Late Holocene Palaeoenvironmental Changes in the Yahagi River Lowland, Central Japan

矢作川下流低地における完新世後半の古環境変化

Kumiko Kawase

[**Abstract**] The author researched the geomorphic development and paleoenviornmental changes in the Yahagi River Lowland, Central Japan. Sedimentological analysis of the boring-core data and diatom analysis were done for the southern area of the lowland which was inundated by the Holocene transgression. The stratigraphy of uppermost deposits suggests that the environment of this region has changed from broad marsh with several ponds to unstable land which damaged by frequent floods. The results of diatom analysis support this sedimentary condition. The fluvial effect in the Yahagi River Lowland had become significant since ca. 2,000 yr. B.P., and natural levees had developed after ca. 1,200-1,400 yr. B.P. It has been reported by the previous study that the similar environmental change was seen in the northern half of this lowland. The causes of such enviromental and geomorphological changes are considered to be due to the climatic change and deforestation by human activity in the upper reaches.

1. Introduction

Over the past few decades a lot of studies have been done on the morphology and stratigraphy of alluvial lowlands in Japan. The typical stratigraphy of alluvial deposits has been presented by Iseki (1962), and regional differences in the evolution after the Last Glacial Maximum have been clarified by Umitsu (1981). Ohira *et al.* (1994) and Ohira (1995) reported that coastal lowlands in Hokkaido have expanded not gradually but in particular periods in relation to minor sea level fluctuations. Although detailed studies have been carried out for several areas recently, several issues remain unsolved concerning the evolution of lowlands since the maximum transgression (so-called "Jomon Transgression") in Japan. For example, former standlines after the transgression have not been indicated yet for most lowlands, and changes in former terrestrial environment of alluvial lowlands have not been studied well. In order to discuss these matters above mentioned, detailed research of the uppermost sediments of lowlands is necessary. On the other hand, recent archaeological excavations often employ scientific techniques which provide us with important information on palaeoenvironments around archaeological sites. Although most data obtained from such archaeological excavations are concerned with terrestrial environments, the excavations are restricted in their area and it is not clear what significance they have for the whole evolution of lowlands.

The author made research in the Yahagi River Lowland under the above mentioned purpose, and has obtained some results from sedimentological and microfossil analyses

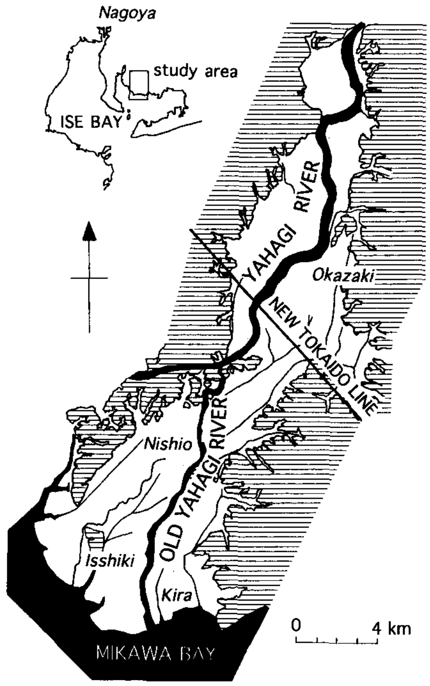

Fig. 1 Map of the study area (Kawase, 1998)

(Kawase, 1998). This paper discusses palaeoenvironment of the Yahagi River Lowland as reconstructed based on those results, and causes of environmental changes.

2. Study area

The Yahagi River Lowland is located along the lower reaches of the Yahagi River, and faces to the Mikawa Bay, in central Japan (Fig. 1). The main channel of the Yahagi River was diverted artificially in 1607, and the river flows down across the Hekkai Upland since then. The former main channel in the lowermost area is now called the "Old Yahagi River". The study area in this paper is in the lowermost area that evolved along the former main channel of the Yahagi River, and was mostly submerged when the Holocene transgression reached its maximum.

Elevations of the alluvial surface in the study area are below about 8 m in the northeast and 0 m on the coast. The landform of the alluvial lowland is subdivided into three morphological regions; floodplain, delta, and reclaimed land (Fig. 2). Most of the regions is characterized by natural levees which are distributed all over the lowland. Height difference between the levee top and the backswamp is 1-2 m in most places. Sandy ridges similar to natural levees may also contain crevasse splay deposits. Moreover, it may be possible that buried beach ridges, reported in the Nobi plain to the west of this lowland, are included among them.

