LATE MIOCENE FLORAS FROM THE SO-CALLED OGAWA FORMATION IN NAGANO PREFECTURE

Introduction

Neogene sediments, both of marine and terrestrial origin, are well distributed in Nagano Prefecture. Plant fossils have been known to occur from the Lower Miocene to the Pliocene in various localities, although they have not yet been fully described. It is important for Tertiary vegetational history of central Honshu to establish Neogene floristic sequence in Nagano Prefecture.

Yagi (1921) reported some Tertiary plants from various localities in Nagano Prefecture, and later Kryshtofovich (1930) first described 24 species, based on Yagi's collection. Kon'no (1931) is the first author who comprehensively clarified Tertiary flora of Nagano Prefecture; he described 4 floras from the Paleogene to the Pliocene; the Kitaaiki, Bessho, Omi and Saku. Of these 4 floras, the Omi flora is one of my subject to reinvestigate here. The Omi flora is known in the Omi Formation, which is correlative with the so-called Late Miocene Ogawa Formation distributed in the middle and north-central part of Nagano Prefecture. Kon'no (1931) identified 81 species with only illustrations from the Omi Formation and its correlatives, but no detailed description has unfortunately been given. He divided the Omi flora into the Kangawa-Yamazaki and Bodaira florules in ascending order. However, subsequent stratigraphic studies (Morishita et al., 1957; Saito, 1961a, etc.) revealed that the plant-bearing rocks of these two florules are confused stratigraphically. The Chausuyama flora from the so-called Ogawa Formation in the south of Nagano City was first announced by Endo (1948). Tanai (1961) defined the Omi and the Chausuyama floras as Late Miocene Mitoku type flora in Neogene floral sequence of Japan ; he described 20 species from the Omi and 26 species from the Chausuyama flora. Saito (1962a) and Tanaka (1962) listed some plant fossils from the "Ogawa" Formation, based on the identification by K. Suzuki.

I started to investigate Late Tertiary floras of north-central Nagano Prefecture with collection of several times since 1983. Through the investigation during these several years, I could identify 120 plants which are enough to discuss Late Tertiary forests of Nagano Prefecture.

Geologic Occurrence

In central to northern Nagano Prefecture, belonging to a part of northern Fossa Magna region, the Neogene sediments are widely distributed between east side of Itoigawa-Shizuoka Tectonic Line and western margin of the Kwanto Mountains, and northward are dominated by volcanics. These Neogene sediments were studied by many authors (Honma, 1931 ; Kobayashi and Isomi, 1950 ; Morishita et al., 1957 ; Yagi and Yagi, 1958 ; Saito, 1961-1963 ; Tanaka et al., 1961, 1964 ; Tomizawa, 1962, 1964 ; Sai-Kawa Research Group, 1965 ; Hirabayashi, 1966, 1970 ; Kato, 1980 ; Mizuno, 1976 ; Suzuki, K., 1977 ; Kato and Sato, 1983 ; Kimura and Hayashi, 1988, etc.). Honma (1931) first divided these sediments into the Miocene Moriya, Uchiyama, Bessho, Aoki and Ogawa Formations and the Pliocene Shigarami Formation in ascending order. Most of these formations are of marine origin except some of the upper formations. The

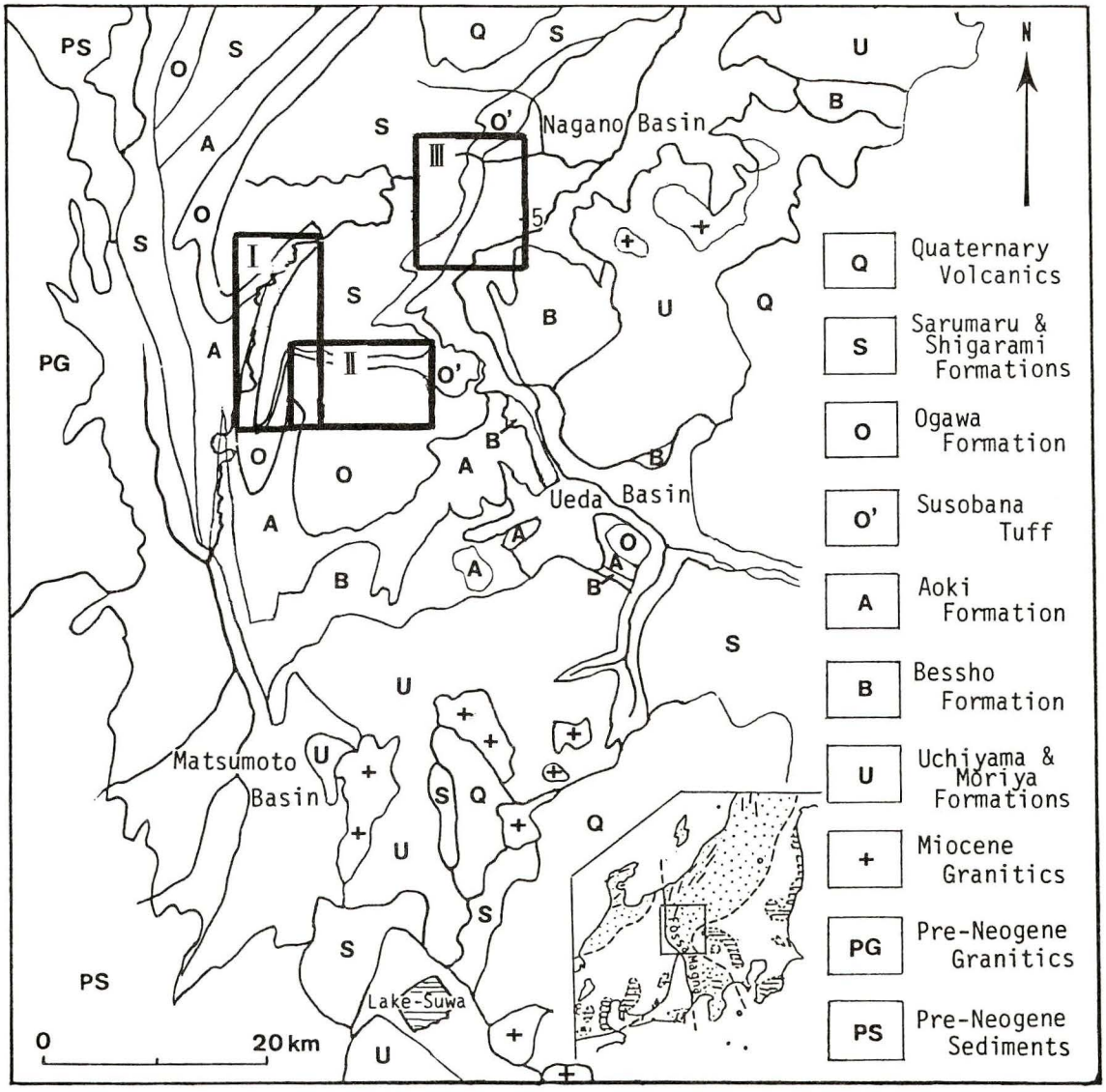

Fig. 10. Map showing the geologic outline in central to northern Nagano Prefecture and investigated areas
I : Fig.14, II: Fig.11 III: Fig.13

Moriya Formation distributed at the south of Lake Suwa is composed of conglomerate, sandstone, siltstone and greenish tuffs. This formation contains marine molluscan and some plant fossils (Tanaka et al., 1962) together with larger foraminifers such as *Miogypsina* (Matsumaru et al., 1982). The Moriya Formation has been considered to be one of the lowest member of the northern Fossa Magna and to be correlated with the lower part of the Uchimura Formation. The Uchimura Formation distributed from the east of Matsumoto City to the south of Ueda City is dominated by volcanic and pyroclastic rocks in the east, and contains marine molluscs from the sandstone and mudstone in the west. The Bessho Formation characterized by black mudstone covers conformably the Uchimura Formation and contains many fish scales, mollusca such as *Palliolum peckhami, Calyptogena akanudaensis*, and some ill preserved plant fossils. This formation is distributed from the northern area of Ueda City to near the Matsumoto City. It is considered that the Bessho Formation is partly unconformably overlain by the Aoki Formation. The Aoki Formation is composed mostly of alternation of sandstone and siltstone, and is distributed from Ueda City and westwards. The plant-bearing so-called Ogawa Formation distributed in east-central to north of Nagano Prefecture conformably covers the Aoki Formation. The lithology of this formation changes both laterally and

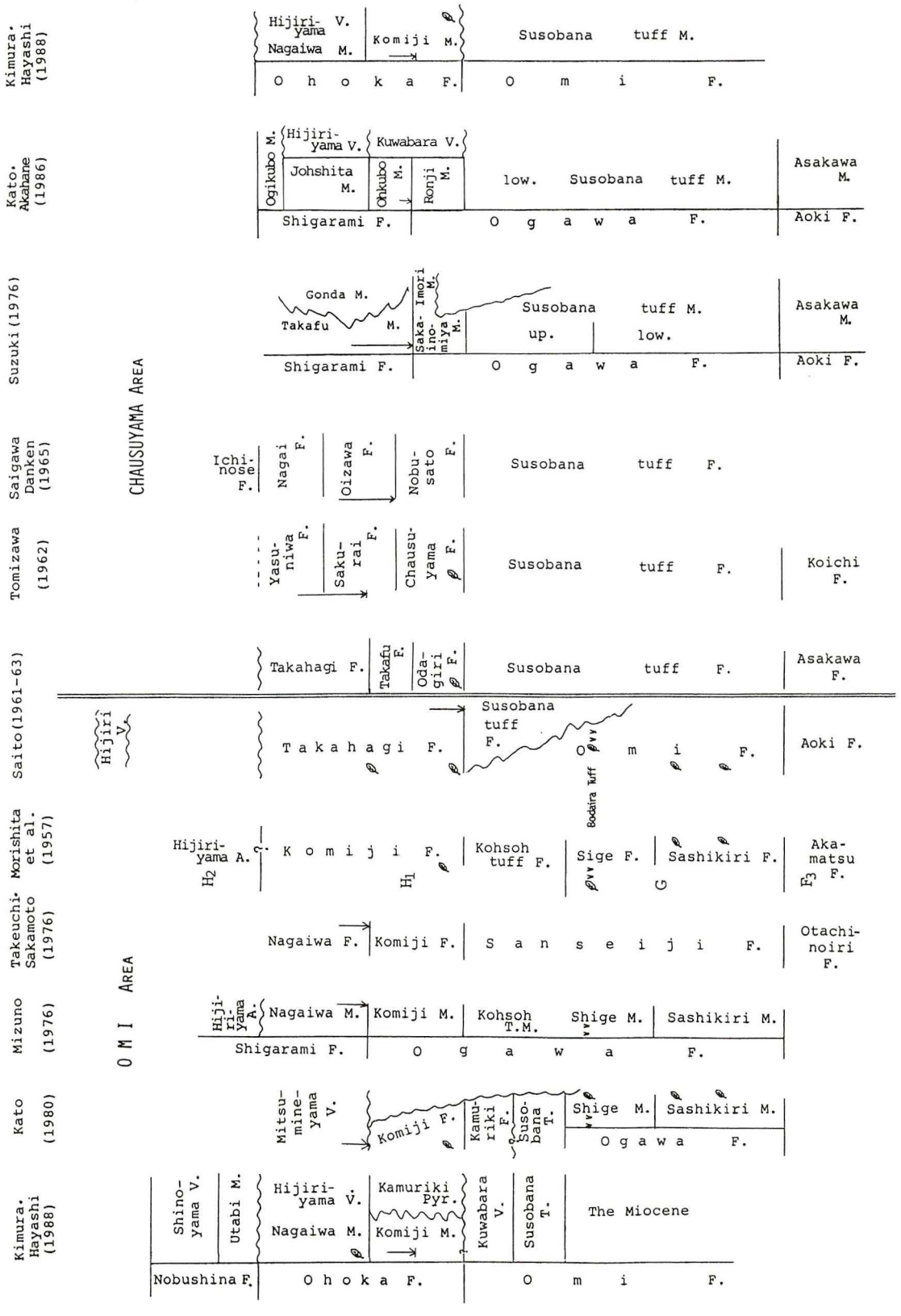

Table 27. Stratigraphic correlation of the Neogene in the central to the northern Nagano Prefecture
F. : Formation M. : Member Pyr. : Pyroclastics T. : Tuff A. : Andesite V. : Volcanics ⌀ : Plant fossils
→ : Base of the Pliocene indicated by each author.

vertically and was divided into the Minochi and Tochiku Facies by Honma (1931). The Minochi Facies distributed in the northwestern area is dominated by fine-grained thick sediments containing many marine animals. The plant-bearing Tochiku Facies distributed mainly in the central to eastern areas is composed largely of conglomerates, sandstones and siltstones, interbedding some thin lignite beds in the upper horizon. The formation of the Tochiku Facies is of terrestrial origin except in the lower part. Due to the variable lithology and sowewhat complicated structure, the so-called Ogawa Formation has been variously subdivided by many authors; the subdivisions by some authors are correlated as shown in Table 27.

In Omi and its northwestern area south and west of Mt. Hijiriyama, plant fossils are obtained mainly from three horizons. The Sashikiri flora is from the Sashikiri Formation by Morishita et al. (1957) or from the lower part of the Omi Formation by Saito (1961-63) or from the Sashikiri Member by Kato (1980). The Bodaira flora is from the Bodaira tuff bed which is intercalated in the Shige Formation by Morishita et al., (1957) or in the middle part of the Takahagi Formation by Saito (1961a) or in the Shige Member by Kato (1980). Only one locality of the upper Bodaira florule reported by Kon'no (1931) belongs to the Bodaira tuff bed. Plant fossils from the middle part of the Takahagi Formation by Saito (1961a) or from the uppermost part of the Komiji Member to the lower part of the Nagaiwa Member of the Ohoka Formation by Kimura and Hayashi (1988) are combined as the Ohoka flora in this work.

