# The Hydraulic Systems in Turfan (Xinjiang)

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The *qanat* system is a very old underground structure built since high antiquity to supply water in dry areas. This system contains a very rich nomenclature and depending on its location is designated by a different term. In Palestine we talk of *fuqara*, in Spain of *madjira*, in Arabia of *falaj*, in Morocco of *khottara*, in Sahara of *khottara*, in Afghanistan and in Xinjiang of *karez*. I have chosen the Iranian word *qanat* for this article (Loubes 1998, p. 222; Smith 1957; Briant 2001; Goblot 1979, p. 499).

This system is very simple in appearance and is usually characterized by two important aspects: When the area to tap the water is identified (usually next to a pre-mountainous alluvial fan [Trombert 2008, p. 118]), an underground down-slope tunnel is built in order to use gravity leading the aquifer water to the farms and the towns connected to this channel. On the down slope of the mountain, air shafts or wells are dug at regular intervals to aid in the construction and the maintenance of the tunnel. The water is provided by the *mader-tchah* (the mother well) (Goblot 1979, p. 30; Loubes 1998, pp. 221–222), the deepest of all the shafts and the first well connected to the water reservoir. Water is then released and flows naturally by gravity along the tunnel until arriving at the surface (Sala 2008) [Figs. 1, 2]. This system contains two main advantages: with a natural slope, there is no need for pumps or other devices to raise the water to a higher level. Secondly, the aquifer water is accessible all year long and, with the use of proper storage devices, human settlements can properly control its flow through the changing seasons.

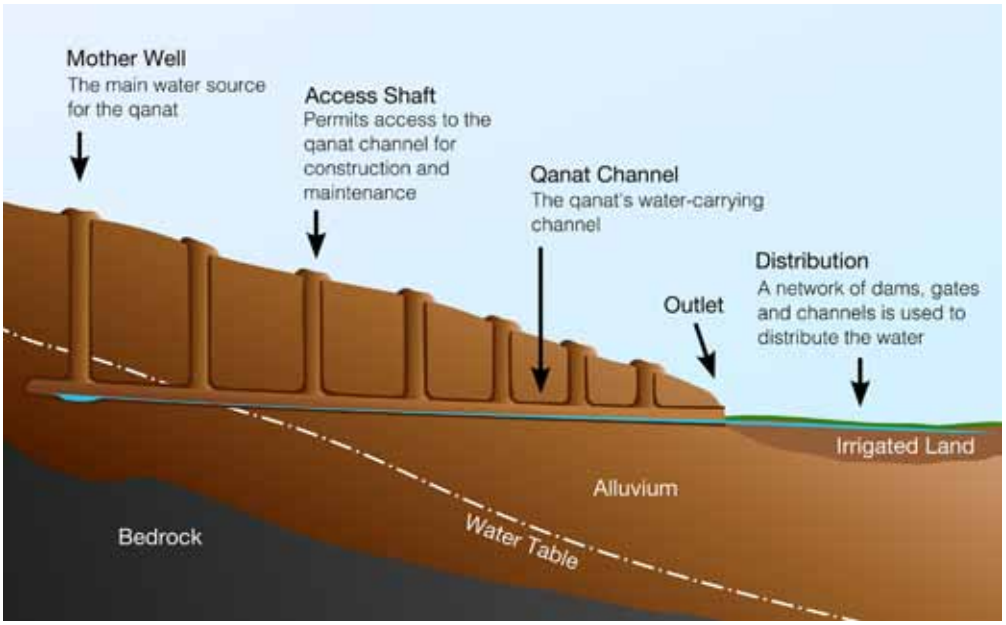


*Fig. 1. Cross-section of a qanat.* Created by Samuel Bailey (confuciou@gmail.com); from Wikipedia <http://en.wikipedia.org/wiki/File:Qanat_cross_section.svg>.

*Fig. 2. Model of qanat supplying water to the city of Yazd, Iran.* Photo (composite image) © 2010 Daniel C. Waugh taken at the Water Museum in Yazd, Iran.

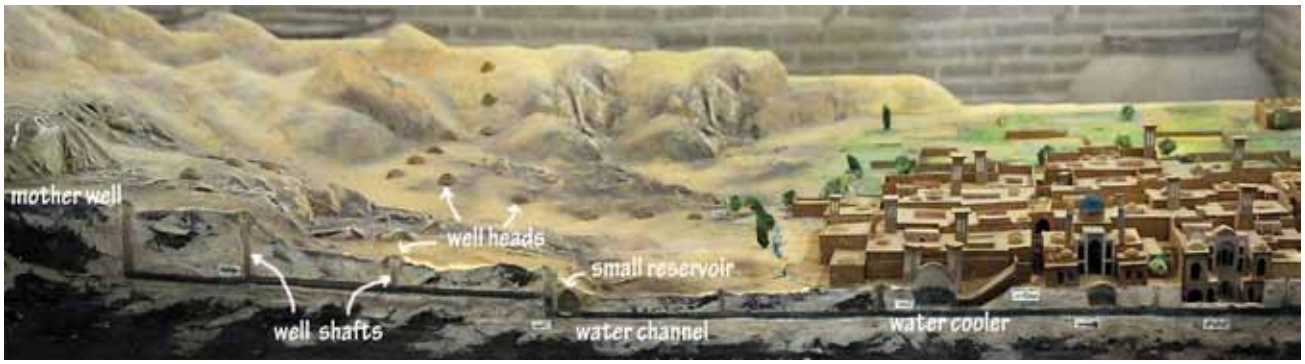

*Fig. 3. Workers digging a qanat.* *Photo © 2010 Daniel C. Waugh, from a photo in the Water Museum, Yazd.*

In its function, the qanat, from the Semitic definition "to dig" (Wulff 1968), has never been an irrigation system but a mining technique invented to bring the aquifer water to the surface by the use of underground shafts and tunnels (Goblot 1979, p. 27) [Fig. 3]. As with many different water devices in our world, past or present, we tend to generalize their functioning. Hence, we see very often that wells are used only for urban life, whereas water canals from a river, for example, are used only for irrigation (Bruneau 1991; 1994/95).

