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Diatom assemblages during the Holocene transgression at the Minato Bridge in Osaka Port along Osaka Bay

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The sediments collected from a caisson at the Minato Bridge in Osaka Port along Osaka Bay were studied to clarify the sedimentary environments during the Holocene transgression by diatom analysis. Based on the character of diatoms, the sediments are divided into five zones. (1) F-D Zone (freshwater diatiom zone) is dominated by *Stephanodiscus carconensis*, and freshwater species are about 70% of the total. (2) M-D Zone (marine diatom zone) is dominated by *Cyclotella striata* and *Melosira sulcata* and the proportion of marine species is about 57%. (3) F-D Zone (freshwater diatom zone) is subdivided into two subzones. Lower subzone is dominated by *Stephanodiscus carconensis* and the proportion of freshwater species is 36%. Upper subzone is dominated by *Diploneis elliptica* and the proportion of freshwater species is about 60%. (4) Transitional Zone has a few frustules of unidentified diatoms. (5) M-D Zone (marine zone) is dominated by *Cyclotella striata* and *Melosira sulcata* and the proportion of marine species increases to 97%.

Key Index Words: Diatom zone; freshwater species; Holocene transgression; marine species; mollusks; Osaka Bay; sedimentary environments.

MATSUSHIMA and OHSHIMA (1974) and MATSUSHIMA (1978) first studied the littoral molluskan assemblages of the Holocene transgression around Tokyo Bay and Sagami Bay in Japan. As to Osaka Bay, KAJIYAMA and ITIHARA (1972) and YASUDA (1978) reconstructed the developmental history of the Osaka Plain based on an abundant record of molluskan fossils, sedimentary facies, and pre-historical remains. MAEDA (1976, 1977, 1978, 1980) determined the sea level and shore line changes during the Holocene transgression by means of radiocarbon dates of mollusks, molluskan assemblages and direct observations of sediments in caissons around Osaka Bay. By means of diatom analysis, KUMANO and MIYAHARA (1981) ascertained the sedimentary environments at the Samondo Gawa site, which were consistent with molluskan assemblage analyses by Maeda. The present study follows the above mentioned work and reconstructs an environmental history at the Minato Bridge in Osaka Port along the shore line of Osaka Bay.

Materials and Methods

The materials were collected by Dr. Y. MAEDA from a caisson of the foundation of the Minato Bridge situated at 34°38′N lat. and 135°26′E long. in Osaka Port. Samples of about 1 g were boiled with 15% hydroperoxide and treated with conc. hydrochloric acid. The cleaned and washed materials were dried and mounted with pleurax. The identification of diatoms was made by means of photomicrographs. About three hundred frustules of diatoms were counted in each sample along a transect chosen at random and the relative abundance of each taxon and each ecological group is presented as a

