New data on the Aral Sea level changes in the Holocene and Pre-Holocene times

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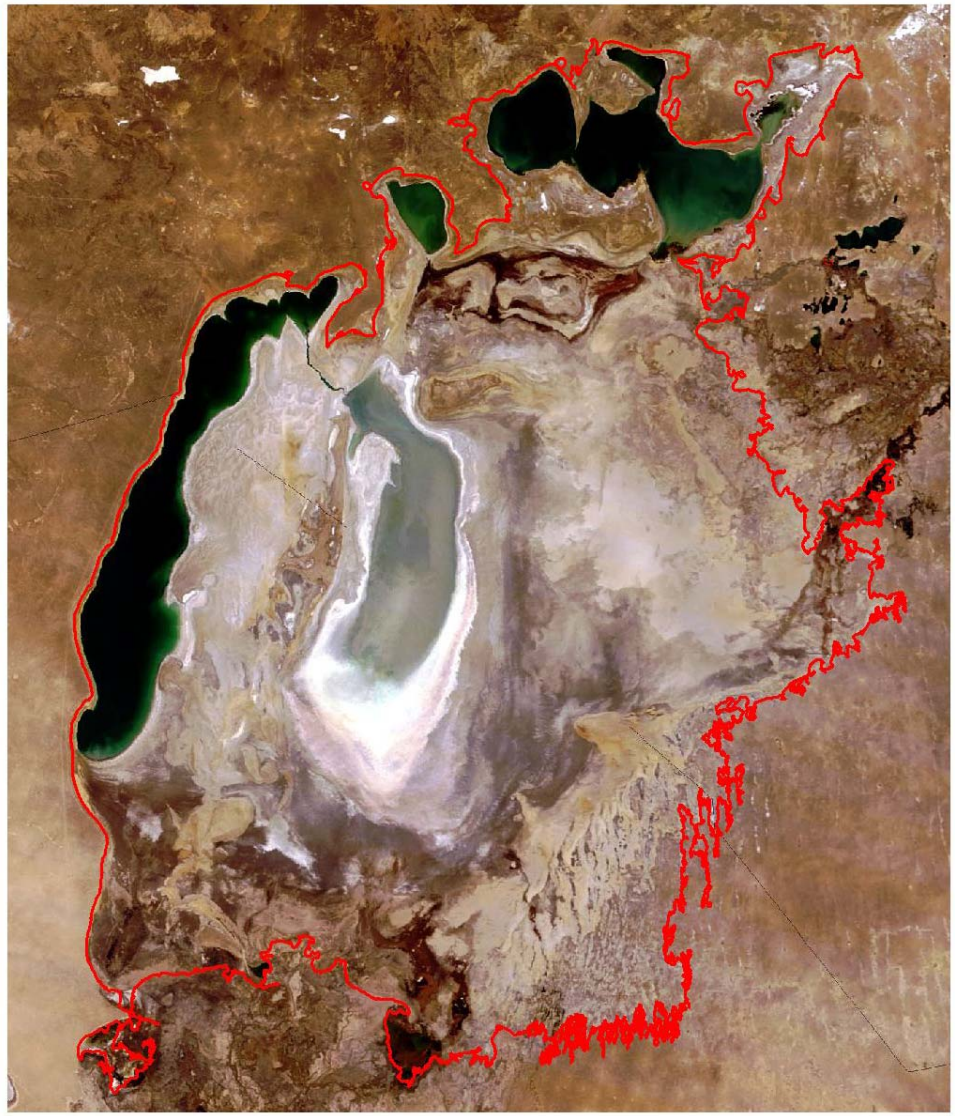
Preliminary results of international research project:
ENVIRONMENTAL HISTORY OF THE ARAL SEA FOR THE LAST 10,000 YEARS:

NATURAL AND ANTHROPOGENIC COMPONENTS

Civilian Research and Development Foundation RUG1-2921-NO-07
Russian Foundation for Basic Research 08-05-91105

