Jpn. J. Histor. Bot. Vol. 5. No. 1 p. 3—14 April 1997 植生史研究

Taixian Guo*, Mutsuhiko Minaki**, Sei-ichiro Tsuji***, Yayoi Ueda****: Paleovegetation in Relation to Human Activities around the Yoshinogari Site, Northern Kyushu Island, Japan

郭 太現*・南木睦彦**・辻 誠一郎***・植田弥生****：吉野ケ里遺跡における古植生と人間活動の関係

Abstract The Yoshinogari Site is one of the nuclear sites in northern Kyushu during the Yayoi Period, and from the Yayoi Period to the Middle Ages. Pollen analyses and plant macrofossil analyses were carried out for sediments from the East and West Points of the surrounding lowland. Pollen assemblage zones and plant macrofossil assemblage zones were recognized for each site, and five stages, from A to E, were established based on them. At stage A before the Early Yayoi Period, laurel forests grew on the hills with *Alnus* marsh or a river in the lowland with no human activities. At stage B at the Early to early Middle Yayoi Periods, human beings began to inhabit the hill, and *Alnus* trees were cut down, while Cyperaceae and *Phragmites* marsh developed in the lowland. The hills were deforested to some extent. At stage C before the later Middle Yayoi Period, the marsh was developed into paddy fields and continuous activities of human beings on the hills induced secondary forests of *Celtis* or *Aphananthe*. At stage D around the Ancient or Middle Ages, the paddy fields near the hill became a farm or an open field. Overuse of secondary forest trees on the hill decreased their number. At stage E around the Recent Age, paddy fields got the largest expansion in the lowland, and *Pinus* forests expanded with *Cryptomeria*, which might be an indication of tree planting. Boundaries of these stages reflect changes of human activities in relation to vegetation. The land development or employment of natural resources changed according to the cultural needs, from the Yayoi Period to Recent Ages.
Key Words : Development of nature, Plant macrofossil, Pollen analysis, Vegetation, Yayoi Period

要 旨 吉野ケ里遺跡は北部九州における弥生時代の拠点集落のひとつであり，弥生時代以降の様々な時代を含む大規模複合遺跡である。この遺跡の東側低地と西側低地で花粉分析と大型植物化石分析を行い，両地点で花粉化石群帯と大型植物化石群帯を設けた。これらに基づき以下のA～Eの五つの時期区分を設定した。A期は弥生時代前期以前で，丘陵上には照葉樹林が発達し，低地はハンノキ属が生育する湿地ないし河川で，人間活動の影響は認められない。B期は弥生時代前期～中期前半頃で，丘陵上に人間が住み始め，湿地のハンノキ属の林は切り払われ，カヤツリグサ科ならびにヨシ属を伴う湿地になると共に，丘陵上の森林はいくらか伐採される。C期は弥生時代中期後半で，湿地は開発されて水田になり，丘陵上での持続的活動によりエノキ属あるいはムクノキ属などの二次林が発達する。D期は古代または中世で，水田の面積がやや縮小し丘陵の縁辺は畑地ないし裸地になり，丘陵上の二次林は，過度の利用により減少する。E期は近世頃で，水田面積は最大となり，丘陵上および山地ではマツ属の林がスギ林と共に拡大するが，これは植林の可能性がある。以上の時期区分の境界は人間の開発行為の質的変化を示している。すなわち，弥生時代から近世にかけて，開発の仕方や資源の利用の仕方が段階的に変化することが分かった。
キーワード：大型植物化石，開発，花粉分析，植生，弥生時代

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Introduction

Holocene vegetaional history has a close relationship with human activity: human activity affects the vegetation, and human itself are affected by the vegetation. Recently, increasing excavations supply new knowledge in this field (Tsuji, 1996). According to him, there had been three distinct human affections on the vegetation in Japan. Taking examples in the Kanto District, the first affection is around the Late Yayoi Period or Kofun Period, which is related to the beginning of cultivation of *Oryza sativa*. At this time, marsh with *Alnus* are developed into the paddy field, but the vegetation on the hill are not affected so much. The second affection is around the Middle Age. At this time, the hill is developed and the vegetation on them is decreased and the secondary forest is developed. The third affection is around the Recent Age. Deforestation and cultivation of the forest characterized this age. Similar affections on the vegetation are reported from other district of Japan, but the details are not revealed yet.

The Yoshinogari Site is situated at 130° 23'E and 33° 19'N and is a compound site from the Yayoi Period to the Middle Ages (Board of Education of Saga Prefecture, 1990a, 1990b). The site covers ca. 25 ha. and is situated on a hill extending from the southern slope of the Sefuri Mountains. During the Yayoi Period, there were deep double moats (kango), mounded graves (funkyubo), rows of earthen coffins (kamekan boretsu), many houses including a big one, and many storehouses. Many bronze articles, ornamental glasses, and silk cloth have been excavated from the site (Board of Education of Saga Prefecture, 1990a, 1990b). The Yoshinogari Site was one of the nuclear sites of politics and religions during the Yayoi Period in northern Kyushu, and are regarded as one of the important sites during the Yayoi Period in Japan.

Northern Kyushu faces the Sea of Japan and was the window to the cultures of continental Asia, especially after the Yayoi Period. Many researchers reported paleovegetation or flora around the Yayoi Period of this area from pollen analyses (Nakamura, 1982; Nakamura and Hatanaka, 1976; Hatanaka, 1980, 1983; Noi, 1987, 1991; Tasaki, 1994; Yasuda, 1976, 1978, 1985) or from plant macrofossil studies (Kasahara, 1982; Kokawa, 1977, Watanabe and Kokawa, 1982), which are partly summarized by Noi (1996). No paleobotanical study considering both pollen and plant macrofossils has been carried out around the Yoshinogari Site that was the center of the politics or religion in northern Kyushu. This is the first study that reveals a continuous interaction between human beings and nature around a center site of the Yayoi Period since the first human settlement. Combined analyses of the plant macrofossil assemblage zones and pollen assemblage zones revealed the vegetational change on hill and lowland separately in relation to human activities.

