# ATLAS OF WATER MINING DEVICES IN THE ARID ZONES OF KAZAKHSTAN

## (HISTORICAL EVOLUTION OF WATER USE IN THE MIDDLE DESERTS)


ЛАБОРАТОРИЯ ГЕОАРХЕОЛОГИИ
Алматы

**On the cover, above:**
Map of the belt-zonal division of the territory of Kazakhstan (Yevstifeev Yu.G., Rachkovskaya E.I., Sadvokasov R.E.) where 6 arid zones explored in this book are highlighted in yellow.
**Below:**
**left:** at a well in the South-Western Balkhash on the border of the Taukum desert (Rumyantsev, 1913)
**right:** beginning of a karez line trapping groundwater between 2 dried aquifers of the Sauran district, Turkestan oasis (aerial photo by R. Sala 2003)

AL-FARABI KAZAKH NATIONAL UNIVERSITY
FACULTY OF HISTORY, ARCHAEOLOGY AND ETHNOLOGY
INTERNATIONAL LABORATORY "GEOARCHEOLOGY"

**R. SALA , J.-M. DEOM**

# ATLAS OF WATER MINING DEVICES IN THE ARID ZONE OF KAZAKHSTAN
## (HISTORICAL EVOLUTION OF WATER USE IN THE MIDDLE DESERTS)

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*The research will be inclusive of field and cameral works and laboratory analyses: reading all available information about past and present, relict and active water collection devices; documenting their surface or buried structure and all the elements of the material culture associated with their activity; studying the hydrogeological, environmental and archaeological context; gathering ethnological data through local documents and interviews.*

**УДК 55:902**

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## CONTENTS

# INTRODUCTION: TRADITIONAL WATER MANAGEMENT SYSTEMS IN THE ARID ZONES OF KAZAKHSTAN, AN ETHNO-GEOARCHAEOLOGICAL APPROACH

## 1- Landscape

Kazakhstan is an arid landlocked territory, where precipitation is scanty and mainly concentrated in the mountain and foothill zones (13%). The rest of the territory is arid landscape (44% desert and 33% semi-desert) and steppe and forest steppe (10%).

Desert, semi-desert and steppe, when flat and deprived of springs, have groundwater as only available resource; steppe, when undulated, favors the establishment of lacustrine landscapes. Today agricultural land, including the meager exploitation of deserts, represents the 80% of the entire territory, of which the 84.0% pastoral, 11.7% arable (rain-fed or irrigated), 0.75% irrigated.

## 2- Pastoralism

Accordingly, the pastoral societies of Kazakhstan, starting with the Early Bronze Age (~ 4.5 ka BP) throughout the following history, in order to cope with water scarcity, developed very original techniques of water collection. Here the basic practice for optimizing the use of natural water resources have been seasonal transhumances between summer (June-September) pastures in moist areas (lacustrine landscapes and mountain meadows) and arid wintering deserts, across transitional autumn and spring camps. Winter, spring and summer residences, because close to snow, snowmelt or surface waters, are partially answering the water needs; but autumn remains a crucial period when water is scarcest and artificial supply most required. Moreover, for socio-historical reasons (clanic confinement), many communities in the past had restricted access to watered places and were pushed even harder to the search of artificial ways of water supply.

In the semi-arid zone, like Northern Pre-Balkhash and the Chu-Ili mountains, the most widespread pastoralist water resources are ephemeral springs and streams. Water collection is implemented through managed springs, storage devices like ponds dug near springs to the water table, ponds dammed across seasonal streams, reservoirs. Local embanked irrigated fields allow haymaking and gardening. In extreme deserts (Kyzylkum and Ustyurt plateau) water is mined from wells and basins dug in sand and claypans (*takyr*).

An interesting case of pastoralist hydraulic expedient based on infiltration principles is the cutting of one or more open canals across the mid-slopes, with the function of collecting the surface runoff and to transport it until chosen pastures where its incline decreases and in that way moistens by infiltration the land below. Its course generally ends into a small valley, enhancing the activity of the local ephemeral spring. It is a kind of collector fed by surface runoff from the slopes.

## 3- Irrigation systems and urbanization

Referring to agricultural lands, 80% of the modern rain-fed arable croplands are located in the north of the country, mainly developed during Soviet time from former pasturelands; and most of the agricultural irrigated areas are, today like in the past, traditionally located in the south (Syrdarya, Talas and Chu river valleys), which are also the regions that started to be urbanized starting from the V century BC.

This initial urbanization happened in the Syrdarya delta, supported by an early agricultural development based on the redirection, through channels and reservoirs, of the water of seasonal floods; and in the middle Syrdarya region by water catchment and distribution though short comb canals departing from active streams. It was followed by the development of a train of foothill canal irrigation schemes (Turkestan oasis, II BC-V AD) and by the domestication of the flood waters of the Arys river, a right tributary of the middle Syrdarya (Otrar oasis, I-VI AD).

A following important step started in the VII AD with the implementation of larger irrigation networks by trunk canals applied to big active rivers, like the Arys and the Syrdarya itself, feeding a capillary network of secondary channels (Sangyl aryk, Otrar, VII AD).

A peak development was reached during the Timurid and Early Kazakh khanate periods (XIV-XVI AD) when a mosaic of middle size towns and irrigated fields was concentrated into just four large middle Syrdarya towns managing their respective centralized irrigation systems (Otrar, Turkestan, Sauran, Signak) and sharing similar regional population numbers (~10000 peoples) and irrigated surfaces (~ 8000 ha). Otrar and Signak, river-fed, could expand their hydraulic works and irrigated area, while Turkestan and Sauran were limited by the poor availability of a variable runoff and stimulated to the development of innovative hydraulic techniques.

**4 – The karez system of the Turkestan region**

The hydraulic history of the oasis of Sauran (XIV-XVIII AD) represents a special case by the exhaustive use of a very original groundwater infiltration system that, based on the alignment of a series of wells dug in opportune areas, allows water transport in absence of an underground gallery. It is called karez. Its basic unit, the well, has average diameter of 1.5 m, depth of 3-4 m, mutual distance of 12-15 m; each wells' line develops up to more than 1.5 km sloping by 1-0.3% along the itineraries of a semi-dry hydrographic network. The system is intended for catching and infiltrating, vertically and horizontally through permeable material, both ephemeral surface runoff and groundwater circulation, in that way replenishing the elongated groundwater corridor of naturally sloping aquifers. The aligned wells enhance the well-to-well circulation and, most important, they favor, with the help of an additional micro-artesian pressure, water resurgence from the wells' mouths, resulting all together as man-made fountains. In 70% of the cases the line is paralleled by a small canal (aryk) that collects the water and distributes it to the surrounding fields. During the season the debit of the wells' mouth decreases gradually from up-to-down together with the aquifers' water table, making the bottom line active all along the growing season. Here are located the best fields and is sometimes dug a final pond provided of uplifting devices (*chigyr*). In that way, by XV AD, a total of 420 karez lines and 14000 wells arrived to transform a former desert into the Sauran agricultural oasis.

In Central Asia, a karez is detected on the land surface, through remote sensing, in the form of wells of three different types, locations and functions. From up to down the karez will be seen like a chaotic cluster of wells at the head of some short wells' lines converging, as dendrite-like tributaries, to a main line.

Most probably lines of wells without underground gallery constitute an important element of the replenishing zone of a large number of the shafts-and-gallery groundwater aqueducts widespread around the world (qanat in Iran) of which the whole functioning has never been deeply explored. We must recall that, during the last 3000 years, the entire Kazakhstan territory, with all its landscapes, has been concerned by pastoralist waterwork implementations for the management of aquifer sources. When the qanat technology reached the Central Asian region during the Middle Ages (at the turn of the second millennium AD), it was incorporated within a local traditional know-how of groundwater infiltration dynamics (karez) that evolved from the second half of 1st millennium AD until the last century.

In this introduction, we shortly describe the case of the historical evolution of the irrigation scheme, water provision, land use and demographic development of the Otrar oasis (I-XVIII AD); but we mainly focus on the phenomenon of the karez infiltration systems without transport gallery of the Sauran region: as all groundwater management systems throughout the world and epochs, it represents an intriguing hydrogeological technique that, because its high potential of rehabilitation and diffusion, deserves further study and interpretation.

## Illustrations and commentaries

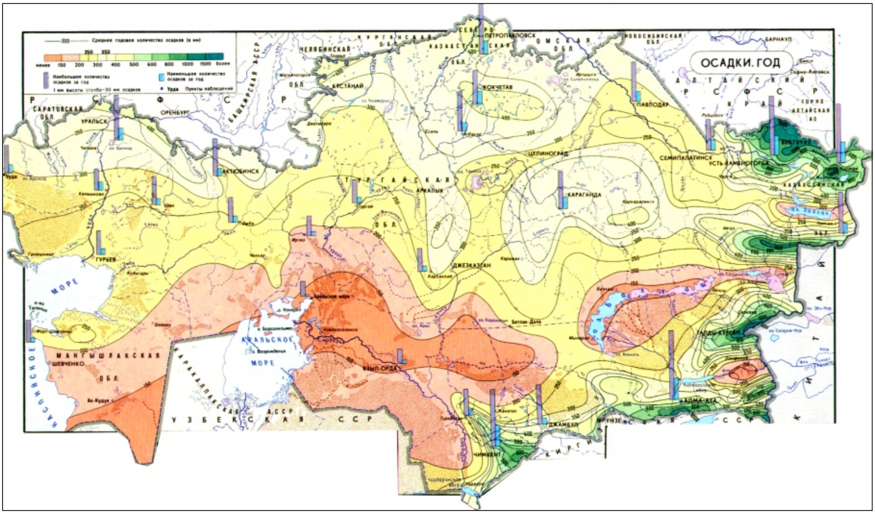



**Fig.1 - Map of the precipitations in Kazakhstan (*Atlas Kazakhskoi SSR*)**

Modern Kazakhstan constitutes the NW section of Central Asia. It is a continental region of which the water resources mainly consist of precipitation from N-Atlantic air masses: during spring in the south and during summer in the north. Meteoric water is caught proportionally to altitude, mainly by mountain ranges, and carried down by few rivers into landlocked evaporation basins. The sediments of the Aral and Balkhash lakes are recording post-glacial climatic fluctuations.

Altitudinal gradients decrease quite regularly from the mountainous E-SE to the flat west. Together with relief, are decreasing precipitation values, so that, under a certain altitudinal level, the desert develops and widens in the same east-to-west direction, from the Balkhash to the Aral and Caspian seas. Latitudinal gradients are responsible for lesser evaporation and better catchment of Atlantic air masses, and so for the northward succession of parallel vegetation belt-zones (BZ): southern, middle and northern (semi-) deserts, followed by desert, dry, arid and forest steppes.

This system of desert and steppe belts is bordered in the east and south-east by a relatively narrow SW-NE band of piedmont plain and mountain vegetation.
Altogether the Kazakh territory can be subdivided into 18 belt-zones. They are individuated taking in consideration relief and vegetation characters, so that we can refer to them as natural landscapes.

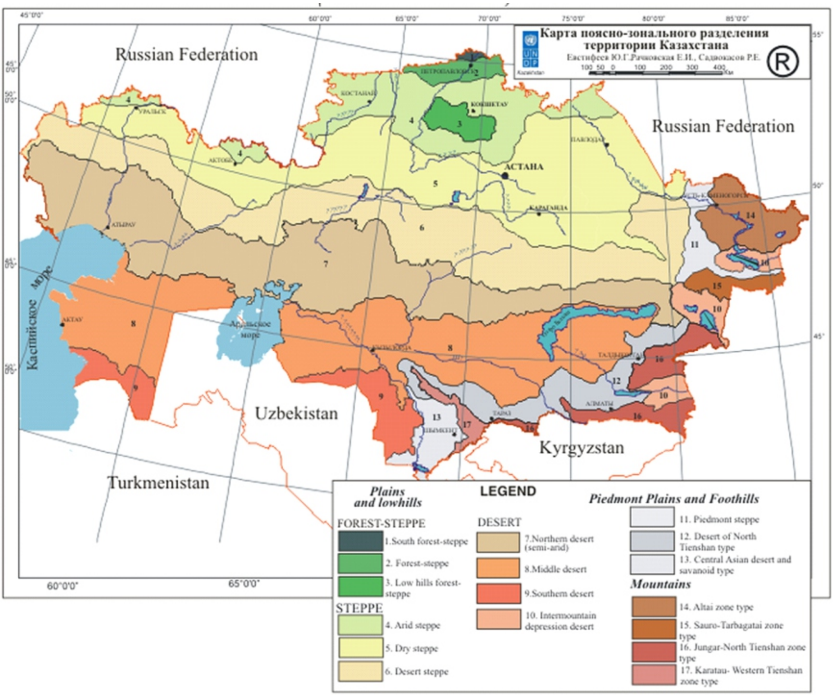



**Fig.2 - Belt Zones of Kazakhstan (*Rachkovskaya et al. 2003*)**

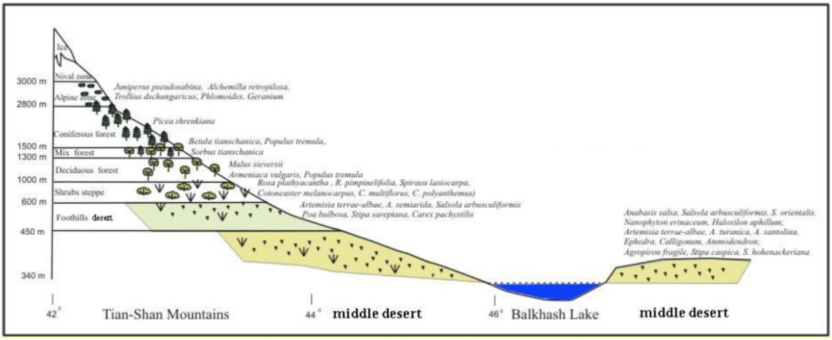



**Fig. 3 - Vertical belt zones of Semirechie (*Nigmatova 2009*)**

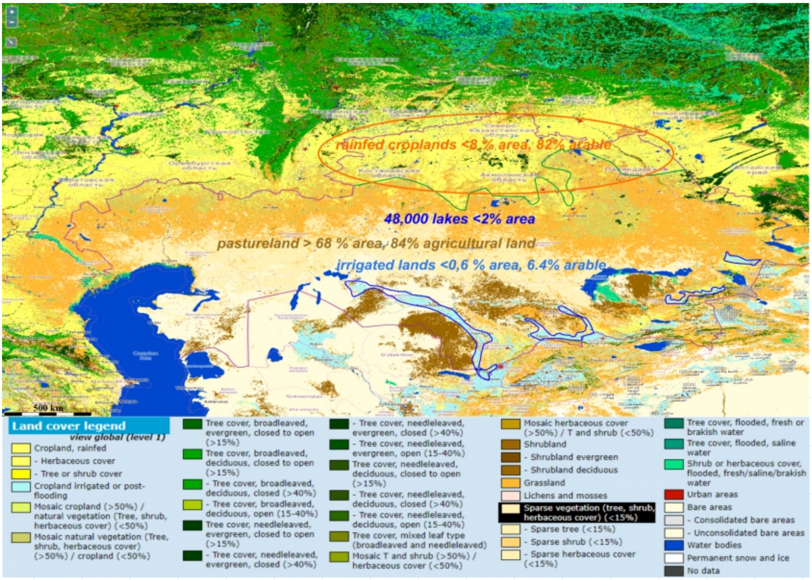



**Fig. 4 - Map of the land cover and land use of Kazakhstan**

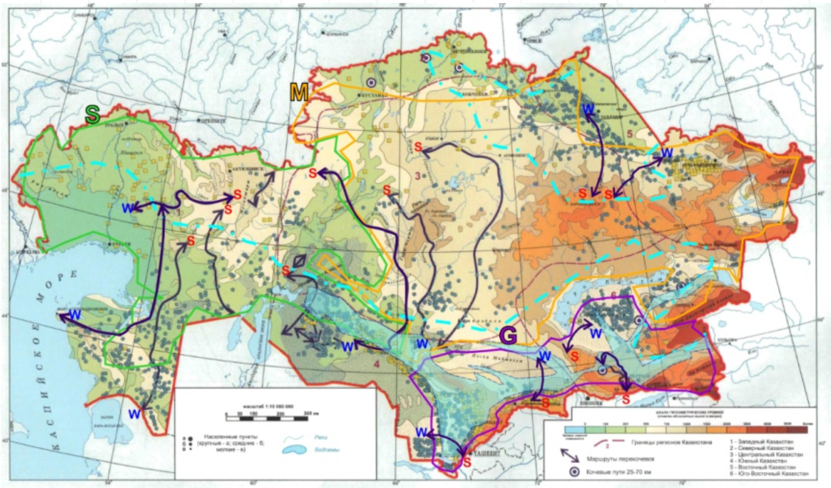



**Fig. 5 - Map of the pastoral use of Kazakhstan**

The pastoral use of the territory of Kazakhstan justifying the tripartition of the pastoral landscape among the 3 zhuz. Altitudinal migrations concern G (Great Zhuz) with short vertical transhumances between alpine meadows in summer and desert in winter; longitudinal migrations concern S (Small Zhuz) with long horizontal transhumances between river valleys and mountains in summer and desert in winter; the Middle Zhuz

(M) have similar longitudinal migrations but with foddering and a more sedentary life.