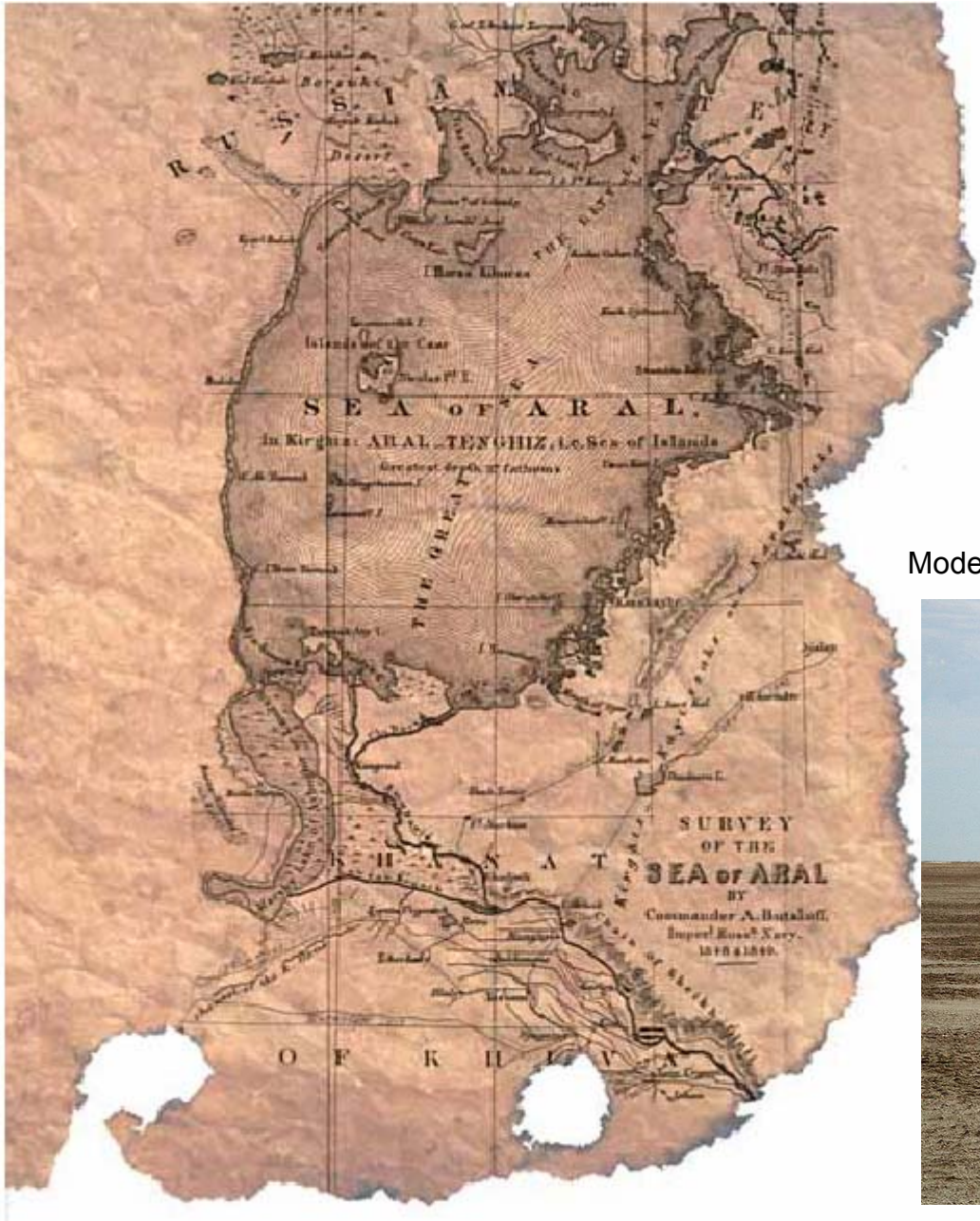
Landsat Geocover circa 1990



MODIS October 2008

Red – shoreline of 1960th +53 m a.s.l.

The catastrophic drop of the Aral since 1970th



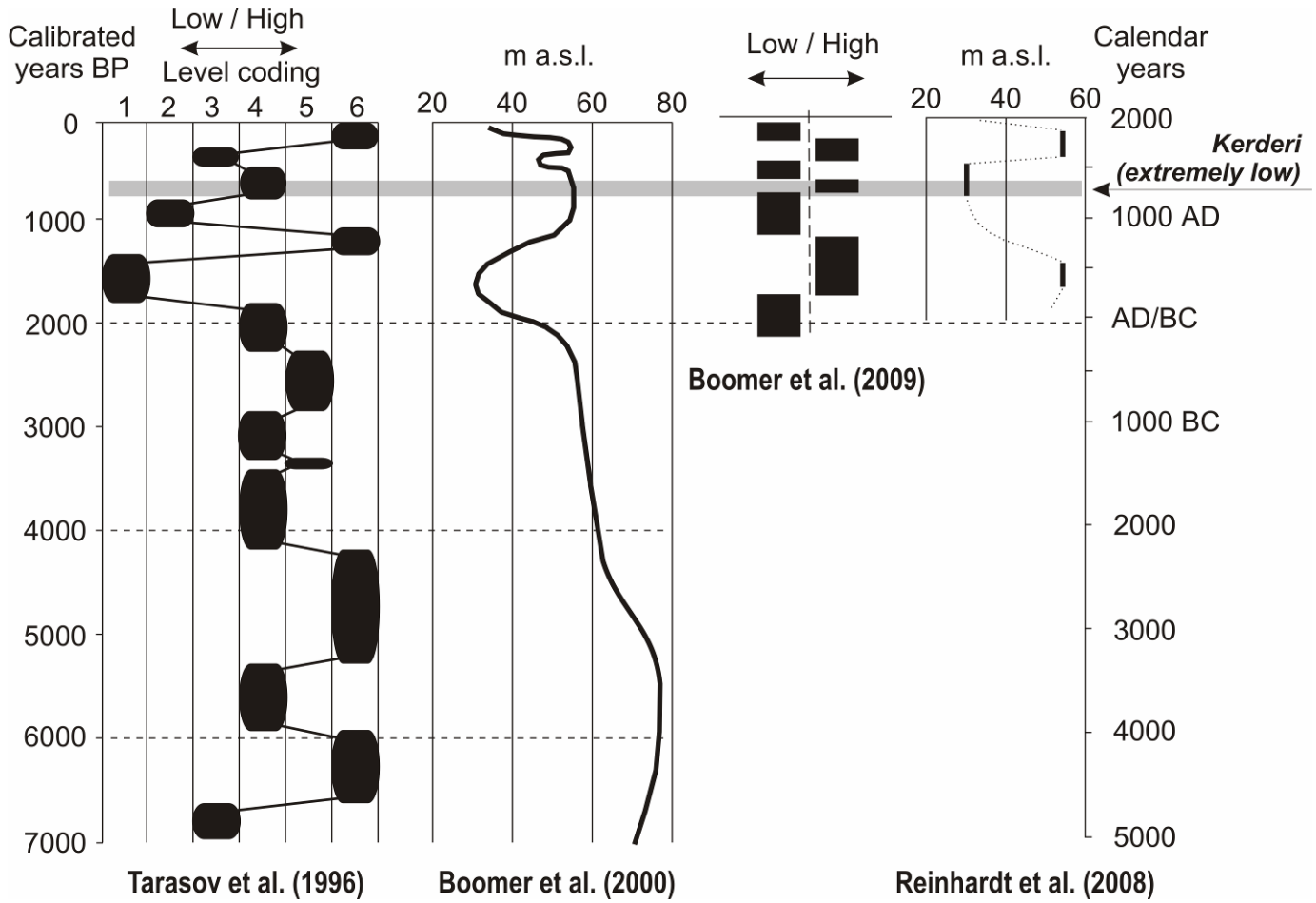
Though the Aral Sea was mentioned by the Antique authors and shown on the maps by Arabian annalists since X century AD, its first instrumental survey was conducted only in 1848-49 by Russian expedition of Commander A.I. Butakov.

1221 – destroy of the irrigation systems, turn of Amudarya to Caspian
1417 – Aral Sea disappeared (Khafizi-Abru)
1573 - Turn of Amudarya back to Aral (Abulgazi)
1627 – Blue Sea of the "Big Draft Book"

Modern man-made drop of the lake resembles ancient natural ones

Reprint of the Butakov's map in the article "*Survey of the Sea of Aral by Commander A. Butakoff, Imperial Russian Navy, 1848 and 1849*" published in the Journal of the Royal Geographical Society, *Vol. 23, 1853*

Comparison of the data obtained by predecessors



In general, we see matching of the presented curves.
Inconsistencies probably result from:
-Problems of radiocarbon dating by different methods
-Sample quality
-Calibration without correction of the reservoir effect

ENVIRONMENTAL HISTORY OF THE ARAL SEA FOR THE LAST 10,000 YEARS:
NATURAL AND ANTHROPOGENIC COMPONENTS

Aim of the Project:

to reconstruct the Holocene history of the Aral Sea using geochronological, sedimentological, paleontological, and geoarchaeological methods, with special attention to changes of its level and evolution of the river network.