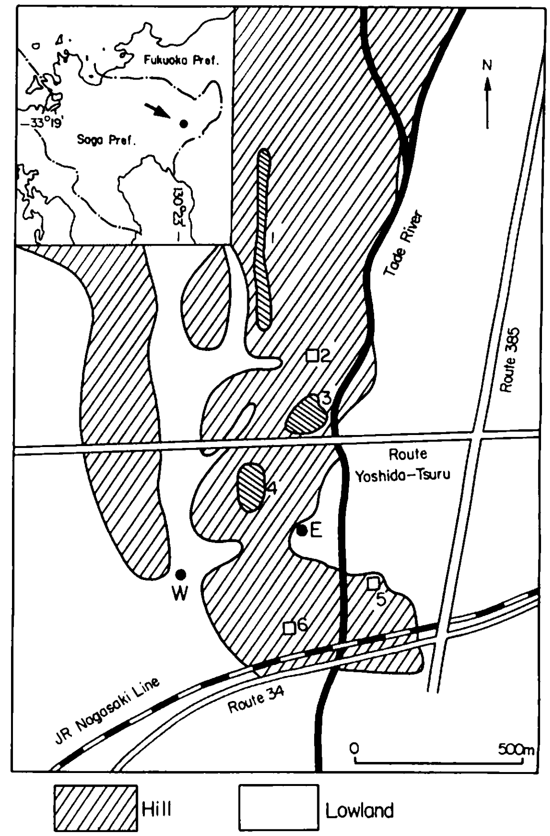

Fig. 1 Location of the Yoshinogari Site and the sampling points. E : East Point. W : West Point. Numerals show land mark relics. 1 : row of earthen coffins (Kamekan Boretsu). 2 : northern mounded graves (Kita Funkyubo). 3 : northern enclosed area of the inner moat (Kita Naikaku). 4 : southern enclosed area of the inner moat (Minami Naikaku). 5 : eastern mounded graves (Higashi Funkyubo). 6 : southern mounded graves (Minami Funkyubo).

Stratigraphy

The hill of the Yoshinogari Site is an extention

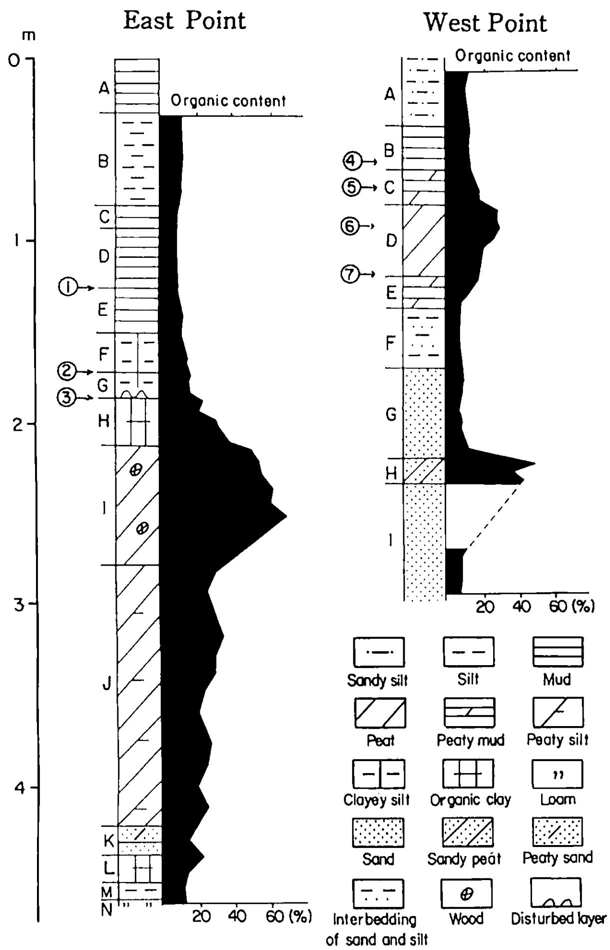

Fig. 2 Stratigraphy of the study points at the Yoshinogari Site. Organic contents were measured with the ignition loss test. Numbers on the columns show artificial relics or remains as follows. ① : relics and remains of the Middle Age. ② : root trace of *Oryza sativa.* ③ : earthen ware of the Early Yayoi Period. ④ : earthen and ceramic wares of the Ancient and Middle Age. ⑤ : earthen ware of the later Middle Yayoi Period. ⑥ : earthen ware of the early Middle Yayoi Period. ⑦ : man made channel.

southward from the Sefuri Mountains and is surrounded by a Holocene lowland. Several boring cores are obtained from the lowland, and the stratigraphy are exmined. The East and West Points are typical points which have the whole stratigraphic units at the eastern lowland and western lowland, respectively (Fig. 1).

The East Point is below a small scarp of the hill. The recent Tade River runs from north to south ca. 100 m east of the point. The sediments are composed of fourteen single beds, from N to A (Fig. 2). Bed N is a loam layer and is the basal sediments of Holocene. Beds M to K are thin, sand, silt, or clay layers. Bed J is a grayish brown peaty silt layer, and the sedimentary phases gradually shift to bed I. Bed I is a peat layer containing woods, catkins, and fruits of *Alnus*. The boundary of bed I and bed H is very sharp. Bed H is a black organic clay layer containing charcoal. Bed G is a disturbed layer with black sediment blocks of bed H. Bed F is a blue gray, clayey silt layer and very sticky. Beds E to A are mud or silt layers. Earthen ware of the Early Yayoi Period is recovered from the upper surface of bed H. On the upper surface of bed G, many root traces of *Oryza sativa* spread. From the upper surface of bed E, relics and remains of the Middle Ages are discovered.

