Memoir of the Fukui Prefectural Dinosaur Museum 3: 31—38 (2004)

XENOXYLON FOSSIL WOODS FROM THE LOWER CRETACEOUS TETORI GROUP IN TOYAMA PREFECTURE, CENTRAL JAPAN

Kazuo TERADA[1], Kenyu NAKAGAWA[2] and Masato FUJITA[3]

[1]Fukui Prefectural Dinosaur Museum, 51-11 Terao, Muroko, Katsuyama, Fukui 911-8601, Japan
[2]Toyama Paleontological Research Club, 100 Nishitakagi, Kosugi, Toyama 939-0303, Japan
[3]Board of Education of Ohyama Town, 523 Kamidaki, Ohyama, Toyama 930-1392, Japan

ABSTRACT

Fossil woods from the Lower Cretaceous Tetori Group collected at two areas (the Kamiichi and the Nagato River areas) in Toyama Prefecture, Central Japan were studied anatomically. In the Kamiichi area, nine fossil woods were collected from the Wasabu Member of the Atotsugawa Formation in the Tetori Group. In the Nagato River area, one washed-out specimen was collected from the Nagato River, so the original horizon is uncertain. Among ten specimens studied, two washed-out specimens from the Omata River and the Nagato River, respectively, were identified as *Xenoxylon latiporosum* (Cramer) Gothan and the third specimen which was found from the strata on left side of the Sengoku River, was regarded as *Xenoxylon* sp. The rest were not identifiable because of poor preservation.

Key words: fossil wood, Tetori Group, Cretaceous, Protopinaceae, *Xenoxylon latiporosum*, Toyama Prefecture

寺田和雄・中川賢勇・藤田将人（2004）富山県下部白亜系手取層群から発見されたゼノキシロン属の材化石．福井県立恐竜博物館紀要３：31－38．

富山県の下部白亜系手取層群の分布する２つの地域（上市地域と長棟川地域）から発見された材化石について材構造を検討した．上市地域では手取層群の跡津川累層和佐府互層から９点の材化石を採集した．長棟川地域では，産出層準はわからないが長棟川から１点の材化石を採集した．この10点のうち，小又川と長棟川の転石として採集した２点は，*Xenoxylon latiporosum* (Cramer) Gothanと同定し，千石川左岸の地層中から採集した１点は*Xenoxylon* sp.と同定した．残りは保存が悪く，同定できなかった．

INTRODUCTION

The Tetori Group is one of representative Mesozoic strata of Japan, chronologically extending from the Middle Jurassic to the Early Cretaceous, and is widely distributed over several prefectures, Fukui, Ishikawa, Gifu and Toyama Prefectures (e.g. Maeda, 1961 ; Yamada, 1988 ; Fujita, 2003). The Group is stratigraphically divided into three subgroups, Kuzuryu, Itoshiro and Akaiwa, in ascending order.

The Tetori Group yields a lot of plant fossils, which consist mainly of ferns and gymnosperms. The plant fossil assemblage is called the Tetori Flora, one of the typical Mesozoic Floras of Japan (e.g. Oishi, 1940 ; Kimura, 1958 ; Kimura and Ohana, 1997 ; Yabe et al., 2003). Petrified fossil woods such as silicified woods have been frequently found throughout the three subgroups (Maeda, 1955b, 1961) ; especially in Hakusan region, *in situ* fossil forests have been reported to occur (Ogura et al., 1951 ; Maeda, 1954, 1955a ; Ishikawa Prefectural Board of Education, 1978 ; Suzuki and Terada, 1992). In earlier studies, however, only one species of coniferous wood *Xenoxylon latiporosum* (Cramer) Gothan has been reported at several localities (Shimakura, 1934, 1936 ; Ogura et al., 1951 ; Suzuki and Terada, 1992 ; Terada et al., 2002).

With regard to the Tetori Group in Toyama Prefecture, Maeda (1956, 1958) reported the occurrence of *Xenoxylon latiporosum* in his geological studies. According to Maeda (1956), a lying trunk of *Xenoxylon latiporosum* ca. 20cm in diameter was discovered in sediments along the Joganji River 400m upstream from the junction with the Shitaka Valley. He also found *X. latiporosum* at upper reaches of the Shiraiwa River. Maeda (1958) reported *X. latiporosum* from the middle reaches of the

---

Corresponding author — Kazuo TERADA
Phone: +81-779-88-0001, Fax: +81-779-88-8710
E-mail: k-terada*dinosaur.pref.fukui.jp
(*を半角@に変えてご入力ください)

Omata River and the south of the Sengoku in the Kamiichi area, although details of fossil localities were not shown. Maeda and Takenami (1957) noted the occurrence of *X. latiporosum* from the Ma River and the Sukenobe-higashi Valley only in their table. Furthermore, Kawai and Nozawa (1958) mentioned that some fragments of *X. latiporosum* were found as gravels within the Ioridanitoge Conglomerate Member of the Nagatogawa Formation exposed along the Kitanomata River (Kawai, 1961). However, there are no reports of *X. latiporosum* identified exactly basing on description of wood structure in the Tetori Group of Toyama Prefecture.

We had opportunities to study some fossil woods from the Lower Cretaceous Tetori Group at two areas (the Kamiichi and the Nagato River areas) in Toyama Prefecture. Here we report the results of anatomical studies on these fossil woods.

