Palaeo-Environmental Change at Kaman-Kalehöyük, Central Anatolia, Turkey – Geo-Archeological Survey in 2004 and 2005 –

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INTRODUCTION

The geo-archaeological research project in Central Anatolia, a multidisciplinary research program to investigate the environmental history, has started in 1991 in conjunction with the excavation of Kaman-Kalehöyük of the Japanese Institute of Anatolian Archaeology. Our previous results at the Konya basin, the Tuz Lake, the Seyfe Lake and Kültepe provided evidence for significant environmental changes over the past several millennia in Central Anatolia (Kashima 2002, 2003; Kashima *et al*. 2004; Omura and Kashima 2003).

Since 2004, we have started a palaeo-environmental survey at the northern section of Kaman-Kalehöyük in corresponding to the archaeological excavation at Sector North-X, located at northern margin of the höyük. We took sediment samples from the section walls of the excavation grid and took drilling core sampling at the lowland surrounding the höyük to reconstruct their sedimentary environment and dating. Our survey revealed the palaeo-hydrologic histories of the höyük, such as water levels, soil moistures and fluvial hazards. They have changed abruptly since the Bronze Age through the Roman Period and have influenced the distributions of archaeological architectures in the höyük.

PREVIOUS STUDIES OF PALEO-ENVIRONMENT AT KAMAN-KALEHÖYÜK

Kaman-Kalehöyük is located about 100 km south east of Ankara. It lies on the Pleistocene alluvial fan at the northern slope of Mt. Baran (Fig.1) (Ishimaru and Kashima 2000).

The archaeological excavation by the Japanese Institute of Anatolian Archaeology has continued since 1986. The following four archaeological strata were excavated in the höyük; Stratum I; the Ottoman Period, Stratum II; the Iron Age, Stratum III; the Middle-Late Bronze Age and Stratum IV; the Early Bronze Age. The höyük was abandoned for about two thousand years after the Iron Age (12th-4th century BC) till the Ottoman Period (16th -17th century AD).

There were a few previous studies of palaeo-environment at Kaman–Kalehöyük. Yasuda (1992) reported two C^{14} dates and pollen fossils taken by the well digging at the north of the höyük in 1990. Kashima and Matsubara (1993, 1994) reported diatom fossils using the same samples. Diatom fossils from the sediment presumed that the shallow swamp was formed about 2m below than the surface. However the samples were not continuous, because those samples were taken by a power shovel. There were problems for the datings of the samples.

The drilling of deposits at the lowlands surrounding the höyük could not be done till our drillings in 2005, because there was not enough space to set a big drilling machine. It was impossible to penetrate its very hard deposit by a handy drilling auger. We brought a new drilling machine from Japan in 2005. It is so compact that we can bring it by ourselves. It has enough power of the engine to penetrate very hard sediments and to get undisturbed samples for analyses.