Tasks:

1) collection of material for radiocarbon dating (mollusk shells; plant remains) from the lacustrine and alluvial sediments in the outcrops and boreholes of the Aral Sea basin;

2) AMS radiocarbon dating of the collected samples;

3) establishment of reservoir age correction value for the Aral Sea water;

4) determination of the genesis of sediments, and understanding their relationship to the regressive and transgressive phases of Aral Sea;

5) integration of results obtained into a reliable paleogeographic model of the Aral Sea region, and their combination with archaeological data.

Y.V. Kuzmin, L.A. Nevesskaya, S.K. Krivonogov, G.S. Burr. 2007. Apparent 14C ages of the 'pre-bomb' shells and correction values (R,ΔR) for Caspian and Aral Seas (Central Asia). Nuclear Instruments and Methods in Physics Research B, 259, 463–466.

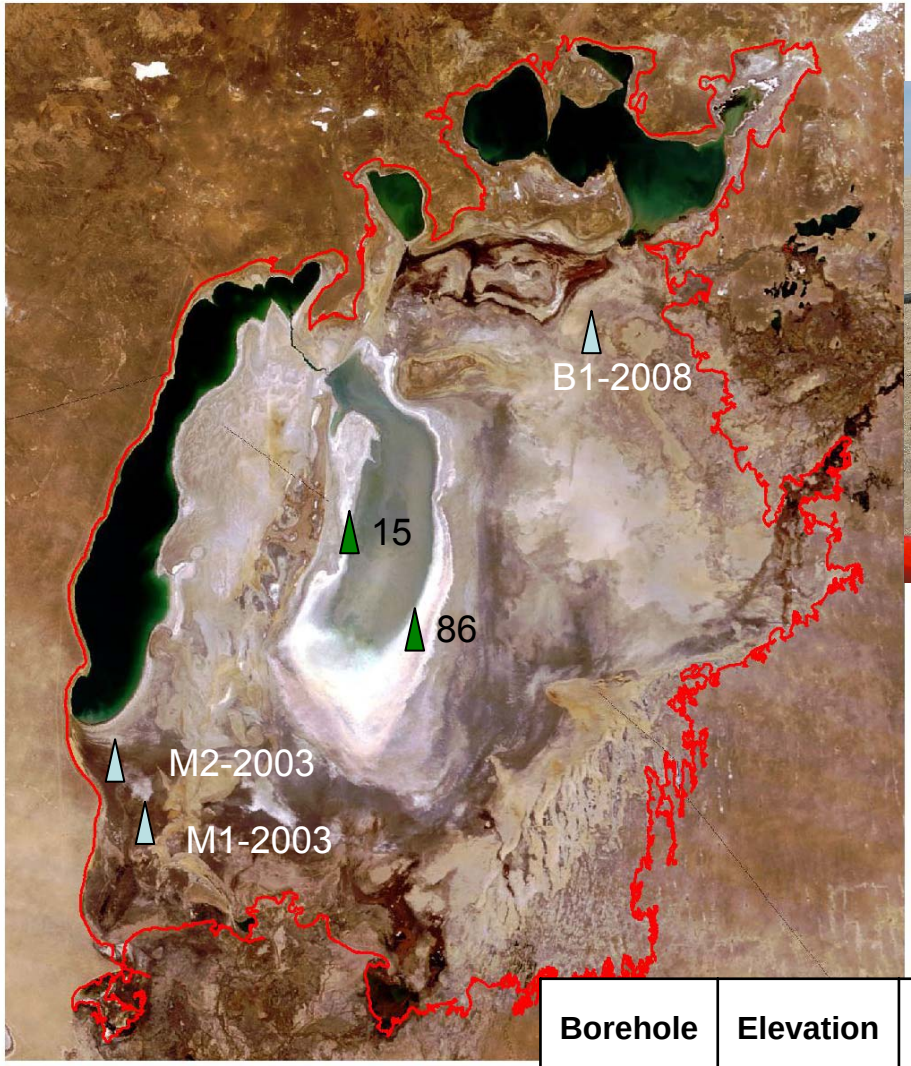
Water body reservoir effect

Site	^{14}C age	Lab code, AA-	Material	Year and collector
Aral Sea, **south**, near Muynak village	**271 ± 49**	65490	Shell *Cerastoderma* sp.	1937, N.A. Alekseev
Aral Sea, unknown place	**433 ± 48**	65491	Shell *Cerastoderma* sp.	1944 N.A. Alekseev
Aral Sea, **east**, Kuzhetpes island	**276 ± 48**	65492	Shell *Cerastoderma* sp.	1936, N.A. Alekseev

Site	^{14}C age	Lab code, AA-	Material	Year and collector
Aral Sea, unknown place	**100 ± 40**	61736	Near-water plant *Butomus umbellatus* L.	1900, L.S. Berg
Aral Sea, **east**, Kosaral island	**190 ± 40**	61735	Water and near-water plant *Saggitaria trifolia* f. *typica*	1898
Aral Sea, **east**, Kosaral island	**330 ± 40**	61737	Water plant *Potamogeton perfoliatus* L.	1921
Aral Sea, **north-east**, near Aralskoe more railway station	**600 ± 40**	61738	Water plant *Potamogeton perfoliatus* L.	1925 L.S. Berg
Aral Sea, **south**, near Muynak village	**1070±40**	61739	Water plant *Potamogeton lucens* L.	1925 L.S. Berg