The West Point is situated at the mouth of a narrow lowland between the hill of the Yoshinogari Site and the western hill. The sediments are composed of nine single beds, from I to A (Fig. 2). Beds I to G are composed of sandy sediments. Bed F is composed of interbedding of sand and silt. Bed E is a gray brown peaty mud layer rich in sand. Bed D is a black brown undecomposed peat layer. Bed C is a black peaty mud layer. Bed B is a mud layer, and bed A is a sandy silt layer. Organic contents of each bed well agree with the sedimentary phases, i. e., high in the peat or peaty bed, and low in the silt, mud, or sandy bed (Fig. 2). Man made channels are found at the top of E bed. Earthen ware of the early Middle Yayoi Period is found from the upper part of bed D, and that of the later Middle Yayoi Period is found from bed C. Bed B yields earthen and ceramic ware of the Ancient and Middle Ages.

Materials and Methods

From the columnar samples of the East and West Points, 51 and 38 block samples were collected respectively, paying attention to the phases of sediments. The number of the block samples are shown in Fig. 3, Fig. 4, Fig. 5, and Fig. 6. Organic contents is measured by the ignition loss test for all 89 samples. Selected block samples, most from the same horizons, are used for pollen analyses and plant macrofossil analyses.

Block samples for pollen analyses were treated with the KOH and acetolysis method (Tsuji *et al.*, 1994).

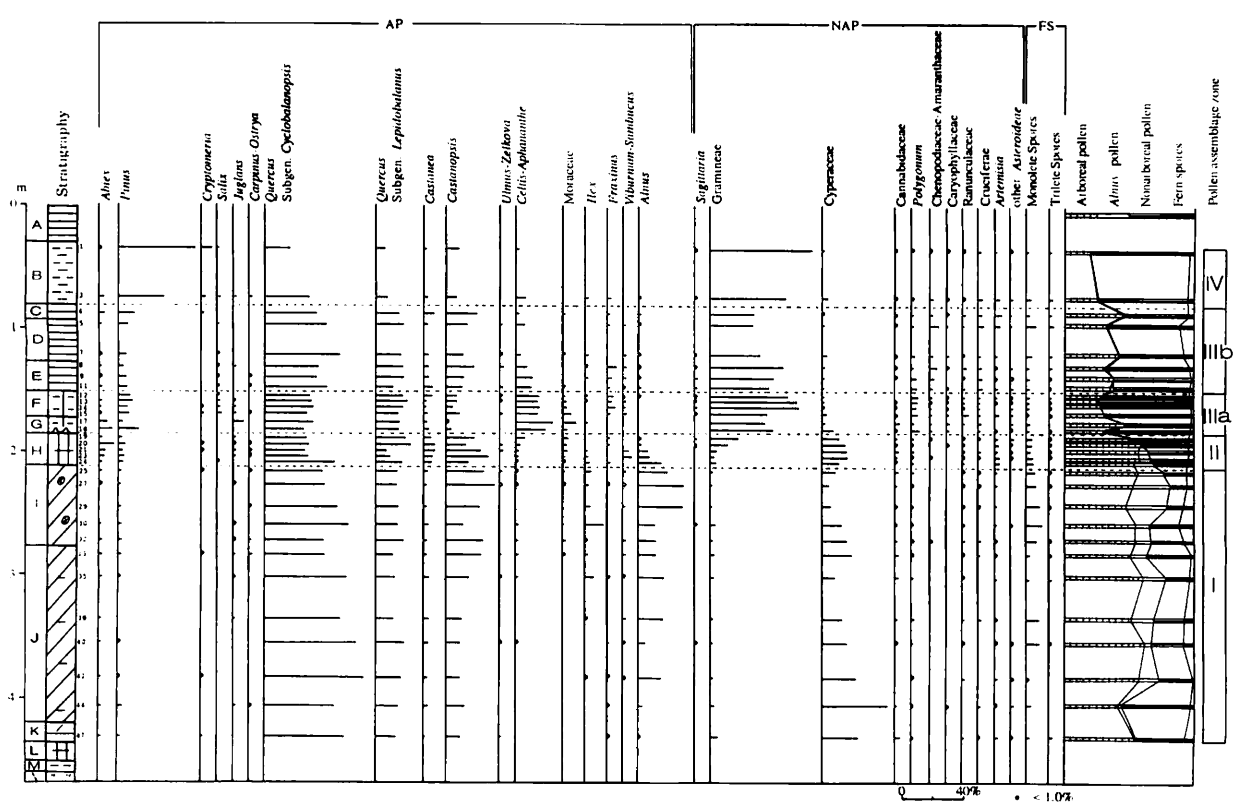

Fig. 3 Pollen and spore diagram of the East Point at the Yoshinogari Site
AP : arboreal pollen. NAP : non arboreal pollen. FS : fern spores. Percentages of AP are based on total arboreal counts excluding *Alnus* pollen. *Alnus* pollen, NAP and FS are based on total pollen and spore counts.

For most samples, more than 200 arboreal pollen (AP) was counted. Some sandy samples however contained very rare pollen and some muddy samples yielded ill preserved pollen. As for these samples, less than 200 arboreal pollen could be counted. The percentages of arboreal pollen taxa are calculated on the basis of total arboreal pollen counts excluding *Alnus* pollen counts. Percentages of *Alnus* pollen, non arboreal pollen (NAP) taxa, and fern spore types are calculated on the basis of total pollen and spore counts. We excluded *Alnus* pollen from the calculation base of arboreal pollen because the present study revealed that *Alnus* are local lowland elements.

Plant macrofossils were obtained by water sieving with a 0.25 mm mesh sieve. About 50cm³ sediments were washed for each sample.

All pollen assemblage samples are deposited in glycerin. Single-grain pollen preparations of identified and unknown taxa were made according to the method of Tsuji (1975). Plant macrofossil specimens are deposited in 50% alcohol. All these specimens are deposited in National Museum of Japanses History.