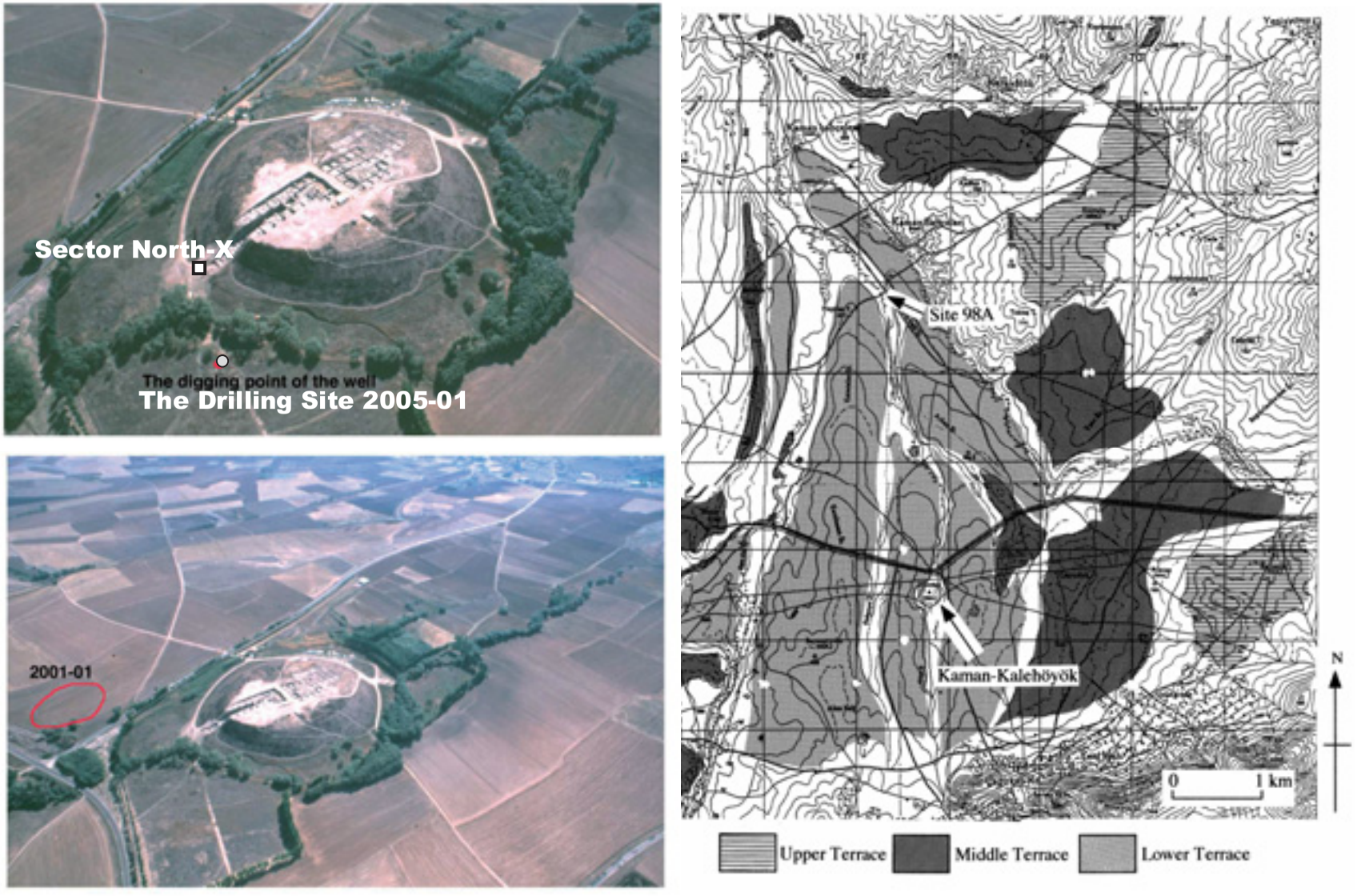

Fig.1 Geomorphological map surrounding the Kaman-Kalehöyük (after Ishimaru and Kashima, 2000) and airplane photos surrounding the höyük

