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Radiocarbon Measurement and ^{14}C Ages of Holocene Deposits in the Eastern Margin of the West Osaka Area, Southwest Japan

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(With 4 Tables and 7 Figures)

Abstract

The Alluvial formation in the Osaka Plain is divided into three parts: the lower part, the middle part, and the upper part, in ascending order. Around the Uemachi Upland, running north to south in the Osaka Plain, clays of the middle part grade laterally into sands; the Alluvial formation is not so clearly defined in this area.

^{14}C ages of molluscan fossils and wood samples from sandy layers in the marginal area of the Osaka Plain were measured, using the standard ^{14}C dating system. Based on this dating, these layers, which range in age from 7460 years B.P. to 3530 years B.P., are correlated with the middle part of the Alluvial formation. They are regarded as the marginal depoists of the Osaka Bay during the maximum stage of the Holocene Transgression.

Key Words: Radiocarbon Dating, Holocene, Osaka Plain, Molluscan fossil

I. Introduction

Late Cenozoic sediments are widely developed both on and under the ground in Osaka City and its surrounding areas. Near the subsurface of the Osaka Plain, the Alluvial formation (the Nanba Formation; KAJIYAMA and ITIHARA, 1972) and the Upper Pleistocene deposits (IKEBE *et al.*, 1970) are developed.

The stratigraphy of the Alluvial formation is studied by lithology, ^{14}C dating and pollen analysis (KAJIYAMA and ITIHARA, 1972; MAEDA, 1976a,b; FURUTANI, 1979). The Alluvial formation is typically divided into three parts: the lower part (clay-silt layer with organic matter and sand layer, 10000–7000 years B.P.), the middle part (marine clay layer, 7000–2000 years B.P.), and the upper part (well-sorted sand layer, younger than 2000 years B.P.), in ascending order.

The main part of the Osaka Plain is divided into the West Osaka area and the East Osaka area by the Uemachi Upland which runs from north to south. Around the Uemachi Upland, the clay layer of the middle part of the Alluvial formation grades laterally into sands; the Alluvial formation is not so clearly defined in this area.

Recently, in the eastern margin of the West Osaka area (Fig. 1), excavation of the Alluvial formation was carried out by a civil engineering project. At this site, the author had opportunities to observe the Alluvial formation and to obtain fossil samples from

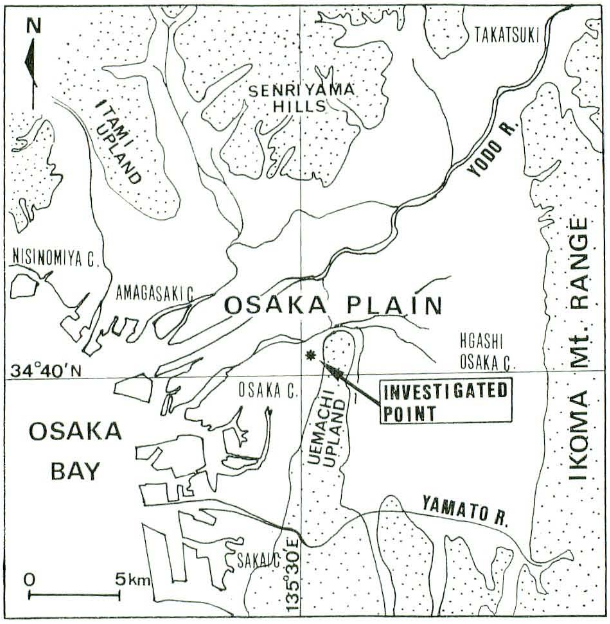

Fig. 1 Locality map showing the investigation site.

the formation.

The ^{14}C dating method established by LIBBY (1952) is one of the most effective methods of determining age in geology, geography and archaeology. Many ^{14}C ages have been measured and utilized in investigations of the Alluvial formation in the Osaka Plain (KAJIYAMA and ITIHARA, 1972; MAEDA, 1976a). The author measured ^{14}C ages of mulluscan fossils and wood samples in the area (Fig. 1) using a proportional gas counter system.