According to recent discoveries and research regarding the origin of this system, it seems that the oldest qanat are located in Iran on the northern edge of the Persian Gulf (Goblot 1963; Boucharlat 2001; *Qanat* 1989). During the Achaemenid period, this system was developed, very well controlled and widely spread along with the Persians conquests in the north, south and west, eventually reaching Egypt (Briant 2001, pp. 109–42; Chauveau 1996). Qanats have continued to be used until today in Central Asia (Sala 2008), in the Arab world (Lightfoot 2000), and in Xinjiang in the northwest of China (Huang 1994, pp. 70-71; Goblot 1963, pp. 504–05) [Fig. 4].

He who passes through Xinjiang, and stops in the Turfan oasis for a couple of hours, discovers the magic of these qanats, which are one of the many treasures of the oasis [Fig. 5]. Your Uighur guide will tell you everything about its performance, its origin, and perhaps the context of its introduction into Turfan. What you hear about the history though may well be wrong, since the subject has been controversial.

There is every reason to believe that the introduction of the qanat from Iran to the Turfan oasis occurred no earlier than the 17th and 18th centuries CE. Many scholars have discussed the

*Fig. 4. The spread of the qanat.* *From Goblot 1963. p. 504; used with permission.*

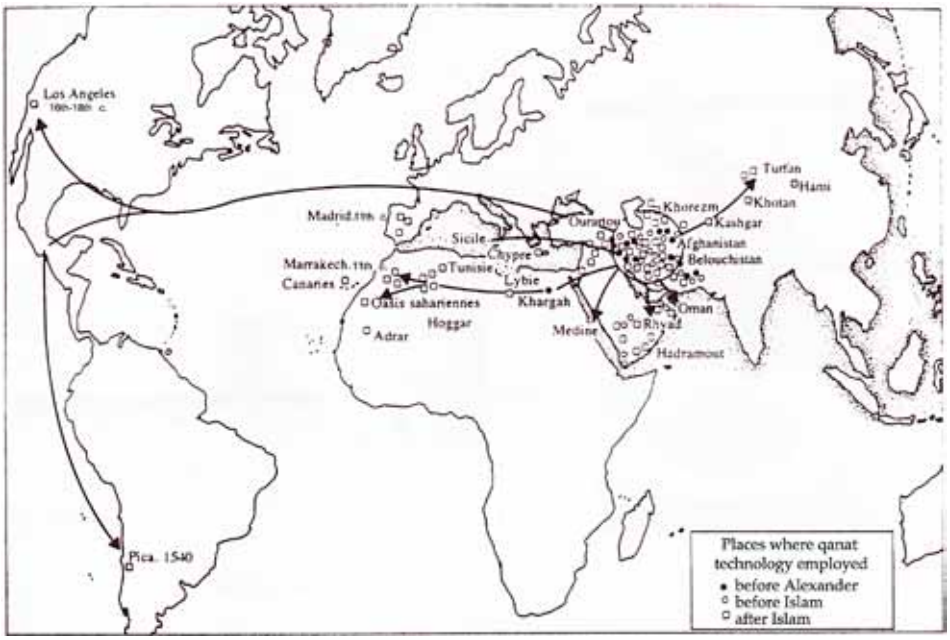



*Fig. 5. The location of Turfan in Xinjiang.* *Satellite photo: NASA Visible Earth, Taklimakan_A2002088_0525_1km.jpg.*

matter of the date, basing their arguments on evidence from different Chinese texts (Wang 1959, pp. 620–22; Trombert 2008). Some suggested that the qanat system was originally from China where it existed as early as the former Han dynasty. As Éric Trombert summarizes (2008, p. 117):

> In China, several theories have been advanced concerning the origins of karez technology in Xinjiang. Depending on individual authors, it was: (1) imported from Persia; (2) locally developed and refined through long-term experience; or (3) developed elsewhere in China's Central Plain and then imported with some minor modifications. Some combination of (1) and (2) seems the most probable. But until today, the Xinjiang Karez system is still commonly considered in China as 'one of the three Great Ancient Chinese Works,' the other two being the Great Wall and the Grand Canal.

Also, following leads first provided by the Otani expedition (Otani 1963), some specialists have maintained that evidence discovered in the cities of Gaochang and Jiaohe during the first half of the 20th century includes the remains of a qanat system dating from the early Tang dynasty. Thus they claim that China adopted the system from Turfan; this in turn would suggest a new date for the importation of the qanat in China.

Since Trombert's recent article (2008) has now provided us with a very complete analysis of the textual references to the qanat in the history of the Turfan oasis, there is now little reason to question a date of the 18th century for the system's introduction there. Assuming then that the date is not an issue, we need to explore other aspects of the hyrdological systems in Turfan. Indeed, the main role of this qanat system in the capture of water is clear, but what kinds of water devices were used prior to its introduciton needs to be determined. After examining this issue we can address the question of why the implantation in Turfan of the qanat was a success and why it arrived so late in history.

Our knowledge of the history of Turfan is now rather extensive, and we have documents and archeological proofs indicating that the main cities of the oasis (Gaochang, Jiaohe, Tocksun, Luckum…) were heavily populated. The demographic and cultural expansion continued until the conflicts which arose starting in the seventeenth century between Chinese and Muslims (Maillard 1973, pp. 19–43). There are some impressive statistics on population: for example, the Western Liang arrived with 10,000 families in Turfan at Gaochang city in 442 CE (Ibid.). Where there is life, there is water. Where such significant numbers of people are involved, we must discuss more precisely the different water techniques used to supply the families living in this space and to irrigate the fields and the grapes…

**A geographical and hydrographical overview of the Turfan valley**

It is not possible to assess the textual or archaeological evidence without making a thorough survey of the natural landscape of the Turfan basin and more precisely of the natural course of water through time.[1] Turfan is divided into three main counties: the Shanshan county on the east, the Turfan County in the center and the Toksun County on the west [Fig. 6]. The oasis, which measures around 2000 km², takes the form of a depression with very few reliefs and lies on the eastern part of the Tienshan 天山, whose highest peak, the Bogda Shan (in Turkic) or sky mountain, rises to 5455 m.