In Chausuyama (Shinonoi) district, the Chausuyama flora is from a tuff bed in basal part of the Odagiri Formation by Saito (1961a) or the Chausuyama quartz sandstone and mudstone Formation by Tomizawa (1962) or the Komiji Member of the Ohoka Formation by Kimura and Hayashi (1988).

The stratigraphic relationships between the Omi and the Chausuyama (Shinonoi) areas have been disputed by several authors; it is uncertain whether or not the Susobana tuff Member below the Chausuyama plant-bearing rocks is doubtlessly correlated with the Susobana tuff Member above the Bodaira tuff which the Bodaira florule is contained in the Omi area. Although a further stratigraphical investigation needs in future, the author considers that the Chausuyama flora is younger than the Bodaira flora on the basis of the stratigraphic correlation shown in Table 27.

The radiometric age of the so-called Ogawa Formation have been reported by several authors. According to Kato and Sato (1983), the K-Ar age of the Hijiriyama Volcanics unconformably overlying the Ogawa Formation in the Omi area is 5.3±0.3Ma. Yamagishi et al. (1984) reported some fission-truck ages: 12.3 Ma for the lower Aoki Formation, 7.9 Ma for the upper Ogawa Formation, and 7.5 Ma for the Susobana tuff Member at its type locality. According to Kato and Akahane (1983) the K-Ar age of the Susobana tuff Member in Omi area is 6.1±0.4 Ma. The K-Ar age of the Kitayama Dacite intruding upper part of the Sashikiri Member is 6.1±1.0 Ma, according to the measurement by the Teledyne Isotopes with which I entrusted. Judging from the above-described radiometric dating, the Ogawa Formation is assigned to Late Miocene in age.

In the following description, I define 4 leaf assemblages in north-central Nagano Prefecture: the Sashikiri flora from the Sashikiri Member in Omi area, Bodaira flora from the Bodaira tuff bed of the Shige Member in Omi area, the Ohoka flora from the upper part of the Komiji Member to the Nagaiwa Member of the Ohoka Formation in the north and west of Omi area, and the Chausuyama flora from the tuff bed in Chausuyama area.

The Sashikiri Flora

Among the specimens from the seven localities of the Kangawa-Yamazaki florule by Kon'no (1931), fossils from two localities, Yamazaki and Shunara, are obtained from the Sashikiri Member and belong to the Sashikiri flora, although the precise locations of these two

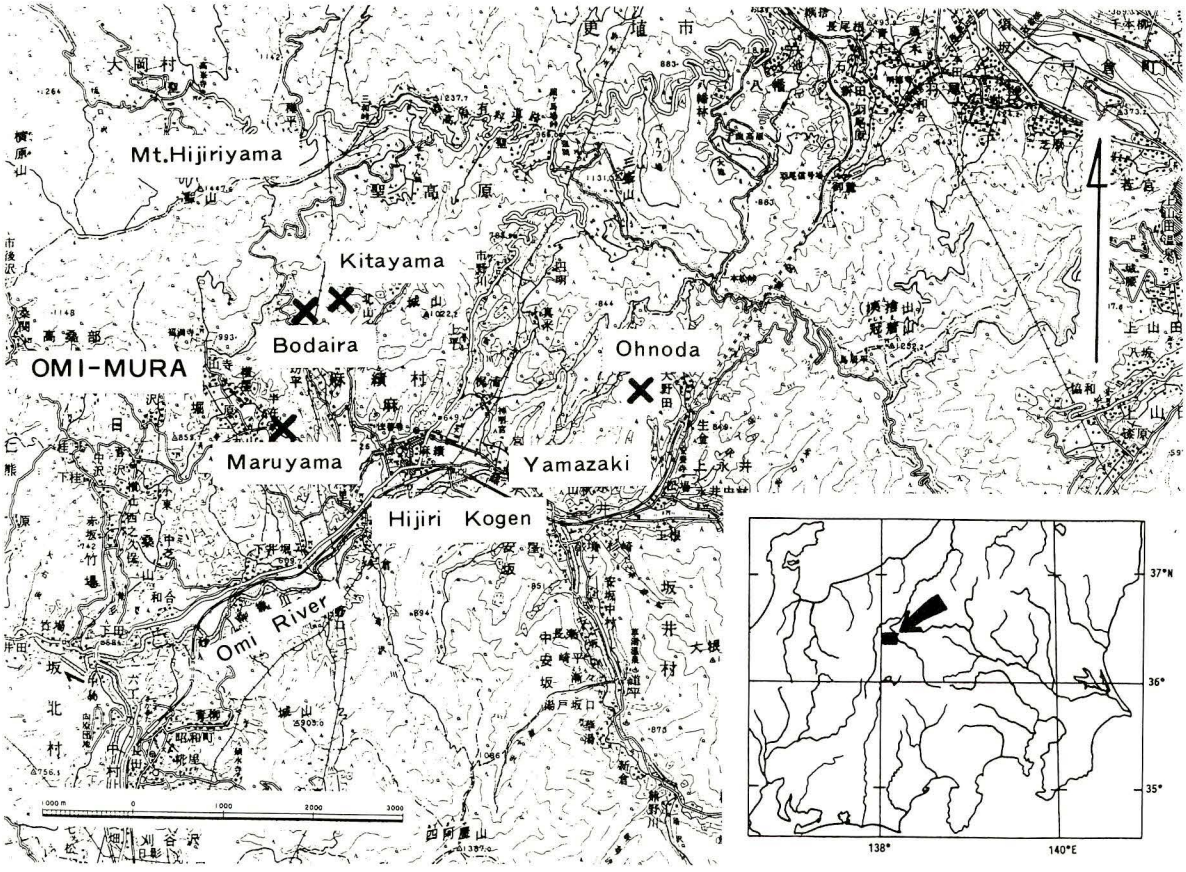

Fig. 11. Localities of the Sashikiri and Bodaira floras in Omi-mura, Nagano Prefecture.

localities are uncertain. The other localities belong to the different formation or to straitgraphycally uncertain horizon in the so-called Ogawa Formation. Nearly all the species reported by Kon'no from Yamazaki and Shunara are confirmed also by the author, except some species such as Lauraceae from Shunara locality and taxonomically uncertain species.

The fossil localities and characteristics of the fossil assemblages at each locality are as follows.

Maruyama locality (1): A cliff on a ridge east of Maruyama village; it is west-northwest of Hijirikogen Station of JR Shinonoi Line. The fossil-bearing rocks correspond to the middle part of the Sashikiri Member of Kato (1980), which consists of alternation of conglomeratic sandstone, arkosic sandstone and sandy siltstone. A small amount of leaf fossils are found in sandy siltstone. A few of them preserve the tertiary or higher-order veins of leaves. 27 species are identified, including 1 fern and 1 monocot. *Fagus stuxbergii* was the largest in number of specimens.

Yamazaki locality (2): A cliff on a hill ridge southwest of Ohnoda village; it is north-northwest of Kamuriki Station of the JR Shinonoi Line. This locality has known since early time. It corresponds to the upper part of the Sashikiri Member of Kato (1980), consisting of alternation of conglomerate, conglomeratic sandstone, arkosic sandstone and siltsone. Leaf fossils occur in sandy siltstone which is stratigraphically situated about 40 m below the fine tuff corresponding to the Bodaira tuff. Most of the specimens are generally poor in preservation; a few specimens retain the tertiary veins, and even the secondary veins are indistinct in many specimens. Among about 500 specimens, 95 species were identified, including 2 ferns, 5 conifers and 4 monocots. *Fagus stuxbergii* is most predominant with 187 specimens (38%), and other species are less than 2% in number of specimens. Although the evergreen species are

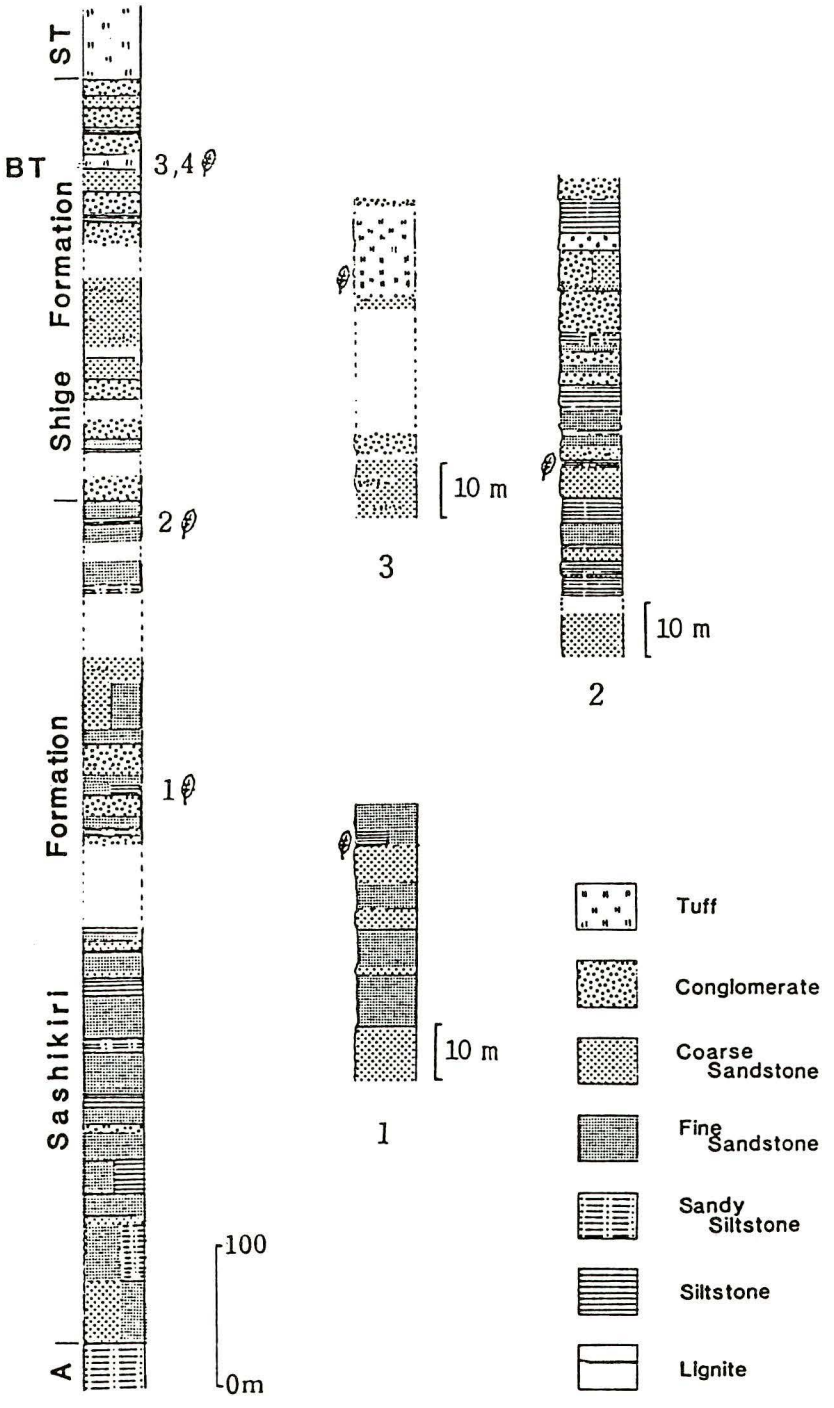

Fig. 12. Stratigraphic position of plant megafossil localities of Sashikiri (1, 2) and Bodaira (3, 4) floras.
ST: Susobana Tuff Formation BT: Boudaira Tuff bed
A: Aoki Formation
1: Maruyama 2: Yamazaki 3: Bodaira 4: Kitayama

few in the collection, entire-margined broad-leaved trees occupy 32.5% of the total broad-leaved ones.

