

Palaeo-Environmental Changes at Kaman-Kalehöyük, Kırşehir, Turkey

- A Verification of the Humid Periods during the Bronze Age and the Iron Age -

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INTRODUCTION

The paleo-environmental research in Central Anatolia started in 1991. The multidisciplinary surveys using methods of geology, geochemistry, geography and paleontology at Konya Basin, Lake Tuz, Lake Seyfe and Kayseri made clear the fluctuations of climate during the Late Pleistocene and the Holocene (Ishimaru and Kashima 2002; Kashima 2002 ; 2003a; 2003b; Kashima *et al.* 2005).

The climate in Central Anatolia was generally humid during the LGM (Last Glacial Maximum; about 20,000-30,000 years ago). The lake levels kept 30m higher than current lake levels at Konya Basin and Lake Tuz by the height of lake terraces and their ¹⁴C ages. At Lake Seyfe too, the level was higher, although the exact lake level at LGM was not calculated yet (Roberts 1983; Ishimaru and Kashima 2002; Kashima 2002; 2003b).

The humid climate turned to be drier after LGM, because lake levels of the above three lakes became lower. However the lake levels did not decrease smoothly but fluctuated two times (Konya Basin) or three times (Lake Tuz) through YD (Younger Dryas; about 13,000-12,000 years ago) stage (Roberts 1983; Kashima 2002; 2003b).

After YD stage, the dry climate covered widely Central Anatolia. The water disappeared completely at Konya Basin and Lake Seyfe and extremely decreased at Lake Tuz. Although the main part of Konya Basin has been dried up till now, the lake water has recovered at eastern margin of Konya Basin and Lake Seyfe since about 6500 cal. B.P. (Roberts 1983; Ishimaru and Kashima 2002; Kashima 2002; 2003a; 2003b).

The short term fluctuations of water levels after about 6500 cal. B.P. were presumed by the drilling surveys at marshes beside Kültepe, a capital city of the

Hittites in the Middle Bronze Age in Kayseri. According to C¹⁴ ages, a grain size analysis and microfossil analyses (diatom and pollen), there were three humid periods, dated to 6500 cal. B.P., 2200 cal. B.P. and 1000 cal. B.P. respectively. However the change of water levels during Bronze Age (5000 cal. B.P. – 3200 cal. B.P.) and Iron Age (3200 cal. B.P. – 2400 cal. B.P.) has not been examined yet at the core, because interruption of sedimentation might be occurred (Kashima *et al.* 2005).

In contrast to the detailed studies on lakes and marshes mentioned above, the paleo-environmental studies at Kaman-Kalehöyük were limited, although the archaeological excavation has been continued more than 20 years. Yasuda (1992) and Kashima and Matsubara (1993; 1994) reported three ¹⁴C ages and microfossil analyses (pollen and diatom) taken from marsh deposits at north of Kaman-Kalehöyük. They estimated that there existed a humid climate that was characterized by the deposition of the shallow swamp before 1800 years B.P. Kashima and Matsubara (1994) presumed that the swamp deposit could be divided into two layers at different levels, and humid environment had fluctuated less than twice at Kaman-Kalehöyük. However the exact ages and detailed examination of the both humid periods could not be come out from the samples, because they were taken with a power shovel at the well dug near the höyük and contaminated a lot.

The excavation at Kaman-Kalehöyük by Japanese Institute of Anatolian Archaeology (JIAA) made clear that there existed a very huge walled city with original culture prospered there through Bronze Age and Iron Age without a blank period. Therefore, Kaman-Kalehöyük presumed to be one of the best areas in Central Anatolia to discuss the relationship between civilizations and the changes of water environment caused by climatic changes during Bronze Age and Iron Age.

