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# HUMAN SETTLEMENTS ON THE NORTHERN SHORES OF LAKE ARAL AND WATER LEVEL CHANGES

N.G.O. BOROFFKA*, H. OBERNHÄNSLI, G.A. ACHATOV[1], N.V. ALADIN[2], K.M. BAIPAKOV[1], A. ERZHANOVA[1], A. HÖRNIG[3], S. KRIVONOGOV[4], D.A. LOBAS[1], T.V. SAVEL'EVA[1] and B. WÜNNEMANN[3]

*GeoForschungsZentrum, Potsdam, Germany*

[1]*Margulan Institute of Archaeology, Academy of Science of the Republic of Kazakhstan, Almaty, Kazakhstan*

[2]*Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia*

[3]*Free University, Berlin, Germany*

[4]*Geo Information Technologies, Novosibirsk, Russia*

*(*Author for correspondence: Tel.: ++ 49 331 288 1332; Fax: ++49 331 288 1349; E-mail: nboroffka@t-online.de)*

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**Abstract.** The shore of Lake Aral in Kazakhstan is a perfect area for studying the human adaptation strategy to past climate changes. New archaeological material, gathered along the northern shores during the expedition of the INTAS project 'CLIMAN', is briefly presented. Changes in settlement activity during the Atlantic and Subboreal are related to lake level changes of the Aral Sea. A previously proposed lake level maximum needs to be revised. In particular the lake level stand at 72/73 m, with an assumed age of 5000 BP is definitely refused. Based on the presented data the maximum lake level most probably never reached beyond 57/58 mean average sea level (masl). Furthermore the regression during the 15$^{th}$–16$^{th}$ centuries has been underestimated. It may have been lower than the present day level. Thus the present desiccation of the Aral Sea is historically not unique, as a similar regression, probably induced by man as well, has occurred at least once during history. A readjustment of the water level is, therefore, possible at any time.

**Keywords:** Aral Sea, archaeology, Central Asia, climate, holocene, human settlement, lake level oscillations, Kazakhstan

## 1. Introduction

In the 19$^{th}$ century interest in the archaeological monuments from the surroundings of the Kazakhstan Aral Sea and its two major tributaries, the Amu Darya and Syr Darya rivers, grew. The orientalist Lerch (1867) was one of the first to visit the ruins of Dzhankent, Sauran und Syganak in 1867 and to dig soundings in the medieval site of Dzhankent, south of the Syr Darya Delta. In the following period further studies were carried out (Vereshchagin 1874; Stasov 1894; Livaev 1897; Livaev 1905). At the beginning of the 20$^{th}$ century first lists with monuments were published, in which, for example, the caravan routes and irrigation systems were also considered (Kallaur 1900a, b; Simonov 1900; Kallaur 1901a, b;

Kallaur 1904; Klare et al. 1904). After a longer interruption, Jakubovskij (1929) published a comprehensive study of the monuments from Syganak. Since the end of the 1930s, with a break during World War II, up to the end of the 1980s, the Khorezmian Archaeological-Ethnographical Expedition, led by S.P. Tolstov, carried out very extensive, often interdisciplinary research (scientist like B.V. Andrianov, M.A. Itina, L.M. Levina, A.V. Vinogradov and many others took part in this great programme[1]).

The problems of changing river courses and climatic variability were discussed by some authors (e.g. Tolstov 1962; Andrianov 1969; Vinogradov et al. 1975; Mamedov 1991), however, without reaching generally accepted agreements. Many results, especially on the lower course of the Syr Darya, have been published only recently and are still incomplete[2]. A fairly good stage of research has been reached for the areas south of the Syr Darya and along the Amu Darya. This also includes the recording of large scale irrigation, though a precise dating of the entire complexes and the components thereof is not yet certain. One major drawback in previous research was the fact that most of the research took place at a time, when the water-level of the Aral-Sea was fairly high. Evidence for a major regression during the Middle Ages was not found, because possible under water sites were not identified and research at that time did not even seriously consider this option.

Archaeological sites from the northern shores of the Aral-Sea, where new data has now been acquired, were less well known, because the studies from the 19th century were not intensely continued. First finds from the sites at Akespe (Agispe), Aral'sk and Saksaul'sk were published by Formozov (1949, 1950, 1951) in the 1940s to 1950s and Vinogradov (1959, 1968, 22, 1981) visited the region again a few years later[3]. Tolstov (1962) merely cites the studies by Formozov. Neither Formozov nor Vinogradov, both concerned only with the Neolithic period, discussed hydrological or climatic changes of the northern Aral-Sea. Even ten years later Mamedov (1991) does not mention further studies or new sites, although he discussed the climatic evolution of the Aral-Sea. Surprisingly, none of the authors mentioned so far, made use of the archaeological map of Kazakhstan, published in 1960 (Ageeva et al. 1960, N° 2761–2792, maps 27–28), in which several more sites of Neolithic and Bronze Ages are indicated.