Systematic Representation

The Sashikiri flora is composed of 43 families, 75 genera and 102 species. There are 2 ferns, 6 conifers, 4 monocotyledons, and the remainders are dicotyledons. The largest family is the Betulaceae with 5 genera and 9 species; next come the Rosaceae with 5 genera and 8 species, the Fagaceae with 2 genera and 7 species, the Aceraceae with 1 genus and 7 species, the Salicaceae with 2 genera and 5 species, the Fabaceae with 4 genera and 5 species, the Ulmaceae with 3 genera and 5 species, and the Lauraceae, Ericaceae, Oleaceae and Caprifoliaceae with 3 genera and 3 species each. The remaining families have less than 2 species; most of them being represented by a single species. The following genera are predominant in number of species; *Acer* with 6 species, *Quercus, Salix* and *Sorbus* with 4 species each, and

Table 28. Systematic List of Families and Species

Selaginellaceae	*Sellaginella*? sp.
Aspleniaceae	*Asplenium* sp.
Athyriaceae	*Diplazium* sp.
Pinaceae	*Keteleeria ezoana* Tanai
	Pinus miocenica Tanai
	Pseudolarix japonica Tanai & Onoe
	Pseudotsuga tanaii Huzioka
Taxodiaceae	*Glyptostrobus europaeus* (Brongniart) Heer
	Metasequoia occidentalis (Newb.) Chaney
Magnoliaceae	*Magnolia* sp. cf. *M. obovata* Thunb.
	Magnolia sp.
Lauraceae	*Cinnamomum* sp. cf. *C. camphora* Sieb.
	Neolitsea sp.
	Persea sp.
	Sassafras sp.
Illiciaceae	*Illicium*? sp.
Coriariaceae	*Coriaria* sp. cf. *C. japonica* A. Gray
Cercidiphyllaceae	*Cercidiphyllum crenatum* (Unger) Brown
Hamamelidaceae	*Liquidambar miosinica* Hu & Chaney
	Parrotia sp.
Ulmaceae	*Celtis hokiensis* Ozaki
	Celtis nathorstii Tanai & Onoe
	Ulmus protojaponica Tanai & Onoe
	Ulmus sp.
	Zelkova ungeri Kovats
Juglandaceae	*Platycarya miocenica* Hu & Chaney
	Pterocarya asymmetrosa Kon'no ex Tanai
Fagaceae	*Fagus palaeojaponica* Tanai & Onoe
	Fagus stuxbergii (Nathorst) Tanai
	Fagus sp.
	Quercus miovariabilis Hu & Chaney
	Quercus protoaliena Ozaki
	Quercus protosalicina K. Suzuki
	Quercus protoserrata Tanai & Onoe
Betulaceae	*Alnus* sp. cf. *A. japonica* Steud.
	Alnus sp.
	Betula sp. cf. *B. protoglobispica* Tanai & Onoe
	Carpinus heigunensis Huzioka
	Carpinus miocenica Tanai
	Carpinus subcordata Nathorst
	Carpinus sp.
	Corylus subsieboldiana K. Suzuki
	Ostrya aizuana K. Suzuki

Polygonaceae	*Rumex*? sp.
Tiliaceae	*Tilia* sp.
Sterculiaceae	*"Ficus" tiliaefolia* Heer
Salicaceae	*Populus hokiensis* Ozaki
	Salix akitaensis Huzioka & Uemura
	Salix k-suzukii Tanai
	Salix parasachalinensis Tanai & N. Suzuki
	Salix sp. cf. *S. integra* Thunb.
Ericaceae	*Leucothoe*? sp.
	Lyonia? sp.
	Rhododendron sp.
Styracaceae	*Halesia* sp.
Symplocaceae	*Symplocos* sp. cf. *S. coreana* (Leveille) Ohwi
Pittosporaceae	*Pittosporum* sp. cf. *P. illicioides* Makino
Saxifragaceae	*Deutzia* sp.
	Hydrangea sp.
Rosaceae	*Crataegus hokiensis* Ozaki
	Malus sp.
	Pyrus hokiensis Ozaki
	Sorbus hokiensis Ozaki
	Sorbus lesquereuxi Nathorst
	Sorbus palaeojaponica Murai
	Sorbus uzenensis Huzioka
	Spiraea protothunbergii Tanai & N. Suzuki
Caesalpiniaceae	*Gleditsia miosinensis* Hu & Chaney
Fabaceae	*Cladrastis aniensis* Huzioka
	Desmodium tatsumitogeanum Ozaki
	Lespedeza sp.
	Maackia sp.
	Wisteria fallax (Nathorst) Tanai & Onoe
Cornaceae	*Cornus miowalteri* Hu & Chaney
Celastraceae	*Tripterygium*? sp.
Aquifoliaceae	Cf. *Ilex rotunda* Thunb.
	Ilex sp. cf. *I. serrata* Thunb.
Buxaceae	*Buxus protojaponica* Tanai & Onoe
Euphorbiaceae	*Sapium hokianum* Ozaki
	Mallotus? sp.
Rhamnaceae	*Rhamnus* sp.
Sapindaceae	*Sapindus* sp.
Aceraceae	*Acer nordenskioeldii* Nathorst
	Acer protojaponicum Tanai & Onoe
	Acer protomatsumurae Tanai
	Acer rotundatum Huzioka
	Acer subnikoense Tanai & Ozaki
	Acer tricuspidatum Bronn.
	Acer sp.
Anacardiaceae	*Rhus miosuccedanea* Hu & Chaney
Rutaceae	*Fagara* sp.
Araliaceae	*Kalopanax* sp.
Boraginaceae	*Ehretia* sp.
Oleaceae	*Fraxinus* sp.
	Ligustrum sp.
	Syringa? sp.
Caprifoliaceae	*Lonicera* sp.
	Viburnum? sp. cf. *V. opulus* Linn.
	Weigela sanzugawaensis Huzioka & Uemura
Cyperaceae	*Carex* spp.
Poaceae	*Bambusites* sp.
	Phragmites sp.
Smilacaceae	*Smilax trinervis* Morita

Carpinus with 3 species. *Celtis, Ulmus, Fagus* and *Cladrastis* have 2 species each, and the remainder are represented by one species.

The Sashikiri flora consists largely of cool temperate families such as the Pinaceae, Ulmaceae, Betulaceae, Salicaceae, Rosaceae, Aceraceae and Caprifoliaceae. The Fagaceae is composed of cool temperate species except one evergreen oak. Warm temperate or tropical families are also contained, such as Lauraceae, Hamamelidaceae and Fabaceae. Eight species such as *Cinnamomum, Neolitsea, Illicium, Quercus protosalicina, Pittosporum, Ilex rotunda* and *Ligustrum* are evergreen broad-leaved trees.

Assumed Habits and Leaf Characters

The probable habits of the Sashikiri plants are indicated in Table 29. Since these estimates are based upon the habits of the equivalent living species, we are not including fossils whose representation is too inadequate to suggest modern relationships, such as *Bambusites* and "*Ficus*".

Table 29 shows that 61 trees make up 68.5 per cent of the total taxa, 19 small trees or

Table 29. Assumed Growth Habit and Leaf Characters of the Sashikiri Plants

Species	Growth Habit	Leaf Characters
Glyptostrobus europeaeus	Tree	DC
Metasequoia occidentalis	Tree	DC
Pinus miocenica	Tree	EC
Pseudolarix japonica	Tree	DC
Pseudotsuga tanaii	Tree	EC
Acer nordenskioeldii	Tree	Ds
Acer protojaponicum	Tree	Ds
Acer protomatsumurae	Tree	Ds
Acer rotundatum	Tree	Ds
Acer subnikoense	Tree	Ds
Acer tricuspidatum	Tree	Ds
Betula cf. *protoglobispica*	Tree	Ds
Carpinus heigunensis	Tree	Ds
Carpinus miocenica	Tree	Ds
Carpinus subcordata	Tree	Ds
Celtis hokiensis	Tree	Ds
Celtis nathorstii	Tree	Ds
Cinnaomum sp. cf. *C. camphora*	Tree	Ee
Cladrastis aniensis	Tree	De
Cornus sp. cf. *C. miowalteri*	Tree	De
Crataegus hokiensis	Tree	Ds
Ehretia sp.	Tree	Ds
Fagus palaeojaponica	Tree	Ds
Fagus stuxbergii	Tree	Ds
Fraxinus sp.	Tree	Ds
Gleditsia miosinensis	Tree	De
Halesia sp.	Tree	Ds
Cf. *Ilex rotunda*	Tree	Ee
Illicium? sp.	Tree	Ee
Kalopanax sp.	Tree	Ds
Liquidambar miosinica	Tree	Ds
Lyonia? sp.	Tree	De
Magnolia sp.	Tree	De
Magnolia sp. cf. *M. obovata*	Tree	De
Mallotus? sp.	Tree	De
Malus sp.	Tree	Ds
Ostrya aizuana	Tree	Ds
Persea? sp.	Tree	De
Platycarya miocenica	Tree	Ds
Populus hokiensis	Tree	Ds
Pterocarya asymmetrosa	Tree	Ds
Pyrus hokiensis	Tree	Ds
Quercus miocrispula	Tree	Ds
Quercus miovariabilis	Tree	Ds
Quercus protoaliena	Tree	Ds
Quercus protoserrata	Tree	Ds
Rhus miosccedanea	Tree	De
Salix akitaensis	Tree	Ds
Salix k-suzukii	Tree	Ds
Salix parasachalinensis	Tree	Ds
Sapindus? sp.	Tree	De
Sapium hokianum	Tree	De
Sassafras sp.	Tree	De
Sorbus hokiensis	Tree	Ds
Sorbus lesquereuxi	Tree	Ds
Sorbus palaeojaponica	Tree	Ds
Symplocos sp. cf. *S. coreana*	Tree	Ds
Syringa? sp.	Tree	De
Tilia sp.	Tree	Ds
Ulmus protojaponica	Tree	Ds
Zelkova ungeri	Tree	Ds
Buxus protojaponica	St or Shrub	Ee
Coriaria sp. cf. *C. japonica*	St or Shrub	De
Corylus subsieboldiana	St or Shrub	Ds
Desmodium tatsumitogeanum	St or Shrub	De
Deutzia sp.	St or Shrub	Ds
Fagara sp.	St or Shrub	Ds
Hydrangea sp.	St or Shrub	Ds
Ilex sp. cf. *I. serrata*	St or Shrub	Ds
Lespedeza sp.	St or Shrub	De
Leucothoe? sp.	St or Shrub	De
Ligustrum? sp.	St or Shrub	Ee
Lonicera sp.	St or Shrub	De
Neolitsea sp.	St or Shrub	Ee
Pittosporum sp. cf. *P. illicoides*	St or Shrub	Ee
Rhododendron sp.	St or Shrub	De
Sorbus uzenensis	St or Shrub	Ds
Spiraea protothunbergii	St or Shrub	Ds
Viburnum sp. cf. *V. opulus*	St or Shrub	Ds
Weigela sanzugawaensis	St or Shrub	Ds
Cocculus? sp.	Vine	De
Smilax trinervis	Vine	Ee
Wisteria fallax	Vine	De
Asplenium sp.	Terr. Herb	
Carex sp.	Terr. Herb	
Diplazium sp.	Terr. Herb	
Phragmites? sp.	Terr. Herb	
Rumex? sp.	Terr. Herb	
Selaginella? sp.	Terr. Herb	
"*Ficus*" *tiliaefolia*		De
Bambusites sp.		

ST : Small Tree Terr. : Terrestrial D : Deciduous E : Evergreen C : Conifer s : Serrate-margined broad-leaf
e : Entrie-margined broad-leaf

shrubs make up 21.3 per cent, 3 vines consist 3.4 per cent and 6 herbs 6.7 per cent. Judging from these percentages, the Sashikiri plants were predominantly arboreal; the percentage of small trees or shrubs is higher than those in the other floras in this article. Of the 5 species of conifers, *Pinus miocenica* and *Pseudotsuga tanaii* were evergreen. Referring to the abscission habit of the broad-leaved members of the flora, the 6 herbs and *Bambusites* are omitted from consideration, but we shall include several angiosperms which have not been assigned specific status, and whose leaf characters indicate whether they were evergreen or deciduous. Of the total of angiosperms numbering 80, the followings appear to have had an evergreen habit, as judged from the abscission regime of their living equivalents, or from the thick texture of the fossil leaves: *Cinnamomum* sp. cf. *C. camphora* Sieb., Cf. *Ilex rotunda* Thunb., *Illicium*? sp., *Buxus protojaponica* Tanai et Onoe, *Ligustrum*? sp., *Neolitsea* sp., *Pittosporum* sp. cf. *P. illicioides* Makino, and *Smilax trinervis* Morita. These plants occupies 10 per cent of the total broad-leaved tree species.

Numerical Representation

The following quantitative appraisal of the Sashikiri flora is based on a count of 501 specimens from two localities, Maruyama and Kitayama. Of the 94 Sashikiri species, 18 species are common or abundant members in the Sashikiri forest, with representation of more than 1 per cent each in leaf counting. These predominant species consist 74 per cent of the total specimens, and the first species, *Fagus stuxbergii,* occupies 43 per cent of the total. *Fagus stuxbergii* is predominant in the number of leaves in the two localities, and it was the main tree of the Sasihkiri forest. The second, third and fifth species, *Quercus miovariabilis, Liquidambar miocenica,* and *Quercus protoaliena* , are represented rather large size of leaves which would seem unsuited to survive transport for a long distances. These predominant species including *Fagus protojaponica* were dominant members of the slope forest near the sites of deposition, considering from the living equivalents. Several dominant species such as *Acer, Carpinus, Ostrya, Zelkova, Bambusites,* and *Celtis* may have formed mainly the valley forest near the depositional sites. Small number of specimens of the water loving plants, *Glyptostrobus, Metasequoia, Salix* and *Ulmus,* may indicate that there was no wide swamp forest near the depositional sites. This inference is also consistent with the fact that the plant-bearing rocks are largely composed of conglomeratic sandstone and sandstone. *Pseudolarix japonica* probably lived on slopes at some distances from the depositional sites, because the detached leaves of this species is too small in the number. Eight broad-leaved evergreen species make up 10 percent of the total species of the flora, while their leaves occupy only 2.6 percent of the total specimens. The deciduous leaves enter the fossil record in large quantities at the end of each growing season, while the evergreen trees are not well suited for shedding their leaves. Moreover, all of these evergreen species are considered to be small trees, shrubs or vine, except for *Cinnamomum* cf. *camphora.* There is rather small chance for leaves of small trees or shrubs to enter the fossil record than those of trees. It may be assumed that evergreen broad-leaved species must have been subordinate members of the Sashikiri forest, and that they may have formed the understory of the above trees.

The Sashikiri flora has 30 entire-margined broad-leaved tree species that count 34.1 per cent of the total broad-leaved species.

Distribution of the Allied Living Species

Table 31 shows most allied living plants of the Sashikiri species and their distribution in the modern forests of Japan and continental East Asia.