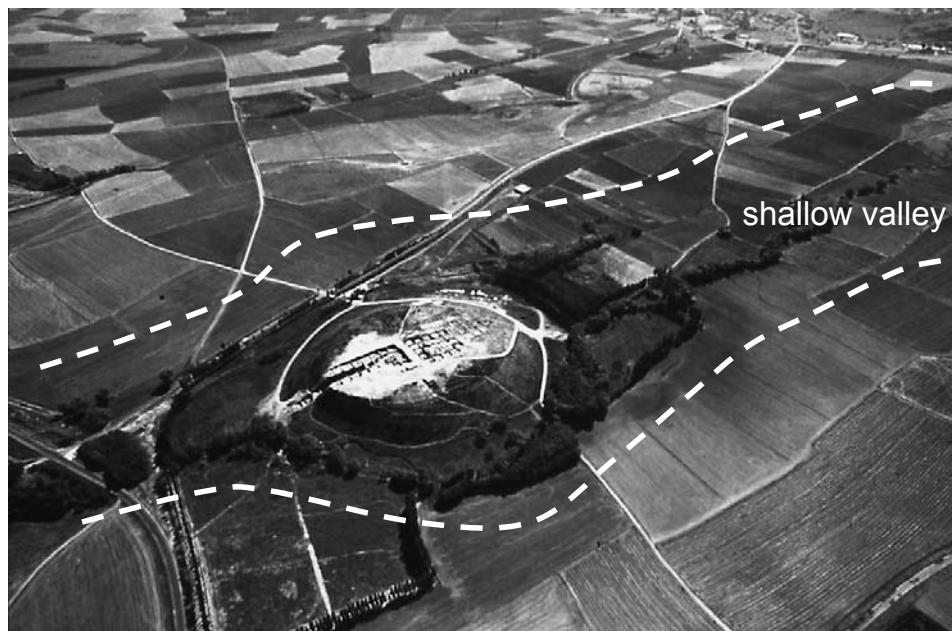
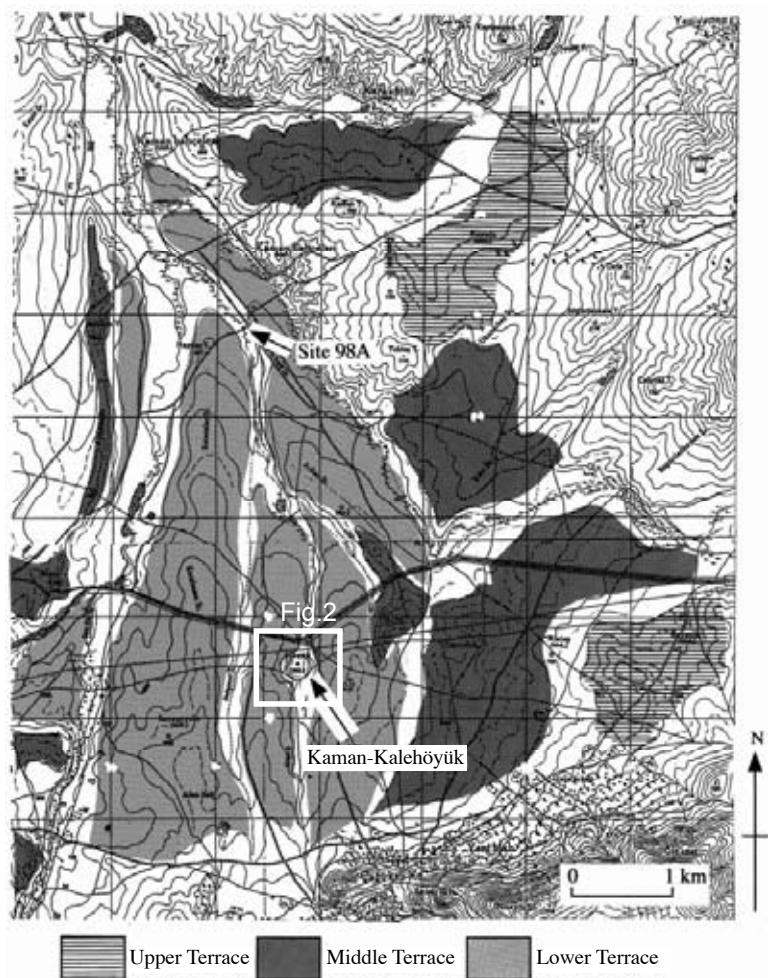


Fig. 1 Geomorphological classification map and aerial photographs at surrounding Kaman-Kalehöyük

We started the paleo-environmental surveys at Kaman-Kalehöyük in 2004 combined with the archaeological excavation by JIAA. The samplings of the sediments for analyses were conducted at trench sections of Sector North-X excavation grid (2004 and 2005) and at the lowland which surrounds the höyük (2005-2007), drilling surveys were conducted with using a drilling machine. The purposes of the surveys are to examine the date and the magnitudes of the humid periods during Bronze Age and Iron Age, and to discuss the influences of water environmental changes to the cultures and archaeological remains at Kaman-Kalehöyük (Kashima 2007; 2008).

Geographical Setting at Kaman-Kalehöyük

Kaman-Kalehöyük is located about 100 km south east of Ankara, and consisted with a mound (the höyük) of about 200 m diameter, and the wide lower towns. The archaeological excavation by JIAA since 1986 divided archaeological deposits of the höyük into the following four strata according to their archaeological date; Stratum I; the Ottoman Period, Stratum II; the Iron Age, Stratum III; the Middle-Late Bronze Age and Stratum IV; the Early Bronze Age. Therefore, there was no interruption of culture at Kaman-Kalehöyük since 5000 years B.P. (beginning of Early Bronze Age) through 2400 years B.P. (the end of the Iron Age). As the excavation continued, more layers under the layer of the Early Bronze Age will be uncovered.

The geomorphologic analysis using 1:25000 geographical map and aerial photographs brought a presumption that Kaman-Kalehöyük lies on the

Pleistocene alluvial fan at the northern slope of Mt. Baran (1618m), Kırşehir Prefecture. The fan topography can be divided into three terraces which were formed in different ages during the middle and the late Quaternary. The fan is cut by very shallow valleys whose bottom levels are several meters under the fan surfaces (Fig.1) (Ishimaru and Kashima 2000).

The höyük of Kaman-Kalehöyük is located at the lower land in the bottom of one of the shallow valleys. Therefore, the location of the höyük should be suitable to get underground water easily. The narrow valley lowland surrounding the höyük is now completely dry, however the underground water level was positioned at about two meters under the surface when a new well was drilled in 2001 at north of the höyük (Ishimaru and Kashima 2000).

