A Study on Water Environments in Moenjodaro
モヘンジョダロの水利施設の目的を推理する

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ABSTRACTS: Moenjo-daro, one of the old civilizations in the world, was equipped with the perfect drainage system, wells and a great bath, which were excavated during 1920-30's, by British archaeologists, Sir John Marshall, Earnest MacKay and others. Those archaeologists supposed that these facilities associated with water had served almost same purpose as those in modern times do. However, there are many things which these hypotheses couldnot explain the real conditions. In this paper we would like to highlight the exact purpose of these water-related facilities, on the basis of hydraulic viewpoints.

KEYWORD: Moenjodaro, drainage system, well, bath, archaeology

Introduction

Moenjodaro, located along the Indus Valley, is one of the oldest civilizations of the world. According to archaeological survey, this civilization flourished from 2,500 BC to 1,800 BC. There was a very high concept on sanitation. There were many wells, drainage system, washing basins and a large bath. These facilities were buried for thousands of years, and in the middle of the 1920's British archaeologists had excavated them. It is said that only 10 per cent of all the heritage of Moenjodaro had been excavated and the rest remained covered by the natural deposits.

The British archaeologists, led by Sir John Marshall and Mr. Earnest MacKay, analyzed and interpreted the remains. These interpretation, however, were based on western common sense and/or on modern concepts, which would be quite different to the Asian concept, especially from the Indus rural point of view. Their interpretation was not based on the hydraulic and hydrological aspects.

Recently some researchers, not only archaeologists, but other specialists, such as architects, geologists, anthropologists and professors of religion, are checking the hypotheses, presented in the 1930s. For example, Prof. Michael Jansen, dealing with a history of architecture at Aachen Technical University, is a leading researcher on Moenjodaro, with a long years' field survey, and he has presented many new hypotheses on the facilities, based on a hydraulic theory.

Our research group consists of environmental and urban engineers, who have specialized in the fields of planning, designing and construction of sewer networks. The primary issues taken up by this group was: what was the essential and basic motivation behind the installation of the sewer networks in Moenjodaro. However, on knowing the system there, many questions arise. The most basic and essential question is: was there enough water in Moenjodaro? Generally speaking, wells, especially more than 10 m deep, are usually dug in the water deficit districts, not in area with abundant water.

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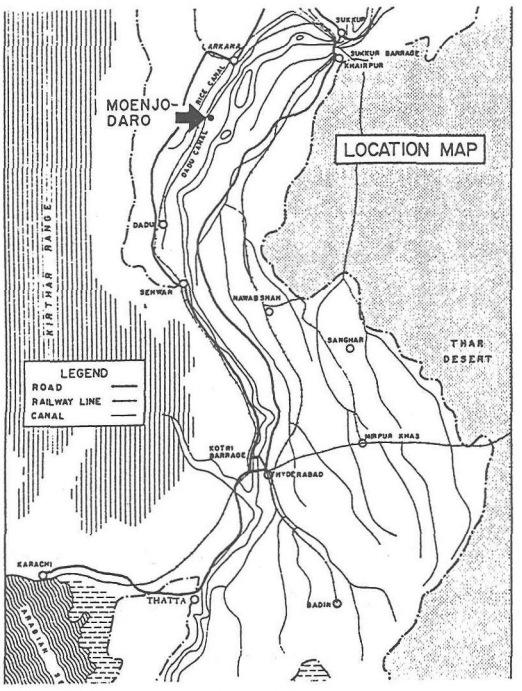

Fig.1 Location Map of Moenjodaro

Moenjodaro; Location and Characteristics

Moenjodaro is located in the Indus Valley (Fig.1), and is generally past of site Harappan Civilization, which is comparative with the Egyptian and Mesopotamian civilization. We have found more than 250 heritages or villages in the Indus Valley, among which Harappa in the Punjab. Among them, Moenjodaro in Sindh are the biggest and the most important. They look like each other, and are categorized as the same civilization. However, both the civilizations are apart by about 480 km and are based on quite different conditions.