The following table indicates the total number of species in each forest zone and the percentages for the cumulative number of species in all zones.

Table 30. Numerical Representation of the Sashikiri Flora

Species	Number of specimens	Percentage
Fagus stuxbergii	214	42.7
Quercus miovariabilis	34	6.8
Liquidambar miosinica	16	3.2
Fagus palaeojaponica	12	2.4
Quercus protoaliena	10	2.0
Acer rotundatum	9	1.8
Acer nordenskioeldii	8	1.6
Carpinus sp.	8	1.6
Ostrya aizuana	8	1.6
Pesudolarix japonica	8	1.6
Zelkova ungeri	8	1.6
Bambusites sp.	7	1.4
Acer sp.	5	1.0
Carpinus miocenica	5	1.0
Carpinus subcordata	5	1.0
Celtis hokiensis	5	1.0
Lespedeza sp.	5	1.0
Pyrus hokiensis	5	1.0
Pterocarya asymmetrosa	4	0.8
Tilia sp.	4	0.8
Betula sp. cf. *B. protoglobispica*	3	0.6
Cf. *Ilex rotunda*	3	0.6
Cladrastis aniensis	3	0.6
Desmodium tatsumitogeanum	3	0.6
Deutzia sp.	3	0.6
Ehretia sp.	3	0.6
Glyptostrobus europaeus	3	0.6
Ligustrum? sp.	3	0.6
Phragmites? sp.	3	0.6
Quercus protoserrata	3	0.6
Salix parasachalinensis	3	0.6
Ulmus protojaponica	3	0.6
"Ficus" tiliaefolia	2	0.4
Carex spp.	2	0.4
Celtis nathorstii	2	0.4
Cocculus? sp.	2	0.4
Cornus sp. cf. *C. miowalteri*	2	0.4
Crataegus hokiensis	2	0.4
Fagara sp.	2	0.4
Fraxinus sp.	2	0.4
Gleditsia miosinensis	2	0.4
Illicium? sp.	2	0.4
Lyonia? sp.	2	0.4
Malus sp.	2	0.4
Metasequoia occidentalis	2	0.4
Platycarya miocenica	2	0.4
Pseudotsuga tanaii	2	0.4
Rhus miosuccedanea	2	0.4
Rumex? sp.	2	0.4
Sorbus palaeojaponica	2	0.4
Sorbus uzenensis	2	0.4
Viburnum? sp. cf. *V. opulus*	2	0.4
Wisteria fallax	2	0.4
Acer protojaponicum	1	0.2
Acer protomatsumurae	1	0.2
Acer subnikoense	1	0.2
Acer tricuspidatum	1	0.2
Asplenium sp.	1	0.2
Buxus protojaponica	1	0.2
Carpinus heigunensis	1	0.2
Cinnamomum sp. cf. *C. camphora*	1	0.2
Coriaria sp. cf. *C. japonica*	1	0.2
Corylus subsieboldiana	1	0.2
Diplazium sp.	1	0.2
Fagus sp.	1	0.2
Halesia sp.	1	0.2
Hydrangea sp.	1	0.2
Ilex sp. cf. *I. serrata*	1	0.2
Kalopanax sp.	1	0.2
Leucothoe? sp.	1	0.2
Lonicera sp.	1	0.2
Magnolia sp. cf. *M. obovata*	1	0.2
Magnolia sp.	1	0.2
Mallotus? sp.	1	0.2
Neolitsea sp.	1	0.2
Persea? sp.	1	0.2
Pinus miocenica	1	0.2
Pittosporum sp. cf. *P. illicioides*	1	0.2
Populus hokiensis	1	0.2
Quercus miocrispula	1	0.2
Quercus sp.	1	0.2
Rhododendron sp.	1	0.2
Salix akitaensis	1	0.2
Salix k-suzukii	1	0.2
Sapindus? sp.	1	0.2
Sapium hokianum	1	0.2
Sassafras sp.	1	0.2
Selaginella? sp.	1	0.2
Smilax trinervis	1	0.2
Sorbus hokiensis	1	0.2
Sorbus lesquereuxi	1	0.2
Spiraea protothunbergii	1	0.2
Symplocos sp. cf. *S. coreana*	1	0.2
Syringa? sp.	1	0.2
Ulmus sp.	1	0.2
Weigela sanzugawensis	1	0.2
	sum 501	100.1

Region	1	2	3	4	5	6	7	Sum
No. of Species	9.0	29.5	52.0	51.0	37.5	1.0	1.0	181.0
Percentage	5.0	16.3	28.7	28.2	20.7	0.6	0.6	100.1

The Sashikiri flora has nearly the equal cumulative number of species in the zone 3 (the upper warm temperate forest zone) and the zone 4 (the lower cool temperate forest zone): 52 in the former and 51 in the latter.

Inferred from the distribution of the living plants that are allied to the fossil species, the Sashikiri flora is similar in composition to the extant forests in the upper warm temperate to lower cool temperate zones. All the predominant species taking more than 1% in number of specimens, except *Liquidambar,* are elements of cool temperate zone forest, but a half of them extend to the temperate zones. Warm temperate species such as *Cinnamomum, Neolitsea,*

Table 31. Distribution of the most allied living species

Fossil species	Most allied living species	1	2	3	4	5	6	7
Cinnamomum sp. cf. *C. camphora*	*C. camphora* Sieb.	*	*	−	−	−	−	−
Cf. *Ilex rotunda*	*I. rotunda* Thunb.	*	*	*	−	−	−	−
Ehretia sp.	*Ehretia* sp.	*	*	*	−	−	−	−
Fagara sp.	*F. fauriei* Nakai	*	*	*	−	−	−	−
Glyptostrobus europeaeus	*G. pensilis* K. Koch	*	*	*	−	−	−	−
Mallotus? sp.	*M. japonicus* Muell. -Arg.	*	*	*	−	−	−	−
Neolitsea sp.	*N. sericea* (Blume) Koidz.	*	*	*	−	−	−	−
Rhus miosuccedanea	*R. succedanea* Linn.	*	*	*	−	−	−	−
Desmodium tatsumitogeanum	*D. caudatum* DC.	*	*	*	*	+	−	−
Asplenium sp.	*Asplenium* sp.	−	*	*	−	−	−	−
Hydrangea sp.	*H. macrophylla* Seringe	−	*	*	−	−	−	−
Ligustrum sp.	*Ligustrum* sp.	−	*	*	−	−	−	−
Lyonia? sp.	*Lyonia* sp.	−	*	*	−	−	−	−
Pinus miocenica	*P. thunbergii* Parl.	−	*	*	−	−	−	−
Pseudolarix japonica	*P. kaempferi* Gord.	−	*	*	−	−	−	−
Sapium hokianum	*S. sebiferum* (Linn.) Roxb.	−	*	*	−	−	−	−
Selaginella? sp.	*S. nipponica* Fr. et Sav.	−	*	*	−	−	−	−
Tilia sp.	*T. kiusiana* Makino et Shirasawa	−	*	*	−	−	−	−
Quercus miovariabilis	*Q. variabilis* Blume	−	*	*	+	−	−	−
Liquidambar miosinica	*L. formosana* Hance	−	*	*	*	−	−	−
Platycarya miocenica	*P. strobilacea* Sieb. et Zucc.	−	*	*	*	−	−	−
Quercus protoaliena	*Q. aliena* Blume	−	*	*	*	−	−	−
Sassafras sp.	*S. tsumu* Hemsl.	−	*	*	*	−	−	−
Celtis nathorstii	*C. sinensis* Pers. v. *japonica* Nakai	−	*	*	*	*	−	−
Cornus miowalteri	*C. walteri* Wanger	−	*	*	*	*	−	−
Lespedeza sp.	*Lespedeza* sp.	−	*	*	*	*	−	−
Smilax trinervis	*S. china* Linn.	−	*	*	*	*	−	−
Sorbus hokiensis	*S. torminalis* Crantz.	−	*	*	*	*	−	−
Wisteria fallax	*W. floribunda* (Willd.) DC.	−	*	*	*	*	−	−
Zelkova ungeri	*Z. serrata* Makino	−	+	*	*	−	−	−
Buxus protojaponica	*B. microphylla* Sieb. et Zucc. var. *japonica* Rehd. et Wils.	−	−	*	−	−	−	−
Illicium? sp.	*I. religiosum* Sieb. et Zucc.	−	−	*	−	−	−	−
Pittosporum sp. cf. *P. illicioides*	*P. illicioides* Makino	−	−	*	−	−	−	−
Spiraea protothunbergii	*S. thunbergii* Sieb. ex Blume	−	−	*	−	−	−	−
Acer nordenskioeldii	*A. palmatum* Thunb.	−	−	*	*	−	−	−
Acer tricuspidatum	*A. pycnanthum* K. Koch	−	−	*	*	−	−	−
Carpinus heigunensis	*C. tschonoskii* Maxim.	−	−	*	*	−	−	−
Fagus palaeojaponica	*F. japonica* Maxim.	−	−	*	*	−	−	−
Gleditsia miosinensis	*G. japonica* Miq.	−	−	*	*	−	−	−
Ilex sp. cf. *I. serrata*	*I. serrata* Thunb.	−	−	*	*	−	−	−
Metasequoia occidentalis	*M. glyptostroboides* Hu et Cheng	−	−	*	*	−	−	−
Pseudotsuga tanaii	*P. japonica* Shirasawa	−	−	*	*	−	−	−
Pyrus hokiensis	*P. callyana* Decne.	−	−	*	*	−	−	−
Quercus protoserrata	*Q. serrata* Murray	−	−	*	*	−	−	−
Salix k-suzukii	*S. jesssoensis* Seemen	−	−	*	*	+	−	−
Acer rotundatum	*A. mono* Maxim.	−	−	*	*	*	−	−
Coriaria sp. cf. *C. japonica*	*C. japonica* A. Gray	−	−	*	*	*	−	−
Kalopanax sp.	*K. pictus* (Thunb.) Nakai	−	−	*	*	*	−	−
Magnolia sp. cf. *M. obovata*	*M. obovata* Thunb.	−	−	*	*	*	−	−
Populus hokiensis	*P. sieboldii* Miq.	−	−	*	*	*	−	−
Symplocos sp. cf. *S. coreana*	*S. coreana* (Lev.) Ohwi	−	−	*	*	*	−	−
Carpinus miocenica	*C. laxiflora* Blume	−	−	+	*	+	−	−
Ostrya aizuana	*O. japonica* Sarg.	−	−	+	*	*	−	−
Salix akitaensis	*S. sachalinensis* Fr. Schm.	−	−	+	*	*	−	−
Salix parasachalinensis	*S. sachalinensis* Fr. Schm.	−	−	+	*	*	−	−
Acer subnikoense	*A. nikoense* Maxim.	−	−	−	*	−	−	−
Acer protomatsumurae	*A. palmatum* Thunb. var. *matsumurae* (Koidz.) Makino	−	−	−	*	*	−	−
Betula sp. cf. *B. protoglobispica*	*B. globispica* Shirai	−	−	−	*	*	−	−

Carpinus subcordata	*C. cordata* Blume	−	−	−	*	*	−	−
Celtis hokiensis	*C. jessoensis* Koidz.	−	−	−	*	*	−	−
Cladrastis aniensis	*C. platycarpa* (Maxim.) Makino	−	−	−	*	*	−	−
Corylus subsieboldiana	*C. sieboldiana* Blume	−	−	−	*	*	−	−
Diplazium sp.	*D. squamigerum* (Mettenius) Matsumura	−	−	−	*	*	−	−
Fagus stuxbergii	*F. crenata* Blume	−	−	−	*	*	−	−
Leucothoe? sp.	*Leucothoe* sp.	−	−	−	*	*	−	−
Malus sp.	*Malus* sp.	−	−	−	*	*	−	−
Pterocarya asymmetrosa	*P. rhoifolia* Sieb. et Zucc.	−	−	−	*	*	−	−
Sorbus lesquereuxi	*S. alnifolia* (S. et Z.) K. Koch	−	−	−	*	*	−	−
Sorbus palaeojaponica	*S. japonica* (Decne.) Hedlund	−	−	−	*	*	−	−
Syringa? sp.	*S. reticulata* (Blume) Hara	−	−	−	*	*	−	−
Weigela sanzugawaensis	*W. sanguinea* (Nakai) Nakai	−	−	−	*	*	−	−
Acer protojaponicum	*A. japonicum* Thunb.	−	−	−	+	*	−	−
Ulmus protojaponica	*U. davidiana* Planch. var. *japonica* (Rehd.) Nakai	−	−	−	+	*	−	−
Viburnum? sp. cf. *V. opulus*	*V. opulus* Linn.	−	−	−	+	*	−	−
Crataegus hokiensis	*C. maximowiczii* Schneid.	−	−	−	−	*	−	−
Quercus miocrispula	*Q. mongolica* Fisch. var. *grosseserrata* Rehd. et Wils.	−	−	−	−	*	−	−
Sorbus uzenensis	*S. commixta* Hedlund	−	−	−	−	*	*	*

1) Subtropical forest zone 2) Lower warm temperate zone 3) Upper warm temperate forest zone
4) Lower cool temperate forest zone 5) Upper cool temperate forest zone 6) Subalpine forest zone 7) Alpine forest zone

Pittosporum, Ilex rotunda, Ehretia, Ligustrum, Cocculus, Illicium, Mallotus and *Sapium* are small in number of specimens.