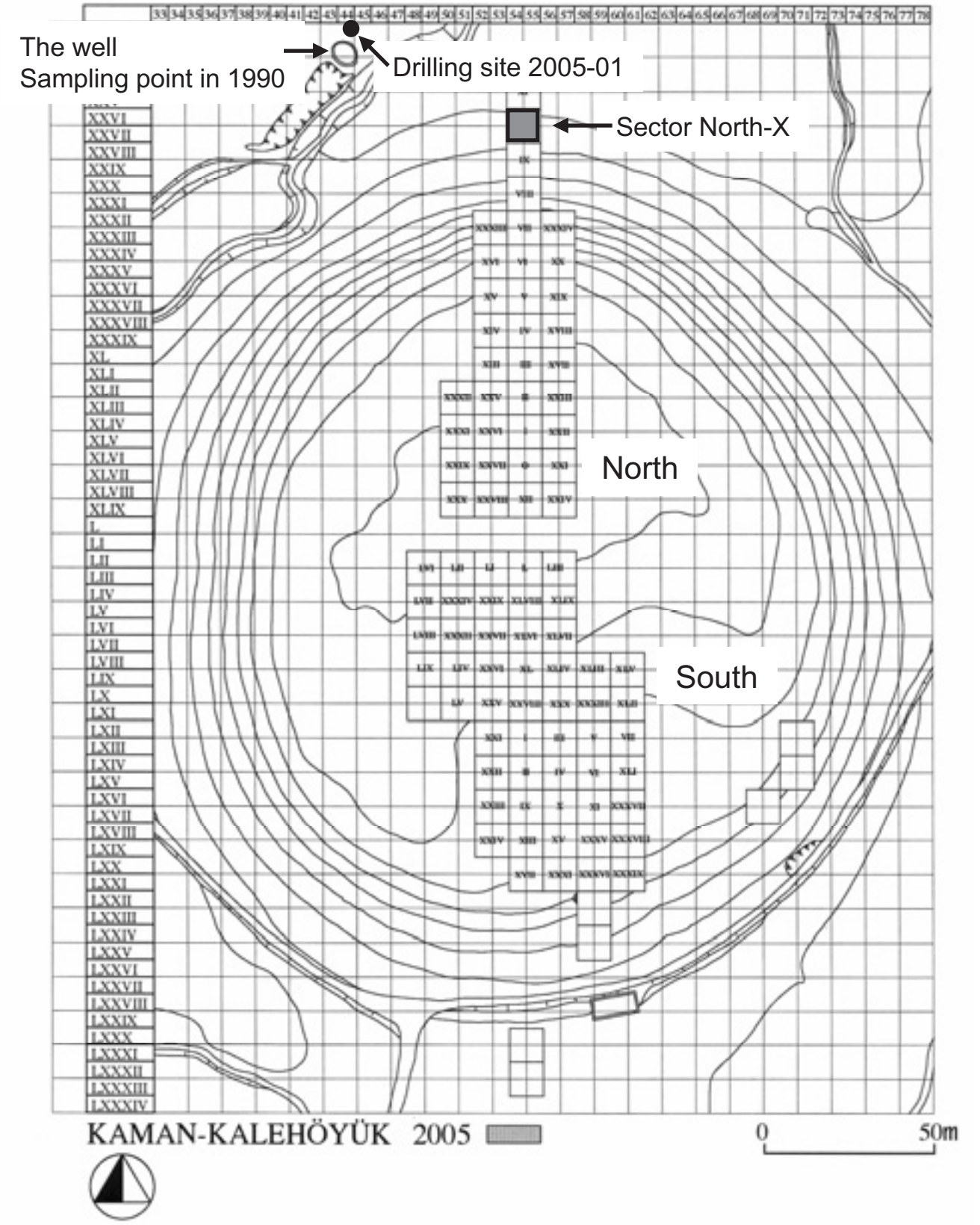

Fig.2 Sampling sites in 2004 and 2005
The sediment samples were taken at the Sector North-X in 2004 and 2005, and at drilling site of 2005-01, north of the höyük in 2005

SAMPLES, LITHOLOGIC DESCRIPTION AND DATING

(Sector North-X, Kaman-Kalehöyük)

The excavation of the North Sector-X has started from 2003. The surface level of the sector decreased gently from the south to the north, because it was located in the north margin of the höyük. The surface level at the northern margin of the sector was 1048.90m at the beginning of the excavation, which was only 1.70m higher than the surface level of the low lands surrounding the höyük. The sector was excavated till 1045.80m of level at the end of the excavation season in 2005.

The continuous stone architecture was found in the north part of the sector. The altitude of the top of the stone architecture was 1046.40m and we did not reach the bottom of them yet at the end of the excavation season in 2005. It was the lowest architecture in Kaman-Kalehöyük, although the archaeological age of it has not been decided yet. There are two possibilities presumed by archaeological remains; IIA period (the latest part of Iron Age) or IIIC period (Assyrian Colonial Period; the Middle Bronze Age).

In 2004, the samples for palaeo-environmental analyses were taken along a vertical transect at the northern grid wall. The samples were collected with 5 -10 cm intervals from 1047.90m to 1046.40m, just above the stone architecture. The sediment between 1047.90m and 1046.90m was coarse sand and granule, and changed to peaty clay below 1046.90m. One C^{14} dating was measured from the peaty clay at 1046.40m just above the stone architecture. It was dated 2,445±35 years BP (Wk-16347), calibrated to 710 BC – 350 BC with 95.7 % probability.

In 2005, we took samples again along a vertical transect at the western grid wall, about 50 cm beside the stone architecture. In this transect, the peaty clay below 1046.90m continued till 1045.80m. The samples were collected with 10cm intervals from 1047.90m to 1045.80m. One C^{14} dating was measured from peaty clay at 1045.80m. It was 3,130±37 years BP (Wk-17963)

