

Makoto NISHIDA\* & Tōru ŌISHI\*\* : **The identity of  
*Araucarioxylon mineense* and a new species  
of *Protocedroxylon* from the Triassic  
of Mine, Yamaguchi Prefecture\*\*\***

西田 誠\*・大石 徹\*\* : *Araucarioxylon mineense* の帰属と  
*Protocedroxylon* の1新種

(Pl. I-II)

*Araucarioxylon mineense* Ogura (1960) from the Hirabara Pass, Mine City, Yamaguchi Prefecture would be the first Triassic wood known in Japan. This was followed by Nishida et al. (1977) who reported *A. mineense* from the Norian (upper Triassic) of Sekigahara, Gifu Prefecture. Recently Yamazaki et al. (1980) described two species of *Xenoxylon*, *Protocedroxylon triassicum* Yamazaki et al. and *Araucariopitys japonica* Yamazaki et al. from the upper Triassic near Nariwa, Okayama Prefecture. Of these, the latter two species resemble very closely *A. mineense* in gross morphology. In the autumn of 1977, we made a short field trip in Mine City and collected several pieces of silicified wood from the Triassic sandstone on the road side of the Hirabara Pass under the guidance of the late Mr. Goro Okafuji, who was a teacher of biology at Mine High School and had renown for an excellent collector of Triassic plants of Mine district. The present specimens were found by the late Mr. Goro Okafuji from the Mugikawa coal beds of the Momonoki Formation at the Hirabara Pass (Fig. 1). The Mine group consists of three subdivided formations; Hirabara, Momonoki and Aso Formations. The Momonoki Formation consists of 1) Mugikawa cyclic coal-bearing beds (lacustrine deposits), 2) Momonoki deltaic sediments (deltaic deposits) and 3) Omine cyclic coal-bearing beds (lacustrine deposits) (Tokuyama 1958). The Mugikawa cyclic coal-bearing beds consists of three cyclothem intercalated with many

\* Laboratory of Phylogenetic Botany, Faculty of Science, Chiba University. 千葉大学 理学部生物学科.

\*\* Geological Laboratory, College of Education, Yokohama National University. 横浜国立大学 教育学研究科.

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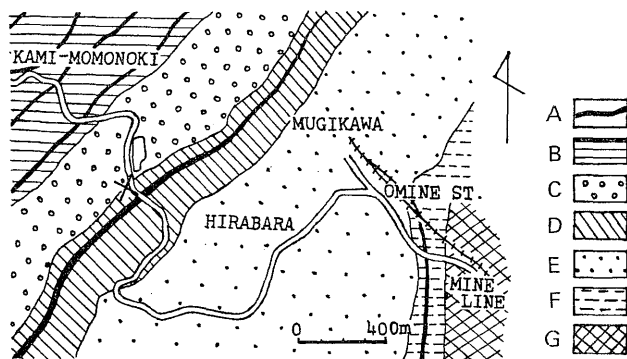


Fig. 1. Geological map showing the locality (x) of *Protocedroxylon okafujii*. A, coal bed. B, Omime cyclic coal-bearing beds. C, Momonoki deltaic sediments. D, Mugikawa cyclic coal-bearing beds. E, Hirabara Formation. F, Takiguchi Formation. G, paleozoic strata.

coal seams (Mugikawa coal beds). The present fossil woods were collected from the grayish medium grain sandstone, under the uppermost coal seam of the Mugikawa coal beds (Table 1). According to Kobayashi (1930) and Kobayashi & Katayama (1938), *Tosapecten suzukii* and *Oxytoma zitteli* are found also from the Aso Formation and these species are common to the *Pecten* bed which is located between the *Halobia* bed and *Pseudomonotis ochotica* bed in the Sakawa district, Shikoku. Judging from the correlation with the Upper Triassic strata of Sakawa district, the Aso Formation would not be younger than the Norian, and the Momonoki Formation would seem to be the Carnian in age.