METHOD OF ANALYSES

Drillings

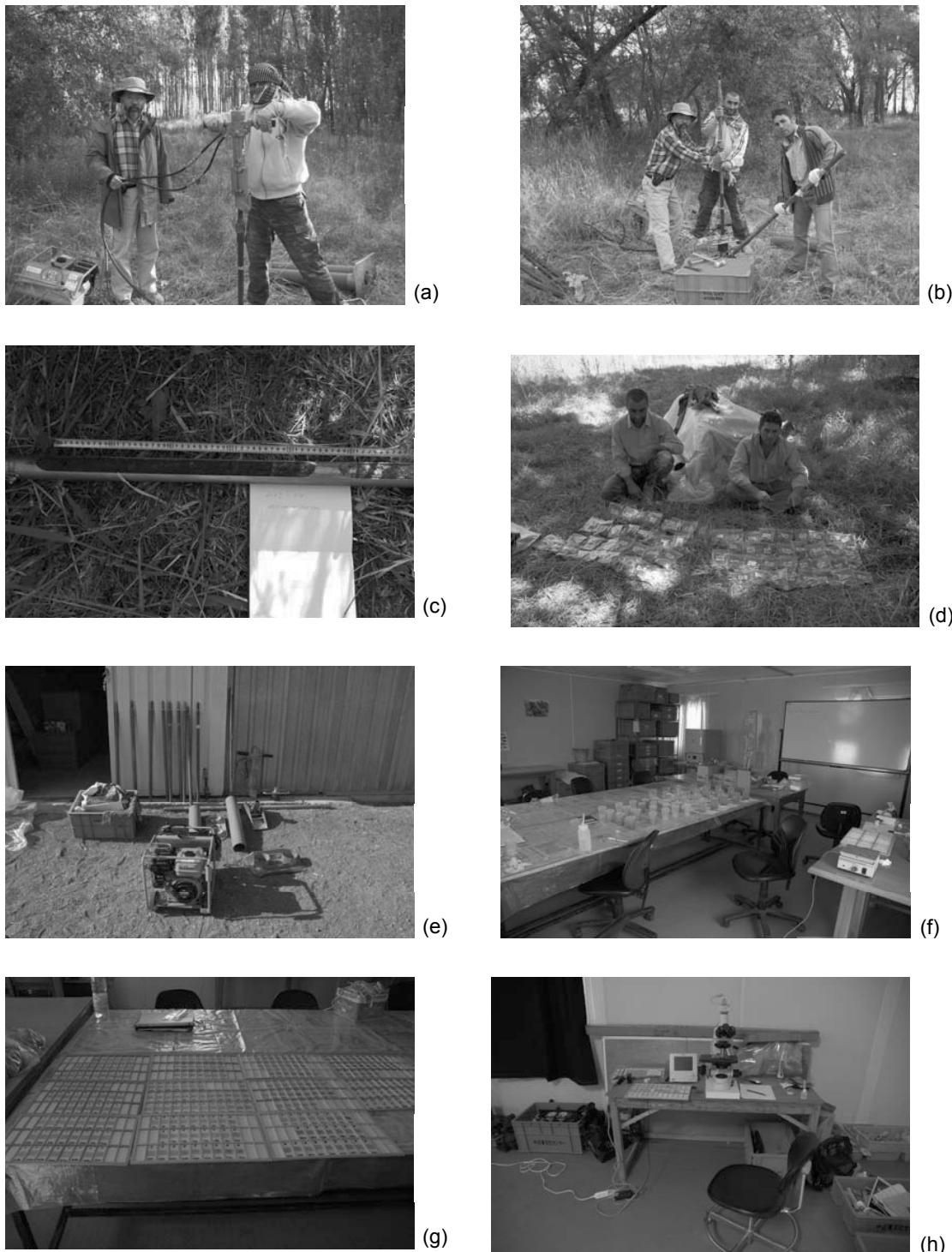
The cores were drilled using a percussion boring machine (DIK-121C, made by the Daiki Soil and Moisture Company, Japan). It is a handy tool, which is easy to transport and operate in a narrow space. Its engine has enough power to excavate an undisturbed core up to 10 m under the surface. Each core was cut into 5 cm layers and packed into plastic bags after preliminary observation of the core at the drilling site (Photo1).

Litho-faces Observation

Soil color, texture, grain size, sedimentary structure and organic contents were observed at the laboratory in

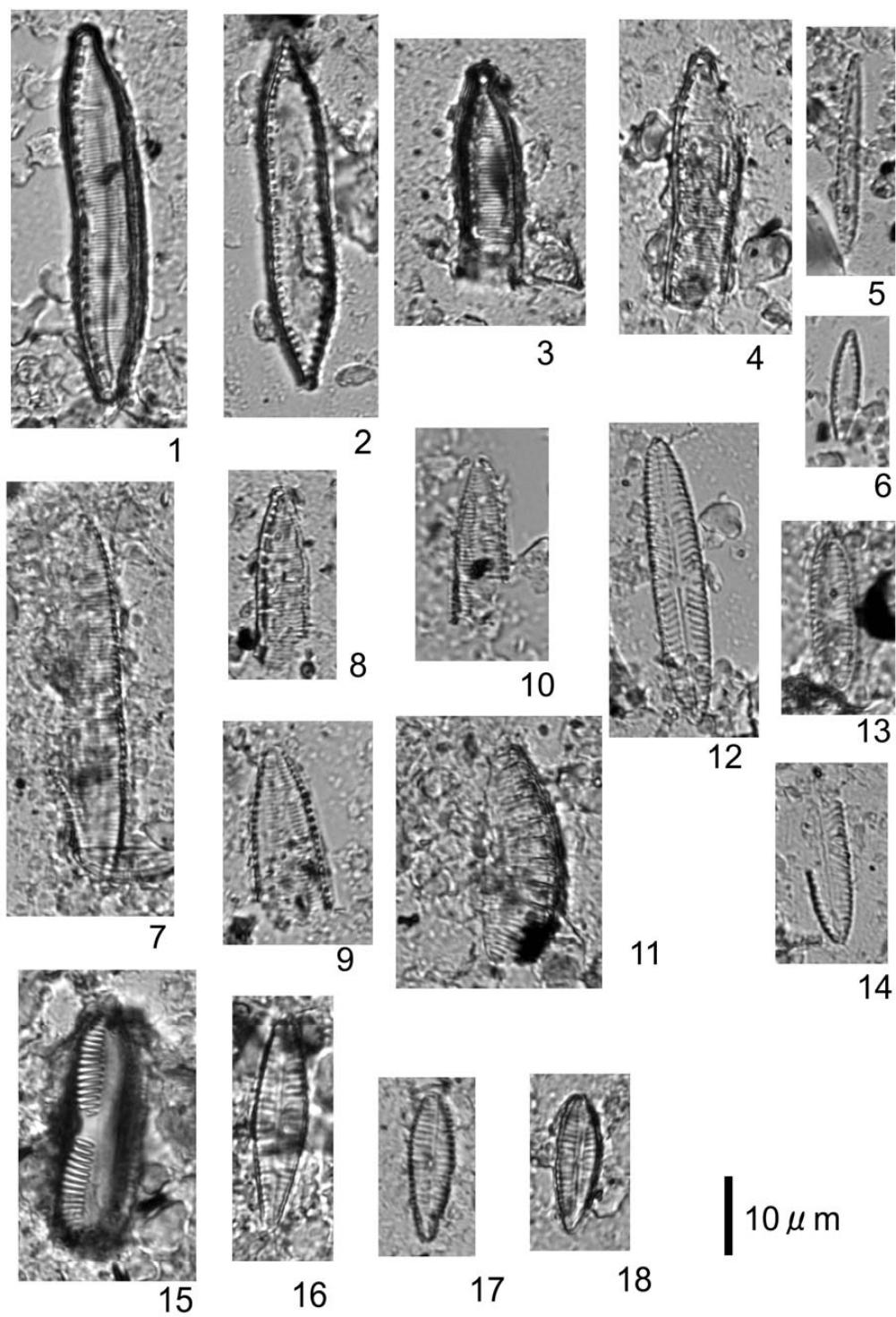
Table1 ^{14}C ages taken from the samples in this survey

