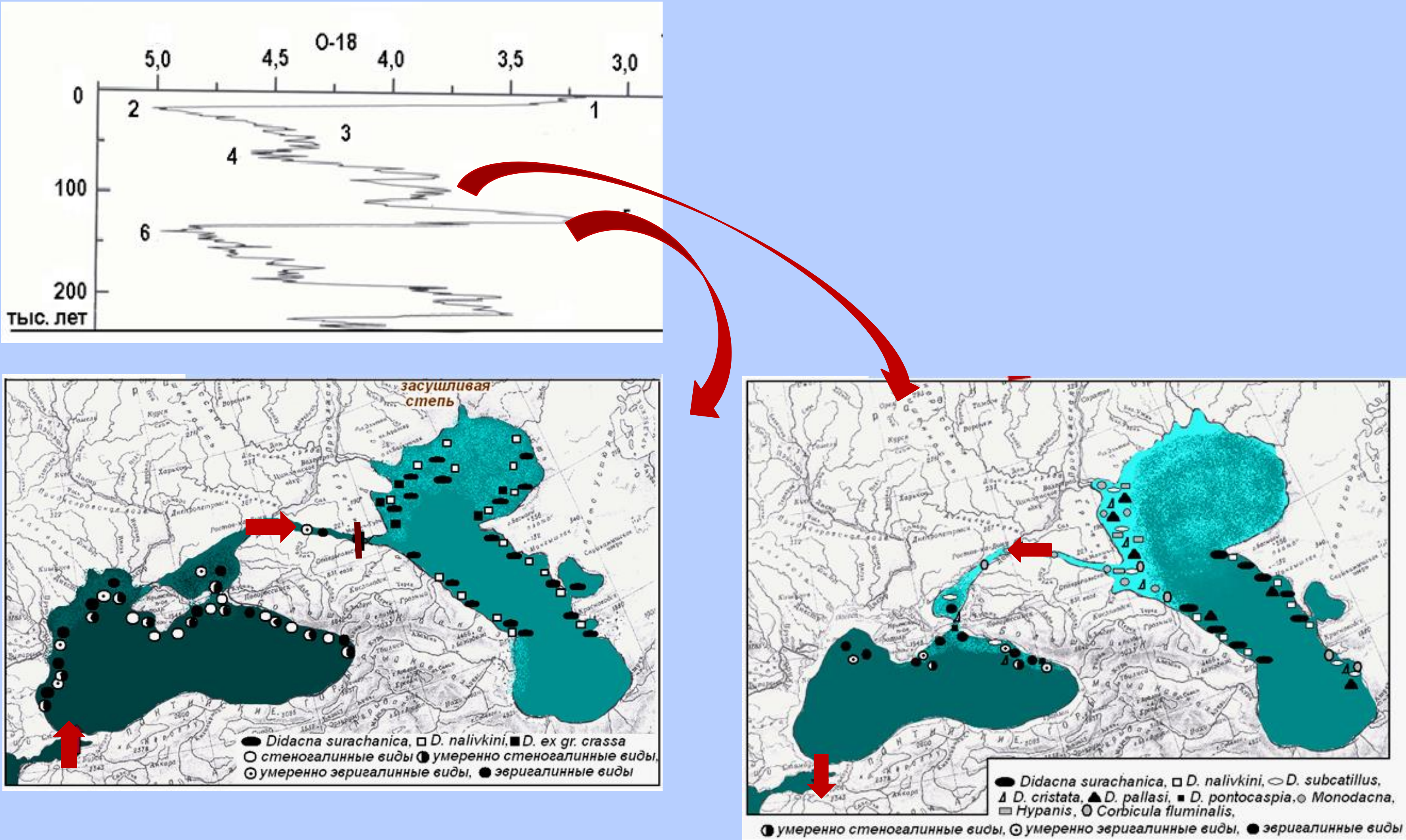
Mix of Karangatian and Hyrcanian fauna

Karangatian fauna



(Kurbanov et al., 2018)

MIS 5

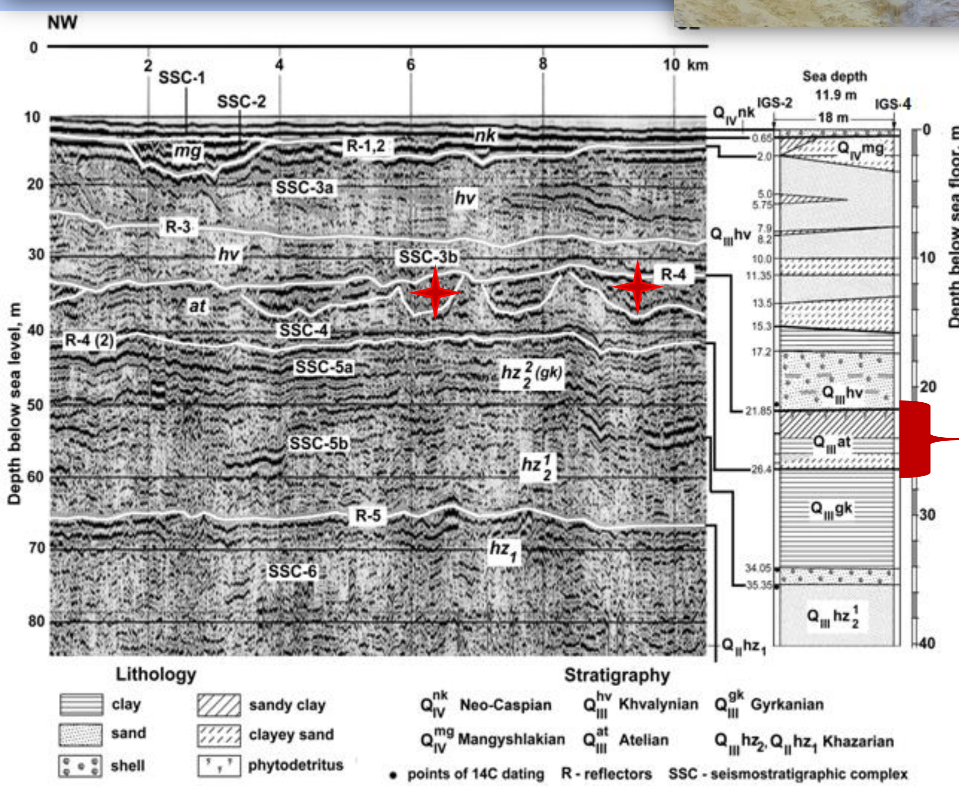


In the history of the Caspian Sea, this period (MIS 5) was followed by the Late Khazarian-Hyrcanian transgressive-regressive stage

Atelian regression

At the base of the series there are well pronounced cryoturbations and ice wedge.

The pollen assemblages of definitely periglacial character recovered from the Atelian deposits from cores (Bolikhovskaya et al., 2017).



The Atelian regression is clearly expressed in the structure of the Pleistocene deposits of the northern basin. It is reflected by the cuttings in the seismic-acoustic profiles under the base of the Khvalynian deposits.

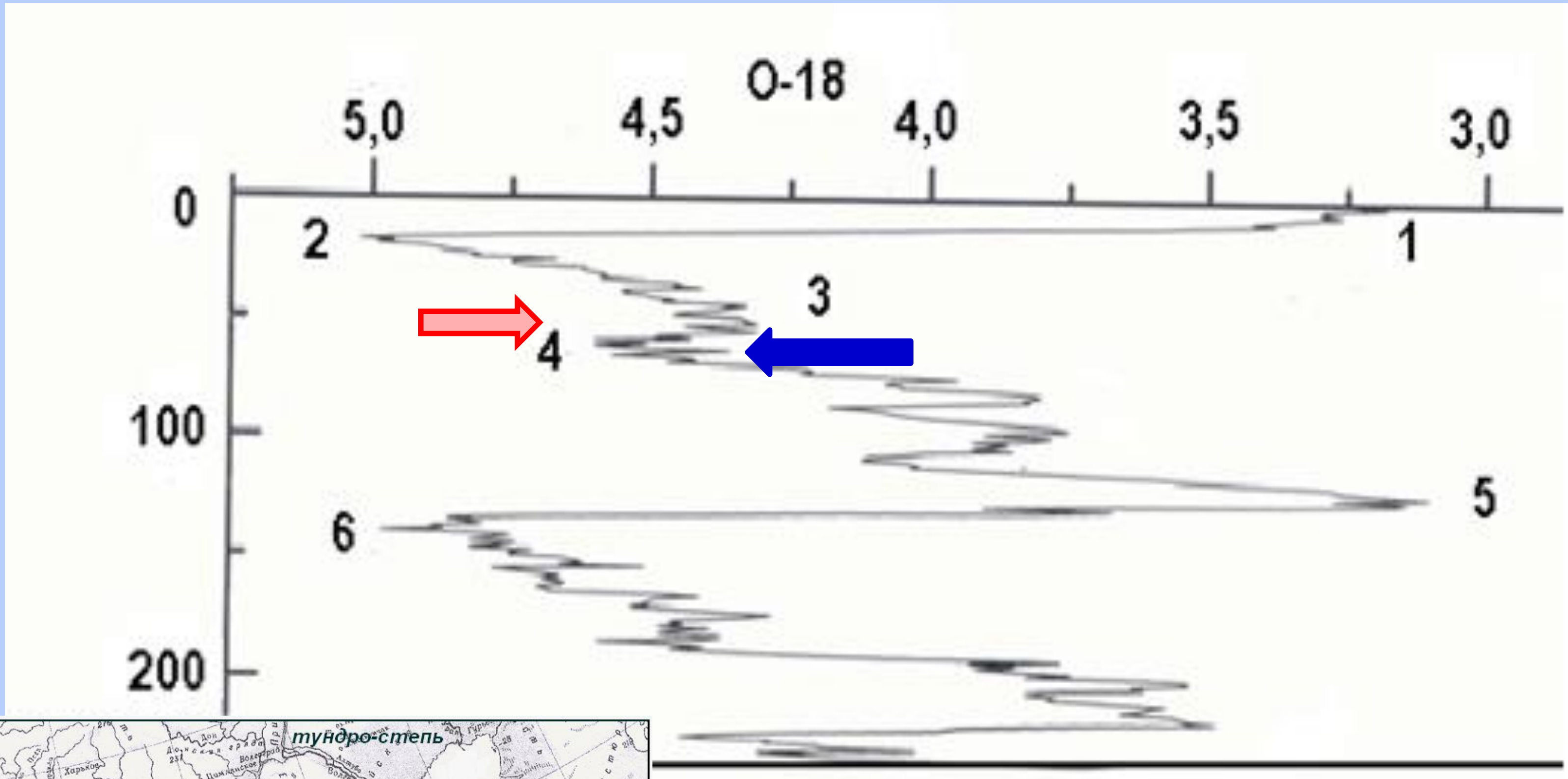
Radiocarbon dating determined using humic acids