Altogether the present state of research shows an intensive settling in the Aral-Sea region from the Neolithic to Bronze Ages and very little information from the Iron Age. Later periods are hardly represented in the north but quite well documented south of the Syr Darya, in the Dzhety-Azar region, and in Khorezmia, along the Amu Darya. The connection between geomorphological, geographic

[1] The results were mainly published in the series: 'Materialy Khorezmskoj Ekspedicii' and 'Trudy Khorezmskoj Archeologo-Etnograficheskoj Ekspedicii'. See also Tolstov 1962 and Levina 1998 with further literature.

[2] Especially in the series 'Nizovaja Syrdar'i v Drevnosti (Moscow), but see also e.g. Jablonskij 1996 and Itina et al. 1997.

[3] These results on the Neolithic were summarised in German by Redlich 1982.

and palaeoclimatic studies and the archaeological results have been summarised in some cases[4], there has, however, not been any extensive collaboration between archaeology and the geosciences.

## 2. The 'CLIMAN' Initiative

The 'CLIMAN' Project primarily proposes to follow climate changes in the Aral Sea Basin through the last 10.000 years. The focus is on lake level changes of the Aral Sea as recorded in shorelines and sediments. The analysis of multiple proxies is being used to study the drainage balance of the Amu Darya and Syr Darya rivers, which are linked to humidity carried by the West wind drifts to the northern and southern Tien Shan and the Pamir Mountains, where these rivers originate. Besides climate as the major factor, an evaluation of human settlement shifts as a reaction to environmental change and human influence on the water balance (e.g. irrigation) is intended. The project thus brings together an interdisciplinary group from the geosciences and the humanities, for the first time concerned primarily with climatic changes and consequent human reactions.

The archaeological-geomorphological expedition in spring 2002 was specifically aimed at identifying the exact location and dating of ancient shorelines and archaeological sites along the northern shores of the Aral Sea. For the archaeological sites it was less important to establish the nature of the sites (permanent or temporary settlements, graves etc.), but rather their exact geographic position to ancient shorelines. To achieve this, a survey was carried out in selected areas to locate the few previously known archaeological sites and to identify new ones. In spite of the limited possibilities of surveying, it was also intended, wherever possible, to take archaeobotanical and archaeozoological samples for the reconstruction of the environment, as well as samples for precise dating (especially Carbon-14). In the most favourable case, shifts of settlements and their relation to changes in lake levels should become recognisable. Mainly preliminary archaeological results and their relevance to the projects aims will be presented in this paper.

## 3. New Archaeological Data from the Northern Aral Sea

During the 'CLIMAN' expedition a total of 36 sites was registered in the surroundings of Akespe, Aral'sk, Aralsul'fat, Shevchenko Bay and Tastubek, of which 31 are completely new sites with traces of human presence (Figure 1). Two of the previously known sites (at Saksaul'sk and Kerderi, identified in the 1940s and in 2001 respectively) and three others (at Tastubek, discovered in 1998) were visited

[4] E.g. Kvasov et al. 1991; Mamedov 1991; Boomer et al. 2000, p. 1274, each with further literature. On the relationship between cultural evolution and changes in the water level of the Caspian Sea. See also Dolukhanov 1986 and Matyushin 1986 with bibliographies.