The present specimens seemed to be identified with *A. mineense* at a glance in exhibiting abundant tyloses in all tracheids which were regarded as the most impressed character of *A. mineense* by Ogura (1960). *Protocedroxylon triassicum* resembles also *A. mineense* in gross morphology including abundant tyloses in all tracheids except for the presence of the abietineous pitting on ray cells. Thereupon we have examined the type specimen of *A. mineense* under the courtesy of the University Museum in the University of Tokyo, and reexamined the specimens from the Hirabara Pass. As a result, we have reached a conclusion that *Protocedroxylon triassicum* would be identical with *A. mineense* and our specimens from the Hirabara Pass would be a new species

belonging to *Protocedroxylon*.

**Protocedroxylon mineense** (Ogura) Nishida et Ōishi, comb. nov.

*Araucarioxylon mineense* Ogura, Journ. Fac. Sci., Univ. of Tokyo Sect. III 7 (10): 501 (1960). *Protocedroxylon triassicum* Yamazaki et al., Mem. School of Sci. & Engin. Waseda Univ. 44: 100 (1980).

Locality. The Hirabara Pass, Mine City, Yamaguchi Prefecture.

Horizon. Upper Triassic: Carnian.

Distribution. Nariwa, Okayama Prefecture and Mine, Yamaguchi Prefecture (Triassic: Carnian to Norian).

Affinity. In the original description of *A. mineense*, Ogura (1960) picked up the following features as diagnostic characters: 1) wood consisting only of tracheids and rays and being devoid of wood parenchyma, 2) araucarian type of pitting on radial walls of tracheids, 3) rays usually uniseriate and often biseriate in part and exhibiting 1-29 cells high, 4) ray cells being narrow in width in tangential section, 5) tracheids having abundant tyloses, and 6) one to two large ovoid pits in a cross field. On the other hand, *Protocedroxylon triassicum* has been characterized by the following diagnostic characters (Yamazaki et al. 1980); 1) araucarian and often protopinoid type of pitting on tangential as well as radial walls of tracheids, 2) abietineous pitting on ray

Table 1. Correlation of the division of Mine Group  
(after Tokuyama 1958).

Mine Group	{	Aso Formation	{	Sannose sandstone (600 m)
				Oda coal-bearing beds (400 m)
				Mitsusugi sandstone (800 m)
				Inoki coal-bearing beds (200 m)
		Momonoki Formation	{	Omine cyclic coal-bearing beds (500 m)
				Momonoki deltaic sediments (450 m)
				Mugikawa cyclic coal-bearing beds (380 m)
		----- unconfornity -----		
		Hirabara Formation	{	Upper (400 m)
				Middle (250 m)
				Lower (450 m)
		Takiguchi Formation (300 m+)		
		----- unconfornity -----		
		Pre-Triassic		

cells, 3) tracheids having abundant tyloses, 4) presence of wood parenchyma, 5) rays uniseriate or often biseriate in part and 1-40 cells high, and 6) 1-2 ovoid pits in a cross field.

Ogura (1960) overlooked the abietineous pitting on the ray cells in his specimen perhaps on account of thickness of original micropreparations and not so good preservation of them. We examined original micropreparations which have been kept in the University Museum in the University of Tokyo and could find out the abietineous pitting on well-preserved ray cells (Pl. I A-C, E). We could find out it also on our new micropreparations of the type specimen made by the ordinary peel method using hydrogen fluoride as a reagent. We also found rays higher than those of original description ranging up to 42 cells high on our own micropreparations as well as the original ones. Moreover we detected the bordered pits on the tangential walls of tracheids, of which Ogura was not aware (Pl. I F). This would suggest that *A. mineense* would not belong to *Araucarioxylon* but to *Protocedroxylon*.