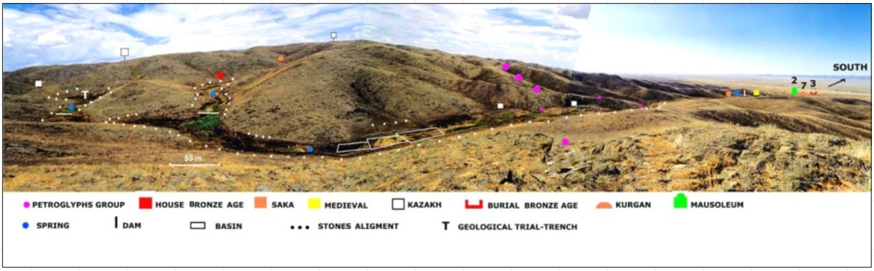



**Fig. 6 -Photo-map of the pastoralist culturalization by settlements, hydrological devices and tombs of the 3 km long Kuljabasy valley-5, Chu-Ili mountains (1500 BC - 1800 AD) (*elaborated by R. Sala*)**

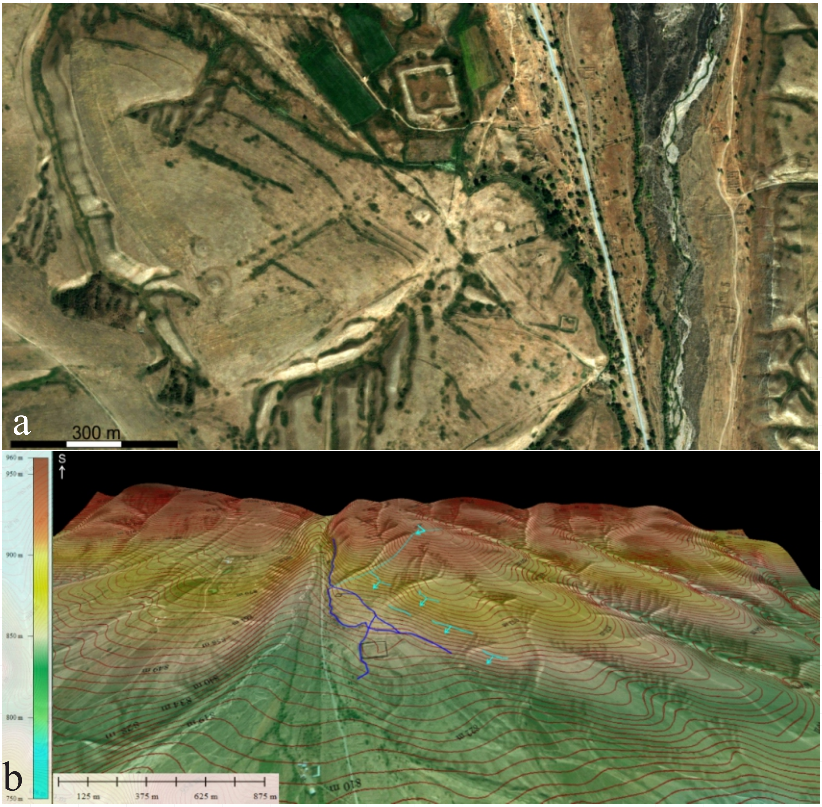



**Fig.7- Satellite image (a) and 3D map (b) of a case of field irrigation in pastoral context Tortkul Kiikbai X-XII AD, Almaty region)**

In the Syrdarya delta the first proto-towns appear in the VIII-VII BC on the Syrdarya delta (Chirik-Rabat and Babish-Mulla culture, VIII-I BC), together with the first irrigation techniques, as result of the northward diffusion of the agro-urban model of the Amudaria-Archadarya delta (Khoresm).
Floodwater was caught during the flood season from mild active segments of the Janadarya distributary, diverted inside paleo-channels serving as canals as well as reservoirs (reservoir irrigation). The geomorphology and hydrology of the region didn't favor the development of perennial irrigation schemes.
Proto-towns (Chirik-Rabat, Babish-Mulla) are surrounded by walls and, at the difference of Mesopotamia, here don't include temples and ziggurats of astronomical significance, but complexes of tombs and mausoleums.

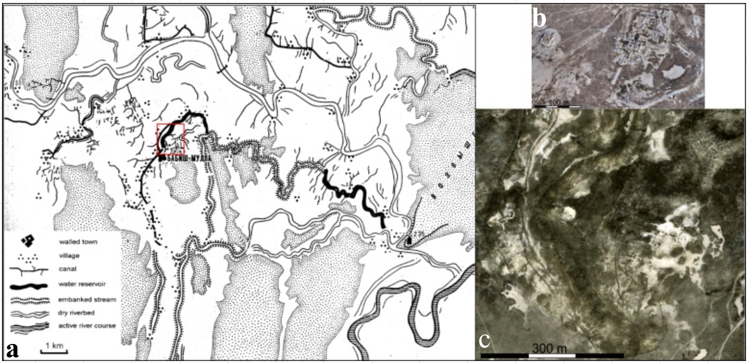



**Fig.8- Early comb canal irrigation system in the Syr Darya delta (VII-IV-II BC). a: plan of Babish-Mulla (Andrianov 1969), b: satellite image of the fort of Babish-Mulla; c: satellite image of the irrigation canal north of the town.**

It was followed by the development of a train of foothill canal irrigation schemes (Turkestan oasis, II BC-V AD) and by the domestication of the flood waters of the Arys river, a right tributary of the middle Syr Darya (Otrar oasis, I-VI AD).
In the Karatau foothills, the earliest towns (fortified castle-farm surrounded by few houses on a raised clay platform) were often located near an active spring.

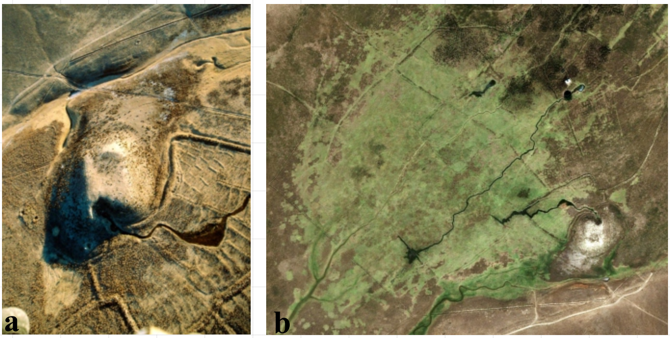



**Fig.9- Early farmlands irrigated by spring-water (Shashana tobe, I-VI AD, Turkestan). a: aerial view to SE(aero-photo R.Sala, 2004; b: satellite image of the irrigated area .**

In the river fed oasis like Otrar, the first towns were located along delta branches of the Arys river.
A following important step started in the VII AD with the implementation of larger irrigation networks by trunk canals applied to big active rivers, like the Arys and the Syrdarya itself, feeding a capillary network of secondary channels (Sangyl aryk, Otrar, VII AD).

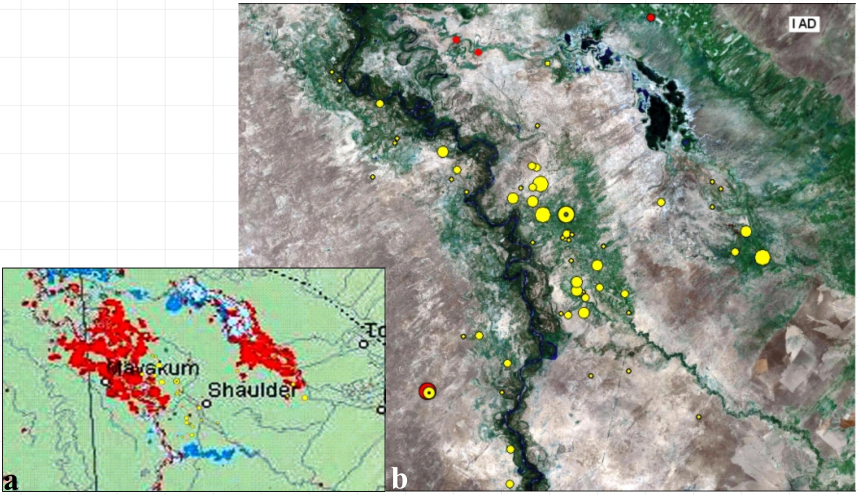
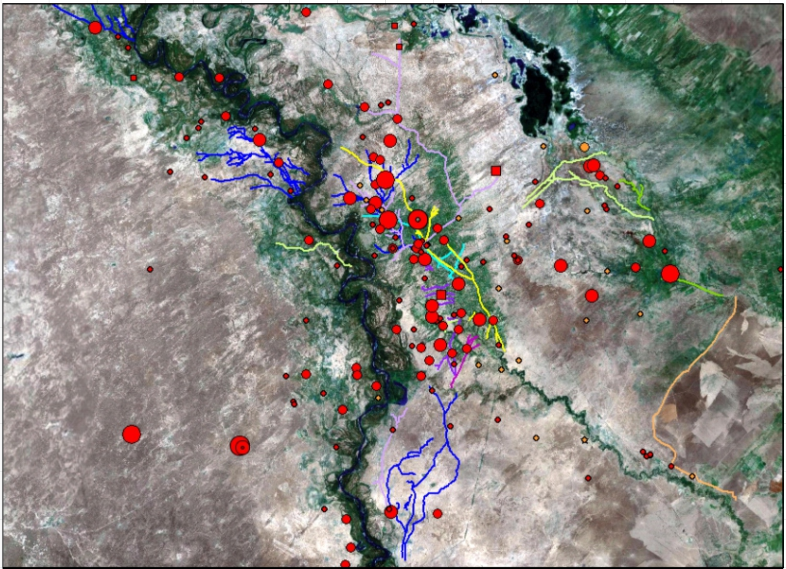



**Fig.10- Early flood basin irrigation in the Otrar oasis during the I-VI AD.**
**a: Map of flooded areas in 2004 (from Landsat images); b: satellite-map of the early settlements (yellow circles, R.Sala 2009).**

The urban park of the Otrar oasis started during the I AD around natural distributaries of the Arys delta, with 39 towns on the limits of the floodplain, based on primitive schemes of **flood-basin irrigation**.
Reservoir irrigation was introduced two centuries later, and perennial irrigation systems in the III-VII AD, which in VII AD brought an urban peak of 58 urban units covering 90 total ha.
Between the III-XIX AD, Otrar saw the succession of 2 reservoir and 4 perennial irrigation schemes, each with average endurance of 3 centuries. A scheme collapses because its itinerary gets sedimented and/or salinized, so that the new scheme tries to avoid the area of the previous.
Exceptional is the persistence of the main paleo-distributary of the Arys delta: it is very crowded of earliest settlements of I AD based on flood-basin irrigation, and then it sees the superposition of the Sangyl (VII-IX, violet), Altyn (X-XIII AD, blue) and Karakunchuk (XIII-XIV AD, azur) perennial irrigation schemes. **The area is anyhow abandoned by the XIV AD and today is totally unfertile**. Also the modern irrigation system, because reproducing the XV century scheme (Temir-Aryk, yellow central), is in fact running along quite depleted soils. Chronological development and measurement of the canals capacity was researched during the years 2002-2004. It enabled to re-construct the patterns of agricultural water use for irrigation between AD700 and AD1500 and to underline that a centralized management of the canals was necessary to ensure correct delivery of water to the

farms. Population estimates were calculated on the base of hectares of croplands by canal capacity, food value of crops (in calories) and food requirements by person. It is estimated that the population in the Otrar oasis grew from about 10,000 in the first millennium to 23,000 people in the later periods (XIII and XVIII centuries).
[1 ton/ha x 2045 ha/y for main canal, average ~ 2000 calories/day/person, and food value crops 3500 cal/kg, 2045000 kg = ~10000 pers].



*Red spots: walled towns (I-XIX AD). Irrigation canals ordered by starting century :*
*crimson (III AD), violet (VI-VII), blue (X), azur (XIII), yellow-orange (XIV-XV), green (XVIII-XIX).*

**Fig.11- Satellite-map of the medieval canal irrigation systems in the Otrar oasis (III-XIX AD) showing 6 phases of irrigation development (R.Sala, 2010)**

The region of **Turkestan** was in located in an agro-pastoralist environment with 60% of its territory belong to pastoral communities making seasonal migration between the Syrdarya banks in winter and mountain pastures in the Karatau in summer.
The remaining 40% consisted of settled farmers (Uzbek, Sart) who were making agriculture mostly from ephemeral streams. At the end of the 19th AD, the fields of the Turkestan town and surrounding (Turkestan aksakalstvo) were fed by 13 canal system (aryk) irrigating 3400 ha. The district of Karnak (including Ikan) represented an additional 4140 ha of croplands. So there were a total of 7540 ha for a population of 11254 persons (1897).
The town of Turkestan was fed by the Kotyrbulak canal supplied by various springs with a weak debit of 206.4 l/sec or 0.21 m3/sec in summer. The only river with a permanent flow was the river Karachik which had a runoff of 1,8 m3/sec in spring (1/3 during summer), the other adjacent streams had a runoff of ~ 0.8 to 1 m3/sec in spring (1/3 during summer).
Therefore, another source of water supply was searched by digging karez lines. At the end of the XIX AD, 16 karez systems existed in the Turkestan region, 15 of them still active.

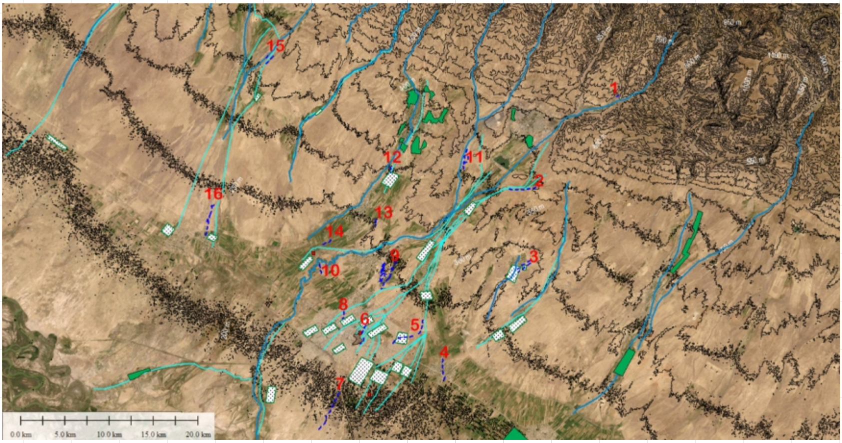



**Fig.13- Relief map of the Turkestan town region at the end 19th AD displaying 13 canal systems (*aryk*) irrigating (dotted rectangles) 3400 ha and the 4140 ha of the Karnak district (solid green fields) . The red numbers and blue dotted lines refer to 16 karez systems of the region (Deom, Sala, 2019).**

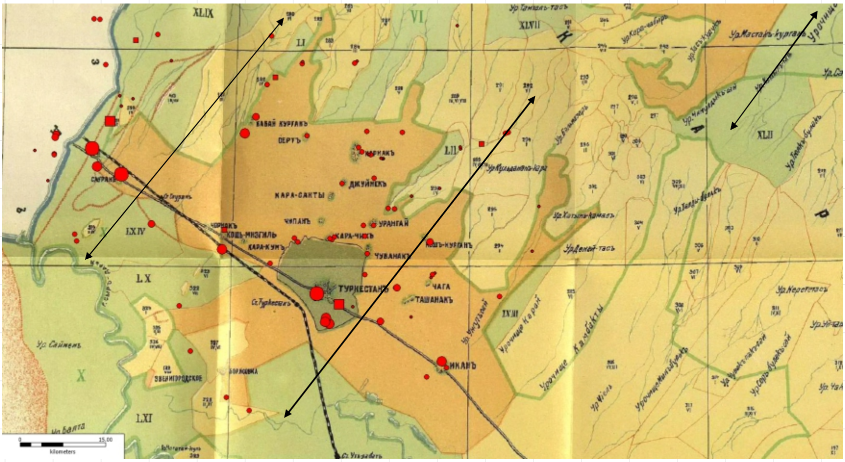



**Fig.14- Land use map of the Turkestan region showing the agro-pastoralist context of the area. In olive color: the “Sart” areas, in yellow: the "Kazakh" areas, in green: the lands of common use. In red, the medieval and ethnographic settlements. The black arrows point to seasonal migrations (MKZ Chimkent county, 1910, 225).**

The region of **Sauran** constituted an independent territory of the Turkestan region with an area of 20x20 km with 26,000 ha covered by karez lines totaling **420 karez lines**, 14000 wells and 183 km. The total irrigated area calculated on the base of fieldwork surveys, aerial and satellite images covered ~ 7000 ha (from the X to the XIX AD, so not all active synchronically).

The area is made of 15 antique and medieval settlements among which 3 big towns, 9 mid-size, 3 small and ~ 100 old farms.  The town of Sauran itself covered a surface of 40 ha, corresponding to ~ 11000 persons. Most of the town surroundings was irrigated by karez lines.