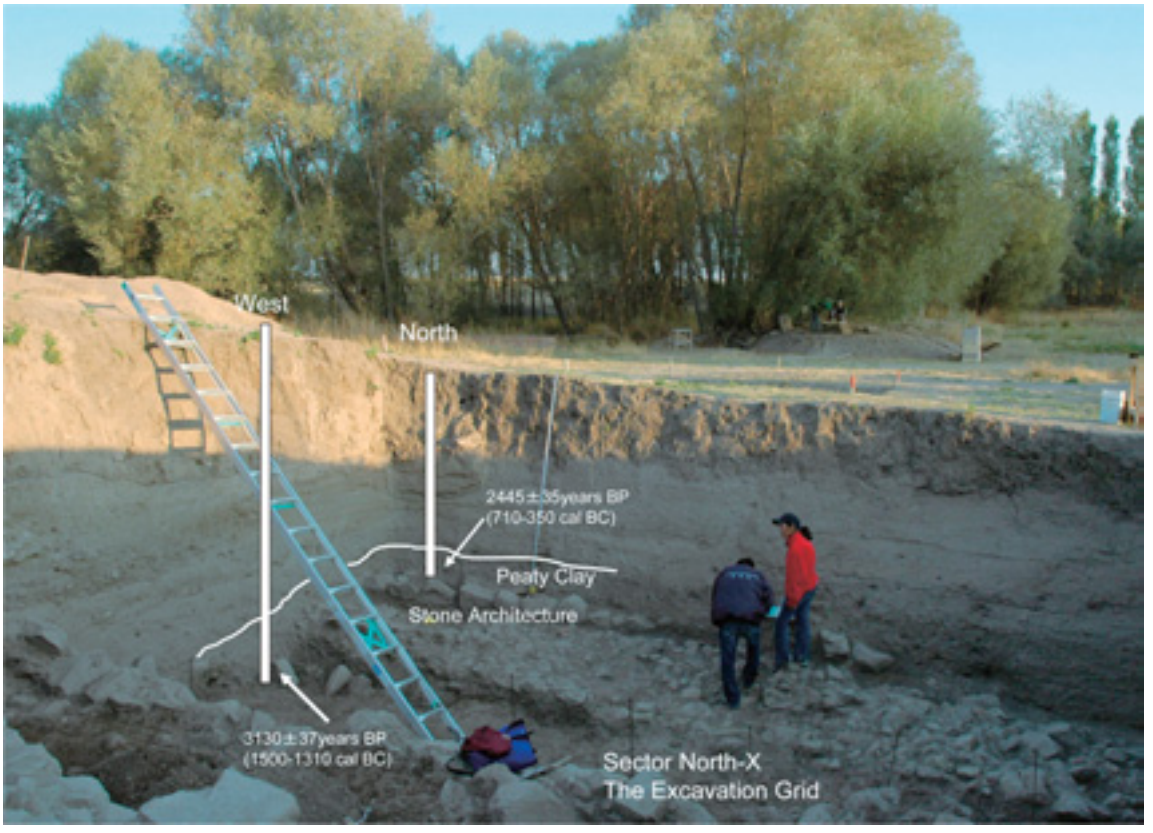

Fig.3 The photo of the sector walls at Sector North-X on September in 2005
Sampling transects (northern and western) and C^{14} dating were taken at northern and western walls of the sector

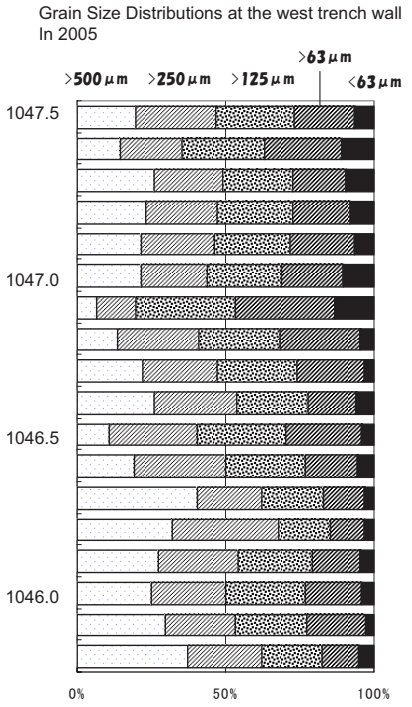

Fig.4 Grain size distributions at the western trench wall at Sector North-X in 2005