Turfan is separated from the Tienshan by the fire mountain (Huoyanshan 火焰山) located on the north of the south valley of the oasis. Because of the collapse of the Tarim plateau (Coque


*Fig. 6. The oasis of Turfan with the three counties. After Loubes 1998, p. 244, № 104; used with permission.*

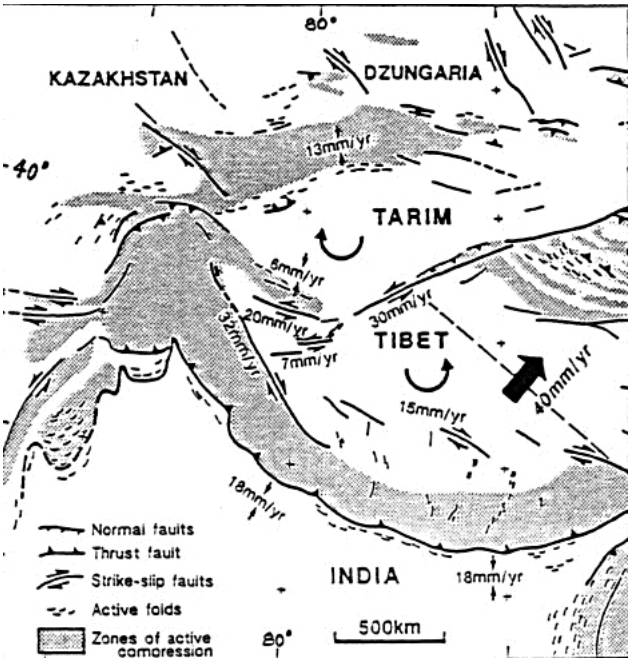


*Fig. 7. The Tibetan plate moving against the Tarim plate. Reproduced with permission from Gentelle 1992, p.557.*

Furthermore, this fault contributed to the depression of the Basin. Today, along with the Dead Sea in Israel, the Turfan basin is one of the two lowest points on earth, at around 162 m below sea level [Fig. 8]. The Yuehu 月湖 (salt lake or Aidingkol in Turkic), represents the lowest point of the basin, and the salt mountain (Cheul-tagh) rising to 1000 m, marks the southern boundary of the oasis. On the east side of the basin, the desert narrows access to the oasis, and only one direct road leads to the sites of Gaochang, Turfan and Toqsun in the east part. On the northwest side, the pass of Devan leads to the current Xinjiang capital of Urumqi.

The natural water course in this oasis is typical of the desert and mountain environments such as those of the Xinjiang region. Between autumn and spring water comes from the melting of the snow lying on the Tienshan in the north. The melting water funnels [Fig. 9] into

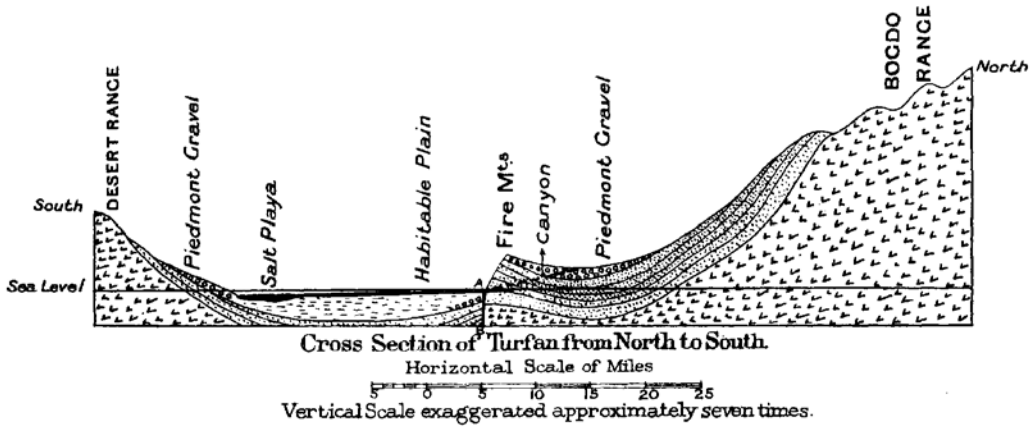


*Fig. 8. Cross-section of Turfan from north to south. From Huntington 1907, p. 254.*

1992; Gentelle 1992, pp. 555–58; Mercier 1980) into the Tienshan, an important geomorphologic fault [Fig. 7] appeared during the quaternary period dividing the basin in two, each area being the focus of settlement. In the northeast, on the fire mountain, we find some well known historic sites such as Bezeklik and Shengjiagou. In the west and south spreads the valley of Turfan with multiple cities and villages still flourishing today.

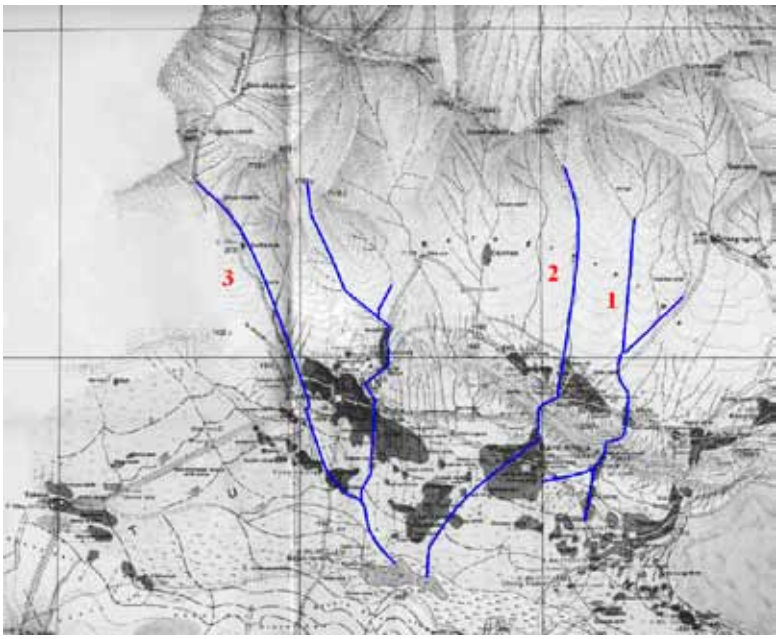


*Fig. 9. Hydrographic relief of Turfan. Reproduced with permission from Maillard 1973, fig. 1. Base map from Survey of India map sheet no. N. K-45 (1922), reproduced in M. Aurel Stein,* Innermost Asia *(1928), vol. IV, p. 31.*

small streams going down the slope and giving birth in the valley to rivers alimenting different parts of the oasis (Maillard 1973, p. 6). Three main gorges, here described from east to west, determine the entry points of the water into the oasis:

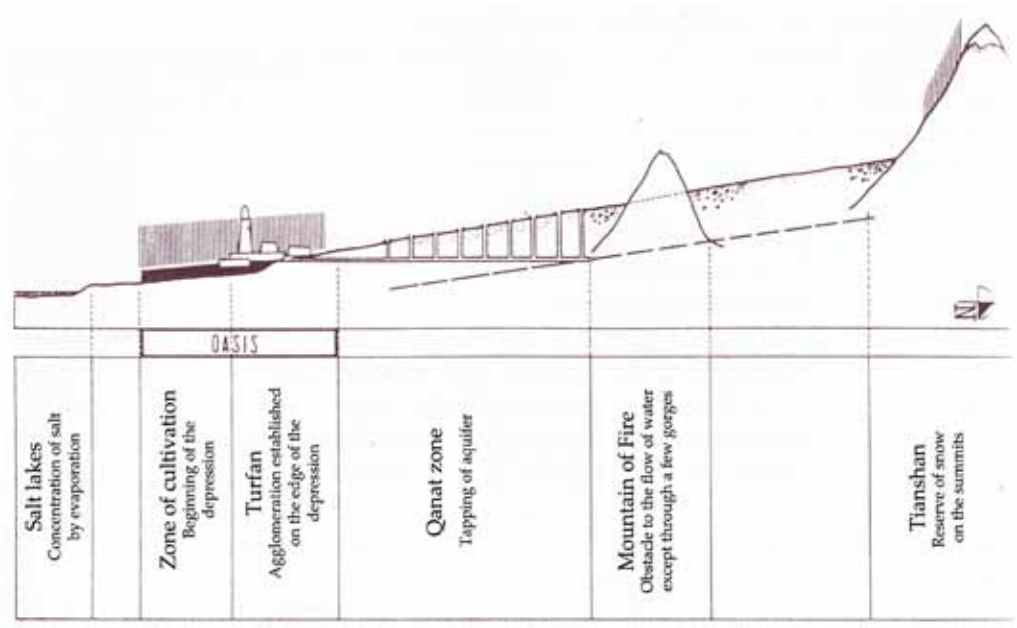


*Fig. 10. Profile of a qanat in the Turfan valley. After Loubes 1998, fig. 103; reproduced with permission.*

• Through the Toyuk gorge (no. 1 on the map), multiple small water courses from the Tienshan slopes meet to form an important river which flows through Subashi in the north-east and then passes west of Lukcun city.

• Via the Shengjinkou gorge (no. 2), a little farther west, a river passes through the cities of Murtuk and Sangym-Aghyz and below Bezeklik. In the valley of the oasis, the river flows west of Gaochang and finally arrives in the south of the basin.

• Finally through the Turfan gorge (no. 3), on the western side of the oasis, the Davandir River, which originates in the Devan corridor passes west of Huoyanshan and so flows without any obstacles to the modern city of Turfan and to the city of Jiaohe (two arms of the river pass around the city). At one time it reached the southern edge of the oasis, bringing water to Aydingkol lake.

In general it is difficult for these main rivers to penetrate to the southern part of the oasis. For example, the rivers and the shallow water slopes tend to create their own way through the Huoyanshan, but disappear in the gravel located on the southern end of the fire mountain. The Turfan region receives annually only 16,6 mm of precipitation. Hence, most of its supply must come from groundwater (Loubes 1998, p. 213).

Historically these rivers permitted many lands to be fertile and gave life to this oasis. However, as the geographer Ellsworth Huntington suggested a century ago, there is an obvious difference between the situation that prevailed under the Han dynasty and what can be observed in modern times (Huntington 1907). Rivers have disappeared or substantially diminished in length. An important desert is advancing in the west and the east of the oasis, bringing ultimately death to some places and birth to others.

The change of climate and hydrographic configuration brought the population of the Turfan Basin closer to the geological fault near the new capital of Turfan. Ancient cities have been abandoned for new sites and only the qanat keeps this oasis from drowning in the desert (Gentelle 1992; Coque 1991; Jing 2000) [Figs. 10, 11].

*Fig. 11. Model of qanat system in Turpan Water Museum, looking N toward the mountains. From Wikimedia <http://upload.wikimedia.org/wikipedia/commons/9/9c/Turpan-karez-maqueta-d01.jpg>.*

*Fig. 12. Model of Jiaohe in museum at the site. Photograph © 2008 Daniel C. Waugh.*

**Water systems in the history of Gaochang 高昌 and Jiaohe 交河 cities**

The two main cities of Turfan, Gaochang and Jiaohe, played a crucial role in the development of the oasis in pre-modern times (Li 1999), serving as its capitals until they were abandoned in the 15th –16th centuries. Located in the valley of the Turfan oasis, Gaochang could expand easily in the north, south and east. One of the main rivers passes close to the west side of the city. Jiaohe city [Fig. 12], located west of the Turfan capital, lies atop a 15 m high mesa. Its river, flowing from the north, divides to surround the city and join once more in the south.[2] Jiaohe is then about 20 m above groundwater and its river is located directly below the city in the plain. Therefore, considering the importance of these cities in the history of the oasis, they needed effective water devices. Their very different geographical features should indicate that the systems for bringing water were naturally different.

Over the period between the Han Dynasty and the 14th century CE, archaeological and textual evidence indicate that the two cities had three different water systems: wells, underground channels linked to surface channels and various kinds of canals (Ibid.; Sun 1983; Maillard 1973, p. 64).

Archaeological discoveries show that under the Jushi people[3] who controlled the oasis prior to the first conquest by the Han Dynasty in 90 BCE in Jiaohe city fields were irrigated by a certain form of irrigation system, about whose functioning we have no information. The *Hou Hanshu*, describing apparently the situation in the late first century BCE or early first century CE, suggests that the Jiaohe and Liuzhong kingdoms were already densely populated:

> The king of Nearer Jushi (Turfan) lives in the town of Jiaohe (Yarkhoto, 20 li west of Turfan). A river divides into two and surrounds the town, which is why it is called Jiaohe ('River Junction'). It is 80 li (33 km) from Liuzhong (Lukchun), the residence of the Chief Clerk. To the east it is 9,120 li (3,792 km) to Luoyang. He [the king] controls more than 1,500 households, more than 4,000 individuals, and 2,000 men able to bear arms [Hill 2009, p. 49].[4]

Given what seems to have been a substantial population of the Turfan oasis cities, especially Jaohe, we may assume that wells were built in the city by the local people before the first century BCE [Fig. 13]. This city was also occupied by the Xiongnu for a time. They used the natural defensive quality of the site for preparing multiple attacks on the other oases of Xinjiang and on the Chinese army during the campaigns launched under Han Wudi (141 – 87 BCE). The wells represented the only way to assure clean and protected water if the city was besieged (Briant 2001, pp. 30–31; Pulleyblank 1981). By the time of its reoccupation by the Chinese in 61 BCE, the city contained multiple deep wells. The city changed hands again. With

*Fig. 13. Model of Jiaohe (detail). Photograph © 2008 Daniel C. Waugh.*

its reconquest under the Eastern Han (73–102 CE), new wells were dug using the techniques employed to create the earlier ones (Li 1999, pp. 310–17; de Crespigny 1984, pp. 173–84; 1970; 1995).