MATERIALS AND METHODS

Geological setting of localities

The Tetori Group is distributed in several regions of Toyama Prefecture (Fig. 1) and is divided into the Higashisakamori, Nagatogawa, Atotsugawa, Nagaoyama, and Shiroiwagawa Formations in ascending order (Yamada, 1988). The Higashisakamori Formation is correlated with the Kuzuryu Subgroup, and the Nagatogawa Formation is correlated with the Itoshiro Subgroup, and the Atotsugawa, Nagaoyama, and Shiroiwagawa Formations are correlated with the Akaiwa Subgroup of the Tetori Group in the Hakusan region (Yamada, 1988). The Kuzuryu Subgroup is dated to the Middle to Late Jurassic, and the Itoshiro and the Akaiwa Subgroups are to the Early Cretaceous (Fujita, 2003).

In the Kamiichi area, there are two rivers, the Omata and the Sengoku (Fig. 2). The Tetori Group is in fault contact with the Hida metamorphic rocks and Funatsu Granite along the Omata River, and strikes N 20° to 45° E and dips 20° to 50° N. Andesitic and felsic dyke rocks, which often show columnar joint, intrude the Tetori Group (Board of Education of Toyama Prefecture, 2003). The Tetori Group of this area is divided into the Nagatogawa, Atotsugawa, Nagaoyama, and Shiroiwagawa Formations in ascending order. The Atotsugawa Formation is subdivided into the Minamimatadani Conglomerate and the Wasabu Members in ascending order. The Wasabu Member (Wasabu alternation by Kawai and Nozawa (1958)), which is about 300 meters in thickness, mainly consists of alternating beds of sandstone and mudstone. The sandstone is fine to coarse grained and often shows planar or trough cross-bedding. Thickness of the sandstone ranges from 5 cm to several meters. Sometimes plant rootlets are recognized in the mudstone. Leaf fossils (Filicopsida, Cycadopsida, Ginkgopsida, and Coniferopsida) were collected from the mudstone of this member (Board of Education of Toyama Prefecture, 2003).

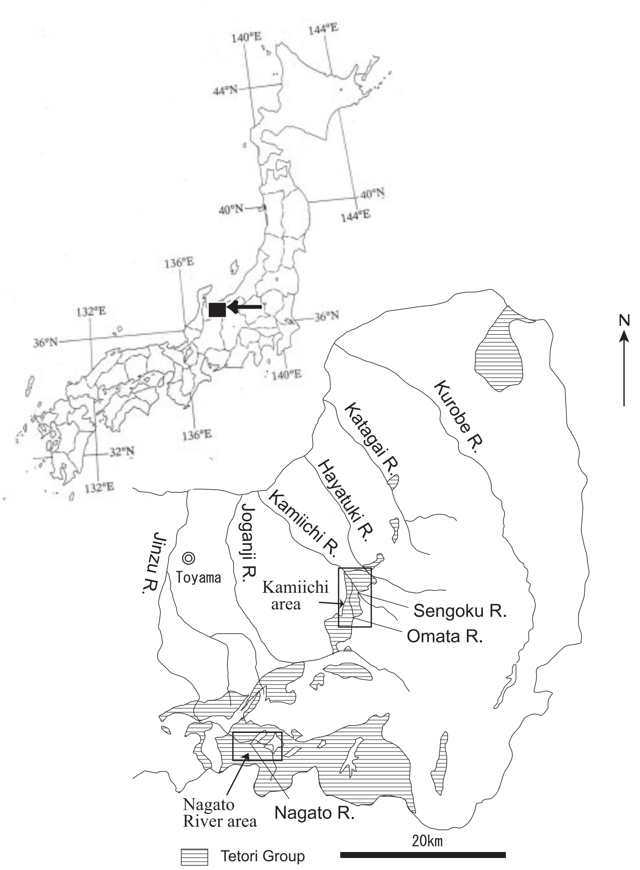

FIGURE 1. The study areas with the distribution of the Tetori Group in Toyama Prefecture.

In the Nagato River area, the Tetori Group strikes N 30° to 70° W and dips 10° to 30° S and is in fault contact with the Hida metamorphic rocks and Funatsu Granite or overlies the Funatsu Granite unconformably (Board of Education of Toyama Prefecture, 2003). Rhyolitic sills, which indicate a date about 90—100 Ma, intrude the Tetori Group in some places (Board of Education of Toyama Prefecture, 2003). The Tetori Group of this area is divided into the Nagatogawa and the Atotsugawa Formations in ascending order. Leaf fossils (Filicopsida, Cycadopsida, and Coniferopsida), turtle bones, molluscan shells and fish ganoid scales were found from the Atotsugawa Formation (Board of Education of Toyama Prefecture, 2003).