Yamazaki et al. (1980) described the presence of the wood parenchyma in their *Protocedroxylon triassicum*. So-called wood parenchyma they figured (Fig. 4-B and Fig. 1 in Pl. VI in Yamazaki et al. 1980), however, would not be true wood parenchyma but septulate tracheids. Because these cells exhibit nodular thickenings on their vertical (tangential) walls which would be vertical sections of the bordered pits on tangential walls. Moreover crowded several pits in the cross field between the ray cells and the so-called wood parenchyma, shown on Fig. 4-B, are obviously bordered. Hence they would not be true wood parenchyma but the septate tracheids. We have found similar structures on the original micropreparations of *A. mineense* (Pl. I C): the septulate cells like so-called wood parenchyma figured by Yamazaki et al. contain tyloses or exhibit araucarian type of pitting on their extensions (Pl. I D). We have also examined that some extensions of vertical elements which constitute cross field containing several crowded bordered pits like those figured by Yamazaki et al. (1980), exhibit also the araucarian type of pitting (Pl. I C). Thus we believe *P. triassicum* is devoid of wood parenchyma and is identical with *A. mineense*. Of course it is reasonable that it belongs to *Protocedroxylon* because of the appearance of the abietineous pitting on the ray cells. *A. mineense* sensu Nishida et al. (1977) from the Triassic of Sekigahara does not exhibit the abietineous pitting on the ray cells. Thus it is

not identical with *A. mineense* but would be the other species belonging to *Araucarioxylon*.

Diagnosis emend. of *Protocedroxylon mineense*.

Wood consisting only of tracheids and rays, devoid of wood parenchyma. Tracheids containing abundant tyloses, sometimes septulate. Bordered pits on radial walls arranged usually in one to two rows and in araucarian type or rarely in protopinoid type. Tangential walls pitted sparsely by smaller bordered pits. Rays usually uniseriate, often biseriate in part, 1-42 cells high. Ray cells comparatively narrow in tangential width, and having abietineous pitting. Usually one to two large ovoid pits, rarely several small crowded pits in a cross field.

The secondary wood of *Araucariopitys japonica* also resembles closely *P. mineense* in general structure except for the presence of traumatic resin canals in the former. *Araucariopitys* is also separated from *Protocedroxylon* by the presence of sclerids in the pith. However, such fundamental structures as tyloses in the tracheids, form and height of rays, pits in the cross field, arrangement of bordered pits on the tracheids, abietineous pitting on ray cells and abundant intercellular spaces among the elements of the secondary wood, tracheids as well as ray cells, are shared by *A. japonica* and *P. mineense*. Traumatic resin canal is sporadic character. All Japanese specimens of *Protocedroxylon* have been devoid of pith. Hence we have not been able to neglect a possibility that *A. japonica* may be identical with *P. mineense*. We have expected future examination to solve this problem.

**Protocedroxylon okafujii** Nishida et Ōishi, sp. nov.

Locality. Road cut of the Hirabara Pass, Mine City, Yamaguchi Prefecture.

Horizon. Upper Triassic: Carnian.

The type specimen (No. 77001) is deposited in the Laboratory of Phylogenetic Botany, Faculty of Science, Chiba University.

Materials. Original petrified trunk immersed in the sandstone constituting the road cut of the Hirabara Pass is ca 30 cm in diameter. We collected several pieces of the fairly preserved secondary wood from the original trunk.

Description. Wood consisting of tracheids, rays and wood parenchyma which littered sparsely in the increments. Growth rings visible. Transition from the early to the late wood, consisting only of several layers of tracheid, abrupt. Tracheids rectangular or more or less radially or tangentially elongated

in shape in cross section, 15-60  $\mu\text{m}$  and 17-72  $\mu\text{m}$  in tangential and radial diameters respectively. Tracheids often occluded with resinous brown substances, and sometimes septulate and always contain abundant tyloses. Bordered pits on radial walls usually arranged in araucarian type; contiguously and alternately arranged in one to two rows, or rarely arranged separately; circular or somewhat flattened, 14-26  $\mu\text{m}$  in diameter. Bordered pits also present on tangential walls arranged contiguously or separately. There are 4-9 rays per 1 mm. Rays usually uniseriate, often biseriate in part, 1-40 cells high or 30-1020  $\mu\text{m}$  in height. Ray cells vertically elongated rectangular and narrow in width in tangential section, 14-36  $\mu\text{m}$  and 9-12  $\mu\text{m}$  in vertical and tangential widths respectively and pitted on all walls; abietineous pitting present. Single or two large ovoid pits in a cross field, 7-18  $\mu\text{m}$  in long diameter. Wood parenchyma thin, 26-28  $\mu\text{m}$  and 18-20  $\mu\text{m}$  in tangential and radial widths respectively and 72-250  $\mu\text{m}$  in length.