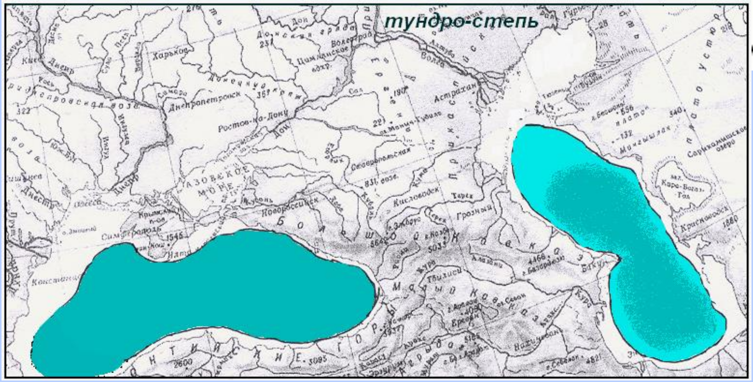
ИГАН-4541	Q_3 at	36680±850	40441-41941 (41191±750)
САМ 163762	Q_3 at	37100±660 AMS	41062-42131 (41596±534)
ИГАН-4542	Q_3 at	40830±100	44210-44570 (44390±180)

Radiocarbon dates obtained on the upper part of the Atelian deposits infilling the older erosional landforms strongly suggest them to have been deposited at the first half of the interstadial warming (MIS 3).

(Yanina et al., 2017)

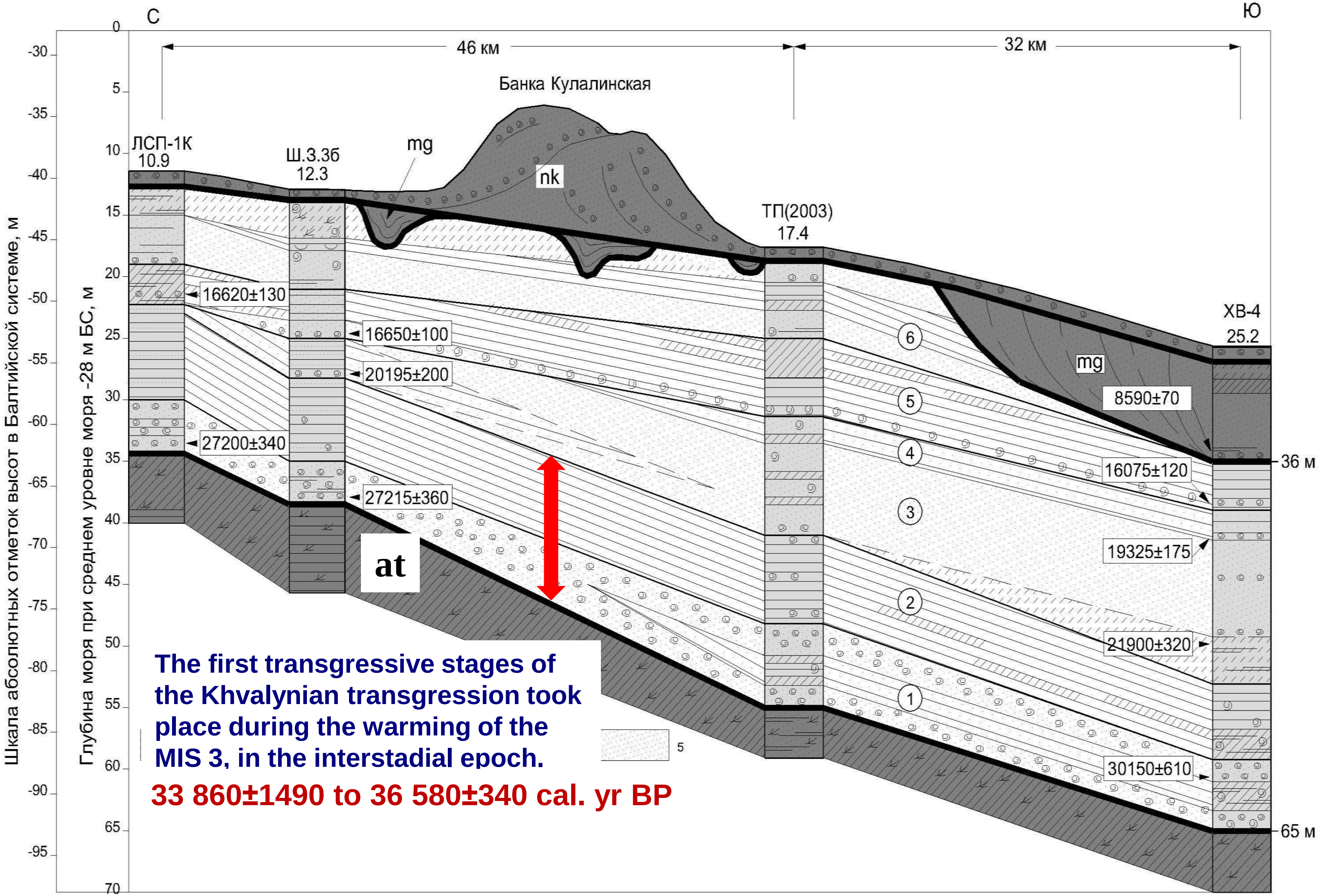
MIS 4. Glacial stage
MIS 3. Interstadial warming