Site	depth(cm)	Carbon Age (BP)	error (years)	Wk-	Calibrated data with 95.4% probability	Layer
B05(B06-01)	150	1888	35	17964	50AD–230AD	Upper Clay
Sector N-X		2445	35	16347	710BC–350BC	Upper Clay (basement)
B06-03	230	2737	36	19800	930BC–750BC	Upper part of the Lower Clay
B06-06	190	2866	39	19802	1150BC–860BC	Upper part of the Lower Clay
Sector N-X		3130	37	17963	1500BC–1310BC	Upper part of the Lower Clay
B06-10	390	3210	37	19803	1560BC–1360BC	Upper part of the Lower Clay
B05(B06-01)	240	3590	36	17965	2040BC–1780BC	Lower part of the Lower Clay
B05(B06-01)	290	3686	39	17966	2200BC–1950BC	Lower part of the Lower Clay
B06-03	380	4110	39	19801	2830BC–2450BC	Lower part of the Lower Clay



(a), (b); Drillings using the machine in 2007, (c), (d); Samples taken by drillings, (e); The drilling machine and their coring pipes, (f); Diatom analysis at the laboratory (g); Slide glasses for microscope observation, (h); Microscope at the laboratory

Photo1 The photographs of the field survey and analyses in the laboratory



1-2: *Hantzschia amphioxys*, 3-4: fragments of *Hantzschia amphioxys*, 5-6: *Nitzschia frustulum*,
7: *Nitzschia constricta*, 8-10: fragments of *Nitzschia constricta*, 11: fragment of *Surirella sp.*,
12-13: *Navicula cincta*, 14: fragment of *Navicula cincta*, 15: *Pinnularia sp.* 16: *Gomphonema angustum*, 17-18: *Gomphonema parvulum*

Photo2 The diatoms taken from the samples

Japanese Institute of Anatolian Archaeology.

Carbon-14 Dating

The samples for ^{14}C dating were sent to the Radiocarbon Dating Laboratory at Waikato University in New Zealand. The samples were measured by the AMS method and were calibrated to calendar ages (Table 1).

Diatom Analysis

Diatoms are single-cell algae that are good indicators of water environment. To identify diatoms in the core samples, 2 g (clay sediment) or 5 g (sandy sediment) of each sample was measured and carefully mixed in 100 ml distilled water with a mixer. The samples were divided into 1/1000 and then each was mounted on a glass slide using a synthetic resin of high refractive index (Mount media by Wako Pure Chemical Industry) for high magnification (x1000) light microscopy observation (Photo1, Photo 2).

LITHO-FACES OF SEDIMENTS AND THEIR ^{14}C AGES

Sector North X

The Sector North-X is located at northern margin of the höyük. The surface level of the sector was only 1.70m higher than the level of lowlands surrounding the höyük. The excavation at the sector started in 2003, and stone architectures of two different levels (2.20m and 2.70m below the surface) were excavated, which were dated to IIa period (the latest part of the Iron Age) and IIIc period (the middle Bronze Age) respectively by archaeological remains (Fig.2).

The samples were taken every five or ten centimeter intervals at the northern section wall in 2004 and at the western section wall in 2005. A small block of sediment of 2cm square was cut carefully at each sampling layer to avoid contamination of sample.

The upper part of the northern section wall sediment was consisted with coarse sand with small gravels and the grain size of sediment became finer gradually to the lower part of the wall. The lowest of the wall, or 50cm from the floor was consisted with peaty clay that covers the stone architecture of IIa period (the latest part of the

Iron Age, ca.2500 - 2400 years B.P.). The litho-face of the western section wall showed very similar feature of the northern wall.

Two ^{14}C ages obtained from peaty clay just above the two stone architectures were well harmonized to the archaeological dating. The peaty clay covered IIa period architecture was measured $2,445 \pm 35$ years B.P. (Wk-16347) calibrated to 2,710 – 2,350 cal. B.P. with 95.7% probabilities, and the peaty clay covered IIIc period (the middle Bronze Age) was measured $3,130 \pm 37$ years B.P. (Wk-16963) calibrated to 3,500 – 3,310 cal. B.P. with 95.7% probabilities (Table 1).

Because the peaty clay covered architectures belonging to two different ages at the two walls, it should be divided into two layers of different sedimentary ages. However it was impossible to divide them by the field observations by the samplings at the walls.

Drillings at Lowlands Surrounding the Höyük

The preliminary drilling (B05) was done at the north of the höyük in 2005. It penetrated beside the well where the previous studies (Yasuda 1992; Kashima and Matsubara 1993; 1994) examined. The core length was 4.0m, and from the surface it was 2.9m to the bottom of the valley deposit. There were two peaty sandy clay layers leveled at 1.1m - 1.9m depth and 2.4m - 2.9m depth respectively. Three ^{14}C ages indicated that the upper layer deposited at Roman Period and the lower layer deposited at the Early Bronze Age. These results were well consistent with the preliminary interpretation by Kashima and Matsubara (1994).