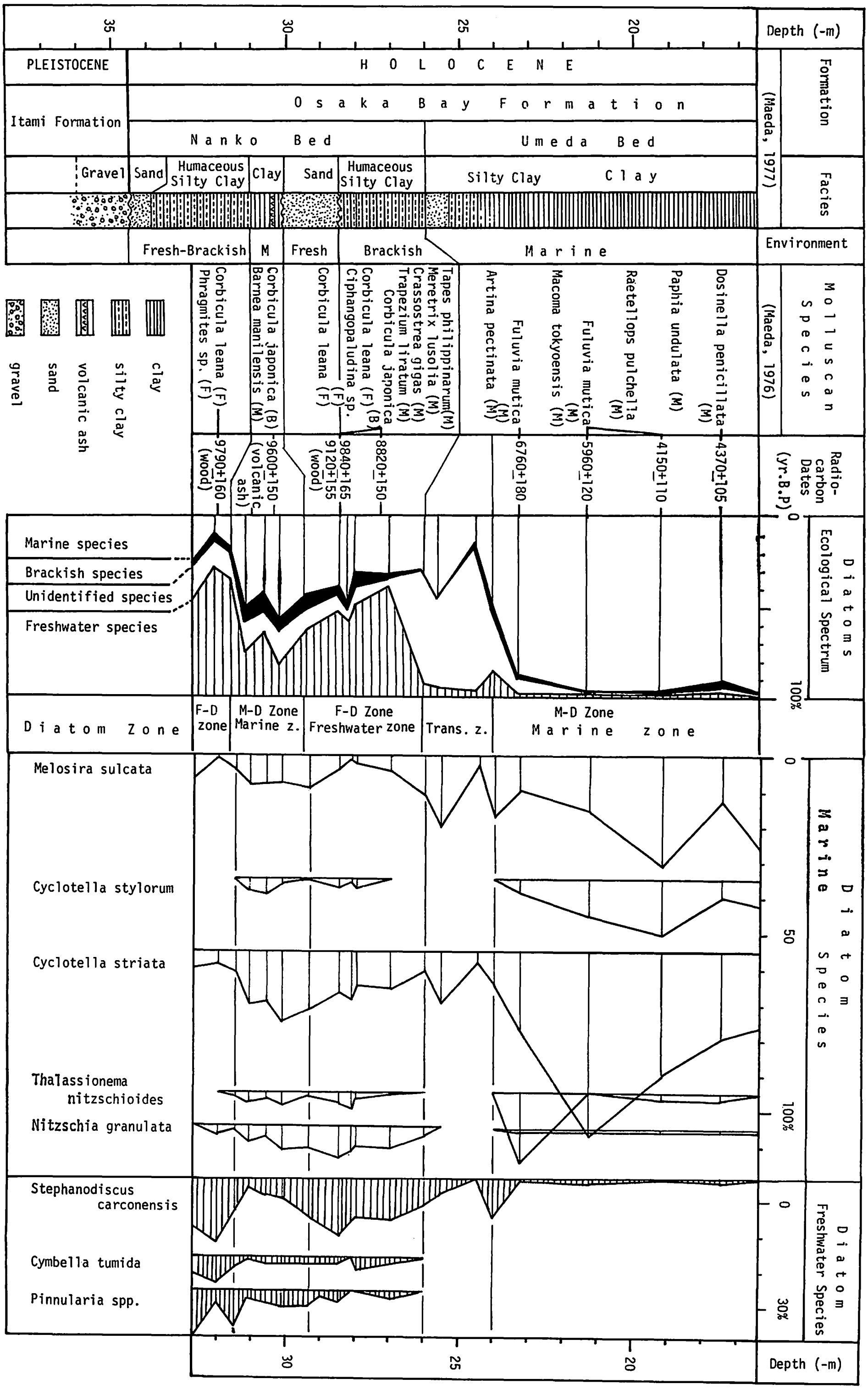

Fig. 1. Stratigraphy, columnar section, molluskan species, radiocarbon dates and diatom diagrams of the sediments from the Minato Bridge in Osaka Port along Osaka Bay, central Japan.

percentage of the total. The radiocarbon ages of nine samples by Dr. T. HAMADA are shown in the 5th column of Fig. 1.

Molluskan Species (MAEDA 1976, 1977)

The stratigraphy of the sediments at the Minato Bridge site is shown in the 1st and the 2nd columns, molluskan species in the 4th column, which were reported by MAEDA (1976, 1977), and radiocarbon dates in the 5th column of Fig. 1.

The Nanko Bed is divided into five units; lowermost sand, lower silty clay, middle clay, upper sand and uppermost silty clay.

1) Lower silty clay (−33.5 m to −31.0 m) contains *Phragmites* sp. and *Corbicula leana* indicating freshwater sediments.

2) Middle clay (−31.0 m to −30.0 m) contains *Corbicula japonica* (brackish species), *Barnea malilensis* (littoral species) and many trace fossils indicating the beginning of the Holocene transgression at this site.

3) Upper sand (−30.0 m to −28.5 m) contains *Corbicula leana* and *Ciphangopaludina* sp. (freshwater species) and this sediment is considered to be fluvial.