Collection and treatment of fossil woods

In the Kamiichi area, all studied fossil woods were found in the Wasabu Member of the Atotsugawa Formation. Six specimens (TYM-7 to 12) were collected from same horizon of the strata on left side of the Omata River (Fig. 2). The horizon is a brown-colored lignitic bed, in which some fossil woods are preserved as lying trunks. Also one specimen (TYM-13) was collected as a washed-out rock in the Omata River at about 1.5 km upstream from the previous locality (Fig. 2). This specimen

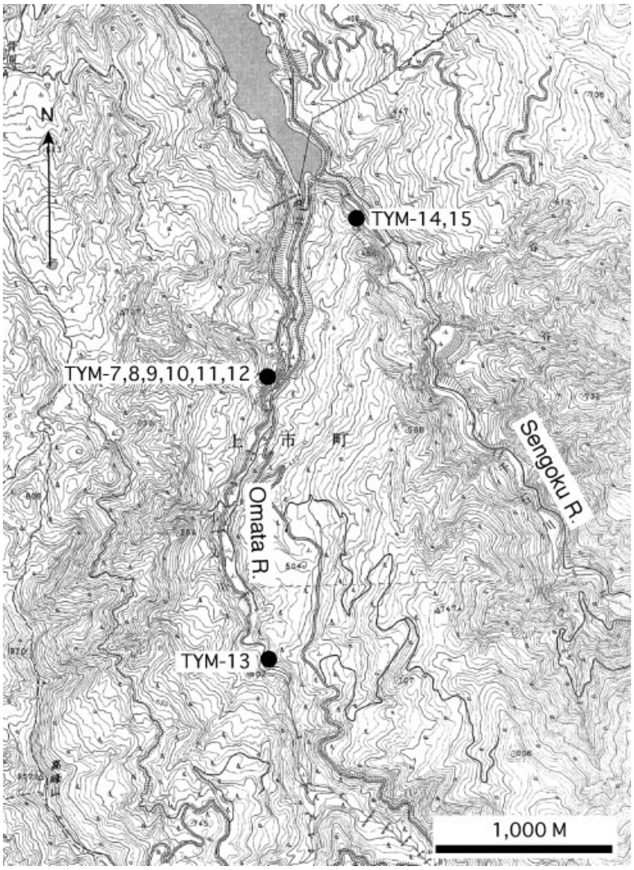

FIGURE 2. Locality map of the Kamiichi area showing collecting points of fossil woods. (using the topographic map of "Ohiwa" scale 1: 25,000 published by Geographical Survey Institute of Japan)

is a fragment of secondary xylem and rather rounded by erosion. Furthermore, two specimens (TYM-14, 15) were collected from the strata on left side of the Sengoku River (Fig. 2). These two specimens are black-colored and carbonized.

In the Nagato River area, only one specimen (TYM-16) was collected as a washed-out rock in the Nagato River (Fig. 3), so the original horizon is uncertain. However, the Nagatogawa Formation is distributed in and around the locality and the Atotsugawa Formation is distributed on the upriver district. This specimen is probably derived from either the Nagatogawa or the Atotsugawa Formations. This specimen is a fragment of secondary xylem and rather rounded by erosion.

Specimens were thin-sectioned in cross, tangential and radial dimensions by a diamond saw, and ground to make thin microscopic slides. These slides were studied and photographed with an optical microscope. Microscopic slides of all specimens are deposited in the Board of Education of Ohyama Town, Toyama Prefecture.

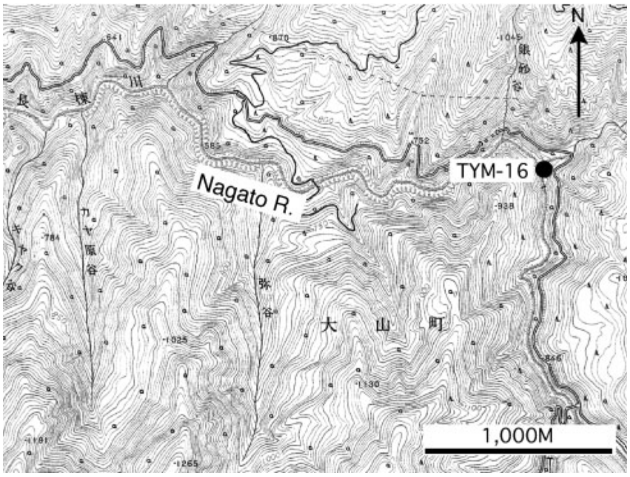

FIGURE 3. Locality map of the Nagato River area showing collecting point of fossil wood. (using the topographic map of "Higashimozumi" Scale 1: 25,000 published by Geographical Survey Institute of Japan)

RESULT

Among ten specimens studied (TYM-7 to 16), six specimens (TYM-7 to 12) collected from the strata on left side of the Omata River in the Kamiichi area have undergone differential mineralizations, and lacked visible internal structure such as Figure 4A. One specimen (TYM-15) collected from the strata on left side of the Sengoku River is carbonized and its internal structure is invisible. Three of ten specimens are identifiable. Two of them, which are washed-out specimens (TYM-13 and 16), from the Omata River and the Nagato River, respectively, were identified as *Xenoxylon latiporosum* (Cramer) Gothan and the third specimen (TYM-14), which is found from the strata on left side of the Sengoku River, was regarded as *Xenoxylon* sp.