Preceding studies of our team

Average R for region: 168 ± 53
Average ΔR (yr): **-128 ± 53**

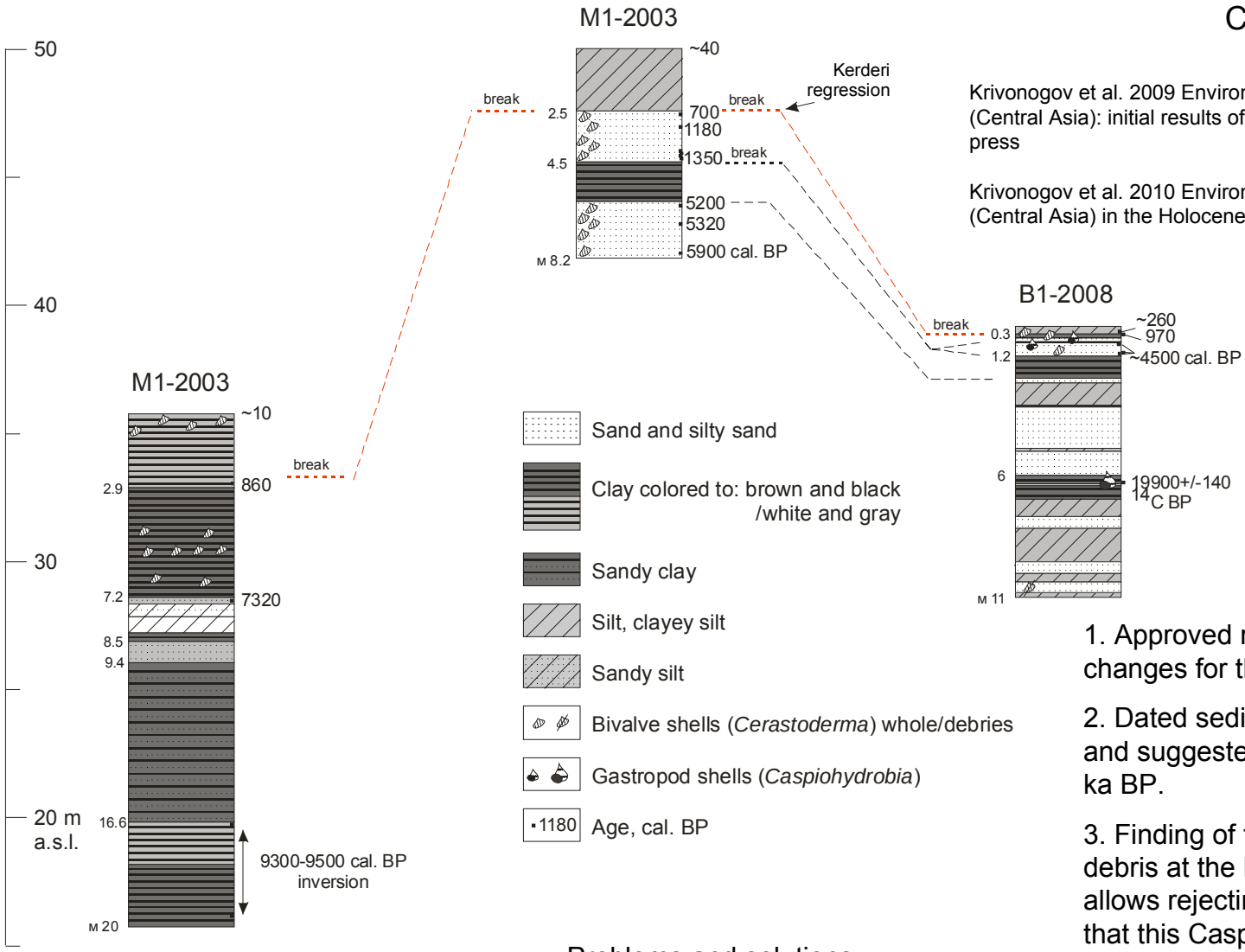


Preliminarily obtained data for the Project

Livingston-type corer and vibrotechnique allowing easy penetration into the soft lake silts

Borehole	Elevation	Core length	Suggesting age at the bottom, yrs BP	Contributors
15	27	3.7	12,000	Maev et al., 1983, 1991
86	30	4.08	6000	
M1-2003	**50**	**8.2**	**6000**	**S.K. Krivonogov, INTAS-Aral Sea Project**
M2-2003	**36**	**20**	**9000**	
B1-2008	**39**	**11**	**40,000**	**S.K. Krivonogov, current Project**

Correlation of cores



Krivonogov et al. 2009 Environmental changes in the Aral Sea region (Central Asia): initial results of radiocarbon-based study. NIMS B, in press

Krivonogov et al. 2010 Environmental changes of the Aral Sea region (Central Asia) in the Holocene: major trends. Radiocarbon, in press

Achievements

1. Approved record of the lake level changes for the last 6 ka BP.
2. Dated sediment sequence to 20 ka BP and suggested age of B1-2008 is 30 to 40 ka BP.
3. Finding of the *Cerastoderma* shell debris at the bottom of the B1-2008 core allows rejecting the previous point of view that this Caspian Sea mollusk appeared in the Aral only at about 5.5. ka BP.

Problems and solutions

1. Stratigraphic breaks, representing regressions, take a valuable part of the sediment sequences.
2. Direct correlation of the sediments across the lake meets problems because of frequent facies changes.
3. We can't correlate just by count of layers.

Thus, radiocarbon dating is the best, unless the only, tool to reconstruct Lake Aral level changes.

Evidences of high levels at the periphery of the lake

Karaumbet Basin

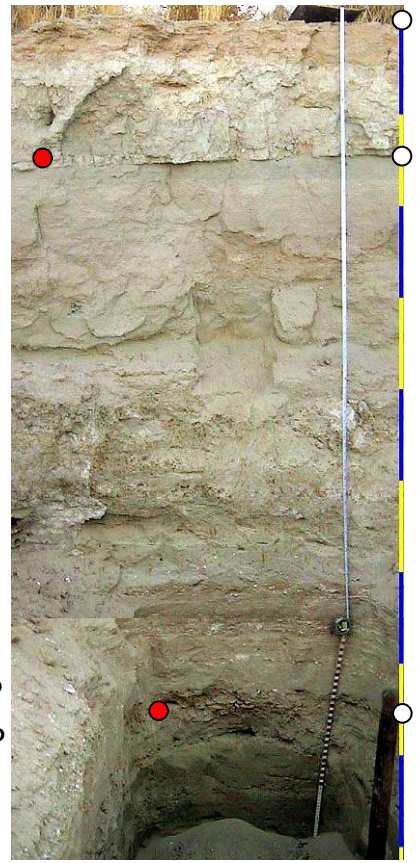
Reinhardt Ch., Wunnemann B., Krivonogov S.K., 2008. Geomorphological evidence for the Late Holocene evolution and the Holocene lake level maximum of the Aral Sea. Geomorphology, 93, 302-315