4) Uppermost silty clay (−28.5 m to −26.0 m) contains many trace fossils, freshwater-brackish and littoral mollusks such as *Ciphangopaludina* sp. (freshwater species), *Corbicula japonica* (brackish species), *Corbicula leana, Tapes philippinarum, Meretrix lusolina, Crassostrea gigas* and *Trapezium liratum* (littoral species). These facts indicate that this silty clay was a brackish or littoral sediment.

The Umeda Bed (−26.0 m to −16.5 m) contains many marine molluskan fossils indicating an inner bay environment.

Diatom Assemblages

Based on the character against salinity (HUSTEDT 1930, 1959, 1961-1966; PATRICK and REIMER 1966, 1975), the diatom assemblages found in the sediments at the Minato Bridge can be grouped into marine species including marine-brackish species, brackish species and freshwater species including freshwater-brackish species. The sediments can be divided into five zone by means of the diatom assemblages as follows:

1) F-D Zone (freshwater diatom zone; −32.5 m to −31.5 m). Freshwater species of diatoms are dominated by *Stephanodiscus carconensis, Navicula mutica, Cymbella tumida* and *Pinnularia* spp., and the proportion of freshwater species is about 70% at a depth of −32.0 m.

2) M-D Zone (marine diatom zone; −31.5 m to −29.5 m). Marine species of diatoms are dominated by *Cyclotella striata* and *Melosira sulcata*. The proportion of marine species increases up to 57%. On the other hand, the percentage of freshwater species decreases to about 16% at a depth of −30.0 m.

3) F-D Zone (freshwater diatom zone; −29.5 m to −26.0 m) is divided into two subzones. In the lower subzone, freshwater species are dominated by *Stephanodiscus carconensis* and the proportion of freshwater species increases up to 36%. At the same time, marine species are still found in the ratio of 35% and dominated by *Cyclotella striata* and *Nitzschia granulata*. In the upper subzone, freshwater species increase up to 60% and the dominant species changes to *Diploneis* sp. and *Stephanodiscus carconensis*, but benthic species such as *Cymbella tumida, Navicula* spp. and *Pinnularia* spp. decrease in this upper subzone.

4) Transitional Zone (−26.0 m to −24.0 m). A few frustules of diatoms are detected and unidentified species are found in the ratio of 30-80%.

5) M-D Zone (marine diatom zone; −24.0 m to −16.5 m). Marine species are dominated by *Cyclotella striata* and *Melosira sulcata* and the proportion of marine species increases up to 96.7% at a depth of −21.3 m. In contrast, the proportion of freshwater species is less than 2% at this horizon.

Discussion

According to MAEDA (1978) the beginning of the Holocene transgression confirmed by intertidal assemblages of mollusks starts at a depth of −23.4 m at Samondo Gawa site. However, KUMANO and MIYAHARA (1981) reported that many marine species of diatoms appeared at a depth of −23.8 m at the same site. At Minato Bridge site, the same phenomenon is observed. MAEDA (1976) reported that the middle clay (−31.0 m to −30.0 m) of the Nanko Bed at Minato Bridge site contained brackish and littoral mollusks and many trace fossils. From that, he indicated that the Holocene transgression at Minato Bridge began at a depth of −31.0 m. However, in the present study, it is observed that marine species of diatoms began to increase and freshwater species of diatoms began to decrease at a depth of −31.5 m deeper than the horizon where brackish and littoral mollusks were found by Maeda. These facts indicate that intertidal assemblage of diatoms appeared prior to those of mollusks in the progress of the Holocene transgression. From the above mentioned imformations, the beginning of the Holocene transgression at Minato Bridge site in Osaka Port is assumed to start at a depth of −31.5 m. The environment of the sea shore at the beginning of the Holocene transgression was so changeable that adaptable organisms such as diatoms could immigrate into it. After the environment became stable, the advanced organisms like mollusks could immigrate and settle there.