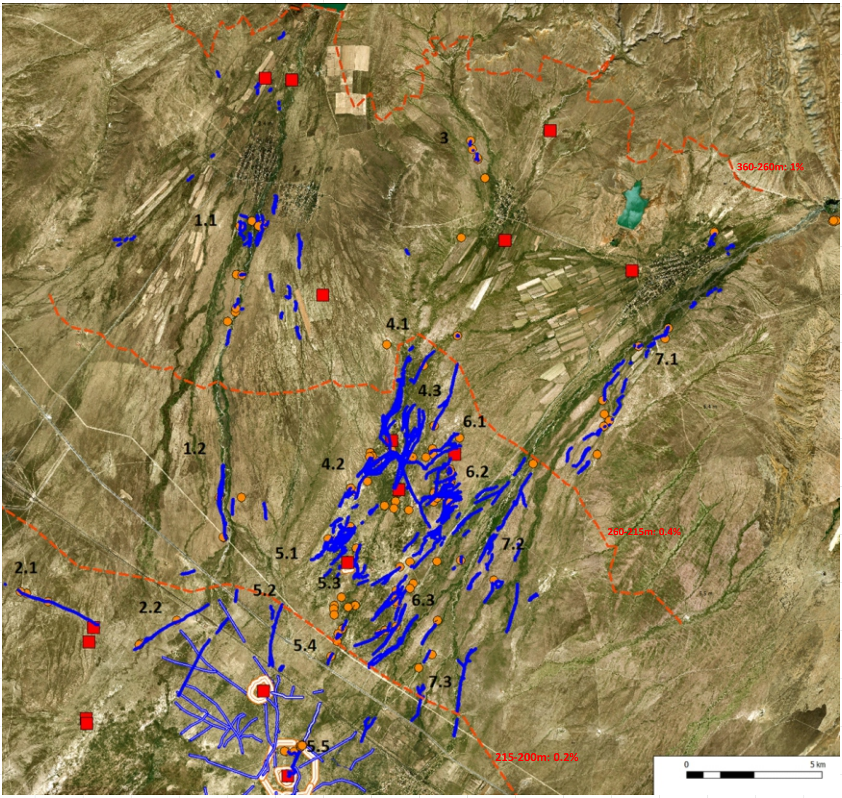



**Fig.15- Relief map of the Turkestan town region at the end 19th AD displaying 13 canal systems (*aryk*) irrigating (dotted rectangles) 3400 ha and the 4140 ha of the Karnak district (solid green fields) . The red numbers and blue dotted lines refer to 16 karez systems of the region (Deom, Sala, 2019).**

# I
# USTYURT PLATEAU

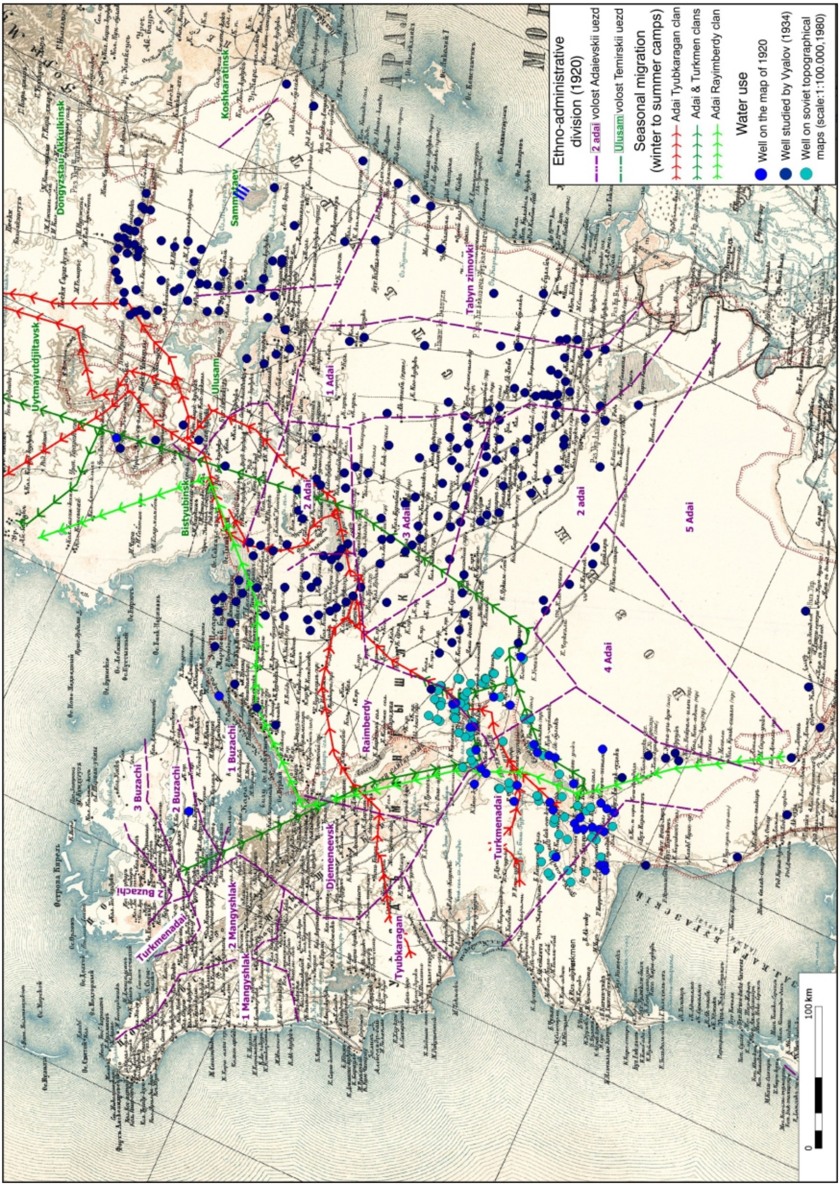



**Fig.1- Map of the traditional land and water use in the Mangyshlak or Adai county in 1920**

# 1-
# TRADITIONAL LAND AND WATER USE IN THE USTYURT REGION ACCORDING TO LATE 19TH - EARLY 20TH CENTURY STATISTICS AND REPORTS

## Introduction

At the turn of the 19 and 20 centuries, the territory of the Mangyshlak county (*uezd*) included the peninsula of Mangystau and the plateau Ustyurt. This region is the home of two main clans of the Small Zhuz, the Adai of the Baiuly tribe (with other centers in Uil and low Emba basin and also in the Ryn sands in the Northern Caspian) and the Tabyn of the Zhetyru (with other centers in Chelkar, Aktiubinsk).

In 1882, Ustyurt becomes a district of the Transcaspian oblast and until 1898 Transcaspia was part of the Governor-Generalship of the Caucasus administered from Tbilisi, Later, it was made an oblast of Russian Turkestan governed from Tashkent.

In this context, the Mangyshlak district (okrug) with center at Fort-Aleksandrovsk (later called Fort Shevchenko) had 93% Kazakh (63,795), 4% Turkmens, 2,6% Russians.

Till 1920 the Mangyshlak uezd had 10 volostei: 1st Buzachinskaya, 2nd Buzachinskaya, 3rd Buzachinskaya, Dzhemeneevskaya, 1st Mangyshlakskaya, 2nd Mangyshlakskaya, Raimberdinskaya, Turkmen-Adaevskaya, Turkmenskaya, Tyub-Karagan.

Then in June 1920, the Mangyshlak district, together with the 4th and 5th Adayevsky volosts of the Krasnovodsk district, formed the Adayevsky district, which in October of the same year was transferred to the Kyrgyz (Kazak) ASSR. And when Adaevskii uezd was created the same year it incorporated 2 more volostei: 4th and 5th Adaevskii volost from the Krasnovodsk uezd, so **12 volostei**.

According to the 1897 census, Mangyshlakskii uezd had 68,555 people with 93,1% Kazakhs.

In 1920 as the Bolsheviks took the region the peninsula was included in the Kyrgyz Autonomous Soviet Socialist Republic renamed Kazakh Autonomous Soviet Socialist Republic in 1925.

The population of 1920 accounted 101,400 persons (98% Kazakh) and in 1926, 135,600.

The Adaevskii uezd (1920-28) was restructured into **27 volostei** (with center in Fort Shevchenko then in Uil (1925-26) as Adaevskii district (*okrug*) in 1928-29 with center in Uil.

The economy of the local population consisted almost entirely in stockbreeding. Around 1922, the Adaievski counted 450 thousand horses, 2000 cows, 518 thousand sheep, 80000 goats, 84000 camels. In Uil, Emba, Sagyz were some agriculture (wheat - 980 tons in 1922 and millet - 840 tons), fishing (57,3 tons of fishes and 155,4 tons of seals in 1922) and salt were also an important source of income.

In 1937, Mangystau became part of West Kazakhstan Region with two districts: Ustyurt Plateau, and a Mangyshlak with its capital Fort-Shevchenko. The region was divided in 5 districts:

1-Beyneu District, with the administrative center in the aul of Beyneu (47.000 persons in 2009)

2-Karakiya District, centered in the aul of Kuryk (with Zhanozen and all the area at the east and south of it; representing 30.000 people in 2009)

3-Mangystau District, centered in the aul of Shetpe (administrating the northern - Buzachi and eastern - central Ustyurt- adjacent regions (in 2009, the area counted 30.000 people)

4- Munaily District, centered in aul of Mangystau (around Aktau) with a population that multiplied only recently (1999-2013: from 14.000 to 100.000 inhabitants)

5-Tupkaragan District, centered in the town of Fort-Shevchenko (20.000 persons in 2009) and 3 towns (Aktau 180,000 p., Bautino 5500 p., Zhanaozen, 80,000 p.)

In 2009, the Mangystau oblast covered an area of 165,600 km2, its population consisted in 416,500 people, its density: 2.5 people/km2 and its ethnic distribution was: Kazakhs - 71%; Russians - 23%.

**1- Natural settings**

Environmentally, the Mangyshlak district is divided between the territory of the Ustyurt plateau and the Mangyshlak and Buzachi peninsulas. Ustyurt is a plateau bounded by steep cliffs - *chinks* rising above sea level to an altitude of 150 to 300 m. The southern part of the plateau represents a plain with a desert, and the north with a semi-desert vegetation.

The Mangyshlak Peninsula is occupied by two parallel low ridges - Aktau and Karatau. On the vast expanses of the plateau, numerous islets of sandy massifs and salt marshes are scattered, which make up about 1/10 of the entire territory of the district, the rest of its area is occupied by a clay desert and semi-desert.

**2- Water use and pastoral migrations**

There are up to 200 springs in the Aktau and Karatau mountains 160 of which with fresh water. The most significant springs form small streams. The construction of dams on these streams allows irrigation of only small area of crops and gardens. In the county, water supply to the population and livestock is carried out, in addition to springs, from wells, of which there are more than two thousand. However, in many of them the water is salty, unusable. In addition to wells and springs, sources

Snow and melt water are the main sources of drinking water.

Despite significant changes in the economy of the Kazakh aul in Mangyshlak district occurred after the annexation of the region to Russia, the main branch of the economy here still remained extremely extensive nomadic economy.

So, in the report of the head of a district in 1915 is said that all the productive forces of Mangyshlak are concentrated exclusively in cattle breeding, in which all, without exception, the Kazakhs are engaged, except for the poor (jatak) who are workers. The scarcity of natural pastures forced the Adai residents to permanently (throughout the year) migrate with herds from well to well. Therefore, their herds were dominated by such types of livestock (sheep, camels, horses), which easily tolerated long movements, at the same time providing the nomad with everything he needs.

A characteristic feature of the cattle-breeding economy in Mangyshglak was the complete absence of forage procurement for the winter. R. Karutz reported that "they do not depend on fodder for their livestock, which sometimes leads to a significant loss, and sometimes to a

complete loss of animals" (Karuts, 1910). For them, no barn or corral is built and they remain in the open air all year round. Only in exceptional cases were fences made of reeds or stone for animals. Limited water supply and scarcity of pastures led to the fact that the average size of the farm in Mangyshlak was significantly lower than in many other parts of Kazakhstan.
According to T. Kiyashko, in the Mangyshlak district on the 1st January 1890, the category of the rich included farms that had at least 100 horses, 20 camels and 500 rams (Kiyashko, 1897). Such "Bai" farms represented only 2% of the pastoral population. Farms that had no livestock reached about 20%. At the same time, say, in the Pavlodar district at the beginning of the 20th century, rich owners accounted for 16% of all farms.

Due to the fact that the Adai village remained nomadic, lived in isolation and scattered (near the wells), far from the markets, retaining a largely natural character, the remnants of the tribal system were preserved in it stronger than in many other parts of Kazakhstan. Here, the old tribal land communities have been preserved, the routes of migrations, the use of watering holes (wells) and pastures, were respected strictly.

However, even here by the end of the 20th century, there have been major changes both in the nature of patriarchal tribal survivals, and in the forms land use. The concentration of the main cattle in the hands of the rich households "baistvo", on the one hand, and the complete impoverishment of a significant part of ordinary people without winter pastures, wells and springs monopolized by those who had livestock.
The lack of pastures forced separate groups of Adai residents to enter the lands of the neighboring Tabyn clan. However, the actual economic unit was the economic aul, which in reality was much smaller than the administrative aul and usually consisted of two to five households. The structure of such village included either 'bai' households and poor families made of farm hands in economic dependence, or some aul consisted in middle and small size households (Vostrov and Mukanov, 1968).

## 3- Socio-economic organization of the pastoral communities of the Ustyurt-Mangystau region

The organization of the economic year for the Kazakhs of Mangyshlak was divided into four cycles, each of which corresponded to certain pastures: winter, summer, spring and autumn. The economic cycles were associated with certain pastures that met the established requirements of a nomadic pastoralist and nomadic routes along which herds moved from one pasture to another.
The winter pastures of the Adai clan in the Mangyshlak district were usually located in those areas where it is impossible to graze cattle in the summer due to lack of water or insufficient amount of it. This is primarily mountains Karatau and Aktau on the Mangyshlak peninsula, where the only sources are springs, pastures around the Karagiye depression and Koshkarata in the southwestern part of the peninsula, serving as shelter for livestock, the sands of Sengirkum, Akkum and Sauzek, as well as a significant part of the Tyub-Karagan and Buzachi peninsulas with the sands of Kyzylkum, Egizlak and Zhilanchik. All these pastures are covered with wormwood and saltwort vegetation (plain parts of the county) and cereals (boz, erek), which grow abundantly on sandy massifs. Approximately 12% of the Adai farms overwintered in these areas (Ishchenko et al. 1928).
The next significant areas of wintering are scattered in Ustyurt, in the sands of Sam and in the adjacent steppe. The clay plains of Ustyurt, occupied for wintering, are covered with *zhusan,*

*biyurgun, bokhlych* and *hodgepodge*; in the sands grow nutritive grasses and shrubs like *kiyak, axleu, zhuzgun, erkek*, *akchagyr*. Approximately 16% of the total households were wintering here. Despite the fact that in all these areas there were quite a few wells, most of them were saline and unusable. Therefore, it is almost impossible to be here in summer. In the sands, where shallow wells (digging) came off, the water is fresh, but the complete absence of artificial shelters for livestock makes it possible to use them mainly in winter, when among the sand dunes livestock finds excellent food and shelter. In addition, in the spring the sands are freed from snow much earlier than the surrounding plain. Grazing in the sands at other times of the year it was difficult due to the abundance of all kinds ticks that exhaust livestock, and incredible heat.

Households that were very poor, deprived of livestock or did not have enough resources for distant migrations, were wintering in the same sites all year round. Some of these farms lived on the Buzachi peninsula, in the Aktau and Karatau mountains, in the Sam, Sammatai and Karynzharyk sands, i.e. all winter pastures.

The most impoverished farms settled along mountain streams, near shallow digs and at lowlands with spring waste waters and were engaged in agriculture, breeding cattle. Farms that had an insignificant number of livestock, staying overwintering, lived here throughout the year, roaming near nearby wells in the spring-autumn and summer periods.

The bulk of the Adai farms only remained in the indicated areas during winter, leaving in spring to the north.

Arriving for wintering in mid-December, the Adai residents stayed there until the second half of March, moving throughout this period from place to place as the pastures were grazed. In those years when there was a warm, long autumn and early spring, the time spent on wintering was correspondingly reduced, and in the harsh early winter and late spring it was extended to 150 days. In such winters, a significant part of the households of the Adais, and even the Tabyns, went south of the usual nomadic border (Khiva - Krasnovodsk - Kokzhol) to the Kungrad region and to the borders of the Krasnovodsk district.

Winters of the Tabyn clan were on the north-western and western shores of the Aral Sea, in the salt and reed steppes of the eastern Ustyurt, in the natural boundaries of Kara, Baiterek, Belsekseul, Akbulak.and in the steppes around the clay lakes (*khaks*) of Barsa-Kelmes (Bukeykhan, 1927). Like the Adai, the herds in the most severe winters went to the vicinity of Kungrad. They did not build permanent dwellings for wintering even at the beginning of the twentieth century. Adai and Tabyn-koshpeli (nomads) also lived in yurts in winter. Their wintering covered an area of 1000-1200 square meters, covered with a layer of dry manure that had accumulated over the years and served as a bedding for livestock. In March, while there was still snow in the steppe and melt water accumulating in the lower reaches, the villages left their wintering grounds and move north to spring and then to summer pastures. Their early spring pastures were located within the Mangyshlak district.

The main areas of the spring-autumn pastures of the Adais and Tabyns were located in the neighboring of Guryev and Temir districts, that is, on the northern edge of Ustyurt, in the Sam and Sammatai sands. These were the first southern tracts of spring pastures. Here the Adai people and their herds stayed for 15-20 days, depending on the weather, feeding their flocks emaciated during winter and then went to the main spring-autumn pastures, to the areas of the Karakum, Chagyrly, Teresken sands, to the Aitam-Oimagut, Togusken tracts, and to the steppe around the Khandyurt-kul, Chirkala and Bukembai mountains. All these pastures were outside the Mangyshlak district and were available only in the spring. Crossing the Emba river, some of the farms moved to the northwest, into the sands of Taisoigan and

Biryuk, located in the Guryevsky district of the Ural region where their summer houses were located. Other farms of the Adai and Tabyn went in summer grazing grounds within the Aktobe district, a third group moved in the sands Bolshie Barsuki desert and at the headwaters of the Irgiz river basin (Ishchenko et al. 1928).

Within the limits of the Mangyshlak district proper, apart from those poor households that lived there throughout the year, a small number of auls roamed also near wells remaining there during summer far from their winter quarters.

Approximately at the beginning of October, the Adai and Tabyn began to move from summer sites to the south, to autumn-spring pastures, and then climbed on the Ustyurt plateau in order to reach their wintering grounds.

This is the picture of the settlement of the Adai and Tabyn clans, who lived within the Mangyshlak district until the beginning of the 20th century. The gradual settlement by Russian settlers in the northern summer areas of the Adais and Tabyns (Karaagach and Chilik volosts of the Ural district, at the watershed of Ilek and the Urals, etc.) at the beginning of the 20th century, the development of haymaking, agriculture and the transition of part of the Kazakhs of the southern districts of the Ural and Turgai regions to sedentary and semi-settlement life led to a significant reduction in summer pastures and the transfer to the south of the northern boundaries of the summer camps of these 2 clans. Now they only occasionally entered the Karaagach and Chilik volosts of the Ural district, did not migrate north of the Zhirenchinsk volost of this district, Khobda and Ilek watershed, and did not go beyond the southern edge of the Mugodzhar mountains.