The first archaeological evidence for these wells dates from as early as the Western Han Dynasty (Li 1999, p. 315), although the latest excavations have determined that most of the 300 wells discovered in Jaohe date between the 5th century (when the Western Liang and the Qu family controlled the oasis) and the end of the Tang Dynasty [Fig. 14]. Because rivers flowed on the east and west sides of Jiaohe, part of the water not used for irrigation fed the groundwater of Jaohe under the plateau. Hence, to capture this underground water and ensure its supply during the many different attacks on the city, wells were dug at least to a depth of 20 – 25 m.

An example is one excavated by Li Xiao's team in 1994 built on the same level as the troglodyte house No. 2 in the northeast of the city. After a first excavation at the surface of the city, the archaeologists discovered the top of the well in a 2 m high chamber called *xiadishi* 下地室. The well itself had extended down some 23 – 30 m before striking water (Ibid., pp. 310–19) [Fig. 15]. This xiadishi was connected to the *jiandifa* 减地法 (a tunnel leading to the house). While during the Han Dynasty the wells of the city had been dug directly from the surface, beginning in the 2nd to 3rd centuries and especially

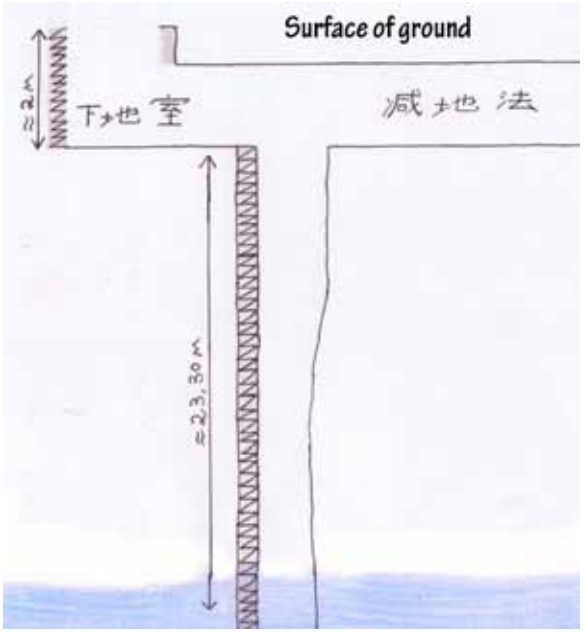


*Fig. 14 (above). Sketch of the well from house № 2 of Jiaohe. Drawing © Arnaud Bertrand.*

*Fig. 15 (right). Picture of well of Jiaohe. Photo © Arnaud Bertrand.*

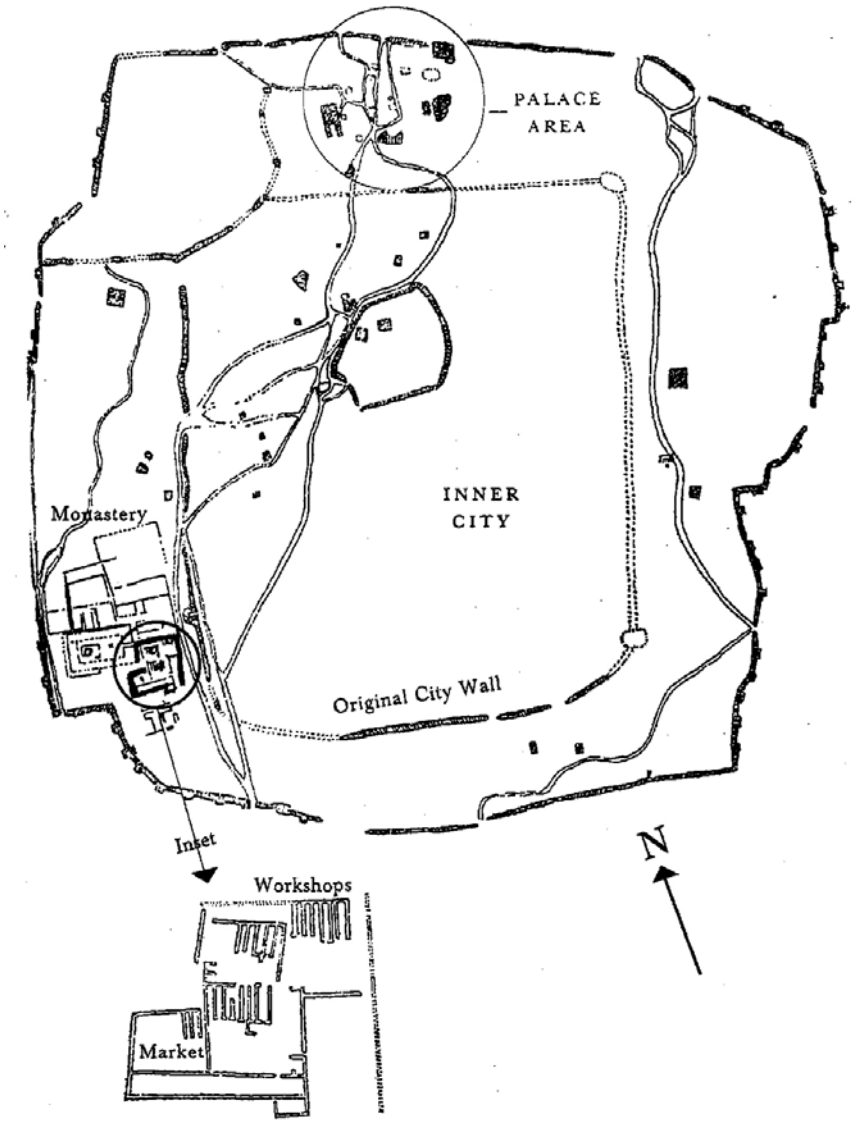


*Fig. 16. Plan of Gaochang city, 5th to 8th centuries, and of its market place. Reproduced with permission from Hansen 2004, p. 11; after* 新疆考古三十年/新疆社会科学院考古研究所编.

under the Tang dynasty, when the houses became troglodyte, some of the well-heads were moved underground to protect the water from the hot temperatures. With the building of the jiandifa corridor, the water could be brought through the tunnel directly to the house via a jar connected to a rope, thus avoiding the hot climate on the surface (Ibid., pp. 311–12).