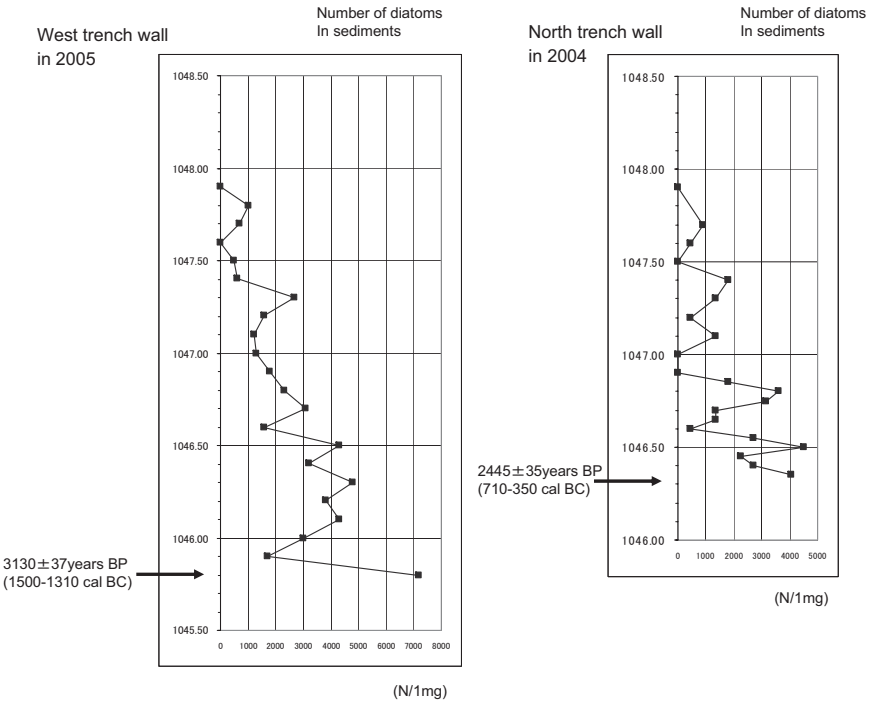

Fig.5 Numbers of diatoms in 1mg sediments from transects at Sector North-X

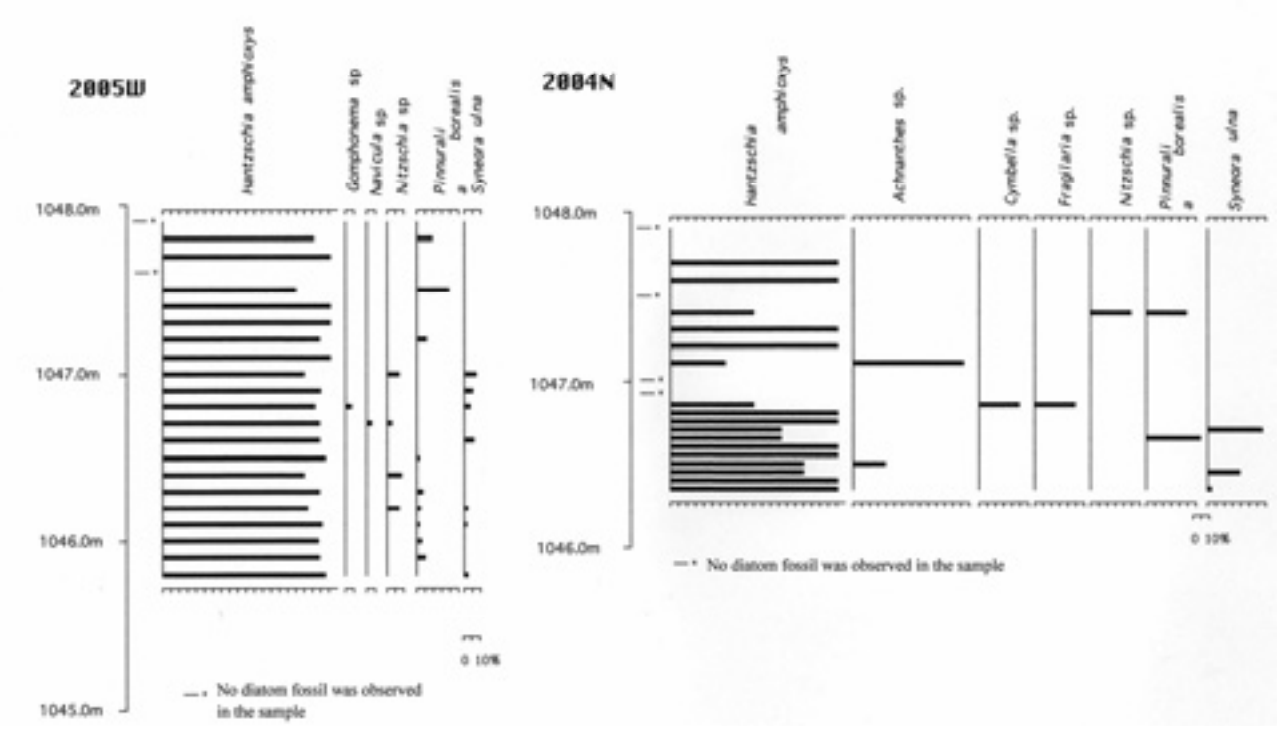

Fig.6 Frequencies (percentages) of Diatom assemblages taken from the western transect (2005W) and the northern transect (2004N) at the Sector North-X

and it was calibrated to 1500BC – 1310BC with 95.7 % probability.

They presumed that the peaty clay covering the stone structure was deposited during the Late Bronze Age and the Iron Age. Therefore the stone architecture, covered by the peaty clay, was presumably built not at the IIA period (the latest part of Iron Age) but at the IIIC period (Assyrian Colonial Period; the Middle Bronze Age).

(Drilling site; 2005-01)

The first drilling site was located about 50m north-west of the North Sector-X. It was just beside the well where samples were taken in 1990 (Yasuda 1992; Kashima and Matsubara 1993, 1994). The surface level was 1047.10m and we took undisturbed core samples to 1043.10m. The sediment of the upper part of the core consisted of very soft clay, sand gravels. It changed to be very hard reddish silt at 1044.15m. Due to the change of the hardness and the color of the sediment, this reddish hard silt was probably the Pleistocene alluvial fan deposit.

The upper valley fill deposit above 1044.15m divided into the following 5 layers; 1047.10 – 1046.50 surface soil, 1046.50m – 1046.00m sand and gravels, 1046.00m – 1045.20m dark grey peaty sandy clay, 1045.20m – 1044.80m sand and gravels, 1044.80m – 1044.15m dark grey peaty sandy clay. The alternations between peaty clay layers and sand and gravel layers were observed in the core.

We measured three C^{14} dating from peaty clay at 1045.60m, 1044.70m and 1044.20m. The upper C^{14} dating was measured at 1045.60m, and was dated 1,888 ±35 years BP (Wk-17964), calibrated to 50AD – 230AD with 95.7 % probability. The second one at 1044.70m was dated 3,590±36 years BP (Wk-17965), calibrated to 2040BC – 1780BC with 95.7 % probability. The lowest one at 1044.20m was dated 3,686±39 years BP (Wk-17966), calibrated to 2200BC – 1950BC with 95.7 % probability. Those dating presumed that the upper peaty clay was deposited at Roman period, and lower peaty clay was deposited Early or Middle Bronze Age.

METHOD OF ANALYSES

For the palaeo-environmental discussions, we took a grain size analysis, moreover a micro-fossil (diatom) analysis and C^{14} dating of the samples. Brief explanation of each analysis are described below as follow.