Assumed Habitat

Table 32 represents the assumed habitat of the Sashikiri species. The aquatic or swamp members show low representation with less than 1% in the fossil record; all of them were not confined to this community, but appear to have also occupied stream-margin sites. Their low representation may be interpreted to indicate that there was small area of swamp depositional sites. It may be supported by the fact that the plant-bearing Sashikiri Formation contains a little fine-grained sediments. The Sashikiri Formation is largely composed of conglomeratic sandstone and sandstone; the predominant coarse-grained lithology is resulted in having a number of riparian or valley members. Fifty-six species of riparian or valley forests are composed largely of the broad-leaved trees; especially, *Liquidambar, Salix, Ulmus protojaponica, Pterocarya, Pyrus, Acer rotundatum, Acer nordenskioeldii* and *Tilia* sp. are common members in these forests along with *Bambusites*. Many members of this forest mingled in the lower slope forest which was composed of 68 species. Deciduous trees, *Quercus miovariabilis, Q. protoaliena, Fagus plaeojaponica,* maples and hornbeams, were common members of the lower slope forest. Although small in number of specimens, in this forest are involved many evergreen broad-leaved species such as *Cinnamomum* cf. *camphora, Pittosporum* cf. *illicioides, Quercus protosalicina, Persea*, sp., *Neolitsea* sp., *Ilex* cf. *rotunda,* and *Illicium*? sp. Most species of the mountain slope forest may be also common to the lower slope forest. This mountain slope forest was dominated by *Fagus stuxbergii* (over 42 percent), which formed dense stands in the region along with some deciduous members.

Summary

The Sashikiri flora of 102 species in 43 families and 75 genera is found in sandy siltstones intercalated in coarse-grained sandstones of the Sashikiri Member of the Omi (Ogawa) Formation in the northeast of Matsumoto City of Nagano Prefecture. The Sashikiri Member

Table 32. Assumed Habitat of the Sashikiri Plants

Species	1	2	3	4
Diplazium sp.	*	*		
Glyptostrobus europaeus	*	*		
Metasequoia occidentalis	*	*		
Phragmites sp.	*	*		
Salix akitaensis	*	*		
Salix k-suzukii	*	*		
Salix parasachalinensis	*	*		
Selaginella? sp.	*	*		
Rumex? sp.	*	*		
Ulmus protojaponica	*	*		
Acer tricuspidatum		*		
Asplenium sp.		*		
Bambusites sp		*		
Buxus protojaponica		*		
Cercidiphyllum crenatum		*		
"Ficus" tiliaefolia		*		
Fraxinus sp.		*		
Hydrangea sp.		*		
Ilex cf. *serrata*		*		
Kalopanax sp.		*		
Populus hokiensis		*		
Pterocarya asymmetrosa		*		
Pyrus hokiensis		*		
Salix cf. *integra*		*		
Sapindus? sp.		*		
Symplocos cf. *coreana*		*		
Viburnum cf. *opulus*		*		
Wisteria fallax		*		
Zelkova ungeri		*		
Acer nordenskioeldii		*	*	
Acer protomatsumurae		*	*	
Acer subnikoense		*	*	
Carex sp.		*	*	
Carpinus heigunensis		*	*	
Carpinus miocenica		*	*	
Celtis nathorstii		*	*	
Cladrastis aniensis		*	*	
Cornus cf. *miowalteri*		*	*	
Corylus subsieboldiana		*	*	
Deutzia sp.		*	*	
Fagara sp.		*	*	
Gleditsia miosinensis		*	*	
Kalopanax sp.		*	*	
Lespedeza sp.		*	*	
Liquidambar miosinica		*	*	
Lonicera sp.		*	*	
Mallotus? sp.		*	*	
Malus sp.		*	*	
Persea sp.		*	*	
Platycarya miocenica		*	*	
Rhus miosuccedanea		*	*	
Sapium hokianum		*	*	
Smilax trinervis		*	*	
Symplocos cf. *coreana*		*	*	
Syringa? sp.		*	*	
Tilia sp.		*	*	
Cinnamomum cf. *camphora*			*	
Coriaria cf. *japonica*			*	
Ehretia sp.			*	
Halesia sp.			*	
Ilex rotunda			*	
Illicium? sp.			*	
Ligustrum sp.			*	
Leucothoe? sp.			*	
Magnolia cf. *obovata*			*	
Magnolia sp.			*	
Neolitsea sp.			*	
Parrotia sp.			*	
Pinus miocenica			*	
Pittosporum cf. *illicioides*			*	
Quercus miovariabilis			*	
Quercus protoaliena			*	
Quercus protosalicina			*	
Quercus protoserrata			*	
Sassafras sp.			*	
Sorbus hokiensis			*	
Acer protojaponicum			*	*
Betula protoglobispica			*	*
Carpinus subcordata			*	*
Celtis hokiensis			*	*
Crataegus hokiensis			*	*
Fagus palaeojaponica			*	*
Ilex cf. *serrata*			*	*
Lyonia? sp.			*	*
Maackia sp.			*	*
Ostrya aizuana			*	*
Pseudolarix japonica			*	*
Pseudotsuga tanaii			*	*
Pyrus hokiensis			*	*
Rhododendron sp.			*	*
Sorbus lesquereuxi			*	*
Sorbus palaeojaponica			*	*
Sorbus uzenensis			*	*
Spiraea protothunbergii			*	*
Tripterigium sp.			*	*
Weigela sanzugawaensis			*	*
Fagus stuxbergii				*

1 : Aquatic or Marsh 2 : Riparian or Valley 3 : Lower Slope 4 : Mountain Slope

conformably rests on the Middle Miocene Aoki Formation of marine origin and grades upward into the Shige conglomeratic Member of fresh-water origin. The Sashikiri Member consists of coarse-grained sandstone, occasionally associated with beds of conglomerate, sandstone and siltstone rarely containing thin lignite beds. Some oyster beds in the western area are diminishing eastward as the formation thinns eastward. It may be concluded that the topography around the depositional sites was narrow with ill-developed floodplain and adjacent hilly

slopes in the east. The Sashikiri flora is characterized by rich deciduous broad-leaved species such as beechs, *Liquidambar,* oaks, hornbeams and maples, among which the leaves of *Fagus stuxbergii* dominated. Eight evergreen broad-leaved species of small trees or shrubs occupy only 2.6% in the total specimens counted. Main vegatations represented by the Sashikiri flora are riparian or valley to lower slope forests. There is a little indication of subalpine or high altitude members. Montane areas were at some distance from the sites of Sashikiri deposition, judging from the low representation of the typical upper mountain slope elements.

In short, the vegetation shown by the Sashikiri flora is the deciduous broad-leaved forest accompanied with some evergreen broad-leaved trees; it covered from the narrow coastal plain to the lower slope. Climate indicated by the flora is thus rather cool-temperate.

The Bodaira Flora

Kon'no (1931) considered that the Bodaira florule representing the upper part of the Late Miocene Omi flora shows warmer climate than that indicated by the Kangawa-Yamazaki florule of the lower Omi flora. However, the Bodaira florule reported by Kon'no is composed of 11 species from four localities belonging to the stratigraphically different horizons: two of these localities are in the Komiji or the Nagaiwa Members above the Bodaira tuff bed from which the main components were obtained, and the rests are in the so-called Ogawa Formation in the south of Ueda City far east of Omi area. The following five species were reported only from the Bodaira tuff bed by Kon'no: *Sequoia* sp., *Glyptostrobus europaeus* Heer, *Bambusium "yadakeides"* Kon'no, *Machilus* sp., *Rosa*? sp.

Saito (1962) reported the following 6 species from the Bodaira tuff bed, based on the identification by Suzuki: *Lastrea* sp., *Lindera "protoaciculata"* K. Suzuki, *Lindera "protostrychnifolia"* K. Suzuki, *Salix* sp., *Machilus protojaponica* K. Suzuki and *Bambusium "yadakeides"* Kon'no.

I determined 9 species from the Bodaira tuff bed at Bodaira and Kitayama localities as shown in the Figs. 11 and 12.

Bodaira locality: A cliff 2.6 km northwest of Hijirikogen Station of JR Shinonoi Line. The plant-bearing rocks belong to a lower part of the so-called Bodaira tuff distributed in the northwest of Bodaira village. As the plant fossils occur in a bent-down condition within the coarse-grained pumiceous hard and compact tuff, it is difficult to obtain a large quantity of specimens. *Alnus* sp. cf. *A. japonica* occupies about three-fourths of the total speciments collected.

Kitayama locality: A cliff northeast of the Bodaira locality and northwest of Kitayama village. The plant-bearing rocks also belong to the lower part of the Bodaira tuff. Specimens collected here is few. *Alnus* sp. cf. *A. japonica* occupies about 60% of the total specimens.

	Bodaira	Kitayama	Sum
Keteleeria ezoana Tanai	5	4	9
Zelkova ungeri Kovats	-	1	1
Ficus sp.	1	2	3
Castanea miocrenata Tanai et Onoe	1	1	2
Quercus protosalicina K. Suzuki	1	2	3
Alnus sp. cf. *A. japonica* Steud.	42	26	68
Carpinus heigunensis Huzioka	-	3	3
Bambusites sp.	4	6	10
Phragmites? sp.	1	1	2
	55	46	101

Adding Kon'no's and Saito's collections to my species list, the Bodaira flora is composed of 11 families, 17 genera and 17 species. There are 1 ferns, 3 conifers, 2 monocotyledons and

Table 33. Systematic List of the Bodaira Flora

Aspidiaceae	*Lastrea* sp.
Pinaceae	*Keteleeria ezoana* Tanai
Taxodiaceae	*Glyptostrobus europaeus* (Brongniart) Heer
	Sequoia affinis Lesq.
Lauraceae	*Lindera "protostrychnifolia"* K. Suzuki
	Machilus "protojaponicus" K. Suzuki
	Neolitsea "protoaciculata" K. Suzuki
Ulmaceae	*Zelkova ungeri* Kovats
Moraceae	*Ficus* sp.
Fagaceae	*Castanea miocrenata* Tanai & Onoe
	Quercus protosalicina K. Suzuki
Betulaceae	*Alnus* sp. cf. *A. japonica* Steud.
	Carpinus heigunensis Huzioka
Salicaceae	*Salix* sp.
Rosaceae	*Rosa*? sp.
Poaceae	*Bambusium "yadakeides"* Kon'no
	Phragmites? sp.

11 dicotyledons. The Lauraceae has 3 genera and 3 species, and the Taxodiaceae, Fagaceae, Betulaceae and Poaceae are composed of 2 genera and 2 species each. The remaining families have a single species. All the genera are represented by a single species.

The Bodaira flora consists of cool temperate and warm temperate families. The Aspidiaceae, Taxodiaceae, Lauraceae and Moraceae are warm temperate to tropical families, while the Pinaceae, Ulmaceae, Betulaceae, Salicaceae and Rosaceae are generally temperate ones. The former group has 7 species and the latter has 6 species. Thus, the Bodaira flora consists of warm temperate families with cool temperate ones although poor in the composition.

The assumed habits of the Bodaira species are judged from their living equivalents. Among the 17 species, 9 were trees, 3 were small trees or shrubs, 2 were vines and 3 were herbs. Of the 3 conifers, *Glyptostrobus europeaeus* was deciduous. The following 4 taxa may be assumed to have had an evergreen habit, as judged from thick texture of their leaves or from the abscission regime of their living equivalents: *Lindera "protostrychnifolia"* K. Suzuki, *Machilus "protojaponicus"* K. Suzuki, *Neolitsea "protoaciculata"* K. Suzuki, *Ficus* sp. and *Quercus protosalicina* K. Suzuki

Alnus sp. is abundant in both Bodaira and Kitayama localities, and this species seems to have lived around the depositional sites together with *Bambusites* and with *Glyptostrobus, Salix* and *Phragmites*. *Keteleeria* appears to have grown on mountain slopes near the depositional sites, considering from predominant detached leaves. It may be assumed that evergreen broad-leaved trees such as *Machilus protojaponica* seem to occupy the valley flat together with shrubs of *Lindera, Neolitsea* and vines of *Ficus* and *Rosa*. The valley to the lower slope forest may represent a mixed forest of evergreen trees such as *Quercus protosalicina* and deciduous trees such as *Zelkova, Castanea* and *Carpinus*.

The Chausuyama Flora

The Chausuyama flora from Chausuyama area south of Nagano City were first introduced by Endo (1948). Ohta (1950) and Tomizawa (1962) reported this flora in the form of a list based on the identification by Endo. In the general account of the Japanese Tertiary floras by Tanai (1961), the Chausuyama flora are assigned to the Mitoku type and their components of 20 species were described.