In 1921, Mr. Banerji started his excavation at Moenjodaro, and Mr. Vat followed. In the next season of 1924-1925, Mr.Dikshit dug many trenches in the DK Area. After these trial diggings, the Indian Government agreed to further excavations, to be conducted by Sir John Marshall, supported by many archaeologists from northern and western India. Mr. Vat, Mr. Dikshit and other

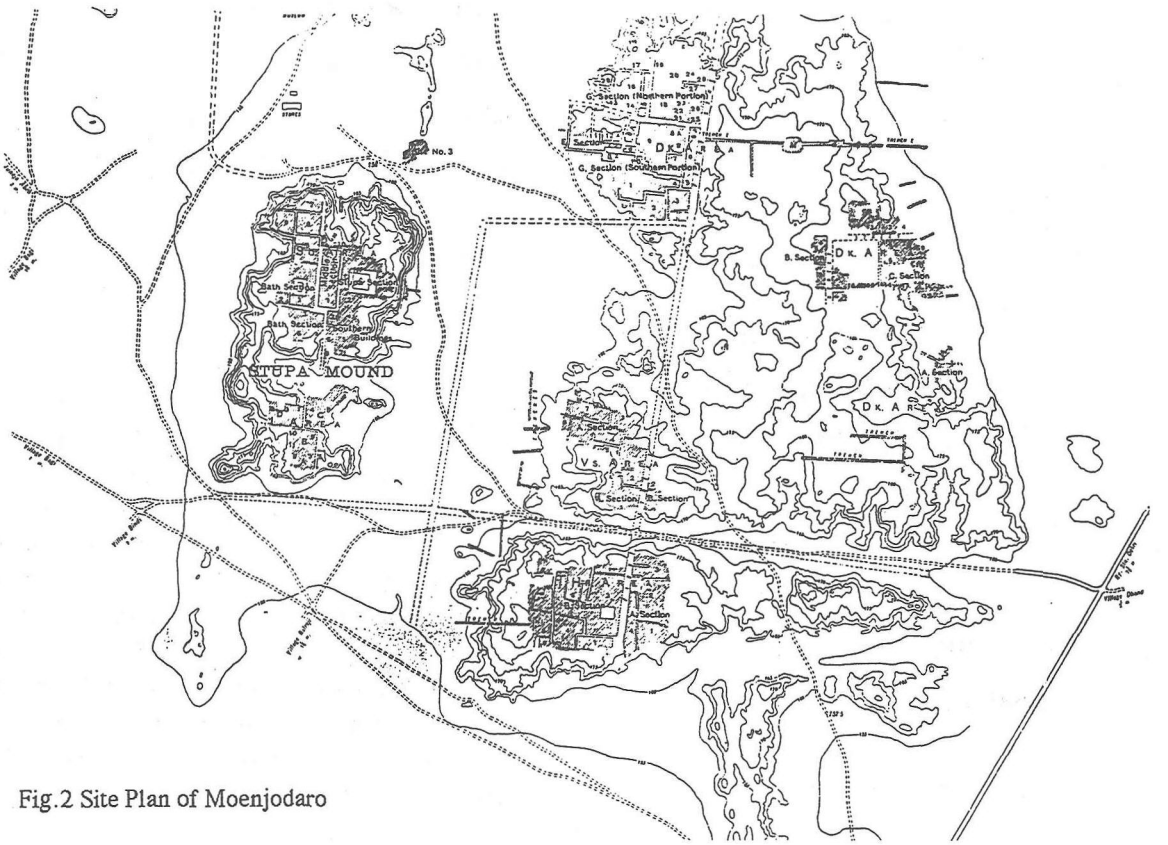

Fig.2 Site Plan of Moenjodaro

archaeologists were parts of this research group. Sir Marshall then edited and published his great book, titled "Mohenjodaro and the Indus Civilization" . In 1926, Mr. MacKay restarted excavations especially in the DK Area. He also edited his report in "The Further Excavation".

In this archaeological survey, Sir Marshall and Mr. MacKay interpreted many remains, such as the strata, seals, wells, platforms and a Great Bath. However, some interpretations were not rational, because at that time the basic archaeological knowledge was not adequate to correctly interpret or to analysis them, as compared with present day. For example, a Great Bath was identified but it was not ascertained as to how water was filled for taking a bath, because the capacity of this bath was too large. Therefore, we are going to check their interpretation, especially from the hydraulic and hydrological aspects.

The Heights of the Heritage

Figure 2 shows the location of the heritage in Moenjodaro, and Figure 3 shows the heights of the several facilities. The northern and eastern corner of the great bath is 54.8 m above mean sea level, converted from feet in Mr. MacKay's book into meter. The height of the museum and the guest house at the Moenjodaro is 47.0 m above mean sea level, which means it locates 7.8 meter lower than the Great Bath. My first question at Moenjodaro is how the Great Bath was buried by winds or flooding?