During the years of the revolution and the civil war in Kazakhstan, the northern borders of the summer migrations of the Adai and Tabyn were reduced even more. Now this border was located within the Uil - Sagyz - Emba rivers - the southern half of the Mugodzhar, that is, south of the 48th parallel. Only after the end of the civil war in Kazakhstan, the radius of summer migrations of the Adai and Tabyn clans was gradually restored.

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| Volost | Name | Tribe | village number | households | residential place | winter (number of households) | summer | Migration tracks |
|---|---|---|---|---|---|---|---|---|
| 1 | Taisugun volost | mix | | 1000 | | | | |
| 2 | Shyili-Sagiz | mix | 11 | 718 | | | | |
| 3 | Emba-Sagiz | mix | | 423 | | | | |
| 4 | Uil | Taz | | 3500 | | | | |
| 5 | Kazybek | Ysykh | | | | | | |
| 6 | Donguzstau-Akhkoltykh | Tabyn Karajon | | 3000 | | | | |
| 7 | Sammatai | Tabyn Karakoily | | | | | | |
| 8 | Uly-sam | Tabyn Jalpak. | | | | | | |
| 9 | Adai-1 | Mix Adai | | 775 | | | | |
| 10 | Adai-2 | Shegem | | 785 | | | | |
| 11 | Adai-3 | Koskulak | | 1078 | | | | |
| 12 | Adai-4 | Begei | | 772 | | | | |
| 13 | Adai-6 | Suyunduk | | 1000 | Karabugas | N and W Karabugas | Sagiz | |
| 14 | Adai-7 | Suyunduk | | 773 | | | | |
| 15 | Ali-Baimbet | Ali-Monal | 6 | 1122 | Baurbas | | | |
| 16 | Bozaschi 1 | Aitumys-Shlym *Jemenei* | 7 | 1213 | Tigen Many agro-pastoralists | **A**:205 (110 Olzhashi+95 Otebai), Karynzharyk, Sengyrkum **B**: 120 Olzhashi, Bas-Uyuk,Temir,Karynzharyk | A:Till Uil Sagiz And Karakum (Karaton) B: to Sam | Spring **A**:Kogusem Bosaga Kynyr Uzun Sam |
| 17 | Bozaschi 2 | Manal | 9 | 1340 | Tuschikuduk | in 1926 around Bosaga | | |
| 18 | Bozaschi 3 | Manal | 8 | 1432 | **A**: 247 Rsaly 14 Zhetymek around Jiloikosy | 153 Eskeldy 20 in Kaplankyr | Karaton | Spring via Karynzharyk Saigyrkum East Caspian |
| 19 | Bozaschi 4 | Ordek-Aitumys-Shlym | 7 | 1043 | | 470 Karabogaz in Karyshyng-Shagly Kulshik-Shagly Kura-Igyn | Emba Uil | Karatulei West Chagyrly |
| 20 | Mangystau 1 | Zorbai- Almenbed | 9 | 1468 | | 655 winter in Bostankum Other remain a.y.r. Karatau | | |
| 21 | Mangystau 2 | Shonai-Almenbed | 7 | 1215 | | | | |
| 22 | Zhemenei | Zhemenei | | 1045 | | | | |

**Graphic 1 - Geographical and socio-economical distribution of the Mangystau tribes in the 27 volosts of the Adaievski county (1926, from Mangistau entsiklopediyasi 2008 )**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 23 | Kelimberdy | Zhanbai, Zhantugan-kunan-orus | 4 | 570 | Between Sayutes and Karatulei | **A**:clan Karash in Karabugas | **A**:at Hobda river | |
| 24 | Raimberdy | Tekei-Aldaberdy | 6 | 1128 | Kendirli-Aktau | Aul Atambek, 148 nomads in Karynzharyk Saigyrkum Karbugaz Kendirli | Chingirlau near Uralsk | |
| 25 | Tyupkaragan | Baimbet-Sabytai | 10 | 1857 | | A:440 Karynzharyk Saigyrkum Kaundy B: 700 in TKM | **A**:West Sam along East Caspian **B**: Sam and Emba | B: via Belsaksaul |
| 26 | Turkmen-Adai 1 | Tanat-Aryktnei | 5 | 792 | | | | |
| 27 | Turkmen-Adai 2 | Bali-Kosai-Kudaike | 5 | 710 | | Jarbol 120 Karynzharyk Saigyrkum Otep 1&2 290 Same: Tuzbair and Sengyrkum Akkuyis (Shojik) | Akmechet (Emba) | |
| *28* | Fort Alexandr. | | | 220 | | | | |
| *29* | Other villages | | | 335 | | | | |
| Total | | | | 29314 | | | | |

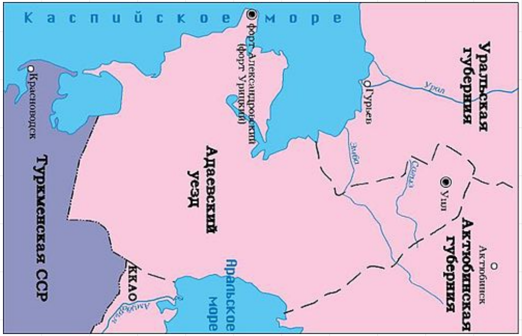


**Fig. 2 - Map of the Adaievskii uezd (1925)**

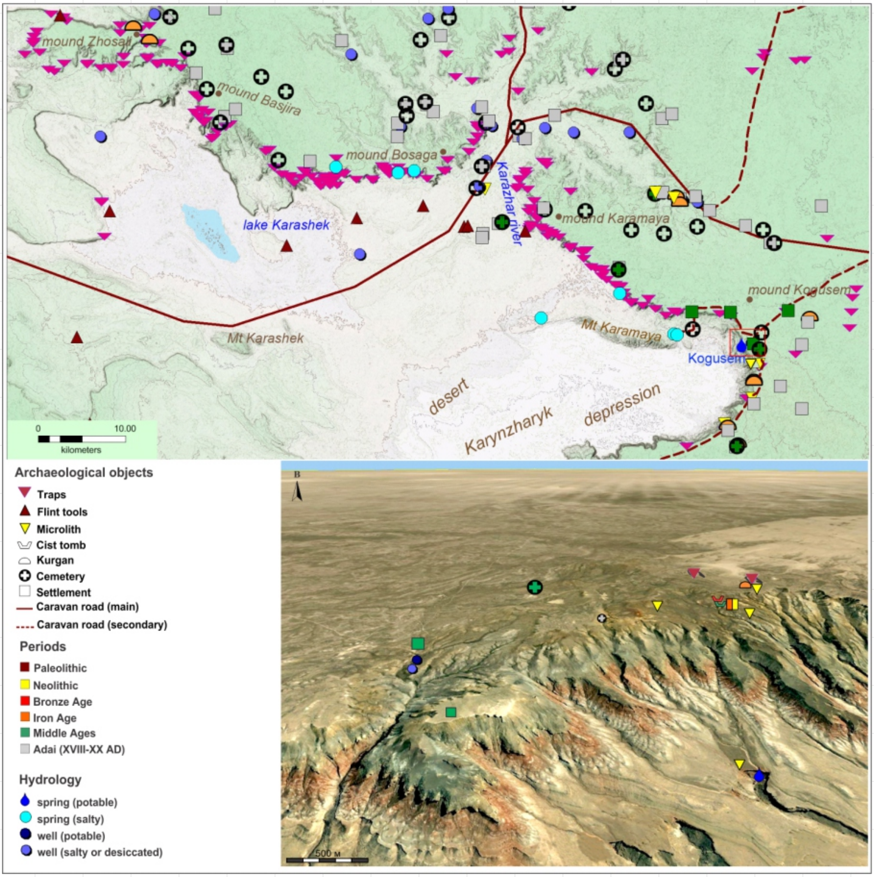


**Fig. 3 - Hydrology and monuments around the well of Kogusem in Southwestern Ustyurt (satellite-map, Deom, 2014)**

**Fig. 4 - Ancient well of Kogusem (SW Ustyurt)**

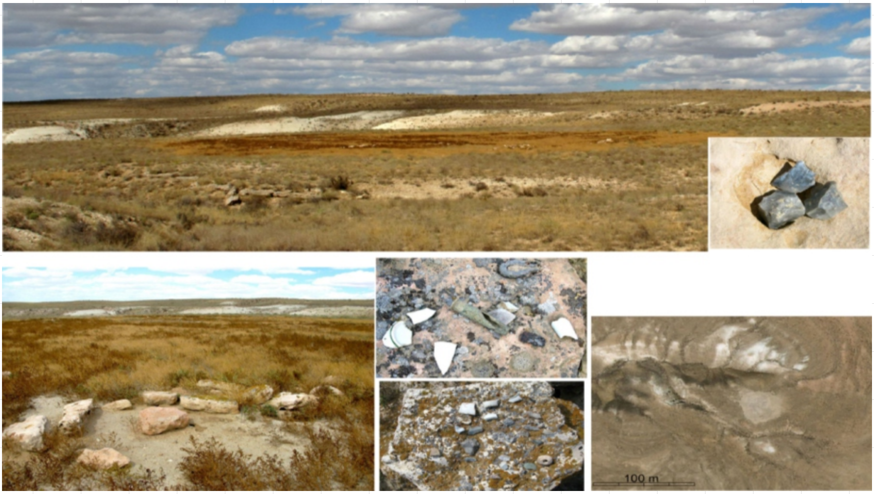


**Fig. 5 - Seasonal camps of hunter-pastoralist communities above the chink of Karamaya (SW Ustyurt)**

**Fig. 6 - Ancient wells of Karagan-Bosaga (N Karynzharyk desert)**

# II
# KYZYLKUM DESERT AND THE LEFT SYR DARYA DELTA

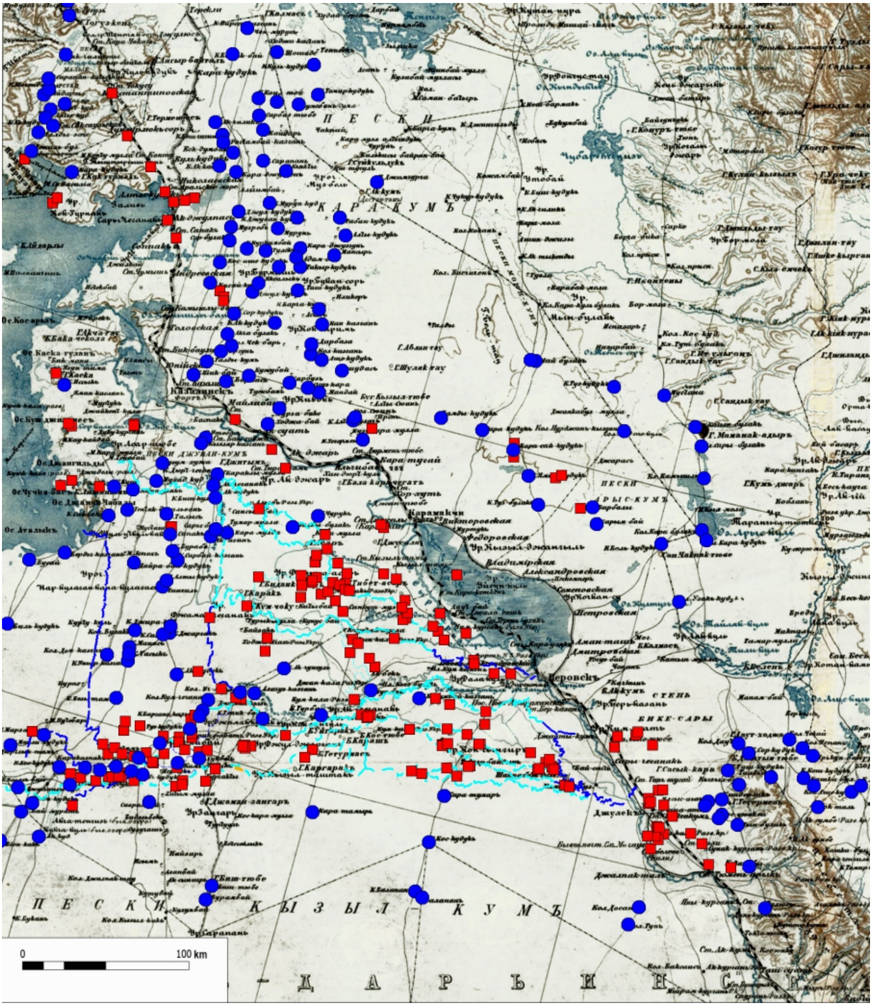


**Fig.1- Map of the archaeological monuments (red square) and main active wells in the territory used by agro-pastoralist communities of the right Syr Darya delta (map of 1910)**

# 2.1- HISTORICAL SURVEY OF IRRIGATION PRACTICES IN WEST CENTRAL ASIA

CONTENTS



## INTRODUCTION

The present article provides a general reconstruction of the historical development of irrigation practices in Western Central Asia, based on existing documents: archaeological reports, theoretical interpretations, contributions from related fields (geology, culturology, linguistics, anthropology). The aim is to provide a background of information for the planning and implementation of further research on the subject. In particular the article is intended to help the study of the irrigation practices that developed during the last 2500 years along the middle course of the Syrdarya, namely in the oasis of Otrar at the confluence between the Arys and the Syrdarya rivers. The text contains references to an alleged bibliography.

The first scientific attention to the existence of the medieval monuments of the Otrar oasis was given in 1898 by IT Poslavskii and was followed by the first excavations of Lykoshin in 1899 and of Klare and Cherkasov in 1904 (Klare&Cherkasov 1904), all members of the 'Amateurs Center of Archaeology of Turkestan'. The first systematic survey of the area was done during the years 1947-51 by Bernshtam, Patsevich and Ageeva, who dated the main tobe of the Otrar oasis by ceramic styles, in the context of a large survey of the monuments of the middle course of Syrdarya, of its tributary Arys and of the southern Karatau valleys (Bernshtam 1951, Ageeva&Patsevich 1958). In 1959-63, Levina, Maximova, Vainberg and Mershchiev provided survey and documentation of the medieval towns of the Chardara oasis, on the left bank of the Syrdarya 70 km south of Otrar (Maksimova et alia 1968; Levina 1971).

The archaeological study by extensive excavations of the Otrar oasis started only in 1969 under the direction of Akishev, Baipakov, Erzakovich, mainly focused on the urbanistic aspects of the upper layers of the tobe (Akishev et alia 1972). Through different phases the works went on until today (Baipakov 1986, 1990): the main medieval towns (Otrar, Kuiruktobe, Altyntobe, Kujruk-Mardan, Kok-Mardan) have been studied together with some small tobe, villages, tombs and few parts of the irrigation system. During the 70's some surveys were dedicated to the study of the prehistoric epochs of the region and brought to the

the discovery of Mesolithic artifacts in the northeastern boundaries of the oasis and of neolithic artifacts within the area of the oasis itself (Alpisbaev 1980).

The middle Syrdarya, with the Otrar and Chardara archaeological expeditions of the 60's, represents the last of the large irrigation zones of western Central Asia to be researched. By that time the other main irrigation zones of Central Asia had been already studied.

In the context of the study of the Otrar oasis of the last 30 years, the archaeologist V Groshev analyzed the evolution of the medieval irrigation system and of the agricultural techniques in use. He individuated 5 generations of irrigation schemes; he correlated them with ceramics and cultural layers of proximate towns; and studied the size, form and function of some hydrological devices (Groshev 1985, 1996).

The study of early irrigation devices evidently requires the reconstruction of the paleo-geomorphological and hydrological features of the territory: Groshev just attempted such a geo-archaeological approach and suggested a qualitative reconstruction of rivers behavior during the last 2000 years as well as of some traits of the paleo-landscape and of the land reclamation potential under successive technological schemes (Groshev 1976). In his book "Early irrigation in South Kazakhstan' he gives a hand-made reconstruction of the genesis and development of the irrigation schemes in Otrar oasis. He analyzes only superficially the geo-hydrological features of the whole territory, arriving anyway to suspect the progressive shrinking of the Arys delta. He individuated the irrigation schemes by surface and aerial surveys and arrived to distinguish one primitive phase of simple devices followed by four phases of large irrigation plans. The first phase, at the beginning of the Christian era, of early agricultural practices without irrigation or with primitive basin-irrigation technique, has only been hypothesized. The second phase (III-VII AD) of early catchment-irrigation has only been suspected in the western part of the delta following the discovery of a few small ancient tobe (but not of the related canals). The irrigation schemes of the 3º and 4º phases (VII-IX and X-XII AD, Turkic period) and especially those of the 5º and 6º phases (XIII-XVII AD, Mongol, Timurid-Early Kazakh periods) are the most detectable on the surface and the only ones that have been extensively investigated: canals have been studied in their sizes, branches, lattices and their chronological correlation with the stratigraphy of the big towns; but the whole scheme has been neglected. The 7º phase of Russian rehabilitation of the oasis has not been object of any investigation.

The data provided by Groshev, based on findings clearly visible on the surface and by aerial photography and trial trenches, is convincing but poorly documented with hand-interpolated figures. The reconstruction of the earlier phases is particularly weak; and seems to be more extrapolated from former studies of other irrigation systems of the Central Asian flood-plains, rather than based on archaeological and geological data collected in situ.

The INTAS project "Geo-archaeological investigation of land-use and irrigation works in Kazakhstan in present and in historical times", which worked in the years 2002-2004, was supposed to be the continuation of the researches of Groshev. The first objectives consisted in providing the geo-environmental investigation, documentation and modeling necessary for the verification of the former reconstruction, the study of the earliest and final phases of the oasis, and the consideration of unexplored aspects of the subject pertaining to the fields of paleo-geography, praxeology and agricultural technology, economy, sociology.