The water systems of Gaochang city are more complex to understand because it appears that several devices were used at the same time for different tasks [Fig. 16]. During the conquest of the oasis by the western Han, the Chinese developed considerably the infrastructure of Turfan and positioned their garrison at the Gaochangbi 高昌壁 (the wall of Gaochang) during the first half of the first century BCE. The Han military strategically located its city next to the river on the west side of the town, which had the strongest flow at the time (Pulleyblank 1981; Gentelle 1992; Huntington 1907, pp. 254–67) and thus must have constituted the main water supply. Hence, when posted in Gaochang, the soldiers must have first tapped the river manually, and when the garrison became an actual town, they built channels going through the town irrigating the crops and supplying water to houses.

The first textual references (Pelliot 2002, p. 128; Yamamoto and Ikeda 1987; Guojia wenwu 1986-1987) mentioning a hydraulic system in Gaochang date between the independent Gaochang Kingdom (500 – 640 CE) and the end of the 8th century. A very ingenious water channel was built in order to irrigate the entire valley located in the vicinity of Gaochang. Located 20 li north of Gaochang City, in the Xinxing Gorge of the Kizil Range (near Sengging-aghiz), a main canal, "called the Manshui 满水 Canal (the full water canal), brought water into the heart of the oasis; it fed the ditch around the city wall and flowed on southward [Fig. 17]. The other canals were connected to it" (Trombert 2008, p. 130). The open air canals all functioned thanks to the existence of dykes and a reservoir (placed on the northern and southern ends of the city) which served as transfer station to irrigate the north and the south of Gaochang. It is still not certain whether this Manshui canal tapped a "well canal" 胡麻井渠 or underground canal built into the Kizil-tagh range. Many Chinese specialists have made a direct link between the "well canal" mentioned in the sources and the qanat system. As Trombert points out (Ibid. p. 133):

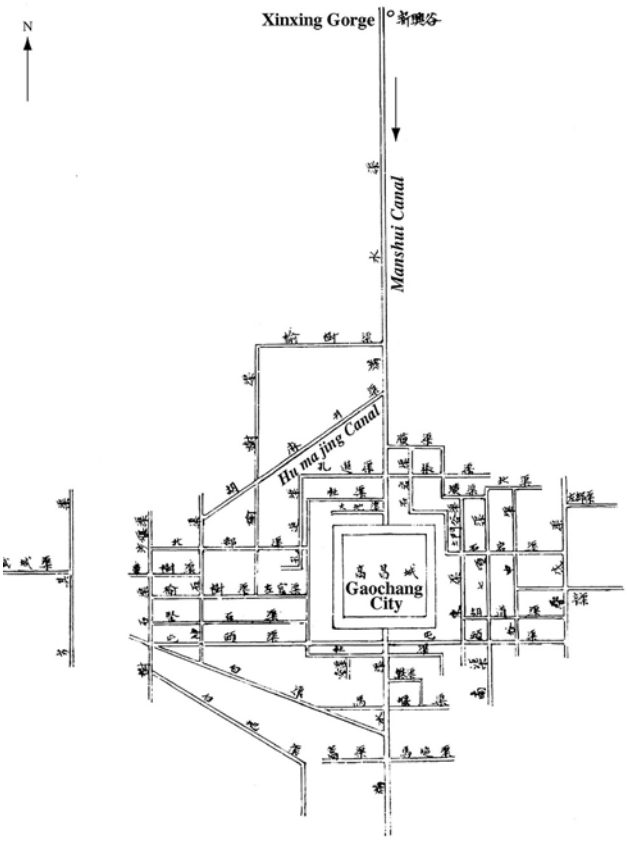


*Fig. 17. The water canal plan near Gaochang from Turfan. Reproduced with permission from Trombert 2008, p. 130 (after Nishimura and Sun Xiaolin).*

> Even if this interpretation were correct, it would only demonstrate that the qanat system was completely marginal in the Turfan Basin since none of the other forty canals was named 'well-canal,' not even the main canal that transferred the water from the Kizil range foothills to the cultivated plain: […] its name was 'Full-Water Canal'.

Such a canal system was probably used for irrigation both inside and outside the city. The city plan indicates that the main canal led directly into the city and fed a network of smaller canals around it. A system of canals enveloping a city is quite common in Chinese towns: Luoyang under the Wei is a good example (Pelliiot 2002, p. 43; Steinhardt 2002, p. 65). Today in Turfan city, irrigation for its trees and grapes is supplied by a canal. Were such canals also used for supplying water to human consumption? One canal went directly to the Buddhist monastery on the southeast side. If this open canal provided water for people, would not tanks and a decantation system have been needed to purify it? In the modern town of Turfan, decantation and reservoir systems are placed in front of many houses so that the water used for irrigation is also used for other purposes [Fig. 18]. Perhaps in Gaochang ancient city the same system was used. Further research is needed to test this hypothesis.

Apart from canals, the German archaeologists Grünwedel (1906) and von Le Coq (1913) discovered some wells in the city without giving their location. These wells were built directly in the clay soil of Gaochang and were usually 4–6 m maximum depth (much less than in Jiaohe) (Maillard 1973, p. 64). Groundwater was quite important until the 20th century, and the water was accessible from within the city by the building of proper wells. The existence of these wells confirms that Jiaohe and Gaochang used the same technique to access water even though their geographical features are completely different. Perhaps the well specialists were work-