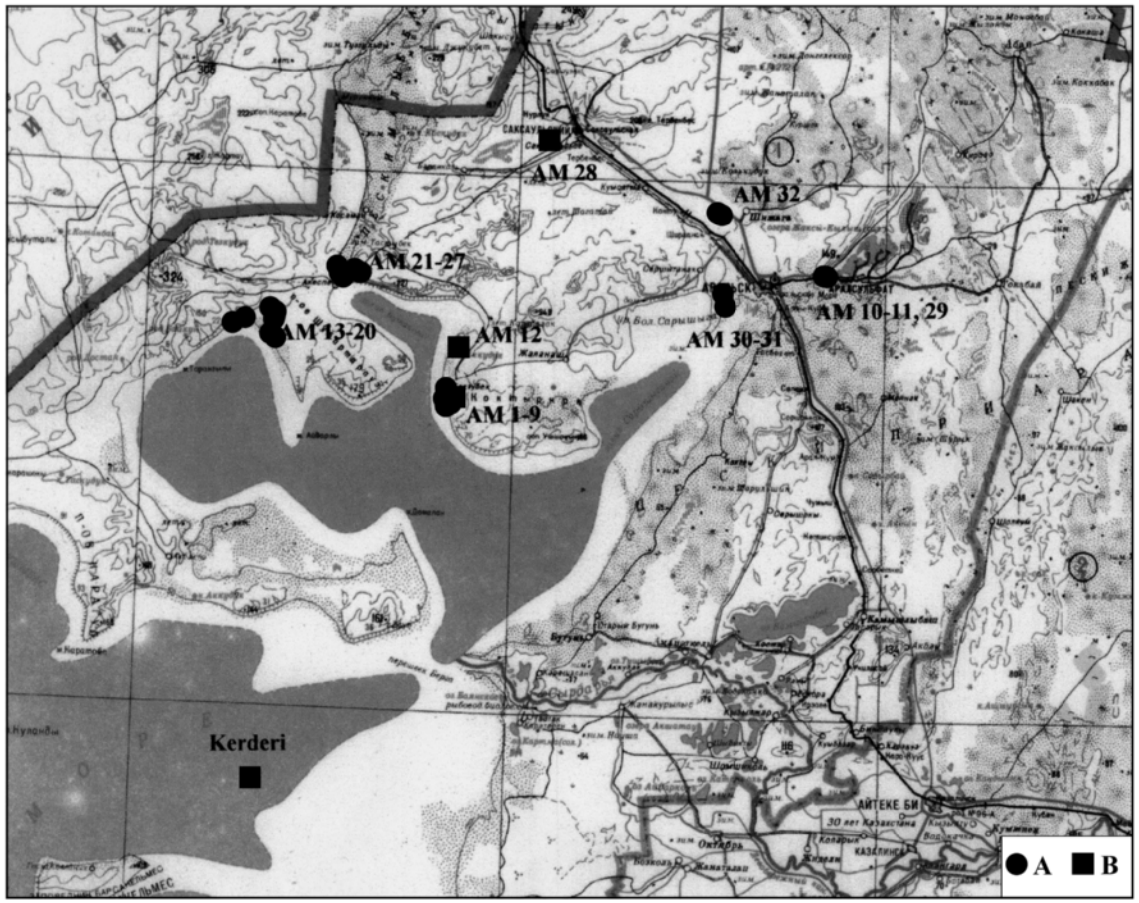


*Figure 1.* Archaeological sites of the northern Aral Sea in Kazakhstan registered during the 'CLIMAN' expedition, spring 2002. A. New sites, B. Previously known sites.