# 1 - HISTORY OF IRRIGATION SYSTEMS IN WEST CENTRAL ASIA (5000 BC-500 AD)

## 1.1 - Geo-hydrological and archaeological background

Central Asia is the land of interior drainage of Eurasia, covering a large territory going from Kazakhstan and Turkmenistan on the west to Mongolia and Tarim on the east (Tibet being sometimes referred as Inner Asia). ***West Central Asia*** is its western part (see Map), consisting of the Kazakh steppes and mountains on the north and of ***Middle Asia*** (also called West Turkestan) on the south, i.e. the desertic floodplains (Turania) and their surrounding lakes and mountain ranges (Caspian sea and Kopet-Dag, Pamir, South Tienshan). The process of progressive aridization of the region started in the middle Pleistocene and continued up to the present, interrupted by occasional minor fluctuations to moister phases. Referring to the Holocene, a first wet transgression happened between the sixth and the fourth millennium BC: it built lacustrine landscapes and human niches in areas where before only cold deserts existed and today only hot deserts and takyr formations (Stamp 1961, Aubekerov 2002). Moister transgressions of lesser dimension happened between 1400-1000 BC, 600-250 BC, 900-1200 AD and 1600-1800 AD.

**a -** Concerning Middle Asia, its orography and climatic conditions make that ***dry farming*** can only be implemented in a narrow band of the middle mountain zone (between 800 and 1700 m) of the Kopet-Dag, Pamir and Tienshan ranges, where precipitation happens mainly in the form of rain, averaging yearly 500-700 mm and peaking during winter and spring. The first appearance of mix-farming settled communities in this mountain zone is quite difficult to date, but most probably already started during Eneolithic times: on the Kopet-Dag before 5000 BC; on the other mountain ranges much later, around 2500-2000 BC.

Even in desertic lowlands with yearly precipitation averaging less than 50-100 mm, basins seasonally moistened by floods exist along the lower course of small piedmonts streams and around mild distributaries of deltas of the large rivers. these lacustrine landscapes have been inhabited by Neolithic communities from the V millennium BC (Kelteminar cultures). Possibly in these flat zones simple farming activities, such as sawing seeds in freshly deposited alluvium after the evacuation of flood waters **(*kair farming*)**, were already carried out by semi-nomadic groups that through their mobility adapted to the yearly variations of water resources (Lewis 1962)

In spite of the arid climate of the Turanian plains, the surrounding high mountain ranges of Kopet-Dag (max 2900m asl), Pamir (max 7000 m) and Tienshan (max 7000 m) act as collectors of precipitation, mainly in the form of snow and ice, that is discharged by few rivers across piedmonts and desertic flood plains down to interior reservoirs. Perennial and seasonal streams, with peaking regimes in spring and summer, provide water sufficient to the reclamation of vast areas for agriculture, making the irrigation potential of Middle Asia very high.

The rivers of the region have water regimes very unstable with relevant yearly and seasonal anomalies, switch of water distributaries and abrupt transgressions, requiring very peculiar skills for the implementation of irrigation works. In spite of such difficulty, in Middle Asia ***irrigation practices*** have been introduced very early, evidently because their high profitability in such environmentally arid conditions: they are precondition of the very existence in loco of human life because they are the only way to allow agricultural works and

have a high land reclamation potential. Their appearance coincides with a huge expansion of the area of human habitats, a sudden enormous demographic growth, social transformations and, as a whole, sign a historical change of primary importance.
The first small irrigation schemes appeared earlier than the V millennium BC in the Kopet-Dag, as a work of few thousand farmers. By the second half of the II millennium BC irrigation practices diffused and rose the number of the population concentrated in few large farming oases to half of the whole Turanian population, the other 50% being constituted by pastoralist communities that expanded in the steppes of the region during the same time (Lewis 1962, Gerasimov 1978); with the XX century AD they constitute the basis of an economical system of more than 25 million people.

**b -** The scientific results of the geo-archaeological studies implemented till now suggest a basic typology of lands and water resources, based on geo-hydrological considerations:

- 4 kinds of streams fed by different water sources: ***water deposits*** (springs, ice) or ***precipitation*** (snow, rain). Streams fed by springs and ice, i.e. depending on stored waters, are characterized by stable water discharges through-the-year and year-by-year and by non destructive transgressions: their stability makes them of easier and earlier exploitation. Streams, when fed by snow and even more when by rain, depend on climatic conditions of which fluctuations make tremendous differences of discharge through-the-year and year-by-year together with destructive mudflows: their control requires more people and higher skill and happened later in time. Each case and each combination of cases present different hydrological conditions and require different irrigation techniques.
- 2 kinds of irrigated landscapes: along ***piedmont streams*** and around ***lowland river deltas***;

Most of the water courses of Middle Asia are snow-ice fed and, because the progressive regression of ice volume in the mountains, show during the Holocene the tendency to the diminution of their water regimes. This process accelerated after 2000 BC; and then again during the first millennium AD when a catastrophic ice retreat in the mountains and a fall of river regimes happened and never recovered.
Rain-fed streams, instead, are totally dependent on yearly climatic changes and show very unstable behavior. In both cases a sound paleo-climatic reconstruction is a necessary reference for the understanding the development of agricultural activities on very vulnerable arid zones like Middle Asia (Sala 1991; Aubekerov et alia 1992, 1993)
In the time-interval going from the V to the I millennium BC, in Middle Asia, all the river segments characterized by profitable irrigation potential, became concerned by irrigation works. Classified as piedmont and floodplains rivers, they are quoted here below together with their hydrological features, approximate dating of the first extensive irrigation works, and with the names of the scientists who first discovered and studied the archaeological traces of irrigation (Kohl 1984).

<u>Piedmonts streams</u>

- Kopet-Dag streams: spring-fed, max flow in spring, min in January. Irrigation (5000 BC) discovered and studied by Masson. They have small and stable water discharges, easy to control, and so hosting the sites where the first irrigation practices are documented. Analogous hydrological features are also found in the Nuratau and Karatau ranges and partly in the Fergana valley. In all these places, during Medieval times, also ground-waters have been exploited by creating artificial springs through underground water devices (karez) (Sala 2003)

- Nuratau range streams: spring-fed, max flow in spring, min in January. Irrigation (1200 BC) discovered and studied by Gulyamov.
- Fergana streams: snow and ice fed, max flow in July. Irrigation (1500 BC, pre-Chust culture) discovered and studied by Bernshtam and Latynin. They coexist with numerous streams spring and rain fed.
- Hissar streams (Surkan-Darya and Kafirnigan rivers): snow fed, max flow in June, min in January. Irrigation (800 BC) discovered and studied by Dyakonov.
- Usrushana streams: snow and ice fed, max flow in July, min in December. Irrigation (600 BC) discovered and studied by Negmatov.
- Kaunchi-Karatau streams (Churchik, Keles, Arys, Karachik, all right tributaries of the Syrdarya): the first two are snow and ice fed, max flow in July, min in December; the last two are spring and rain fed. Irrigation discovered and studied in the region of Tashkent (400 BC) by Terenozhkin, along the Arys river (100 BC) by Podushkin, in Southern Karatau (Turkestan oasis) by Lab of Geoarchaeology of Almaty (Sala, Deom).

Lowland streams and deltas

- Murghab and Tedjen deltas (Margiana): rain fed, max flow in May, min in August. Irrigation (2200-2000 BC) discovered and studied by Masson and IsIAO. Both deltas lose their waters in the desert floodplains. They present the most unstable water regimes among the big rivers of Middle Asia. The Tedjen, most irregular, carried 26 $m^2$/sec in 1925 and 1000 $m^2$/sec in 1956. Similar features characterize the rivers of Dahistan (Atrek, Gorgan) and the ones of southern Bactria. The Murghab delta is the one where have been implemented the first large scale and perennial reservoir irrigation systems.
- Dahistan streams (Atrek, Gorgan): rain fed, max flow in May, min in August. Irrigation (1200 BC) discovered and studied by Masson. Most unstable water regimes.
- Northern Bactria (Surkhandarya) and southern Bactria (Balkhab, Kunduz): snow fed, max flow in June, min in January. Irrigation (2000 BC) discovered and studied by Dyakonov, Kabanov, Sarianidi, Askarov.
- Kashka-Darya delta (Hissar): snow fed, max flow in June, min in January. Irrigation (300 BC?) discovered and studied by Dyakonov. The delta loses its waters in the desert floodplain. The region is poorly studied and irrigation possibly started as early as in northern Bactria.
- Zerafshan river delta and middle course (Sogdiana): snow and ice fed, max flow in August, min in January. Irrigation (1800 BC on the delta, 1200 BC on the middle course) discovered and studied by Latynin, Terenozhkin, Besenval. The delta distributaries, very irregular, dry out 30 km before reaching the Amudarya.
- Amudarya with its Akcha-daria and Sarykamysh deltas: snow and ice fed, max flow in July, min in January. Irrigation (Akcha-darya 1300 BC, Sarykamysh 600 BC) discovered and studied by Tolstov, Andrianov, Ittina. The Amudarya is the most muddy and transporting river, with average water discharges of 2000 $m^2$/sec at the exit from mountains, 500 $m^2$/sec lost in evaporation and all the rest today lost in irrigation practices

- Syrdarya with its Kuvan-daria and Zhana-daria deltas: snow and ice fed, max flow in April and July, min in December. Irrigation (700 BC) discovered and studied in the delta by Tolstov, Andrianov, Levina. The Syrdarya forms the most ill-defined flood plain submitted to relevant holocenic swifts of meanders and distributaries. The middle course is interested by the first irrigation works around 100 AC (Chardara, Otrar)
- Semirechie streams and deltas (Talas and Chu). Snow and ice fed, max flow in July, min in December. Irrigation (200 AD) discovered and studied by Senigova, Kozhemyanko. Both rivers form delta losing their waters in the alluvial-aeolian plains of the Moinkym desert. They have been exploited during different periods along their mountain and middle course as well as along delta distributaries.

**c -** An early stage of agriculture in West Central Asia has been most probably implemented during the Neolithic period without any sort of earthen works, by the exploitation of natural fluctuations of water levels around fading distributaries and ponds, i.e. by seeding plants on lake and stream shores during the season of naturally retiring flood water (kair).

Beyond that stage, the development of agriculture is strictly connected with the introduction and improvement of irrigation techniques, which proceeds through ***four hydraulic phases*** of growing technical complexity, labor investment and social stratification, more or less correlated with 4 historical periods. The first phase consists of the implementation of just field embankments and eventually short canals; the second of long canals and water reservoirs; the third of the integration of small irrigation systems into a large one by construction of upstream trunk canals; the fourth phase consists of the optimization of the existing system by introduction of several new kinds of devices: uplifting devices, better distribution lattices, and technical responses to siltation, salinization and soil depletion.

- ***The first phase*** (5000-2000 BC) sees the appearance of simple piedmont irrigation schemes on the low course of the northern Kopet-Dag streams. The technology, *flood-catchment* by *basin irrigation,* is the most simple: it consists of using seasonal floodwaters of mild streams into depressions provided with artificially embanked fields (where embankments play the double role of protection from freshets at the start of the flood and of preservation of soil moisture after its end). Eventually mild pre-mountain brooks were dammed in order to catch scarce freshets, and water was distributed to neighbor depressions by small artificial canals (*basin-to-basin irrigation*), a kind of transitional stage towards the successive technological phase.
- ***The second phase*** (2000-700 BC) sees the spread of irrigation practices on the Pamir and Tienshan piedmonts along the low course and delta of small streams and on peripheral distributors of the deltas of the main rivers of Central Asia (Tedjen, Murghab, Zerafshan, Amudarya, Syrdarya). These streams, having strong flows and floods difficult to control, required the introduction of a new device between flood waters and fields: a *reservoir* of backwater, from which the name of *reservoir irrigation* or better, due to the impermanent character of flood water, *seasonal reservoir irrigation* .

  It consists in the catchment of water into semi-artificial or artificial water reservoir for controlling the flood as well as for stabilizing the provision of water. To that reservoir is applied one or more canals or canal heads (for different water levels) and then water is distributed to fields by simple rectangular lattices. Several technical steps of water catchment are distinguished. At first the mild waters of fading lateral delta distributaries are artificially directed into relic courses playing as reservoir (a very simple reservoir irrigation scheme that will characterize the irrigation works of the Syrdarya delta during all periods). Then dry river beds are turned into large canals for transporting water to the reservoir from more distant and more active streams. And finally large canals are built anew, mainly reproducing natural hydrological patterns, together with a complex system of artificial banks, dams and reservoirs in order to regulate erosion and siltation of canals and protect canal-heads. Concerning fields, around the 10-20% of the potentially irrigated parts of the oasis are yearly concerned by irrigation and cultivation.

– ***The third phase*** (700 BC-1200 AD) sees the development of the former technology by the integration of several separated schemes into a large irrigation system, which eventually brings to the total domestication and substitution of large parts of the natural river system. For that purpose a large trunk canal is built upstream of several small schemes with the head applied to the main river course, together with a complex system of retaining dams, protective banks and reservoirs and several canal heads in order to catch different water levels. In that way the reservoir irrigation definitely develops from seasonal to *perennial*, thanks to the perennial regime of the main river course to which the system is applied. Concerning the distribution of water, also the lattice of distributors to fields develops from simple rectangular type to more sophisticated branching forms adapted to the relief and enhancing the effective use of water by its intensive distribution on compact areas, by canals characterized by lesser width, sloping, erosion and siltation. The water excess is finally directed by collectors to neighboring depressions or floodplains. Such technology brings on one side to the integration of several former independent oases into large agricultural areas, and on the other to intensive land use and relative reduction of non-cultivated parts of the potentially irrigated surface (from 90% down to 60%).

– ***The fourth phase*** (1200-1500 AD) sees the appearance of new technical and political skills based on complex monitoring, planning and implementation of irrigation schemes and agricultural fields. A well planned system of dams, banks, reservoirs, canals and collectors is realized in order to optimize water distribution and diminish erosion, siltation and salinization; uplifting devices are introduced, coupling the former gravity-irrigation schemes and allowing the watering of elevated areas; crops are selected in compatibility with water facilities. Moreover the building of a new trunk canal allow to rotate or displace an entire irrigation system to neighbor lands, as regulation to the exhaustion of the former irrigation scheme not just by external climatic anomalies but also by the structural geomorphological and pedological effects of its prolonged use.

**d -** Summary reports on the results of the archaeological study, up to the 60ies, of the hydraulic complexes spoken above are provided by: the article 'Early irrigation in West Turkestan' (Lewis 1965), which provides a chronological reconstruction of the whole evolution of irrigation techniques from 4500 BC to 700 AD; the work of Kohl on the cultures of Kopet-Dag, Margiana, Bactria and Zerafshan from prehistory until the Late Bronze age (Kohl 1984); the “History of Civilizations of Central Asia, vol. 1” analyzes the subject down to Early Iron (Dani, Masson 1992). Surprisingly none of these reports consider the Middle Syrdarya cultures: about that region the only summary compilation is represented by the volume 'Srednie Asia rannem srednievekove. Archeologhia SSSR” (Ribakov 1999).

### 1.1 - First phase (5000-2000 BC): from Neolithic to Early Bronze Age

Everywhere, and particularly in arid zones, the implementation of irrigation practices entails a sudden rise of demographic levels, due to the increase of human fertility provoked by sedentary habits and the increase of productivity provoked by intensive irrigation agriculture. For these reasons irrigation practices constituted the precondition of the development of social complexity and stratification, proto-towns, civilizations, epidemics and wars. All together these innovations always constitute a major turn in the history of the territory concerned. In Central Asia the phenomenon, already relevant when applied to small piedmont streams (first phase), becomes extremely significant when applied to the flood-plain of river deltas because here it manages huge water volumes and encounters a huge potential of land reclamation (second phase). This second step manifests at first on the Murghab delta (2000 BC) and then on all the main deltas of Central Asia.

The artificial distribution of riverine waters to fields by ***canal-fed artificial irrigation*** systems started at first in sites where some basic favorable conditions were provided: the low course of small but permanent streams with mild controllable perennial flow; geomorphological features favoring an easy water catchment and diversion together with a good potential of land reclamation; pre-existence of dry farming practices upstream in the mountain valley of the same river; location in areas of easy cultural contacts with earlier irrigation centers.

These conditions, around the end of the VI millennium BC, are provided by the lower courses of all the small piedmont streams of the northern **Kopet-Dag**: dry agricultural practices already existed upstream in the valleys (a rich neolithic pre-Namazga culture is dated back to the VIII millennium BC), and so interconnection with the cultures of the northern Iranian plateau. In fact it is in that kind of hydrological and cultural environment, for the precision around Dzheytun, on the low course of a small spring-fed stream, that have been discovered the oldest traces in Central Asia of a sedentary village (0.7 ha) supported by irrigation works, dated earlier than the V millennium BC. More than 20 other Dzheitun-style villages have been discovered in the region (Togolok, Anau-Ia) and an equivalent number along the Kopet-Dag piedmont corridor 150 km west and east, plus an indefinite number of villages still buried under the 6-9 m sediment layers of the piedmont band. In this site, at the beginning of the V° millennium BC, a primitive form of irrigation agriculture appeared (***basin irrigation***), thought it is unclear whether this phenomenon originated independently from the local cultural substratum or under influences coming from the Iranian plateau where primitive wet farming practices are dated back to the VII millennium BC. The water flow of small permanent springs was channeled by artificial ditches along commanding features of the terrain, and allowed the transport of water across the village and down to a large natural depression where agriculture was practiced. Crop areas were surrounded by embankments and watered by canals; areas over-watered were dried up by collectors; the natural deposit of alluvial silt provided regular soil fertilization; seeds were probably sown with minimum labor when the ground was still moist (Masson 1957, 1981; Sarianidi 1992).

By the end of the IV millennium this primitive irrigation scheme has been applied to most of the small piedmont streams of the Kopet Dag, from Kizil-Arvat in the west to the Geoksyur oasis on the east. Settlements multiplied (Kara, Namazga I-II, Anau Ib-II, Dashlidji), some reaching 10 ha and showing well developed local characters. Irrigation practices diffused upstream applying to the main river course through improved catchment devices like small dams and reinforcement of natural basins ***(basin-catchment irrigation)***. From there channels 3 km long were feeding the surrounding natural and artificial depressions. The sloping gradient favoured agricultural terracing.