This paper describes the ^{14}C dating system used in our laboratory and describes the lithology and ^{14}C ages determined at this investigation site.

II. ^{14}C dating methods

1. Sample Preparation

Samples are converted into acetylene by the method of Suess (SUESS, 1954). The preparation process is summarized in Fig. 2. Prior to sample preparation, rootlets and other contaminating materials in wood samples are removed by handpicking.

Wood samples are bioled in 1% potassium hydroxide solution for a few hours to dissolve lignin and humic acid. The samples are then boiled in dilute hydrochloric acid solution to remove carbonates. After pretreatment, each wood sample is carbonized to charcoal by heating in a furnace with quartz sand. The sample charcoal (7–9 g) is placed in a quartz combustion tube and burned with a bunsen burner in an oxygen stream.

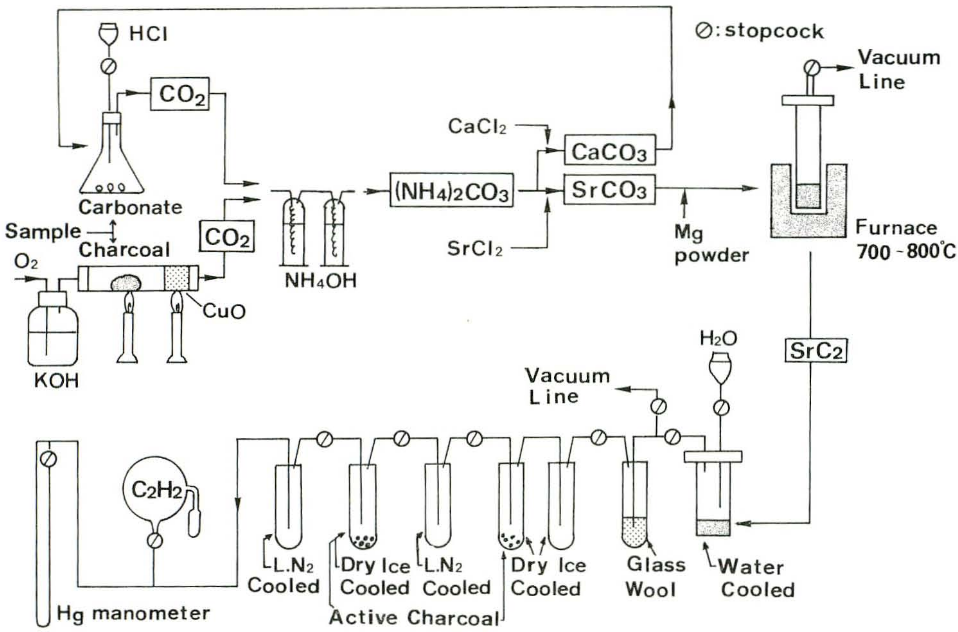

Fig. 2 Schematic diagram of sample preparation.

On the other hand, carbonates such as shell fragments, corals and marble are broken into small pieces, and contaminating materials, if any, are picked out by hand. Crushed carbonate samples (40–50 g) are pretreated with dilute hydrochloric acid solution to dissolve the outer layer. They are then placed in a one-liter flask equipped with a dropping funnel and outlet tubes.

Carbon dioxide is generated by dropping 35% aqueous hydrochloric acid. The carbon dioxide so generated is introduced at room temperature into two glass cylinders, connected in series, which contain 200 ml of 12% ammonia water. After the reaction is completed, the ammonium carbonate solutions are combined, and a 25% aqueous calcium chloride solution (125 g in 500 ml very hot water) is added to precipitate calcium carbonate. The calcium carbonate obtained is washed thoroughly with distilled water.