In order to map the distribution of each clay layer and to presume its sedimentation age and environment in detail, 20 cores were drilled at the lowland surrounding the höyük in 2006 and 2007 (Fig.2, Fig4).

The accumulation between coarse sand-gravels and sandy clay were observed generally in the lowland. We could drill until the lower clay layer at 14 sites among 20 sites. However it was impossible to penetrate at the other six sites, because coarse sand-gravels between the upper clay layer and the lower clay layer were tighten too hard to penetrate. The locations of the six sites were distributed at eastern and western margin of the höyük.

The drillings in 2006 and 2007 made clear that the lower clay layer could be subdivided into two or three

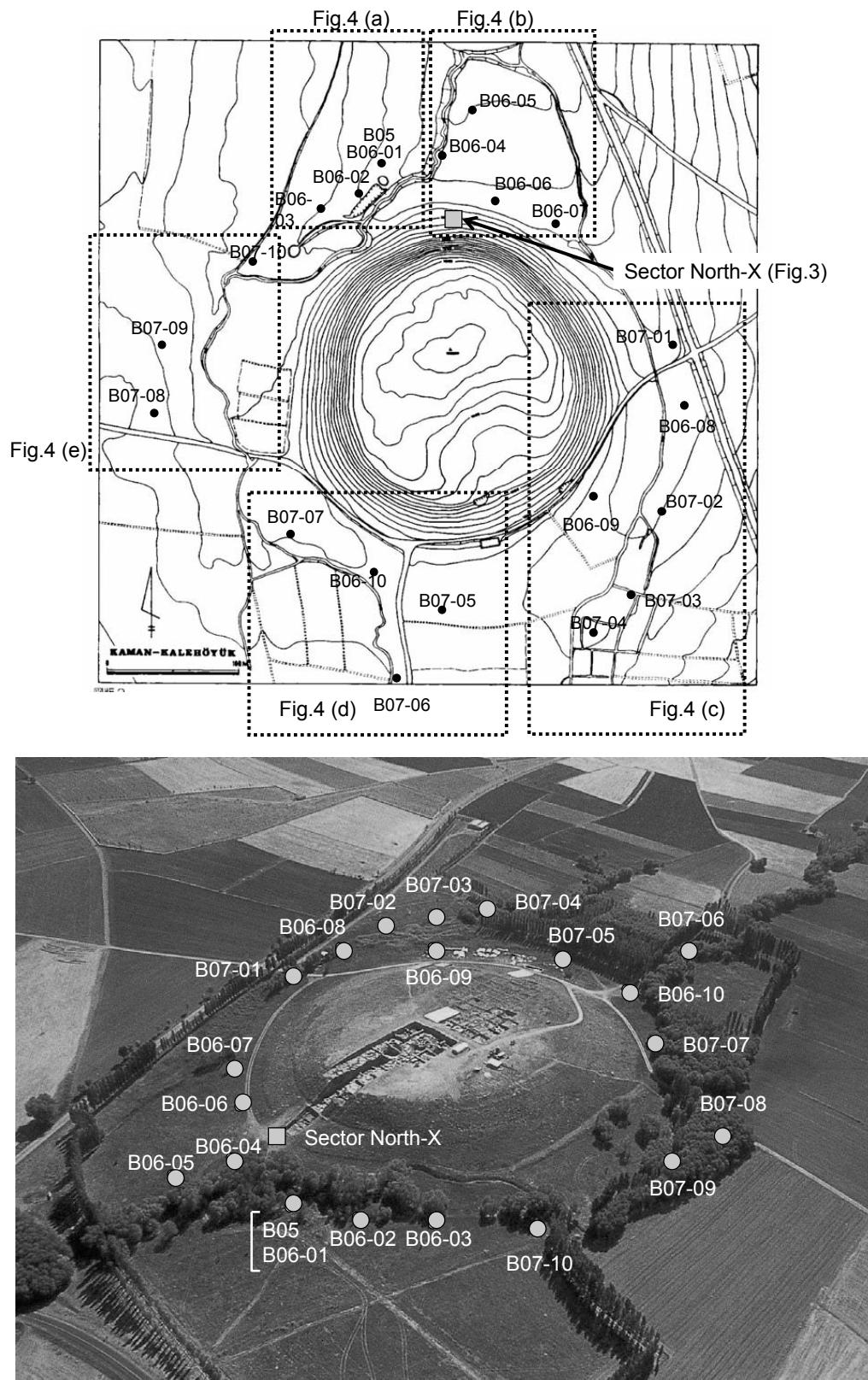


Fig. 2 Sampling grid (Sector North X) and drilling sites surrounding Kaman-Kalehöyük in 2004-2007