MIS 4 – MIS 3 beginning
Atelian regression in the Caspian Sea

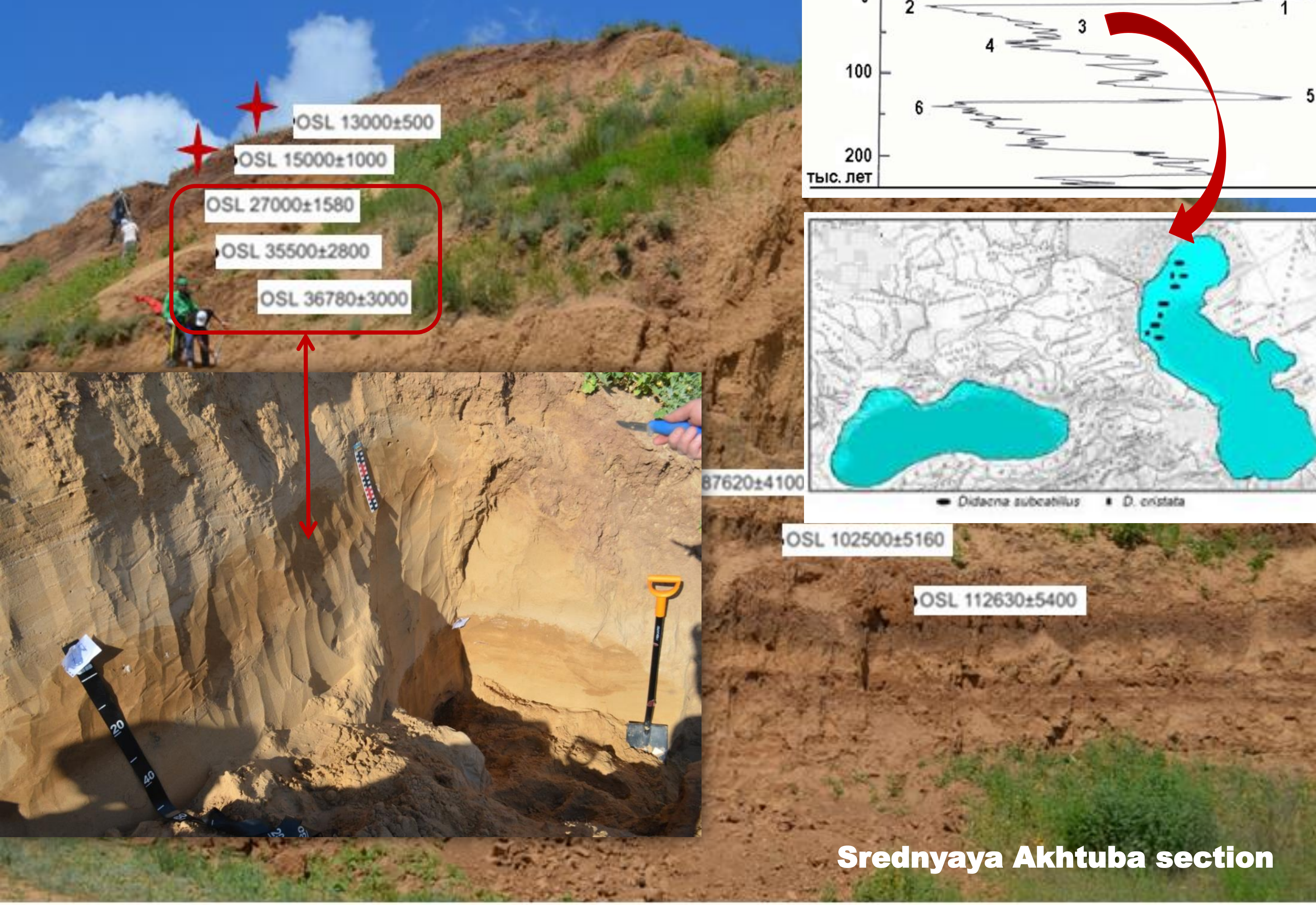
Khvalynian transgressive epoch



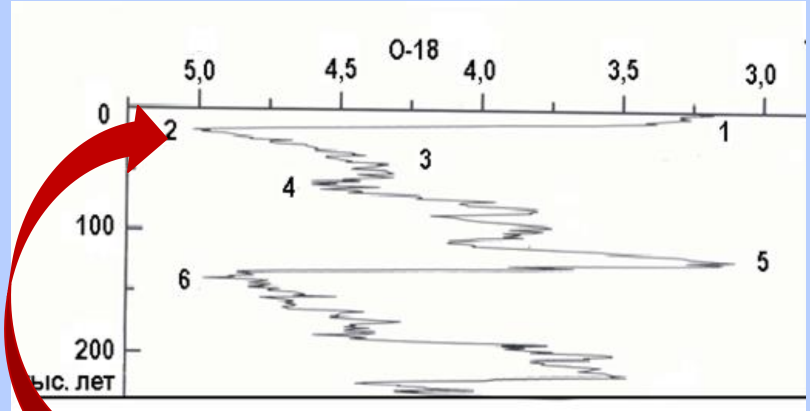
The first transgressive stages of the Khvalynian transgression took place during the warming of the MIS 3, in the interstadial epoch.

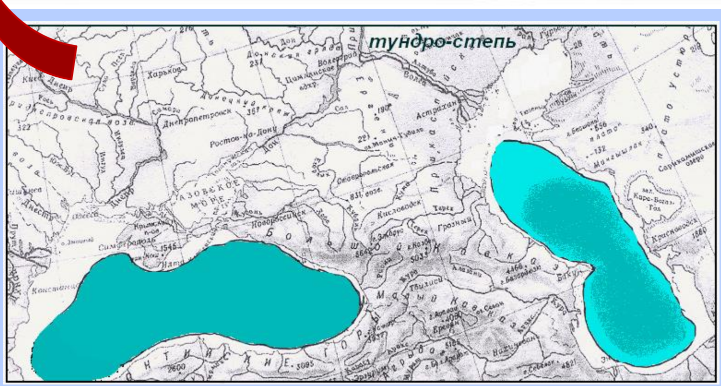
33 860±1490 to 36 580±340 cal. yr BP

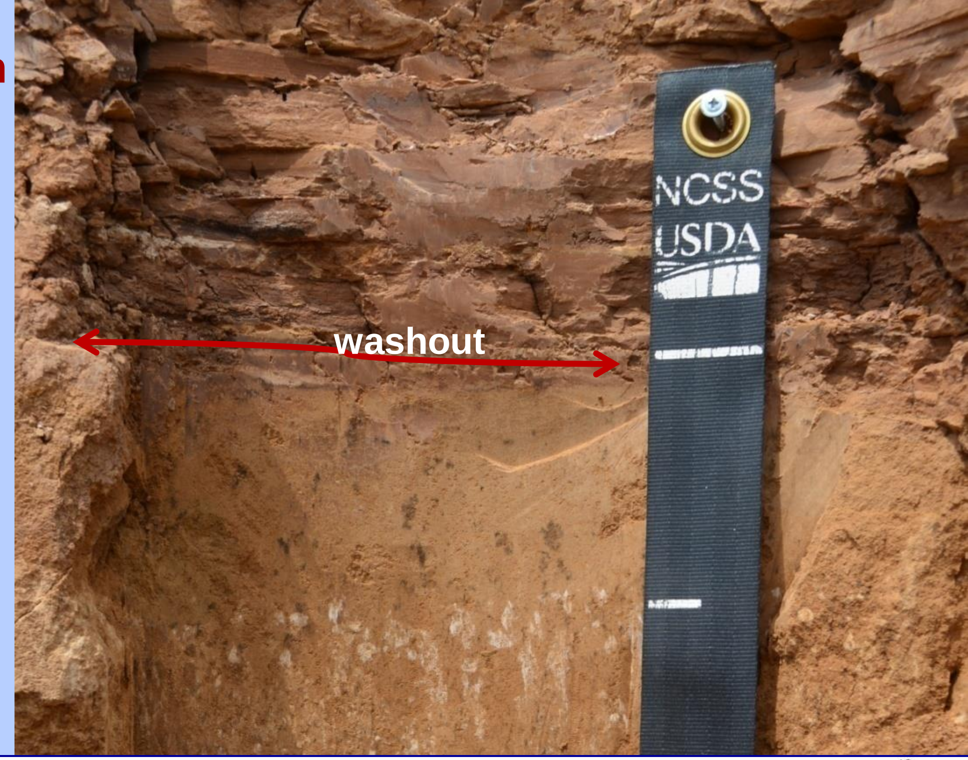
MIS 3. Interstadial warming



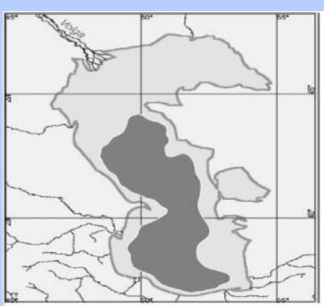
MIS 2. LGM. Inter-Khvalynian regression

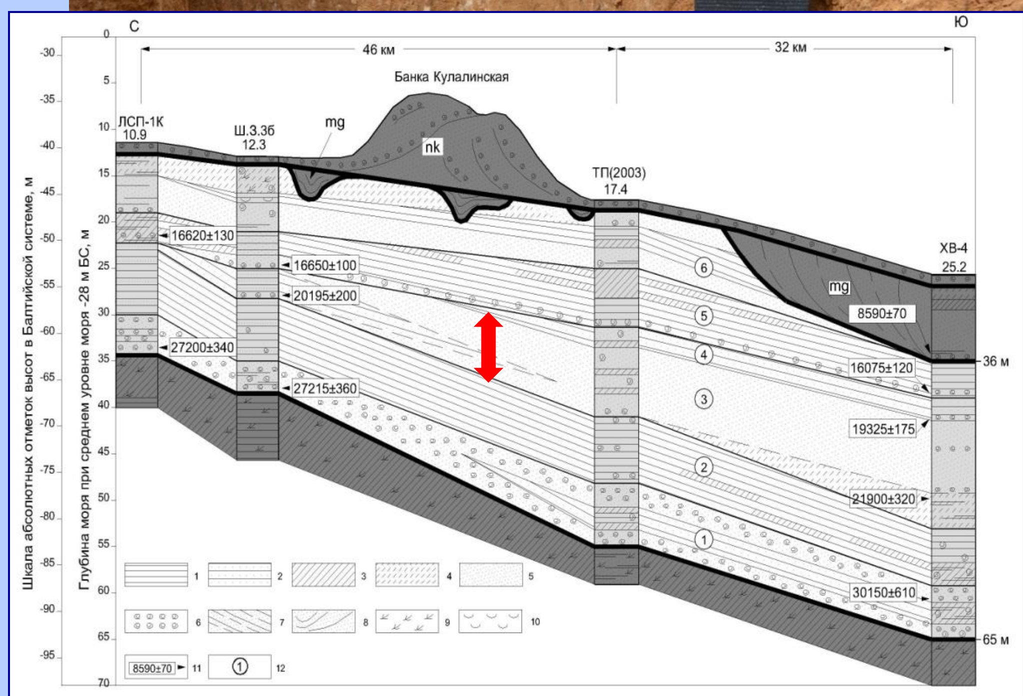






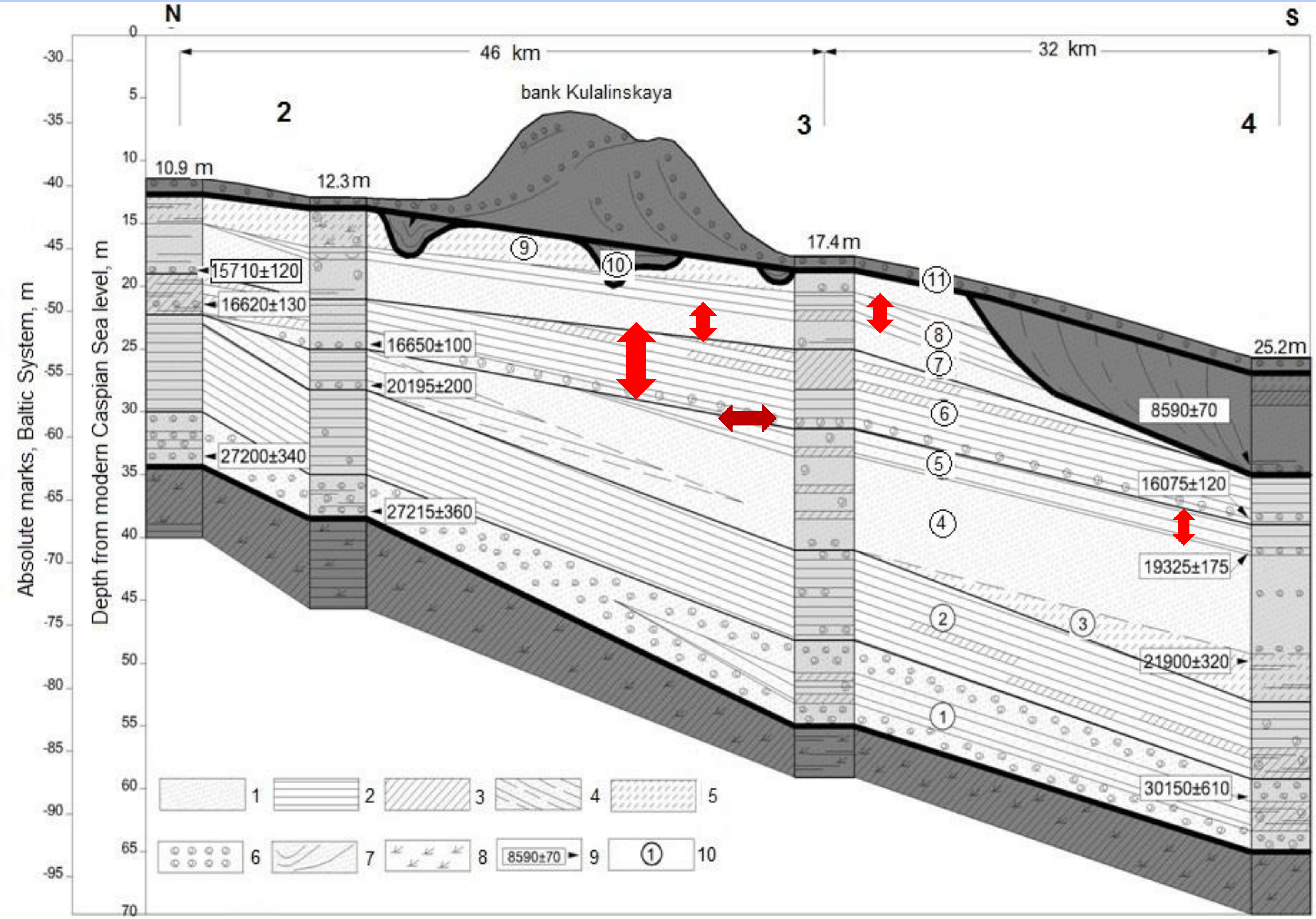
The LGM in Eastern Europe was reflected in the development of a falling sea level in the Caspian Sea