Because of the possibility of impurities, the calcium carbonate is subjected to the same process again. During this process, strontium chloride solution (250 g in 500 ml), instead of a calcium chloride solution, is used to precipitate strontium carbonate.

Strontium carbonate, after washing and drying, is reduced with an excess of magnesium powder (<100 mesh) to strontium carbide. The reaction is carried out inside an evacuated stainless-steel tube equipped with a stopcock connected to a vacuum line, at 700° ~ 800°C.

Strontium carbide is placed in an acetylene generator, and released the acetylene by dropping water. In order to prevent contamination by tritium, the water is obtained from 190 m underground in Ikoma City, Nara Prefecture. The tritium content of the water, checked by mass spectrometry, was 3 TU.

The acetylene generated is purified with a small amount of active charcoal cooled at dry ice-ethanol temperature. The acetylene is stored for at least three weeks to permit decay of radon atoms that are sometimes present in the gas sample.

2. Radiocarbon Measurement and Dating

Our laboratory uses a multi-anode anti-coincidence proportional gas counter made by Ohyokoken Kogyo Co. Ltd., Japan (Type S–1859) with an actual volume of 1.2 liters. The central counter tube is made of aluminized polyethylene film, 0.1 mm thick, with 72 mm inside diameter and 300 mm sensitive length. The external counter tube is made of stainless steel, 4 mm thick, with 93 mm inside diameter and 350 mm length. The anode wires 0.05 mm diameter of both counters are made of tungsten. The counters are surrounded by a paraffin shield, 50 mm thick, and encased in a 250 mm steel shield on all sides.

Purified acetylene gas is introduced into the counter at a pressure of 760 mmHg (101 kPa) at room temperature. The room temperature is controlled at 22 ± 1°C by an air conditioner in order to keep the gas a fixed condition.

Beta rays, formed by disintegration of ^{14}C atoms in the gas, and penetrated cosmic rays are transformed into electric pulses in the detector. The electric pulses from the detector are amplified and discriminated through the measuring system shown in Fig. 3. Finally, only signals from the disintegration of ^{14}C atoms are discriminated by the anti-coincidence circuit.

In order to inspect the gas and detector condition, the plateau curve of each gas is calibrated with penetrated cosmic rays. Its range is stable over 1000 V and the slope is about 1% / 100 V. The plateau curve is measured for each sample at the beginning and the end of countnig (Fig. 4); this verifies absence of variation in the gas.

The activity of each sample is counted for 1000–2500 minutes, replacing the modern standard and background measurement in rotation. Background measurement is carried out with the gas synthesized from Carrara Marble (Italy). Table 1 shows counting rates of background. The mean activity of background is 0.85 ± 0.01 cpm.

Contemporary value for all dates is 95% of the activity of the oxalic acid standard

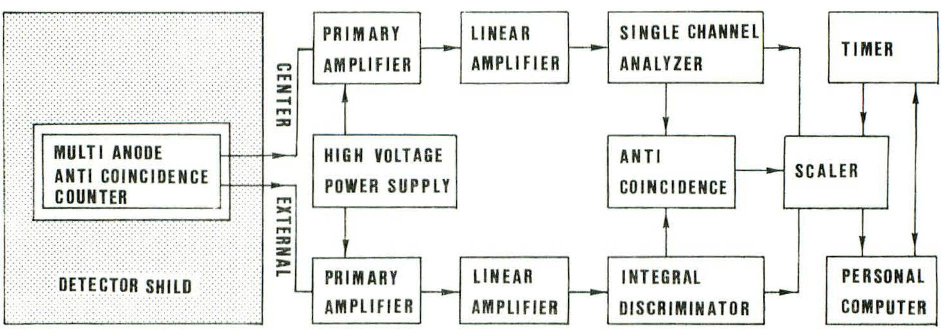

Fig. 3 Schematic diagram of radiocarbon measurement system.