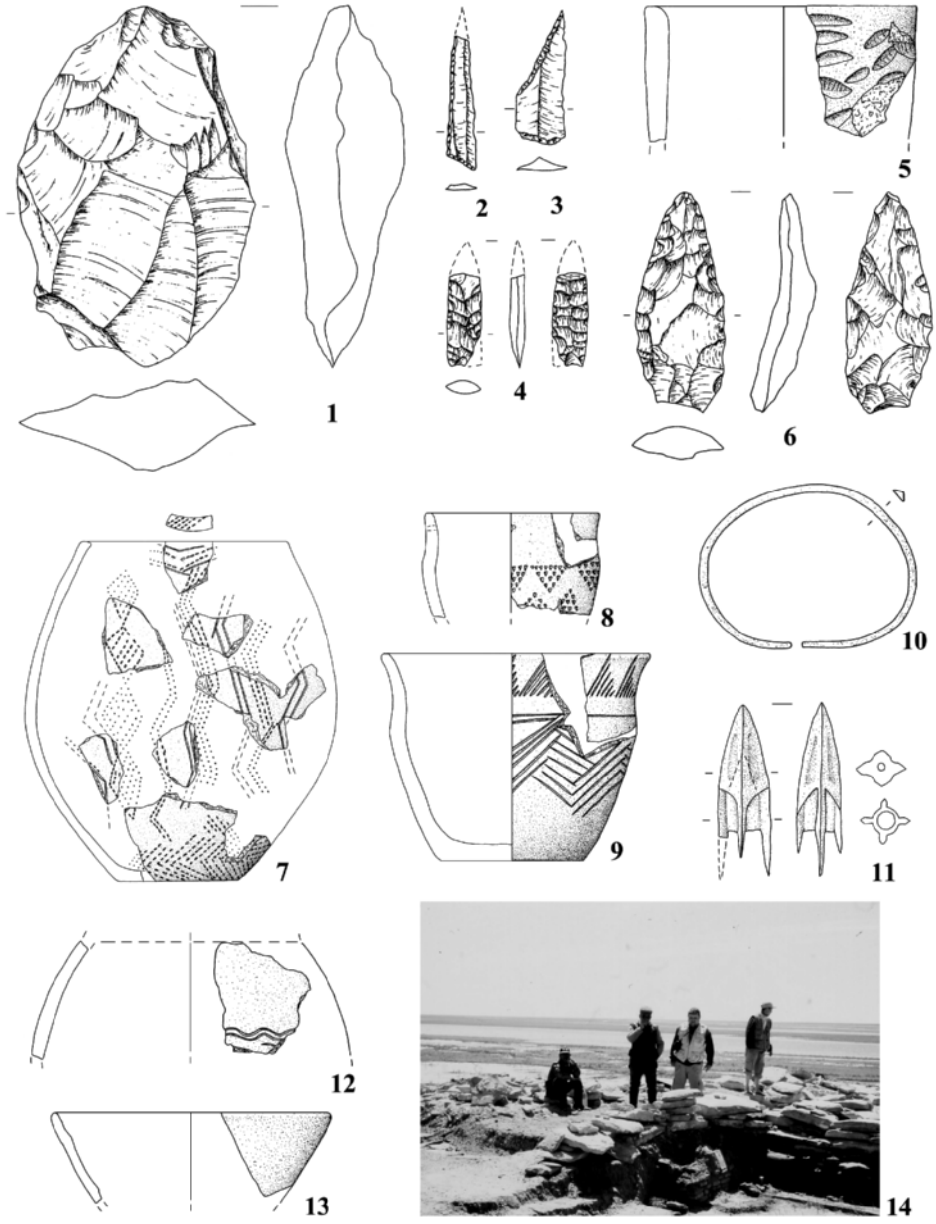


*Figure 2.* Archaeological finds and situations from the spring 2002 'CLIMAN' expedition to the northern Aral Sea. 1 Palaeolithic biface from quarzite, 2–4 Neolithic flint projectile points and insets, 5 Neolithic pottery, 6 Eneolithic projectile point from quarzite, 7 Early Bronze Age pottery, 8–9 Bronze Age pottery, 10 Bronze Age bronze bracelet, 11 Iron Age bronze arrowhead, 12–13 Medieval pottery, 14 Mazar at Kerderi, seen from the southeast (May/June 2002). Note the shallow water in the background covering the adjacent settlement. Various scales.

in order to geo-reference them. The archaeological materials observed during the expedition from the northern part of the Aral Sea (Figure 2) now cover all major periods from the Palaeolithic (ca. 50.000 BP) to the Middle Ages (AD 15th century – 500 BP), a detailed description of the material being published by Bajpakov and Boroffka (Bajpakov et al. 2003; Boroffka et al. 2003).

The sites near Tastubek and Shevchenko Bay lie on former peninsulas in secondary bays, now fallen dry. Their absolute elevation is 60–70 m above sea level (asl). The outcrop consists of Late Tertiary sediments (reworked during the Quaternary: – Wünnemann, unpublished data). The deposits in the former bays are reworked clays, silts and sands as well as sub-recent autochthonous lake sediments rich in molluscs. The highest shoreline is located at 54.5 m asl. No lacustrine sediments or sub-recent molluscs were observed above this level. Most of the archaeological sites are close to the highest shoreline, usually at the top edges of the cliffs standing immediately behind. The sites north of Akespe are located at elevtions of 60–73 m asl. in a sandy strip, dry today, extending towards the north. This may represent a former river course, such as registered on older maps (see below), which could have provided the necessary fresh water supply for prehistoric and early historic settlements[5].

The Palaeolithic (ca. 50.000–35.000 BP) is not yet understood completely enough to draw definite conclusions, but the sites were evidently undisturbed by any later events – such as flooding – or erosion.

The Neolithic finds (ca. 7000–5000 BP) (Figure 2, 2–5) belong to the Kel'teminar culture (Vinogradov 1968; Vinogradov et al. 1975; Vinogradov 1981; Redlich 1982), which spread mainly in the southern part of the Aral Sea, along the old braided streams and deltas (Akcha Darya, Inkar Darya, Kuvan Darya, Zhana Darya) of the Amu Darya, Syr Darya and Zeravshan rivers, as well as in their delta areas and around former lakes in the Kyzyl Kum desert, such as Ljavljakan and Tuskan. The distribution pattern, as well as the small silex toolkits (small projectile points and insets for harpoons – Figure 2, 2–4) are typical for a hunting (for small animals and birds) and fishing economy and therefore indicate a wet climate phase, when the braided streams and deltas were carrying water.