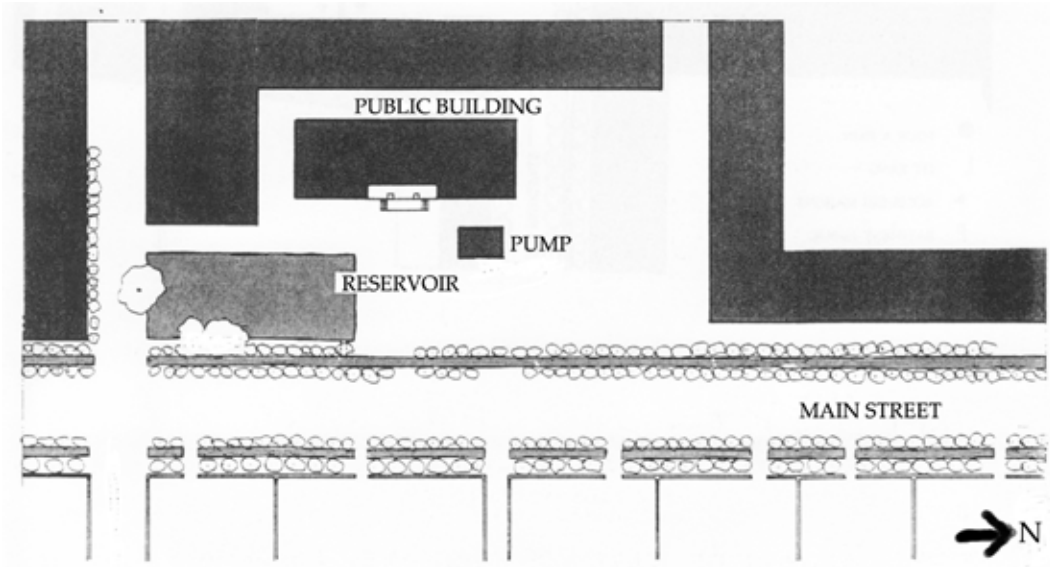


*Fig. 18. Plan of a Uighur house of Turfan city with the water drainage system. After Loubes 1998, p. 289, № 126; reproduced with permission.*

ing for both cities at the time? Surely the study of other ancient towns such as Tocskun or Bezeklik could further elucidate this point.

**Why the success in the introduction of the qanat?**

Now that we have an overview of the different systems used to bring water to the fields and the cities of Jiaohe and Gaochang, we can propose a practical explanation why in Turfan and not in Dunhuang, for example, the qanat managed to work (Trombert 2008, pp. 124–26).

The different water systems require similar expertise in excavation to create wells or underground channels and tap water from the mountains. Thus the methods used and the resulting structures correspond to those of the Iranian qanat. The deep wells in Jaohe, for example, are quite similar to the vertical shafts used for the qanat system. In Gaochang, the same can

*Fig. 19. Even major buildings in Jiaohe were in some cases largely constructed below the ground, here an administrative building in the center of the city.* Photo © 2008 Daniel C. Waugh.

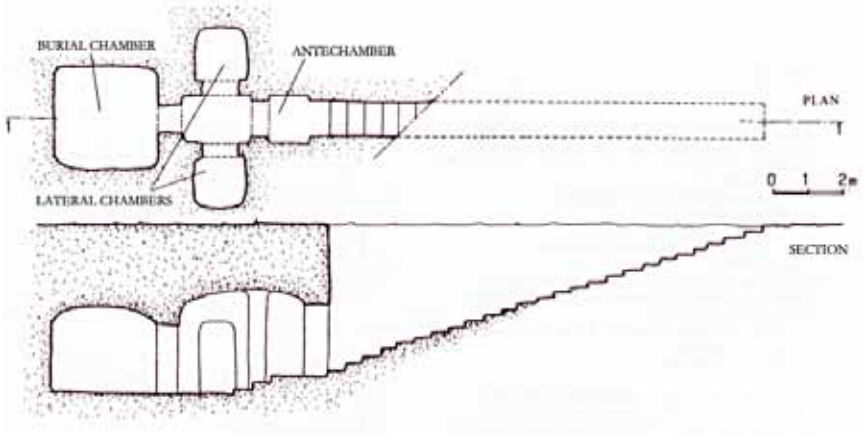


*Fig. 20. Diagram of a tomb at Astana. Long entrance corridors to such tombs often had vertical shafts for ventilation and light.* After Loubes 1998, p. 135; reproduced with permission.

said for the Manshui canal, which required substantial expertise to tap effectively the water from the Kizil Range. The people of Turfan thus were familiar with the techniques required to construct underground canals through alluvial soils and conglomerate.

This expertise in excavation techniques is reflected as well in other structures and drew on traditions going back over two millennia in the region. In Jiaohe, for example, there are various dwelling caves carved out in the first instance to protect people from the severe heat [Fig. 19]. The various Buddhist cave sites such as Bezeklik, north of Turfan in the Huoyanshan (fire mountain), are other illustrations of how the techniques relevant to well construction were employed. Further examples can be seen in the underground shafts of tombs at locations such as the famous Astana cemetery [Fig. 20]. Thus there was a base of practical knowledge that then could be applied to creat the qanat system centuries later. The tools may have been the same for these different constructions and used once more for the qanat system (Sala 2008) [Figs. 21, 22].

The historical evolution of an oasis like Turfan goes hand in hand with the evolution of water control. Over the centuries beginning with the end of the Eastern Han dynasty, the demographic evolution of Turfan required improvements in hydraulic engineering capacity. Yet by the 15th century Jiaohe and Gaochang cities were being abandoned. There are several probable explanations, above all, first, the destruc-

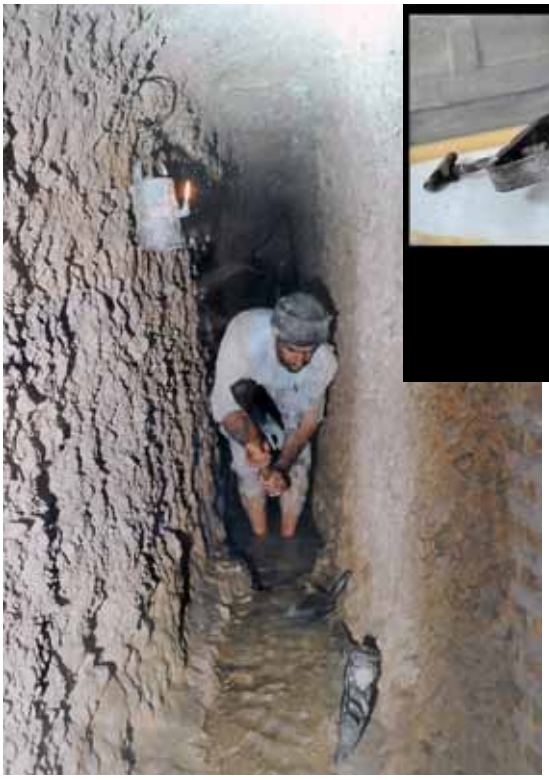

*Fig. 21 (left). A worker cleaning a qanat. Photo © 2010 Daniel C. Waugh, from photo exhibited in Water Museum, Yazd.*

*Fig. 22 (above). Lamps and digging tools used by qanat workers; display in Water Museum, Yazd. Photos © 2010 Daniel C. Waugh.*

tion from wars that started between the Muslims and the Chinese, and second, the destruction of the wells of Jiaohe and the canals of Gaochang, forcing the final abandoment of these two main cities. Climate change also seems to have played an important role with the south of the oasis progressively drying out, leading to increased salinity of the soil and remaining water. Hence, the people of Gaochang started to move north closer to Turfan city, where the water supplies could be guaranteed. (Gentelle 1992). A new Gaochang village, completely transformed by the Chinese in the 1960s, was built north of the ancient city (Loubes 1998, pp. 94–95). However, Jiaohe would never be occupied again.