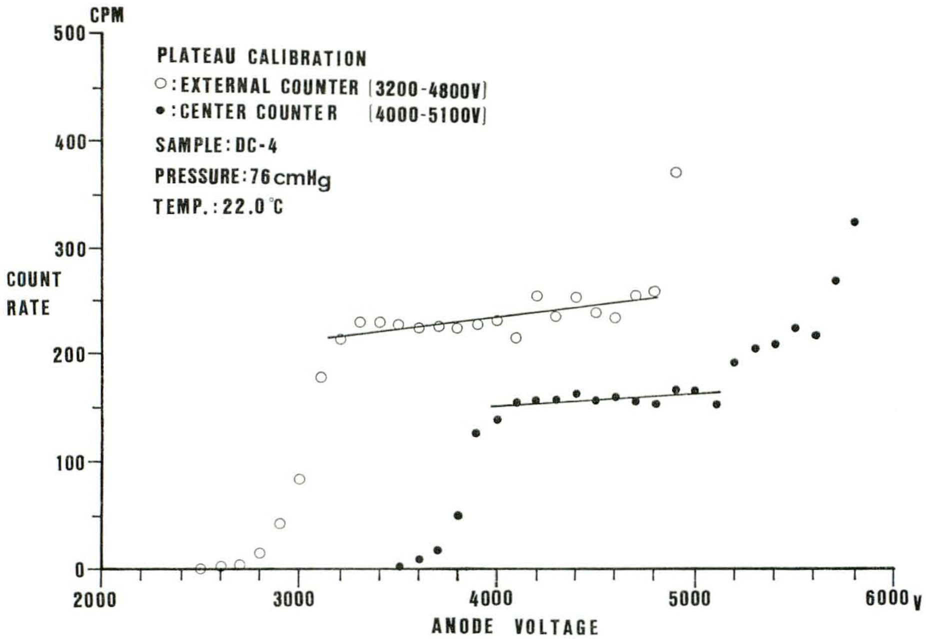

Fig. 4 Example of plateau calibration of detector.

Table 1 The activity of background samples (Carrara Marble).

Sample No.	Counting Rate cpm
DC-2	0.82± 0.03
DC-3	0.83± 0.03
DC-4	0.91± 0.02
DC-5	0.81± 0.02
DC-6	0.88± 0.02
DC-7	0.87± 0.03
Mean	0.85± 0.01

Table 2 The activity of TBS1980 beet sugar.

Sample	Counting Rate (cpm) Gross	Net
TBS1980-1	19.69± 0.09	18.84± 0.09
TBS1980-2	20.04± 0.09	19.19± 0.09
TBS1980-3	19.84± 0.09	18.99± 0.09
TBS1980-4	19.83± 0.09	18.98± 0.09
	Mean	19.00± 0.05
76.46% activity of TBS1980		14.53± 0.04

Table 3 ^{14}C ages at investigation site.

Sample	Counting Rate (cpm) Gross	Net	^{14}C Age y.B.P.	Remarks T.P. m
OCU-1	6.59± 0.05	5.74± 0.05	7460± 80	wood , -11
OCU-4	8.43± 0.09	7.58± 0.09	5230± 100	wood , - 6
OCU-5	7.58± 0.06	6.73± 0.06	6190± 80	shell, - 6
OCU-6	10.22± 0.06	9.37± 0.06	3530± 60	shell, - 5
OCU-7	9.37± 0.06	8.52± 0.06	4290± 60	shell, - 3
OCU-8	6.68± 0.05	5.83± 0.05	7340± 70	shell, -13

(SRM 4990) from the U.S. National Bureau of Standards, as recommended at the 1959 Groningen Radiocarbon Conference. Our laboratory uses beet sugar (TBS–1980) from the ^{14}C Dating Laboratory in the University of Tokyo. This beet sugar was refined beet molasses from the 1980 harvests in Hokkaido, Japan. SRM 4990 is equal to 0.7646 times the specific activity of the TBS–1980 (KOBAYASHI and TERADA, 1984). Table 2 shows counting rates of TBS–1980. The activity of modern standard from TBS–1980 is 14.53±0.04 cpm.