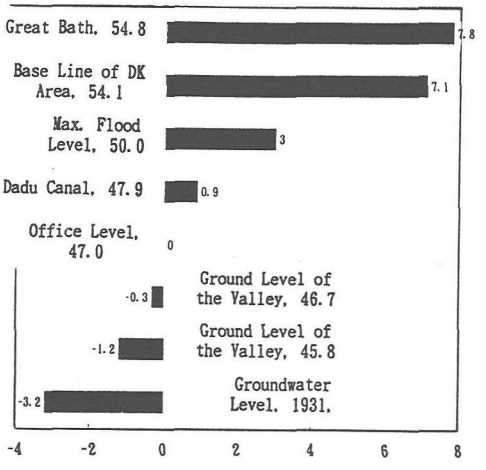

Fig.3 The Heights of the Heritage (m)

With heavy flooding of the heritage of the Great Bath, the surrounding areas would also be flooded, because these areas were much lower than the heritages. However, we could not find traces of flooding around the Museum. Figure 4 shows the basement or door sills for each Phase of the Civilization, defined by MacKay (1938). He claimed that the Civilization of phase I of Intermediate was terminated by heavy flooding and it was buried by 20.4 ft (6 m) with fine muds, which would be brought by flooding. If MacKay's interpretation is right, the ground would be also buried.

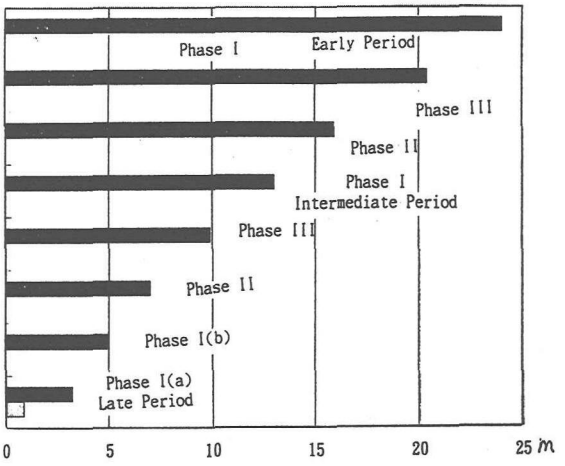

Fig.4 The Height of each Phase of the Civilization

The Heights of Wells

It is said that there are 600-700 wells in Moenjodaro. Figure 5 shows the distribution of wells in the DK area. These wells were not always in use at the same time. By Mackay's reports, the tops of the wells did not pierce through all the strata, which means that some wells had not been used simultaneously. Some wells were very closely located to other wells, and it was supported that one might have replaced the other. The DK area is not flat, so that the heights of the top of the wells are not the same. However, most of wells were higher than the ground levels, the biggest distance is seemed to be about 20 ft (6 m).

Fig.5 Distribution of wells in DK Area

We could not guess what the level of the groundwater table was about 4,500 years ago. There is no method to estimate this. On 13th January 1931, as described in MacKay's book, the depth of the groundwater was 34.2 ft (10.3 m) under the datum of the DK Area. If the depth of groundwater about 4,500 years ago had been the same as in 1931, the maximum depth of a well (s) would have been about 9m. I doubt that about 4,500 years ago there were technologies to draw up water from depth of 9 m, without any machines and tight and unbroken buckets. As can be seen in Figure 5, there were no working space to draw up water. In some books on the history of technical development, the basic and simple techniques for drawing the water in Egypt and Mesopotamia are introduced. In some cases, there were possible by using animal power. However, because the location of the wells (Figure 5) was in small rooms, surrounded by walls, they could have only used man power and the utilization of animals, such as a cow, was not possible. In the case of the well, located just near the Great Bath

