Palynological Study of the Peat Sediments around the Last Glacial Maximum at Hikone, the East Shore of Lake Biwa, Japan

Nobuo OOI* and Sei-ichiro TSUJI* : Palynological Study of the Peat Sediments around the Last Glacial Maximum at Hikone, the East Shore of Lake Biwa, Japan

大井信夫*・辻 誠一郎*：琵琶湖東岸の彦根における最終氷期最盛期頃の泥炭堆積物の花粉学的研究

Abstract

The vegetation during the Last Glacial Maximum was reconstructed from the palynological study on the peat sediments of two sites, in which the wide spread tephra, Aira-Tn ash, was included, at the east shore of Lake Biwa. Throughout the period, the upland was covered with mixed forests of conifers, such as *Pinus* subgen. *Haploxylon*, *Tsuga* and *Abies*, and broad-leaved deciduous trees, such as *Quercus* subgen. *Lepidobalanus*, *Betula*, *Carpinus-Ostrya* and *Ulmus*. In the lowland, the vegetation was grassland consisting mainly of Cyperaceae, Gramineae, *Sanguisorba*, *Thalictrum* and Umbelliferae, in which stands of *Alnus*, *Fraxinus*, *Myrica* and *Salix* are mixed. Before the fall of the Aira-Tn ash, *Pinus* subgen. *Haploxylon* increased and *Quercus* subgen. *Lepidobalanus* decreased reflecting the climatic change to cold and dry. At the same time, wetland forest decreased and grasslands developed more widely in lowland. The fall of the Aira-Tn ash caused changes in ground conditions and forest composition: *Tsuga* and *Quercus* subgen. *Lepidobalanus* apparently decreased, while *Betula* and *Alnus* increased.

Key Words: Fossil pollen—Lake Biwa—Last Glacial Maximum—Palaeovegetation—Pleistocene

Flora and vegetation in the Last Glacial Maximum in Japan, and palaeoenvironments based on them have been studied by many researchers. NASU (in KAMEI *et al*., 1981) and TSUKADA (1984) respectively drew vegetation maps of Japan 20,000 years ago, and SOHMA and TSUJI (1987) compiled fossil plant data in Japan using the Aira-Tn ash as a time index. Flora and vegetation in the Last Glacial Maximum are, however, not clarified fully, because studies in inland and montana regions are few compared with those in maritime areas. Those in this period around Lake Biwa have not been studied.

We studied the peat sediments found in 2 sites at Hikone, east shore of Lake Biwa, include the Aira-Tn ash, which is a wide spread time index in the Last Glacial Maximum. In this paper, we describe the fossil pollen assemblages obtained from these peat sediments, and discuss the flora and vegetation in this period around Hikone and influences of the fall of the Aira-Tn ash on vegetation.

Study Sites and Geology

General Geology

In the underground of Koto Plain where the study sites are located, there is the Middle Muds which includes the Aira-Tn ash. The Middle Muds is mainly composed of peat and clay. It uncomformably overlies the Lower Gravels which are sand and gravel of 30,000 to 40,000 years ago, and is uncomformably overlain by the Upper Gravels which consists of sand and gravel of 10, 000 to 15,000 years ago above the Middle Muds (UEMURA and YOKOYAMA, 1983). The level of the Aira-Tn ash becomes lower closer to the lake, which was caused by the tilting accompanying the formation of the lake basin.

The Aira-Tn ash is a wide spread tephra which originated by a giant eruption 21,000 to 22,000 years ago from the Aira Caldera, whose center cone is Sakurajima Island, southern Kyushu (MACHIDA and ARAI, 1976). It was common in Kyushu, Shikoku and Honshu islands, at the bottom of the Japan Sea and also in the southern Korea Peninsula (MACHIDA and ARAI, 1983). In the Kinki District, it is about 20 cm thick, and just

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above it, a thin tephra named the Kitoragawa volcanic ash is often observed (YOSHIKAWA *et al.*, 1986). This series of tephras makes correlation more reliable.

Location and Stratigraphy of Study Sites

The study sites, which are BWH-1 and BWH-2, are at the north portion of the Koto Plain (Fig. 1).