Ages are calculated using the hlaf-life value 5570, with 1950 as the reference year. The standard deviation quoted includes only 1σ counting statistics of background, sample, and standard counts. Maximum ages are given with a limit of 43,200 years B.P., corrseponding to sample activity less than 3σ above background. The age of each sample is numbered, in series, with "OCU-".

III. Lithology and ^{14}C Age

The investigation site is shown in Fig. 5. This site is situated on the west side of the Uemachi Upland. The geological column of this site is shown in Fig. 6. The lithology and ^{14}C ages (shown in Table 3) at this site are as follows:

T.P.±0 m～T.P.−1 m (T.P.: abbreviation for Tokyo Peil, altitude above standard sea level in Tokyo Bay): very loose, coarse sand with small pebble gravel. This sand layer has trough-type cross lamination.

T.P.−1 m～T.P.−6.5 m: highly sorted, medium- to fine-grained sand with shell fragments. This sand layer has trough-type cross lamination. The list of the shell fragments contained in this layer is given in Table 4. Abundant molluscan fossils inhabiting the shoreface zone and the intertidal zone of the bay area are contained in this layer. The ^{14}C ages of shells and wood samples are from 3530±60 to 6190±80 years B.P.

T.P.−6.5 m～T.P.−8 m: silty, fine sand with parallel lamination. This layer exhibits bioturbation in parts.

T.P.−8 m～T.P.−8.5 m: coarse sand with granules. This layer shows abundant in bioturbation.

T.P.−8.5 m～T.P.−12 m: coarse-grained to granule-sized sand with small pebble

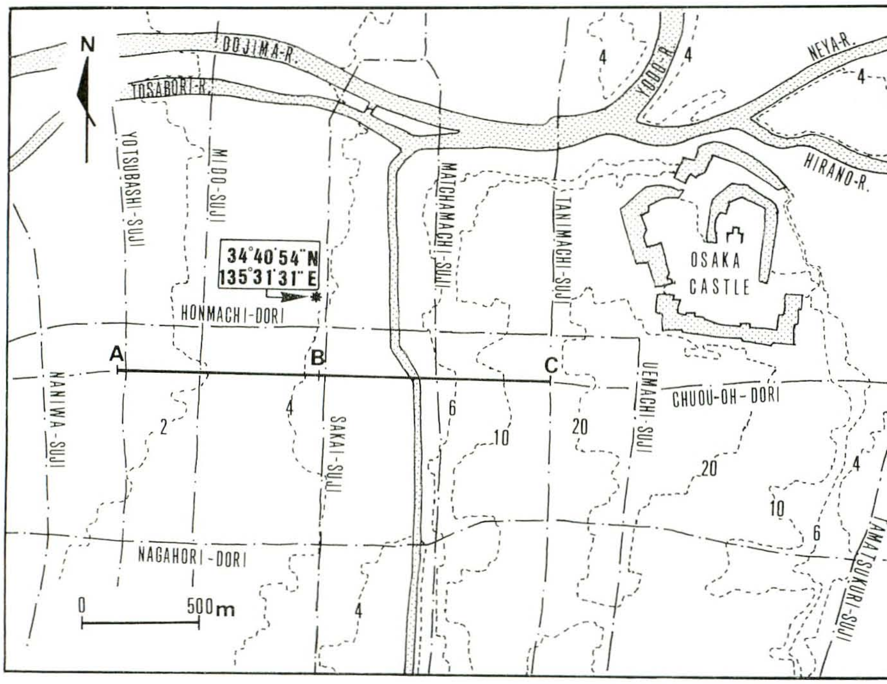

Fig. 5 Detailed map of the showing investigation site and profile line. Broken lines represent topographical contours. Dot-dash lines represent main streets. *=investigation site. A, B, C is the profile line.