Results

Pollen assemblages

Seventy-six taxa were recognized in fossil pollen and spores. Occurrence of most taxa are presented in the diagrams (Figs. 3, 4). Hyphened taxa are tentative pollen taxa: pollen of both taxa is similar and cannot be distinguished. Other taxa out of these diagrams have low appearance and do not show significant stratigrafic occurrence.

Four pollen assemblage zones (PAZ) are recognized made for the East Point, and five PAZ for the West Point.

PAZ I (East Point) : This zone is characterized by constant rich occurrences of arboreal taxa, about 50%, and common occurrence of *Alnus*, about 15%.

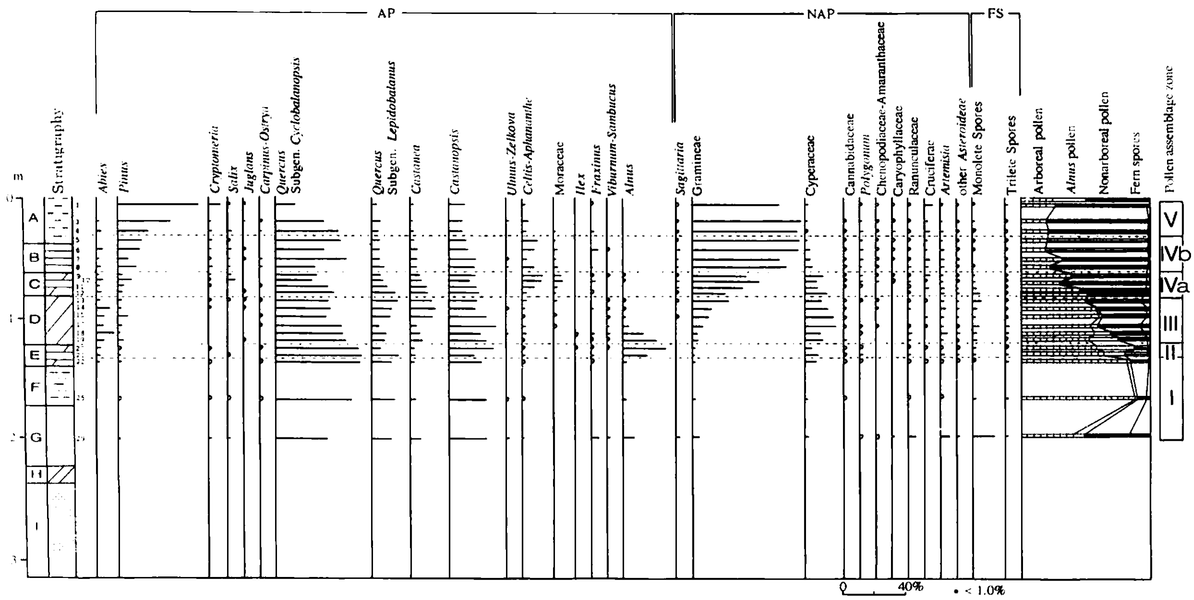

Fig. 4 Pollen and spore diagram of the West Point at the Yoshinogari Site
AP : arboreal pollen. NAP: non arboreal pollen. FS : fern spores. Percentages of AP are based on total arboreal counts excluding *Alnus* pollen. *Alnus* pollen, NAP and FS are based on total pollen and spore counts.

NAP are mostly between 20 and 30%. In the arboreal pollen *Quercus*. subgenus *Cyclobalanopsis, Q.* subgen. *Lepidobalanus, Castanopsis* are dominant taxa. In NAP Cyperaceae is common.

PAZ II (East Point) : Arboreal taxa dominate in this zone (ca. 50%). *Alnus* pollen decrease from 15% to less than 1%, and NAP increase from 25% to 45%. In the arboreal taxa decrease of *Q.* subgen. *Cyclobalanopsis* and *Castanopsis* and increase of *Abies* characterize this zone. *Castanea* also increased. In NAP Cyperaceae pollen is dominant, and Gramineae pollen slightly increased.

PAZ III (East Point) : NAP dominates in this zone (ca. 50% to 70%), while arboreal taxa are relatively poor in dominance (26% to 45%). *Alnus* pollen almost disappeared. From zone II to IIIa *Celtis-Aphananthe,* Moraceae, and *Pinus* increased, while from subzone IIIa to IIIb these decreased and *Q.* subgen. *Cyclobalanopsis* with *Castanopsis* increased. From subzone IIIa to IIIb, Gramineae decreased and Chenopodiaceae-Amaranthaceae increased to ca. 4%. Preservation of pollen is poor in subzone IIIb.

PAZ IV (East Point) : The highest occurrence of *Pinus* pollen (28% to 49%) characterizes this zone. *Cryptomeria* pollen is common, and Gramineae is richer than PAZ IIIb.

PAZ I (West Point) : *Q.* subgen. *Cyclobalanopsis, Q.* subgen. *Lepidobalanus*, and *Castanopsis* dominate in this zone. *Alnus* pollen continuously occurs in low frequency. NAP are low in percentages.

PAZ II (West Point) : Increase of *Alnus* pollen to 29% characterizes this zone. Cyperaceae pollen occupies the most part of NAP.

PAZ III (West Point) : *Alnus* pollen decreased from 20% to less than 1%, and NAP increased from 20% to 40%. In the arboreal taxa, decrease of *Q.* subgen. *Cyclobalanopsis* and increase of *Abies* are characteristic. *Castanea* also increased in the upper half. In NAP Cyperaceae pollen is dominant, and Gramineae pollen slightly increased.

PAZ IV (West Point) : NAP taxa dominate in this zone (ca. 45% to 80%), while arboreal taxa are relatively poor in dominance (ca. 20% to 50%). *Alnus* pollen almost disappeared. From zone III to IVa *Celtis- Aphananthe* and Moraceae increased, while from subzone IVa to IVb these slightly decreased and *Q.* subgen. *Cyclobalanopsis* increased. From subzone IVa to IVb Gramineae increased and Cyperaceae decreased.