Site BWH-1 is at Obori, Hikone City, alt. ca. 100 m, 35°14'42"N, 136°17'21"E. BWH-1 located along the riverbed of the Seri River. There is a small hill of 200 m height close to the site. At the riverbed of the Seri River, the clayish peat bed about 1 m thick is uncomformably covered by the riverine gravels. The lower part of the peat bed is more clayish and gradually changes to a light grayish clay with granules. Two volcanic ashes with a 2 cm interval are intercalated within the upper part of the peat bed. The lower one, 15 to 20 cm thick layer of volcanic ash, is mostly composed of white-yellow glass. The upper one, about 1 mm thick layer of volcanic ash, consists of white pumice and plenty of heavy mineral such as hornblende and orthpyroxene. These tephras are correlated with the Heian-Jingu volcanic ash and Kitoragawa volcanic ash, respectively (YOSHIKAWA *et al.*, 1986). The Heian-Jingu volcanic ash is correlated with the Aira-Tn ash (MACHIDA and ARAI, 1976). Radiocarbon ages of the two horizons surrounding the peat are 21, 240 ± 730 years BP (GaK-9493) just below the Aira-Tn ash and 16,230 ± 400 years BP (GaK-9492) at lower part of the peat.

Site BWH-2 is at Matsubara, Hikone City, 35° 17'17"N. 136°16'00"E. The sediments from this site were obtained as a boring core. The peat and silt layer, which correlated to the Middle Muds is at a depth of 10.85 to 15.50 m and on elevation of 69.57 to 74.22 m, and between the sand and gravel layers, which are the Upper Gravels and the Lower Gravels respectively(Fig. 2). Two volcanic ashes occur in the peat, at elevations of 73.22 to 73.29 m, and 73.31 m. The lower one is a glassy ash which correlates to the Aira-Tn ash, because it consists mainly of bubble wall type volcanic glass and is in the peat of Middle Muds. The upper one, which is about 1 mm thick, correlates to the Kitoragawa volcanic ash described by YOSHIKAWA *et al.* (1986), because it is located

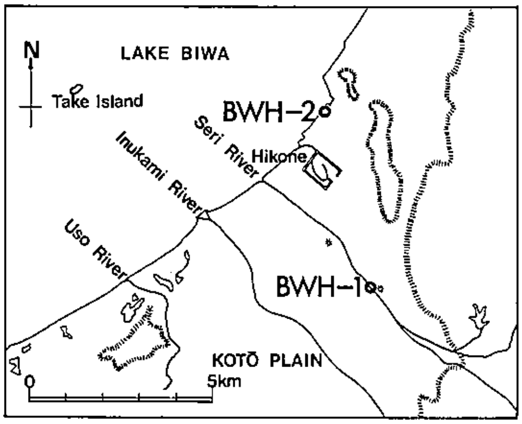

Fig. 1. Locality of the study sites.