The results of climatic modeling (Kislov, Toropov)

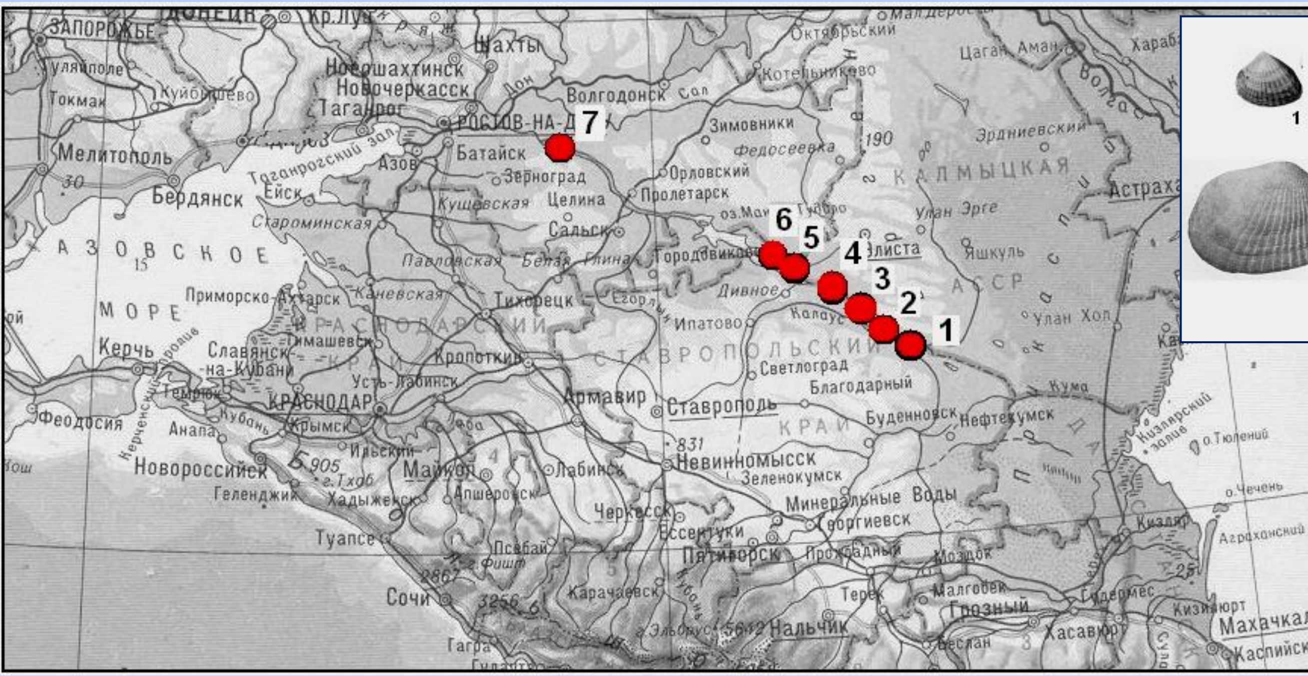
MIS 2. The epoch of degradation of the Late Valdai glacial stage

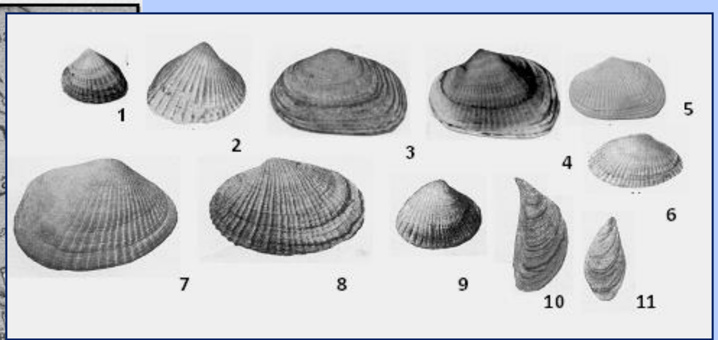



MIS 2. The epoch of degradation of
the Late Valdai glacial stage.
Lower Volga region


Khvalynian chocolate
clays

Manych

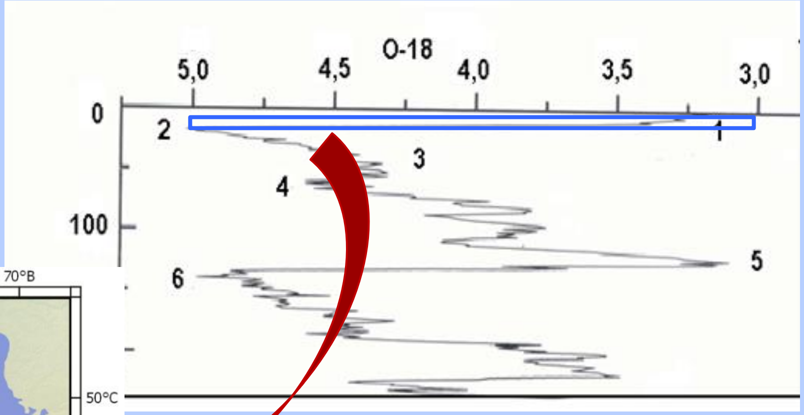




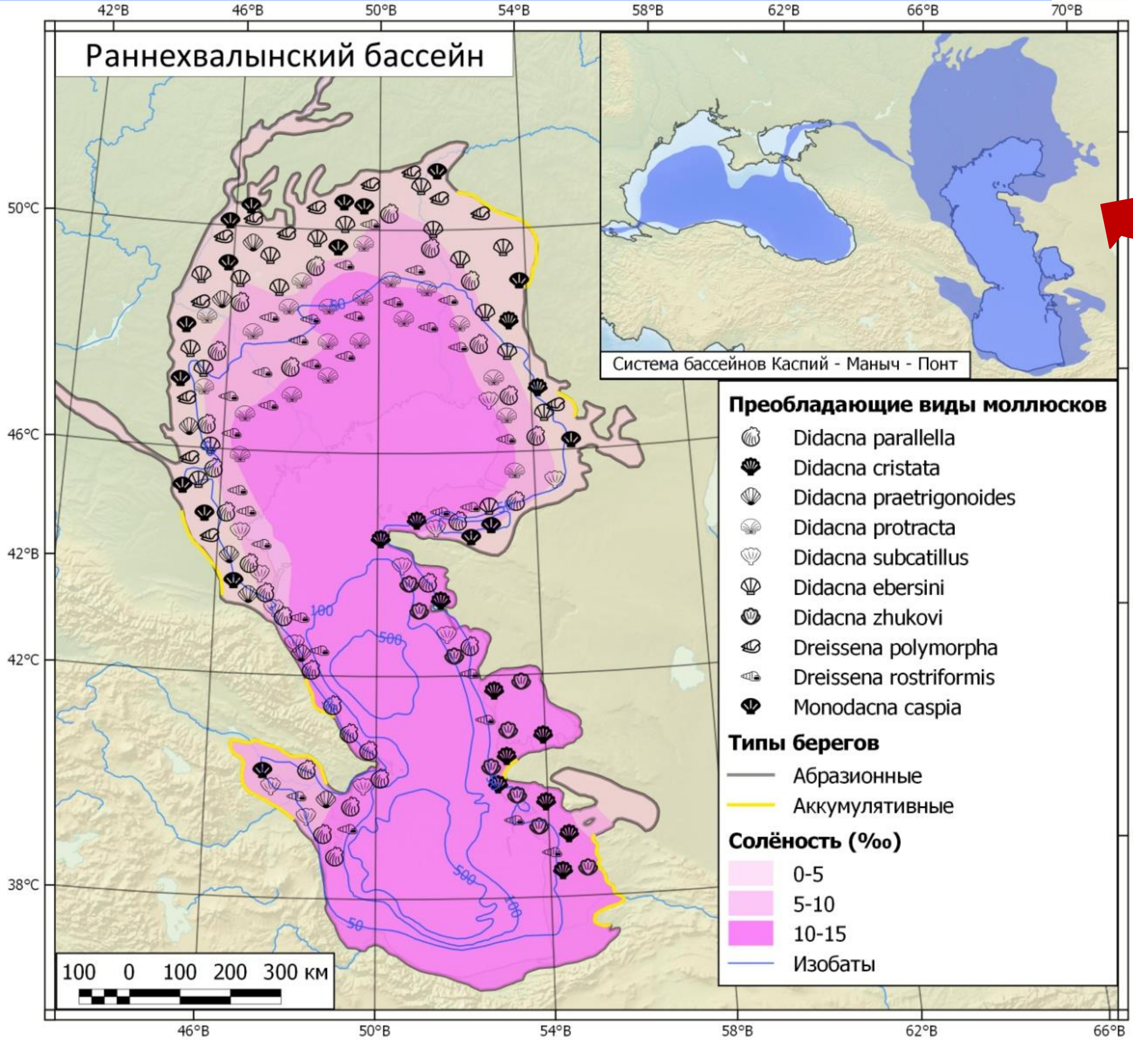
1, 2 – *Didacna ebersini*, 3, 4, 5 – *D. protracta*, 6 – *D. subcatillus*, 7 – *Adacna laeviuscula*, 8 – *Hypanis plicatus*, 9 – *Monodacna caspia*, 10 – *Dreissena polymorpha*, 11 – *Dr. rostriformis distincta*