The Excavation Grid; Sector North-X

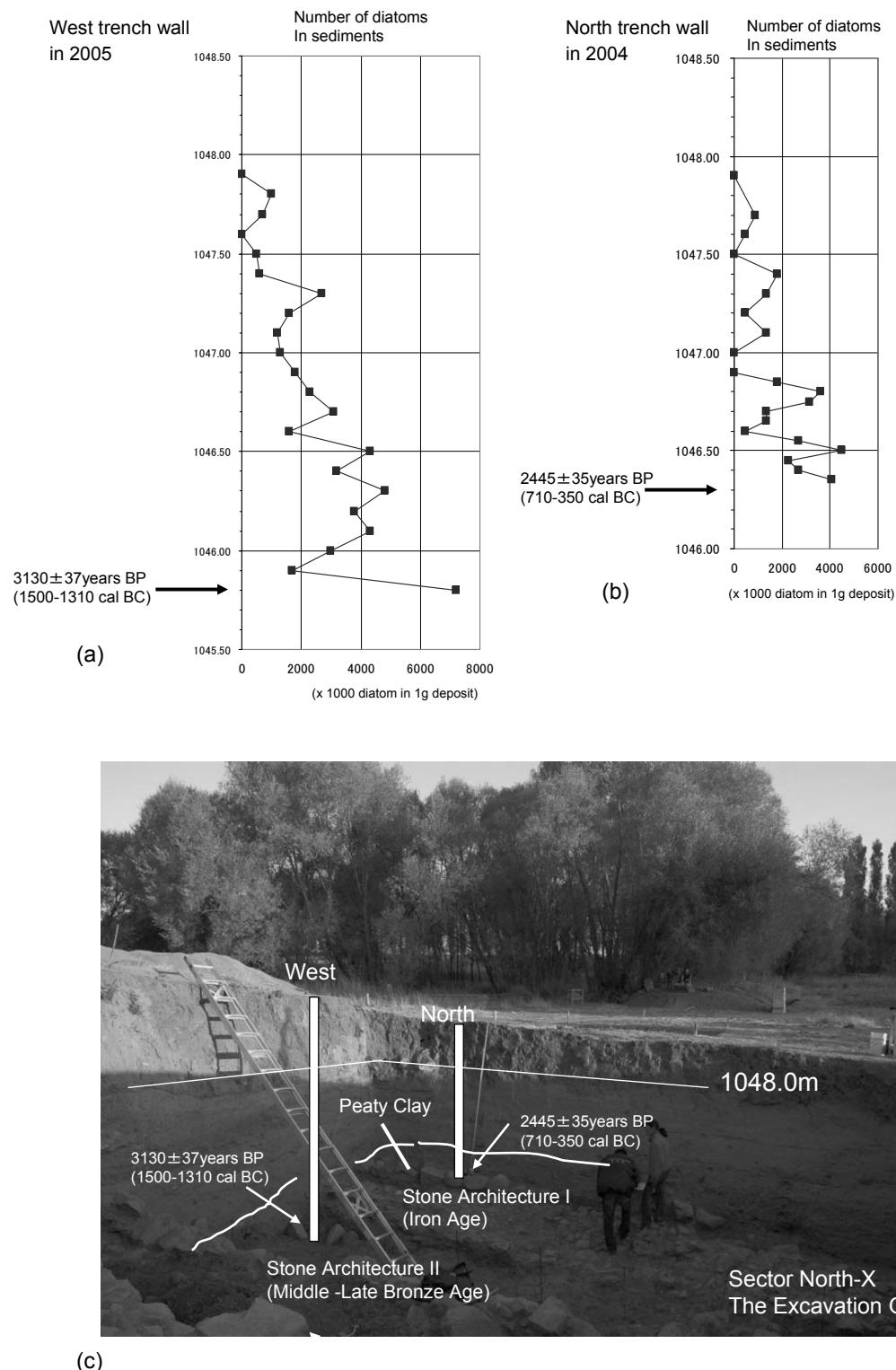


Fig. 3 Sections of northern and western walls at excavation grid (Sector North X) and successions of diatom fossils contained within 1g sediments.

parts. At the four sites (B06-07, B06-10, B07-06, B07-07), the lower clay divided into two parts by coarse sand-gravels of 20-30cm thick, on the other hand, it was divided into three parts at sites B-06-03 and B07-05 (Fig.5).

The subdivision of the lower clay layer seems to be harmonized with ^{14}C ages, measured from the cores. ^{14}C ages presumed that the upper part of it deposited at the Late Bronze Age (3,500 - 3,200 years cal. B.P.) or the early part of the Iron Age (3,200 - 2800 cal. years B.P.), and the lower part of it deposited at the Early Bronze Age (4,000 - 3,000 cal. Years B.P.) (Fig.5, Table1).

RECONSTRUCTION OF PALEO-ENVIRONMENT USING DIATOM ANALYSIS

The Wall Samples at Excavation Grid of North Sector X

The samples were taken along the two vertical lines at the northern wall and the western wall of the excavation grid. The litho-faces of the both lines change similarly. The upper parts of the both lines were consisted with coarse sand and gravels, and then changed to be peaty clay in the lower parts. The peaty clay should be divided into two layers because it covered directly two stone architectures belonging to different period from each other at the northern wall and at the western wall, however it is impossible to separate by filed observations, mentioned before.

Therefore we tried to examine the sedimentary environment using diatom analysis at the both sections. Diatoms which contained sediments were increased at the lower part of the walls, and more than 4,000 diatoms within 1g sediments were observed at the lower part of the walls. The dominated diatom species is *Hantzschia amphioxys* which lives in very shallow pond and wet soil. The percentages of this species into number of total diatom fossils exceed more than 80% at every sample of the walls. Because the compositions of diatom fossils are similar in the peaty clay samples, the subdivision of the peaty clay is not possible by them (Fig.3).

Diatoms are supposed that the water level increased and the shallow swamp spread to cover the stone architectures. The archaeological ages of the stone architectures and ^{14}C ages of the peaty clay indicate the

water level rises two times, at the Late Bronze Age and the last half of the Iron Age or Roman Period (Fig.3).

Drillings at Lowlands Surrounding the Höyük

Diatom analysis was done every drilling core site except B06-01 and B06-09. B06-01 was the trial drilling to control the drilling machine and drilled at the same position at B05 site. B06-09 was located very close to the höyük and the archaeological deposits exposed just under the surface soil (Fig.2, Fig.4).