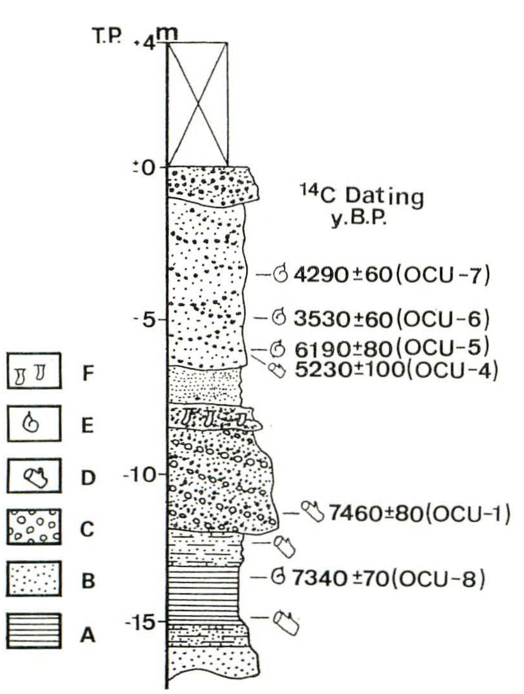

Fig. 6 Geological column and ^{14}C ages at investigation site. A=Clay-Silt; B=Sand; C=Gravel; D=Wood fossil; E=Shell fragments; F=Bioturbation.

Table 4 Faunal list at investigation site.

Species	Habitat Zone	TP-4m	TP-5m	TP-6m	TP-13m
MOLLUSCA					
Umbonium moniliferum	T-S	○	○		
Serpulorbis imbricatus	T		○		
Batillaria multiformis	T		○		
Cerithideopsilla djadjariensis	T		○		○
Ochetoclava kochi	T-S	○	○		
Doxander vittatus japonicus	S		○		
Neverita didyma	T-S	○	○		
Zeuxis succincitus	S				○
Pecten albicans	S	○	○		
Chlamys aspelata pelseneeri	S	○			
Crassostrea gigas	T-S		○		
Ostrea denselamellosa	T-S			○	
Anodontia stearnsiana	M		○		
Callista chinensis	T-S	○			
Dosinia japonicus	S	○			
penicillala	M				○
Paphia undulata	M				○
Protothaca jedoensis	T-S	○			
Mactra chinensis	S-M	○	○		
Venatomya truncata	T-M	○			
Soletellina boeddinghausi	T-S	○			
Arcopagia diaphana	S	○			
Macoma sectior	S	○	○		
Lutrarina maxima	S	○			
Anomina chinensis	T	○	○		
ECHINODERMATA					
Scaphechinus mirabilis			○		
ARTHROPODA					
Macrophthalmus latreillei	M				○

T:Inter Tidal Zone S:Sandy Shoreface Zone
M:Muddy Offshore Zone

gravel. This layer has planar-type cross lamination. The ^{14}C age of wood fossil from the lower part of this layer is 7460±80 years B.P.

T.P.—12 m～T.P.—13 m: silty, medium- to coase-grained sand. This layer is abundant in plant fossils and bioturbation, and has wavy lamination, in parts.

T.P.—13 m～T.P.—15 m: sandy clay with shell fragments. Abundant molluscan fossils, inhabiting the muddy offshore zone of the bay area, are contained in this layer. The upper part of this layer is bioturbated; the lower part is abundant in plant fossils. The ^{14}C age of shell fragments from the upper part of this layer is 7340±70 years B.P.

T.P.—15 m～T.P.—16 m: silty, medium-grained sand. This layer partly has trough-type cross lamination.

T.P.—16 m～T.P.—17 m: well sorted, medium-grained sand.