During the III millennium settlements (Namazga III-IV, Anau III, Altyn, Yassi) grew in number and size (Namazga up to the 30 ha), witnessing a significant increase of population, engineering skills (some attempts of low-plain irrigation), land reclamation. The process was accompanied by urban concentration, fortifications and development of commercial exchanges of row materials and objects between agricultural oases and also periodically with north Iran (see below par 2.1) (Kohl 1981; Masson 1992).

### 1.1 - Second phase (2000-700 BC): Mid-Late Bronze Age

The II millennium sees the start of the second phase of evolution of the irrigation systems in Central Asia, characterized by their diffusion to other piedmont regions and, thanks to technological development into perennial irrigation systems, by their application to other hydrological landscapes like river deltas and floodplains.

**a -** The earliest manifestation of irrigation activities beyond the Kopet Dag (eventually together with physical displacement of human groups) happens on the piedmont courses of small streams of the Pamir mountains (Kafirnigan) (Dyakonov 1953; Kabanov 1956) and Western Tienshan (Nuratau, Fergana, Urushana, Kaunchi-Karatau) (Latynin 1957; Terenozhkin 1950; Negmatov 1953), differently dated situ by situ from the beginning of the II to the beginning of the I millennium BC.

Surprisingly, synchronically with this spread of wet agriculture on other piedmonts, irrigation practices on northern Kopet-Dag sharply decline and large settlements are reduced to villages (Namazga during phases V-VI contracts from 50 to 2 ha). Several factors have been suspected behind this process: climatic and environmental changes towards a dry phase; conflicts between settled farmers and semi-nomadic pastoralist communities that by the end of the III millennium BC started to colonize the Central Asian steppes (Biscione 1977; Masson 1992a); the improvement of transports (wheeled chars and horse riding). A better explanation is that by the time the Kopet-Dag cultures developed sufficient population and hydraulic skill to implement more powerful schemes and to control, through a new generation of hydraulic devices, the water of bigger and wilder rivers flowing across larger plains and huge land-reclamation potential (***large scale irrigation***). Climatic and technological factors are not excluding each other and the colonization of the deltas of the big rivers that followed has been surely compelled by the progressive shrinking of the water discharge of most of the rivers (mainly snow-ice fed) due to the diminishing of ice deposits in the mountains. New irrigation centers developed on the eastern and western boundaries of northern Kopet-Dag where the right preconditions were provided: respectively along the Murghab and Tedjen deltas in Margiana and the Sumbar and Atrek rivers in Dahistan. In both cases we are in presence of agricultural complexes provided of proto-towns and military defenses, witnessing large scale management.

**b -** The regulation of the **Murghab** river and of the Tedjen 100 km west of it (Margiana) started with the II millennium BC from the northern final distributaries of the delta where the water flow was milder and much easier to control. The Murghab, of lesser drainage but also of less irregular behavior, offered the best possibilities and represented the first large delta to be extensively put under control. There appeared the oases of Kelleli, Gonur, Togolok-east (2200-1700 BC) with walled towns surrounded by many fortified and non fortified villages. Then, together with the shrinking of the delta, the system developed upstream with the construction of trunk canals 50 km long and laterals serving an area of 20x40 km. By the half of the I° millennium the irrigation practices shifted definitely upstream (Merv) where waters were more abundant and were controlled and caught by a dam and perennial reservoir ***(perennial reservoir irrigation)*** built across the main course of the river (Masson 1956; Gubaev et alia 1998).

The Murghab irrigation system crossed several crises but had a longstanding activity. It had been destroyed by the Mongols in 1221 and restored under Timurid rule during the XV AD, but never regained its former prosperity. Then the Russian colonization provided again the oasis with irrigation schemes quite similar to the ones realized by the end of the I millennium BC.

The basic features of the irrigation patterns applied to the Murghab waters are the following:

- they apply to a river delta landscape; they start from disused or receding water distributaries;
- they gradually switch upstream a tendency inherent to the evolution of the irrigation system in itself, due to the forcing of drying trends and the improvement of technical capacities;
- they apply canals to perennial reservoirs in order to provide water all along the growing season.
- they require seasonally a large labor investment and so the management and tight control of a large population

These general features will characterize also the hydrological works that will be applied a little later to the deltas of the other large rivers of West Central Asia.

The irrigation system developed on the Murghab delta represents an historical turning point in the development of irrigation practices. It definitely witnesses the existence in Central Asia of social and technological capabilities to exploit zones with wide irrigation potential, which means the wide lowlands surrounding the deltas of large rivers: Balkhab, Kunduz and Surkhan-Darya, Zerafshan, Amudarya, Syrdarya, Arys, Talas and Chu. As such, the event constitutes the first step towards the enormous increase of land reclamation, agricultural productivity, population levels and social organization that happened in Turania during the following 1000 years.

**c -** To the east, in **Dahistan** (Sumbar, Atrek, Gorgan rivers) have been found remains, dated to the end of the II millennium BC, of man-made *trunk canals* 60 km long, branching trough *laterals* into a complex irrigation lattice that follows the edges of the natural distributaries of the local deltas (Masson 1955).

**d -** To the east, with the start of the II millennium BC, irrigation centers appear in the desert oases of **east, south and north Bactria**. In the far east, the proto-town of Shortugai, after an early start around 2500 BC showing clear similarities with the Indo cultures (Harappa), enters around 2000 BC a second period characterized by Murghab influences (Francfort 1989). At that time, in the south, the oasis of Dashli develops along patterns similar to the ones adopted in the Murghab oasis (Sarianidi 1977). The same happens in the north, on the alluvial plains of the delta of the Surkhan-Darya that, with the beginning of the II mil BC, start to be transformed into an irrigated landscape (Dyakonov1954). Bactria and Margiana, because their strict cultural similarities, are said to constitute, between 1900 and 1700 BC, the Bactrian-Margiana Archaeological Complex (BMAC) (Askarov&Abdullaev 1983; Hiebert 1994; Ligabue&Salvadori 1990).

**e -** On the delta of the **Zerafshan** river, which loses its waters in the desert on the right side of the Amudarya 200 km NE of the Murghab oasis, it is during the beginning of the II millennium that disused water beds and receding distributaries have been managed by 'basin type' irrigation practices. Archaeological findings attribute the works to an aboriginal culture intermixed with elements coming from the Kopet-Dag region (Mukhamedzhanov 1978).
During the same period also the waters of intermittent tributaries of the upper course of the Zerafshan in the Samarkand region implemented small irrigation systems of dams and canals that, by the end of the II millennium, improved and were applied to the middle course of the Zerafshan itself (Bernshtam 1949; Latynin 1957, Terenozhkin 1950, Besenval 1989). From that moment the two regions, the delta and the middle course of the river, represented the most profitable points of irrigation agriculture in the Zerafshan basin, in potential rivalry for the share of waters. Both systems degraded during the Late Middle ages but had been active until the Russian colonization.

**f -** The delta that (considering its dimensions and hydrological features) saw, if not the first, surely the largest development of irrigation schemes was the one of the **Amu-Darya**, more precisely its eastern side, the ***Akcha-Darya*** delta. The area was already populated from Neolithic times by mobile farmers practicing non irrigated agriculture (eventually "kair" farming). Then, when during the second part of the II millennium the delta began to dry by the switch of the Amudarya's main distributaries to the south and to the west, it saw the first appearance of practices of water management. They consisted in the catchment and distribution of flood waters at first from small terminal distributaries, then, following the receding water discharge, from distributaries diverging more upstream. During a first phase disused river beds where dammed and used as collectors of seasonal floods; from there water overflowed through short ditches into small agricultural basins 0.5 ha wide surrounded by low embankments. Then also secondary sinking and silted distributaries were reactivated and transformed, through subsequent dredging, into flow-fed canals following the edges of the banks of the dry course. A second phase (Amirabad culture, IX-VIII BC) introduced relevant improvements consisting in damming much larger upstream delta branches, digging longer and larger canals completely artificial (1 km long and 10 m wide) and watering agricultural basins of 150 ha. By the VII century BC, the apex of the Akcha-Darya irrigated agriculture, trunk canals are directly applied to very active courses and run parallel to it for 20 km with laterals 10 km long and a potential of land reclamation of 20000 ha. (Tolstov 1948; Andrianov 1957; Academia Nauk SSSR 1960; Itina 1977; Askarov 1992).
These last hydraulic implementations realized on the Archa-darya delta constitute the prototype of the technological improvements that will be extensively introduced during the following third phase of irrigation systems.

### 1.1 - Third phase (700 BC- 1200 AD): from Early Iron to Mid Middle Ages

Within the first half of the I millennium BC all the deltas of the main rivers of Central Asia are already provided of small and large-scale irrigation systems. The period also coincides with the start of a third phase in the evolution of the delta irrigation schemes, characterized by the restructuring of former systems through their migration upstream for catching active waters rather than flood waters from the course of permanent distributaries. The forcing factors underlying the process are of natural hydrological character as well as technical and social

**a -** During the Iº millennium BC both the Amudarya and Syrdarya deltas show relevant changes: changes of course, the Amudarya having the tendency to switch to the NW and the Syrdarya to the N; and progressive diminution of water regimes in some parts of the delta of which the flow reaches critical levels around the beginning of the I millennium BC. The events provoke the collapse of former irrigation systems with depopulation of the region and displacement of irrigation practices and people on new segments of the river. During the late forties and fifties, two Soviet archaeologists, Tolstov and Andrianov, studied the Early Iron and Medieval archaeological complexes of the Amudarya and Syrdarya deltas together with the technical features of the irrigation system implemented. They point out very clearly the correlation between migration of water courses on one side and evolution of hydrological schemes on the other, with a study that represents the first and yet unsurpassed documentation of such an ancient interactive process. The scientific results show that human activities were affected by hydrological changes; and that also determined such changes, with water courses domesticated by the building of irrigation schemes or dislocated by their sudden abandonment. Both natural and anthropogenic factors operated: the first exogenous and independent (natural changes of climate, tectonic and sedimentary changes of river courses); the second endowed with retroactive nature and with abrupt non-linear effects (water diversion, anthropogenic siltation, upstream evolution). Altogether these factors conditioned the structural features of the irrigation systems: their planning, sustainability, maintenance costs and resistance.
Following the authors, around half of the Iº millennium BC, a technological restructuring happened on the Archadarya, which favored a peak of optimal development of the whole region between the IV BC and the II AD. As a whole in the 2 deltas a total of 2 millions hectares were irrigated, half of which with simple seasonal reservoir irrigation schemes, the other half with permanent reservoir schemes (4 times the area currently under permanent irrigation). The areas of semi-permanent basin irrigation were mainly located on the Syrdarya delta, managed by populations based on mix-farming-pastoralist economy and semi-nomadic habits. Areas with permanent reservoirs irrigation were located by the 70% on the Amudarya, managed by settled farmers practicing an intensive type of agriculture. In irrigated areas the rural population density could have been roughly between 20 and 40 people x $km^2$, reaching along the main canals the 150 persons x $km^2$ (Tolstov 1962).
The development of irrigation techniques happened differently in different hydrological and political contexts.

**b -** On the **Akcha-Darya** delta the shrinking of the distributaries, which between the XII and the V BC promoted the genesis and the evolution of the irrigation practices, by the V century BC reached a proportion that discouraged further improvements and compelled to the abandonment of the region. The irrigation activities moved to some adjacent areas: on the north in the swampy region where the Amudarya and Syrdarya deltas intermingle (**Inkardarya-Janadarya**); on the south in the region of **Turtkul**, in the west on the **Sarykarmish** delta. (Tolstov&Andrianov 1957; Academia Nauk SSSR 1960)

Around the VII-V BC irrigation schemes appear in the very north of the Akcha-Darya, where some dry courses of the Amudarya were flooded by the waters of southern distributors of the Syrdarya delta (*Inkar-Jhana-Darya*) realizing a slightly undulated lacustrine landscape. At the beginning of the Iº millennium AD the area saw the construction of large canals 13 km long and 20 m large. The ceasing of the flow of the Jhanadarya caused the abandonment of the area by the V AD.

During the same period, at the head of the Akcha-Darya delta near the town of *Turtkul*, a new irrigation oasis was built by catching waters directly from the main course of the Amudarya with three large trunk canals running diagonally from it. The irrigation system of the oasis, abandoned by the V AD, has been reconstructed only recently during the Soviet period through schemes quite similar to the early medieval ones.

Another irrigation oasis grew on the western side of the Amudarya delta, more precisely on the final branches of the *Sarykarmish* delta: geomorphological and hydrological similarities made that this irrigation system developed between the VI BC and the V AD across the same phases that characterized the evolution on the Arkha-Darya system between the XII and the V BC. The following history of the Sarykamish irrigation system clearly depends from political factors. It started to decay under nomadic invasions in the V AD and was abandoned during the VIII AD. The eastern part of the system recovered for a short time during the XII century, just before to be destroyed by the Mongols. After that, only the narrow easternmost area nearer to the main course of the Amudarya had been exploited under Timurid rule and during subsequent times.

**c -** Between the VII and the V century BC the start of irrigation practices characterized by the second technological phase is documented on the **Syrdarya** delta, along the middle course of two of its main distributaries: the ***Inkardarya*** and ***Jhanadarya*** deltas in the south, of which the final distributaries at the time already showed a shrinking tendency and were partly fed by the waters of the Archadarya (Amudarya) delta. By the I century BC irrigation works developed also along the ***Kuvandarya*** in the north which, together with the modern course, was the most active.

The hydrological features of the Syrdarya continental delta and the techniques used for the control of its waters show some peculiar traits (semi-artificial reservoirs and multi-functional water catchment) that represent a new step in the evolution of irrigation schemes beyond the primitive forms of the first stage.

The Syrdarya region, situated between the Turanian deserts in the south and the Kazakh steppes in the north, represents the historical border zone between settled irrigation farmers and nomadic shepherds. During the II millennium BC it was inhabited by communities of the Srubnaya and Andronovo cultures, based on stockbreeding, kair farming, hunting and fishing activities, well adapted through mobility to the arid conditions of the territory. Even later, after the development of irrigated agriculture, shepherding will always subsist and pair the agricultural practices. The mobile character of the stockbreeding communities is also characterizing their local primitive agricultural practices (kair) and, somehow, will characterize even the first irrigation schemes built on the Syrdarya delta during the I millennium BC. These similarities can only partly be explained as an effect of the mobile character of the pastoralist cultures of the surrounding steppe environment. Basically they are the product of the specific hydrological characters of the river delta itself which, with its very unstable behavior, promoted on farming communities the same mobile habits that yearly environmental changes generated in the economical life of the shepherds. The whole Syrdarya river presents the most unstable floodplain among the West Central Asian rivers, with frequent changes of meanders and courses. These features are highly pronounced in the delta, of which the distributaries, by constantly changing regime and course, determine a huge surface of reclaimable lands (up to 1.5 million ha) of which actually less than a 20% would be yearly fed by waters and has the potential to be irrigated and cultivated. Moreover this 20% is not stable but switches between different areas, depending from abrupt events, water stock and rate of sedimentation.

In the region the only hydrological source for early irrigation works based on simple technology and low demographic levels has been floodwater. Most of the distributaries of the Syrdarya delta were not active down to the Aral sea, so that the irrigation systems applied to them could catch flood waters from mild terminal branches. They were generally and seasonally mild but unstable, very variable in dependence of yearly climate and precipitation: sometimes dry and receding, sometimes flooding and disruptive. In absence of a developed engineering power and labor investment, the abrupt behavior of floods allowed just the use of fading terminal deltaic seasonal branches; and their changeable character required diversified locational strategies of water catchment. So, the main problem in the implementation of irrigation schemes has been the stability of the strength and location of the source, i.e. the control, catchment and regularization of seasonal floods. All these factors discouraged the building of large stable irrigation networks and promoted the implementation of several small independent water catchment devices, eventually alternatively active in different years, feeding alternate agricultural fields and often connected to more than one distributary.

Technically, the problems of controlling floods and prolonging water provision beyond the short flood season had been ingeniously solved by the use of a specific catchment scheme (semi-artificial reservoir irrigation), i.e. by applying the mouth of the canal system not directly to active waters but to intermediary natural paleo-beds artificially filled and functioning as stabilizing basin-reservoirs. The resulting scheme is the following: river bed - paleo-riverbed as reservoir - canal head - canal lattice (rectangular) - embanked field. Such technology, already in use on the Archadarya more than 500 years before, has been introduced on the Jhanadarya and Inkardarya by the Chirik-Rabat culture (VII BC) and it will characterize the irrigation systems of the Syrdarya delta all along history. A developed variant of this catchment system is represented by some implementations of the Jety-Asar culture on the Kuvandarya (I BC - VIII AD) and mainly of the Middle Ages on all distributaries, when sometimes segments few km long of fading river beds have been dug, embanked and dammed, playing as elongated reservoirs (like the 60 km long Asanas-Uziak canal on the upper Inkardarya).

The canals distributing water from reservoir to fields were most simple: their heads were 2-3 in number for different water levels, their lattice was at first rectangular with quite pronounced sloping (1%) and during Middle Ages branching and less erosive. To such long reservoirs, in late Medieval times, water uplifting devices (chigirs) were also applied.

Fields are located in embanked depressions and, during late Medieval times, even in dry river beds fed by canals running along the banks (Khatyn-Kala).

This semi-artificial reservoir system is ingenious but quite primitive because seasonal: it can be defined as the simplest version of *seasonal reservoir irrigation*. But, as a whole, it is well adapted to regions of unstable deltaic farming and populated by semi-settled farming-herding tribes. By its light, independent and multifunctional character, it is evidently built in such a way:

– to be manageable by small mobile communities

- to be protected from disrupting floods through use of natural features
- to provide water beyond the flood season
- to be adaptive to a yearly changeable hydrological environment by catching waters from different complementary watercourses (eventually interconnected by artificial canals in order the rise the water level of one of them)
- to be only partly integrated, in order to abandon some parts during certain periods and then rehabilitate them with minimum work investment.