Development of such natural levees, characterizes most of the floodplains but levees develop toward the river mouth in this study area. Thus, the border between floodplain and delta is geomorphologically obscure. They differ, however in their deposits: peat and peaty clay are found behind natural levees in the floodplain, and sandy soil are found in the delta. The author determined a border between these two geomorphological regions based on such sedimentary difference. The reclaimed land dates from 1339, but most of it was built since the 16th century.

3. Stratigraphy

The Holocene sediments in this lowland are classified into 7 sub-members: TM, TS, US, MM, LS, LM and BG (Moriyama & Ozawa, 1972). Among them, the author focused on the upper two, i.e., terrestrial sand and terrestrial mud deposited after the emergence of the delta with possible records of environmental changes since then. Sedimentlogical analyses were done on 473 mechanical boring data and 77 hand auger-boring data. A typical geological section from the uppermost deposits is shown in Fig. 3.

The lowermost part in Fig. 3 consists of sandy sediments with occasioned gravel. This part corresponds to the upper sandy layer (US), probably deposited as the foreset bed of the delta. Thickness of this layer is 6-8 m in general. There is an obvious sedimentary boundary at an elevation of 0 m in the back swamp area. While US is

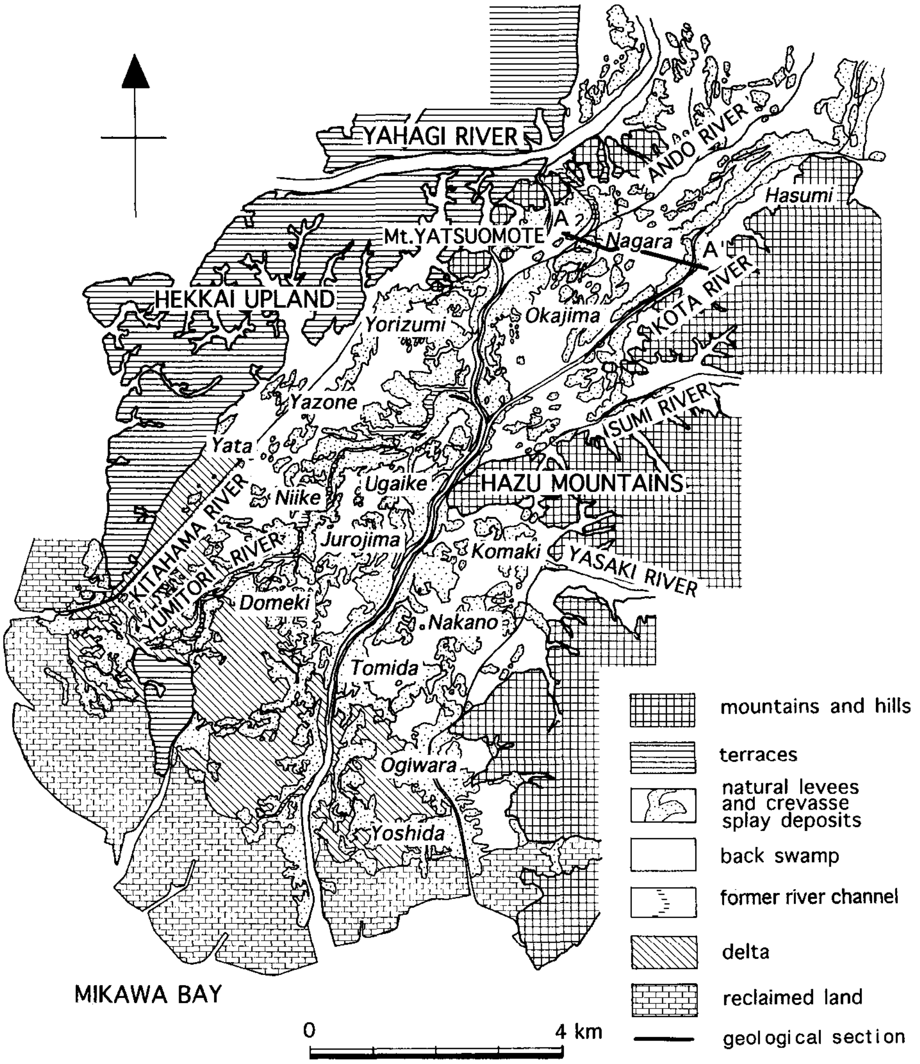

Fig. 2 Geomorphological map of the Yahagi River Lowland (Kawase, 1998)

deposited below 0 m, sediments consist of peaty clay and silty sand above that, which correlate to the top mud (TM) and top sand (TS) of Moriyama & Ozawa (1972). Sandy layer (TS) is thicker along the tributaries and is the building material for natural levees. Mud layer is developed at the back swamp between two distributaries. The top sandy layer and the mud layer are developed in accordance with surface morphology. However, the mud layer in the back swamp is covered with a thin sandy layer. Furthermore, along the edges of the natural levees, there is a structure consisting of peaty sediments covered with the sandy layer composing the natural levees. This stratigraphy shows a palaeoenvironmental change after the delta emergence. Back swamps were relatively large, and peaty sediments deposited there under static conditions in an early stage. Sandy sediments subsequently deposited under flood conditions and they covered marshy sediments.