Местонахождение	Номер образца	Вид раковин	Возраст ^{14}C	Калиброванный возраст
Зунда-Толга	ЛУ-5725	*Didacna protracta*	10670±140	12570±170
Зунда-Толга	ЛУ-5726	*D. ebersini*	11420±220	13320± 220
Зунда-Толга	GrA-33717	*D. ebersini*	12740±50	14030 - 14670
Чограй	ЛУ-5768	*Hypanis plicatus*	11470±180	13360±200
Левый остров	ЛУ-5769	*Didacna protracta*	10930±370	12750±460
Маныч-Балабино	МГУ-1491	*D. ebersini, Monodacna caspia*	14300±680	
Маныч-Балабино	МГУ-1489	*D. ebersini, Monodacna caspia, Cerastoderma glaucum*	25690±300	

MIS 2. The epoch of degradation of the Late Valdai glacial stage

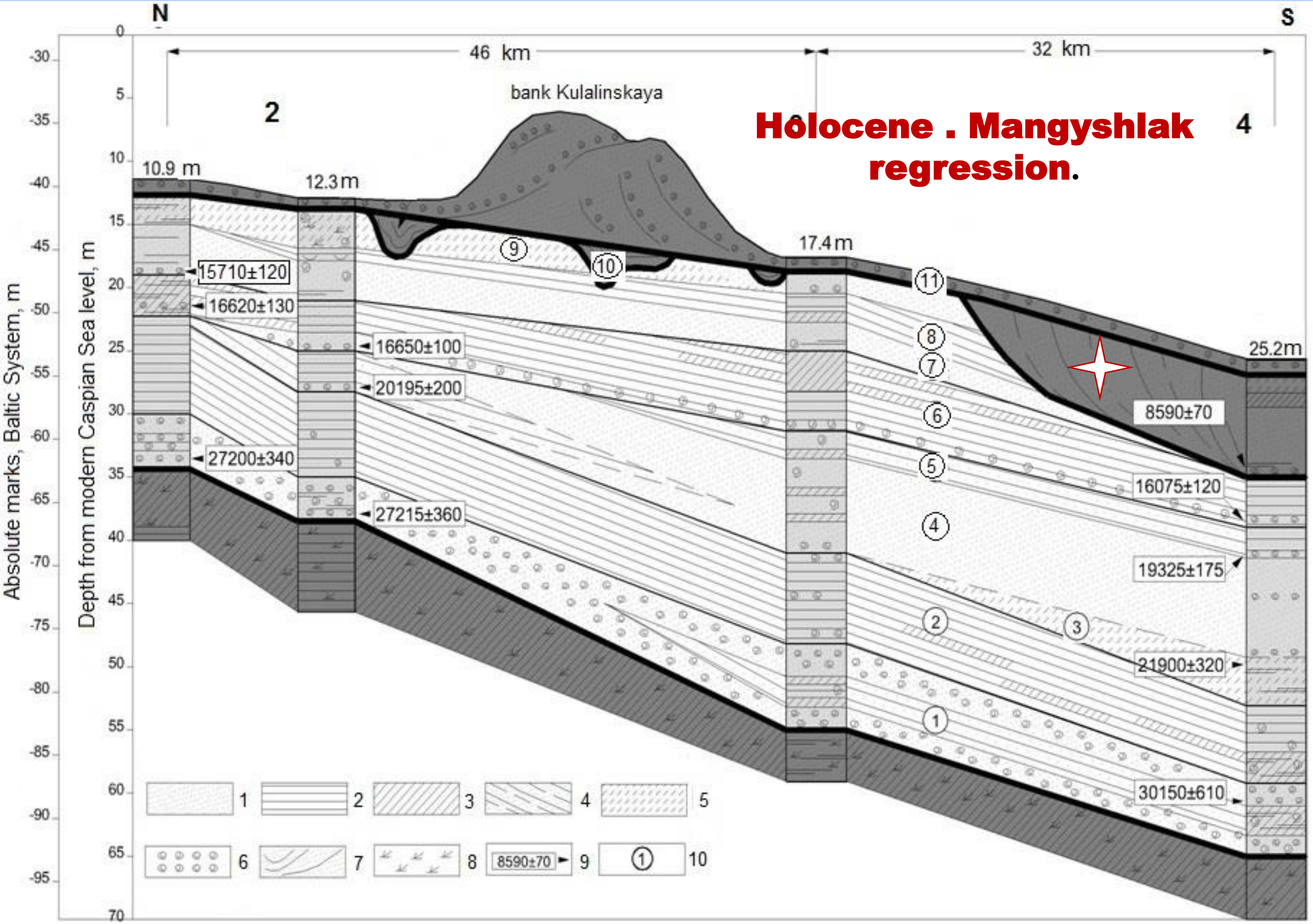


Early Khvalynian transgression

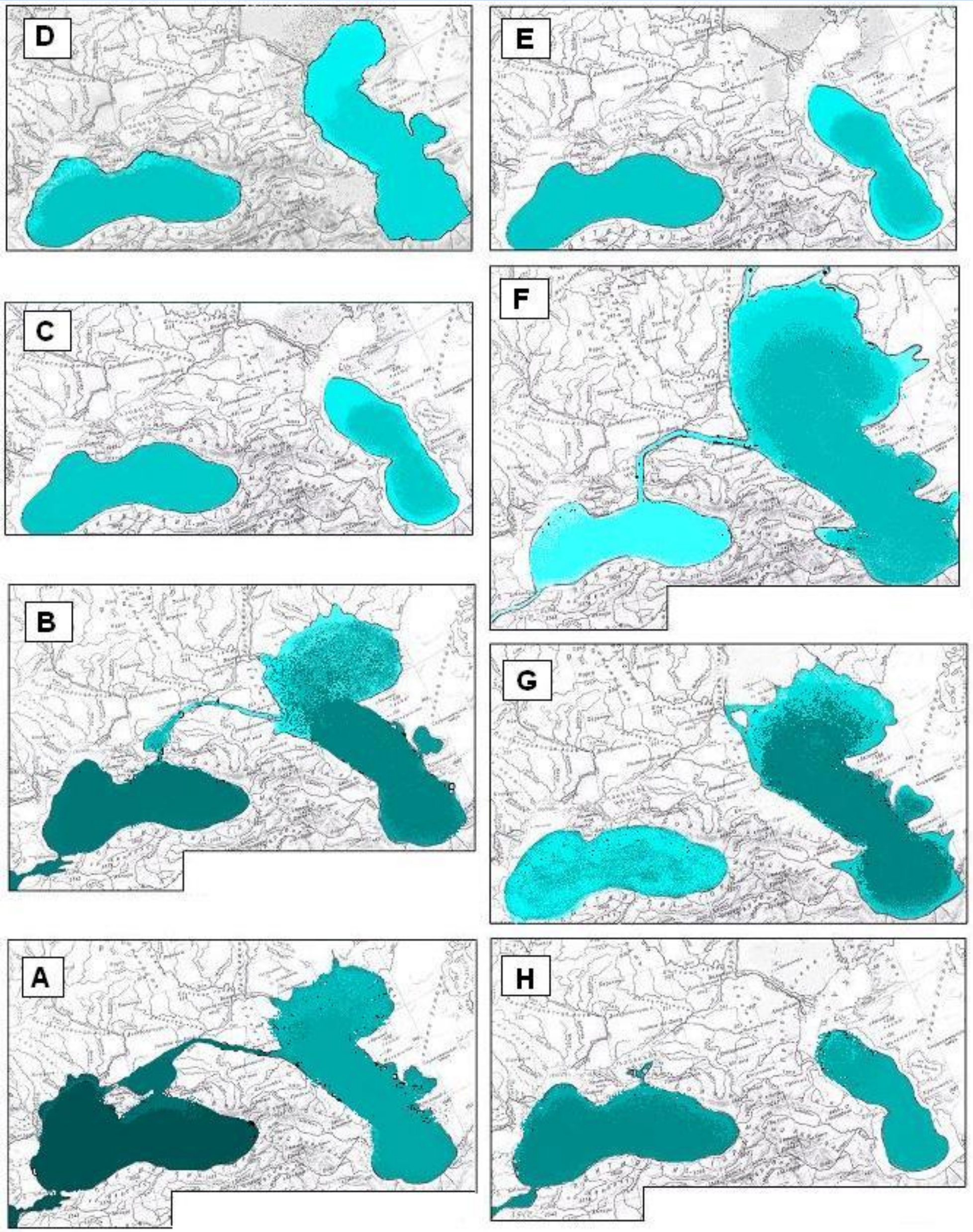


18 000-12 500 years - «pluvial epoch» in the Russian Plain (Panin, 2015)

Holocene . Mangyshlak regression.



Global climate change and evolution of the Caspian basins



A – Eemian (Miculino) epoch (MIS 5): the Late Khazarian transgression in the Caspian (isolated basin) and the Karangatian transgression in the Pont (with ingression in the Manych valley).