The irrigation of the Syrdarya delta ended up by being constituted of separated oases, yearly irrigating an area going from 15 ha (Balandy-I, with a potential claim of 200 ha) to 500 ha (Babish-Mulla, with a potential claim to 10000), respectively populated by 5 to 100 small villages and 300 to 3000 peoples, and, in the case of the main oases, organized around a large fortified proto-town. The yearly maintenance and use of the irrigation system could be implemented by 2 months-work of a fourth or a fifth of the population; the total labor accumulated in the irrigation system consisted of 2 months-work of more than half of the inhabitants, which exceeds the labor resources and witnesses a gradual development of the oasis (Andrianov 1969). Irrigation practices were everywhere included within a mix-farming economy, due to the high pastoralist potential of the surrounding semideserts and river corridors. Large walled towns, fortresses and mausoleums have been built in strategic points, but the majority of settlements are small.

This kind of hydraulic system, settlement patterns and mix-farming economy characterize the hydro-agricultural activities of the Chirik-Rabat culture which blossomed along the low course of the Jhanadarya and Inkardarya between 700 and 200 BC; and of the Jety-Asar culture on the Kuvandarya between 100 BC and 800 AD. Surprisingly, on the Syrdarya delta, such simple technology had been adopted also during the Middle Ages without developing into more advanced schemes. This fact can be attributed to environmental and sociopolitical reasons: to the tiny advantages that would have come from a large artificially integrated system, due to the scarce and ephemeral water volumes distributed by changeable beds on a very wide territory; and to the semi-settled tribal character of the territorial control. So wide trunk canals have not been constructed and the natural river bed played as only hydrological link between successive small oases.

Along the Tedjen river (eastern Kopet-Dag) seasonal reservoir irrigation already appeared at the end of the IV millennium BC. And, at the time of the Chirik-Rabat culture, on the Archa-Darya delta, where the hydraulic civilization started more than 500 years earlier and so was more developed from the technical and socio-political point of view, the same natural conditions have been afforded by much larger implementations: by stabilizing the yearly flood through the building of a complex system of artificial dams and canal-heads applied on large perennial reservoirs or active courses, with big trunk canals integrating local schemes and feeding large integrated oases. (Tolstov 1961, Andrianov 1969)

After the fading of the Chirik-Rabat and Jety-Asar cultures, the populations that inhabited the region inherited and ameliorated the seasonal reservoir irrigation technology. Petchenegs, Khazars, Oghuz tribes, Khoresmians, Mongol and Golden Horde rulers, Karakalpaks and Kazakhs played as irrigation farmers or as distant rulers, developing, displacing or abandoning the irrigation systems. But, because the peculiar geographical context, it is not surprising if, here more than elsewhere, the structural characters of the irrigation systems and the rise and fall of irrigation cultures is correlated not only with political stability but also with hydrological and climatic variations.

All along the Holocene period up to now the active branches of the Syrdarya delta are switching progressively north towards the present main course of the river due to tectonic and sedimentary factors, inducing progressive aridization of the south-western areas. On that trend is superimposed the forcing effect of climatic fluctuations, switching between dry and pluvial phases and changing the hydrological regimes of the river. Because zonal aridity, life in the region largely depends from the Syrdarya water, so that variations in water volume and surficial distribution heavily effected the local environment and the chances of human life.

- All the distributaries of the Syrdarya delta have been colonized by pastoralism and kair farming during the Neolithic and Bronze age epochs.
- During the VII-V BC, with the start of Iron Age and with the establishment of a most wet phase, irrigation agriculture appeared along the mid and low courses of the Inkardarya and Janadarya distributaries (Chirik-Rabat culture); and, starting from the end of the I millennium BC, on the Kuvandarya (Jety-Asar culture).
- The building of irrigation schemes on the mid-course of the most southern and vulnerable distributary, the *Inkardarya*, stopped (most probably together with the decrease of water-flow) during the establishment of a dry phase around 200 BC; and recovered on the upper course (Syrlytam) for a couple of centuries (1200-1400 AD) at the start of the pluvial phase.
- Also the colonization of the mid course of the *Jhanadarya* collapsed around 200 BC, together with its Chirik-Rabat culture. It recovered for a couple of centuries around 1200 AD, slightly downstream, under Khorezm rule, during a pluvial phase (X-XII AD) that brought the river until just 20 km far from the Aral sea (Al-Biruni, X AD); and then again by the action of Karakalpak pastoralists emigrated for political reasons from the middle Syrdarya during the wet phase of the late XVIII 1800 AD.
- The colonization of the *Kuvandarya,* the northernmost delta distributary, and in particular of the Kurauly delta, shows more complex patterns. The region saw a blossoming phase between 100 BC and 100 AD (under a climate similar to the modern one) and resisted across the climatic deterioration that followed. The westernmost parts of the oasis saw a cultural contraction around 400 AD; the eastern part saw in the VI century a relative development and started to contract only in coincidence with the driest phase of the 700-900 AD, signing the end of the Jety-Asar culture.

Generally speaking, with the receding of the south-western branches of the Syrdarya delta, irrigation practices migrated progressively upstream to the head of the delta and further up along the ***middle course of the Syrdarya***, supporting in particular, due to hydrological similarities, the Medieval blossoming of the oases of Chiili and of the floodplain of the left bank of the middle Syrdarya.

As a whole, during ancient history and Middle Ages, 2.5 millions hectares have been concerned by irrigation agriculture. Today the irrigated area is reduced to 100000 ha in proximity of the Syrdarya course.

### 1.5 - Fourth phase (1200-1500 AD): Late Middle Ages

The development of irrigation practices to the middle course of the Syrdarya happened by the same gradual steps that characterized the growing of large hydrological systems in other regions of West Central Asia. The interesting thing is that here, more specifically in the oasis of Otrar, has been documented the succession of 7 generations of water systems. The first 4 generations pass through the first three phases of technical evolution spoken above. The fifth and sixth generations implement a rotation of the angle of distribution of the Arys waters that seems to represent an answer to processes of relief and soil exhaustion. Eventually such processes and adaptations also happened in the history of the irrigation schemes of other river deltas, but in the oasis of Otrar they are particularly well manifested, partly documented by the works of Groshev until the 80ies and then systematically fixed by the Laboratory of Geoarchaeology of Almaty in 2000-2002.

**a -** The hydrological specificity of the Syrdarya delta and the relative difficulty of managing its waters can by itself explain the relative retard of the diffusion of irrigation practices in the region and also the facility by which these delta schemes, once established, could in few centuries diffuse upstream along the **middle Syrdarya course** and make of the region, by the beginning of the I millennium AD, one of the richest and powerful oases of Central Asia. Among the large irrigation systems of West Central Asia, the ones of the Middle Syrdarya have been the last to develop and the last to be abandoned.

It is around 100 BC that the first settlements and irrigation works are documented on the floodplains of the middle course of the river: on the right bank of the Syrdarya at the confluence between the Syrdarya, the Arys and Bogun rivers where is located the ***Otrar*** oasis (Akishev et alia 1972; Baipakov 1986, 1990; Groshev 1985, 1996); and on the left bank in the ***Chardara***, ***Mayakum*** (facing the Otrar oasis) and ***Baltakol*** (facing the Turkestan oasis) regions and further north on the right bank (***Chiili***) until the head of the delta (Maksimova et alia 1968; Levina 1971).

On the left bank of the Syrdarya and in the Chiili oasis the irrigation systems started at the beginning of the I millennium AD and were quite similar to the ones of the Khoresm, with trunk canals up to 30-40 km long applied at first to flooded basins and then to the dammed Syrdarya river course, and feeding a canal network of branching type.

The development of the first irrigation schemes in the region of Otrar started together with a most relevant ice retreat determining the shrinking of the Syrdarya water regimes and provoking contraction of the moist land surface. Most probably the early phase of irrigation practices along the middle Syrdarya course were influenced by more ancient and advanced agricultural societies: the ones settled downstream on the Syrdarya delta or in the northern parts of the Akcha-Darya; and the ones pertaining to the Kaunchi-Karatau cultures settled in the Tienshan piedmonts along the ***Chirchik, Keles*** and ***Arys*** right tributaries and also the ones of the southern slopes of the Karatau mountains (Podushkin1970). The Otrar settlements, ceramics assemblages and irrigation techniques share some analogies with the ones of the Syrdarya and Amudarya deltas and even more with the ones of the sites along the upper course of the Arys. The irrigation system of the Otrar oasis (of which the early periods are still undiscovered) covers an area of 10x10 km and evolved through several phases for almost 2 millennia.

Paleo-hydrological and archaeological data suggest a model of evolution of location and schemes of irrigation agricultural practices in the Otrar region through 7 successive phases. They are all accompanied by 4 tendencies: progressive contraction of water regimes, south-western displacement of the agricultural areas, growing labor investment, intensification of farming techniques. The 1º and 2º phases exploited the waters of peripheral mild distributaries of the Arys delta and determined a first demographic expansion (Kanjiu period). The 3º and 4º phases (early Turkic, Karakhanid) saw the development of the south-

western part of the delta by the implementation of the first large irrigation works and the progressive displacement of the water catchment to the mouth of the delta, reaching a peak of potential land reclamation of 250000 ha. The 5º and 6º phases (Mongol, Timurid) sign the start a major turn in the history of the oasis, with the abandonment of most of the formerly irrigated areas and the development of the south-eastern and eastern parts of the Arys delta by 3 successive displacements of the water catchment upstream along the river course. The plan of restructuring introduced by the 5º and 6º phases witnesses awareness of the existence of threshold points beyond which an old irrigation system becomes exhausted independently from natural or social factors, by its very same activity, by siltation and salinization, awareness of a kind of huge fallow cycle that compels the re-edition of irrigation schemes on neighbor virgin areas.
The Otrar irrigation system is totally abandoned around the beginning of the XVIII century (Groshev 1985, 1996). With the collapse of the Otrar oasis in the XVIII century AD, the last of the large irrigation systems of West Central Asia is abandoned and the economy of the whole territory relied on small scale piedmont agriculture and on pastoralist activities. The following Russian restoration of the Otrar canals during the 20º century will follow the same paths (possibly already exhausted) which have been introduced during the Timurid period.

**b -** Further north-east, in West Semirechie, the ***Talas*** (Senigova 1972) and ***Chu*** rivers (Kozhemyako1959) represent the northern limits of the historical spread of the large scale irrigation systems of West Central Asia. Here irrigation schemes started to be implemented along the middle courses and the delta distributaries during the first part of the I millennium AD, blossomed under the Turkic rule in the second part of the I millennium and faded with the Mongol conquest. Their contraction has been accompanied, here like in the other irrigation areas, by a consistent conversion to pastoralist practices and primitive piedmont agriculture, a tendency that will be inverted only with the Russian domination at the end of the XIX century.

**c -** Large irrigation systems have not been realized in the basin of the ***Ili*** river crossing western Semirechie. Here several small tributaries can be exploited by simple networks of canals in the piedmont zone, climatic conditions allow relaying on dry farming, and the mountain ranges favor the development of very productive stockbreeding activities based on vertical transhumances. Few agricultural centers developed at the end of the I millennium AD (Talgar, Kayilik) that didn't survive the Mongol invasion. These ecological conditions made of Semirechie the niche of the richest pastoralist cultures of West Central Asia and the cradle of the Kazakh nation: the cradle of the pastoralist economy that brought to the abandonment of the Syrdarya irrigation agriculture but also to the optimal pastoralist use of the Kazakh territory; and, after the fall of the Jungarian empire, the cradle of the Kazakh political structure that in a couple of centuries arrived to unify several independent tribes into one people.

## Conclusions

It is reasonable to suspect that during the XIII-XV centuries the implementation of hydraulic plans similar to the ones introduced in Otrar happened also on other deltas of Central Asia (Murghab, Sarykamish, etc). All together these hydrological restructuring represents the last

important technical development and irrigation work in West Central Asia, after which no further hydraulic innovations are introduced neither in Otrar neither on other deltas or large river courses, a fact that represents the start of a long period of decadence of the Central Asian hydraulic civilization.
During the following centuries all the remaining large hydrological implementations of West Central Asia start to decay: in Transoxiana, under the Uzbek Chabanids who didn't have any alternative to an agricultural economy, the systems just contract; on the Syrdarya, under rule of Kazakh pastoralist tribes, they totally collapse (Fourniau 2000).

## 2 - WATER MANAGEMENT, SOCIO-POLITICAL STRUCTURES, IDEOLOGY

### 2.1 - Socio-political structures in irrigation societies

**a -** From the first stages of simple flood-catchment and basin irrigation schemes on lower courses of small streams (Dzheitun) to the complex perennial-reservoir solutions applied on the delta of the large rivers 3000 yrs later (Murghab, Akcha-Darya), the implementation of irrigation works always depended on 2 important preconditions: the existence of some convenient natural features; and the capability to implement collective works, meaning people, social organization and knowledge to the degree requested by the size of the irrigation scheme.

The quantity of ***work and organization*** necessary for the control, management and restructuring of irrigation systems rose together with their dimension. In a small eneolithic settlement of 0.7 ha, 30 houses, 170 persons like the village of Dzheitun, life was largely communal and the planning and division of work could follow family and clan patterns. But Altyn-depe, at the end of the III millennium BC, with its 5000-7000 inhabitants relying on irrigated agriculture, already requires a complex tribal and political society and a stable group of workers (few hundreds) specially devoted to the management of water devices on the basis of well established tasks. It has been estimated that the construction of the trunk canals on the Akcha-Darya delta during the VIII century BC required the work of 1000 persons for more than 2 years (Akademia Nauk 1960). Historical documents about medieval Merv (2000 years later) speak about the existence of a ministry of waters with 10000 stable employees.

The social groups responsible of the building initiative, control and maintenance, evolved together with the complexity of the lattice from assemblies of patriarchal clans to stable ***governments***. Being the integrated aspect of the water management of one oasis, the area controlled by such governments could not be inferior to the size of the oasis itself. The hierarchy of canals, going from main head trunks to final distributaries, determined a correspondent hierarchy between inhabitants of large settlements managing the structural devices and village dwellers responsible of peripheral laterals. Some settlements eventually rose to more than just an agricultural village up to the administrative center of few settlements and zones of the oasis. It is Altyn-depe that, during the second half of the III millennium BC, shows the first signs of incipient urbanism. It reached the size of 25 ha and 5000 inhabitants; had been provided with religious complexes, political buildings, specialized quarters, walls; functioned as a city and, organizing 2 or 3 other towns, acquired the role of city-state. The complex tasks favored the development of social stratification (aristocracy and slaves), and the introduction of some kind of proto-financial expedients for regulating the whole system like water taxes, chores and drudgeries (Kohl 1981; Masson 1981,1992).

So, Altyn-depe, together with Namazga IV, represents the earliest model of ***city-state*** in West Central Asia, which will constitute the basic form of government of the irrigation oases of the region all along history. The scattered character of the oases of Central Asia, separated by large desertic extensions, didn't favor the genesis of large kingdoms centralizing the control of different riverine oases. Regional characters are most pronounced; and some cultural similarities between different regions are not signs of dependence from a same ruling center, but rather the cultural sedimentation of the adaptation to similar environments and of inter-exchanges of goods and human groups prolonged for centuries.

Even the Achaemenid rule, in spite of its powerful and centered administration of the Middle East territories, in Central Asia was mainly limited to the levy of land-taxes and didn't interfere with the management of waters or with the administration of towns, which was left in the hands of local ruling groups. The same is valid even for the Kushan period that saw the peak of irrigation practices in almost all the oases of Central Asia. The policy of these empires only indirectly affected the evolution of the Central Asian irrigation systems, not by acting at the governmental level but by the context of peace or war, of conflict or social cohesion that arrived to ensure to its peripheral provinces.

**b -** The more the oases became rich and socially stratified, the more they attracted and feared external enemies and/or internal upheavals. Starting from the middle Bronze age, at first religious complexes and then entire proto-towns (Altyn-depe) became provided with ***fortifications***. Dangers and walls kept growing with the time. By the end of the II millennium, in the oasis of Murghab, fortifications are a common feature of towns (qala) and also of large villages, introducing defensive military characters that will feature the following settlements of Central Asia all along history and will influence the Early Iron urban architecture of a large territory down to the Persian Gulf.

External enemies could have been other irrigation proto-towns in competition for commerce or for reclamation of new lands. But, with the II millennium BC, potential enemies became also the mobile ***pastoralist tribes*** diffused all over the steppes of Central Asia and exploited for grazing and foraging the semi-desertic landscape surrounding the farming oases (Masson 1992a; Pyankova 1994, Cattani 2008). If on one hand the pastoralist activities became integrated with the agricultural ones into a complementary economy, on the other hand shepherds could easily control roads and commercial activities and their tribal confederation represented a condition of potential rivalry. This bipolar aspect, agricultural and pastoralist, cooperative or rival, of the human communities of Central Asia probably represents the background of any historical process and human implementation in the region from the II millennium BC up to the Russian conquest.

With the beginning of the I millennium BC horse-riding gave nomadic shepherds a ***military superiority*** and obliged the irrigation centers to develop political and defensive expedients that favored the rise of political-military aristocracies (eventually run or supported by alliances with pastoralist leaders) and the construction of larger fortifications (Litvinsky1992). With the second part of the I millennium BC, not only towns but even large agricultural areas became protected by walls of relevant length (on the Akcha-Darya 60 km, on the Murghab more than 200 kms, in Dahistan 170 kms, at the Sogdian 'iron gates' 10 km), evident signs of a structural state of physical danger and treats from outside the oasis (Bader et alia 1998).

But more than antagonism, it is the rise of a ***syncretic society*** among settled people and nomads that constituted a main historical event. During the II millennium BC in south-west Central Asia, through alliances and conflict, the interaction of farmers and shepherds arrived to build syncretic mix-farming societies able to irrigate lowlands, to guaranty political stability and to provide military strength (see 2.3) (Moore et alia 1994). The phenomenon possibly lies already behind the rise of the Bactrian-Margiana Archaeological Complex at the start of the II millennium BC (see below 2.2), and surely behind the later development of the agricultural oases of the Syrdarya.