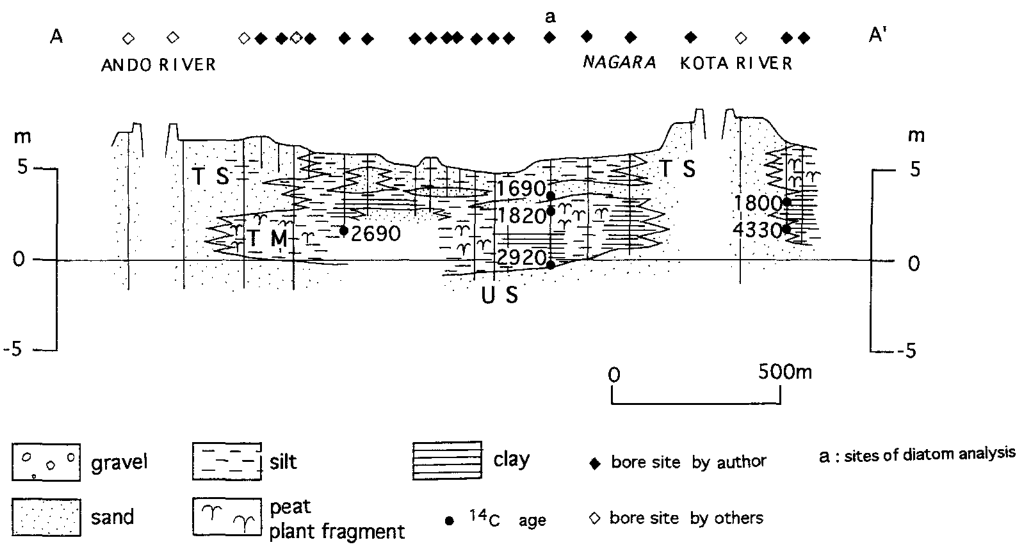

Fig. 3 Geological section in Nagara (Kawase, 1998)
Location is shown in Fig.2

Results of the diatom analysis support this sedimentary interpretation. The uppermost sediments were divided into three parts based on the diatom assemblage. The lowest part corresponding to the top of the upper sandy layer (US) contained brackish diatoms, especially littoral species. The middle part contained many fresh water diatoms living in ponds and marshes. The upper part corresponds a top sandy layer and a part of the mud layer contained diatoms living in flowing water.

The above results show that the environment of this region changed from broad marsh with several ponds to unstable land damaged by frequent floods.

A radiocarbon age of plant fragments collected from the bottom of the mud layer was 2,920±230 yr. B.P. The bottom age of the terrestrial mud layer, should show the time of delta emergence, and such radiocarbon dating at 15 sites in this lowland suggests that the delta emerged extensively at around 2500 yr. B.P. The top age of the mud layer covered with a sandy layer was 1,820±210 yr. B.P. This age indicates the time of the environmental change in sedimentation. Since ca. 1,800 yr. B.P., serious floods frequently occured, and flood debris accumulated in back swamps. Natural levees began to develop during this period at the earliest. Such environmental changes have been dated at a few sites in this study, but reports of archeological excavations provide further information on the natural levee development. For example, remains of the Heian Period were buried with sand forming a natural levee at the Muro site (Hattori, 1994). Iseki (1961) pointed out a similar phenomenon in the northern half of this lowland. He also showed that silty deposits containing sand were widely distributed over the lowland in the Kofun period, and that earthenware of 6-7th century AD were buried below natural levees. Thus the fluvial effect in the Yahagi River Lowland became significant around 2,000 yr. B.P., and natural levees began to develop after ca. 1,200-1,400 yr. B.P.

4. Discussion

The former chapter, pointed out two concerning the late Holocene environmental changes in the Yahagi River Lowland. One is the remarkable expansion of the delta during ca. 3,000-2,500 yr. B.P., and the other is more pronounced fluvial activity during two periods of ca. 2,000 yr. B.P. and 1,400-1,200 yr. B.P.