SYSTEMATIC PALEONTOLOGY

Class CONIFEROPSIDA
Order CONIFERALES
Family PROTOPINACEAE Kräusel, 1917
Genus *XENOXYLON* Gothan, 1905
Xenoxylon latiporosum (Cramer) Gothan

Pinites latiporosus Cramer, 1868. p. 176, pl. 40, figs. 1—8.
Xenoxylon latiporosum (Cramer) Gothan, 1905. p.38. Shimakura, 1934. p. 9. Shimakura, 1936, p. 278, text-fig. 4, pl. 14, figs.7—8; pl.15, figs. 1—8; pl. 16, figs. 1—3; pl. 17, figs. 6—7. Ogura, 1944, p. 349—352, pl. 3, G—H, text-fig. 1-A. Ogura et al., 1951. p. 113, pl. 9, figs. 1—4. Watari, 1960, p. 511, figs. 1—15. Vogellehner, 1968, p. 144. Suzuki and Terada 1992, p. 91—97, fig. 2-1—9, fig. 3-10—15.

Materials.— TYM-13 and TYM-16, The internal structure of

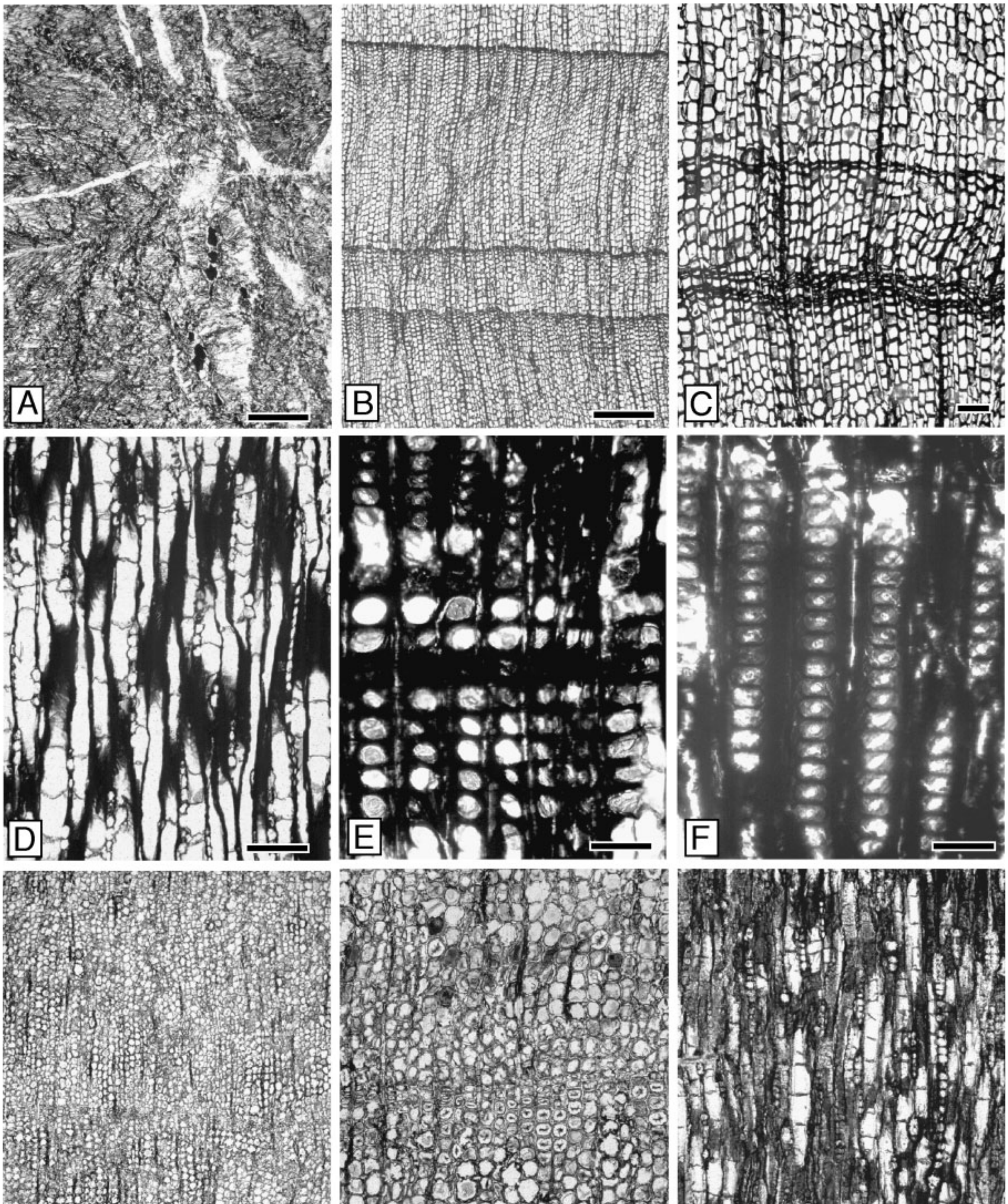

FIGURE 4. Microphotographs of fossil woods. A: TYM-7: Cross section of fossil woods from the strata on left side of the Omata River showing the invisible internal structures. Scale bar: 500 µm. B–F: TYM-16, B: Cross section showing distinct growth rings. Scale bar: 500 µm., C: Magnified cross section showing growth ring boundaries with narrow latewood and a probable false ring. Scale bar 100 µm., D: Tangential section showing uniseriate rays and tracheids with tylosoids. Scale bar: 100 µm., E: Radial section showing numerous large window-like cross-field pits. Scale bar: 50 µm., F: Radial section showing contiguous elliptical bordered pits. Scale bar: 50 µm. G–I: TYM-13: G: Cross section showing indistinct growth rings. Scale bar: 500 µm., H: Cross section showing a growth ring boundary. Scale bar: 100 µm., I: Tangential section showing uniseriate rays and many septa of tylosoids in tracheids. Scale bar: 50 µm.