And * - this study

0-150 cal. BP

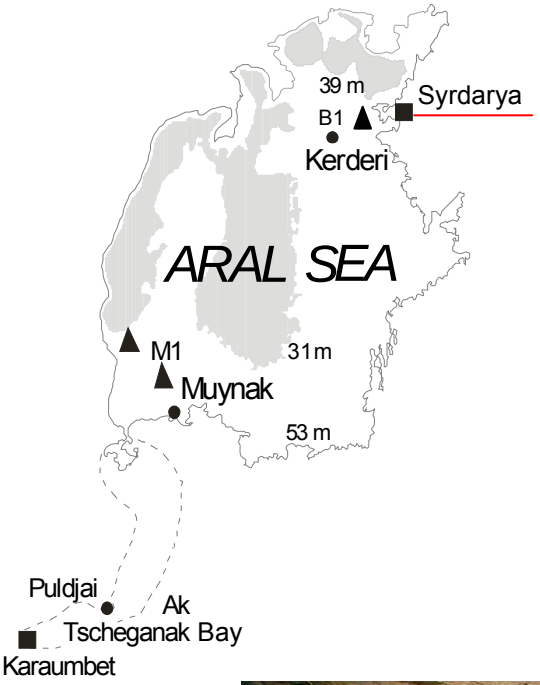
*~1400 cal. BP

~1480 cal. BP

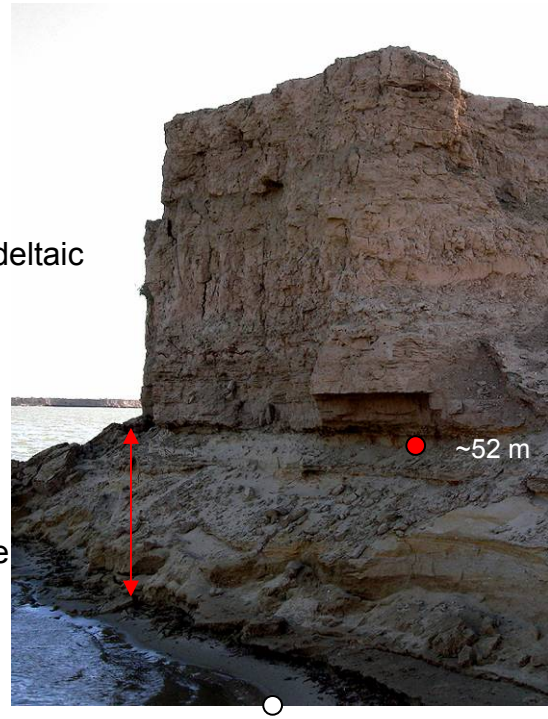


Evidences of high levels at the periphery of the lake

Lacustrine sediments overlapped by the Syrdarya delta

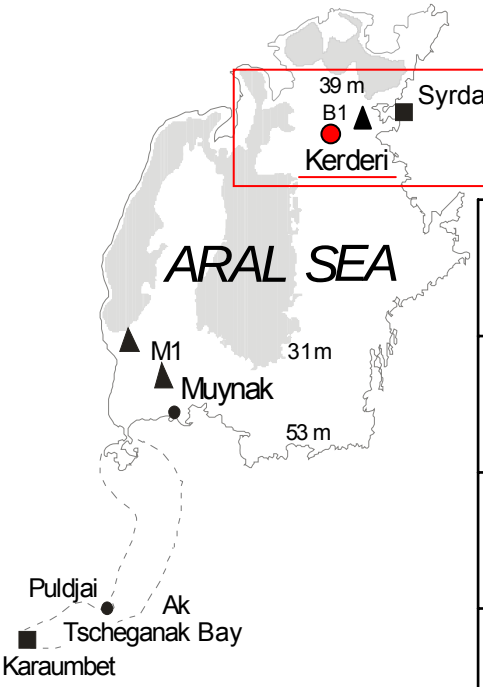


Aklak Reservoir



ca. 1180 cal. BP

Evidences of low levels of the lake