The thesis advanced by some authors that rivalry was dominant and constituted the main cause of the delay in the northern spread of irrigation practices to the delta and middle course of the Syrdarya river, is not totally convincing. Concerning the delta, the thesis is contradicted by the large implementation of irrigation practices that happened in the region during Saka times and probably by Saka tribes, so that at the present state of knowledge better founded explanations of the retard seem to be the high technical difficulties and low demographic levels. Concerning the oasis of Otrar, located in a steppe environment and among nomadic societies, capable to generate a rich and powerful political militarily system that continued uninterrupted for 2000 yrs, across different phases until 3 centuries ago, its development represents a clear example of longstanding positive interaction between the settled and nomadic worlds.

**c -** If on one hand the rise of a specialized political stratum has been the positive answer to the need of administrating larger and more complex irrigation schemes, on the other hand such concentration of power introduced a new point of vulnerability, not natural but social. From the moment that a socio-political specialization was established as unavoidable device for the functioning of the agricultural economy, not only natural disasters, epidemics and external enemies, but also ***internal social conflicts*** could weaken the political structure and even arrive to disrupt the economy and the artificial landscape of an entire oasis.

During the first half of the I millennium, together with a growing stratification of the society and militarization of the territory, ***dynastic aristocracies*** appeared as rulers of the city-states of the large irrigated oases. The fact represents a turn of primary importance in the management of the territory and the planning and diffusion of irrigation works. Dynasties, entering as new protagonists of the building initiative and management of irrigation systems, carry with them new specific goals and strategies: not only the management and military protection of irrigation systems, but also their self-reproduction and expansion as social groups and so the imposition of ideological lines in the construction and localization of water schemes.

In *Mesopotamia* the phenomenon manifested as early as the second part of the IV millennium BC, making of the region the first historical example of what has been called an 'hydraulic civilization' (Wittfogel 1955, 1957). From that moment, in Middle East and Egypt, the central power constituted the main protagonist in the agricultural shaping of the landscape of huge territorial expansions. In Iran an optimal peak was reached under Achaemenid rule and again under the Sasanids; but their power, as we said, never arrived to design the technical and social characters of the water schemes of the Central Asian territory.

In *Central Asia*, being the scattered localization of independent water facilities, it is only during the first half of the I millennium BC that is possible to suspect the existence of powerful military aristocracies capable of ruling different separated oases and of geopolitical

plans in the restructuring, displacing and diffusing agricultural and commercial practices in delta landscapes and along the middle courses of large rivers. Powerful fortified capital towns appeared in Dahistan (Izatkuli), Margiana (Yaz-tepe), Bactria (Altyn-depe I), Fergana (Dalverzin-tepe). There are clear signs of the constitution of a powerful Bactrian empire around 750 BC, probably a step of the Iranian expansion, which had strong influences on the oases of Northern Bactria and Margiana and even on Iran and on the Indus valley. Eventually, within the I millennium, all over Central Asia, the race for military superiority became a basic feature of both shepherds and farmers societies; and their potential conflict played, when not the reason, surely the pretext and legitimization for diverting agricultural economical surpluses to the military castes supposed to insure or to threaten the territorial security.
The Chinese Annals report that, at the time when the *Otrar oasis* started to develop (at the beginning of the I millennium AC), the region was part of the most powerful state in Central Asia, ruled by a strong tribal confederation called Kanjiu. It controlled the large territory of the middle Syrdarya with 600000 inhabitants and, well versed in the yearly skill of managing large groups of irrigation workers and slaves, was capable of gathering a well organized army of 100000 soldiers.

The information at our disposition doesn't allow to determine which kind of successive socio-political structures (local, regional, interregional) promoted in Otrar the first irrigation works, developed them into a wide network of canals and basins up to a perennial reservoir scheme, and integrated several proto-towns and villages into a concerted effort for managing the whole system; which forces managed, after the Mongol invasion, to quickly reestablish the system of power concentrated now in few main cities; and finally why the town was abandoned by the end of the XVIII century AD together with the collapse of the whole agricultural activities. We can just pose the questions in such a way to define some concrete lines of research.
The impact of the dynastic interests surely grew during the *Middle Ages*, playing, in different cases, a progressive or a conservative political role. The Persian historian Sejid Rakhim speaks about a popular rebellion that happened in Kosh-Kurgan (at the mouth of the Fergana valley) in 1633 ("a year of hunger and oppression") against a plan promoted by the khan for the massive restructuring of the hydrological system of the oasis. It is not clear who was right, the farmers and operators of the peripheral devices or the central managers.
By the XVII century we assist to the final abandonment of all the irrigation systems of the river deltas of Central Asia (i.e. the largest ones requiring sophisticated planning and management), a phenomenon pointing to the presence in the whole region of disrupting factors of socio-political nature.

## 2.2 - Settled farmers and nomadic pastoralists

**a -** The farming societies of the oases of Central Asia had from the very beginning economical and cultural ***interregional contacts*** with other hydrological societies settled in southern territories (Iran, Afghanistan, Hindo valley) (Masson 1957). Between the V and III millennium BC Altyn-depe and Namazga (4500-2000 BC) had links with northern Iran; the early Shortugay (2500 BC) with Harappa; Murghab with Iranian Khorassan; Dashli with southern Afghanistan (1900-1700 BC, 700-500 BC).

**b -** Within the II millennium BC pastoralist tribes diffused from northern regions in the steppes and inter-oases expanses of Central Asian and became necessary partners of the farming communities. As we said (par 2.1), from that time up to the Russian conquest, the interaction, cooperation, conflict and syncretism between ***oasis dwellers and mobile shepherds*** constituted the main trait of the social history of the region. It is in the frame of such interaction that all the following processes must be interpreted: during the beginning of the II millennium BC the quick diffusion of irrigation centers and the southern spread of Indo-Aryan cultures; during the end of the same millennium the rise of powerful military and administrative clusters of oases and the southern spread of Iranian cultures.

The earliest centers of diffusion of pastoralist tribes in West Central Asia are the northern-Caspian and south-Ural regions. Here, during the III millennium BC, flourished the timber grave culture (Srubnaya, Samara), represented by mix-farming pastoralist tribes of which the productive economy was based on millet and cattle, well adapted by high mobility to a semi-desertic and variable environment (Kuzmina 1984, Vinigradova&Kuzmina 1986; Masson 1992a). Pastoralist practices spread east to the Altai (Afanasievo) and south to Pre-Aral, Zerafshan and Kopet-dag (Namazga V). At the end of the III millennium they established a stronghold in Margiana and on the Oxus in Bactria (Francfort 1989). From there, as '***Indo-arians***', diffused in south Afghanistan and east Iran and penetrated the Indo valley at the time of the decay of the Harappa civilization.

A second wave of pastoral colonization of the steppe territory appear at the start of the II millennium in Central Kazakhstan and Altai (Andronovo culture) and diffuse southwards along the piedmont steppes until Margiana and Bactria (Kuzmina&Lyapin 1984). The spread coincides with the decay of the Kopet-dag farming communities (Namazga VI) and the flourishing of the oases of Murghab (Togolok 2) in Margiana and Dashly in Bactria (Masson 1992a). Eventually there, between the 1900 and 1700 BC, Andronovo tribes interacted with Kopet-Dag farmers in the genesis of the so-called MBAC culture: tombs of farmers and shepherds share the same cemeteries with syncretic funerary rituals; terracotta statuettes of animals and 'adorantes' are found in pastoralist graves and nomadic ceramics in town buildings (Hiebert 1994); the intermixing of different populations gave rise to new anthropological types (Litvinsky 1992). And 700 years later, with the riding of the horse, at the time when in northern Central Asia Late Bronze age communities were generating the early Saka culture, tribes from Bactria diffused south as '***Iranians***' and settled on the Iranian plateau. In both cases, of the Indo-aryans and of the Iranians, the irrigated oases of Bactria played a major role in recycling, strengthening and spreading further south physical and cultural characters of pastoralist tribes of northern origin (Sarianidi 1987).

Everything suggests that during the II° and the early I° millennium BC the interaction between irrigated oases of Central Asia and northern semi-nomadic pastoralist tribes has been the main factor in determining the following turn in the history of the civilizations of the southern regions of the Eurasian continent.

**c -** The difficulty in imagining such a symbiosis depends from our tendency to think the settlers as too settled and the shepherds as too nomadic. Shepherds rely on grasses and adapt by migratory itineraries; farmers rely on water facilities and adapt by water canals. But optimal environmental conditions can stabilize shepherds and unstable hydrological conditions can mobilize farmers, as is well shown by the example given above concerning the use and control of the waters of the unstable distributaries of the Syrdarya delta (par 1.4). In that region farming communities were necessarily mobile enough to exploit yearly different fields; and excogitated irrigation schemes of small dimension and temporary-multifunctional use that could be abandoned or put at rest with minimum losses. In that region farmers, like shepherds, developed their activity not to a site but to a set of possible sites as object of economical strategies, so that the same ***logic of land and water use*** was operative in both the stockbreeding and farming economical contexts. Natural and technical factors ended up in generating a mix-farming irrigation society endowed with very mobile characters in their practical as well as in their intellectual cultural life. Semi-settled farming, mix-farming and pastoralist communities shared a naturalistic pragmatic approach to land exploitation, and a fuzzy conception of property that must be relocated year by year by social consensus. These are the basic traits of the protagonists of the genesis and government of the irrigation systems of the middle Syrdarya and in particular of the Otrar oasis (Baipakov 1990).

**2.3 - Ideology and religion**

The religious ideology of the irrigation city-states of West Central Asia develops in 3 phases: a first Neolithic phase characterized of female representations with natural fertility symbols (Neolitic); a second Bronze and Early Iron phase where a divine female-male couple is introduced; and a third Medieval phase where all these elements are merged within the Islam religion.

**a -** The religious practices of the agricultural communities of north and east Iran and of Central Asia during the Eneolithic and Bronze Age have ***naturalistic and polytheistic features***. Characteristic cultic objects are terracotta figurines found in temples and tombs (Pittman1984, Sarianidi 1986) and represent stout women, animals, chariots. By sites and periods they show slightly different features, evidently result of local development of common archetypes rooted in Neolithic times. Such artifacts are still diffused as cultic objects in the early Medieval Samarkand and Otrar. Women are represented with naked breast, long necks, rich adornments and hairdressings, together with engraved or painted symbols. These symbols in Namazga IV are crosses, zig-zag waves and plants, which could correspond respectively to stars, rivers and fields (i.e. stellar fire as sky, power and holy spirit; water and earth as fertility) (Masson 1992). In the Amirabad culture on the Akcha-darya delta, 2000 yrs later, statuettes and symbols are the same, with zig-zag substituted by lattices, like if not streams but irrigation lattices are now considered (Askarov 1992). Animal statuettes during the Bronze age are mainly figures of humped bulls (Masson 1976); and, when dragons and dungeons, they represent mineral spirits and underground worlds (Francfort 1994). Within the Iron Age, in the south (Bactria) statuettes became rare, as a consequence of the affirmation of Zoroastrism; on the Syrdarya they continue to be produced, now with predominant representations of sheep, till the middle Middle Ages (Baipakov 1980).

**b -** During the II and early I millennium BC, the growing importance of the urban establishments and the contact with pastoralist tribes reinforced patriarchal elements (i.e. masculine deities and male ancestors worship) in the former neolithic religious pantheon and in the funerary ritual of the irrigation societies of Middle Asia and East Iran. As a consequence a bipolar female-male structure becomes predominant in the religious cosmos. The elements of such new syncretism provided in the Iranian plateau and Bactria the genetic ground of ***Zoroastrism*** (Boyce 1975); and, after its affirmation in the VII BC, they survived by changing role but anyhow smoothing the strict centralization and monotheism of the earliest Zoroastrian wave: some deities were degraded to occult gods (asuras), others resisted in popular pantheon until the time of the Arabs (VIII AD). In Central Asia the autonomous regional character of the farming communities always discouraged the religious centralization and the theological and ecclesiastic developments that happened on the territories of the Iranian empire: the religious practices continued in the frame of local pre-Zoroastrian city cults and kept pre-Zoroastrian characters until the Islamic conquest (IX AD). The analogies that the Early Iron cults of West Central Asia share with the Zoroastrian system don't concern the supreme being and the 7 major deities of the early Zoroastrian pantheon (the “amesha spenta”, the beneficient immortals), but the more popular traditional division of the pantheon in two groups of male and female deities. The Central Asian female deity Aradvi Sura Anahiti (Anaitis or Anahita) unifies in herself the attributes of 4 other feminine spirits (Asi, Armaiti, Haurvatat, Ameretat) and represents justice, devotion, wholeness and immortality. The male deity could be the Zoroastrian supreme god Ahura Mazda (power) or his 3 masculine emissions (holy creative spirit, right thinking and right rule), or most probably the syncretic Achaemenian god Mithra (sun, sovereign, convenant and war): in any case the Central Asia male deity tends to represents all the male attributes (power, spirit, war). Female and male deities are blessing respectively: nature, fields and fertility on one side; citadel, rulers and order on the other. They perform the same two basic functions of the older religious substratum of the Bronze age Central Asian city-states and so will continue to do without major changes until the spread of Islam. Even in Iran, during Achaemenid times, only two deities, Anahiti and Mithra, are specifically mentioned.

The female deity Anahiti is, among all, the most important and mysterious. Ahura Mazda is represented masked by a golden winged solar disk. Mithra is represented holding a burning torch and a knife, sits near a spring, a child of earth itself, and fertilizes vegetation with the blood of a sacrificial bull. Instead the female goddess Anahiti, at least until the Sasanian reform introduced the cult of her statues, is not physically represented but just invoked, a fact that denotes her mysterious natural character and antiquity.

Aradvi Sura Anahiti literally means 'damp, strong, untainted'. She is spoken in Yasht 5 of the Avesta (the “Hymn to the waters” composed around the beginning of the I millennium BC) as primigenia spring of Ahura Mazda and virgin mother of Mithra, showing the important primordial place she covers in the pantheon of the Iranians. Most probably she played a role even bigger among their northern enemies of Central Asia, the so-called 'Turanians'.

In the same hymn she is clearly defined as goddess of waters and fertility. She is spoken as Aradvi Sura (humid, powerful) and as a 'girl splendid, powerful, harmonious, belted and straight, with endless lineage…'. In the Gatha (sacrifice prayers constituting the most ancient nucleus of the Avesta) she is quoted as kindred with the divine pair Haurvatat and Ameretat, who respectively represent the spirits of water and purity and the spirit of plants and immortality; and with the god Apam Napat (child of water, the vedic Varuna) who specifically rules the distribution of waters.

Moreover, she invoked as the one who 'drives forward in her chariot…with 4 horses all white, crushing down the hate of all haters…' and is invited by Mazda to rule the new created planet earth: in that way it is also promoted as goddess of help and protection. In that way, being primigenia mother, water goddess and ruler, she concentrates in herself in herself the constituents and powers of the whole cosmos; and seems to continue the traditional symbolism stars-waters-vegetation that has been found inscribed on the Bronze age statuettes of the Kopet Dag.

Celestial fire, water and ground fertility are main elements in the Central Asian as well as in the Zoroastrian cults: both traditions have temples provided of fire altar and sacred well and located or on the top of water-managing citadels (Jarkutan) and specialized religious centers (Sidak) or in underground caves. But, in the case of Anahiti, not architectural buildings but natural sites constituted her earliest sanctuaries; not images but natural elements have been objects of worship. Eventually the streams of the large rivers, in Central Asia the Amudarya and the Syrdarya, were considered her embodiments; mythical mountains as water collectors were her highest abodes (mount Hukarja).

During the IV century BC, together with the spread of her cult in western regions, the traits of Aradvi Sura Anahiti have been enriched with elements of the Mesopotamian pantheon (Anaitis-Nana-Ishtar), namely royal paraphernalia and stable consortium with Mithra or Ahura-Mazda. At that time she acquires in hymns and prayers the martial attributes normally attributed to her male counterparts, which makes of her, riding a lion and pretending bloody sacrifices of bulls and horses, also a goddess of war and then, in post-Achaemenian times, also of heroes and rulers. By that, known as 'the Lady', she appears supreme, lord of fertility and power, crowned and in the act of conferring a garland as royal investiture.

When later, under *Sasanian* kings, Zoroastrism became state religion and statuary images of Anahiti were finally introduced, the goddess is represented holding in the hands a fire and/or celestial bodies (stars, sun, moon), surrounded by attributes of fertility and of protection against demons. *Hellenistic* and *Hindu* influences provided Anahiti with a court of natural spirits, fantastic beings (tritons and seahorses), holy musicians and dancers, all connected with the qualities of water: purity, sounds, flow, speed, whirls, springs, floods, lakes, underwater realms, river branches and canals.

**c -** With the spread of ***Islam*** and monotheism in Central Asia, idol worship was forbidden. All the former Central Asian water deities were banned or, when too popular, reduced to natural local spirits: beneficent (like Hubby, underwater god helping to avoid floods) or malicious (like Aranglari, the one who provokes floods), inserted and controlled in the frame of a new theological context.
In Medieval times, under repressive Islamic rule, some temples of Anahiti and of other female deities were converted in mausoleums of mythical ladies (Bibi Sahrbanu). In Khorezm Anahiti became Amba-ana, identified with the fertile waters of the Amudarya. She is still worshipped today together with 40 saints (the “kurkchigen”) supposed to live in the river: they guarantee the right course of water channels and severely judge the irrigation schemes by disrupting straight artificial constructions and protecting naturally adapted meandering courses. The opening of a new canal represents still today a major ceremony accompanied by sacrifices, baths and prayers: the sudden coming of fishes together with the first waters is seen as a good omen. (Mkrtchiev 1998)

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