Affinity. As mentioned above, the present specimen shares almost all diagnostic characters with *P. mineense*, except for the presence of wood parenchyma. Mesozoic petrified trunks exhibiting both the araucarian type of pitting on the tracheids and the abietineous pitting on the ray cells have been described in several works (Stopes & Fujii 1910, Shimakura 1937, Ogura 1944, Nishida 1962, 1966, 1967a, 1967b, 1967c, 1970, 1973, Yamazaki et al. 1980). *Planoxylon* in which Japanese species have been recognized by Nishida (1962, 1966, 1967a, 1973) would be distinguished from *Protocedroxylon* in having vertical pairs of pits in the cross field. *Araucariopitys* in which only *A. japonica* (Yamazaki et al. 1980) is registered in Japan differs from *Protocedroxylon* in having traumatic resin canals and sclerids in the pith, though all Japanese specimens of *Protocedroxylon* are devoid of pith. *A. japonica* differs from the present species in having traumatic resin canals and being devoid of wood parenchyma. *Protocedroxylon japonicum* and *P. pseudo-araucarioides* from the Cretaceous of Choshi (Nishida 1967b, 1973) have also tyloses in the tracheids, though they are not so abundant as the present species, but differs from the present species in having several half-bordered pits in a cross field and lower rays, 2-22 cells high instead of 1-2 large ovoid pits in a cross field and higher rays, up to 40 cells high in the latter. *Metacupressinoxylon*, in which five Japanese species including tyloses-bearing ones were recognised by Nishida (1965, 1967a), is distinguished from the present specimen in having

lower rays, 1-13 cells high and exhibiting mainly ordinary coniferous type of pitting on the tracheids. *Cedroxylon* species in Japan do not have any tylosis in the tracheids. Thus we would like to register the present specimen as a new species belonging to *Protocedroxylon*. Specific epithet is dedicated the late Mr. Goro Okafuji who assisted us in collecting the materials.

The authors wish to express their thanks to the late Mr. Goro Okafuji for his kindness to assist us in collecting the materials. They also wish to thank for the courtesy of the University Museum in the University of Tokyo giving permission to examine the type specimens of *Araucarioxylon mineense*.

#### Literature

- Kobayashi, T. 1930. Journ. Geol. Soc. Tokyo 37: 329-333 (in Japanese).  
— & M. Katayama 1938. Proc. Imp. Acad. Jap. 64: 184-189. Nishida, M. 1962. Jap. Journ. Bot. 18: 87-104. — 1965. Bot. Mag. Tokyo 78: 138-146. — 1967a. ibid. 80: 383-393. — 1967b. Journ. Jap. Bot. 42: 261-264. — 1967c. Bot. Mag. Tokyo 80: 487-497. — 1973. ibid. 86: 189-202. —, M. Adachi & H. Abe 1977. Journ. Jap. Bot. 52: 33-38 (in Japanese with English summary). Ogura, Y. 1960. Journ. Fac. Sci. Univ. Tokyo, Sect. III 7: 501-509. Shimakura, M. 1937. Sci. Rep. Tohoku Imp. Univ. 2nd ser. 19: 1-73. Stopes, M. & K. Fujii 1910. Phil. Trans. Roy. Soc. London 201: 1-90. Tokuyama, A. 1958. Journ. Geol. Soc. Jap. 64: 457-463, 537-550 (in Japanese with German summary). Yamazaki, S., K. Tsunada & N. Koike 1980. Mem. School Sci. & Engin. Waseda Univ. 44: 91-131.

#### Explanation of plates I~II

- Pl. I. *Protocedroxylon mineense*. Cross (A), radial (B-D), and tangential (E, F) sections of the type specimen (original micropreparations) of *Araucarioxylon mineense* Ogura. Abietineous pitting of ray cells are exhibited in A & E. Nodules ascribed to abietineous pitting on horizontal and tangential walls of ray cells are seen in B. Several crowd half bordered pits in the cross field between ray cells and tracheid are exhibited in C (arrow: cf. fig. 4 in Yamazaki et al. 1980). Septulate tracheid which is easy to be misunderstood as wood parenchyma is seen in the center of D. Arrow indicates bordered pits (cf. Pl. VI, fig. 1 in Yamazaki et al. 1980).