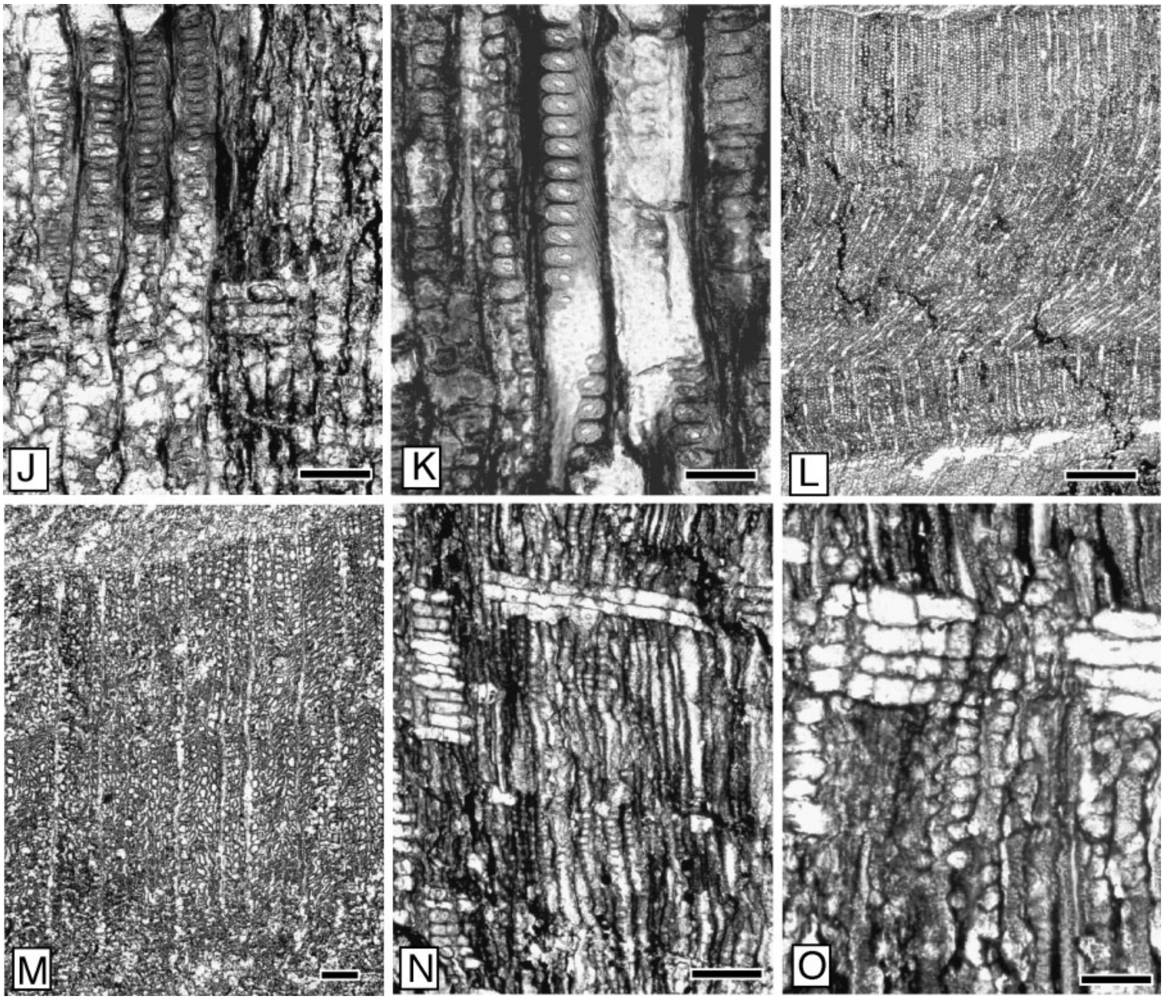

FIGURE 5. Microphotographs of fossil woods. J—K: TYM-13, J: Radial section showing uniseriate, elliptical and contiguous bordered pits on radial walls of tracheids. Scale bar: 100 µm., K: Magnified radial section showing contiguous of elliptical bordered pits and septa of tylosoids in tracheids. Scale bar: 50 µm. L—O: TYM-14, L: Cross section showing indistinct growth ring boundaries. Scale bar: 500 µm., M: Magnified cross section showing two indistinct growth ring boundaries. Scale bar 100 µm., N: Radial section showing bordered pits on radial walls of tracheids. Scale bar: 100 µm., O: Magnified radial section showing indistinct cross-field pits and contiguous bordered pits. Scale bar: 50 µm.

TYM-16 is best preserved among the specimens studied and considerable for investigating in detail. The following description is based on TYM-16.

Repository.— Board of Education of Ohyama Town.