For the Eneolithic (Copper Age) and the Early Bronze Age Periods (5000–4000 BP) the cultural orientation changed. The archaeological finds now show clear connections to the north and northeast, to the forest and forest steppe areas of the eastern foreland of the Ural Mountains and the Tobol-Ishim-Irtysh river system (see Bajpakov et al. 2003 and Boroffka et al. 2003). The points of the projectiles also become larger. This would indicate a vegetation cover (forest or forest steppe) differing from the one encountered today (steppe to semidesert). Especially the sites

[5] In Rubanov et al. 1987, Fig. 8,3 this strip is marked as Mid-Quaternary fluvial sand and alluvial sediments. How far it reaches to the north remains an open question, as well as the date of possible water courses here. River valleys, which are dry today but ran towards the sandy strip from the hills to the east, were observed by members of the INTAS Expedition in spring 2002 during the journey from Akespe to Saksaul'sk.

of the Tobol-Ishim-Irtysh system towards the east with comparable archaeological material have yielded large collections of horse bones (an animal well adapted to a steppe environment), so that a forest steppe vegetation is most probable. This could mean that climate 5000–400 BP was more humid than today.

From the Middle Bronze Age to the Iron Age (ca. 4000–2500/2300 BP), the archaeological finds do not directly serve as reliable indicators, because the animal breeding cultures of these periods were spread throughout Central Asia and Siberia, covering a wide range of vegetation zones from forest steppe to semi-deserts. Man evidently became more independant from his surrounding area (see Bajpakov et al. 2003 and Boroffka et al. 2003 for details).

A major change occurs again in the classical period of Antiquity, when agriculture played an important economic role. From Greek sources, it is known that this was only possible when irrigation became common practice (Barthold 1910; Tolstov 1962; Andrianov 1969). Irrigation began when the Persians pushed forward to the southern Aral Sea shore during the 7$^{th}$–5$^{th}$ century BC, their cultural influence reaching as far as the Dzhety Azar region south of the Syr Darya river. We suggest, that irrigation may have caused – similar to 1960 through 1990s – a sea level lowering during the classical epoch.

Early and Late Medieval sites in the northern Aral-Sea foreland had previously only been known from Dzhankent, Kesken-Kujuk kala and Kujuk kala, all southwest of Kazalinsk. New finds have been observed near Akespe, Aral'sk, Aralsul'fat, Shevchenko Bay and Tastubek. Especially the qualitatively better finds from Akespe and Aral'sk indicate far distance commercial contacts along a northern branch of the Great Silk Road, running from Turkestan along the Syr Darya via Kyzyl Orda up to Dzhankent (Jangikent) (Bajpakov 1998; Bajpakov et al. 1991). One route then continued west around the northern shore of the Aral-Sea (Aral'sk and Akespe), on to the northern end of the Caspian Sea (Sarajchik) and up to eastern Central Europe[6]. These sites are located near the shoreline of the 1960s at elevations of 60–80 m asl, so that the northern Small Aral probably existed during these periods and had to be circumvented.

A different situation is encountered in the region now falling dry east or northeast of the former island Barsa Kelmes in the Great Aral. The mazar (islamic mausoleum) of Kerderi discovered in 2001 (Figure 1; 2, 14) has glazed architectural decorations, which permit a secure date to the late 15$^{th}$ or 16$^{th}$ century AD and also show contacts to the south or southeast. The central building of the mazar at Kerderi lies on an artificial mound of ca. 180 m diameter and ca. 2,00 m height (Figure 2, 14). Around the base of the mound several graves were excavated[7].

[6] This is described in the other direction as the shortest route in the manual by Balducci Pegolotti from 1340 (Barthold 1910).

[7] According to information by the discoverers of the mausoleum Kerderi, Askirbeg Makash and Umirbeg Shintaev from Karateren, a similar structure exists about 20 km further. A visit, even for them, was not yet possible, since the area is still too swampy. For a preliminary report of the excavations at Kerderi see Smagulov 2001.

Towards the north and northeast many traces of an adjacent settlement are visible, which have not yet been studied, since they are still under water most of the time. The entire complex today lies in the region, which is still periodically submerged (Figure 2, 14 under water in the background), so that its absolute height may be stated as roughly 34 m asl. At the time of its construction, respectively life in the neighbouring settlement, the water level must have been significantly lower than today and possibly the Great Aral did not exist at all.