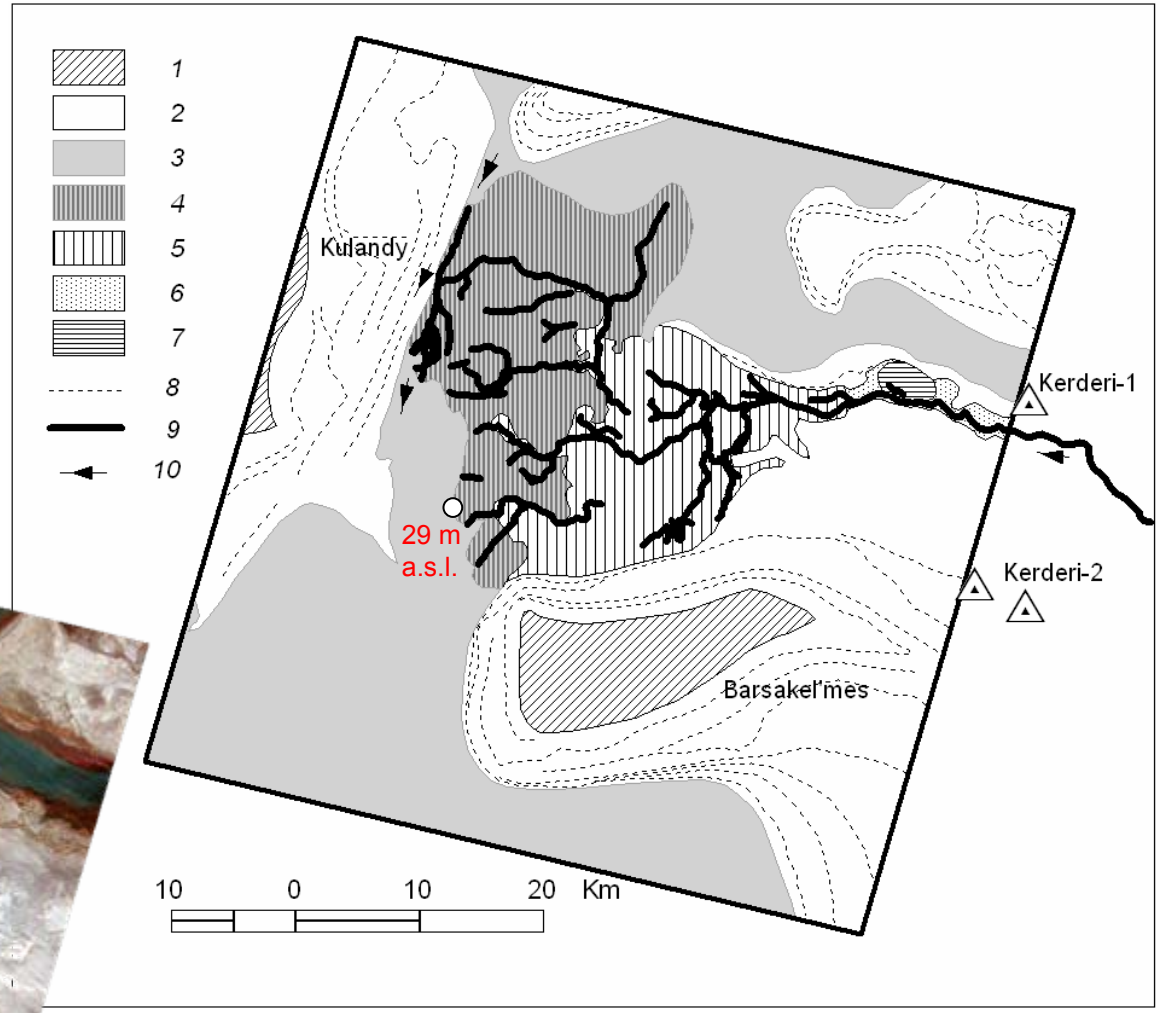
Kerderi settlements

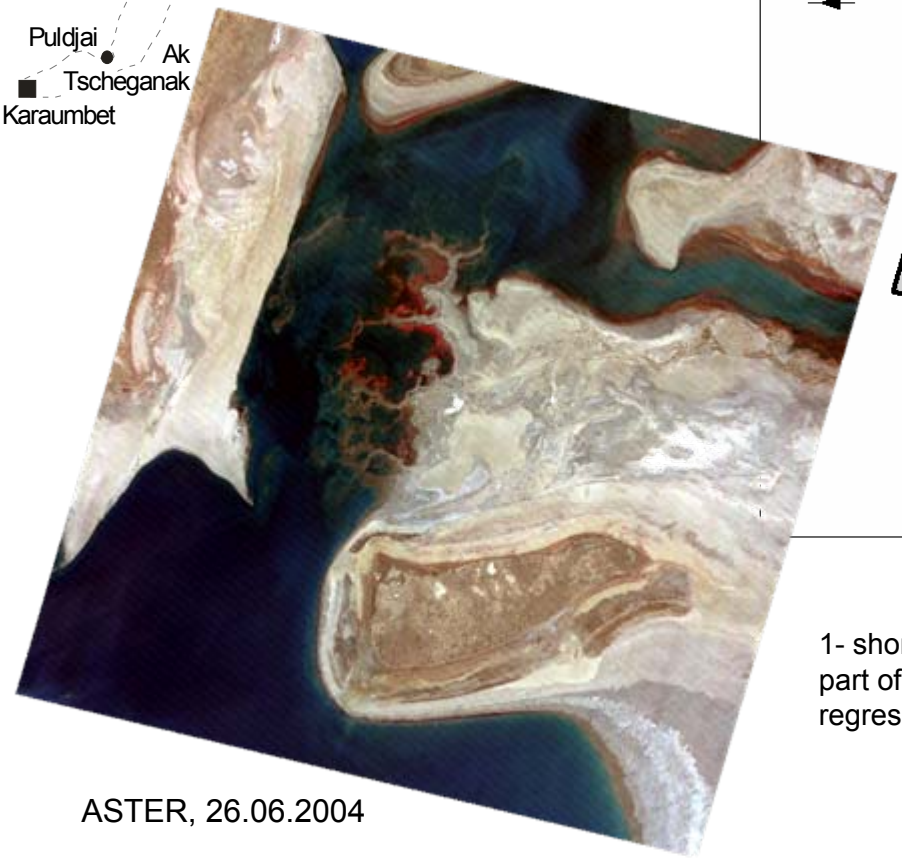
Site	Material	14C age	Lab No. SOAN	Age cal. AD	Age cal. BP
Mausoleum Kerderi II	Thin wood stick	**600±65**	7688	1280-1430	520-670
Mausoleum Kerderi II	Thick wood desk	**820±55**	7687	1150-1280	670-800
Settlement Kerderi II	Bones of domestic animals	**910±80**	7686	990-1250	690-950