Generally, the number of diatoms fluctuated corresponded to the successions of grain size of the sediments. At the upper clay layer, more than 50,000 diatom fossils were observed within 1g sediment at 5 sites. At the other sites, generally 10,000-20,000 diatoms were counted except one site (B06-10). The dominated diatom speicy is *Hantzschia amphioxys* which lives very shallow pond and wet soil, and its ratio to total diatom fossils exceeds more than 80% at every sample. This trend is similar to the diatoms from peaty clay at North Sector X. The diatom assemblages taken from the upper part of the lower clay layer are almost similar to those of the upper clay layer. *Hantzschia amphioxys* exceeds more than 80% at every sample. Very shallow swamp was reconstructed by the composition of diatoms (Fig.4).

The water environment presumed by diatoms is different from the two layers at the lower part of the lower clay layer. Although fresh water species like *Hantzschia amphioxys* are dominated, salty species such as *Navicula cincta*, *Nitzschia constricta*, *Nitzschia frustulum* are observed with 10-30 % frequency. The surveys of living diatoms at inland salty lakes in Turkey indicated that those salty diatoms live at high saline water environment like Lake Tuz. Therefore, the water of the swamp of this stage could not be used to drink and to cultivate (Fig.4).

DISCUSSION

Humid Periods since the Bronze Age at Kaman-Kalehöyük

The paleo-environmental studies from 2004 to 2007 presumed that there existed three humid periods at Kaman-Kalehöyük.

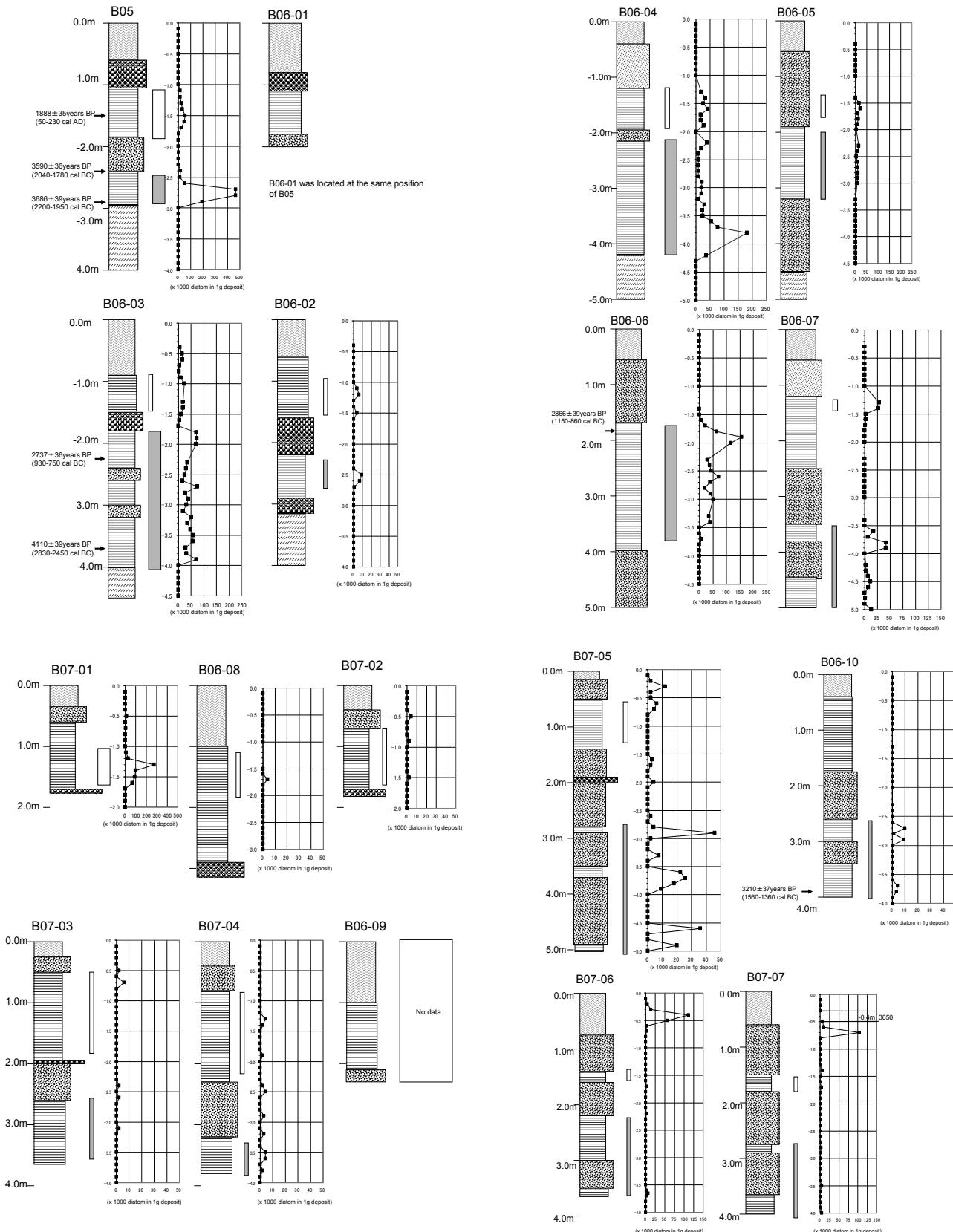
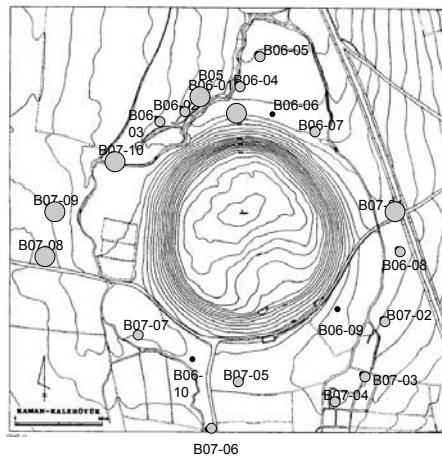


Fig. 4 Geological column and ^{14}C ages, successions of diatom fossils contained within 1g sediments