(Grain size analysis)

10 g of each sample was dried and crushed carefully in a mortar. It was screened with different size meshes and was weighted. We used four meshes; 500μm, 250μm, 125μm and 63μm, because the samples generally contained a lot of sand.

(Diatom analysis)

Diatom is one of the single cell algae and is a good indicator of water environment. 2g (clay sediment) or 5g (sandy sediment) of each sample was measured and a mixture was carefully mixed in 100 ml distillated water with a mixer. The samples were divided to 1/1000 and then were mounted in slide glasses using a synthetic material of high refractive index (Mount media by Wako Pure Chemical Indust.) for high magnification (x1000) light microscopic observation.

(C^{14} datings)

The samples for C^{14} dating were sent to the Radio-carbon Dating Laboratory at Waikato University in New Zealand. The samples were measured by the AMS method and were calibrated to calendar ages.

PALAEOENVIRONMENT OF THE SAMPLES

(Sector North-X, Kaman-Kalehöyük)

The grain size analysis was done at the west transect. The variation of the grain size between 1045.80m and 1047.50 m was not clear, although the face of the sediment changed to be peat below 1046.90m. The weight percentage of coarse materials (>500μm) were slightly decreased at 1046.90m – 1046.40m.

The diatom analysis was done at the north transect in 2004 and at the west transect in 2005. We found abundant diatoms at sandy peaty clay below 1046.90m

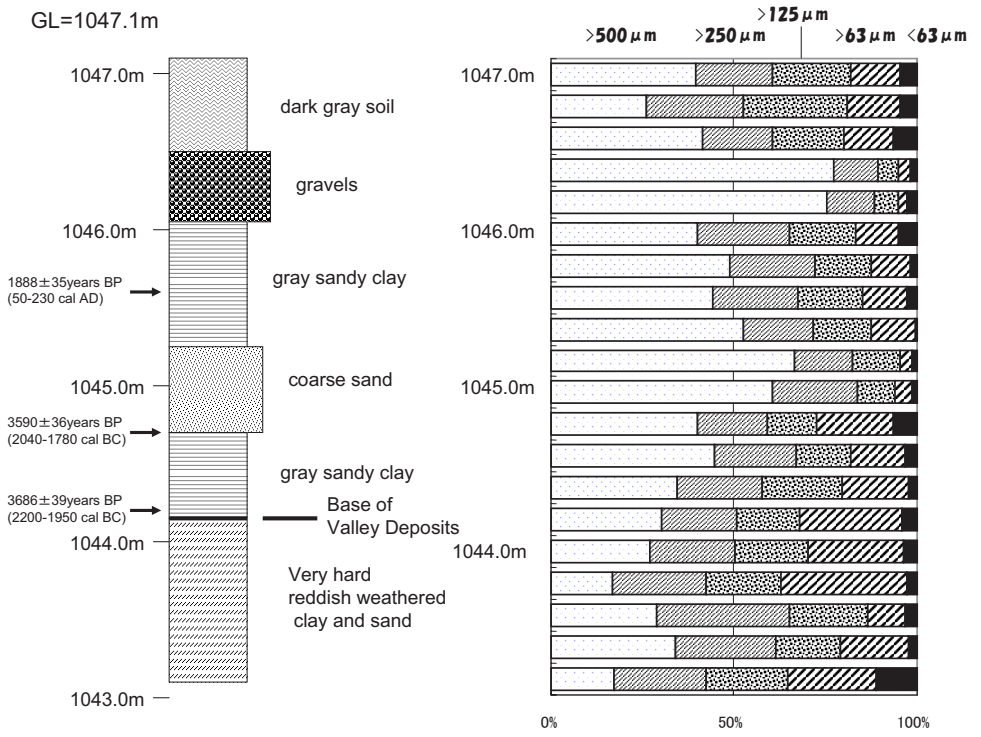

Fig.7 Geologic column of the drilling at 2005-01 and its Grain size distributions