B – Transitional epoch from interglacial (MIS 5) to Early Valdai glacial (MIS 4) epochs: the Hyircanian transgression in the Caspian and beginning of the Karangatian regression; Hyircanian passage.

C – Early Valdai glacial stage maximum (MIS 4) and beginning of warming (MIS 3): Atelian regression in the Caspian Sea and Post-Karangatian regression in the Pont.

D – Interstadial warming (MIS 3) (second part), glacial degradation: first stage of the Early Khvalynian transgression in the Caspian and Surozh basin in the Pont.

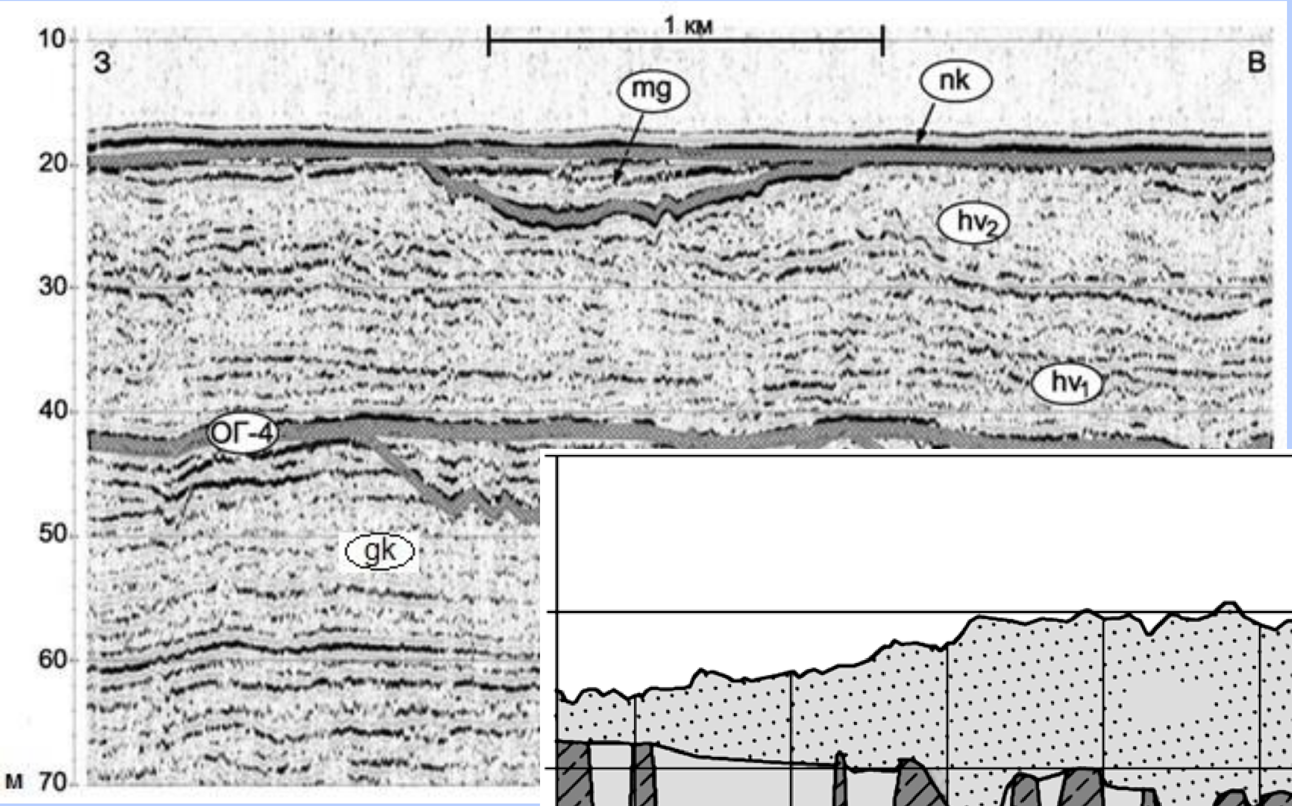
E – Late Valdai, LGM (MIS 2): Elton (?) regression in the Early Khvalynian basin and the Neoeuxinian regression in the Pont.

F – Glacial degradation (MIS 2): the Early Khvalynian transgression in the Caspian and the Neoeuxinian transgression in the Pont.

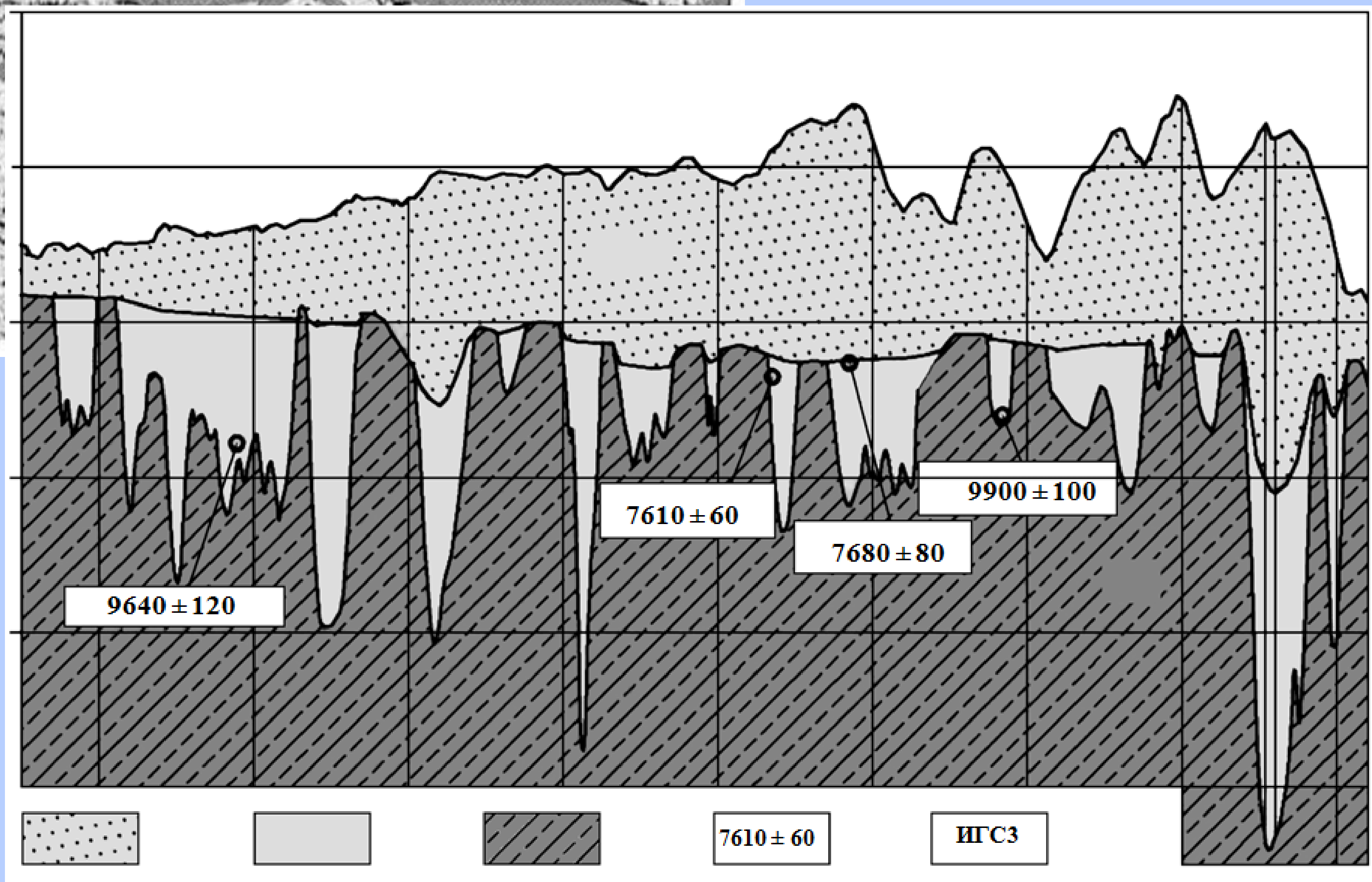
G – Glacial degradation (MIS 2) – beginning of post-glacial epoch: the Late Khvalynian transgression in the Caspian Sea and the Neoeuxinian transgression in the Pont.

H – Holocene, beginning of the Interglacial (MIS 1): the Mangyshlak regression in the Caspian and beginning of the Black Sea transgression.