Description.— Wood is coniferous consisting of tracheids and ray parenchyma, and lacks resin cells and resin canals (Fig. 4B). Growth rings are present and distinct; ring width is variable, 0.4 to 2.5 mm (Fig. 4C). Earlywood tracheids are regularly arranged in radial rows, more or less radially elongated; rectangular to elliptical in cross section; 20—50 x 45—75 µm in tangential x radial diameters. Transition from earlywood to latewood is abrupt (Figs. 4B, C). Latewood is very narrow, 1—3 cells in width (Fig. 4C). Latewood tracheids are 25—50 x 10—30 µm in tangential x radial diameters, thin-walled (Fig. 4C). Bordered pits on the radial walls of the earlywood tracheids are arranged contiguously in uniseriate rows (Fig. 4F). The pits are elliptical, vertically compressed and horizontally flattened, 28—32 x 15—20 µm in horizontal x vertical diameters with round to oval aperture of about 7.5 µm in diameter (Fig. 4F). Tracheids are usually occluded by thin-walled tylosoids and look-like as septate tracheids (Fig. 4D). Helical thickenings and crystals are not observed in tracheids. Rays are entirely uniseriate, rather low, 1—10 cells, mostly 4—7 cells tall (15—300 µm), about 15 µm wide in tangential section and composed wholly of parenchyma cells (Figs. 4D, E). Pits are absent on the horizontal and tangential walls of ray cells. Ray cells are sometimes occluded by dark substance, and lacking crystals (Fig. 4E). Cross-field pits are large and window-like, and usually one per field (Fig. 4E).

Note.— The wood structure of TYM-13 is very similar to TYM-16 in all anatomical features, but its preservation of internal structures is rather poor (Figs. 4G—I, 5J, K). Growth rings of TYM-13 are rather indistinct because it is probably compression wood (Figs. 4G, H), which often comprises thick-walled and round earlywood tracheids as seen in Figure 4 H.

Specimen of TYM-14 is quite poor in preservation so it is difficult to observe minutely (Figs. 5L—O). However, the following wood structures are visible. The wood is coniferous consisting of tracheids and ray parenchyma, and lacks resin cells and resin canals (Figs. 5L, M). The growth rings are present but indistinct because it is probably compression wood (Figs. 5L, M), which comprises round tracheids as seen in Figure 5M. The poorly preserved bordered pits on radial wall of the tracheids are probably arranged contiguously in uniseriate rows (Figs. 5N, O). The pit is elliptical or round, 17—20 µm in diameter, with small round apertures (Fig. 5O).

AFFINITY AND DISCUSSION

The fossil woods of TYM-13 and 16 are prominently characterized by the presence of (1) the single, large and window-like cross-field pits, (2) the vertically compressed, elliptical, uniseriate and contiguous bordered pits on radial walls of earlywood tracheids, (3) entirely uniseriate rays with 10 or less cells tall, (4) thin-walled tylosoids in the tracheids, and (5) the absence of vertical parenchyma and resin cells or canals. These features indicate that these fossils are assigned to *Xenoxylon latiporosum* (Cramer) Gothan of the Protopinaceae. With regard to TYM-14, it is difficult to identify exactly this specimen because of poor preservation. However, the following characters of the fossil wood: (1) the coniferous wood consisting of tracheids and ray parenchyma, (2) probably contiguous bordered pits on radial walls of tracheids, and (3) the absence of vertical parenchyma and resin cells or canals, indicate that the fossil wood is a member of *Xenoxylon*.

Xenoxylon latiporosum was firstly described by Cramer (1868) as *Pinites latiporosus* from the Upper Jurassic of Spitzbergen in Norway. Gothan (1905) established the genus *Xenoxylon* based on Cramer's species. In addition to Norway, this species has been reported from large area of the Northern Hemisphere, such as Britain, Poland, Germany, Vietnam, Central Russia, Siberia, China, Korean Peninsula, and Alaska, etc. (Tsunada and Yamazaki, 1987; Philippe and Thevenard, 1996). In Japan, Shimakura (1934) firstly identified a silicified wood from the Tetori Group at Kuwajima, Shiramine in Ishikawa Prefecture as *X. latiporosum*. Then, Ogura et al. (1951) identified all fossil woods collected from 19 sites of the Tetori Group in Ishikawa and Gifu Prefectures as the same species. After that, only the same species, *Xenoxylon latiporosum*, has been reported from the Tetori Group (Ishikawa Prefectural Board of Education, 1978; Suzuki and Terada, 1992; Terada et al., 2002). Besides the Tetori Group, this species has been reported from the Triassic Nariwa Group of Okayama Prefecture (Shimakura and Fujiyama, 1962) and the Jurassic Kuruma Group of Niigata and Toyama Prefectures (Watari, 1960; Suzuki et al., 1982). Our study adds new geographic and stratigraphic information of *X. latiporosum* in the Tetori Group. As earlier workers have pointed out, however, it is very interesting that only one species of fossil wood have been found from the Tetori Group in spite of the discovery of diverse gymnosperm megafossils from the same group.