## 4. Discussion

The lake level history of the Aral Sea has recently been summarised by Boomer et al. (2000). Two major points on their lake level curve need further consideration.

The highest terrace (level I) first described by M.I. Epifanov in 1961 (Boomer et al. 2000) is located at an elevation of 72–73 m asl and has been dated to match with the transition from the Atlantic to the Subboreal phase. The currently described Neolithic to Early Bronze Age sites from the northern shores of the Aral Sea, located at 58/59 m asl, would fall exactly into this period. A lake level at 72–73 m during at this time, as proposed by Boomer et al. (2000) can therefore be excluded. Furthermore the tools observed at the prehistoric sites point to changing climate as documented by shifts in vegetation zones and economy. The changes observed indicate a wetter climate for this period (most probably time equivalent to the Ljavljakan pluvial phase: – Boomer et al. 2000). Due to the fact that the Palaeolithic sites (Late Pleistocene) at 58/59 m asl, are not disturbed at all, it becomes evident, that a lake level close to 72/73 m asl was probably never reached during the Holocene, while a maximum water level of 57/58 m asl (corresponding to shoreline II) seems very plausible. This matches well with the observation of the geomorphologists, who identified the highest shoreline along the northern Aral Sea during the 'CLIMAN' expedition at the elevation mentioned above. In the higher cliffs and on the top of the cliffs no traces of flooding or lake-sediments were found. In case the lake level 58/59 m a.s.l. has been attained repeatedly, i.e. in different periods, this would explain the widely differing radiocarbon dates published for this shoreline (Boomer et al. 2000, 12.000 BP, 5000 BP, 3000 BP and 3000–2000 BP). It probably marks the maximum water level during the Holocene.

Furthermore the medieval regressions of the Aral Sea needs some consideration. Major regressions have been proposed for Antiquity ($4^{th}$ century BC to $4^{th}$ century AD) and the $16^{th}$–$17^{th}$ centuries (Kvasov et al. 1991; Boomer et al. 2000). The site of Kerderi, dated to the $15^{th}$–$16^{th}$ centuries was falling dry during summer 2002. Presently the lake level of the Great Aral-Sea is considered to be low, as it is less than 34 m asl. Thus the regression during the $15^{th}$–$16^{th}$ century must have been significantly more serious than was proposed by Boomer et al. (2000, Figure 8). Whether this is also true at this time for the northern Little Aral Sea remains