(a) The upper clay layer ; Latest part of the Iron Age and Roman Age

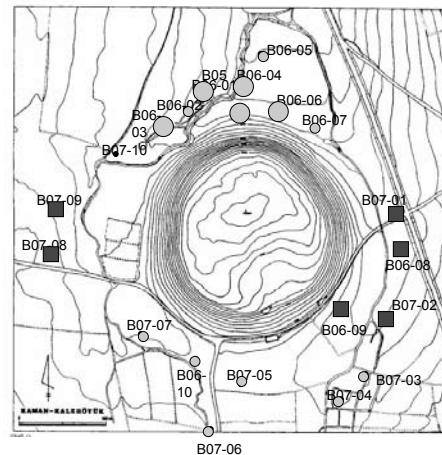
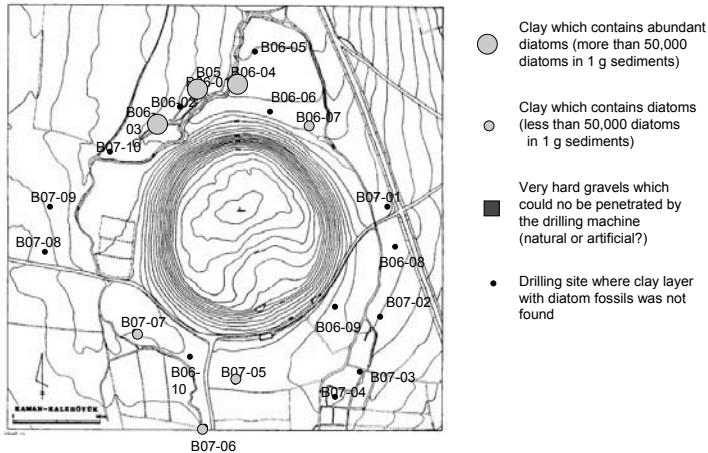
(b) The upper part of the lower clay layer;
the Late Bronze Age and the latest part of the Iron Age(c) The lower part of the Lower Clay layer;
the Early Bronze Age

Fig. 5 Distribution of peaty clays with diatom fossils at humid periods surrounding Kaman-Kalehöyük

The first one is dated to the last half of the Iron Age and Roman Period by two ^{14}C ages. The swamp caused by water level increasing was distributed over the area surrounding the höyük, and covered the architectures of the Late Iron Age at the margin of the höyük. The diatom fossils indicates that the water depth of the marsh was not deep, less than 1m (Fig.5-a).

The second one is dated to the Late Bronze Age and the early part of the Iron Age by four ^{14}C ages. The swamp covered the architecture at the Middle Bronze Age at the margin of the höyük and was distributed widely at the northern and southern parts of the lowland. The coarse sand - gravels below the upper clay layer was too hard there for the drilling machine to penetrate them. The water depth was shallow, probably less than 1m presumed by diatom assemblages from the cores (Fig.5-b).

The third one is dated to the Early Bronze Age. The swamp deposition at this stage distributed at north of the lowland was confirmed by ^{14}C ages (B05, B06-03). On the other hand, there was no ^{14}C age to estimate this period in the southern part. However as the sequences of litho-faces of the cores are similar to those at northern cores, distribution of the swamp should have expanded to southern part of the lowland in this period. The direct relationship between the swamp of this stage and the archaeological remains has not been observed yet. The diatoms indicated that the swamp water contained a slight salt, which might not be suitable for drinking and agricultural uses (Fig.5-c).

The Influences of Water Environmental Changes to the Cultures and Archaeological Remains at Kaman-Kalehöyük

Kaman-Kalehöyük prospered continuously through Bronze Age and Iron Age, but its culture was interrupted at the end of the Iron Age until the Ottoman Period. Yasuda (1992) proposed that the fluvial disasters caused by heavy rainfalls in Roman Period damaged the Kaman-Kalehöyük. However no trace of such disaster in Roman Period was found from the höyük and its surroundings. Our drillings made clear that the increase of water level occurred at the last part of the Iron Age and Roman Period. The wide swamp surrounded the höyük and the marginal part of the höyük was sunk into swamp water.

This condition at the höyük might not be suitable for residence, and inhabitants should left the höyük for drier places.

There are two possibilities for the swamp environment at the Late Bronze Age and the early part of the Iron Age at Kaman-Kalehöyük. The first possibility is that the swamp might be an artificial moat to protect the höyük from enemies, because Kaman-Kalehöyük prospered without break during those periods. However the moat structure was not excavated around the höyük. The second possibility is that this high water stand was related with cold climate in the early part of the Iron Age, called "Dark Age". This climatic event might damage a lot of archeological sites and their cultures in Anatolia, although arguments have been continued. If this high water environment was caused by natural climate, it might damage the culture of Kaman-Kalehöyük like at other archeological sites.

The origin of salty swamp at the Early Bronze Age needs more considering, because the data of drillings are limited. The salty swamp probably caused by dry climate during early to middle part of the Holocene remained until the Early Bronze Age. Since salty water was not suitable for large settlements and agriculture, limited the residence area of Kaman-Kalehöyük. After the salty swamp disappeared in the end of Early Bronze Age, Kaman-Kalehöyük expanded quickly, and became a large wall city in Middle and Late Bronze Age.

CONCLUSION

The paleo-environmental studies at Kaman-Kalehöyük presumed three humid periods after Bronze Age. The first period is dated to the last part of the Iron Age and Roman Period. The water level increased greatly and the marginal part of the höyük was sunk under the water. It might be one of the reasons for the interruption of residencies at Kaman-Kalehöyük from Roman Period to Ottoman Period. The second period is dated to Late Bronze Age and the early part of the Iron Age. The swamp surrounding the höyük might be an artificial moat or might be caused by cold climate during "Dark Age". The third period is dated to Early Bronze Age. The appearance of salty water swamp of this period

limited the residence area of Kaman-Kalehöyük.

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