Plant fossils are obtained mainly from an upper part of the southern cliff at the Chausuyama Shizen Koen in the south-east foot of Mt. Chausuyama. It is situated about 3 km

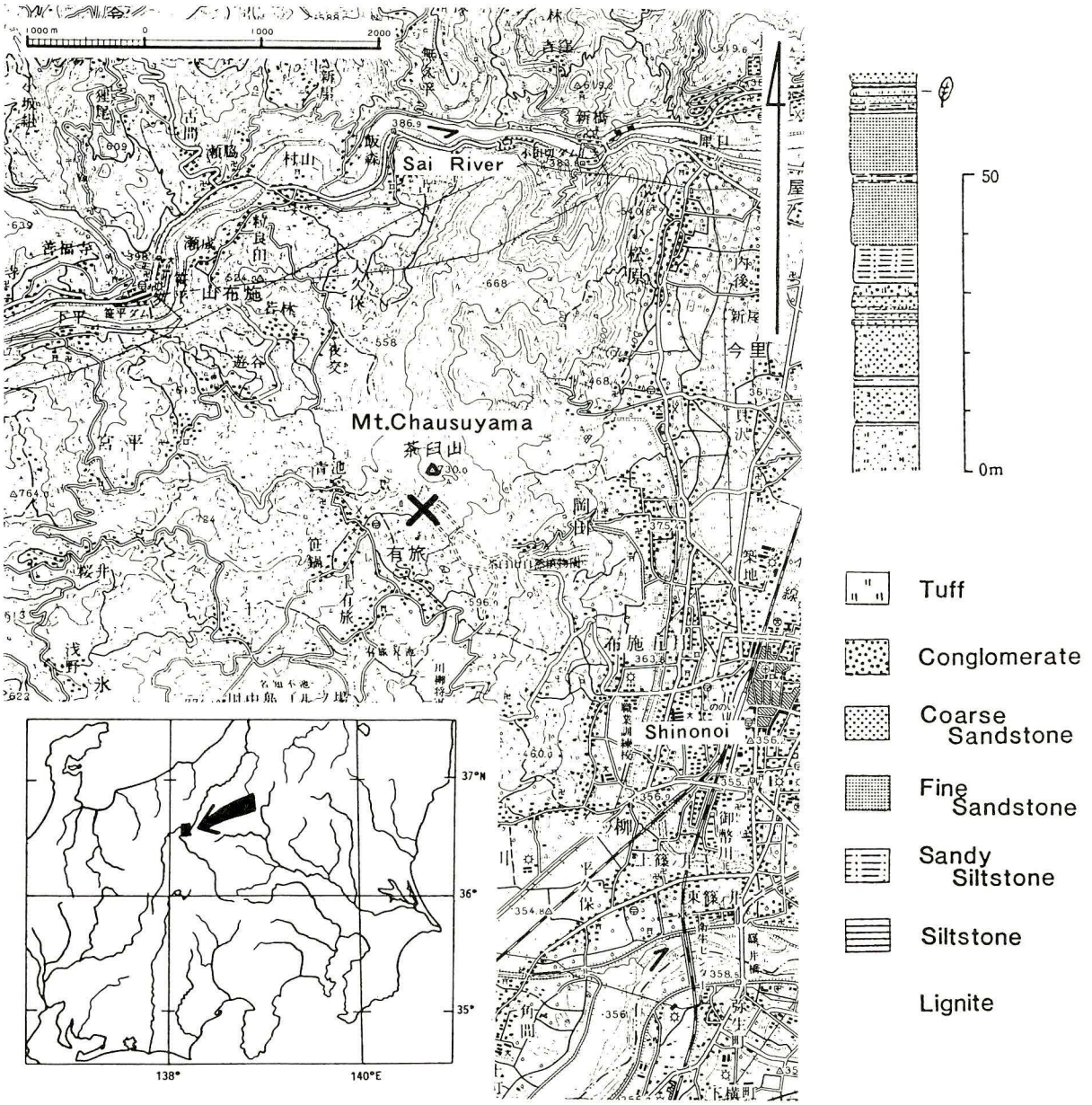

Fig. 13. Locality of the Chausuyama flora in Nagano Prefecture, and the columnar section in the fossil locality.

southwest of Shinonoi Station of JR Shinonoi Line. Well-preserved leaf impressions occur in a tuffaceous siltstone bed. The plant-bearing rocks belong to the basal part of the Chausuyama quartzose sandstone and mudstone Formation by Tomizawa (1962), the Odagiri Member by Saito (1962) and the Komiji Member by Kimura and Hayashi (1988). This fossil locality is included in a known landslide area, and well-preserved plant fossils were reported to have occurred in boulders within landslide debris. But this area has been improved as the park. Most of the plant fossils reported from Chausuyama by many authors probably come from the correlative of my plant-bearing rock level, as inferred from the lithologic character. I identified 39 species, including 4 ferns, 7 conifers and 3 monocots. *Alnus* sp. cf. *A. japonica* takes up nearly half of the total specimens. *Glyptostrobus* and *Phragmites*? sp. are also predominant, represented by 6 percent of the totals each. Judging from the species composition and their relative abundance, the assemblage from the locality strongly reflects a riparian

habitat. I examined the specimens which were reported from Chausuyama by Ohta (1950) and Tomizawa (1962), but no species is added in my floral list.

Systematic Representation

The Chausuyama flora is composed of 26 families, 35 genera and 39 species. There are 3 ferns, 7 conifers, 3 monocotyledons, and the remainders are dicotyledons. The predominant families are the Pinaceae, Taxodiaceae with 3 genera and 3 species each, and the Aceraceae with 1 genus and 3 species. The Athyriaceae, Lauraceae, Salicaceae, Styracaceae and Poaceae have 2 genera and 2 species each, and the Ericaceae has 1 genus and 2 species. The remaining families have a single species.

The Chausuyama flora consists both of warm temperate and cool temperate families. The Athyriaceae, Taxodiaceae, Lauraceae and Styracaceae are warm temperate to tropical families. While the Pinaceae, Salicaceae, and Aceraceae are generally cool temperate ones. Thus, the Chausuyama flora consists of warm temperate families accompanied with cool temperate ones.

Table 34. Systematic List of Families and Species

Blechnaceae	*Woodwardia* sp.
Athyriaceae	*Cornopteris* sp.
	Diplazium sp.
Pinaceae	*Abies protofirma* Tanai
	Pseudotsuga tanaii Huzioka
	Tsuga miosieboldiana Ozaki
Taxodiaceae	*Glyptostrobus europaeus* (Brongniart) Heer
	Sequoia affinis Lesq.
	Taxodium dubium (Sternb.) Heer
Cupressaceae	*Thuja nipponica* Tanai & Onoe
Magnoliaceae	*Magnolia* sp.
Lauraceae	*Cinnamomum* sp. cf. *C. camphora* Sieb.
	Sassafras sp.
Ulmaceae	*Zelkova ungeri* Kovats
Moraceae	*Ficus* sp.
Juglandaceae	*Juglans japonica* Tanai
Betulaceae	*Alnus* sp. cf. *A. japonica* Steud.
Sterculiaceae	*"Ficus" tiliaefolia* Heer
Salicaceae	*Populus hokiensis* Ozaki
	Salix sp. cf. *S. integra* Thunb.
Ericaceae	*Rhododendron hokiense* Ozaki
	Rhododendron sp.
Styracaceae	*Halesia* sp.
	Styrax protoobassia Tanai & Onoe
Symplocaceae	*Symplocos* sp. cf. *S. coreana* (Leveille) Ohwi
Saxifragaceae	*Deutzia* sp.
Fabaceae	*Wisteria fallax* (Nathorst) Tanai & Onoe
Rhamnaceae	*Rhamnus* sp.
Vitaceae	*Vitis naumannii* (Nathorst) Tanai
Aceraceae	*Acer nordenskioeldii* Nathorst
	Acer rotundatum Huzioka
	Acer tricuspidatum Bronn.
	Acer sp.
Rutaceae	*Fagara* sp.
Oleaceae	*Ligustrum*? sp.
Caprofoliaceae	*Lonicera* sp.
Cyperaceae	*Carex* sp.
Poaceae	*Bambusites* sp.
	Phragmites? sp.

Assumed Habits and Leaf Characters

The assumed habits of the Chausuyama species are shown in Table 35, judged from the texture of fossil leaves and from their living equivalents. Twenty trees make up 55.6 percent, 8 small trees or shrubs make up 22.2 percent, 3 vines comprise 8.3 percent and 5 herbs 13.9 percent. Trees were predominant in the Chausuyama members, but the ratio of trees to shrubs is somewhat lower than those of the other 3 floras, and the proportion of the vines and herbs is higher than that of the Sashikiri flora.

Of the 7 conifers, *Glyptostrobus europaeus* and *Taxodium dubium* were deciduous. The following three taxa may be assumed to have had an evergreen habit as judged from the thick texture of their leaves and from the abscission regime of their living equivalents: *Cinnamomum* sp. cf. *C. camphora* Sieb., *Ligustrum*? sp. and *Ficus* sp. It is considered that *Woodwardia* sp. was also evergreen, judging from its living equivalents.

Table 35. Assumed Habit and Leaf Characters of the Chausuyama Plants

Species	Habit	Leaf Characters
Abies protofirma	Tree	EC
Glyptostrobus europaeus	Tree	DC
Pseudotsuga tanaii	Tree	EC
Sequoia affinis	Tree	EC
Taxodium dubium	Tree	DC
Thuja nipponica	Tree	EC
Tsuga miosieboldiana	Tree	EC
Acer nordenskioeldii	Tree	Ds
Acer rotundatum	Tree	Ds
Acer tricuspidatum	Tree	Ds
Alnus sp. cf. *A. japonica*	Tree	Ds
Cinnamomum sp. cf. *C. camphora*	Tree	Ee
Halesia sp.	Tree	Ds
Juglans japonica	Tree	Ds
Magnolia sp.	Tree	De
Populus hokiense	Tree	Ds
Sassafras sp.	Tree	Ds
Styrax protoobassia	Tree	Ds
Symplocos sp. cf. *S. coreana*	Tree	Ds
Zelkova ungeri	Tree	Ds
Deutzia sp.	ST or Shrub	Ds
Fagara sp.	ST or Shrub	Ds
Ligustrum? sp.	ST or Shrub	Ee
Lonicera sp.	ST or Shrub	De
Rhamnus sp.	ST or Shrub	Ds
Rhododendron hokiense	ST or Shrub	De
Rhododendron sp.	ST or Shrub	De
Salix sp. cf. *S. integra*	ST or Shrub	Ds
Ficus sp.	Vine	Ee
Vitis naumannii	Vine	Ds
Wisteria fallax	Vine	De
Carex sp.	Terr. Herb	
Cornopteris sp.	Terr. Herb	
Diplazium sp.	Terr. Herb	
Phragmites? sp.	Terr. Herb	
Woodwardia sp.	Terr. Herb	
"Ficus" tiliaefolia		De

ST : Small Tree Terr. : Terrestrial D : Deciduous E : Evergreen C : Conifer s : Serrate broad-leaf
e : Entire broad-leaf

Numerical Representation

The following quantitative appraisal of the Chausuyama flora is based on a count of 266 specimens from a single locality. Of the 39 Chausuyama species, 17 species represent more than 1 percent in leaf counting and make up 89.1 percent of the total specimens. *Alnus* sp. cf. *A. japonica* Steud. occupies nearly a half of the total specimens. *Glyptostrobus europaeus, Phragmites*? sp. and *Bambusites* sp. exceed 5 percent in number of specimens. These predominant species seem to have lived near the depositional sites. It is noteworthy that the predominant species till the ninth, except the seventh species (*Ligustrum*? sp.) are all water-loving species, considering from the living equivalents. The abundance of these species along with three species of fern indicates that there was well-watered flood-plain or valley flats flanking the depositional sites. The Chausuyama flora has many conifers such as *Abies, Tsuga, Pseudotsuga, Sequoia* and *Thuja*. Judging from that all of them except for *Sequoia* are represented by detached leaves on the rather coarse-grained rocks and from the habitats occupied by similar living plants, it may be assumed that a conifer forest appears to have grown on mountain slopes nearby the depositional sites. It is suggested that the evergreen species such as *Cinnamomum* cf. *camphora* was a members of lower slopes along with *Halesia* and *Sassafras*, considering from their small representation. Despite of scant representation, many species of fern probably formed the understory of the Chausuyama forest.

The ratio of the entire-margined broad-leaved species to the total broad-leaved species is 9/25 that makes up 36.0 percent.

Table 36. Numerical Representation of the Chausuyama Species

Species	Number of specimens	Percentage
Alnus sp. cf. *A. japonica*	125	47.0
Phragmites? sp.	16	6.0
Glyptostrobus europaeus	16	6.0
Bambusites sp.	14	5.3
"Ficus" tiliaefolia	11	4.1
Acer tricuspidatum	10	3.8
Ligustrum? sp.	6	2.3
Sequoia affinis	6	2.3
Taxodium dubium	5	1.9
Abies protofirma	4	1.5
Acer sp.	4	1.5
Tsuga miosieboldiana	4	1.5
Woodwardia sp.	4	1.5
Carex spp.	3	1.1
Lonicera sp.	3	1.1
Pseudotsuga tanaii	3	1.1
Rhododendron hokiense	3	1.1
Cinnamomum sp. cf. *C. camphora*	2	0.8
Cornopteris sp.	2	0.8
Diplazium sp.	2	0.8
Fagara sp.	2	0.8
Halesia sp.	2	0.8
Sassafras sp.	2	0.8
Symplocos sp. cf. *S. coreana*	2	0.8
Acer nordenskioeldii	1	0.4
Acer rotundatum	1	0.4
Deutzia sp.	1	0.4
Ficus sp.	1	0.4
Juglans japonica	1	0.4
Magnolia sp.	1	0.4
Rhamnus sp.	1	0.4
Rhododendron sp.	1	0.4
Salix sp. cf. *S. integra*	1	0.4
Styrax protoobassia	1	0.4
Thuja nipponica	1	0.4
Vitis naumannii	1	0.4
Wisteria fallax	1	0.4
Zelkova ungeri	1	0.4
sum	266	100.7

Distribution of the Allied Living Species

Table 37 shows the most allied living species of the Chausuyama species and their distribution in East Asia.