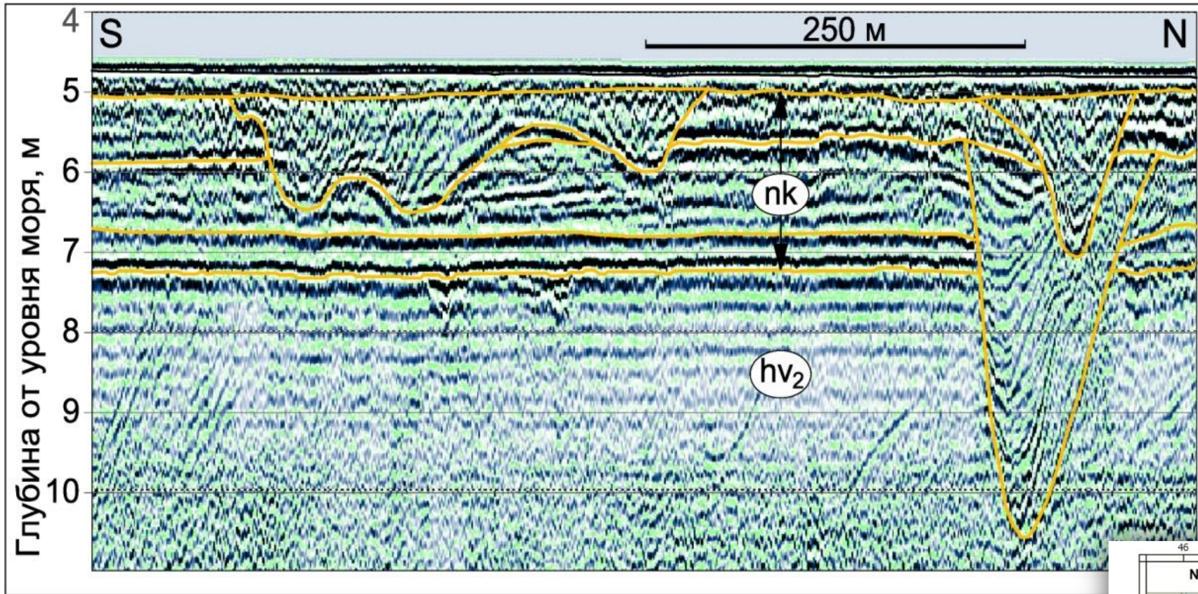
MIS 1. Holocene. Mangyshlak regression



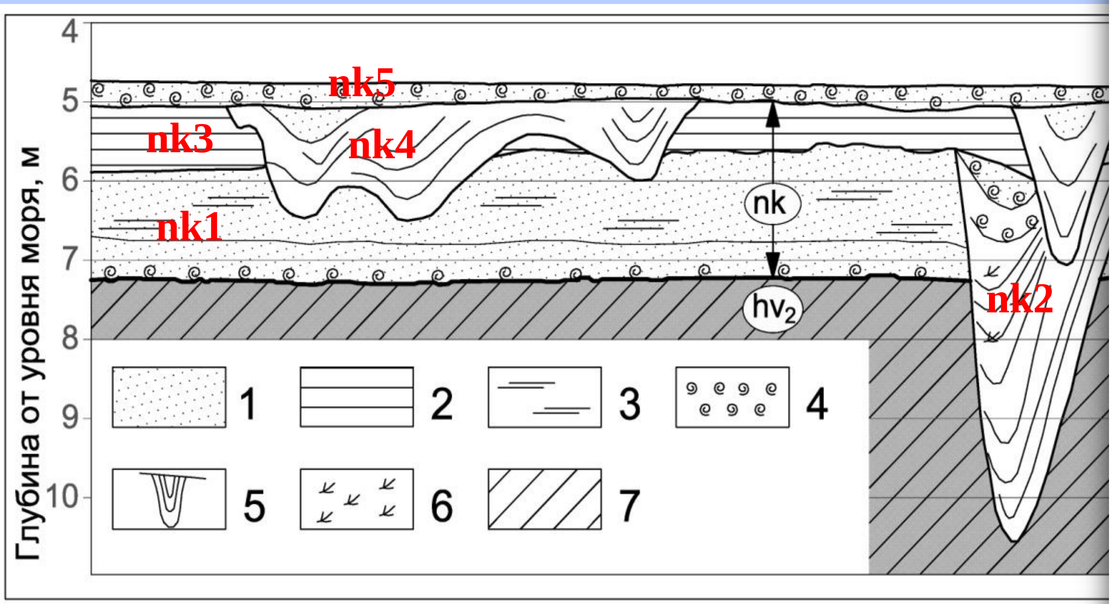
The Mangyshlak regression is dated to the Holocene and was essentially a response of the Caspian Sea to the increase in the climate continentality during the Boreal period.

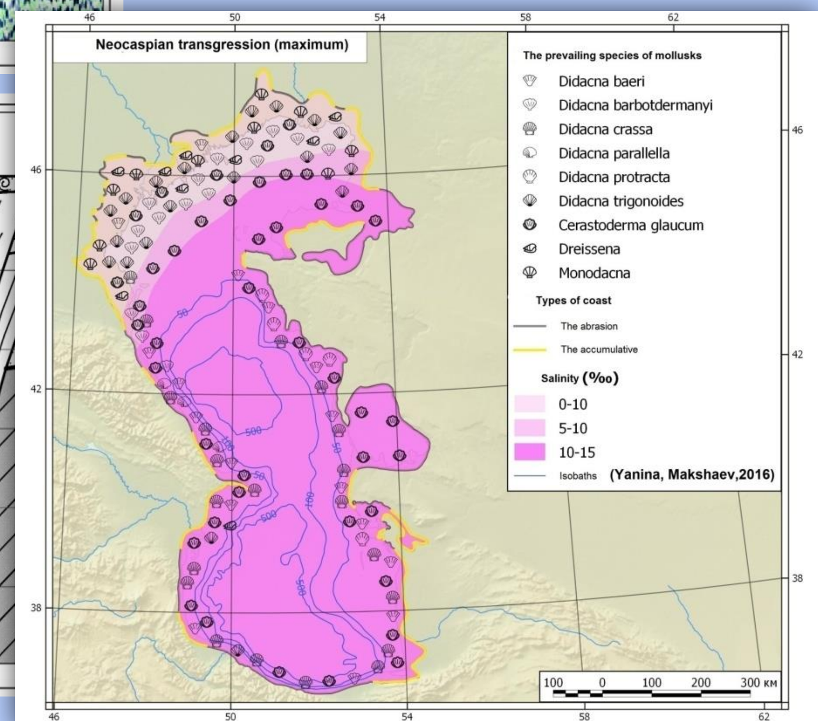


New Caspian (Novocaspian) transgression



New Caspian series consists of three layers with horizontal or sub-horizontal bedding (nk1, nk3, nk5).
The stratigraphical gaps between the layers are well identifiable erosional landforms (gullies, ravines, etc.) and paleo-depressions (nk2 and nk4) filled with sediments.
The depth of the gullies is up to 10-14 m, their thalwegs being at a depth of 40-42 m below sea level.





Fauna and radiocarbon dating of the New Caspian deposits

		index			
MSU-1567	Shells	nk5	*Cerastoderma glaucum, Didacna barbotdemarnyi, D. parallella*	Modern	
MSU-1572	Shells	nk5	*Cerastoderma glaucum, Didacna barbotdemarnyi*	860±40	357-499
LU-8160	Shells	nk5	*Cerastoderma glaucum*	1180±70	788-946
LU-6878	Shells	nk5	*Cerastoderma glaucum*	1240±70	885-1013
MSU-1511	Shells	nk5	*Cerastoderma glaucum*	1330±60	948-1099
AMS-172873	Shells	nk5	*Cerastoderma glaucum*	1435±30	1304-1346
MSU-1560	Shells	nk5	*Monodacna caspia,Didacna barbotdemarnyi, D. parallella*	1690±40	1304-1416
MSU-1656	Shells	nk5	*Monodacna caspia, D. parallella, Didacna barbotdemarnyi*	2050±60	1544-1691
SPb-2007	Shells	nk4	*Viviparus viviparus*	2254±50	2341-2301
IG-5096	OM	nk4	-	2620±60	2709-2799
MSU-1638	Shells	nk4	*Dreissena polymorpha, Monodacna caspia*	2750±60	2286-2552
MSU-1662	OM	nk4	-	2830±70	2753-3214
IG-5098	OM	nk4	-	2860±60	2919-3064
MSU-1571	Shells	nk4	*Monodacna caspia, Dreissena polymorpha*	2895±60	2952-3080
UBA-35034	Shells	nk3	*Cerastoderma glaucum*	2182±23	2159-2291
MSU-1566	Shells	nk3	*Monodacna caspia, Adacna laeviuscula*	3200±50	3370-3464
SPb-2005	Shells	nk3	*Cerastoderma glaucum, Didacna barbotdemarnyi, D. longipes*	3324±50	3611-3544
LU-6130	OM	nk2	-	3520±50	3720-3804
MSU-1635	Shells	nk2	*Monodacna caspia, Dreissena polymorpha*	4050±60	3867-4124
MSU-1644	Shells	nk2	*Monodacna caspia, Dreissena polymorpha*	4305±80	4199-4498
MSU-1661	OM	nk2	-	3980±200	4222-4652
MSU-1570	Shells	nk2	*Monodacna caspia, Dreissena polymorpha*	4130±70	4569-4714
MSU-1637	Shells	nk2	*Monodacna caspia, Dreissena polymorpha*	4500±100	4474-4787
MSU-1619	OM	nk2	-	4610±70	4595-4853
IG-5097	OM	nk2	-	4170±70	4615-4766
MSU-1512	Shells	nk2	*Monodacna caspia, Dreissena polymorpha*	4780±50	4830-5069
SPb-2012	Shells	nk2	*Monodacna caspia, Dreissena polymorpha*	4912±70	5718-5590
MSU-1617	OM	nk2	-	6350±100	6604-6902
MSU-1614	Shells	nk1	*Dreissena polymorpha, Monodacna caspia, Didacna barbotdemarnyi, D. baeri*	5225±110	5382-5645
LU-6920	Shells	nk1	*Dreissena polymorpha, Monodacna caspia, Didacna barbotdemarnyi*	5700±430	5841-6739
MSU-1563	Shells	nk1	*Monodacna caspia, Didacna barbotdemarnyi*	5750±80	5972-6208
MSU-1643	Shells	nk1	*Monodacna caspia, Didacna barbotdemarnyi, D. baeri*	6410±100	6663-6961
MSU-1509	Shells	nk1	*Monodacna caspia, Didacna barbotdemarnyi*	6610±60	6944-7165

nk5 last 1500 years.