PAZ V (West Point) : Increase of *Pinus* pollen from

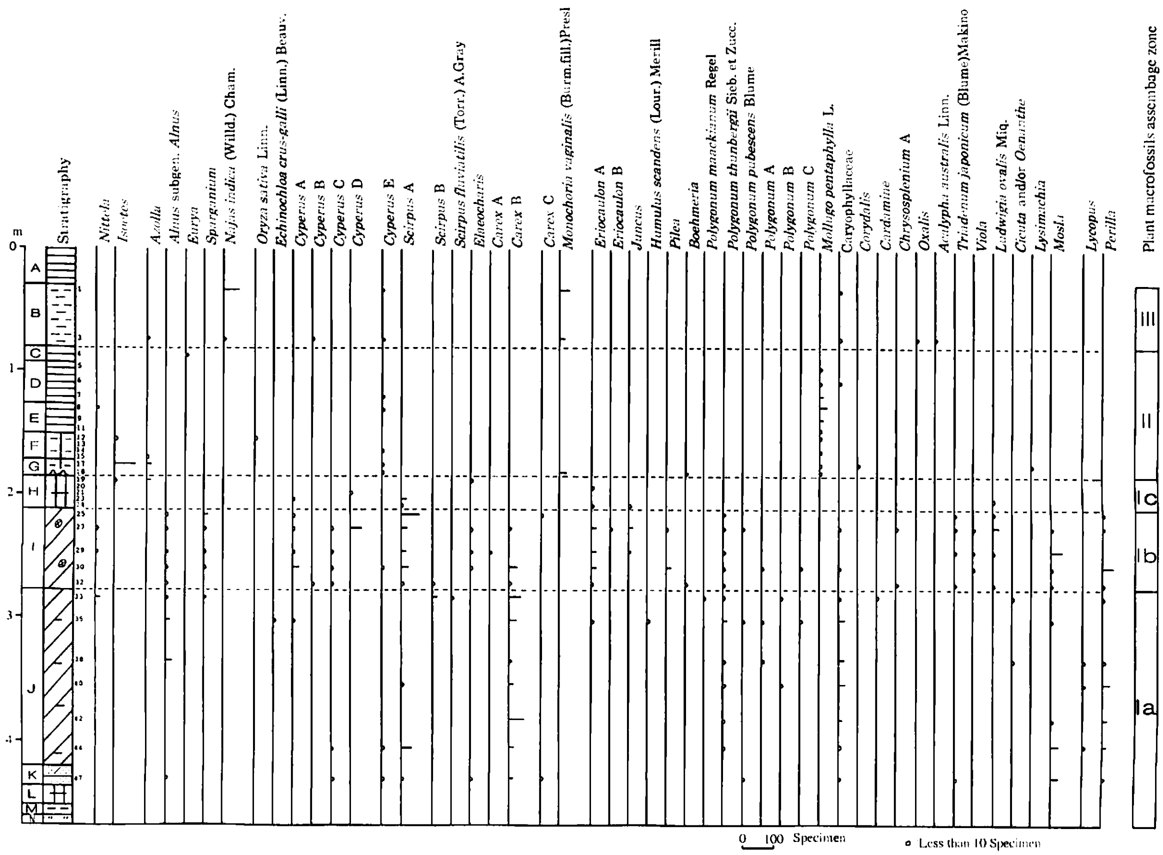

Fig. 5 Plant macrofossil diagram of the East Point at the Yoshinogari Site · Specimen numbers per 50cm³ sediments are shown for each taxa.

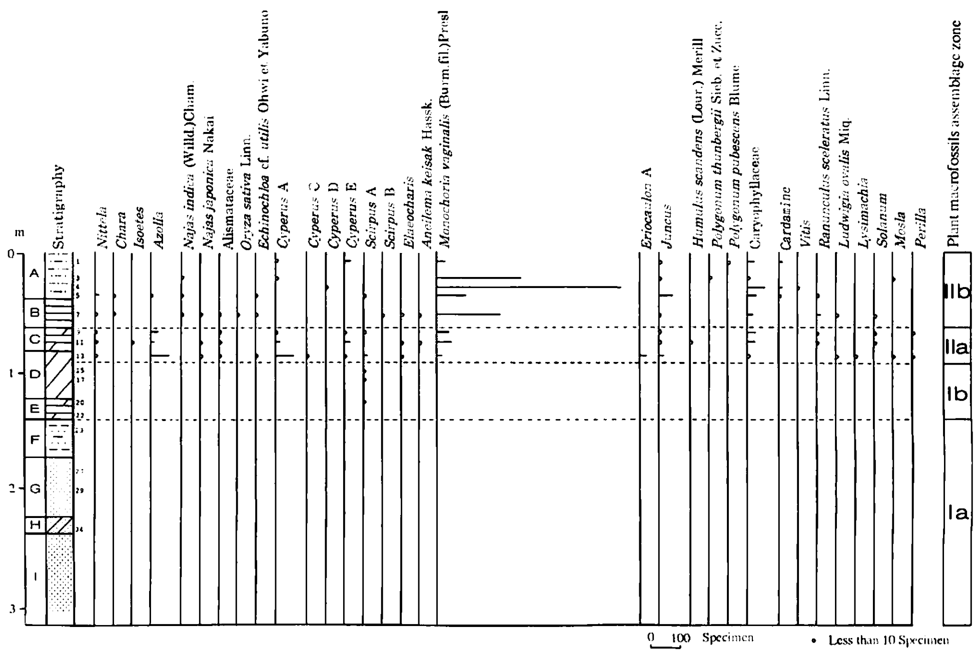

Fig. 6 Plant macrofossil diagram of the West Point at the Yoshinogari Site Specimen numbers per 50cm³ sediments are shown for each taxa.

19% to 51% characterizes this zone. *Cryptomeria* pollen continuously occurs.