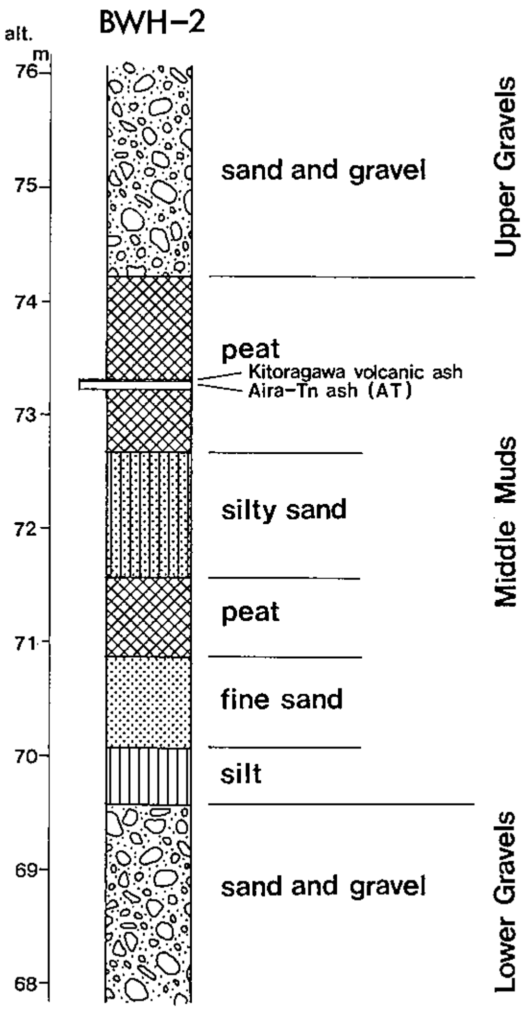

Fig. 2. Columnar section of BWH-2.

just above the Aira-Tn ash and consists of white pumice and a lot of hornblende and orthpyroxene. This peat is undecomposed with a lot of *Menyanthes trifolia* seeds.

Samples and Methods

At BWH-1 samples were taken at 0.5 to 5 cm intervals from the peat bed. The intervals are narrower at just above and below the Aira-Tn ash. At BWH-2, 7 samples was taken at 0.5 to 1 cm intervals from just above and below the Aira-Tn ash. The samples are cut into 3 mm thick segments which weighted about 1 g.

The samples are, first, treated with 10% KOH, decanted, treated with HF, and finally, treated with the acetolysis method. The treated samples were then saturated in glycerin.

For occurrences of *Myrica, Salix, Alnus* and *Fraxinus* pollen, fluctuated greatly from horizon to horizon, arboreal taxa percentages were calculated based on total arboreal pollen counts excluded the above 4 genera. These genera are regarded as local arboreal pollen taxa (LAP). Other pollen taxa and spore type percentages, including local arboreal taxa, were calculated based on total pollen and spores. Arboreal pollen counts exceeded more than 200 for each sample. The count just over the Aira-Tn ash at BWH-1 was only 109 because of poor pollen occurrence.

Results

BWH-1 Fifty-six pollen taxa are recognized in 21 samples of BWH-1 (Fig. 3A). Throughout the all samples, *Quercus* subgen. *Lepidobalanus* is most dominant and some conifers, that is *Tsuga and Pinus* subgen. *Haploxylon*, and deciduous broad-leaved trees, that is *Carpinus-Ostrya, Betula* and *Ulmus*, are common. Local arboreal taxa, that is *Salix, Myrica, Alnus* and *Fraxinus*, and Gramineae, Cyperaceae, *Thalictrum, Sanguisorba* and Umbelliferae are also common.

At the lower part of Fig. 3A, *Pinus* subgen. *Haploxylon* is fewer and temperate conifers such as *Sciadopitys, Cryptomeria* and Taxaceae-Cephalotaxaceae-Cupressaceae, and deciduous broad-leaved trees such as *Pterocarya-Juglans, Acer, Aesculus, Tilia* and *Ligustrum* are more than at the upper part. Wetland trees such as *Alnus* and *Fraxinus* are also more abundant at the lower part. In this part, herbaceous taxa scarcely occur. In particular, Cyperaceae, *Thalictrum* and *Artemisia*, which are common in upper part, are noticeably rare. Fern spores occurred more in the lower part. And consequently, the assemblage just below the Aira-Tn ash is characterized by dominance of *Quercus* subgen. *Lepidobalanus* with arboreal taxa of *Ulmus, Betula, Carpinus-Ostrya, Pinus* subgen. *Haploxylon* and *Tsuga*, and herbaceous taxa of Cyperaceae.

The pollen composition changes remarkbly above the Aira-Tn ash. In arboreal pollen taxa, *Quercus* subgen. *Lepidobalanus* and *Tsuga* decrease, while *Betula* and *Abies* increase. *Eriocaulon* and *Drocera*, which require damp areas, disapper above the Aira-Tn ash. Among the other taxa, *Salix, Alnus, Typha* and *Sanguisorba* increase.