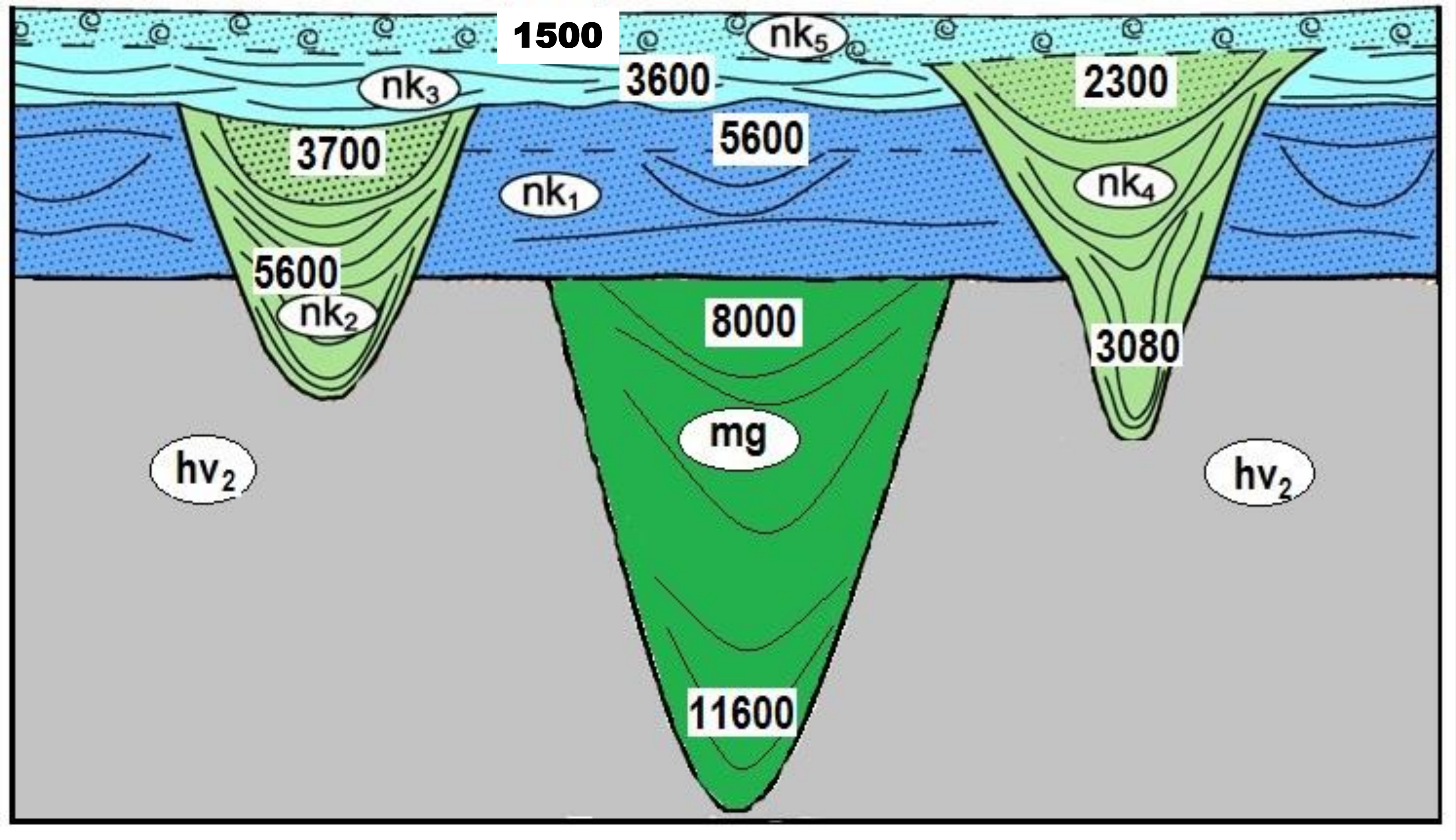
nk4 from 3000 to 200 ^{14}C yr BP.

nk3 from 3400 to 3200 ^{14}C yr BP.

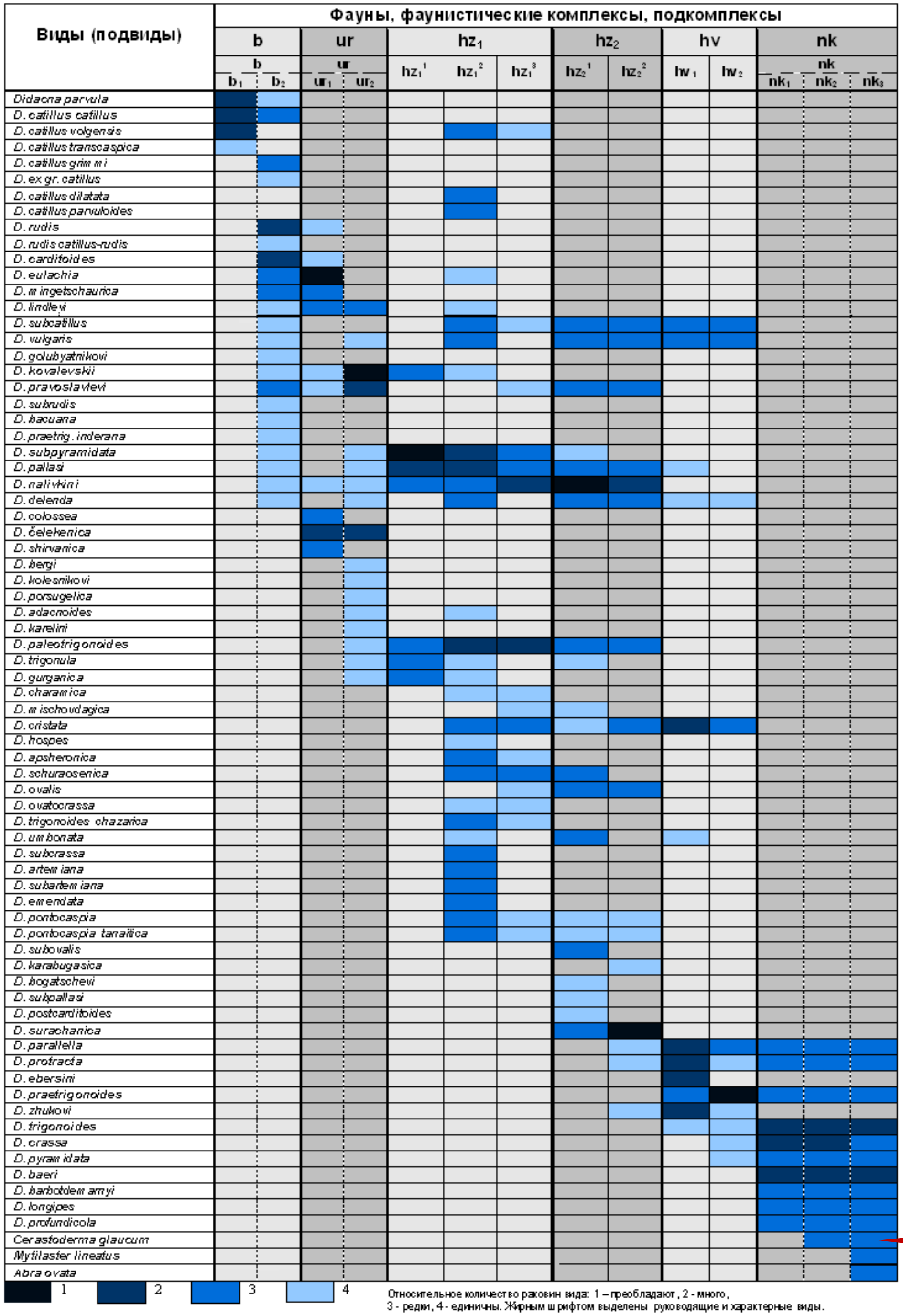
nk2 from 4900 to 3400 ^{14}C yr BP.

nk1 from 7100 to 5300 yr BP.

Development of the Caspian Sea during the Holocene



Фауны, фаунистические комплексы и подкомплексы плейстоцена Каспия



Only in the Holocene New Caspian basin is the broad movement of the marine species *Cerastoderma glaucum* noted. It is the characteristic feature of faunistic structure distinguishing this basin from all Neopleistocene basins of the Caspian Sea.

Domination of Cerastoderma glaucum in the New Caspian deposits

Область побережья / Виды моллюсков	Юго-западная	Апшеронский п-ов	Западная: Азербайджан	Западная: Дагестан	Северо-западная	Северная	Восточная	Юго-восточная	Иран
D. crassa	2	2	2	3	4		2	3	1
D. baeri	2	2	2	2	4	4	2	3	
D. barbotdemarnyi	3		3	3					
D. longipes	3		3	3					
D. trigonoides	4	3	2	2	2	2		3	4
D. pyramidata	3	4	3	4					3
D. praetrigonoides	4	3	4	3					4
D. parallella		3	4	3					
D. protracta							4		
D. profundicola		4	4	4					
Monodacna caspia	3	3	3	3	2	2			4
Adacna vitrea	3	3	3	3	2	2			4
A. laeviuscula	3	3	3	3	2	3			4
Hypanis plicatus	3	3	3	3	2	3			
Cerastoderma glaucum	1	1	1	1	3	4	1	1	1
Dreissena polymorpha	3	3	3	3	2	2	4	4	4
Dr. rostriformis	3	3	3	3			3	3	
Dr. caspia	3	3	3	3	3	3			

1 2 3 4

Modern Caspian Sea

Now in bottom biocenoses of the Caspian Sea, *Abra ovata*, *Mytilaster lineatus*, and *Cerastoderma glaucum* often dominate. All of them have a Mediterranean origin. Obviously, as a result of evolutionary development from a small number of sibling species, the Caspian autochthonus fauna began to possess universal qualities but weak species specialization. It provided stability and relative resistance for communities to changing environmental factors, but it made them noncompetitive to installed marine species. Invasive species and acclimatized species made much more essential changes to the biodiversity than was caused by natural factors.

Natural ecosystems have undergone an anthropogenic transformation.

In historical time, not only has a rapid change in biodiversity been observed, but also an irreversible change in water ecosystems.

Now, the role of anthropogenic factors has become the most important in the distribution of molluscan species in the basin.

The modern development of the Caspian Sea malacofauna has led to the seeming increase in molluscan biodiversity due to the emergence of new taxa.

But, in fact, we currently observe a loss of biodiversity at the global level, which is turning unique ecosystems of the Caspian Sea into something similar to that of the Azov-Black Sea.


Thank you!