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

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The catastrophic drop of the Aral since 1970th

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

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.
### Water body reservoir effect

<table>
<thead>
<tr>
<th>Site</th>
<th>$^{14}$C age</th>
<th>Lab code, AA-</th>
<th>Material</th>
<th>Year and collector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aral Sea, <strong>south</strong>, near Muynak village</td>
<td>$271 \pm 49$</td>
<td>65490</td>
<td>Shell <em>Cerastoderma</em> sp.</td>
<td>1937, N.A. Alekseev</td>
</tr>
<tr>
<td>Aral Sea, unknown place</td>
<td>$433 \pm 48$</td>
<td>65491</td>
<td>Shell <em>Cerastoderma</em> sp.</td>
<td>1944, N.A. Alekseev</td>
</tr>
<tr>
<td>Aral Sea, <strong>east</strong>, Kuzhetpes island</td>
<td>$276 \pm 48$</td>
<td>65492</td>
<td>Shell <em>Cerastoderma</em> sp.</td>
<td>1936, N.A. Alekseev</td>
</tr>
</tbody>
</table>

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<tr>
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<th>$^{14}$C age</th>
<th>Lab code, AA-</th>
<th>Material</th>
<th>Year and collector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aral Sea, unknown place</td>
<td>$100 \pm 40$</td>
<td>61736</td>
<td>Near-water plant <em>Butomus umbellatus</em> L.</td>
<td>1900, L.S. Berg</td>
</tr>
<tr>
<td>Aral Sea, <strong>east</strong>, Kosaral island</td>
<td>$190 \pm 40$</td>
<td>61735</td>
<td>Water and near-water plant <em>Sagittaria trifolia</em> f. <em>typica</em></td>
<td>1898</td>
</tr>
<tr>
<td>Aral Sea, <strong>east</strong>, Kosaral island</td>
<td>$330 \pm 40$</td>
<td>61737</td>
<td>Water plant <em>Potamogeton perfoliatus</em> L.</td>
<td>1921</td>
</tr>
<tr>
<td>Aral Sea, <strong>north-east</strong>, near Aralskoe more railway station</td>
<td>$600 \pm 40$</td>
<td>61738</td>
<td>Water plant <em>Potamogeton perfoliatus</em> L.</td>
<td>1925, L.S. Berg</td>
</tr>
<tr>
<td>Aral Sea, <strong>south</strong>, near Muynak village</td>
<td>$1070 \pm 40$</td>
<td>61739</td>
<td>Water plant <em>Potamogeton lucens</em> L.</td>
<td>1925, L.S. Berg</td>
</tr>
</tbody>
</table>

Average $R$ for region: $168 \pm 53$
Average $\Delta R$ (yr): $-128 \pm 53$
Preliminarily obtained data for the Project

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

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


And * - this study

*~1400 cal. BP
~1480 cal. BP
Evidences of high levels at the periphery of the lake

Lacustrine sediments overlapped by the Syrdarya delta

ARAL SEA

Kerderi
M1
Muynak
Ka
r
A
Ak
Tscheganak Bay

Syrdarya

Puldjai
Ak
Tschenanak Bay
Karaumbet

Aklak Reservoir

deltaic

lacustrine near-shore

~52 m
50.5 m a.s.l.

ca. 1180 cal. BP
Evidences of low levels of the lake

**Kerderi settlements**

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

Woods, extracted from a grave of the mausoleum Kerderi II
Evidences of low levels of the lake

Medieval delta of Syrdarya

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.
<table>
<thead>
<tr>
<th>Borehole</th>
<th>Elevation</th>
<th>Core length</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1-2009</td>
<td>47</td>
<td>2</td>
</tr>
<tr>
<td>B6-2009</td>
<td>44.7</td>
<td>4</td>
</tr>
<tr>
<td>B2-2009</td>
<td>42</td>
<td>11</td>
</tr>
<tr>
<td>B3-2009</td>
<td>36.3</td>
<td>12.4</td>
</tr>
<tr>
<td>B4-2009</td>
<td>32</td>
<td>13.2</td>
</tr>
<tr>
<td>B5-2009</td>
<td>29.3</td>
<td>14.9</td>
</tr>
<tr>
<td>K1-2009</td>
<td>33.5</td>
<td>12</td>
</tr>
<tr>
<td>K2-2009</td>
<td>38.8</td>
<td>4.3</td>
</tr>
<tr>
<td>B1-2008</td>
<td>39</td>
<td>11</td>
</tr>
</tbody>
</table>
Barsakelmes Island

Lacustrine Sediment series:

Non-lacustrine (subaerial, Quaternary?)

Paleogene/Neogene

B5-2009

B4-2009

B3-2009

B2-2009

B6-2009

Sediment series:

Lacustrine

Non-lacustrine (subaerial, Quaternary?)

Paleogene/Neogene

m 15

Barsakelmes Island

7.5 km

1.5 km

m 15

Barsakelmes Island
Thank you and welcome to cooperate.