At Samondo Gawa site, MAEDA (1978) pointed out that sea level rose slowly in the period between 8,800 years BP and 8,000 years BP. KUMANO and MIYAHARA (1981) considered that the sea was very shallow at the horizon between −24.0 m and −21.8 m, where *Nitzschia granulata* was a dominant species. At Minato Bridge site *Nitzschia granulata* is found at the horizons between −31.5 m and −24.0 m. It is considered that the sea was very shallow throughout these horizons because *Nitzschia granulata* is frequent on sandy shores in England (HENDY 1964). As if a small regression had taken place, freshwater species dominated by *Stephanodiscus carconensis* occur at a depth of −28.5 m. These facts agrees with the occurrences of freshwater mollusks such as *Corbicula leana* and *Ciphangopaludina* sp. at these horizons reported by MAEDA (1976).

As already pointed out (KUMANO and MIYAHARA 1981), *Stephanodiscus carconensis* has been one of the most noticeable phytoplankters in Lake Biwa Ko for the last 250,000 years (MORI and HORIE 1975) and is regarded as a drifted phytoplankter from Lake Biwa Ko. Probably the Minato Bridge site was located near the fringe of a lobated delta of Paleo Yodo Gawa at the horizons between −32.5 m and −24.0 m. In accordance with the appearance of *Corbicula japonica*, a brackish mollusk, and many other intertidal mollusks, the dominant species of diatoms change from freshwater species to brackish ones at a depth of −26.0 m.

Benthic genera of freshwater diatoms such as *Cymbella*, *Navicula*, *Gomphonema*, *Fragilaria* and *Pinnularia* disappear at a depth of −24.0 m. Moreover, the freshwater plankter, *Stepahnodiscus carconensis*, also disappears at a depth of −23.3 m. This fact

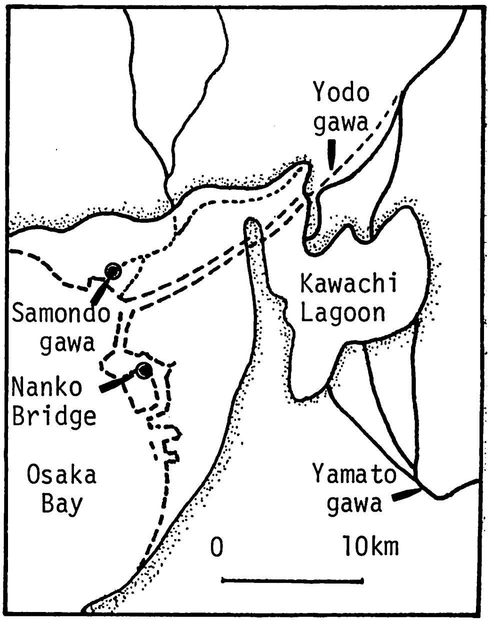

Fig. 2. Map showing study sites (Samondo gawa site and Minato Bridge site), shore line of Osaka Bay and Kawachi Lagoon at 3,000-2,000 years BP. (after KAJIYAMA and ITIHARA 1972).

indicates that most of plankters drifted from Lake Biwa Ko were deposited in the bottom of Paleo Kawachi Bay and Paleo Kawachi Lagoon, which were formed at the period from 7,000 years BP to 2,000 years BP due to the Holocene transgression as shown in Fig. 2 (KAJIYAMA and ITIHARA 1972). In fact, KAJIYAMA and ITIHARA (1972) found *Corbicula sandai*, one of the endemic mollusks in Lake Biwa Ko, in the inner region of Paleo Kawachi Lagoon at 3,000-2,000 years BP.

In the marine diatom zone (M-D Zone), the dominant species of diatoms changes from *Cyclotella striata*, a marine plankter, to *Melosira sulcata*, showing a neritic habitat. The proportion of *Cyclotella striata* is at its maximum at a depth of -21.3 m, which horizon shows a radiocarbon age of 5,960 ±120 years BP. This fact seems to indicate that the sea was deepest at the time of that horizon, in other words, the peak of the Holocene transgression was at about 6,000 years BP.