IV. Discussion

The Ground of Osaka (Kinki Branch of the Japanese Society of Architecture and Kansai Branch of the Japanese Society of Soil Mechanics and Foundiation Engineering, 1966) regards the base of the very coarse sand layer (T.P.—1 m) as the base of the Alluvial formation in this area, based on N values of the penetration tests. On the other hand, The Ground of Osaka (Kansai Branch of the Japanese Society of Soil Mechanics

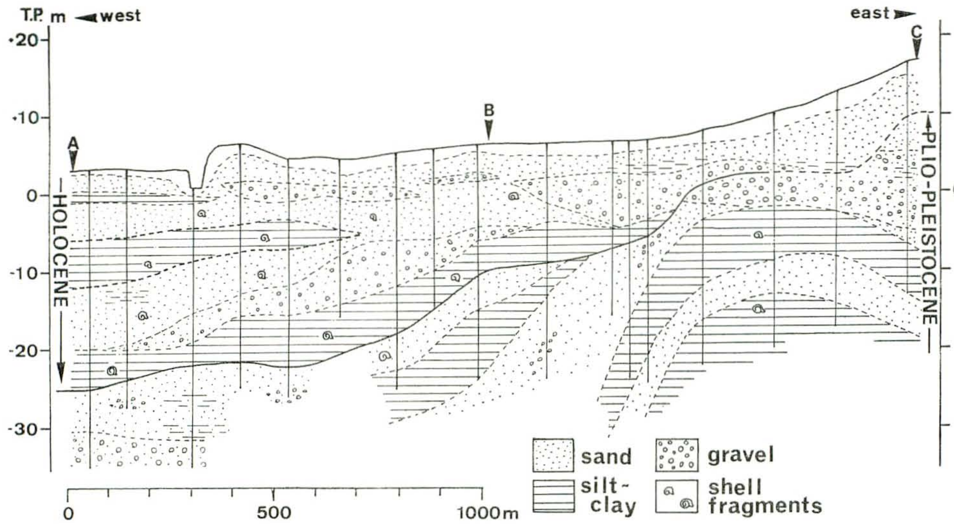

Fig. 7 Geological section along the profile line A-B-C near the investigation site.

and Foundiation Engineering and Kansai Chishitsu Tyousagyou Kyoukai, 1987) correlates the sand layer containing molluscan fossils (T.P.—1～T.P.—8.5 m) with the middle part of the Alluvial formation in this area. As mentioned above, the Alluvial formation was not divided on the basis of its lithology in the studied area. The results of ^{14}C dating in this paper show that the layers above the silty, medium-grained sand layer (T.P.—15 m～T.P.—16 m) in the investigation site are regarded as the Holocene deposits.

The sandy layers (T.P.—1 m～T.P.—8.5 m) contain conspicuous molluscan fossils which inhabited the shoreface zone of the bay area. The clay layer contains *Dosinia penicillala* and *Paphia undulata*, indicating the muddy, offshore zone of the bay area. These contained fossils therefore indicate that these layers were the marginal faices of the bay area.

Fig. 7 is an E-W geological section along the profile line A-B-C in Fig. 5, south of the investigation site. The sandy layers on the west side of the profile grade laterally into the clay layer, which is correlated with the middle part of the Alluvial formation.

Hence, the sandy layers from T.P.—15 m to T.P.—1 m in the investigation site are correlated with the middle part of the Alluvial formation. These layers are regarded as having been the marginal deposits of Osaka Bay during the maximum stage of the Holocene Transgression.

V. Conclusion

This paper demonstrates that the sandy layers (in ^{14}C age from 7460 to 3530 years B. P.) in the eastern margin of the West Osaka area are the marginal facies of Holocene deposits in Osaka Bay. Sands and gravels similar to the sands at the investigation site, are distributed around the Uemachi Upland. The underlying the Upper Pleistocene deposits at the investigation site are not clearly defined. Further investigations around the Uemachi Upland should clarify the stratigraphy of these formations.

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