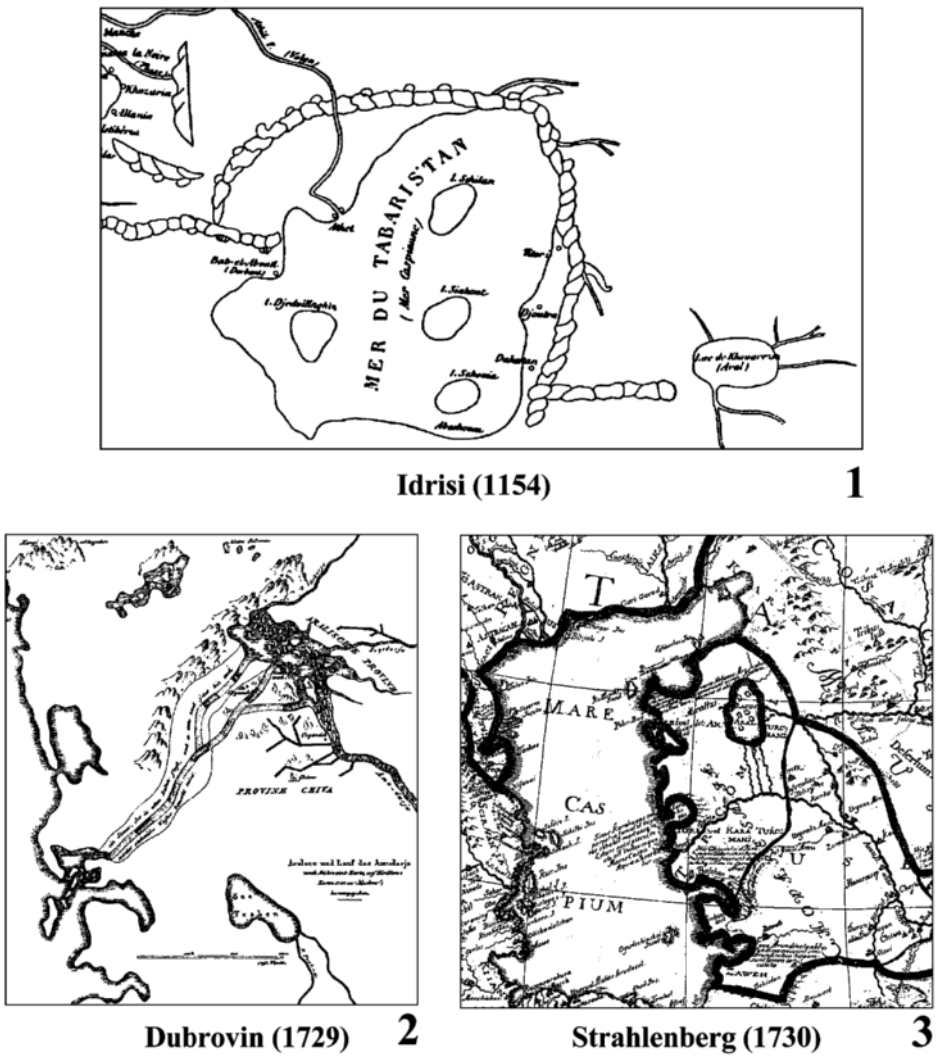


*Figure 3.* 1 Historic Aral Sea maps by Idrisi (1154), 2 Map by M. Dubrovin (1729), 3 Map by Ph.J. Strahlenberg (1730).

debatable[8]. The position of the Medieval sites at Aral'sk, Shevchenko Bay and Tastubek would plead against this, no matter whether the shore line lay nearby at that time. These sites were built along a route leading around the Northern or Small Aral Sea, which should therefore have existed, possibly even as an independent lake. This would be possible even if the Great Aral was completely dry, since the delta of the Syr Darya had roughly the same position in the Middle Ages as in the 1960s. Such a scenario is supported by older maps, e.g. that of Dubrovin from

[8] Today the level of the Little Aral is again slightly higher than that of the Great Aral.

*Figure 4.* Drowned saxaul groves now falling dry in retreating Aral Sea. They were originally found at a depth of 13–14 m in 1960.

1729 (Figure 3, 2) (Berg 1908), where the deltas of Syr Darya and Amu Darya have almost joined and discharged into a rather small lake towards the northern end of a mountain chain, obviously designating the cliffs of the Ust Jurt Plateau. Thus, in the medieval period, the Syr Darya could have discharged only into the Northern Aral-Sea, as is almost the case again today. In addition several older maps (Dubrovin 1729) (Figure 3, 1–3) show further inflow from at least one river to the north, which does not exist today[9], but the traces of which could be represented by the sandy strip extending north of Akespe. Such inflow would have further replenished the northern part of the Aral Sea and could also have provided the necessary fresh water supply for the medieval sites near Akespe. Saxaul groves which had existed along the Great Aral shore were drowned at the end of the 17$^{th}$ century (radiocarbon age 287 $\pm$ 5 $^{14}$C years BP) and are now falling dry again (Figure 4). Their position at roughly 40 m asl clearly confirms the regression of the Great Aral Sea at this time.

The medieval low water level of the Great Aral Sea did not necessarily need to have been caused only by climate change[10]. Since Early Antiquity (4$^{th}$–2$^{nd}$ centuries BC) water from the Amu Darya and the Syr Darya was used on a large scale for irrigation, mostly in open canals (Tolstov 1962; Andrianov 1969). The culminating point of irrigation was reached during the pre-Islamic Middle Ages (4$^{th}$–6$^{th}$ centuries AD) and was then gradually reduced up to the almost total collapse as a consequence of the Mongol invasions of the 13$^{th}$ century. The surface on which archaeological traces of irrigation have been registered encompasses approximately 4,5–5 $\times$ 10$^6$ ha and is thus a little smaller than the surface irrigated at the fall of the Soviet Union (6,5 $\times$ 10$^6$ ha) (Kvasov et al. 1991; Boomer et al. 2000)[11]. However, it must be taken into account, that not all archaeological traces may have been recognised or preserved and that the medieval canals, at least partly, were not as efficient as the modern ones. A similar human influence on the water level of the Aral Sea, as the one observed since the 1960s, can therefore, perhaps with interruptions, also be expected for Antiquity and the pre- and early Islamic

[9] See, for example, Butakoff 1853 with temporary (dashed line) rivers, which flow into Butakov Bay from the east and the north. Besides this, in the Tabula itineraria of Idrisi (1154), the map by Remezov 'Chertezh zemli vsej bezvodnoj i maloprokhodnoj kamennoj stepi' from 1697 (south is at the top here!) and the one by Dubrovin from the year 1729, northern inflow is marked (Berg 1908, p. 13, p. 55, pl. 2). Although these maps do not correspond to modern geographic standards, the repeated registration of a northern inflow is remarkable. The fact, that it is not present on other maps, may be explained if it was active only during certain seasons.