Table 37. Distribution of the Allied Living Species

Fossil species	Most allied living species	1	2	3	4	5	6	7
Cinnamomum sp. cf. *C. camphora*	*C. camphora* Sieb.	*	*	—	—	—	—	—
Fagara sp.	*F. fauriei* Nakai	*	*	*	—	—	—	—
Ficus sp.	*F. pumila* Linn.	*	*	*	—	—	—	—
Glyptostrobus europeaeus	*G. pensilis* K. Koch	*	*	*	—	—	—	—
Woodwardia sp.	*W. orientalis* Swartz.	*	*	*	—	—	—	—
Cornopteris sp.	*C. fluvialis* (Hayata) Tagawa	—	*	*	—	—	—	—
Ligustrum? sp.	*Ligustrum.* sp.	—	*	*	—	—	—	—
Taxodium dubium	*T. distichum* Rich.	—	*	*	—	—	—	—
Sassafras sp.	*S. tsumu* Hemsl.	—	*	*	*	—	—	—
Rhododendron hokiense	*R. kaempferi* Planch.	—	*	*	*	*	—	—
Sequoia affinis	*S. sempervirens* Endl.	—	*	*	*	*	—	—
Wisteria fallax	*W. floribunda* (Willd.) DC.	—	*	*	*	*	—	—
Zelkova ungeri	*Z. serrata* Makino	—	+	*	*	—	—	—
Abies protofirma	*A. firma* Sieb. et Zucc.	—	—	*	*	—	—	—
Acer nordenskioeldii	*A. palmatum* Thunb.	—	—	*	*	—	—	—
Acer tricuspidatum	*A. pycnanthum* K. Koch	—	—	*	*	—	—	—
Juglans japonica	*J. ailanthifolia* Carr.	—	—	*	*	—	—	—
Pseudotsuga tanaii	*P. japonica* Shirasawa	—	—	*	*	—	—	—
Tsuga miosieboldiana	*T. sieboldii* Carr.	—	—	*	*	—	—	—
Acer rotundatum	*A. mono* Maxim.	—	—	*	*	*	—	—
Alnus sp. cf. *A. japonica*	*A. japonica* Steud.	—	—	*	*	*	—	—
Populus hokiensis	*P. sieboldii* Miq.	—	—	*	*	*	—	—
Salix sp. cf. *S. integra*	*S. integra* Thunb.	—	—	*	*	*	—	—
Symplocos sp. cf. *S. coreana*	*S. coreana* (Lev.) Ohwi	—	—	*	*	*	—	—
Diplazium sp.	*D. squamigerum* (Mettenius) Matsum.	—	—	—	*	*	—	—
Styrax protoobassia	*S. obassia* Sieb. et Zucc.	—	—	—	*	*	—	—
Thuja nipponica	*T. standishii* Carr.	—	—	—	*	*	*	—
Vitis naumannii	*V. coignetiae* Pulliat	—	—	—	+	*	—	—

1) Subtropical forest zone 2) Lower warm temperate forest zone 3) Upper warm temperate forest zone
4) Lower cool temperate forest zone 5) Upper cool temperate forest zone 6) Subalpine forest zone 7) Alpine forest zone

The total number of species in each forest zone and the percentages for the cumulative number of species in all zones are shown as follows:

Forest Zone	1	2	3	4	5	6	7	Sum
No. of Species	5.0	12.5	23.0	19.5	12.0	1.0	0.0	73.0
Percentage	6.8	17.1	31.5	26.7	16.4	1.4	0.0	99.9

The cumulative numbers of the species of the Chausuyama flora is the largest in the upper warm temperate forest zone (zone 3), with 23 species taking up 31.5 percent of the total of all zones. Next come the lower cool temperate forest zone (zone 4), and the lower warm temperate forest zone (zone 2). The living species most allied to the Chausuyama species of the cool temperate families range well to the warmer zones except some species. All the living species most similar to the fossil ferns are now growing in the warm temperate to subtropical regions.

Inferring from the distribution of the allied living plants, the Chausuyama flora bears a close resemblance to the existing forest of the upper warm temperate zone in East Asia.

Assumed Habitat

Table 38 shows assumed habitats of the Chausuyama plants. The four species of the swamp community seem to have inhabited in the lake-shore, and also on stream sides in the region. The abundance of *Alnus* cf. *japonica* (47.0%) indicates that dense stands of alder lined the lake and stream margin swamps, along with *Phragmites* (6.0%) and *Glyptostrobus* (6.0%). On moist tracks such as valley bottom and stream border, *Acer tricuspidatum* and *"Ficus" tiliaefolia* were probably common along with *Woodwardia, Cornopteris* and other ferns. *Bambusites* (5.3%) is considered to be a predominant member in a well-drained, moist, valley sites along with *Sequoia affinis*. The lower slope forest was composed of deciduous hardwoods, and was mixed with evergreen broad-leaved trees. Some conifers represented by detached leaves such as *Abies, Pseudotsuga, Thuja* and *Tsuga,* probably found their most luxuriant growth in the mountain slope forest.

Table 38. Assumed Habitat of the Chausuyama Species.

Species	1	2	3	4
Alnus cf. *japonica*	*	*		
Glyptostrobus europaeus	*	*		
Phragmites? sp.	*	*		
Taxodium dubium	*	*		
Acer tricuspidatum		*		
Bambusites sp.		*		
Cornopteris sp.		*		
Diplazium sp.		*		
"Ficus" tiliaefolia		*		
Juglans japonica		*		
Salix cf. *integra*		*		
Woodwardia sp.		*		
Zelkova ungeri		*		
Acer nordenskioeldii		*	*	
Lonicera sp.		*	*	
Populus hokiensis		*	*	
Sequoia affinis		*	*	
Symplocos cf. *coreana*		*	*	
Wisteria fallax		*	*	
Cinnamomum cf. *camphora*			*	
Deutzia sp.			*	
Fagara sp.			*	
Ficus sp.			*	
Halesia sp.			*	
Lonicera sp.			*	
Magnolia sp.			*	
Rhamnus sp.			*	
Rhododendron hokiense			*	
Sassafras sp.			*	
Styrax protoobassia				*
Abies protofirma				*
Pseudotsuga tanaii				*
Thuja nipponica				*
Tsuga miosieboldiana				*

1 : Aquatic or Marsh 2 : Riparian or Valley 3 : Lower Slope 4 : Mountain Slope

Summary

The Chausuyama flora of 39 species in 26 families and 35 genera occurs in a fine acidic tuff bed at the base of the Komiji Member of so-called Ogawa Formation in the Chaysuyama area south of Nagano City in Nagano Prefecture. The formation in this area is made up largely of coarse quartzose sandstone that was probably derived from the unconformably underlaid Susobana tuff Member. The formations in this area are generally of brackish origin, but are complex with a wide variety of sedimentary facies and grades westward into thick mudstones of marine origin.

The Chausuyama flora is characterized by abundant occurrence of water-loving plants and by having many warm-temperate plants such as *Woodwardia, Cornopteris, Taxodium, Sequoia* and *Cinnamomum*. The coastal plain was covered mainly by mesic plants, and the hills and lower slope were covered by conifers with evergreen and deciduous broad-leaved trees, lacking the beech which was predominant in the Sashikiri flora. The ratio of the entire-margined broad-leaved trees is 36.0 percent. This flora implies a period when the growth of plants of the warm-temperate zone such as evergreen Lauraceae and *Woodwardia* was possible to live and the evergreen broad-leaved forest expanded its domain. Hill to lower slope areas seem to have been covered by evergreen-mixed conifer forest.

The Ohoka Flora

The Ohoka Flora is composed of 27 families, 34 genera and 37 species, of which 26 species were collected from the Kabauchi locality by the author. The Kabauchi locality is in an outcrop along the road about 400 m northwest of Kabauchi, Ohoka-mura. It is 8 km northwest of Hijirikogen Station of the JR Shinonoi Line. The plant-bearing rocks consist of alternation of conglomerate, sandstone and siltstone, and correspond to the Takahagi Formation of Saito (1962) or the upper part of the Komiji Member of Kato (1980) or the lower part of the Nagaiwa Member of Kimura and Hayashi (1988). Plant fossils are obtained from a thin lenticular siltstone bed within the alternation. The following species were collected from this locality:

Taxodium dubium (Sternb.) Heer	1
Cercidiphyllum crenatum (Unger) Brown	1
Celtis sp.	1
Pterocarya asymmetrosa Kon'no ex Tanai	1
Alnus sp. cf. *A. japonica* Steud.	5
Carpinus sp.	1
Tilia sp.	2
"Ficus" cf. *tiliaefolia* Heer	28
Salix parasachalinensis Tanai et Suzuki	1
Salix sp.	1
Symplocos sp.	1
Deutzia sp.	1
Rosa usyuensis Huzioka?	1
Cladrastis aniensis Huzioka	1
Sophora? sp.	1
Daphne? sp.	3
Ilex sp.	1
Staphylea sp.	2
Acer sp.	1
Fagara sp.	3
Callicarpa sp.	2
Berchemia sp.	3
Ehretia? sp.	1
Ligustrum? sp.	3
Syringa? sp.	1
Bambusites sp.	24

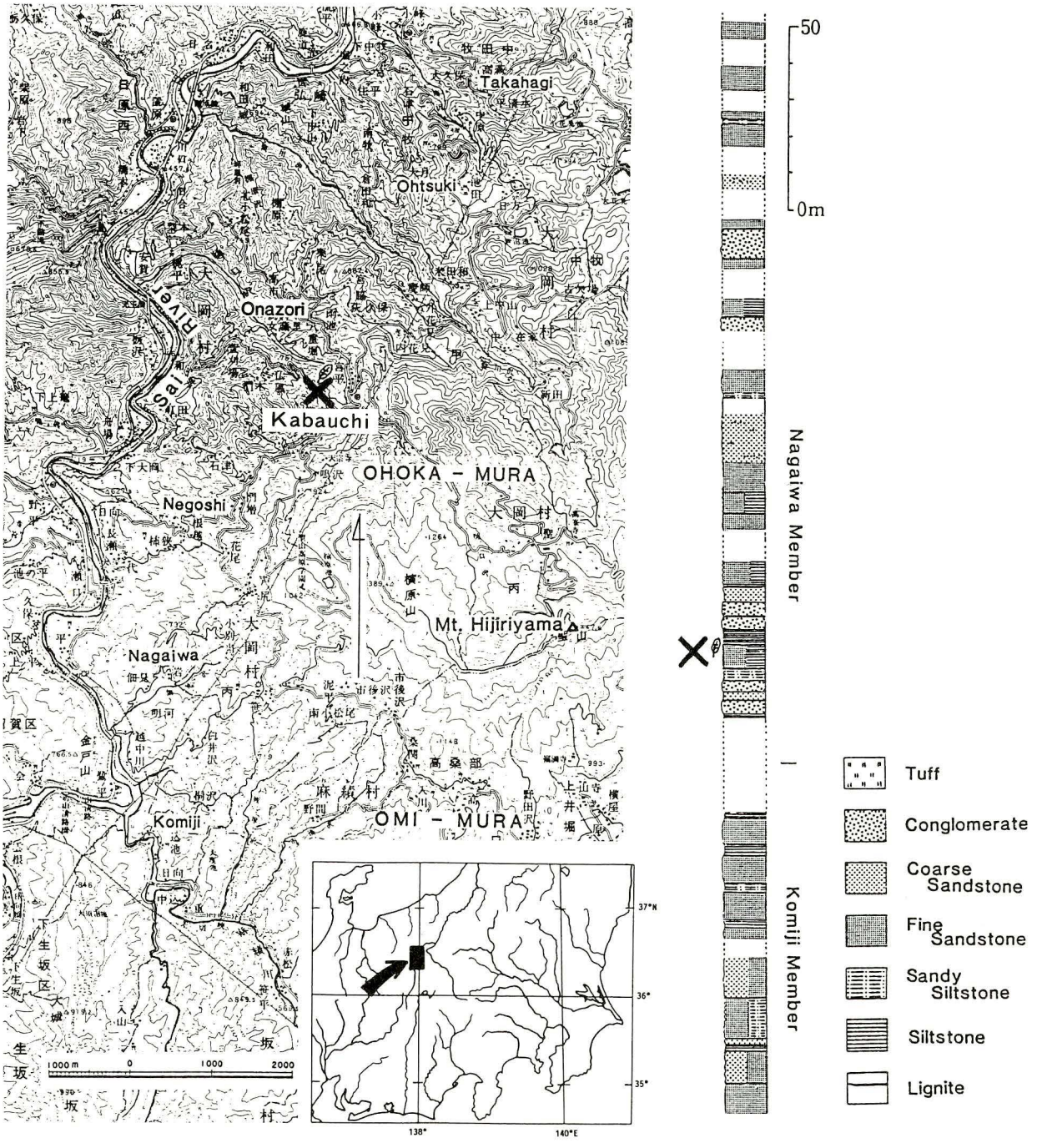

Fig. 14. Localities of the Ohoka flora in Ohoka-mura, Nagano Prefecture, and columnar section from Kabauchi to Onazori.

Sixteen species were cited or figured by Kon'no (1931) from Negoshi, Kabauchi, Takahagi and Ohtsuki localities, all of which are situated west of Mt. Hijiriyama. Kon'no (1931) considered that the plants from these localities are the members of the Omi flora ; the first three localities were considered to belong to the lower Kangawa-Yamazaki florule and the last one was to the upper Bodaira florule. All these localities reported by Kon'no are precisely unknown, but a recent stratigraphic studies (Kimura and Hayashi, 1988) revealed that the areas including these localities are occupied by the Komiji or Nagaiwa Members of the Ohoka Formation.