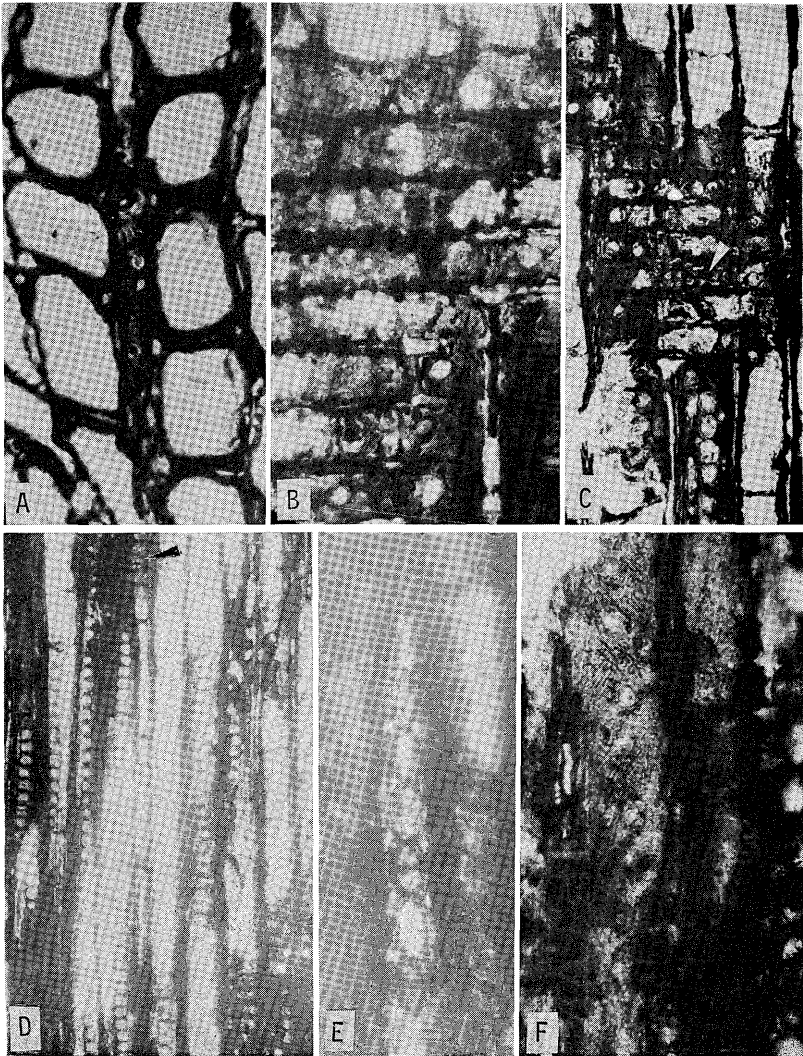
Bordered pits on tangential walls of tracheid are seen in F. A, B and F,  $\times 280$ ; C and E,  $\times 145$ ; D,  $\times 70$ .

- Pl. II. *Protocedroxylon okafujii*. A, cross section showing a wood parenchyma. B, radial section showing nodules ascribed to abietineous pitting on horizontal and tangential walls of ray cells. C, radial section exhibiting wood parenchyma (arrow). D, tangential section showing wood parenchyma (arrow). A and B,  $\times 310$ ; C and D,  $\times 80$ .