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熊野　茂・藤本いずみ：大阪湾大阪南港大橋における完新世海進時の珪藻遺骸群集

大阪南港大橋の潜函より前田（1976）の採取した堆積物の珪藻分析を行った。大阪湾累層は南港層と梅田層に，南港層は更に5層に細分される。堆積物の珪藻遺骸群集は下部より上部へ，淡水生珪藻帯，海水生珪藻帯，淡水生珪藻帯，遷移帯および海水生珪藻帯と変化がみられる。

−31.5 m の層準から，海水生貝類に先行して，海水生珪藻が増加し完新世海進がこの層準から開始したことを示している。−31.5 m から −24.0 m までの層準には *Nitzschia granulata* が優占することから，浅い海が続いたことが推察できる。

−23.3 m の層準からは海水生珪藻が97%に達し，海が深くなったことを示している。−21.3 m の層準に *Cyclotella striata* のピークがみられるが，この層準の年代（5,960±120 y. BP）は完新世海進のピークと一致する。

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新刊紹介

横浜康継著「海藻の謎」緑への道，環境と人間の科学 5，235 pp. 三省堂（1,900円）

とにかく面白い価値ある一冊の本がでたと思う。著者はご存知のように，海藻類の光合成と色素分析についてのわが国における第一人者である。そして光合成のしくみを目でみることができるプロダクトメーターの製作者でもある。だから20年近く一歩一歩積み重ねてきた研究成果が，そのまま素晴らしい読み物となり，海藻という一般に馴の薄い植物群を中心に，その光合成のしくみと体色との関係を，全く知らない人々にも楽しく読ませ，興味をもたせ，海藻の謎について丁寧に教えてくれる。これは本当に自分で研究し，理解し，納得のいく資料を示し，豊富な知識を駆使して書かれているからであろう。

一応5章に分けられているが，前半は一研究者の自伝を含め，研究は自分で工夫創造していくものであることを，身をもって実証してくれる。適切な図表等と簡潔な文章によって読者の理解を助け，ある時は童話の世界に誘い，自然観察への手引きをし，さらに，なぜ磯に生育する海藻の色と深所のものとは異っているのか，なぜ海藻の色は多彩なのかといった疑問から，紅藻，褐藻，緑藻へと生態環境と色素との関係を手際よく説明してくれる。特に緑藻の謎の色素を解明していく過程は，まるで名探偵と一緒に謎解きに夢中にさせられ，推理小説を読むような興奮を覚え，一気に読ませてくれる。また，本著は一貫して著者の海藻に対する尽きない好気心と，愛情が満ち溢れていることが読者に伝ってくる。だから海洋環境の汚染に対する警言も，しっかりした研究の裏付けを伴って，迫力があり説得力がある。

終章は環境と人関の科学シリーズに相応しく，クリーンエネルギーや地球の定員問題など重要視されながら，今一歩一般に理解されていないテーマを分り易く説明してくれる。光合成の測定実験を通じて“地球を致命的な環境破壊から救う青年たちを育てる”といったらおおげさだろうか，と著者は自問しているが，決しておおげさではなく，みなが真剣に考えていくべき問題である。そして現在，研究者のなかで，どれほどの人々が，自分の研究と人間社会や地球全体との関連性を考えて仕事をしているだろうかと，深く反省させられるし，著者の研究室において，異った分野の研究者たちの討論や雑談を通じて生れてくる研究への活力，その新しい発展を知るとき，豊富な研究費がなくても素晴しい研究を産み出す研究室とは，どうあるべきかといった点も考えさせてくれる。本書は，海藻を研究している人々は勿論，これからの若い世代の研究者たち，そして一般の人々に是非読んで欲しいと思う価値ある一冊である。

（北大・海藻研　舘脇正和）