The plants reported by Kon'no are listed as follows :

Bambusites yadakeides Kon'no (MS)	K
Dolichites koyamae Kon'no (MS)	K
Ficus cf. *faveolata* Wall.	K
Lindera subtriloba Kon'no (MS)	K
Phragmites? sp.	K
Salix sp.	K
Pterocarya asymmetrosa Kon'no ex Tanai	K, N
Wisteria fallaxi (Nathorst)	K, N
Acer cf. *rotundatum* Huzioka	N
Fagus cf. *pliocenica* Sap.	N
Liquidambar protopalmata (Suzuki) Uemura	N
Fagara natsumei Kon'no (MS)	O
Gleditsia sp.	O
Ilex subcornuta Huzioka et Uemura	O
Acer nordenskioeldii Nathorst	T
Populus cf. *balsamoides* Goepp.	T

K : Kabauchi N : Negoshi O : Ohtsuki T : Takahagi

Systematic representation

Except for 1 conifers and 2 monocotyledons, all the plants are dicotyledons. The Salicaceae and the Fabaceae have 3 species each, and the Betulaceae, Aquifoliaceae and Oleaceae have 2 species each. The remaining families are represented by only one species. The Cercidiphyllaceae, Ulmaceae, Juglandaceae, Betulaceae, Tiliaceae, Saxifragaceae, Salicaceae, Rosaceae, Aquifoliaceae and Aceraceae are typically temperate. The Lauraceae, Hamamelidaceae, Fabaceae, Rutaceae, and Boraginaceae are distributed generally warm temperate or tropical regions. Thus, the Ohoka flora is composed mainly by the cool temperate families with some warm temperate to tropical families. A single species of conifer was deciduous. Three evergreen broad-leaved vine and small tree or shrubs, *Ficus* cf. *faveolata, Ilex subcornuta* and *Ligustrum*? sp. are found.

Of 26 species I collected from the Kabauchi locality, *"Ficus"* cf. *tiliaefolia, Bambusites, Cladrastics* and *Alnus* are abundant in the number of specimens. It seems that these plants, together with the other many water-loving plants such as *Taxodium, Cercidiphyllum* and *Pterocarya,* lived near or in the depositional sites and accumulated in the well-drained, moist sites such as back swamp.

The proportion of the evergreen broad-leaved species to the total broad-leaved species is 3/34 that makes up 8.8 percent, and that of the entire-margined species is 10/34 and 29.4 percent.

Assumed Habit and Leaf Characters

The probable habit of the members of the Ohoka flora, judging from their most similar living species, is indicated in Table 40, with 20 trees (58.8%), 10 small trees or shrubs (29.4%) and 3 vines (8.8%). Only a single herb has been found. The Ohoka flora was slightly arboreal ; the ratio of shrubs to trees is higher than those of the Sashikiri flora.

Table 39. Systematic List of Families and Species

Taxodiaceae	*Taxodium dubium* (Sternb.) Heer
Lauraceae	*Lindera "subtriloba"* Kon'no
Cercidiphyllaceae	*Cercidiphyllum crenatum* (Unger) Brown
Hamamelidaceae	*Liquidambar protopalmata* (Suzuki) Uemura
Ulmaceae	*Celtis* sp.
Moraceae	*Ficus* sp. cf. *F. faveolata* Wall.
Juglandaceae	*Pterocarya asymmetrosa* Kon'no ex Tanai
	Juglans japonica Tanai
Fagaceae	*Fagus palaeojaponica* Tanai & Onoe
Betulaceae	*Alnus* sp. cf. *A. japonica* Steud.
	Carpinus sp.
Tiliaceae	*Tilia* sp.
Sterculiaceae	*"Ficus"* cf. *tiliaefolia* Heer
Salicaceae	*Populus* cf. *P. balsamoides* Goepp.
	Salix parasachalinensis Tanai et N. Suzuki
	Salix sp.
Symplocaceae	*Symplocos* sp.
Saxifragaceae	*Deutzia* sp.
Rosaceae	*Rosa usyuensis* Tanai
Fabaceae	*Cladrastis aniensis* Huzioka
	Gleditsia sp.
	Wisteria fallax (Nathorst) Tanai & Onoe
	Sophora? sp.
Thymelaeaceae	*Daphne?* sp.
Aquifoliaceae	*Ilex subcornuta* Huzioka et Uemura
	Ilex sp.
Rhamnaceae	*Berchemia* sp.
Staphyleaceae	*Staphylea?* sp.
Aceraceae	*Acer nordenskioeldii* Nathorst
	Acer cf. *A. rotundatum* Huzioka
Rutaceae	*Fagara* sp.
Verbenaceae	*Callicarpa?* sp.
Boraginaceae	*Ehretia* sp.
Oleaceae	*Ligustrum?* sp.
	Syringa? sp.
Capriofoliaceae	*Weigela intermedia* Kon'no
Poaceae	*Bambusites* sp.
	Phragmites? sp.

Table 40. Assumed Habit and Leaf Characters of the Ohoka Plants

Species	Growth Habit	Leaf Characters
Taxodium dubium	Tree	DC
Acer nordenskioeldid	Tree	Ds
Acer cf. *rotundatum*	Tree	Ds
Alnus cf. *japonica*	Tree	Ds
Carpinus sp.	Tree	Ds
Celtis sp.	Tree	Ds
Cercidiphyllum crenatum	Tree	Ds
Cladrastis aniensis	Tree	De
Ehretia sp.	Tree	Ds
Fagara sp.	Tree	Ds
Fagus palaeojaponica	Tree	Ds
Gleditsia sp.	Tree	Ds
Ilex sp.	Tree	Ds
Juglans japonica	Tree	Ds
Lindera "subtriloba"	Tree	Ds
Liquidambar protopalmata	Tree	Ds
Populus cf. *balsamoides*	Tree	Ds
Pterocarya asymmetrosa	Tree	Ds
Staphylea? sp.	Tree	Ds
Tilia sp.	Tree	Ds
Callicarpa? sp.	ST or Shrub	Ds
Daphne? sp.	ST or Shrub	De
Deutzia sp.	ST or Shrub	Ds
Ilex subcornuta	ST or Shrub	Es
Ligustrum? sp.	ST or Shrub	Ee
Salix parasachalinensis	ST or Shrub	Ds
Salix sp.	ST or Shrub	Ds
Symplocos sp.	ST or Shrub	De
Syringa? sp.	ST or Shrub	De
Weigela intermedia	ST or Shrub	Ds
Berchemia sp.	Vine	De
Ficus cf. *faveolata*	Vine	Ee
Rosa usyuensis	Vine	Ds
Wisteria fallax	Vine	De
Phragmites sp.	Terrestrial Herb	
"Ficus" tiliaefolia		De

ST : Small Tree D : Deciduous E : Evergreen C : Conifer s : Serrate-margined broad-leaf
e : Entire-margined broad-leaf

Table 41. Distribution of the Allied Living Species

Fossil species	Most allied living species	1	2	3	4	5	6	7
Ehretia sp.	*Ehretia* sp.	*	*	*	—	—	—	—
Ficus cf. *faveolata*	*F. nipponica* Fr. et Sav.	*	*	*	—	—	—	—
Ilex subcornuta	*I. cornuta* Lindl.	—	*	*	—	—	—	—
Ligustrum? sp.	*Ligustrum* sp.	—	*	*	—	—	—	—
Liquidambar protopalmata	*L. styraciflua* Linn.	—	*	*	—	—	—	—
Taxodium dubium	*T. distichum* Rich.	—	*	*	—	—	—	—
Fagara sp.	*F. mantchurica* Honda	—	*	*	*	—	—	—
Rosa usyuensis	*Rosa* sp.	—	*	*	*	*	—	—
Salix sp.	*S. koriyanagi* Kimura	—	*	*	*	*	—	—
Wisteria fallax	*W. floribunda* (Willd.) DC.	—	*	*	*	*	—	—
Acer nordenskioeldii	*A. palmatum* Thunb.	—	—	*	*	—	—	—
Berchemia sp.	*B. racemosa* Sieb. et Zucc.	—	—	*	*	—	—	—
Gleditsia sp.	*G. japonica* Miq.	—	—	*	*	—	—	—
Ilex sp.	*I. macropoda* Thunb.	—	—	*	*	—	—	—
Lindera subtriloba	*Parabenzoin trilobum* (Sieb. et Zucc.) Nakai	—	—	*	*	—	—	—
Acer rotundatum	*A. mono* Maxim.	—	—	*	*	*	—	—
Alnus sp. cf. *A. japonica*	*A. japonica* Steud.	—	—	*	*	*	—	—
Callicarpa sp.	*C. japonica* Thunb.	—	—	*	*	*	—	—
Staphylea? sp.	*S. bumbalda* DC.	—	—	*	*	*	—	—
Symplocos sp.	*S. coreana* (Lev.) Ohwi	—	—	*	*	*	—	—
Carpinus sp.	*C. laxiflora* Blume	—	—	+	*	+	—	—
Salix parasachalinensis	*S. sachalinsis* Fr. Schm.	—	—	+	*	*	—	—
Fagus palaeojaponica	*F. japonica* Thunb.	—	—	—	*	+	—	—
Celtis sp.	*C. jessoensis* Koidz.	—	—	—	*	*	—	—
Cercidiphyllum crenatum	*C. japonicum* Sieb. et Zucc.	—	—	—	*	*	—	—
Cladrastis aniensis	*C. platycarpa* (Maxim.) Makino	—	—	—	*	*	—	—
Populus balsamoides	*P. balsamifera* Linn.	—	—	—	*	*	—	—
Pterocarya asymmetrosa	*P. rhoifolia* Sieb. et Zucc.	—	—	—	*	*	—	—
Syringa? sp.	*S. reticulata* (Blume) Hara	—	—	—	*	*	—	—
Weigela sp.	*W. sanguinea* (Nakai) Nakai	—	—	—	*	*	—	—
Tilia sp.	*T. japonica* Simonkai	—	—	—	+	*	—	—

1 : Subtropical forest zone 2 : Lower warm temperate forest zone 3 : Upper warm temperate forest zone
4 : Lower cool temperate forest zone 5 : Upper cool temperate forest zone 6 : Subalpine forest zone 7 : Alpine forest zone

Distribution of the Allied Living Species

Table 41 shows most allied living species of the Ohoka species and their distribution in East Asia and North America. The following table indicates the total number of species in each forest zose (+symbol stands for 0.5) and the percentages for the cumulative number of species in all zones.

Zone	1	2	3	4	5	6	7	Sum
No. of Species	2.0	10.0	21.0	24.5	18.0	0.0	0.0	75.5
Percentage	2.6	13.2	27.8	32.5	23.8	0.0	0.0	99.9

The cumulative number of species is largest in the lower cool temperate forest zone (zone 4) with 24.5 species, taking up 32.5% of the total. Next come the upper warm temperate forest zone (zone 3) with 21 species and 27.8% and the upper cool temperate forest zone (zose 5) with 18 species and 23.8%. The distribution of the most allied living species of the fossils indicates that the Ohoka flora is closely similar to the forests of lower cool temperate zone.

Table 42. Assumed Habitat of the Ohoka Species

Species	1	2	3	4	Species	1	2	3	4
Alnus cf. *japonica*	*	*			*Carpinus* sp.		*	*	
Taxodium dubium	*	*			*Fagara* sp.		*	*	
Acer rotundatum		*			*Populus balsamoides*		*	*	
Berchemia sp.		*			*Rosa usyuensis*		*	*	
Cercidiphyllum crenatum		*			*Staphylea*? sp.		*	*	
Cladrastis aniensis		*			*Symplocos* sp.		*	*	
Ilex subcornuta		*			*Weigela intermedia*		*	*	
Juglans japonica		*			*Daphne*? sp.			*	
Liquidambar protopalmata		*			*Deutzia* sp.			*	
Pterocarya asymmetrosa		*			*Ehretia* sp.			*	
Salix parasachalinensis		*			*Fagus palaeojaponica*			*	
Salix sp.		*			*Ilex* sp.			*	
Tilia sp.		*			*"Lindera" subtriloba*			*	
Wisteria fallax		*			*Sophora*? sp.			*	
"Ficus" tiliaefolia		*			*Celtis* sp.			*	*
Berchemia sp.		*	*		*Ligustrum* sp.			*	*
Callicarpa? sp.		*	*		*Syringa*? sp.			*	*

1 : Aquatic or Swamp 2 : Riparian or Valley 3 : Lower Slope 4 : Mountain Slope

Assumed Habitat

Most of the Ohoka species are included in the members of the riparian or valley and lower slope forests as shown in Table 42. These forests are composed mostly of deciduous hardwoods and vines. Water-loving and sunnier site species, *Cladrastics aniensis*, alders, *"Ficus" tiliaefolia* and other species of this riparian community occupied stream banks in the region; most of them mingled with members of the valley forest. Many deciduous broad-leaved trees seem to have formed dense deciduous slope forest, on which *Fagus stuxbergii* was of most luxuriant growth.

Summary

The Ohoka flora composed of 37 species is from the middle horizon of the Ohoka Formation distributed in Ohoka-mura along the eastern area of Sai River between Nagano and Matsumoto Cities, Nagano Prefecture. The Ohoka Formation unconformably overlies the Susobana tuff Member of the Omi (Ogawa) Formation, and unconformably underlies the Nobusato Formation. The Ohoka Formation is composed mainly of sandstone and siltstone with intercalations of conglomerate, tuff, tuff breccia and lignite. The depositional sites of the Ohoka plants were a coastal plain along the northwestern margin of hills with volcanoes.

The Ohoka flora is composed of mainly broad-leaved deciduous species, lacking nearly in the evergreens. It consists of two communities: wet plain to valley and rather dry slope secondary communities. The Ohoka flora may represent a deteriorated climate in comparison with the Chausuyama flora of the preceding time, and the cool-temperate forests probably spread to the lowland.