Successive changes in the pollen assemblages of both points are quite similar, except for the sequence of *Alnus* and some NAP taxa, and correlation of the pollen assemblage zones of the both points is possible (Fig. 7).

Plant macrofossil assemblages

Sixty-eight taxa were recognized in plant macrofossils. Occurrence of most taxa are presented in the diagrams (Figs. 5, 6). Taxa with an alphabet such as *Cyperus* A or *Cyperus* B are morphological types within a taxon. Each type may contain plural species. Identified parts of plant macrofossils are fruits, seeds, glumes, endocarps (stones), inflorescens, infructescense, macrospores, and oospores. Other taxa out of these diagrams have low appearance and do not show significant stratigrafic occurrences. Three plant macrofossil assemblage zones (MAZ) are recognized for the East Point, and two plant macrofossil assemblage zones for the West Point.

MAZ I (East Point) : This zone is characterized by the common occurrence of herbaceous marsh taxa including *Scirpus* A. In subzones Ia and Ib *Alnus* subgen. *Alnus* was a common element, while in subzone Ic it disappeared. In subzones Ia and Ib *Scirpus* A, *Carex* B, *Polygonum thunbergii*, Caryophyllaceae, *Mosla*, and *Perilla* are common elements. Subzone Ib is the richest in composition and yields *Nittela, Sparganium, Cyperus* A, *Cyperus* C, *Eriocaulon* A, *Pilea, Chrysosplenium* A, *Triadenum japonicum, Viola*, and *Ludwigia ovalis* as common elements. Subzone Ic is the poorest in composition and yields *Cyperus* A, *Scirpus* A, *Eriocaulon* A, and *Ludwigia ovalis* as continuous elements from subzone Ib.

MAZ II (East Point) : *Mollugo pentaphylla* and *Cyperus* E occur continuously. *Isoetes* and *Azolla* with few other taxa characterizes the bottom of this zone.

MAZ III (East Point) : This zone is characterized by the common occurrence of *Najas indica, Cyperus* E, *Monochoria vaginalis*, and Caryophyllaceae.

MAZ I (West Point) : This zone is characterized by the poor occurrence of plant macrofossils. From subzone Ia we could extract no identifiable plant macrofossils. Subzone Ib yields *Scirpus* A successively.

MAZ II (West Point) : This zone is characterized by the large number of herbaceous taxa. *Monochoria vaginalis, Juncus*, and Caryophyllaceae are common elements of this zone. Common occurrence of *Azolla*, Alismataceae, *Cyperus* A, and *Perilla* characterizes subzone IIa, while *Chara, Najas indica*, and *Cardamine* characterizes subzone IIb.

Plant macrofossil assemblage zones are quite different between the West Point and the East Point (Fig. 7). The differences seem to reflect local vegetation around both points.

Discussion

Vegetation and human activity stage (Fig. 7)

Based on the successive changes of pollen and plant macrofossil assemblages, five stages of vegetation and human activities have been established. These stages are mainly based on the pollen assemblage zones which reflect both local and regional vegetational changes. The plant macrofossil assemblages give us information on local vegetation, and sedimental phases and the organic contents show changes in the sedimentary environments. The stage boundaries reflect four events in the interaction between man and nature.

Stage A : PAZ I, MAZ Ia, and MAZ Ib of the East Point, and PAZ I, PAZ II, MAZ Ia and the bottom of MAZ Ib represent this stage.

In the east lowland, marsh with *Alnus* developed, judged from the pollen and plant macrofossil assemblages. Cyperaceae including *Carex* and *Scirpus* were rich in this marsh with ferns of monolete spore and some *Polygonum* species. Some wet land elements such as *Nittela, Sparganium, Cyperus, Eriocaulon, Triadenum japonicum*, and *Ludwigia ovalis* became the elements of the marsh in the latter part of this stage. Caryophyllaceae, *Mosla* and *Parilla* also inhabited the marsh or grew around the marsh. In the west lowland, sediments are sandy at the beginning of this stage, probably deposited in a river, and NAP taxa are poor and plant macrofossils are absent, Later in this stage, in the west lowland, marsh with *Alnus* developed, judged from the pollen and plant macrofossils.

As for the vegetation on the hill, laurel trees such as *Q.* subgen. *Cyclobalanopsis* and *Castanopsis* dominated, with some deciduous trees such as *Q.* subgen. *Lepidobalanus*, judged from their abundant or common occurrence in the pollen assemblages.

Thus, there were laurel forests on the hill and marsh with *Alnus* in the east lowland, while a river ran in the west side which were replaced by marsh with *Alnus* later.

Stage A is before the Early Yayoi Period, i. e., before the human settlement in Stage B.

Stage B : PAZ II and MAZ Ic of the East Point, and PAZ III, the major part of MAZ Ib and the lowermost part of MAZ IIa of the West Point represent this stage.

The boundary of stages A and B is quite clear, and fossil assemblages and sedimentary phases changed. As for the lowland vegetation, pollen assemblages show the same succession at both points, i. e., the continuous decrease of *Alnus* pollen. Plant macrofossil assemblages of the East point also show the disappearance of *Alnus* trees at this time. Cyperaceae pollen are common while Gramineae pollen began to increase. Among gramineous taxa of this stage, *Phragmites* markes peak occurrence without *Oryza* judged from phytolith assemblages (Sugiyama, personal communication). Sediments of bed H of the East Point are black and sticky, and looks like a decomposed peat, but the organic contents is not so high (Fig. 2). The black materials are mainly charcoal from herbaceous taxa, and the common occurrence of charcoal seems to reflect continuous firing of *Phragmites* at this time. Thus, marsh with *Alnus* and Cyperaceae of stage A changed into marsh without *Alnus* and with *Phragmites* and Cyperaceae of stage B.