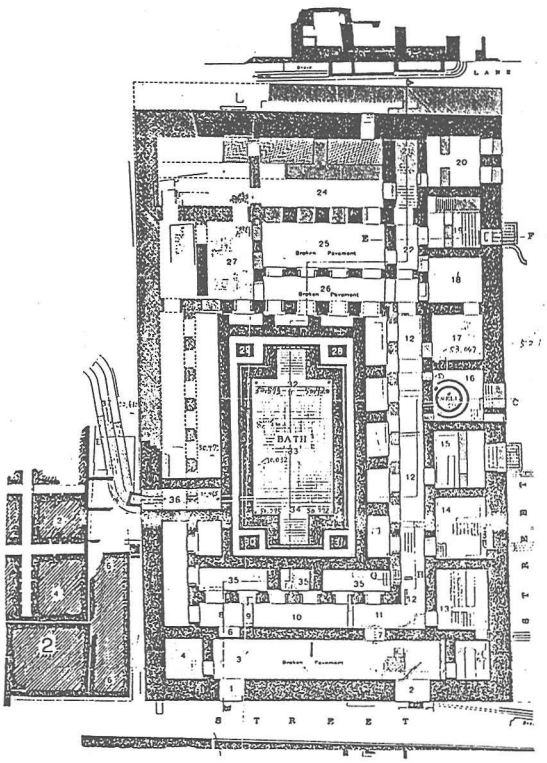

Fig.6 Great Bath and a Well

(Figure 6) it seemed to be the source of water for the Great Bath. But the height of the top of the well was 53.047 m, as surveyed by us on 26th December 1993, which was 1.8 m lower than the top of the Great Bath. This well was also surrounding by walls and there was no place for drawing water by machines or man power. If this well had been the source of water for the Great Bath, it would have been necessary to transport the water in buckets or other containers. The dimen-sions of the Great Bath are about 7 m wide and 12 m long, so to fill 10 cm of water depth in the great Bath needs 8.4 cubic meters of water. When the capacity of a bucket or container being about 10 liters, it should draw water 840 times to fill the Great Bath. Even if these drawing and transpor-tation were carried out by slaves, they needed a lot of man power and buckets or containers. However, I could not imagine these working places and roads in the map, edited by Marshall. And we could not find any evidences of suitable tools for drawing up the water.

Of course, the groundwater table was more than 10 m from the tops of wells, even if it were the same depth as that in 1931. I did not know what technologies had been applied to draw the water from such a "deep well". Even in today, wells with depth of more than 10 m need some engine powers to draw water, because the atmospheric pressure is almost

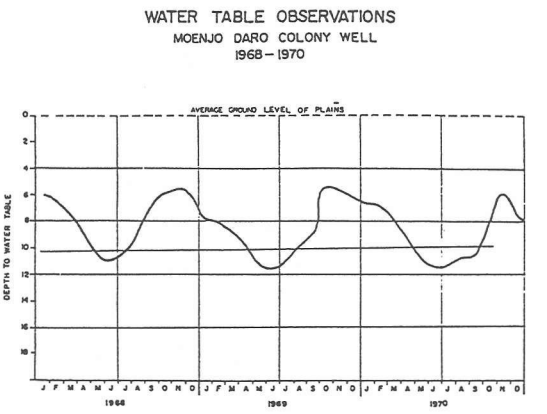

Fig.7 Water Table Observation in 1968-1970 (m)

the same as at the 10 m depth. Figure 7 shows the variation of groundwater table from 1968 to 1970

(Khan 1973), and adding the height of the ground-water table on 13th January 1931. The difference between the two years is thought due to the Dadu Canal, which delivered irrigation water from Sukkar Weir, constructed in 1932, supplying a lot of water to the area of Sindh District, including Moenjodaro area. According to this graph, the height of the water table is maximum in January. This complies that, the water table in most of the season in 1931 might have been much lower than that on 13th January 1931. The distance of the water table from the top of a well in 4500 years ago must have been more than 10 m.

Capacities of the Drainage System

In an earlier work (Ichikawa, et al: 1994) we illustrated the flowing capacities of the drainage system in Moenjodaro, based on our survey and calculations by using Manning Formula. According to our surveys we concluded that these drainage systems were not used for rainwater nor sanitary sewerage drainage. And we proposed the hypotheses that these drainage systems were used for the drainage of water which was used for some religious purposes.

Adding to this survey, the hydrological consideration showed that the well could supply only a very little volume of water for drinking water or the religious purpose. However, these hypotheses are still "Speculations". To confirm that our speculation is to be "Theory", further examination, verification, research work and/or survey is necessary. However, there are fewer possibilities that we can find more evidences from the sites of Moenjodaro and other areas of the Indus Civilization, because it had passed already 4,500 years, even though it is said that there more than 90 per cent of this heritage still remains buried and only 10per cent of heritages was excavated by Marshall, Mackay and Wheeler.

The Customs and Habits in Sindh

Another aspect of research is to investigate the neighboring districts to know the customs and habits. However, several cities surrounding Moenjodaro, such as Larkana, Khairpur Rohli and so on, had been modernized during the British Reign. For example, a local government, supported by the British Regime, constructed a modern sewer system to drain sanitary sewerage, and there were no evidence of a drainage system from the old days.