BWH-2 Forty-eight pollen taxa are recognized in 7 samples of BWH-2 (Fig. 3B). Among arboreal pollen taxa, *Pinus* subgen. *Haploxylon, Tsuga, Quercus* subgen. *Lepidobalanus, Carpinus-Ostrya, Betula* and *Ulmus* were common. Pollen composition of BWH-2 resembles to that of BWH-1. But *Quercus* subgen. *Lepidobalanus* is less in BWH-2 than in BWH-1. Among herbaceous taxa, *Iris* and *Lythrum* are found only in BWH-2, while *Drocera* and *Eriocaulon* are not found. Additionally, *Thalictrum* is less and *Menyanthes-Fauria* is more in BWH-2.

Above the Aira-Tn ash, *Tsuga* and *Quercus* subgen. *Lepidobalanus* decrease, on the contrary, *Carpinus-Ostrya, Betula, Ulmus, Alnus* and *Fraxinus* increase. *Abies* increases a little. In herbaceous taxa, Gramineae, Cyperaceae, *Sanguisorba* and *Menyanthes-Fauria* increase and *Typha* appears at the same time. This change of pollen composition is fairly similar to that observed in BWH-1.

Discussion

From the pollen assemblages of BWH-1 and 2, it is clarified that the vegetation around Hikone during the studied period was a mixed forest of conifers and broad-leaved deciduous trees in the uplands, and wetland forests and grasslands at lowlands. Conifers of the mixed forests were represented by *Pinus* subgen. *Haploxylon, Tsuga*, and *Abies*, and deciduous trees were by *Quercus*