The introduction of the qanat system in the 18th century, by then already known in other oases not far from Turfan on the north road of Xinjiang (Li 2005, pp. 25–28; Huang 1994), was a response to the need for a new water technology. Only the qanat could save the oasis from complete desertion such as had happened in other oases in Xinjiang due to a deficiency of water. The familiar examples are the cities of Loulan, Niya and Miran, located in the eastern and southeastern part of the Taklamakan Desert, which up to the fifth century were part of a flourishing kingdom of Kroraina (in Prakrit; Shanshan in Chinese). The abandonment of Loulan was mainly due to the failure of the Tarim River to continue supplying water to Lake Lop-nor. In the north of the Taklamakan as well, the ancient oases of Caohu, Tarim, Luntai and Yuli are now abandoned, because no solutions were advanced to bring back water to the villages and feed the crops (Berque 2005, pp. 277–80).

If the qanat had not been introduced to Turfan, the same situation would have happened there. And it worked there due to the suitable geographic conditions. The qanat must be established in a mountainous environment where there is sufficient groundwater and with space to link the system to the surface canals. The technical expertise developed over many centuries in constructing dwellings, wells and canals was available to take advantage of the favorable geography.

**Can the qanat save Turfan now?**

Today the qanat feeds the oasis, but cannot continue to do so into the future. Demand for water is growing, too many qanats are being built in close proximity and too many wells are being dug, thus exceeding the capacity of the ground water to keep the system functioning (Halik 2003; Lein and Shen 2006). From 1946 to 1981 in the Shanshan county of the Turfan oasis (on the east of the valley), about 1985 qanats and wells were dug [Fig. 24, next page]. The increase of wells lowers the groundwater level (Loubes 1998, p. 228): in 1949, the annual quantity of underground water reached

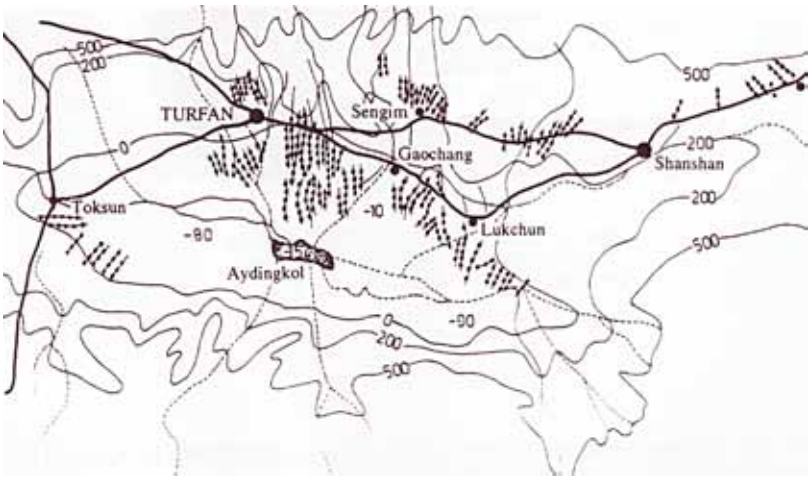


*Fig. 23. Even a century ago, the qanat network in some parts of the Turfan area was quite dense. Reproduced with permission from Loubes 1998, p. 246, № 107; after the 1922 Survey of India map based on Aurel Stein's data.*

2,101,300 m3; by 1985, the quantity was only 1,772,400 m3. Examples from Iran illustrate how exactly the same process has undermined the qanat system there (Qanat 1989, esp. Part III).

As Allés (2006, p. 413) puts it,

> Water is going to become in a few years a major problem in the oases [fed by the qanat system]. The local authorities announce the progressive extinction of the traditional wells (qanat), the water level being now too poor. Motor pumps are replacing them because we need to dig deeper in order to reach the groundwater level. In Xinjiang, new water systems like electronic water basins are tested in order to save these many oases gnawed by the qanat.

So it seems that very soon the people of Turfan will need to make a new choice: must they move elsewhere, or must they introduce a yet another new hydraulic system to save its beauty for the centuries to come?

## About the author

A graduate student from the Sorbonne in Paris, **Arnaud Bertrand** is a specialist in the archaeology of the Xinjiang region. His field of research focuses on the ancient water systems in Chinese Central Asia and the history of the military conquest of Xinjiang under the Han Dynasty. He is now an associate curator at the Guimet Museum in Paris where he is working with Laure Feugère (official representative of the Buddhist Central Asian collections), Jacques Giès (director of Guimet Museum) and Zhao Fang (Donghua University Shanghai) on the publication of a catalogue regarding the collections of the ancient textiles discovered by Paul Pelliot in Dunhuang. After completing a year in Yale in the East Asian Department as a postgraduate, he will prepare his Ph.D. under the direction of Alain Thote (Director of Studies at the École Pratique des Hautes Etudes) and Éric Trombert (CNRS) in Paris.

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## Notes

1. For a survey of the geography of Turfan see Huntington 1907, pp.254-257; Stein 1925, pp. 473-498; Maillard 1973, pp. 5-12.

2. The name Jiaohe means literally "between the rivers."

3. According to the archaeological evidence, the Jushi people, possibly Indo-Europeans, have been living in the Turfan basin since the late Bronze Age or early Iron Age (see Mair 1998, I, p. 242). On the history of Turfan before the Han conquest see Lin 2000; Luo 2009.

4. Many specialists have debated the accuracy of numbers in the official documents which tend to inflate the actual figures. On this matter see Loewe 1967; 1974.