Woods, extracted from a grave of the mausoleum Kerderi II

Medieval delta of Syrdarya

Evidences of low levels of the lake

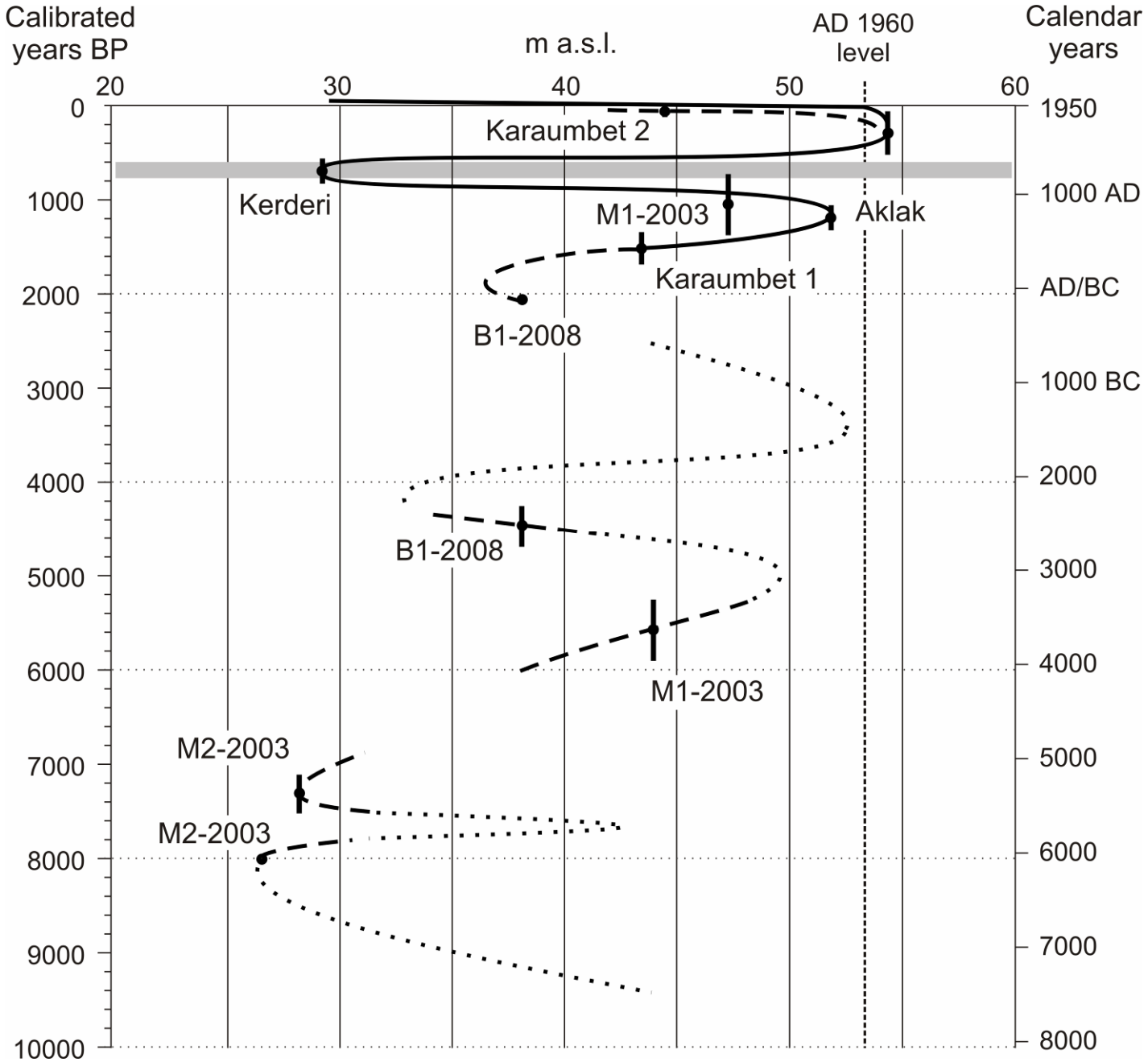




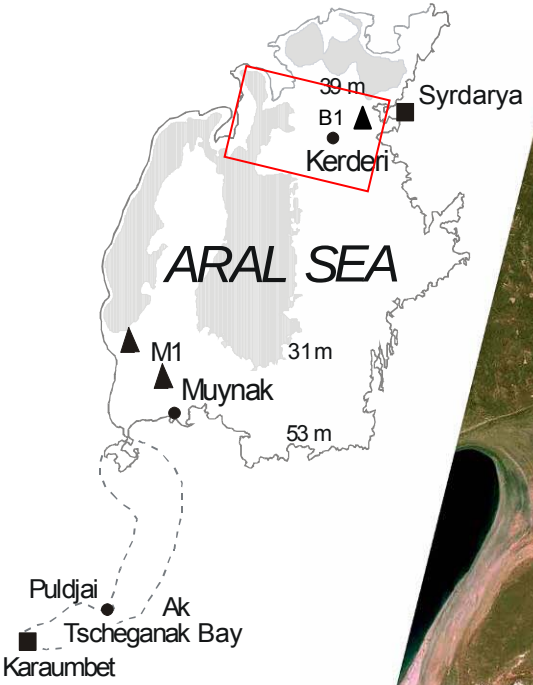
ASTER, 26.06.2004

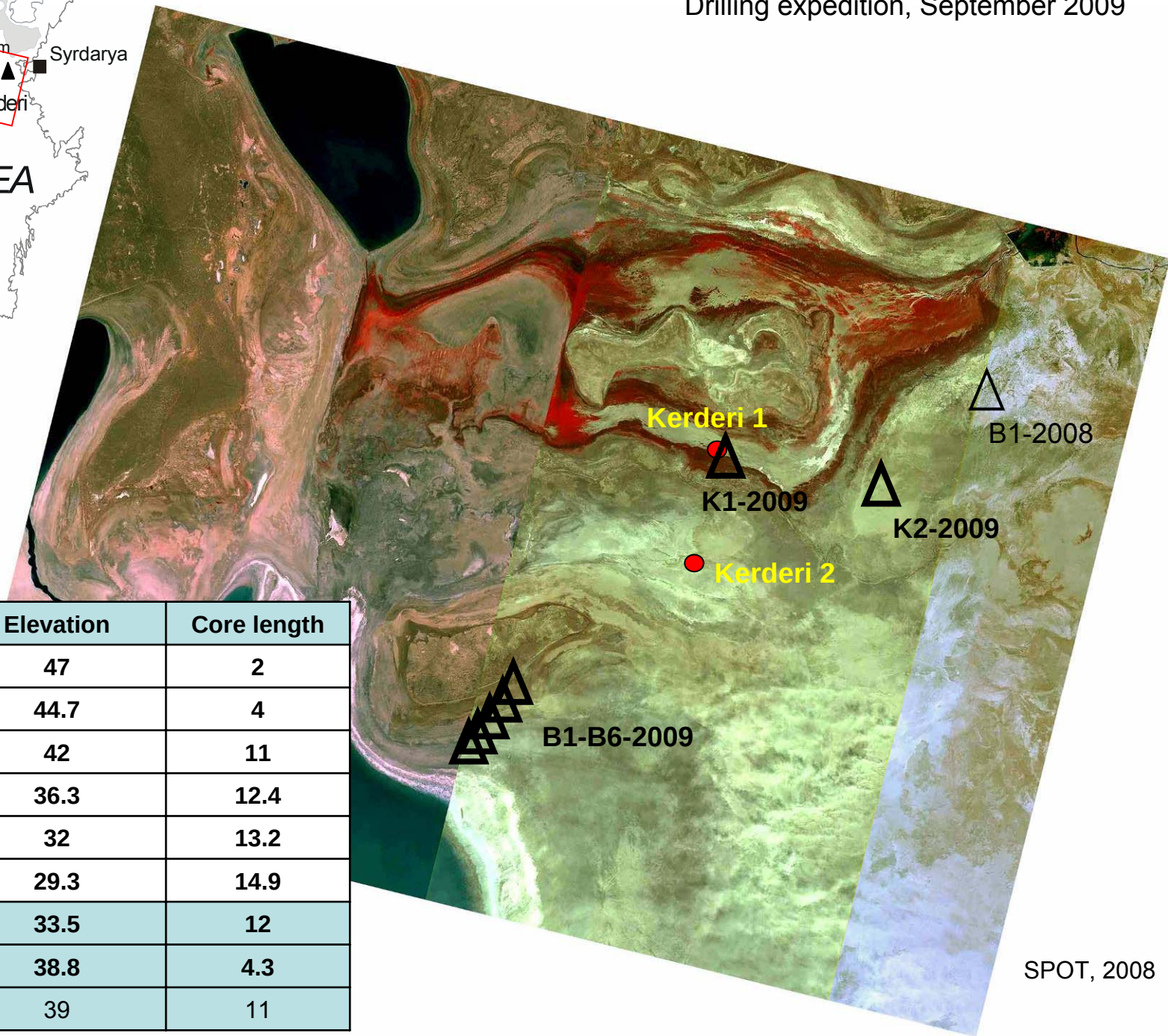
Interpretation of the ASTER image:

1- shore, 2- dry bottom, 3- water, 4- submerged part of Medieval delta, 5- dried part of Medieval delta, 6- floodplain, 7- small lake (?), 8- shorelines of modern regression, 9- channels, 10- directions of water flows.


Calibrated years BP
m a.s.l.
AD 1960 level
Calendar years
20
30
40
50
60
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
1950
1000 AD
AD/BC
1000 BC
2000
3000
4000
5000
6000
7000
8000
Karaumbet 2
Kerderi
M1-2003
Aklak
Karaumbet 1
B1-2008
B1-2008
M1-2003
M2-2003
M2-2003

Drilling expedition, September 2009



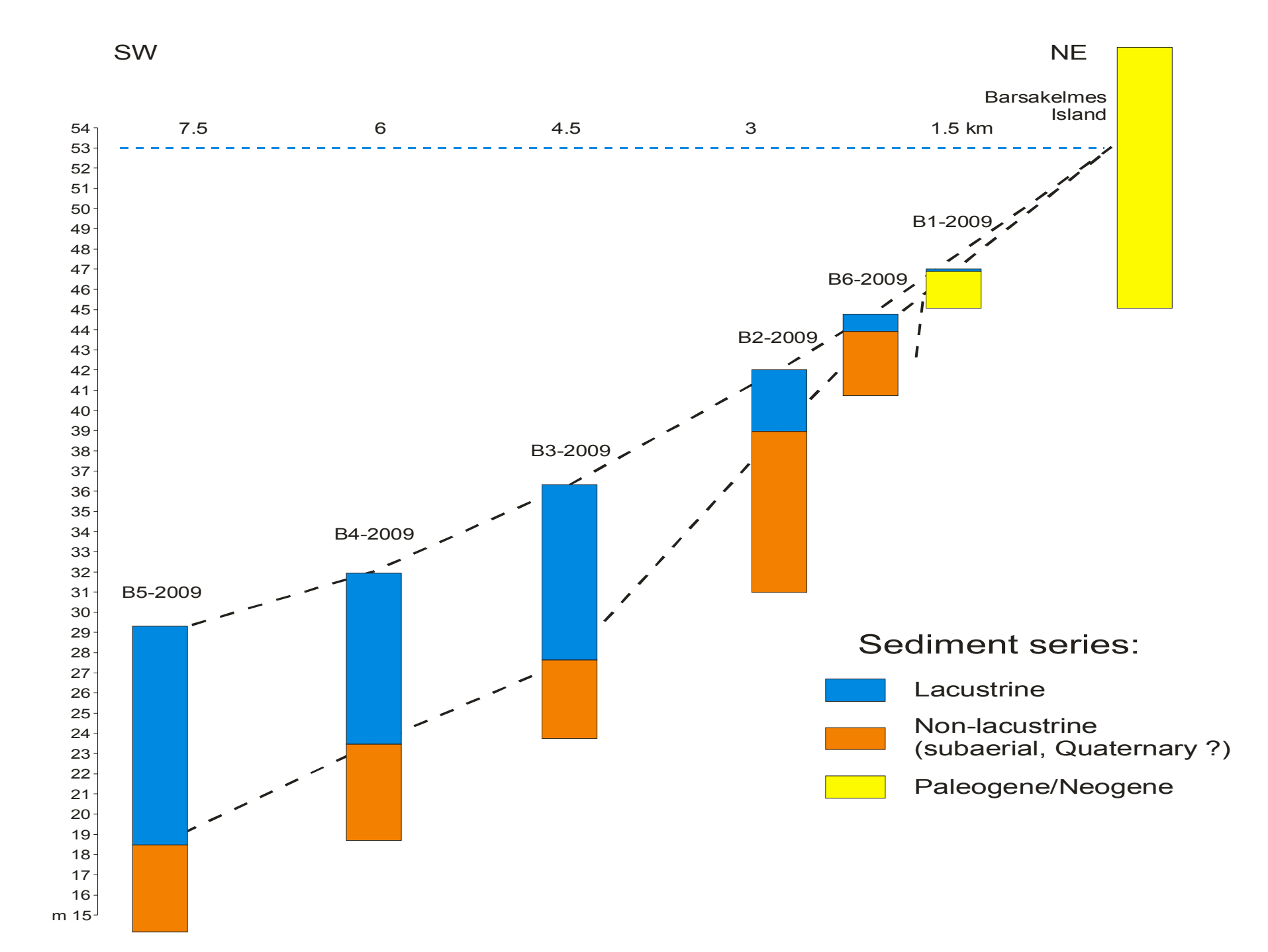


Borehole	Elevation	Core length
B1-2009	47	2
B6-2009	44.7	4
B2-2009	42	11
B3-2009	36.3	12.4
B4-2009	32	13.2
B5-2009	29.3	14.9
K1-2009	33.5	12
K2-2009	38.8	4.3
B1-2008	39	11

SPOT, 2008


C 081 AP


SWITZERLAND


SW
NE
Barsakelmes Island
7.5
6
4.5
3
1.5 km
54
53
52
51
50
49
48
47
46
45
44
43
42
41
40
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24
23
22
21
20
19
18
17
16
m 15
B1-2009
B6-2009
B2-2009
B3-2009
B4-2009
B5-2009
Sediment series:
Lacustrine
Non-lacustrine (subaerial, Quaternary ?)
Paleogene/Neogene

Thank you and welcome to cooperate