Xenoxylon latiporosum is the type species of the genus *Xenoxylon* that is a morphotaxon (Greuter et al. 2000) adopted for representative Mesozoic wood, which occurs from the Late Triassic to the Late Cretaceous (Tsunada and Yamazaki, 1987; Philippe and Thevenard, 1996). About ten or more species of *Xenoxylon* have been described worldwide until now (Vogellehner, 1968; Tsunada and Yamazaki, 1987; Philippe and Thevenard, 1996; Ding et al., 2000). Tsunada and Yamazaki (1987) summarized that the distributional change during the Mesozoic as follows: the genus *Xenoxylon* had extended from Europe to Asia in the Northern Hemisphere during the end of the Triassic to the Jurassic, subsequently declined in Europe during the Cretaceous, and finally became isolated in Sakhalin or Alaska in the Late Cretaceous. Philippe and Thevenard (1996) inferred that the distribution of *Xenoxylon* was related to relatively wetter and/or cooler climate on circumpolar continental margin during the Mesozoic based on paleophytogeography of *Xenoxylon* and the continental distribution at that time. Despite the large amount of data for *Xenoxylon*, its taxonomic position is still unclear. Furthermore, the leaves which were originated from the same plant with *Xenoxylon* are not identified yet, but some researchers consider *Podozamites* as a possible candidate. To clarify the taxonomic position of *Xenoxylon*, it is necessary to examine *Xenoxylon* fossil woods in detail, and it is surely expected to discover the leaves and cones associated with the woods.

Recently, large-scale investigations are being carried out in various places of Japan in order to discover vertebrate fossils such as dinosaur fossils in the Tetori Group. Although wood fossils are sometimes found by those investigations, much enough scientific attention is not given for them in many cases. However, in order to clarify local paleoflora and the taxonomic position of *Xenoxylon*, careful examinations for each wood specimen should be required.

ACKNOWLEDGMENTS

We would like to express our thanks to the Board of Education of Toyama Prefecture for the opportunity to study these fossils. We also thank Mr. H. Mizoguchi (Board of Education of Toyama Prefecture) for his help of field research. Special thanks to Prof. Dr. H. Nishida (Chuo University) for his critical comments and useful suggestions on our manuscript.

REFERENCES

Board of Education of Toyama Prefecture. 2003. Report of the Geological Survey of the Tetori Group in Toyama Prefecture. Board of Education of Toyama Prefecture, Toyama, 109 pp.***

Cramer, C. 1868. Fossile Hölzer der arctischen Zone; pp. 167—180 *in* O. Heer (ed.), Flora fossilis arctica —Die Fossile Flora Der Polarländer. Druck und Verlag von Friedrich Schulthess, Zürich.

Ding Q-H., S-L. Zheng, and W. Zhang 2000. Mesozoic Fossil woods of genus *Xenoxylon* from Northeast China and its palaeoecology. Acta Palaeontologica Sinica 39 (2): 237—249.$^{+}$

Fujita, M. 2003. Geological age and correlation of the vertebrate-bearing horizons in the Tetori Group. Memoir of the Fukui Prefectural Dinosaur Museum 2: 3—14.

Gothan, W. 1905. Zur Anatomie lebender und fossiler Gymnospermen-Hölzer. Abhandlungen der Preussischen Geologischen Landesanstalt 44: 1—108.

Greuter, W. et al. (of the Editorial Committee). 2000. International Code of Botanical Nomenclature (Saint Louis Code). Reg. Veg. vol. 138. Koeltz Scientific Books, Königstein, 474 pp.

Ishikawa Prefectural Board of Education (ed.) 1978. Research report on the silicified wood localities of the Tetori Group along the Tedori River. Ishikawa Prefectural Board of Education, 301 pp., 117 pls, 11 maps.***

Kawai, M. 1961. Late Mesozoic crustal movements in the eastern part of the Hida Plateau, Central Japan (Geological study in the Etchu and Hida moutainlands, Gifu and Toyama Prefectures). Bulletin of the Geological Survey of Japan 12: 903—920, pls. 1—3.*

Kawai, M., and T. Nozawa. 1958. Higashimozumi. Explanatory text of the geological map of Japan, scale 1: 50,000, Geological Survey of Japan, 76 pp.*

Kimura, T. 1958. Mesozoic plants from the Tetori Series, Central Honshu, Japan (Part1). Transactions and Proceedings of the Palaeontological Society of Japan, New Series, 29: 166—168, pl. 25.

Kimura, T., and T. Ohana. 1997. Catalogue of the Late Jurassic and Early Cretaceous plant-taxa in Japan. Memoirs of the Geological Society of Japan 48: 176—188.

Kräusel, R. 1949. Die Fossilen Koniferen-Hölzer (Unter Ausschluss von *Araucarioxylon* Kraus). II: Kritische Unertsuchungen zur Diagnostik Lebender und Fossiler Koniferen-Hölzer. Palaentographica, Abteilung B, 89: 83—203.