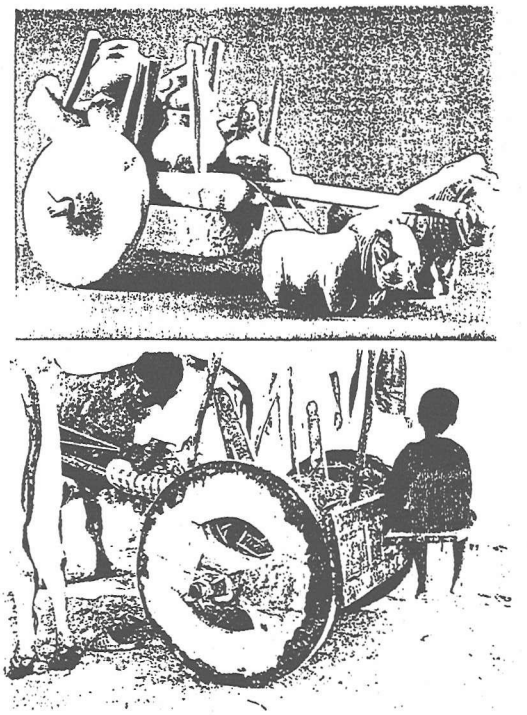

Fig. 8 Old and New Cow Carriers near Moenjodaro

However, in a rural area, there was simple evidence of what had come down through the ages. Figure 8 shows the carriers, driven by cows, in 1994, and the terracotta artifact of a trolley. These two figures seem very much close alike. In the center of a small village of local habitants, whose houses are made of clay and weeds (Figure 9), one saw a clay container, about 80 cm of diameter, in which the grain seeds were stored, because inside of the clay container is much cooler than the temperature outside. Similar containers were found during the excavations of the Harappa Civilization. Such specific research could bring about fruitful results, if one compared and checked with present day's rural facilities.

Figure 10 shows the drainage system in a rural area, close to the village of Kairpur, which is almost the

same style of that in Moenjodaro. The drainage system in Kairpur is clogged with the deposits of night soils and produces smells and odors, which

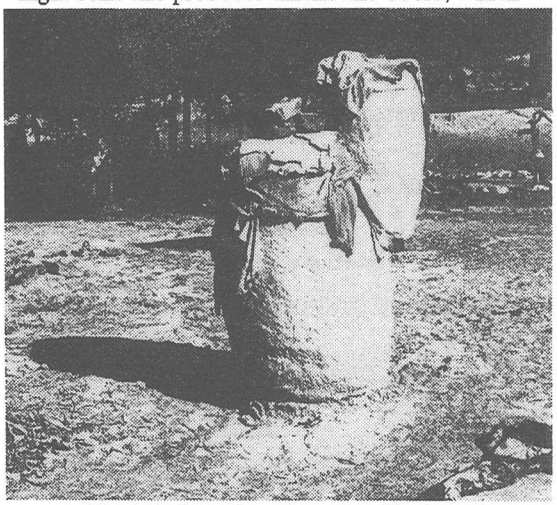

Fig.9 A Clay Container near Khairpur

are detrimental environment. If the drainage system at Mohenjodaro were used for same purpose, the town of Moenjodaro, which has been thought to be more densely populated than Kairpur, could have been extensively polluted by the night soils. Therefore, we concluded that the drainage system in Moenjodaro was not used of the drainage for sanitary sewerage.

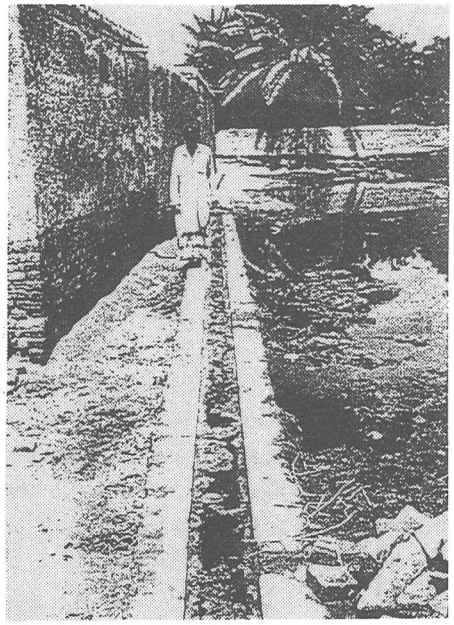

Fig.10 Drainage system near Khairpur

Conclusion and Further Consideration

We are dealing with very old phenomena, but we could not explain them through the remains, because the civilization is too old and there were not always left for us. However, through these survey we highlighted the necessity of a "multidiscipenary approach" to interpret these old civilizations. This study was the first case for us to deal with archaeological phenomena, so there is scope of many misunderstandings. In further research, we are going to "dig" out these problems and to approach the real image of Moenjodaro.

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