The increase of *Abies* and decrease of *Q.* subgen. *Cyclobalanopsis* and *Castanopsis* in the arboreal pollen reflect vegetation change on the hill or mountains. Apparently laurel trees on the hill were deforested to some extent judged from the many archaeological relics including houses on the hill at this time (Board of Education of Saga Prefecture, 1990a, 1990b). The increase of *Abies* may be an apparent result of the

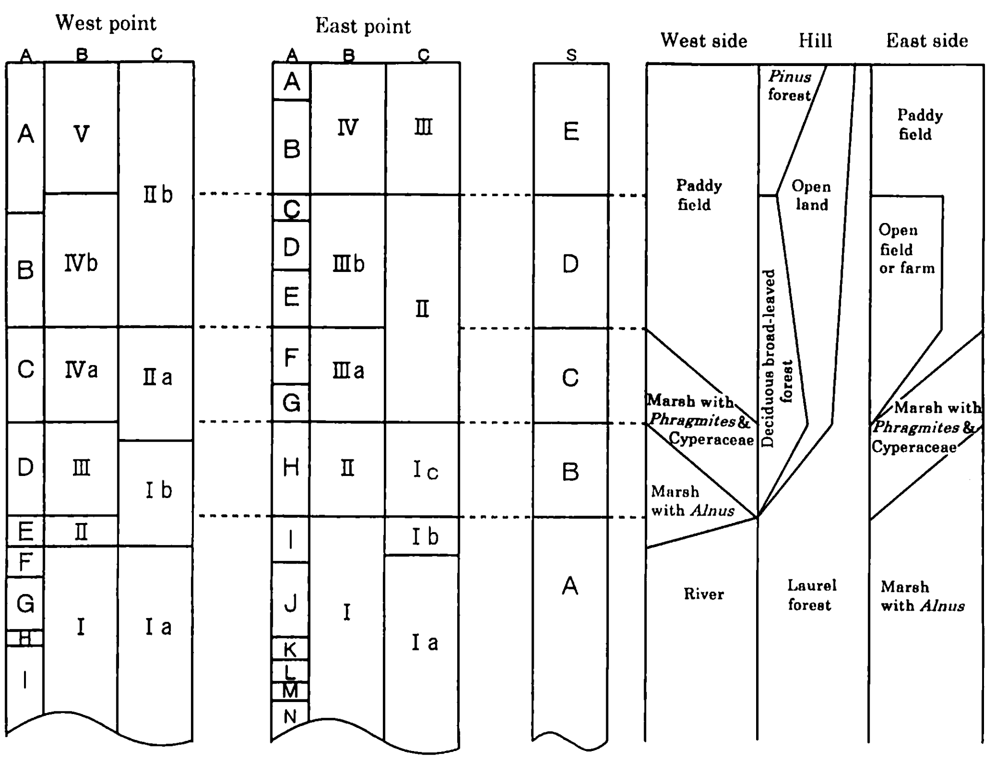

Fig. 7 Historical schema of vegetation and human activities. A : stratigraphy. B : pollen assemblage zones. C : plant macrofossil assemblage zones. S : stages of vegetation and human activities. Vegetation in relation to human activities in space and time is reconstructed in the right side of this figure.

deforestation of laurel trees on the hill which induced relative high occurrence of pollen from the mountain region including *Abies*. However, *Abies* trees could possibly increased in the hill community. Pollen of *Castanea* also increased in this stage. *Castanea* sometimes becomes a major element of secondary forests in Kyushu Island (Yuriki & Setsu, 1992), and may have been an element of secondary forests at this stage. On the other hand, *Castanea* has been a common domesticated element in Japan since the Jomon Period (Minaki, 1994), and may have been cultivated on the hill. Common usage of *Castanea* wood in the northern Kyushu during the Yayoi Period (Yamada, 1993) agrees with the *Castanea* expansion at this stage.

During this stage, human beings began to inhabit the hill with some deforestation, but the major development were in the lowland where *Alnus* trees in the marsh were all felled down.

The time of stage B is the Early to early Middle Yayoi Period judging from earthen ware of the Early Yayoi Period from the upper surface of bed H of the East Point, and earthen ware of the early Middle Yayoi Period from D bed of West Point. Archaeological data of Board of Education of Saga Prefecture (1990a, 1990b) are consistent with this chronology.

Stage C : PAZ IIIa and the lower part of MAZ II of the East Point, and PAZ IVa and the most part of MAZ IIa of the West Point represent this stage.

In the lowland, paddy fields were developed in both sides. Typical weeds of paddy fields began to occur in plant macrofossil assemblages, such as *Isoetes, Azolla*, and *Monochoria vaginaris*. Root traces of *Oryza sativa* spread widely on the surface of bed G of the East Point. Pollen of Gramineae successively increased to high percentages with continuous occurrence of *Sagittaria* pollen at both points. Among Gramineous taxa in this stage, continuous occurrence of *Oryza* phytoliths from the both point (Sugiyama, personal communication) show that *Oryza sativa* were common at this stage.

Among arboreal taxa, pollen of *Celtis-Aphananthe* increased in both points. This increase probably shows development of secondary forests of *Celtis* or *Aphananthe* on the hill because the human activities increased at the Middle Yayoi Period (Board of Education of Saga Prefecture, 1990a, 1990b). Moraceous pollen, excluding *Cannabis* and *Humulus* as Cannabidaceae, at both points also increased in this stage. The Moraceous pollen can be regarded as *Morus*, beasd on their size and the aperture morphology. Occurrence of silk cloth from this site also supports the cultivation of *Morus* trees at this time.

Thus, this stage is characterized by the development of paddy fields in the lowland and the expansion of secondary forests of *Celtis* or *Aphananthe* on the hill. *Morus* may have been cultivated.

The time of stage C is the later Middle Yayoi Period judging from earthen ware of that period from bed C of the West Point.

Stage D : PAZ IIIb and the upper part of MAZ II of the East Point, and PAZ IVb and the lower part of MAZ IIb of the Weat Point represent this stage.