[10] A wetter and cooler climate is assumed for the 13$^{th}$–15$^{th}$ centuries and would actually plead against a climatically caused low level for this period. Summarised in Vinogradov et al. 1975, p. 234sqq. with further literature.

[11] Although the ancient irrigation traces do not all need to have been active at the same time, it must be considered, that the most outlying areas could only have been provided with water, if the region between them and the water source was at least traversed by canals.

Middle Ages. The reduction of irrigation economy in the Islamic Middle Ages[12], and the resulting higher inflow to the Aral Sea, could well have contributed to a subsequent rise in the water level.

Another aspect, which is essential for the water balance of the Aral Sea, especially in the Middle Ages, tackles the issue of the former discharge of the Amu Darya via the Sarykamysh Basin and the Uzboj channel to the Caspian Sea. This almost certainly occurred during the Neolithic (Tolstov 1962; Redlich 1982). Reports from antiquity are uncertain in this respect (Barthold 1910), but this does not hold for the better medieval descriptions. According to the latter, the Amu Darya appears to have flown into the Aral Sea until the devastating Mongol invasion in 1221, however, after this several reports state that the course changed and water ran in the Uzboj (Barthold 1910). A major regression of the Aral Sea at this time is supported by the fact that Hamdallah Kazwînî in 1339 mentions it only as a salt lake and the merchant Bedr-ad-dîn al-Khowârizmi does not mention it at all, although he does describe the lower course of the Syr Darya (Barthold 1910). This dry situation appears to have lasted until the 16$^{th}$ century, as can be deduced from the report of Anthony Jenkinson, the first Englishman to travel in the region in 1558. He already prophesied, that this country (along the Uzboj) would become a desert, if the people lost control of the water[13]. His prophecy was soon fulfilled because Khan Abulghazi (1603–1663) reports that 30 years before his birth (i.e. in 1573) the Amu Darya again began to flow into the Sea of Syr (= Syr Darya, Sea of Syr = Aral Sea)[14]. Tolstov, based on archaeological findings, refused that the Uzboj river existed during this period. He passed the solution of this problem on to geographers and geologists (Tolstov 1953, 1962). According to him, they have to find evidence that the Uzboj was keeping water in the 17$^{th}$ century as proposed by Boomer et al. (2000).

## 5. Conclusions

The presented data show, that the Aral Sea is a fruitful field for studying climate change and human reaction thereon. A close collaboration between historians and geoscientists, as realised for the 'CLIMAN' programme, can resolve the puzzle of

[12] If the 13$^{th}$–15$^{th}$ centuries had a wetter and cooler climate (see above note 10), this may have led to an intentional neglecting of the irrigation systems, which would no longer have been so important. In this way climatic conditions and human factors, in respect to a rising level of the Aral Sea, would have reinforced each other.

[13] Barthold 1910, p. 64sqq. It could be concluded from this, that the diversion was artificial, although it is not completely clear from Jenkinsons report. See also Boomer et al. (2000) (mistakenly given as Anthony Jenkins).

[14] Barthold (1910). See also the corresponding maps compiled by Berg (1908), where even as late as 1730 the Amu Darya is marked, at least partly or periodically (interrupted), as flowing into the Caspian Sea (Berg 1908) maps of Dubrovin – 1729 and Strahlenberg – 1730) and only the maps by Basile Vatace – 1732 and Ioannis Kyrilow – 1734, show it flowing only to the Aral Sea (Berg 1908).

past climate variability in this historically sensitive area. Aspects, like the Uzboj controversy, however, need further interdisciplinary research. The first expedition of 'CLIMAN' to the northern shore of the Aral Sea has contributed important new data to human settlement and lake level changes. During Early Prehistory man reacted immediately to climatic changes. From the Palaeolithic through the Early Bronze Age cultural and economic changes could be observed. During the Bronze and Early Iron Ages man adapted irrigation systems to develop new agricultural areas. This, of course, has influenced the lake level of the Aral Sea.

Digital GPS data show that the highest shorelines lay at 57/58 m asl, while the previously proposed terrace at 72/73 m asl was not identified. Archaeological sites rule out this possibility. As a consequence previously drawn conclusions on water level amplitudes need to be revised. The high water level at the transition from Atlantic (Eneolithic) to Subboreal (Bronze Age), was overestimated, while the regression caused by the medieval desiccation was underestimated. New 'CLIMAN' results will elucidate lake level changes in more detail for specific periods.

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