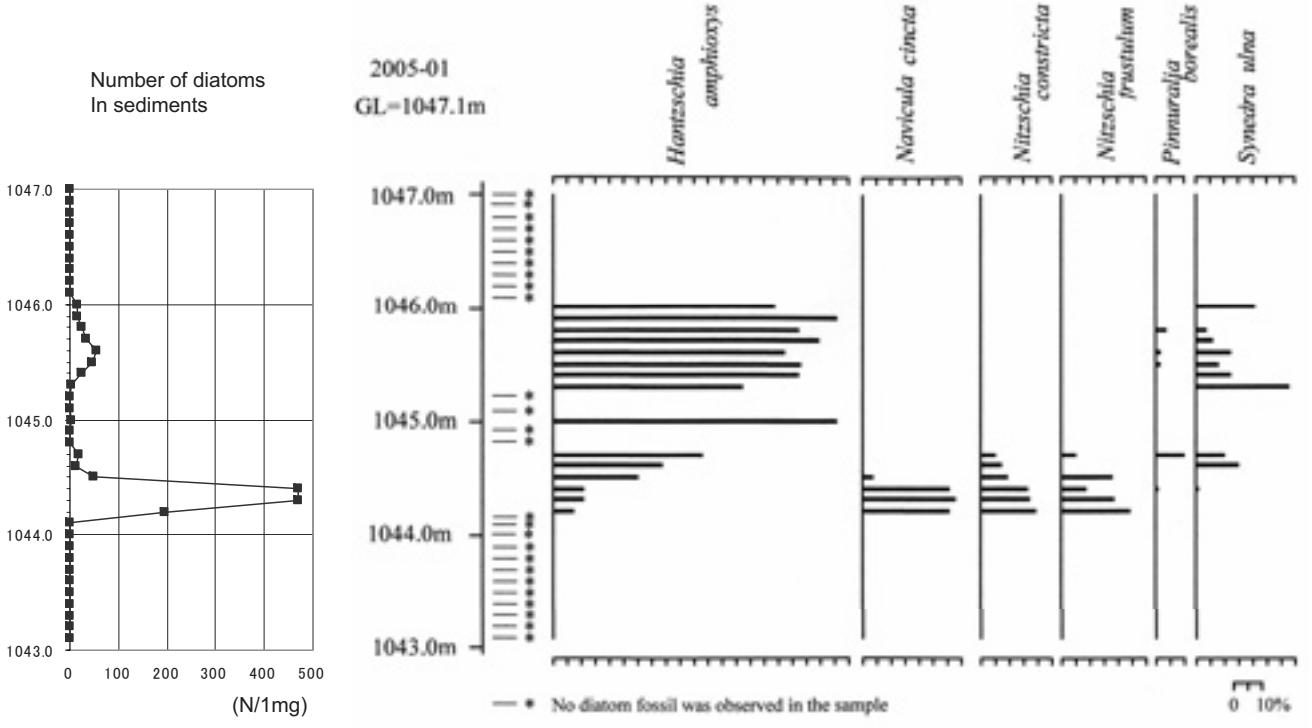

Fig.8 Numbers of diatoms in 1mg sediments and Frequencies of Diatom assemblages from the drilling at 2005-01

at the two vertical transects. The number of diatoms in 1g sediment increased gradually to the lower layers. It reached 7000 diatoms in 1g sediment at 1045.80m, the lowest layer at the west grid wall.

The dominated diatom species was *Hantzschia amphyoxys* that was an indicator of very shallow water environment. The fragments of *Pinnularia* sp., *Nitzschia* sp. and *Synedra* sp. were also observed. The results of diatoms presumed a shallow water swampy environment formed during the Late Bronze Age and the Iron Age. If the stone architecture was build for dwelling or storage, the water level was below their level. The local water level rose more than 1m and a shallow swamp covered the stone architecture.

(Drilling site; 2005-01)

The grain size analysis was done at every 20 cm of the drilling core. The weight percentages of the coarse materials (>500*μm*) showed clearly two times of alternations between peaty clay layers and sand and gravel layers at the core.

The number of diatoms in sediments also changed corresponding with the grain size changes. Diatoms were abundant at two clay layers. The upper diatom rich clay was leveled at 1045.40m – 1046.00m. It contained about 50,000 diatoms in 1g sediment. The dominated species from the layer was *Hantzschia amphyoxys*. Fragments of *Pinnularia* sp. and *Synedra* sp. were also observed. Those characteristics of diatoms were very similar to those of the Sector North-X, mentioned before. A shallow water swamp was presumed at the layer. The C^{14} dating presumed that the upper peaty clay was deposited at Roman period.

The lower diatom rich clay was leveled at 1044.2m – 1044.7m. It contained about 10 times as many diatoms as those of the upper layer in 1 g sediment, although the grain size distributions were almost the same at the two layers. The dominated species at the lower layer were *Navicula cincta*, *Nitzschia constricta* and *Nitzschia frustulum*. They were indicators of lakes and swamps with slight salt. *Hantzschia amphioxys* that was dominated at the upper layer was also observed. It was a very shallow salty swamp. The C^{14} dating presumed that the lower peaty clay was deposited in the Early or the Middle Bronze Age.

WATER LEVEL CHANGE AT KAMAN-KALEHÖYÜK
– A PRELIMINARY DISCUSSION –

The results of the palaeo-environmental surveys presumed that a very shallow swamp had been existing at the north of Kaman-Kalehöyük since the Bronze Age through the Roman Period. The water environment of it was not stable and the water level and water salinity changed.

The oldest swamp layer was the lowest peaty clay at 2005-01 drilling site. It was a salty shallow swamp and its water level was 1044.2m – 1044.7m. Two dating from the peaty clay (1044.70m; 3,590±36 years BP (2040 – 1780 cal.BC), 1044.20m; 3,686±39 years BP (2200 – 1950 cal.BC) presumed that it deposited at the last part of the Early Bronze and the Middle Bronze Age. The levels of the stone architectures in IIIC period (Assyrian Colonial Period; the Middle Bronze Age) at Sector North-X were1046.40 -1045.80 m, therefore they were built 1m above the water level.