Maeda, S. 1954. On the Tetori Forest Fossils from the Upper Reaches of the Sho River District, Gifu Prefecture. Research Bulletin of the Geological and Mineralogical Institute Tokyo University of Education 3: 43—47. *

Maeda, S. 1955a. Sedimentary environment of the Tetori fossil forests. The Journal of the Sedimentological Society of Japan 9: 12—13. ***

Maeda, S. 1955b. Biofacies of the Tetori Group. Journal of College of Arts and Sciences, Chiba University. Natural Science Series, 1 (4): 293—299. *

Maeda, S. 1956. Stratigraphy and Geological Structure of the Tetori Group in the Joganji-gawa District, Toyama Prefecture, Japan. Journal of the College of Arts and Science, Chiba University. Natural Science Series, 3 (1): 44—49.*

Maeda, S. 1958. On the Tetori Group in Toyama Prefecture. Jubilee publication in the commemoration of Professor H. Fujimoto sixtieth birthday. 124—134.*

Maeda, S. 1961. On the geological history of the Mesozoic Tetori Group in Japan. Journal of the College of Arts and Science, Chiba University. Natural Science Series, 3 (3): 369—426.*

Maeda, S., and K. Takenami. 1957. Stratigraphy and Geological Structure of the Tetori Group on the Southern District of Toyama Prefecture. Journal of Geological Society of Japan 63: 273—288.*

Ogura, Y. 1944. Note on fossil woods from Japan and Manchoukuo. Japanese Journal of Botany 8: 345—365.

Ogura, Y., T. Kobayashi and S. Maeda. 1951. Discovery of erect stumps of *Xenoxylon latiporosum* in the Jurassic Tetori Series in Japan. Transactions and Proceedings of the Palaeontological Society of Japan, New Series, 4: 113—119.

Oishi, S. 1940. The Mesozoic floras of Japan. Journal of the Faculty of Science, Hokkaido Imperial University, Series 4, 5 (2—4): 123—480, pls. 1—48.

Philippe, M., and F. Thevenard 1996. Distribution and palaeoecology of the Mesozoic wood genus *Xenoxylon*: palaeoclimatological implications for the Jurassic of Western Europe. Review of Palaeobotany and Palynology 91: 353—370.

Shimakura, M. 1934. Notes on fossil woods, III. *Xenoxylon latiporosum* (Cramer) Gothan in the East Asia. Journal of the Geological Society of Japan 41: 9—19. ***

Shimakura, M. 1936. Studies on fossil woods from Japan and adjacent lands, I. Some Jurassic woods from Japan and Manchoukuo. Science Reports of Tohoku Imperial University, Second Series (Geology), 18: 267—310.

Shimakura, M. and I. Fujiyama. 1962. *Xenoxylon latiporosum* from the Triassic Nariwa Group. Journal of the Geological Society of Japan 68: 418—419. ***

Suzuki, M., M. Goto and H. Akahane 1982. Some fossil woods from the Kuruma Group of Toyama and Niigata Prefectures. Annals of Science, College of Liberal Arts, Kanazawa University 19: 43—61. **

Suzuki, M., and K. Terada. 1992. *Xenoxylon* fossil woods from the Lower Cretaceous Akaiwa Subgroup of Shiramine, Central Japan. Journal of Phytogeography and Taxonomy 40: 91—97.

Terada, K., S. Sekido and T. Higashino. 2002. Fossil woods from the Tetori Group at the Mekko Valley, Oguchi, Ishikawa Prefecture; pp. 31—37 *in* Research Report of the Mesozoic Tetori Group in the Tedori River area, Hakusan Nature

Conservation Center, Ishikawa.***

Tsunada, K., and S. Yamazaki. 1987. Distribution of Mesozoic Coniferous Woods in Eurasia, pp. 201—221 *in* A. Taira and M. Tashiro (eds.), Historical Biogeography and Plate Tectonic Evolution of Japan and Eastern Asia. TERRAPUB, Tokyo.

Vogellehner, D. 1968. Zur Anatomie und Phylogenie mesozoischer Gymnospermenhölzer, Beitrag 7: Prodromus zu einer Monographie der Protopinaceae, II. Die protopinoiden Hölzer des Jura. Palaeontographica, Abteilung B, 124: 125—162.

Watari, S. 1960. On some structures and affinity of *Xenoxylon latiporosum*. Journal of Faculty of Sciences, University of Tokyo, Section III, Botany, 7: 511—521.

Yabe, A., K. Terada and S. Sekido. 2003. The Tetori-type flora, revisited: a review. Memoir of the Fukui Prefectural Dinosaur Museum 2: 23—42.

Yamada, K. 1988. Tetori Group; pp. 26—37 *in* N. Yamashita, Y. Kaseno and J. Itoigawa (eds.), Regional Geology of Japan. Part 5, Chubu II, Kyoritsu Shuppan Co., Tokyo.***

* : in Japanese with English abstract
** : in Japanese with English summary
*** : in Japanese
$^{+}$: in Chinese with English abstract

＜　地名・地層名　＞

Akaiwa	赤岩
Atotsugawa	跡津川
Funatsu	船津
Hakusan	白山
Hida	飛騨
Higashisakamori Formation	東坂森累層
Ioridanitoge	庵谷峠
Itoshiro	石徹白
Jinzu River	神通川
Joganji River	常願寺川
Kamiichi	上市
Kitanomata River	北ノ俣川
Kuwajima	桑島
Kuzuryu	九頭竜
Ma River	真川
Minamimatadani	南俣谷
Nagaoyama Formation	長尾山累層
Nagato River	長棟川
Nagatogawa Formation	長棟川累層
Ohyama	大山
Omata River	小又川
Shiraiwa River	白岩川
Shiramine	白峰
Shiroiwagawa Formation	白岩川累層
Shitaka Valley	志鷹谷
Sukenobe	祐延
Tedori River	手取川
Tetori Group	手取層群
Wasabu	和佐府