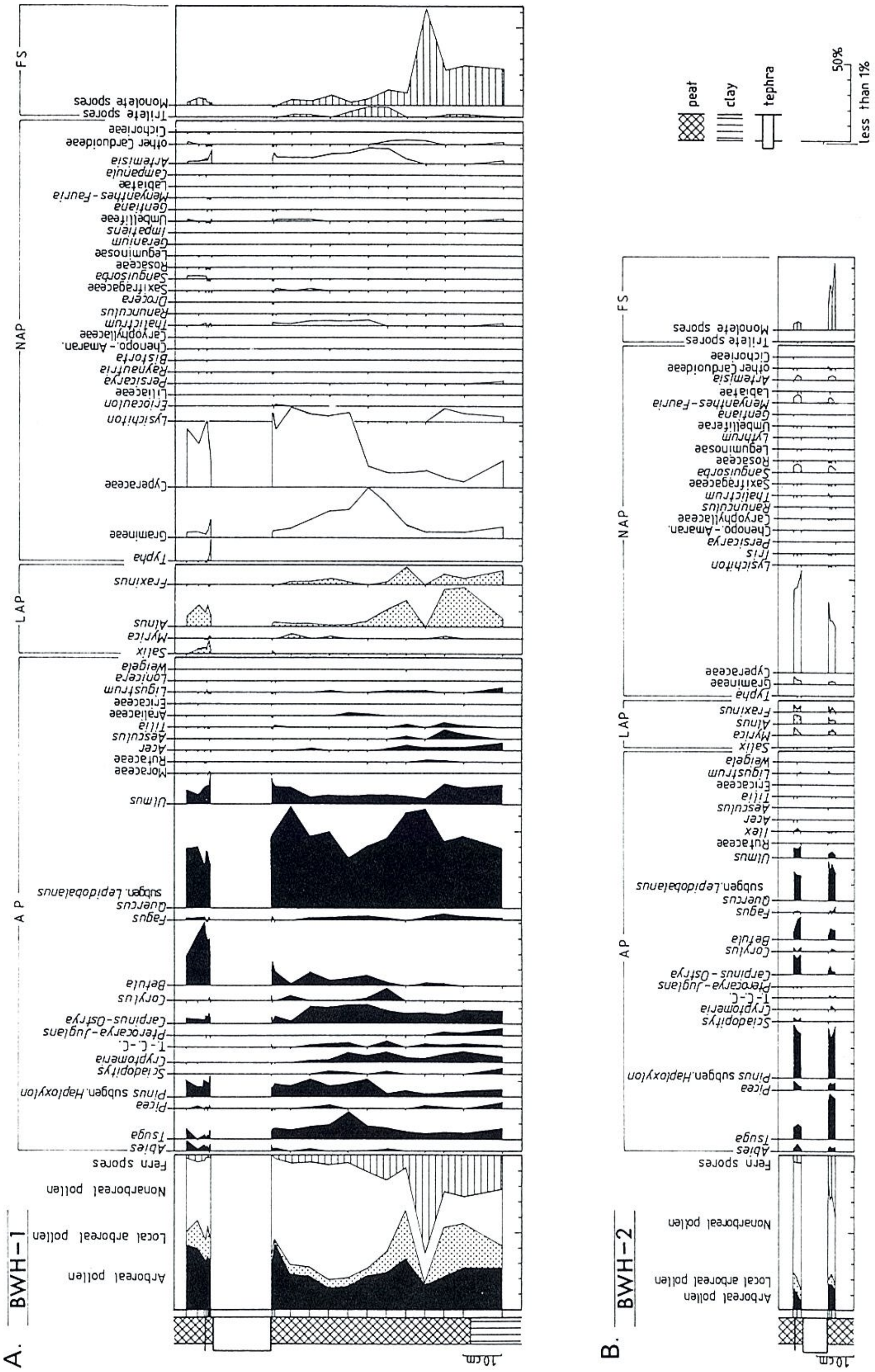

Fig. 3. Pollen and spore diagrams for BWH-1 (A) and BWH-2 (B). Percentages of arboreal taxa based on total arboreal counts, and others based on total pollen and spore counts. AP: arboreal pollen, LAP: local arboreal pollen, NAP: nonarboreal pollen, FS: fern spores, T.-C.-C.: Taxaceae-Cephalotaxaceae-Cupressaceae, Chenopo.-Amaranth.: Chenopodiaceae-Amaranthaceae.

subgen. *Lepidobalanus, Betula, Carpinus-Ostrya* and *Ulmus*. Wetland forests consisted of *Alnus, Fraxinus, Myrica* and *Salix*, and the grasslands consisted mainly of Cyperaceae, Gramineae, *Sanguisorba, Thalictrum* and Umbelliferae.

Although the vegetation was consistent, there are some changes in composition. As indicated in BWH-1, *Pinus* subgen. *Haploxylon* is increasing and temperate conifers and broad-leaved trees are decreasing from the lower part to just below the Aira-Tn ash. It will be regarded as a reflection of the climatic decline, that is decreasing of temperature and precipitation, from interstadial to Last Glacial Maximum. Furthermore, the decrease of wetland trees and ferns, and the increase of herbaceous taxa in number and quantity suggest that lowland vegetation chnaged from wetland forests to grasslands.

After the fall of the Aira-Tn ash, *Tsuga* and *Quercus* subgen. *Lepidobalanus* apparently decreased, while *Betula* and *Alnus* increased, *Abies* increased a little, *Typha* appeared and *Sanguisorba* increased in the two sites. The changes in the arboreal pollen taxa by the ash fall suggest that *Quercus* and *Tsuga* forests were damaged and *Betula* invaded there. The change of vegetation should have been caused by the ash fall through the deposition of ash.

Local conditions of the two sites, however, are slightly different just below the Aira-Tn ash. Hygrophytes found in BWH-1, which were *Drocera* and *Eriocaulon*, while those in BWH-2 are *Menyanthes-Fauria, Iris*, and *Lythrum*. This indicates that BWH-1 was a marsh or wet grassland, while BWH-2 had a marsh with pools of standing water with *Menyanthes trifolia*. This difference relates to their geographical setting, that is BWH-2 is located at lower elevation than BWH-1. Differences in arboreal pollen composition suggest that *Quercus* forests were growing on hills or uplands near the site BWH-1. Among the arboreal taxa, *Quercus* subgen. *Lepidobalanus* was quite dominant with about 40 % in BWH-1, whereas it is less with about 20 % in BWH-2. Just east side of BWH-1, there is a small hill with 200 m height. It may be said that the pollen of *Quercus* subgen. *Lepidobalanus* was originated from the forest of the hill.