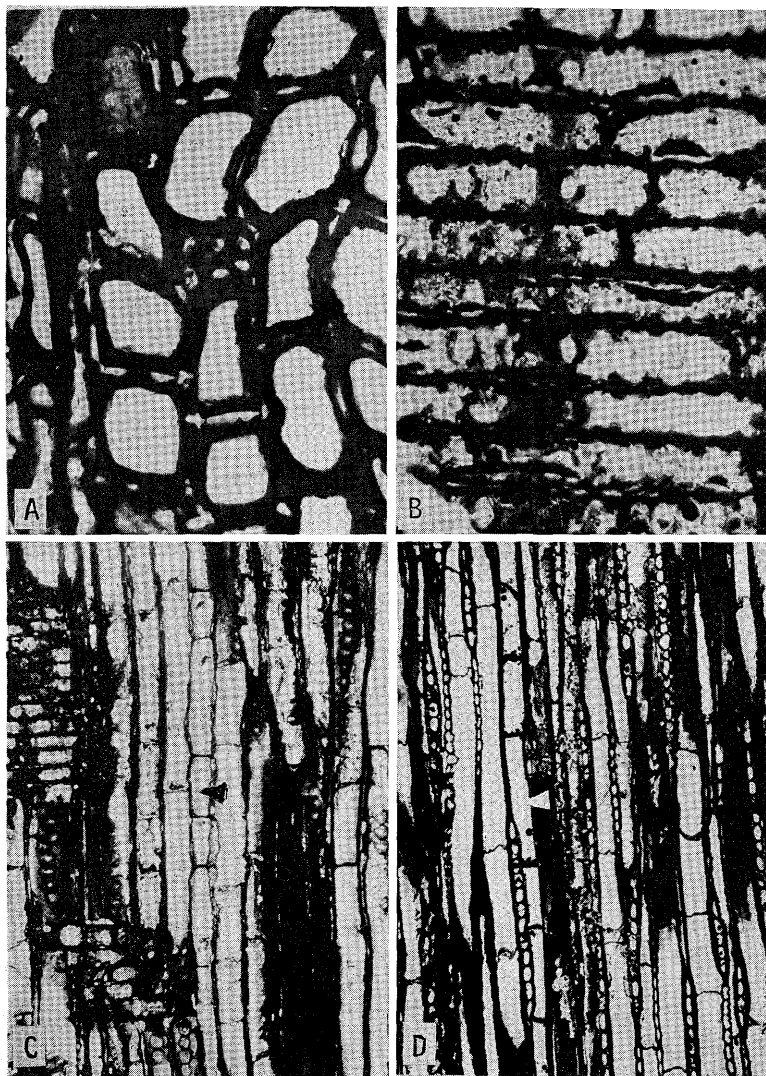
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*Araucarioxylon mineense* Ogura (1960) は山口県美祢市平原峠の三疊紀から得られた珪化木で、ナンヨウスギ型の有縁孔を放射壁にだけ生ずる仮道管に多数のチロースをもち、放射組織は1~29細胞高で、さらに直交分野に1-2個の大きな卵形の半有縁孔をもつ。最近、山崎ら (1980) が岡山県成羽町の三疊紀から記載した *Protocedroxylon triassicum* Yamazaki et al. は放射組織細胞にモミ型膜孔があることと木部柔組織があることを除いて、その他の特徴は *A. mineense* とそっくりである。東大総合資料館の基準標本 (プレパラート) を再検したところ、*A. mineense* にもモミ型膜孔があり、(Pl. I A, B, E) かつ、しばしば仮道管切線壁上にも有縁孔があり、放射組織も42細胞高に達し、*P. triassicum* の記載と木部柔組織の存在をのぞいて一致した。ところが、*P. triassicum* の原記載で示された木部柔組織は隔壁をもった仮道管と思われる。*A. mineense* の基準標本においても同様な隔壁をもった細胞が見られ、よくしらべるとその延長上に縁孔がある (Pl. I D)。また、山崎らは有縁孔が密集している直交分野を観察し、それを構成する縦の細胞を木部柔組織細胞としているが、その細胞にも有縁孔があった (Pl. I C)。結局 *P. triassicum* には木部柔組織はなく、それと見まちがい易い隔壁のある仮道管があるにすぎない。かくして、*P. triassicum* は *A. mineense* と同じものであることがわかった。むろん *A. mineense* はモミ型膜孔をもつので *Protocedroxylon* に属する。ところで、筆者らが故岡藤五郎氏の案内で美祢市平原峠の道路沿いの砂岩露頭から採った珪化木は基本構造は殆んど *P. mineense* と同じであるが、はっきりした木部柔組織のあることがわかった (Pl. II C, D)。これこそ *Protocedroxylon* の新種である。種小名は多年美祢の三疊紀化石の収集に貢献された故岡藤五郎氏に献名した。





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