After then, the water level increased till 1046.90m and the swamp deposits covered the stone architectures. Two dating of peaty clays (1046.40m: 2,445±35 years BP, 710 – 350 cal.BC; 1045.80m m: 3,130±37 years BP 1500 – 1310 cal.BC) presumed that this high water epoch was dated in the Late Bronze Age and the Iron Age. Water environment was also changed in corresponding to the water level rise. The salinity of swamp water decreased and salty water became to be fresh water.

At the end of the Iron Age, Kaman-Kalehöyük was abandoned for two thousand years. The water level lowered again. The water level of the Roman Period was lowered to about 1045.60m (1,888±35 years BP; 50 – 230 cal. AD).

Our previous drillings at lakes and swamps in Central Anatolia made clear that the huge climatic change occurred during the Holocene (Kashima 2002; 2003 Kashima *et al*. 2005). The precipitation and evaporation rates have changed abruptly in corresponding to the temperature fluctuation. The drilling surveys at small swamps near Kültepe in 2003, presumed that the three flood events attacked the lower town (Karum) of Kültepe. The first flood

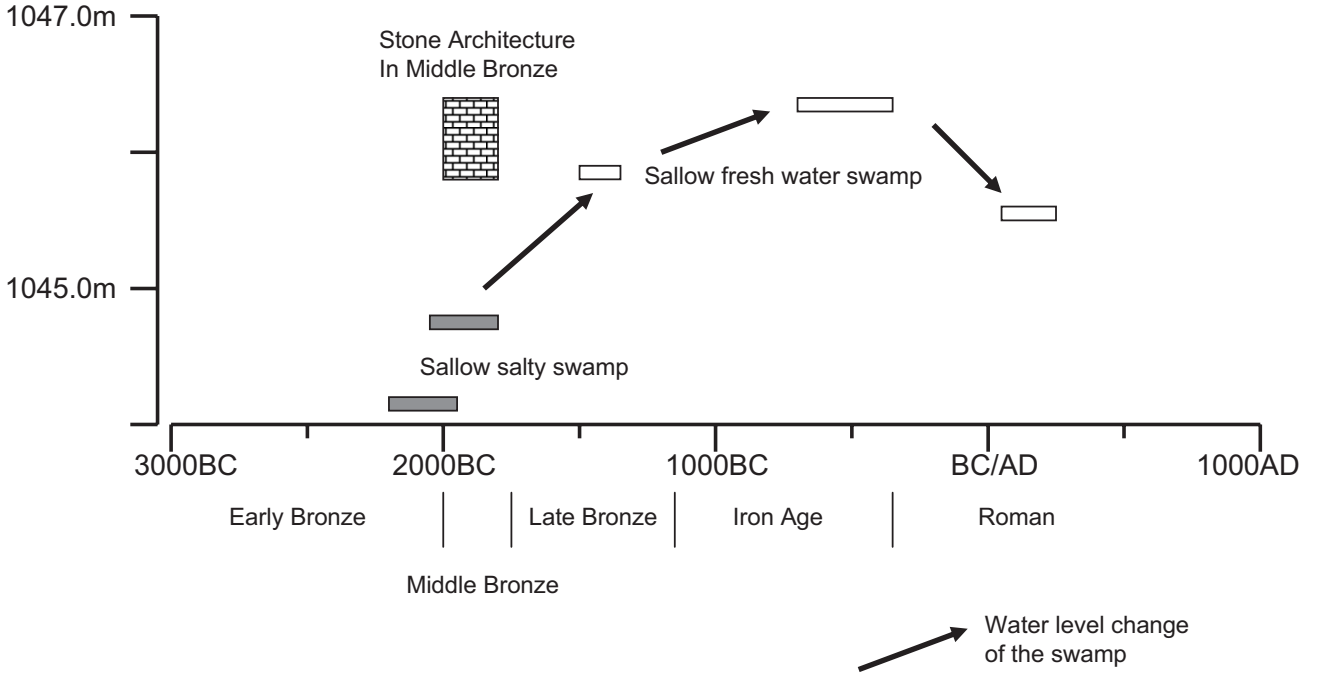

Fig.9 A water level and water salinity changes at shallow swamp, north of the Kaman-Kalehöyük

event was dated to ca. 4500 BC, the second one to ca. 200 BC and the last one to after 700 AD by calibrated AMS ^{14}C (Kashima *et al*. 2005). Those changes were not in harmony with the water level change at Kaman-Kalehöyük.

The high water epoch at the swamp north of the höyük during the Late Bronze Age and the Iron Age was probably caused artificially. It might be a canal for defense for enemies or for irrigation, although we have to take do further sampling round the höyük in order to get a clear answer. Further drilling survey would make clear the distribution and the age of this water supply structures.

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