Compared to other studies in the Last Glacial Maximum, the pollen flora of Hikone resembles those in the inland basin of the Kinki District, Heian Shrine in Kyoto (NASU, 1970; IKEDA and ISHIDA, 1972; MACHIDA and ARAI, 1976), Tsugeno District, east of Nara (MATSUOKA, 1978), Rokko Island in Kobe (MAEDA, 1985), or in the Japan Sea coast, Lake Mikata in Fukui Prefecture (YASUDA, 1982). In the inland basins, *Pinus* exceeds *Tsuga* (NASU, 1970: MATSUOKA, 1978; MAEDA, 1985), in contrast to the Japan Sea side, where *Tsuga* exceeds *Pinus* (YASUDA, 1982). At Hikone, *Pinus* and *Tsuga* occurred at almost the same percentage below the Aira-Tn ash. Therefore, the pollen composition at Hikone is regarded as an intermediate between those of the inland basins and that of the Japan Sea coast.

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摘　要

湖東平野の地下には中部泥層が分布し，そのなかの泥炭質部分に最終氷期最盛期頃の指標層である姶良 Tn 火山灰（AT）が狭在する。本研究では，湖東平野北部の BWH—1，BWH—2 の 2 地点で AT 前後の泥炭の花粉化石群集を記載し，当時の植物相・植生と，AT 降灰の影響について議論した。当時の彦根周辺の植生は近畿地方の内陸盆地と日本海側に類似したマツ属単維管束亜属・ツガ属・モミ属といった針葉樹とコナラ属コナラ亜属・カバノキ属・ニレ属，シデーアサダ属などの落葉広葉樹の混交林であった。マツ属とツガ属の比率から見ると内陸盆地と日本海側の中間的な植生である。2 地点の違いは局地的な環境を反映し，BWH—1 ではじめじめした湿地，BWH—2 では水位がある湿地に生育する分類群が産出する。また，BWH—1 でコナラ属コナラ亜属が多いのは近くの丘にコナラ属の林があったためであろう。花粉化石群集の変化は，AT 降灰に向かって，気候の寒冷乾燥化に対応した植生の変化と，低地での湿地林から草地への変化を示す。AT 降灰は土壌の荒廃をもたらし，ツガ属・コナラ属コナラ亜属が減少し，カバノキ属・ハンノキ属が増加した。

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表紙写真の説明

輪島市三井町内屋伊勢神社の神紋—橘紋—

橘は，古く田道間守（タジマモリ）が勅命を受けて中国に渡り，持ち帰ったのが，“ときじくのかぐのみ”，すなわち，橘であったと言い伝えられ，宮中の紫宸殿の前庭に，左近の桜とともに右近の橘が植えられた。

こういった史実に基づき，文様として橘が用いられたのは藤原時代にさかのぼる。紋章としては，敏達天皇の皇孫，葛城王を始祖とする橘一門に多いはずであるが，これを家紋とする家系は少い。この理由は，橘氏が，一時政権の座に着いたが，藤原氏の勢力に及ばす，中央での栄達が望めないまま，地方に出て武士となっても，公家の出身故，武勇に優れた人物が出なかったことによると考えられる。江戸期大名家では，近江井伊氏と筑前黒田氏の家紋として知られるぐらいで，井伊家は，藤原氏の出と言うものの，井伊共保出生の折，井戸の傍に一本の橘が植えられていたことから，井筒に橘をあしらった紋を産衣に使ったことから使用されるようになった。また，黒田家は，播磨の豪族小寺氏の家臣であった時，小寺氏から賜わり使用されるようになった。寺紋としては，日蓮宗の紋として有名である。これは，日蓮が井伊家と祖を同じくし，井伊家の庇護を受けたことによる。

写真は，輪島市三井町内屋に鎮座する伊勢神社の拝殿扉に，刻まれている橘紋で、葉の巾がやや細く，先端尖る点が，通常の橘紋と違っている。「石川県神社誌」に，祭神を天照大神と記しているが，何故，橘紋をこの社で採用しているのか不明である。しかし，強いて推察すれば，この社を勧進した有力な氏子代表が，中央から下向した橘氏に縁のある者であったのではなかろうか。

ついでに記すと，“茶実紋（チャノミモン）”は，橘紋と酷似し，区別がむつかしい。（写真・文ともに里見信生）