This remarkable expansion of the lowland was possibly effected by sea level fluctuations. Ota *et al.* (1990) sifted through the data of Holocene sea level changes in Japan and concluded that the "middle Jomon Minor Regression" and the "Yayoi Minor regression" can be confirmed in many areas in Japan. The sea level in the Nobi Plain, located to the west of the Yahagi River Lowland, has been already studied by several researchers. Iseki *et al.* (1982) and Fuji *et al.* (1982) clarified that the sea level fell from the late Jomon period to the Kofun period. This sea level fall (so-called "Yayoi Minor Regression") became pronounced around ca. 2,000 yr. B.P. in many studies. The date of ca. 2,000 yr. B.P. might indicate the time of the lowest sea level in this fluctuation, and the fall might have begun earlier than ca. 2,000 yr. B.P. The expansion of the Yahagi River Lowland seems to have corresponded with the beginning of the sea level fall. It is thought that this sea level fall might have caused emergence of a delta platform submerged until then. However, the evolution of the delta was controlled not only by the sea level change but by the sediment supply from its catchment, and additional data are needed for further discussion of this issue.

The change of fluvial activity during two periods was possibly caused by changes in the palaeoclimate and sediment supply. Sakaguchi (1982) reconstructed palaeoclimate in Japan based on pollen-analysis data and revealed that it was cooler and more unstable from the Yayoi period to the Kofun period. He cited examples of Yayoi remains found below flood deposits, and considered that frequent floods occurred after the yayoi period as a result of a climatic change. However, ages of natural levee development are not the same in other regions. For example, Yasuda (1978) clarified geoenvironmental change in the Kawachi Plain during the Holocene and found that natural levees developed after 1,600 yr. B.P. In the Kumoizu River Plain, natural levees developed in two periods; once after the Yayoi period and again after the 10th century (Takahasi, 1979). Ohira (1995) researched the Sarobetsu Plain in Hokkaido and concluded that fluvial influences were more pronounced around ca. 3,000-2,000 yr. B.P.

In the Yahagi River Lowland, it was after ca. 2,000 yr. B.P. that sandy sediment was deposited to cover the back swamp, and natural levees were built after ca. 1,400-1,200 yr. B.P. The evidence of simultaneously environmental change around ca. 2,000 yr. B.P. is abundant. Moreover, these changes seem to have coincided with a climatic change. However, natural levees developed not only in that period but also in more recent times, and their ages vary from region to region. Thus another factor in the development of natural levees should be considered.

Iseki (1979) pointed out that the sedimentary environment changed in the historical age in many areas due to human impact. He also cited historical records of the Nara-Heian period in which one ruler prohibited people's reckless deforestation. This record suggests that forests in those time were being damaged considerably by human activity. Deforestation in the upper reaches of a river might cause an increase in sediment supply and, as a result, natural levees might develop in the lower area. The regional differences in the period of natural levee development may reflect the degree of human activity. Thus changes in the sedimentary environment were affected by both climatic change and human impact.

5. Conclusion

The Yahagi River Lowland has been under an influence of sea level fluctuations during the late Holocene. The lowland expanded remarkably around ca. 3,000-2,500 yr. B.P., have been influenced by the Yayoi Minor Regression. Terrestrial environment, especially sedimental conditions, changed during the late Holocene. The backswamp had been wider during ca. 3,000-2,000 yr. B.P. than it is today. Sandy deposits spread over the lowland after 2,000 yr. B.P., and natural levees developed around 1,400-1,200 yr. B. P. Such enviromental and geomorphological changes are induced a climatic change and deforestation by human activity in the upper reaches.

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矢作川下流低地における完新世後半の古環境変化

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中部日本の矢作川下流低地において，縄文海進のおよんだ地域を対象として，ボーリング資料の整理，加速器質量分析計による堆積物の^{14}C年代値の測定，珪藻分析を行い，完新世後半の低地の地形環境の変化を明らかにした。表層地質の整理から，沖積層上部砂層の上位に腐植物混じりの後背湿地堆積物が堆積し，洪水氾濫堆積物と考えられる砂層によって覆われていることが明らかとなった。後背湿地堆積物を覆う砂層は，支流沿いでは自然堤防を構成している。堆積物の珪藻分析結果は，後背湿地堆積物が安定した止水環境で堆積し，その上位は流水の影響が強まったことを示唆しており，堆積物からみた堆積環境の変遷を支持している。静穏な環境から河成作用が卓越する環境への変化は，約2,000年前におこった。本研究で推定された上記の環境変化が，対象地域の上流部においてもみられたことが従来の研究で指摘されている。それらによれば，約2,000年前頃から洪水氾濫の影響が強くなり，古墳時代には顕著な自然堤防が形成されるようになった。この一連の堆積環境の変化には，気候の湿潤化による洪水氾濫の激化と，人為的な森林破壊による土砂供給量の増大が関与している可能性がある。

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