The condition of the lowland differed between the east and west sides. In the east side, continuous occurrence of Chenopodiaceae-Amaranthaceae in pollen assemblages and *Mollugo pentaphylla* in plant macrofossils show that this point was not paddy fields anymore, but a farm or an open land. Poor preservation of pollen also supports this. In the west side, all fossil assemblages suggest that this area was covered by paddy fields.

Decrease of *Celtis-Aphananthe* pollen and increase of the pollen of laurel taxa reflect a vegetation change on the hill or mountains. This may be a real retrieval of laurel forests, or an apparent increase caused by the decrease of *Celtis-Aphananthe.* Because human activities on the hill continued into the Ancient Period (Board of Education of Saga Prefecture, 1990 b), the later explanation seems reasonable. The secondary forests on the hill must have been felled over the maximum sustainable yield, and secondary forests decreased. The apparent increase of the pollen of laurel trees is only relative without a real expansion of laurel forests.

Thus, this stage is characterized by the continuous existence of paddy fields in the west side, and the expansion of an open field or a farm in the east side. Secondary forests of *Celtis* or *Aphananthe* were deforested to some extent. This stage corresponds to the Ancient and Middle Ages judged from the earthen or ceramic ware from the both points.

Stage E : PAZ IV and MAZ III of the East Point, and PAZ V and the upper part of MAZ IIb of the West Point represent this stage.

Phytoliths of *Oryza* occurred highest (Sugiyama, personal communication) with the highest occurrences of Gramineous pollen among all stages. Weeds of paddy fields in both points become the richest in all stages both in pollen and plant macrofossil assemblages. All this evidence shows that paddy fields around both points got the maximum expansion at this stage. Increase of *Pinus* pollen and successive occurrence of *Cryptomeria* in both points suggest that these increased in mountain regions or on the hill.

Thus, this stage is characterized by the wide expansion of paddy fields, and the expansion of *Pinus* with *Cryptomeria*. There are no direct evidence of the time of this stage, except it is after the Middle Ages. Wide expansion of *Pinus* are relatively recent epoch in the vegetational history of Japan, at Middle or Recent Age in Kanto and Kinki District (Tsuji *et al.*, 1986, 1992; Kanehara & Izumi, 1989). There are no detailed evidence for the time of *Pinus* expansion at the northern Kyushu. In most pollen analysis in this area, *Pinus* pollen dominated at the top of the column far after the Yayoi or Ancient Period (Nakamura, 1982; Nakamura & Hatanaka, 1976) though in some sites, it increase slightly earlier (Yasuda, 1985). As a result, this seems to occur quite recently and we supposed it as in Recent Age. Tsuji *et al.* (1986) attribute the dominance of *Pinus* in the Kanto District as a wide cultivation of *Pinus* at 17 th to 18 th centuries. This cultivation model may be adapted for the expansion of *Pinus* in the northern Kyushu too.

Comparison with the other sites of northern Kyushu

Among the studies of Holocene vegetation history in Northern Kyushu, that of the Nabatake Site (Nakamura, 1982) is closely related with this study. The Nabatake Site is situated at Karatsu City, Saga Prefecture, facing the Karatsu Bay in the Japan Sea. This site is famous for the earliest paddy fields in Japan at the Latest Jomon Period. Stages of development can be read from the diagrams as follows. In the first stage *Oryza sativa* cultivation began in the Latest Jomon Period. Nakamura (1982) suggested destruction of vegetation at that time based on the sedimentary phases and poor preservation of pollen. However there were no apparent changes in the arboreal pollen assemblages. In the second stage secondary forests developed *Celtis-Aphananthe* at the Early Yayoi Period. In the third stage secondary forests disappeared in Middle Yayoi Period. And in the fourth stage *Pinus* forests expanded. Except for the first impact on vegetation, the pattern and timing of the changes are similar to those of the Yoshinogari Site. The differences of the first impact seem to be due to the character of the site : the Nabatake site is an agricultural site where development of paddy fields began first, and the Yoshinogari Site is a nuclear site of politics or religion where development of the hill and the lowland preceded agricultural one.

Small peaks of deciduous broad-leaved trees in the pollen diagrams around the Middle Yayoi Period are common in northern Kyushu : for example, the Jurokucho-hirata Site of Fukuoka City (Noi, 1993), the Hie Site of Fukuoka City (Noi, 1991; Tasaki, 1994), the Kadota Site of Kasuga City (Yasuda, 1976), and the Nabatake Site of Karatsu City (Nakamura, 1982). All these existed at the northern foot of the Sefuri Mountains. In northern Kyushu formation and destruction of secondary forests of deciduous broad-leaved trees seem to have been common during Yayoi Period.

Small peaks of conifers in the pollen diagrams contrast with the decrease of laurel trees in some localities. Among them, close relation with human activities is indicated in two localities. At the Yasunagata Site of Tosu City, conifers were rich in the Middle Yayoi Period, when the *Artemisia* pollen dominated the assemblages (Yasuda, 1985). Yasuda (1985) concluded that the destruction of the forest around the site resulted in the dominance of mountain elements such as conifers in the diagram. He mentioned that the climatic cooling also has relation to this phenomena. At the Itatsuke Site of Fukuoka City where pollen amounts in fixed sediments volume and laurel elements decreased at the Latest Jomon or the Early Yayoi Period, and conifer pollens including *Pinus* and *Abies* increased (Nakamura & Hatanaka, 1976). Nakamura & Hatanaka (1976) concluded that the destruction of the forest around the site resulted in the dominance of mountain elements such as conifers in the diagram. They also mentioned increasing precipitation as the background of this phenomena.

Compared with these former studies in northern Kyushu, this study is the first one to have revealed human and nature interaction around a nuclear site in northern Kyushu from the Yayoi Period to the Recent Ages. The first development of nature in the Early Yayoi Period is quite unique in that development of the hill and lowland preceded production of crops.

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